Delineation of 2001 Land Use Patterns For the Cooperative Hydrology Study in the Central Platte River Basin

Final Report
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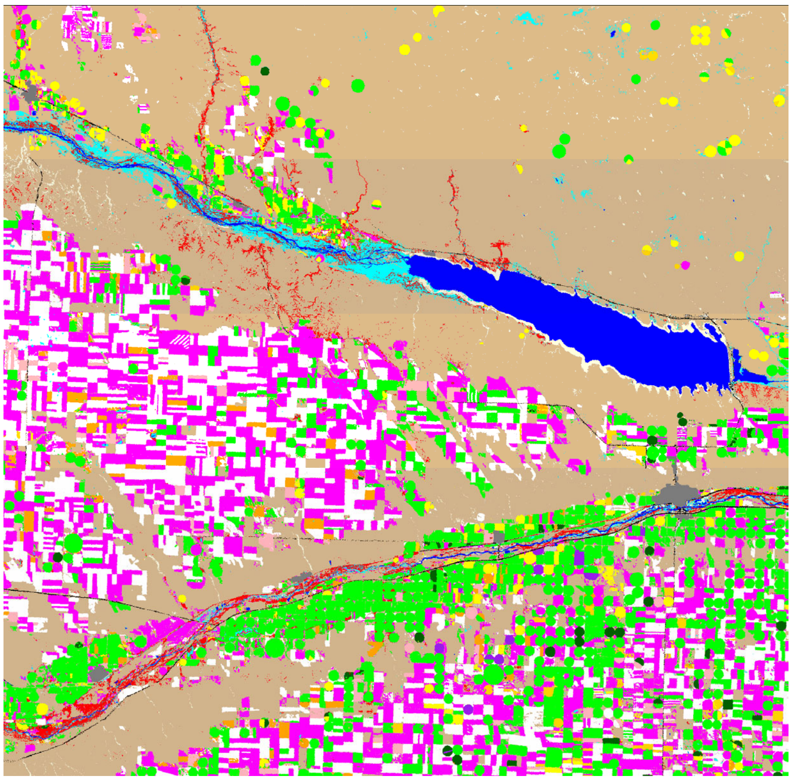

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CONTENTS

List of Tables

List of Figures

INTRODUCTION

The Platte River Cooperative Hydrology Study (COHYST) is a multi-agency effort that seeks to improve the understanding of the hydrological conditions in the Platte River watershed in Nebraska upstream of Columbus, NE. COHYST seeks to produce scientifically supportable hydrologic databases, analyses, and modeling to: 1. assist Nebraska in meeting its obligations under the Cooperative Agreement among Colorado, Nebraska, Wyoming, and the U.S. Department of the Interior; 2. assist the Natural Resources Districts within the Platte River Basin in providing appropriate management and regulation of groundwater; 3. provide the citizens of Nebraska with a basis to develop policies and procedures related to groundwater and surface water; 4. help the citizens of Nebraska analyze the proposed activities developed under the Three-State Cooperative Agreement and understand the hydrologic consequences of these activities. The results of COHYST will provide a basis to develop policy and procedures related to groundwater and surface water. This will enable existing and new water uses in the Platte River Basin to proceed without additional actions required for the four species covered under the Endangered Species Act: *Grus Americana* (Whooping Crane), *Charadrius melodus* (Piping Plover), *Sterna antillarum* (Least Tern), and *Scaphirhynchus albus* (Pallid Sturgeon).

The Central Platte River Valley in Nebraska is an internationally significant staging area for migratory water birds of the Central Flyway and is best known for the one-half million sandhill cranes and the several million other waterfowl that migrate annually through the valley. Changes in water and land use have transformed the river channel and altered adjacent wet meadows (U.S. Bureau of Reclamation *et al*., 1983). Changes in the Platte River have been caused by shrinkage of the river channel and associated woody vegetation encroachment. In addition, adjoining native grasslands have been destroyed and water table levels have declined due to the conversion of these lands to cropland (U.S. Fish and Wildlife Service, 1981). All of these factors have altered and reduced habitat for migratory birds.

PROJECT OBJECTIVES

Comprehensive and current information on land cover and land use, especially irrigation and crop patterns, are critical to COHYST, since hydrologic conditions change in relation to crop dynamics. In January of 2001, The Center for Advanced Land Management Information Technologies (CALMIT) completed the development of a land cover database for the COHYST region based on 1997 Landsat-5 satellite imagery and ancillary data. To identify changes in crop patterns, this land cover map was updated using 2001 landsat-7 satellite imagery as the primary data source. The objective of this study was to capitalize on the seasonal dynamics of the agricultural crops and native plant communities in order to develop an updated land use and land cover map of the Platte River Basin in Nebraska for the year 2001.

Process-based hydrologic models utilize inputs based on quantifiable variables. Land cover has been identified as one of the key variables in hydrologic modeling (Bobba *et al*., 2000, Srinvasan *et al*., 1998), and an important factor in determining consumptive water use (Zheng and Baetz, 1999). An analysis of land cover and land use is critical to determine what current crops are grown, whether they're grown under irrigated or non-irrigated conditions, or whether the fields are in pasture or range, rather than cultivation. Different land uses all yield different kinds of water use. Updating the land cover map for the year 2001 will provide a more accurate input layer for use in COHYST hydrologic modeling efforts.

THE STUDY AREA

The study area includes parts of 42 counties in Nebraska and covers approximately 28,800 square miles (see Figure 1). Elevation in this area ranges from 1,427 feet above sea level in Platte County to approximately 5,424 feet in Kimball County.

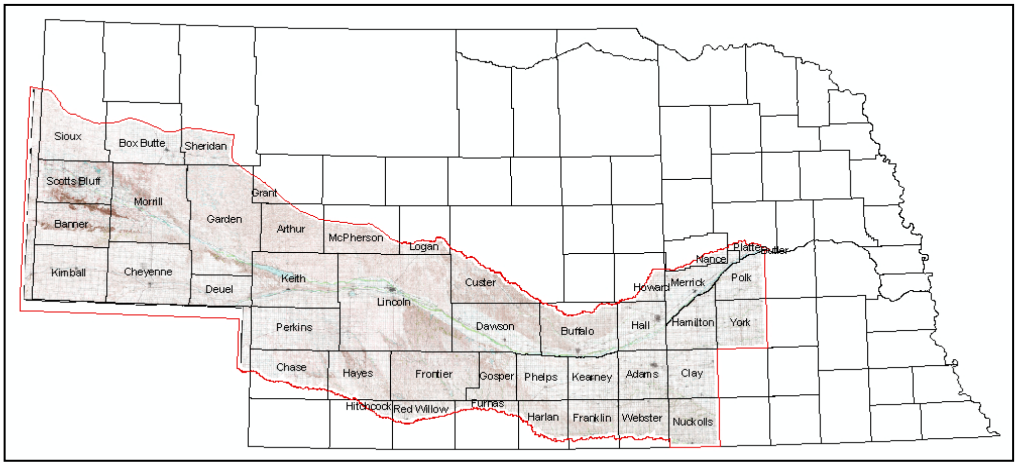


Figure 1. The COHYST Study Area.

Topography and Climate

The general topography of the study area consists of gently rolling hills broken by isolated buttes, mesas, ravines, and shallow streams flowing to the east-southeast. The geography of the western half of the study area is characterized by relic sand dunes and rolling loess hills. The eastern half of the study area consists of a terraced landscape. The Platte River, along with its tributaries, forms a distinct basin between plains, sand hills and rolling hills. Years of erosion have left the central portion of the valley broad and well developed, while the eastern end of the basin is more narrow. (Jenkins, 1993).

The climate of the Platte River basin is typical of the interior of the mid-latitude United States. Two-thirds of the precipitation falls during the growing season, and summers are generally hot, and winters severe. Temperature and precipitation vary widely between years. Short-term weather changes are influenced by large masses of warm, moist air from the Gulf of Mexico; cold, dry air from central Canada; cool, dry air from the northern Pacific Ocean; and hot, dry air from the southwestern United States.

The 2001 Growing Season

Growing conditions for the majority of Nebraska in 2001 were much improved from the previous 2000 growing season. As observed in Figure 2, precipitation was greater in 2001 than 2000. Increased precipitation levels strongly contributed to a successful growing season. Severe drought conditions in 2000 had resulted in below average crop yields, while better weather conditions in 2001, primarily higher precipitation levels, contributed to a 15-20% yield increase for row crops. In 2001, both dry-land producers and irrigators saw higher yields, resulting in record setting irrigated yields in 60 of Nebraska's 93 counties, and record dryland corn yields in 10 counties (Nebraska Agricultural Statistics Service, 2002).

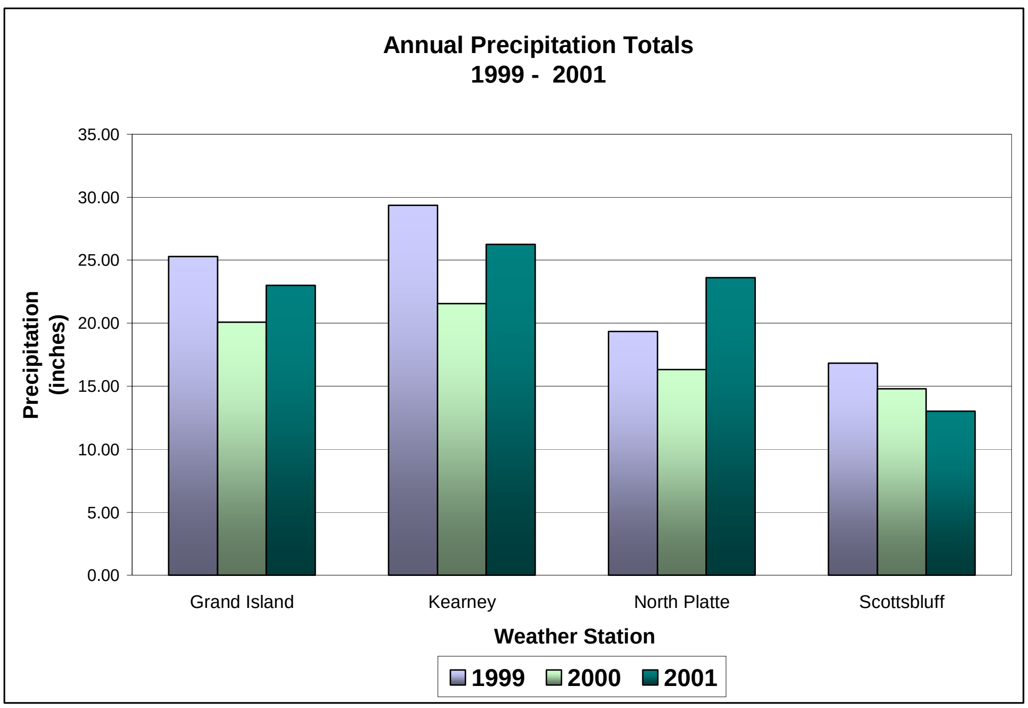


Figure 2. Precipitation Totals for Select Weather Stations 1999-2001.

By mid-May 2001, many areas of Nebraska had received 150-250% percent of normal precipitation levels, replenishing soil moisture deficits induced by the drought conditions of 2000. For the same time period in 2000, there was little to no moisture in surface soil. In fact, planting in spring 2001 for some farmers was delayed due to wet soil conditions (IANR, 2001). Improved overall weather conditions and timely precipitation contributed to a better than average 2001 growing season (Nebraska Agricultural Statistics Service, 2002).

Temperatures during the 2001 growing season were near 20-year norms (Nebraska Agricultural Statistics Service, 2002). In eastern Nebraska, the temperatures were lower than normal, while western Nebraska experienced near-normal temperatures. Figure 3 shows that annual average temperatures for 2001 were actually higher than 2000. However, this condition was offset by sufficient subsoil moisture levels produced by the above average spring precipitation, creating near ideal conditions for the 2001 growing season (IANR, 2001).

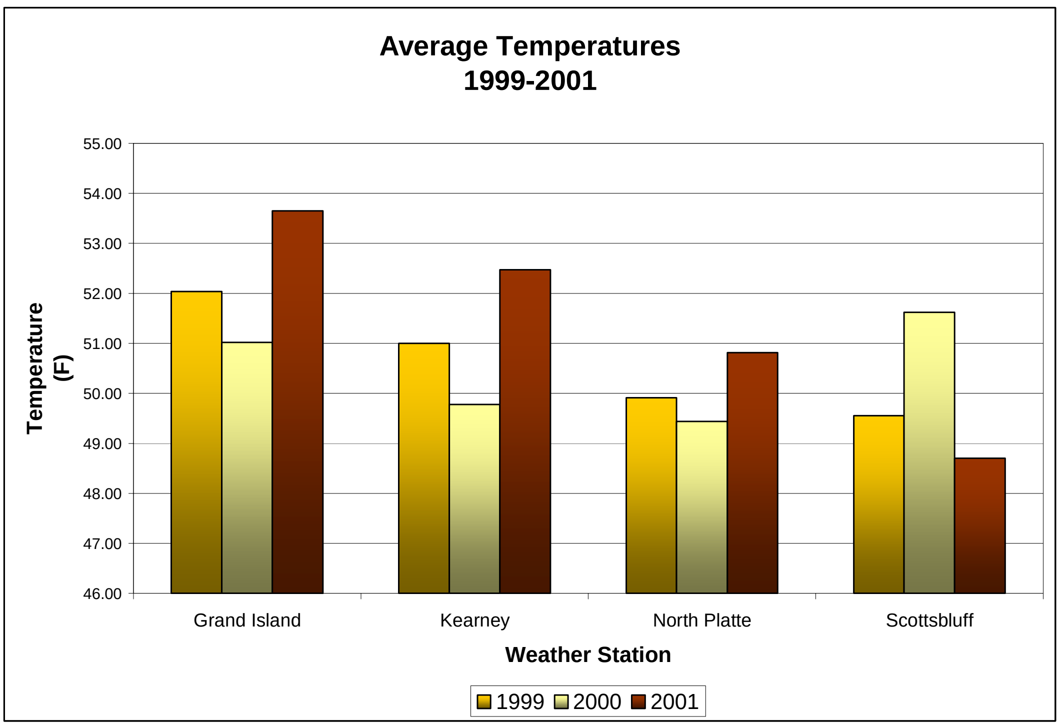


Figure 3. Average Temperatures for Select Weather Stations 1999-2001.

Crop progress in 2001 is evident by the reduction in number of counties filing for Secretarial Natural Disaster Designation—11 in 2001, as opposed to 83 in 2000. The growing season faced limited insect pressure, disease, and weather-related crop damage.

Temperatures during the growing season were around 20-year norms. Extended or prolonged hot days of 95 F and higher, typical of summer months in eastern Nebraska, were less frequent in 2001 than in 2000. (Nebraska Agricultural Statistics Service, 2002). The well-timed cooler days and higher humidity levels in eastern Nebraska contributed to increased dry-land corn yields.

Plant Community Characteristics

Biologically, the Platte River Basin contains a wide variety of plant species. Four distinct plant communities exist in the region: (1) mixed-grass prairie; (2) tallgrass prairie; (3) sandhills prairie; and (4) floodplain or riparian forest (Jenkins, 1993). Mixed-grass prairie is particularly dominant in the loess hills on the northern side of the Platte River. The most common grasses include *Agropyron smithii* (western wheatgrass), *Bouteloua gracilis* (blue gramma), *Panicum virgatum* (switchgrass), and *Elymus canadensis* (Canadian wildrye). Common forbs include *Amorpha canescens* (leadplant), *Aster ericoides* (white aster), *Ratibida pinnata* (prairie coneflower), Solidago missouriensis (Prairie goldenrod), *Chondrilla juncea* (skeltonweed), and *Erigeron strigosus* (daisy fleabane). Much of the original mixed-grass prairie is under cultivation or used for grazing cattle.

The tallgrass prairie, found in central and eastern Nebraska, is made up of upland and lowland prairies. Upland tallgrass prairie is dominated by *Andropogon gerardii* (big bluestem), *Schizachyrium scoparium* (little bluestem), *Panicum virgatum* (switchgrass), and *Sorghastrum nutans* (Indian grass). Characteristic forbs of the tallgrass prairie are *Helianthus rigidus* (stiff sunflower), *Silphium integrifolium* (rosin weed), *Silphium lacianatum* (compass plant), and *Liatris punctata* (dotted gayfeather) (Great Plains Flora Association, 1986). Lowland prairies are a combination of marshes, sedge meadows, and well-drained prairies. Many of these have been drained and cultivated. Dominate species include grasses such as *Andropogon gerardii* (big bluestem), *Sorghastrum nutans* (Indian grass), *Spartina pectinata* (prairie cordgrass), *Sporobolus asper* (tall dropseed), and *Panicum virgatum* (switchgrass), as well as sedges.

In the sandhills prairie, grass types include *Andropogon scoparius* (sand bluestem), *Schizachyrium scoparium* (little bluestem), *Calamovilfa longifolia* (sand reedgrass), *Stipa comata* (needle and thread), and *Panicum virgatum* (switchgrass), usually with an understory of *Koeleria macrantha* (junegrass), *Sporobolus cryptandrus* (sand dropseed), and grama grasses (Jenkins, 1993). On the windward side of dunes where blowouts occur, *Redfieldia flexuosa* (blowout grass) and *Muhlenbergia pungens* (sandhills muhly) act as stabilizers.

The floodplain or riparian forest communities have open canopies and are dominated by *Populus deltoides* (cottonwood) with an understory of *Juniperus virginiana* (red cedar) and *Cornus drummondii* (rough-leaf dogwood). Other species include: *Fraxinus pennsylvanica* (Green ash), *Celtis occidentalis* (hackberry), *Ulmus americana* (American elm), *Morus rubra* (red mulberry), and *Ulmus rubra* (slippery elm) (U.S. Fish and Wildlife Service, 1981). Common to the major river channels are low shrub islands and vegetated sandbars. *Salix amygdaloides* (peach-leaf willow), *Salix hindsiana* (sandbar willow), and *Dalea pulchra* (indigo bush) are the dominant shrub species. *Eragrostis* sp.(lovegrass), *Cyperus* sp.(nutsedge), *Echinochloa crusgalli* (barnyard grass), *Xanthium strumarium* (cocklebur), and scattered *Salix sp*. (willow) and *Populus deltoides* (cottonwood) seedlings characterize the vegetation on the low shrub islands and sandbars (Great Plains Flora Association, 1986).

Agriculture has transformed the pre-settlement landscape of the Platte River Basin. Agriculture represents the primary economic base of the study area and accounts for 97% of the Platte River Basin lands. Of this, 57.7% is used for pasture and range (U.S. Fish and Wildlife Service, 1981). The major crops include corn, wheat, soybeans, sorghum, and hay. Other crop types include oats, sugar beets, dry beans, sunflowers, and potatoes. Nearly two-thirds of the non-agricultural lands are urban developed areas. Remaining lands include privately owned irrigation and power structures, state and federal lands that are not cropped, canals, and other non-agricultural lands.

Land Cover Classes and Their Characteristics

Since agriculture represents such a large percentage of the study area, the main focus of the land cover classification was to identify agricultural crops. The land cover classes used in the study were (Table 1): irrigated & non-irrigated corn, irrigated sugar beets, irrigated & non-irrigated soybeans, irrigated & non-irrigated sorghum, irrigated and non-irrigated dry edible beans, irrigated potatoes, irrigated & non-irrigated alfalfa, irrigated & non-irrigated small grains, irrigated and non-irrigated sunflower, summer fallow, range (grass/pasture/CRP), urban land, open water, riparian forest & woodlands, wetlands, other agricultural lands, roads, and barren areas. Each class is further detailed and described in Table 1.

Table 1. Land Cover Classes and Characteristics

(Descriptions from Nebraska Agricultural Statistics Service, 1990; National Agricultural Statistics Service, 1997, 2002; Maxwell and Hoffer, 1996).

Land Cover Classes	General Description
Irrigated & Non-Irrigated Corn	Includes corn used for grain or silage. Planted late April to early May, full cover by late July and harvested September through November.
Irrigated Sugar Beets	Sugar Beets are planted in April. Full cover in August and harvested in October. Sugar Beets are usually irrigated.
Irrigated & Non-Irrigated Soybeans	Soybeans are planted in May and are at full cover by July. They are harvested September through October.
Irrigated & Non-Irrigated Sorghum	Includes sorghum for grain and silage, as well as milo, sudan, and cane. Planted in May, full cover by July and harvested September through October.
Irrigated & Non-Irrigated Dry Edible Beans	Includes great northern beans, pinto beans, white beans, and others. Planted in May to early June. Cutting starts mid-August when plants are windrowed to dry. Harvested late August to late September.
Irrigated Potatoes	Potatoes are planted in late April to early May, harvested September/October. Potatoes are usually irrigated.
Irrigated & Non-Irrigated Alfalfa	Alfalfa green-ups during April and early May with first cut beginning in May. Harvested 3-4 times during the growing season ending in early October.
Irrigated & Non-Irrigated Small Grains	Includes winter wheat, spring wheat, oats, barley, rye and millet. Winter wheat planted September of previous year and harvest begins early July. Oats and barley are generally planted late March or early April, and harvested in July.

Land Cover Classes	General Description
Irrigated & Non-irrigated Sunflower	Planted in May and harvested in October.
Summer Fallow	Cropland that is purposely kept out of production during a cropping season mainly to conserve moisture for the next season. It is common for wheat producers to rotate half their cropland to summer fallow each year.
Range/Grass/Pasture	Mostly range grasses and pasture, with some cultivated grass and hay. Includes brome grass and land in the Conservation Reserve Program. Green-up in spring and early summer. Grazing occurs at irregular intervals.
Urban Land	Areas defined as towns or cities with a population greater than 100 people.
Open Water	Lakes, streams, ponds, reservoirs. Water levels varies due to irrigation draw-downs and evaporation.
Riparian Forest & Woodlands	Forested areas including areas next to streams, lakes and wetlands
Wetlands	Emergent wetlands, lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. This class may also include sub-irrigated grassland areas and areas of shallow water.
Other Agricultural Lands	Includes developed areas associated with farming, such as farmsteads, feedlots, etc.
Roads	Interstate and highway roads.
Barren Areas	Areas with no vegetation, including blowouts and sandbars.

LITERATURE REVIEW

Remote Sensing of Land Cover

There are a variety of definitions available for remote sensing. The Canada Centre for Remote Sensing defines remote sensing as a ‘group of techniques for collecting image or other forms of data about an object from measurements made at a distance from the object, and the processing and analysis of the data’. Remote sensing systems acquire data at a variety of spatial, spectral, temporal, and radiometric resolutions, which make them extremely valuable for natural resource mapping and monitoring applications.

One important application is land use and land cover mapping. Since early in the 1970s, it was determined that general vegetation and land cover types could be mapped from satellite imagery faster and at a lower cost than with aerial photography (e.g., Belward and Hoyos, 1987; Campbell, 1981; Chuvieco and Congalton, 1988; Green, 1992). In recent years, more detailed vegetation classification studies have improved classification results utilizing satellite data with higher resolution. Landsat ETM data are well suited for vegetation/land-cover mapping due to the frequency of satellite coverage, images are collected every 16 days for the same ground area.

Remote sensing of land cover is based on principles of interaction between matter and electromagnetic energy (EMR). “In principle, remote sensing systems could measure energy emanating from the earth’s surface in any sensible range of wavelengths (Richards et al., 1999).” Detection of changes in the amount and properties of EMR reflected or reradiated from matter allows for interpretation of land cover phenomena (Jensen, 1996). This basic principle enables various kinds of surface materials to be recognized and distinguished from each other by differences in spectral reflectance. These differences are also known as spectral signatures. While spectral signatures are often plotted as single lines (as in Figure 4), in reality they should appear more like “ribbons” since spectral reflectances vary somewhat within a given material type. The spectral signature of one tree species, for example, will not be identical to a different tree species, or even the same tree species. Variables such as the amount of total cover, the health and vigor of the plant, and changes in atmospheric conditions will cause differences in spectral responses. In spite of these external effects, there are general spectral patterns that emerge for different types of materials.

The visible and near infrared regions of the electromagnetic spectrum are frequently used for analysis of land cover types. The visible region, the portion of the spectrum our eyes can detect, determines what color an object appears to us. The visible region of the spectrum is represented by the three primary colors of blue (0.4 to 0.5 μm), green (0.5 to 0.6 μm), and red (0.6 to 0.7 μm). For example, in the visible region of the spectrum, green grass appears green to us because it is reflecting green and absorbing blue and red light. On the other hand, an object appearing black is absorbing all three primary colors of the visible region while an object appearing white is reflecting all three primary colors of the visible region. The near-infrared region of the spectrum is energy beyond what our eyes can detect.

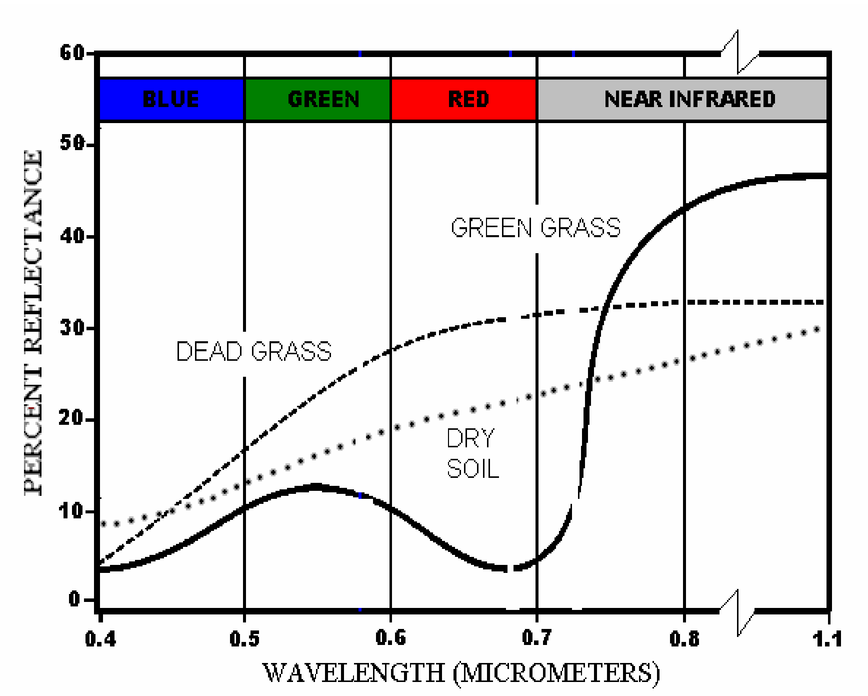


Figure 4. Spectral reflectance of Green Grass, Dead Grass and Dry Soil

(Adapted from the U.S. Geological Survey, 2002).

The near infrared region of the electromagnetic spectrum ranges from approximately 0.7 to 1.1 μm. Reflectance in the near infrared region is an indication of plant health and vigor. For example, the near-infrared region in Figure 4 depicts healthy green grass reflecting strongly while dead grass has a weaker reflectance in that range. Near-infrared reflectance is based on a plants physiological structure and health. Therefore, reflectance in this region is not based on a plant's color but on how well a plant's cell structure reflects solar energy. This region is used to analyze, monitor and assess changes or differences among plants.

The general spectral signatures of green grass, dead grass, and dry soil illustrate a basic example of how remote sensing can delineate materials based on their reflectance signatures. Using spectral reflectance to differentiate materials, remote sensing can be used to evaluate, assess and inventory land cover types. Reflectance signatures of like materials tend to have similar spectral characteristics.

Absorption characteristics of vegetation vary due to seasonal cycles. Healthy green vegetation absorbs in the blue and red regions of the spectrum because of chlorophyll absorption bands in the blue and red regions (Gibson, 2000). Our eyes see green vegetation because of the high absorption of blue and red energy and the reflection of green energy. If a plant is diseased or stressed, chlorophyll production decreases, resulting in less absorption of blue and red energy. When red energy is not absorbed but reflected, leaves appear yellow—a combination of red and green energy. For vegetation, spectral reflectance is highest in the range between 0.70 – 1.30 μm, as plant leaves typically reflect 40%-50% of the energy incident upon it (Lillesand and Kiefer, 2000).

These high reflectance values result from the internal structure of plant leaves. Algorithms used to extract information about vegetation from remotely sensed data are collectively known as vegetation indexes. Most vegetation indexes take into account these unique properties found in the spectral curves. Variations within the spectral curves provide insight into such things as the health, condition, and type of vegetation.

Typically, land cover is mapped from remotely sensed data through the use of supervised or unsupervised classification techniques. While both use statistical algorithms in classifying satellite imagery, the steps required are quite different. For a supervised classification there are three general steps; the training stage, the classification stage, and the output stage (Lillesand and Kiefer, 2000). In the training stage the user identifies representative training areas for each land cover type desired. In identifying a training area, a numerical description of the spectral attributes of each land cover type is collected. The success of a classification is directly dependent on collection of truly representative training samples (McGwire, Estes, and Star, 1996), as these spectral attributes become a statistical representation of the samples collected. In the classification stage, each pixel (picture element) in the satellite imagery is sorted into the land cover class it most closely represents statistically. The class or value assigned to each pixel in this process results in the creation of the output classified image (the third stage). After the entire multi-band satellite image is characterized, the results are then output into a thematic map of the resulting land cover classes.

Unsupervised classifications do not involve training data as the basis for classification. Generally, this method is used when ground reference information is unavailable or knowledge of the study area is lacking. Unsupervised classification relies on the computer to group pixels with similar spectral characteristics into unique clusters according to some statistically determined criteria (Jensen, 1996). The user must then examine the resulting clusters and determine which classes they belong to. In this case, ancillary data is important in helping to identify which clusters belong to each land cover class.

Remote Sensing of Agriculture

Satellite remote sensing data have been used extensively for agricultural applications. Agricultural applications include using satellite data to estimate crop yield, monitoring of crop conditions, and canopy activity.

The timing and progression of vegetation canopy development provides information about the condition of plants relative to the local environment. Schwartz (1994), who examined the fundamental feedback between canopy phenology and climate, suggests that significant seasonal increases in temperature and relative humidity corresponded with the timing of ground-observed leafing out of vegetation in the Great Plains Region. In order to capture changes in vegetation development, multi-temporal imagery is needed, as seasonal changes in the characteristics of agricultural crops are quite rapid.

Classification methodologies capitalize on differences in crop phenology displayed by different species to increase classification accuracy. Because of changes in crop characteristics during the growing season, it is desirable to use imagery acquired on several dates throughout the growing cycle for crop identification. For agricultural land cover classifications, single date data sets rarely provide accurate classifications (Lo, *et al.*, 1986). In general, the best time for image acquisition is when a crop is at full canopy cover so that the soil background has less influence on spectral reflectance (Tao and Nellis, 1999). Yet, at one particular date one crop may have full canopy cover while another crop may have been harvested.

Creating a temporal-spectral profile of crops produces a phenological pattern of crop development. Once a phenological pattern is established, crop delineation and labeling can be accomplished. Odenweller (et. al., 1984) was able to identify crop types based on their distinctive profile and amplitude through three stages of development. The first stage identifies crops based on their general trajectory below vegetative greenness. In the second stage, crops are identified by the timing of initial vegetative greenness. The third and final stage allows for delineation based on a crop's distinctive profile and amplitude. For example, during stage one, alfalfa can be delineated from fallow because its greenness is greater during July and September. In another example, during stage three, corn is distinguished from soybeans based on corn's faster ascent to greenness and sudden decline, while soybeans tends to have a more gradual increase and decrease in greenness (Odenweller et al., 1984).

Ortiz, *et al*. (1997) classified croplands by integrating GIS and remote sensing techniques. Using a land cover database with ancillary ground data in a GIS framework they were able to improve classification accuracy. Information such as field type and location were used to determine which areas were to be most useful as training sites in the digital classification. For their multi-date image classification, using the integrated GIS framework, overall accuracy increased 20 percent over conventional digital classification techniques.

In a study conducted by Oetter et al. (2000) in the Williamette River Basin of western Oregon, a land cover map of 20 land classes was produced using multiseasonal Landsat TM scenes. The mapped area was mainly agricultural, but included forested areas, natural cover types and urban buildings. The study relied on Landsat TM imagery to predict land cover and employed Farm Service Agency compliance photographs to train imagery pixels. This study produced an accuracy of 74% and serves as a model for other land cover studies in the basin (Oetter et al. 2000).

A multi-seasonal approach to classifying corn, soybean, sugar beets, and small grains was conducted in the “Regione del Veneto” of northeastern Italy (Ehrlich et al., 1994). The authors evaluated Landsat TM, Landsat MSS, and SPOT HRV imagery for use in the study. Ultimately, four Landsat TM scenes were chosen over SPOT and Landsat MSS images because TM scenes offered the best trade-off in spatial resolution and price. A sequential masking procedure (SMP) was used to delineate vegetation—a procedure in which image processing and GIS techniques are combined to identify the most distinguishable land cover types first. Once the more obvious land cover types are identified, sequential rounds of image processing are employed to classify remaining fields. The classification produced accuracies of 90% for corn, 96% for soybeans, 76% for sugar beets, and 99% for small grains (Ehrlich et al., 1994).

Knowledge of the crop growth cycle is very important in selecting the dates of imagery used in a classification. The crop calendar in Nebraska extends from March to November. This project capitalized on the seasonal dynamics of the crops in the study area by using multi-date imagery acquired from April through October of 1997 for the land cover classification (see Table 2).

Maxwell and Hoffer (1996) evaluated dates of imagery for accuracy in mapping agricultural crops for their study area near Ft. Collins, Colorado. Eleven different crops or cover types were evaluated in different combinations of one, two and three date classifications using imagery from May, July, and September. The crops were divided into two groups according to their dates of maturity (spring to mid-summer or later summer). May was found to be the best single date for spring to mid-summer maturing crops and September was best for later summer maturing crops. For the spring to mid-summer maturing crops the combination of using both May and September dates increased the classification accuracy for alfalfa and spring grains.

Table 2. Major Crop Planting and Harvesting Dates.
(Adapted from 2002 Nebraska Agricultural Statistics Service, 2002)

Crop	Usual Planting Dates			Usual Harvesting Dates		
	Begin	**Most Active**	**End**	**Begin**	**Most Active**	**End**
Barley Spring	Mar 20	Mar 25 - Apr 10	Apr 18	Jul 18	Jul 20 - Jul 25	Jul 30
Beans Dry	May 26	Jun 9 - Jun 16	Jun 23	Sep 8	Sep 15 - Sep 29	Oct 13
Corn for Grain	Apr 21	May 3 - May 19	Jun 1	Sep 21	Oct 11 - Nov 6	Dec 1
Corn for Silage	Apr 21	May 3 - May 19	Jun 1	Aug 25	Sep 5 - Sep 25	Oct 10
Alfalfa Hay				May 03		Oct 03
Hay Other				Jun 03		Sep 03
Oats Spring	Mar 24	Apr 2 - Apr 27	May 9	Jul 4	Jul 15 - Aug 2	Aug 12
Rye	Aug 30	Sep 12 - Sep 26	Oct 6	Jun 30	Jul 12 - Jul 30	Aug 8
Sorghum-Grain	May 11	May 20 - Jun 8	Jun 19	Sep 19	Oct 8 - Oct 30	Nov 17
Sorghum-Silage	May 11	May 20 - Jun 8	Jun 19	Aug 25	Sep 10 - Sep 30	Oct 10
Soybeans	May 9	May 18 - Jun 4	Jun 17	Sep 19	Sep 30 - Oct 15	Oct 27
Sugar beets	Apr 1	Apr 10 - Apr 30	May 5	Oct 5	Oct 10 - Oct 30	Nov 5
Wheat Winter	Aug 30	Sep 12 - Sep 26	Oct 6	Jun 26	Jul 7 - Jul 26	Aug 8

Using the three dates of May, July, and September produced the highest accuracies for winter wheat, grass/hay/pasture, and range. For the late-summer maturing crops, the two-date combination of July and September produced the highest accuracies for sugar beets, dry beans, and onions. Corn was classified with the highest accuracy when using all three dates of imagery.

There are a number of problems associated with classifying agricultural areas using satellite imagery (Tao and Nellis, 1999). First, the phase lag in planting dates between fields having the same crop can cause a large variation in spectral response. Spectral response is also affected by changes in soil moisture levels at different landscape locations, slopes, and elevations. Lastly, differences in row spacing and direction can have a serious impact on spectral response of the crop due to the affects on sun-sensor-scene geometry.

METHODS

Data Collection and Initial Processing

Satellite Data Acquisition and Image Preprocessing

To cover the entire study area, ten Landsat 7 Enhanced Thematic Mapper Plus (ETM+) scenes were needed (see Figure 5). To compensate for the differences in crop types and phenology, three dates were acquired for the majority of scenes to represent spring, summer, and fall conditions.

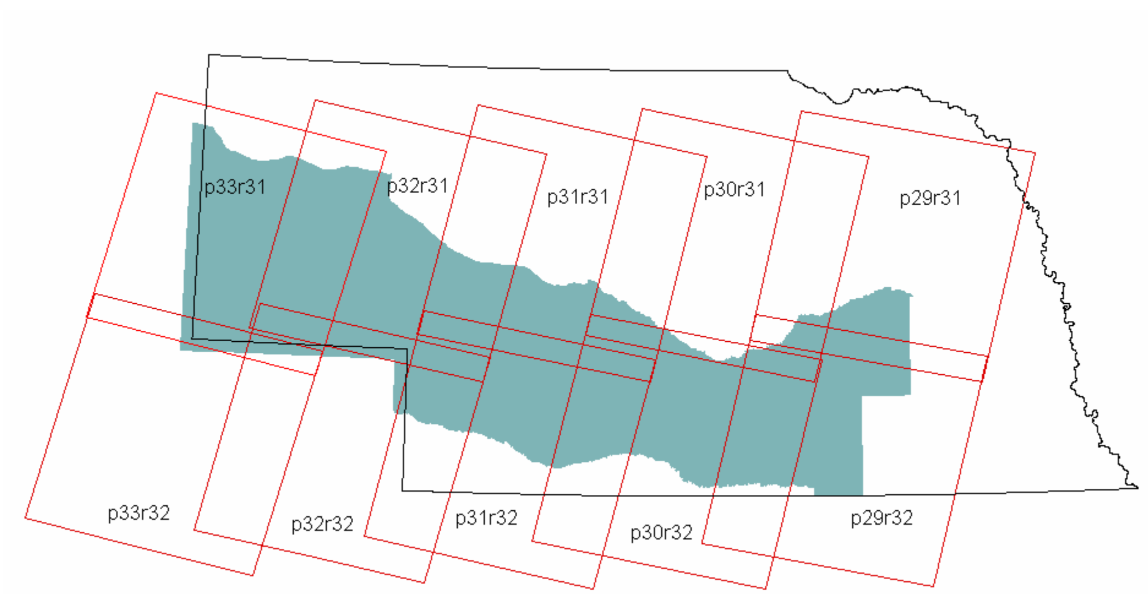


Figure 5. Landsat 7 ETM+ Coverage of the Study Area by Path/Row.

A total of 24 Landsat 7 ETM + satellite images were purchased from the U.S. Geological Survey EROS Data Center in a geocoded and systematic-corrected format. The selection of imagery was limited due to difficulties in finding relatively cloud-free dates.

Further image rectification was performed on the imagery to achieve greater positional accuracy. Images were rectified using the 1993, 1:12,000 scale DOQQs and multiple Ground Control Points (GCPs). The Polynomial Geometric Model was used in the image-to-image rectification process and set at an order of 2 as there was only subtle spatial distortion in the Landsat ETM+ images. At least 20 GCPs were used in the collection reference and registration of coordinates for each image. The points were evenly distributed along the top, bottom, sides, and middle of the Landsat TM image. Features such as roads, airports, and large buildings served as effective GCP targets. The GCPs were further analyzed to lower the Root Mean Square (RMS) error. The lower the RMS error, the more accurate the spatial transformation. For all images, the RMS error of the model was calculated below 1.0. As a final step, the GCPs were reviewed to assure their spatial position relative to each associated point in the DOQQ and the satellite image.

Table 3. Landsat 7 ETM+ Data used in Classification

Path/Row	Date of Image Acquisition	Scene ID
29/31	6/1/2001	LE7029031000115250
29/31	8/4/2001	LE7029031000121650
29/31	9/21/2001	LE7029031000126450
29/32	6/1/2001	LE7029032000115250
29/32	8/4/2001	LE7029032000121650
29/32	9/21/2001	LE7029032000126450
30/31	8/11/2001	LE7030031000122350
30/32	5/23/2001	LE7030032000114350
30/32	8/27/2001	LE7030032000123950
30/32	9/28/2001	LE7030032000127150
31/31	5/14/2001	LE7031031000113450
31/31	8/18/2001	LE7031031000123050
31/31	9/19/2001	LE7031032000126250
31/32	5/14/2001	LE7031032000113450
31/32	8/18/2001	LE7031032000123050
31/32	9/19/2001	LE7031032000126250
32/31	6/22/2001	LE7032031000117351
32/31	9/10/2001	LE7032031000125350
32/31	9/26/2001	LE7032031000126950
32/32	9/10/2001	LE7032032000125350
33/31	5/12/2001	LE7033031000113250
33/31	7/15/2001	LE7033031000119650
33/31	9/1/2001	LE7033031000124450
33/32	9/1/2001	LE7033032000124450

Band 8, the pan-chromatic band, was not used in the image classification. The spectral range of band 8 is better covered with bands 1-4 and the 15 meter cell size does not match the 30 meter cell size used in the analysis. Spectral bands 6 and 9 (thermal infrared) were not used as they measure the amount of infrared radiant flux emitted from surfaces (Jensen, 1996). While other bands provide a measure of reflected energy, bands 6 and 9 measure transmitted energy. The remaining bands, 1-5 and 7, were subset from each individual Landsat 7 scene and were layer stacked to create an 18-band image for each Path/Row on each of the three dates of imagery.

Image preprocessing was done individually for each Path/Row and included masking out urban and clouded areas. Clouded areas were on-screen digitized and removed from all bands containing cloud contamination.

Table 4. Characteristics of Landsat 7 ETM+

Spectral Band	Spectral Range (μm)	Nominal Spectral Location	Ground Resolution (m)
1	0.45- 0.52	Visible Blue	30
2	0.52 – 0.61	Visible Green	30
3	0.63 – 0.69	Visible Red	30
4	0.78 – 0.90	Near infrared	30
5	1.55 – 1.75	Mid-infrared	30
6	10.40 – 12.50	Thermal infrared (low)	60
7	2.09 – 2.35	Mid-infrared	30
8	.52 - .90	Pan-chromatic	15
9	10.40 – 12.50	Thermal Infrared (high)	60

Urban areas were identified using 2000 TIGER (Topologically Integrated Geographic Encoding and Referencing system) line data from the U.S. Census Bureau. TIGER is a digital database of geographic features, such as roads, railroads, rivers, lakes, political boundaries, and census statistical boundaries developed at the Census Bureau to support its mapping needs for the Census and other Bureau programs. Data were downloaded from the U.S. Census Bureau’s web site, (http://www.census.gov/geo/www/tiger/) by county and re-projected into a common map projection of State Plane, fipszone 2600, and NAD 83. Urban areas, identified using road density, were on-screen digitized and masked from the imagery.

Collecting Training Areas for Image Classification

The primary objective of image classification is to automatically categorize all pixels in an image into land cover classes. It is the spectral pattern present within the data for each pixel that is used as the numerical basis for the classification (Lillesand and Kiefer, 2000). For a supervised classification, the user identifies pixels that represent various land cover types present in the scene. Sites of known cover types, also called training areas, are used to develop a numerical description of the spectral attributes of each land cover type. By identifying these areas in the satellite imagery you can train the computer system to identify pixels with similar spectral characteristics. In this project, spectral signatures were collected using three dates of imagery combined into one 18-band image for each scene.

Farm Service Agency (FSA) Data

USDA Farm Service Agency (FSA) certified reporting records from 2001 were the main source of crop information used to determine training areas for agricultural classes. FSA reporting records provide detailed information on crop type, irrigated and non-irrigated fields, and field boundaries. This information is gathered by enumerators who draw field boundaries onto NAPP 1:8,000 black and white aerial photos, according to their observations and the farmer-reported information. The fields are labeled and the cover type is recorded using a grease pencil on the aerial photo. Certified FSA reporting records have been checked for accuracy to provide the most accurate crop information. An example of a partial FSA certified reporting record is found in Figure 5.

Certified FSA reporting records were randomly collected for approximately 5,000 sections across the entire study area. FSA records by county were randomly split into two groups. One group was used to determine training sites for specific crops; the second group was set aside and used for the accuracy assessment.

FSA data were used to locate training areas for the following land cover classes: Corn, Sugar Beets, Soybeans, Sorghum, Dry Edible Beans, Potatoes, Alfalfa, Small Grains, Range/Pasture, Open Water, Sunflower, and Summer Fallow. For each crop type, special attention was given to collecting signatures from homogenous areas. Spectral signatures were taken in the center of fields and not close to field boundaries where spectrally mixed pixels decrease accuracy. These boundary pixels are not reflective of a particular cover type, but are rather a mixture of adjacent cover types (Grunblatt, 1987). FSA data are organized by Township/Range/Section, allowing exact field locations to be identified on the imagery. The spectral and tonal variations in the imagery are then used to determine field boundaries.

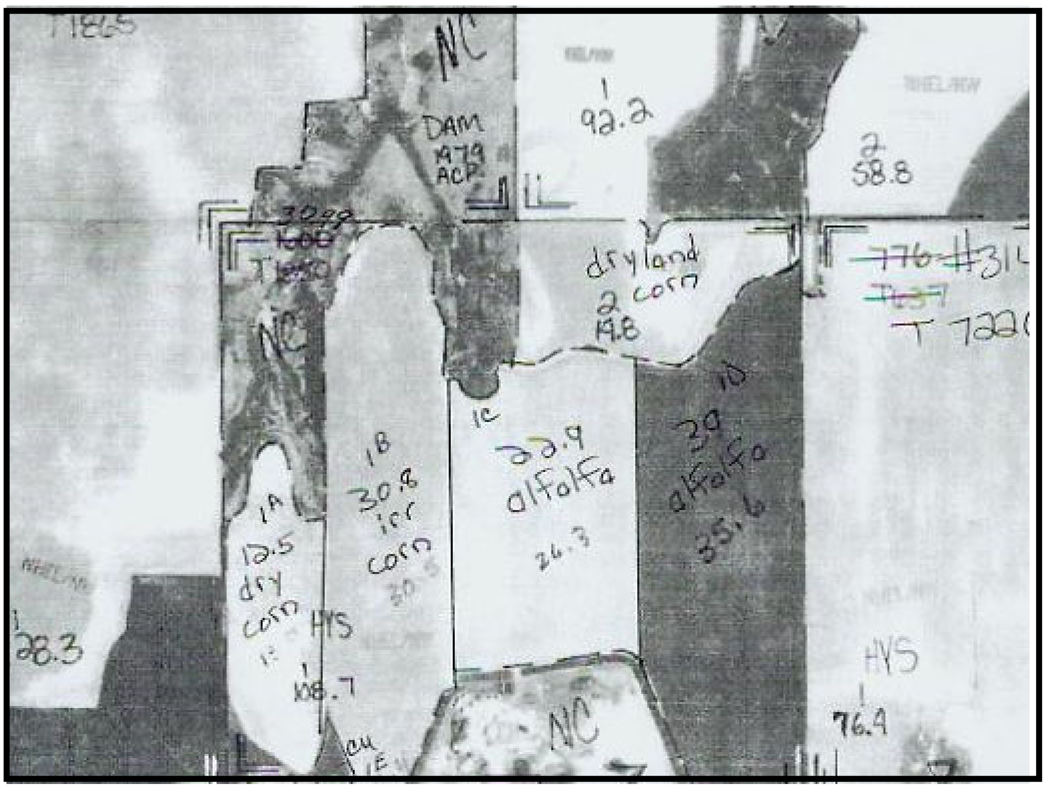


Figure 5. Example of a Certified FSA reporting record from 2001

Digital Orthophoto Quarter Quadrangles

Another source of land cover data were digital orthophoto quarter quadrangles (DOQQs). A digital orthophoto is a digital image of an aerial photograph with image distortion removed, corrected for aircraft pitch, yaw and altitude, landscape relief, and camera lens (optic correction) orientation. The DOQQs used in this project were developed from 1993 National Aerial Photography Program (NAPP) aerial photos mapped to 1:12,000 scale accuracy specifications. DOQQs have the positional accuracy of a map while providing the spatial detail of a photograph. Because of these features, DOQQs were used to locate training sites for open water, roads, wooded areas, and other agricultural lands such as homesteads and feeding lots.

1993 DOQQs were obtained from the Nebraska Department of Natural Resources and were re-projected to a common State Plane projection. The DOQQs were then mosaiced for the entire study area using MrSID image compression software. The 1993 MrSID files were mosaiced in three pieces due to the large file sizes. Since the DOQQ's were rectified with a high degree of positional accuracy they could be overlaid on the satellite imagery to determine exact field locations for the training areas. Additional 1999 DOQQs were obtained and used for image classification, although they were not available for the entire COHYST Study area.

National Wetlands Inventory

The National Wetlands Inventory (NWI) of the U.S. Fish and Wildlife Service provides information on the characteristics, extent, and status of wetlands and deepwater habitats in the United States. NWI digital data files are records of wetland location and classification as defined by the U.S. Fish & Wildlife Service. This dataset was originally available in 7.5 minute by 7.5 minute blocks containing ground planimetric coordinates of wetland features and attributes.

Available NWI files used in this project were downloaded from the Conservation and Survey Division at the University of Nebraska (http://csd.unl.edu/csd/gisdata.html), joined together to form one coverage, and then reprojected to Stateplane, fipszone 2600 and NAD 83. To identify training areas, polygons that fell into any combination of the following wetland types and water regimes based on judgment from the COHYST group (see Table 5), were selected.

Wetlands smaller than 3x3 pixels or 90 meters square were deleted. This was done to assure training areas represented homogenous wetland areas and to avoid any problems associated in the NWI. The spatial extent of wetlands may have changed since the NWI was created using 1972-1986 aerial photography. It should be stressed that in most cases, the NWI data were used as a guide, and signatures were only collected for wetlands that were visible in 2001satellite imagery.

Table 5. NWI Wetland types used to identify potential training areas

Wetland Type	**Wetland Code**	**Water Regime**
Emergent	**PEM**	**Permanently Flooded**
Pond with floating or submerged aquatic vegetation	**PAB**	**Intermittently Exposed**
Pond with open water	**PUB**	**Semi-permanently flooded**

Spectral Signatures by Scene and Land Cover Type

As mentioned previously, spectral signatures were collected using three dates of imagery (Landsat ETM+ bands 1-5 and 7) combined into one 18-band image per scene. Spectral signatures were collected for the following land cover classes; corn, sugar beets, soybeans, sorghum, dry edible beans, potatoes, alfalfa, small grains, range/pasture, open water, riparian forest/woodlands, wetlands, other agricultural lands, sunflower, summer fallow and roads. An example of spectral signatures collected for corn, soybeans, and sorghum is found in Figure 6. The x-axis represents the 18-band image (or three dates of imagery: May 23, August 27, and September28). The y-axis represents spectral reflectance values.

The spectral reflectance curves in Figure 6 are characteristic of healthy vegetation. Chlorophyll strongly absorbs energy in the wavelength bands centered between approximately 0.45 and 0.67 µm. The internal structure of plant leaves, specifically the mesophyll cells, reflects highly in the region between 0.70 – 1.30 µm (near to mid-infrared) (Lillesand & Kiefer, 2000). The high reflectance values in the near to mid-infrared correspond with bands 4 & 5 (spring), 10 & 11 (summer), and 16 & 17(fall) found in Figure 6.

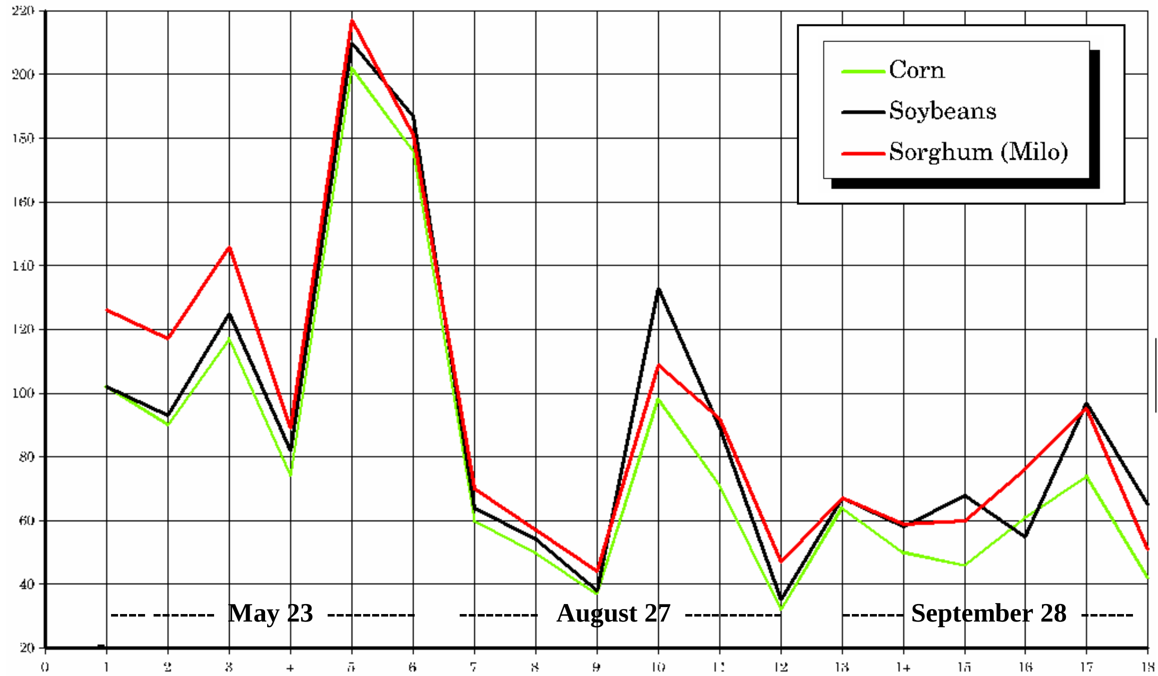


Figure 6. Spectral Reflectance Curves for Corn, Soybeans, and Sorghum.

The seasonal dynamics of corn, soybeans and sorghum are evident in these spectral reflectance curves. Supervised classifications incorporate these differences in crop phonologies to increase classification accuracy. Crops are identified based on their distinctive profile throughout the stages of crop development. For example, corn is distinguished from soybeans based on corn's faster ascent to greenness and sudden decline, while soybeans tends to have a more gradual increase and decrease in greenness (Odenweller et al., 1984). These seasonal dynamics in 2001are verified in Figure 7.

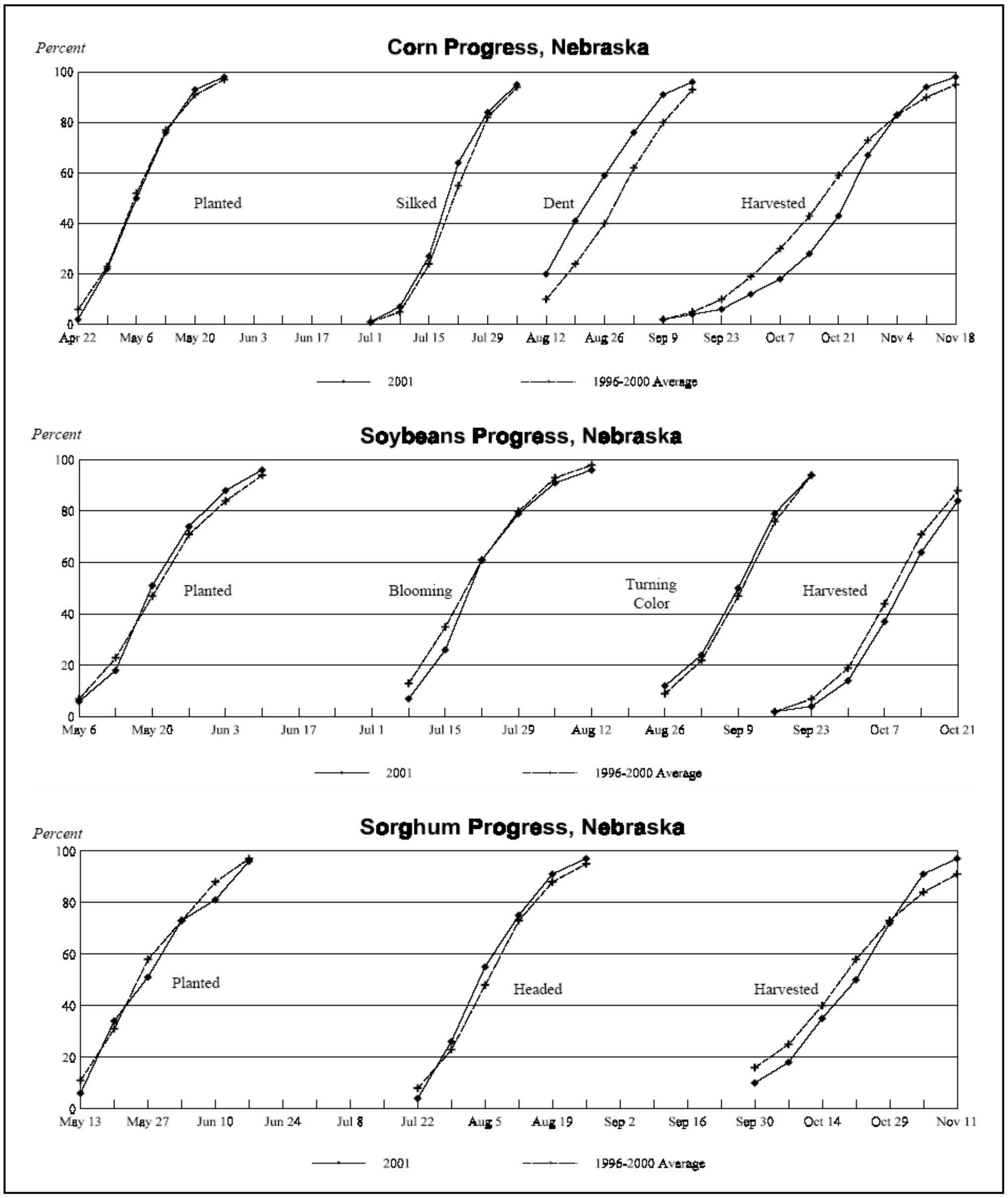


Figure 7. 2001 Crop progress for Corn, Soybeans and Sorghum.

(Nebraska Agricultural Statistics Service, 2002)

After collecting spectral signatures for each land cover class, the signatures files were examined for consistency. Signatures that diverged greatly from others of the same land cover class were deleted to prevent misclassification. The number of signatures used to drive the classification are found in Table 6. Signatures are listed for each class and Landsat 7 path row scene. The numbers reflect the size of the scene, the diversity and acreage of crops in that scene, and the available field data obtained by FSA certified reporting records. For example, sunflower and sugar beet signatures were only collected in four Landsat scenes found in the western half of the study area, reflecting the different agricultural practices found throughout the study area.

Table 6. Number of Spectral Signatures for each Land Cover Class by Scene

Scene Class Name	29/31 & 29/32	30/32	31/31	31/32	32/31	33/31
Corn	33	44	37	38	34	44
Sugar Beets	0	0	1	5	7	5
Soybeans	15	48	24	24	1	0
Sorghum	25	11	22	22	4	5
Dry Edible Beans	0	0	0	7	24	36
Potatoes	4	3	0	0	3	0
Alfalfa	23	37	26	27	22	24
Small Grains	21	40	42	43	38	40
Range/pasture	44	42	51	43	28	31
Open Water	39	36	38	39	19	40
Forest/woodlands	34	25	27	29	22	25
Wetlands	20	31	23	24	26	30
Other Ag. lands	33	37	44	38	24	20
Sunflower	0	0	12	11	6	10
Summer fallow	14	16	37	36	26	22
Roads	18	12	21	21	15	14

Image Classification

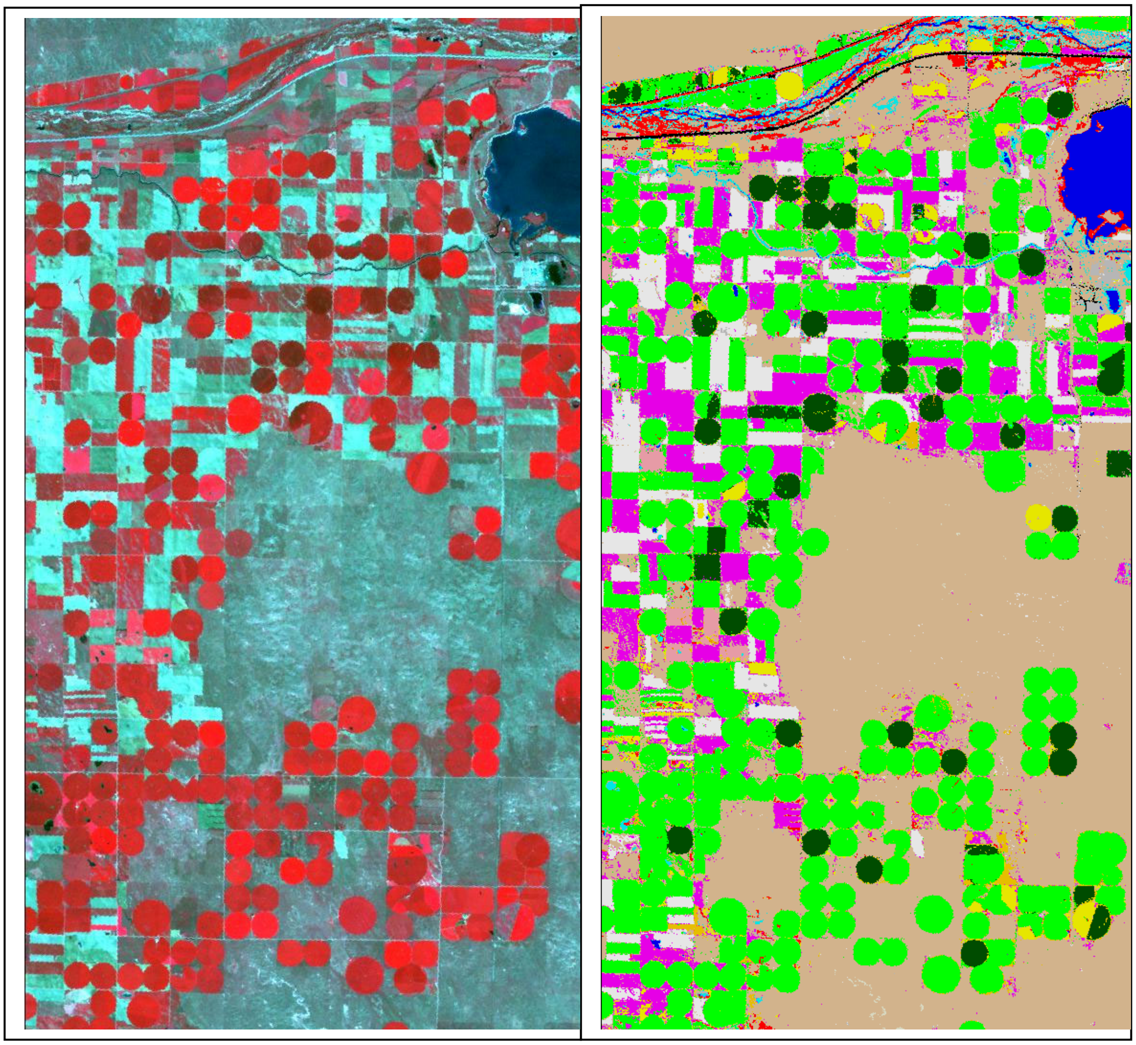
Supervised Classification

The basic steps used in a typical supervised classification can be summarized in three basic stages: the training stage, the classification state, and the output stage. After all of the training sites (spectral signatures) were collected and evaluated, they were used to drive the supervised classification. The classification process uses different decision rules. These rules are mathematical algorithms that, using data contained in the signature, sort the pixels into separate classes. Decision rules are either parametric or nonparametric. Parametric rules are based on statistics while non-parametric rules are not.

A supervised classification based on a minimum distance to means parametric decision rule was chosen for the classification of the imagery. A parametric decision rule is based on statistical parameters (e.g., mean and covariance matrix) of the pixels that are in the training sample or cluster. When the parametric decision rule is used, every pixel is assigned to a class. The minimum distance to means classifier computes the mean of each desired class and then classifies unknown pixels into the class with the closest mean using simple euclidean distance. (Lillesand & Kiefer, 2000) The maximum likelihood decision rule, used in the 1997 classification, was tested with the 2001 imagery. After multiple tests, it was determined that the minimum distance to means classifier resulted in a more accurate classification.

It should be emphasized that supervised classification methods are an iterative process. A supervised classification involves collecting training samples, preliminary classification, and comparison with FSA data. This training, classification, and comparison are then performed several times until the classification achieves the desired accuracy for the initial classification.

In this project, after the initial classification, areas of mixed pixels were further identified, through visual inspection of the classification, as well as by comparing the FSA reporting records used to identify training sites for crops. Mixed pixels were reclassified using a technique of splitting or merging clusters referred to as “cluster busting” (Jensen et al., 1987). In this process, mixed pixels were identified and masked from the raw ETM+ data. The raw data was then re-classified using an unsupervised classification approach. The resulting output clusters were re-assigned to the output land cover classes they most closely resembled. This method was useful in clearing up much of the confusion in the classification, although there were areas where mixed pixels could not be completely resolved due to the spectral similarities of certain crop types. An example of a resulting supervised classification is found in Figure 7.



Imagery 8-18-2001
(ETM+ Bands 4,3,2)

Classified Image

Figure 7. Example of Supervised Classification

The output of our initial classification resulted in 16 classes: Corn, Sugar Beets, Soybeans, Sorghum (Milo, Sudan), Dry Edible Beans, Potatoes, Alfalfa, Small Grains, Range/Pasture/Grass, Open Water, Riparian Forest and Woodlands, Wetlands, Other Ag. Land, Sunflower, Summer Fallow, and Roads. Irrigated and non-irrigated crops were not distinguished in the supervised classification process. Irrigation information was collected at the field level and added to the classification at a later stage.

An additional class, Barren areas, was identified after the draft classification was completed. Signatures collected for Summer Fallow fields identified barren areas throughout the imagery, so this class was re-examined. Following a re-classification, Summer Fallow and Barren areas were separated into two classes.

Unsupervised Classification

An unsupervised classification was performed on scenes with only one date of imagery and for areas under cloud cover. Within the multi-date imagery there were often areas of cloud and cloud shadows. These areas were subset from the imagery and not classified during the supervised classification stage. Later, using the remaining cloud-free date(s), these areas were classified using unsupervised methods. Unsupervised classifications do not use training sites as the basis for classification. Instead, the image is classified using mathematical algorithms that search for natural groupings of the spectral properties of pixels (Jensen, 1996).

Once these data were classified, resulting clusters were identified based on the surrounding areas of overlap with the supervised classification. Clusters were also identified using ancillary data such as DOQQs and FSA certified reporting records.

Post Classification Smoothing

Due to inherent spectral variability within satellite imagery, resulting classified scenes often have a salt-and-pepper appearance. A field of corn, for example, may have multiple soybean pixels scattered amongst the corn pixels. In these situations, a smoothing technique is often employed to show only the dominant classes within fields. One such technique is to apply a majority filter on the classified image. In this operation, a moving window is passed over the classified data and the majority class within the window is determined. If the center pixel in the window is not the majority class, it is changed to the majority class value (Lillesand & Kiefer, 2000). For this study, a majority filter using a window size of 3x3 pixels, was applied to agricultural classes. The filter was not applied to all land cover classes, so that smaller classes such as roads, wetlands and riparian/woodland areas would be retained.

Identifying 2001 Irrigated Areas

2001 Center Pivot Inventory

Due to their unmistakable pattern across the study area, center pivots were visually interpreted using satellite imagery. Center pivot irrigation areas were on-screen digitized using multi-date Landsat 7 ETM+ satellite imagery from 2001. Accuracy was checked using 2001 FSA certified reporting records, registered irrigation well data, 1993 and 1999 DOQQs and existing knowledge of 2001 irrigated areas provided by Nebraska Natural Resource Districts and the Nebraska Department of Natural Resources

Updating of 1997 Irrigation Layer

Other irrigated areas across the study area were not as easily identifiable as center pivots. To locate these areas, multiple field and ancillary sources were incorporated to provide an accurate inventory. One main task was to update the detailed irrigation base layer developed in 1997 as part of the 1997 COHYST land cover mapping project.

2001 FSA certified reporting records were used to add or remove irrigated areas from the 1997 base layer. The final irrigation layer incorporated field data from over 5,000 sections across the study area. Newly registered irrigation wells, provided by the Nebraska Department of Natural Resources, installed between 1997-2001, were also incorporated into this study. The new irrigation wells point coverage was used to help identify irrigated areas and validate 2001 FSA data.

1997 Irrigation Layer

The process of creating the 1997 irrigation layer base layer incorporated digital and paper maps of irrigated acres obtained from many sources. A majority of the maps were obtained from the Nebraska Department of Natural Resources. These paper maps identified surface water irrigation rights and included; Castle Rock, Steamboat, Chimney Rock, Empire, Midland-Overland, Graf Canal, Keith-Lincoln, North Platte Canal (Platte Valley I.D.), Paxton-Hershey, Birdwood, Suburban, Cody-Dillon, Western Canal, Thirty

Mile Canal, Six Mile Canal, Cozad Canal, and Orchard-Alfalfa Canal. Each map was individually digitized using ArcInfo and then merged into one map. Another source of irrigation data came from the

Additional irrigation data were obtained from the Pathfinder Irrigation District and the Central Nebraska Public Power and Irrigation District. These original section-sized AutoCAD files were imported into ArcInfo, edited, attributed, and appended to create one large area map.

Map's of individual Natural Resource Districts (NRD) were created from this large map and sent out to each NRD within the study area to be checked for accuracy. Maps were checked using existing knowledge of 1997 irrigated areas and 1997 Farm Service Agency reporting records. When these maps were returned, the original vector files were edited and all files were merged into one final vector irrigation map.

Combining of Map Layers

After final edits were made to the classified imagery, all of the separate layers were combined to produce a single classified image. The order in which the layers were mosaiced is shown in Table 7. Classified cloud-covered areas were on the bottom of the mosaic while classified triple date scenes were at the very top. The order of map layers is important as those scenes with triple dates provided more information and their classifications were more accurate than scenes with single or double dates.

Table 7. Mosaic Order of Classified Scenes

Top ↓	Classified triple date scenes
	Classified double date scenes
	Classified single date scenes
Bottom	Classified cloud covered areas

Urban areas defined using the 2000 TIGER data were digitized as polygons. These polygons were then rasterized and overlaid on the classified image.

The final irrigation vector coverage was rasterized so that it could be combined with the classified image. Using ArcInfo, the irrigation coverage was converted to a GRID file and the classified image was converted from an ERDAS Imagine file to a GRID file. An irrigation mask was created so that all irrigated areas would have a cell value of 1 and all non-irrigated areas would have a cell value of 0. The classified image and the irrigation map were compared and combined into one final map using the DOCELL command in ArcInfo GRID (see Figure 8). The DOCELL command controls cell processing on a cell-by-cell basis. This command was used to compare both GRID files and provide a set of conditional statements by which a final map would be created.

An AML (Arc Macro Language) was run from the GRID module of ArcInfo. The cell by cell analysis compared all potentially irrigated crop pixels with corresponding pixel locations within the irrigation map. If the corresponding irrigation pixel cell had a value of 1, the crop pixel would be coded as irrigated, if the irrigation cell had a value of 0, the crop pixel would be coded as dryland.

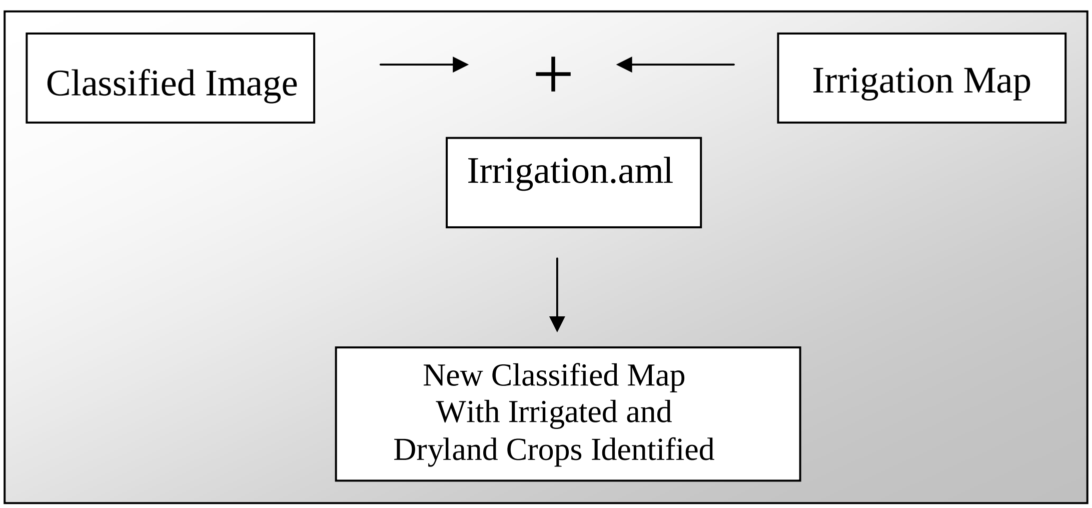


Figure 8. Flowchart of Irrigation Analysis to Create Final Map

This procedure was performed done for all agricultural classes excluding sugar beets and potatoes. For this study, all sugar beet and potato fields were considered to be irrigated as these crops rely entirely on irrigation. It should be noted that separate maps were created, one for the accuracy assessment and one for the final classification. The final land cover classification incorporated all 2001 FSA reporting records to update the irrigation layer (approximately 5,000 sections), while the land cover classification used for the accuracy assessment only used half of the 2001 FSA data. This allowed for an unbiased accuracy assessment to be performed.

Accuracy Assessment

An error matrix, also known as a contingency table or confusion matrix, was used to calculate the accuracy of the classified satellite imagery. Considered a standard format for evaluating classifications (Congalton, 1991, Congalton & Green, 1999), an error matrix is a cross tabulation of the classes assigned in the classified image versus the observed reference data. The descriptive statistics derived from the error matrix are the overall accuracy, producer's accuracy, and user's accuracy. The overall accuracy is computed by dividing the total number of correctly classified pixels by the total number of pixels in the error matrix. Producer's accuracy is derived by taking the total number of correct pixels in a category divided by the total number of pixels of that category. This type of accuracy indicates the probability of a referenced pixel being correctly classified and is a measure of omission error (Congalton, 1991). The user's accuracy indicates the reliability that the pixel classified on the image actually reflects that category on the ground and provides a measure of commission error (Congalton & Green, 1999).

Reference data are key in determining the accuracy of the image as they are the benchmark for the comparison of correctly versus incorrectly classified pixels. Reference data were collected from the 2001 certified (FSA) reporting records set aside for the accuracy assessment. Information from every third FSA certified reporting record was digitized with land cover/land use type identified. For less frequent crops, such as potatoes and sugar beets, all fields were digitized. Random points were then created for each polygon digitized. This provided a more representative sample of land cover classes. For open water and riparian areas, random points were generated and 1999 and

1993 DOQQs were used to label points that fell in areas of open water and in riparian woodland and forested areas.

Another measure of accuracy can be derived using KAPPA analysis, which yields a K_{HAT} statistic. KAPPA analysis is a measure of association between two categorical variables and is widely used in remote sensing classification to assess the degree of success of a classification approach (Congalton and Green, 1999). The K_{HAT} statistic measures the difference between the actual agreement between the reference data and an automated classifier, and the chance agreement between the reference data and a random classifier (Lillesand & Kiefer, 2000). The error matrix derives overall accuracy by incorporating the major diagonal and excluding the omission and commission errors. The K_{HAT} statistic incorporates the non-diagonal elements of the error matrix as a product of row and column marginal (Jensen, 1996). Kappa values range from 0.0 to 1.0, with 0.0 indicating agreement no greater than that expected by chance alone and 1.0 indicating perfect agreement.

RESULTS

Mapping Results

The final 2001 land cover maps were produced in both digital and paper formats. An example of the final land cover classification is found in Figure 9. In this figure irrigation appears as a separate vector layer (black outlined areas), while in fact the digital land cover classification specifies irrigated and non-irrigated crops for each associated grid cell.

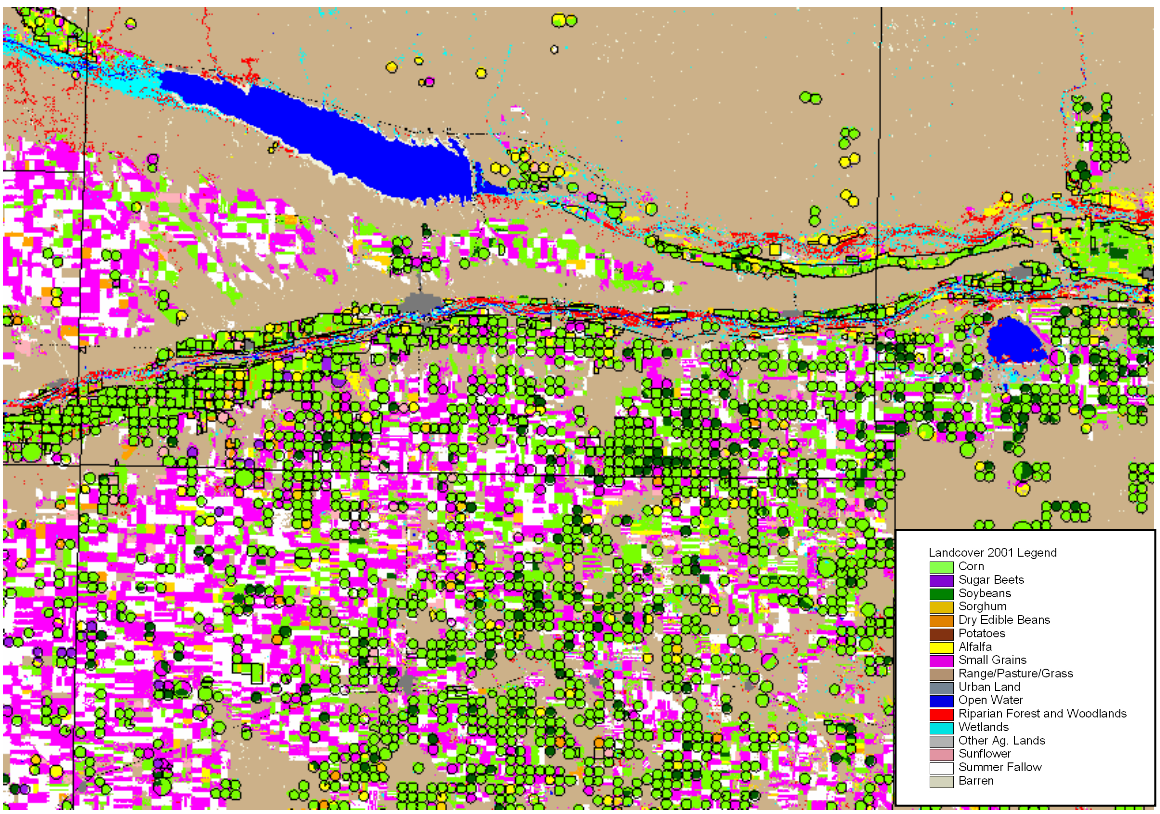


Figure 9. Example of 2001 Land Use Classification

Table 8 details the diversity and acreage totals of each land cover class found in the study area. Range/Pasture/Grass represented the largest land cover class at just over 53% of the study area. Irrigated Corn was the largest agricultural class representing 13.2% of the study area, followed by Dryland Small grains (6.89%), Summer Fallow

(5.06%), Irrigated Soybeans (4.64%), and Dryland Corn (4.43%). Crops representing smaller amounts of the project area and other land cover classes can be found in Table 8.

Table 8. 2001 Acreage Totals by Land Cover Class for the COHYST Study Area

Landcover Class	Pixels	Acres	Percent of Total Study Area
Irrigated Corn	12,330,063	2,473,506.80	13.20%
Irrigated Sugar Beets	196,470	39,413.41	0.21%
Irrigated Soybeans	4,333,948	869,423.77	4.64%
Irrigated Sorghum (Milo, Sudan)	204,805	41,085.48	0.22%
Irrigated Dry Edible Beans	479,902	96,272.08	0.51%
Irrigated Potatoes	25,768	5,169.26	0.03%
Irrigated Alfalfa	1,466,516	294,194.55	1.57%
Irrigated Small Grains	768,809	154,229.08	0.82%
Range, Pasture, Grass	50,152,582	10,060,999.07	53.68%
Urban Land	438,242	87,914.76	0.47%
Open Water	613,084	122,989.43	0.66%
Riparian Forest and Woodlands	1,602,668	321,507.70	1.72%
Wetlands	1,272,370	255,247.34	1.36%
Other Agricultural Land	200,090	40,139.61	0.21%
Irrigated Sunflower	68,337	13,708.94	0.07%
Summer Fallow	4,728,629	948,599.85	5.06%
Roads	227,225	45,583.11	0.24%
Dryland Corn	4,141,189	830,754.81	4.43%
Dryland Soybeans	1,246,295	250,016.50	1.33%
Dryland Sorghum	631,767	126,737.39	0.68%
Dryland Dry Edible Beans	226,160	45,369.46	0.24%
Dryland Alfalfa	1,069,856	214,621.46	1.15%
Dryland Small Grains	6,441,118	1,292,138.50	6.89%
Dryland Sunflower	200,875	40,297.09	0.22%
Barren	363,418	72,904.48	0.39%

The digital land cover maps were distributed to the COHYST group in ERDAS Imagine, ArcInfo GRID, and Geo Tiff formats. Vector irrigation data were also distributed as separate coverages. All data layers are available on line at the following website: **http://www.calmit.unl.edu/cohyst.** The digital land cover data were also converted into tabular format to be used for COHYST modeling efforts.

Accuracy Assessment of the Classified Imagery

An error matrix was computed to determine the accuracy of the classified satellite imagery. Table 9 lists the accuracy totals by land cover class and additional information is contained in the error matrix found in Table 10. The overall classification accuracy for the entire image was 82.71% and the overall K_{HAT} statistic was .8024. These accuracy results are considered better than average when taking into account the types of land cover classes identified in the classification (Congalton *et al*., 1998; Maxwell and Hoffer, 1996).

The land cover class that had the highest accuracy was Open Water (97.06%) followed by Summer Fallow (91.97%), Irrigated Corn (91.02%), Irrigated Sugar Beets (90.91%), Irrigated Dry Edible Beans (88.01%), Dryland Small Grains (87.87%), Range/Pasture/Grasslands (84.79%), Irrigated Soy Beans (84.63%), Irrigated Potatoes (84.21), Riparian Forest & Woodlands (81.14%), Dryland Sunflower (77.83%), Irrigated Alfalfa (75.71%), Dryland Sorghum (74.78%) and Irrigated Small Grains (70.20). Classes with less than 70% overall accuracy included Dryland Corn (68.32%), Dryland Soybeans (61.02%), Dryland Alfalfa (58.34%), Irrigated Sunflower (41.64%) and Irrigated Sorghum (12.5%). Explanations for the lower accuracies are presented in the error matrix in Table 10.

The error matrix details the classification accuracy in rows and columns. The classified land cover classes are listed in the rows and the reference data are found in the columns. The training set pixels that were classified correctly are found along the major diagonal and are shaded in blue. The causes of lower accuracies for the land cover crops can also be explained by examining the error matrix. Looking at the Dryland Corn classification, the bulk of the error arose from Dryland Corn class mixing with Irrigated Corn and, to a lesser degree with Dryland Sorghum and Dryland Soybeans. Thirty-five Irrigated Corn, eleven Dryland Sorghum, and five Dryland Soybean reference points fell on pixels classified as Dryland Corn.

Similar errors were found with the Dryland Soybeans class. The bulk of the error arose from misclassification with Irrigated Soybeans and, to a lesser extent, with Dryland

Table 9. Accuracy Totals by Land Use Type

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Overall Accuracy
Irrigated Corn	523	491	461	88.15%	93.89%	91.02%
Irrigated Sugar Beets	22	22	20	90.91%	90.91%	90.91%
Irrigated Soybeans	239	248	206	86.19%	83.06%	84.63%
Irrigated Sorghum	8	8	1	12.50%	12.50%	12.50%
Irrigated Dry Edible Beans	56	49	46	82.14%	93.88%	88.01%
Irrigated Potatoes	19	13	13	68.42%	100.00%	84.21%
Irrigated Alfalfa	61	72	50	81.97%	69.44%	75.71%
Irrigated Small Grains	29	28	20	68.97%	71.43%	70.20%
Range, Pasture, Grass	141	186	136	96.45%	73.12%	84.79%
Urban Land	0	0	0	---	---	---
Open Water	80	85	80	100.00%	94.12%	97.06%
Riparian Forest & Woodlands	98	66	64	65.31%	96.97%	81.14%
Wetlands	0	15	0	---	---	---
Other Ag. Land	0	0	0	---	---	---
Irrigated Sunflower	6	4	2	33.33%	50.00%	41.67%
Summer Fallow	111	113	103	92.79%	91.15%	91.97%
Roads	0	0	0	---	---	---
Dryland Corn	109	141	84	77.06%	59.57%	68.32%
Dryland Soybeans	69	72	43	62.32%	59.72%	61.02%
Dryland Sorghum	57	36	33	57.89%	91.67%	74.78%
Dryland Dry Edible Beans	0	1	0	---	---	---
Dryland Alfalfa	48	36	24	50.00%	66.67%	58.34%
Dryland Small Grains	120	119	105	87.50%	88.24%	87.87%
Dryland Sunflowers	26	17	16	61.54%	94.12%	77.83%
Barren	0	0	0	---	---	---
Totals	1822	1822	1507			

Overall Classification Accuracy = 82.71%
Overall Kappa Statistics = 0.8024

Table 10. Error Matrix for the 2001 Land Use Classification

Classified Data	Irr Corn	Irr SB	Irr Soy	Irr Sorgh.	Irr DEB	Irr Pots	Irr Alf	Irr Sm Grain	Range	Open Water	Reference Riparian& Woodlands	Data Irr Sunflw.	Sumer Fallow	Dry Corn	Dry Soy	Dry Sorgh	Dry DEB	Dry Alfa	Dry Sm Grains	Dry Sunflw	Row Total
Irr Corn	**461**	1	6	2	0	0	3	0	1	0	0	0	0	10	5	1	0	0	1	0	491
Irr S. Beets	0	**20**	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	22
Irr Soybeans	21	0	**206**	2	0	5	0	0	0	0	0	0	0	0	13	0	0	1	0	0	248
Irr Sorghum	1	0	3	**1**	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	8
Irr Dry EB	0	1	0	0	**46**	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	49
Irr Potatoes	0	0	0	0	0	**13**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13
Irr Alfalfa	1	0	0	1	0	0	**50**	2	1	0	1	1	0	0	1	0	0	13	1	0	72
Irr Sm Grains	0	0	0	0	5	1	0	**20**	0	0	0	0	0	0	0	0	0	0	2	0	28
Range /Pasture	2	0	4	1	0	0	0	1	**136**	0	15	1	1	9	1	3	0	5	7	0	186
Open Water	0	0	0	0	0	0	0	0	0	**80**	5	0	0	0	0	0	0	0	0	0	85
Riparian & Wood.	0	0	0	0	0	0	0	1	0	0	**64**	0	0	0	0	0	0	1	0	0	66
Irr Sunflower	0	0	0	1	1	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0	0	4
Sum Fallow	0	0	0	0	4	0	0	2	0	0	0	0	**103**	0	0	0	0	0	3	1	113
Dry Corn	35	0	0	0	0	0	1	0	1	0	1	0	0	**84**	5	11	0	1	0	2	141
Dry Soybean	0	0	20	0	0	0	0	0	0	0	1	0	1	3	**43**	2	0	1	0	1	72
Dry Sorghum	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	**33**	0	0	0	0	36
Dry Dry EB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	1	1
Dry Alfalfa	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	5	0	**24**	1	0	36
Dry Sm Grains	0	0	0	0	0	0	0	1	0	0	0	0	5	1	1	0	0	2	**105**	4	119
Dry Sunflower	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	**16**	17
Column Total	523	22	239	8	56	19	61	29	141	80	98	6	111	109	69	57	0	48	120	25	1822

Corn, and Dryland Sorghum. Twenty Irrigated Soybean, three Dryland Corn, and two Dryland Sorghum reference points fell on pixels classified as Dryland Soybeans.

The Dryland Alfalfa class also had errors explained by mixing with Irrigated Alfalfa and Dryland Sorghum. Six Irrigated Alfalfa and five Dryland Sorghum reference points fell on pixels classified as Dryland Alfalfa.

The error associated with the Irrigated Sunflower class was caused by the small number of reference points available for the analysis. Only four fields of Irrigated Sunflowers were found within the FSA reporting records set aside for the accuracy assessment. Two of the four reference points were correctly classified, while one Irrigated Sorghum and one Irrigated Dry Edible Bean reference point fell on pixels classified as Irrigated Sunflower.

The large error found in Irrigated Sorghum is also due to the small number of reference points available for the analysis. Of the eight reference points collected, only one was classified correctly. Three Irrigated Soybean, two Dryland Sorghum, one Irrigated Corn, and one Irrigated Small Grain reference points fell on pixels classified as Irrigated Sorghum.

Those classes with a low accuracy often had errors associated with the irrigation layer, while the crop itself was classified correctly. Looking at just the crop classification, the overall accuracy was very high (Table 11). Sorghum had an overall accuracy of 68.6%, while Irrigated Sorghum had the lowest accuracy at 12.5%. This was the only crop with an overall accuracy less than 70%.

Table 11. Accuracy Totals for Crops

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Overall Accuracy
Corn	632	635	592	93.67%	93.23%	93.45%
Sugar Beets	22	22	20	90.91%	90.91%	90.91%
Soybeans	308	320	282	91.56%	88.13%	89.85%
Sorghum	65	44	36	55.38%	81.82%	68.60%
Dry Edible Bean	56	51	46	82.14%	90.20%	86.17%
Potatoes	19	13	13	68.42%	100.00%	84.21%
Alfalfa	109	108	93	85.32%	86.11%	85.72%
Small Grains	149	147	128	85.91%	87.07%	86.49%
Sunflower	32	21	18	56.25%	85.71%	70.98%
Summer Fallow	111	111	103	92.79%	92.79%	92.79%
Totals	1503	1472	1331			

Overall Classification Accuracy = 88.55%

Accuracy Assessment of the Irrigation Layer

Determining the accuracy of the irrigation layer provided greater insight into the overall classification accuracy. Irrigated and non-irrigated pixel reference points were collected using the 2001 FSA reporting records reserved for the accuracy assessment. The land cover classification was recoded so that irrigated pixels were given a value of 1 and non-irrigated pixels a value of 2. The reference points were also recoded so that reference points found to be irrigated were recoded to a value of 1 and non-irrigated reference points were recoded to a value of 2. A total of 1,718 randomly collected reference points were used for this analysis. The overall classification accuracy for the irrigation layer was calculated at 92.37% (Table 12). More detail about the accuracy assessment can be found in the error matrix (Table 13).

Table 12. Accuracy Totals For 2001 Irrigation Layer

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Overall Accuracy
Irrigated Pixels	922	887	839	91.00%	94.59%	92.80%
Dry Land Pixels	796	831	748	93.97%	90.01%	91.99%
Totals	1718	1718	1587			

Overall Classification Accuracy = 92.37%
Overall Kappa Statistics = 0.8471

Table 13. Error Matrix for 2001 Irrigation Layer

	Reference Data		
Classified Data	Irrigated Pixels	Dry land Pixels	Row Totals
Irrigated Pixels	839	48	887
Dry Land Pixels	83	748	831
Column Totals	922	796	1718

Accuracy Totals for Eastern, Central and Western Sections of the Study Area

Land cover types vary across the study area, this becomes especially apparent when comparing individual land cover acreage totals between counties. In light of these differences, further information can be obtained by performing the accuracy assessment on separate sections of the study area. To do this, the study area was broken into three sections representing western, central and eastern areas. These three areas were selected to represent similar areas designated for the COHYST eastern, central, and western hydrologic modeling units. See Figure 10.

Accuracy totals for the three sections showed the western section with the highest overall accuracy at 88.39%, followed by the central section at 83.02%, while the eastern section had the lowest accuracy at 79.83%. These totals were somewhat surprising, since the western section had proved to be the most difficult to classify. One possible reason for these differences can be found in the number and variety of land cover classes in each section; western section had the lowest number of land cover classes at 13, compared to 17 for the central and 16 for the eastern. Classification in the eastern section was complicated by cloud cover in the spring image dates. This lowered the accuracy for spring/early summer crops such as small grains (spring wheat) and alfalfa.

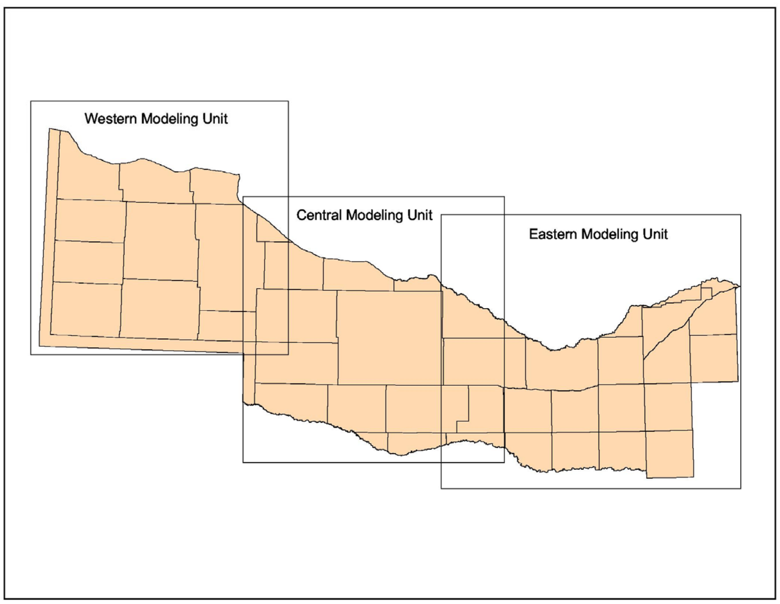


Figure 10. COHYST Study Area and Modeling Units

Table 14. Accuracy Totals for Western Section

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Overall Accuracy
Irrigated Corn	31	31	30	96.77%	96.77%	96.77%
Irrigated Sugar Beets	22	22	20	90.91%	90.91%	90.91%
Irrigated Soybeans	0	0	0	---	---	---
Irrigated Sorghum	0	0	0	---	---	---
Irrigated Dry Edible Beans	54	46	44	81.48%	95.65%	88.57%
Irrigated Potatoes	0	0	0	---	---	---
Irrigated Alfalfa	21	20	20	95.24%	100.00%	97.62%
Irrigated Small Grains	15	18	13	86.67%	72.22%	79.45%
Range, Pasture, Grass	18	26	17	94.44%	65.38%	79.91%
Urban Land	0	0	0	---	---	---
Open Water	62	64	62	100.00%	96.88%	98.44%
Riparian Forest & Woodlands	28	12	11	39.29%	91.67%	65.48%
Wetlands	0	7	0	---	---	---
Other Ag. Land	0	0	0	---	---	---
Irrigated Sunflower	3	2	1	33.33%	50.00%	41.67%
Summer Fallow	52	56	50	96.15%	89.29%	92.72%
Roads	0	0	0	---	---	---
Dryland Corn	5	7	5	100.00%	71.43%	85.72%
Dryland Soybeans	0	0	0	---	---	---
Dryland Sorghum	0	0	0	---	---	---
Dryland Dry Edible Beans	0	1	0	---	---	---
Dryland Alfalfa	0	0	0	---	---	---
Dryland Small Grains	60	62	58	96.67%	93.55%	95.11%
Dryland Sunflowers	8	5	4	50.00%	80.00%	65.00%
Barren	0	0	0	---	---	
Totals	379	379	335			

Overall Classification Accuracy = 88.39%

Overall Kappa Statistics = 0.8692

Table 15. Accuracy Totals for Central Section

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Overall Accuracy
Irrigated Corn	134	120	115	85.82%	95.83%	90.83%
Irrigated Sugar Beets	3	3	3	100.00%	100.00%	100.00%
Irrigated Soybeans	34	34	30	88.24%	88.24%	88.24%
Irrigated Sorghum	2	2	0	0.00%	0.00%	0.00%
Irrigated Dry Edible Beans	6	6	5	83.33%	83.33%	83.33%
Irrigated Potatoes	0	0	0	---	---	---
Irrigated Alfalfa	28	34	18	64.29%	52.94%	58.62%
Irrigated Small Grains	11	9	7	63.64%	77.78%	70.71%
Range, Pasture, Grass	51	64	51	100.00%	79.69%	89.85%
Urban Land	0	0	0	---	---	---
Open Water	19	19	19	100.00%	100.00%	100.00%
Riparian Forest & Woodlands	30	22	22	73.33%	100.00%	86.67%
Wetlands	0	6	0	---	---	---
Other Ag. Land	0	0	0	---	---	---
Irrigated Sunflower	3	3	1	33.33%	33.33%	33.33%
Summer Fallow	51	51	49	96.08%	96.08%	96.08%
Roads	0	0	0	---	---	---
Dryland Corn	42	58	39	92.86%	67.24%	80.05%
Dryland Soybeans	6	10	5	83.33%	50.00%	66.67%
Dryland Sorghum	8	4	3	37.50%	75.00%	56.25%
Dryland Dry Edible Beans	0	0	0	---	---	---
Dryland Alfalfa	31	21	15	48.39%	71.43%	59.91%
Dryland Small Grains	46	45	40	86.96%	88.89%	87.93%
Dryland Sunflowers	19	13	13	68.42%	100.00%	84.21%
Barren	0	0	0	---	---	
Totals	524	524	435			

Overall Classification Accuracy = 83.02%

Overall Kappa Statistics = 0.8088

Table 16. Accuracy Totals for Eastern Section

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Overall Accuracy
Irrigated Corn	425	401	373	87.76%	93.02%	90.39%
Irrigated Sugar Beets	0	0	0	---	---	---
Irrigated Soybeans	228	234	196	85.96%	83.76%	84.86%
Irrigated Sorghum	7	6	1	14.29%	16.67%	15.48%
Irrigated Dry Edible Beans	0	0	0	---	---	---
Irrigated Potatoes	19	13	13	68.42%	100.00%	84.21%
Irrigated Alfalfa	25	39	19	76.00%	48.72%	62.36%
Irrigated Small Grains	4	3	1	25.00%	33.33%	29.17%
Range, Pasture, Grass	92	119	88	95.65%	73.95%	84.80%
Urban Land	0	0	0	---	---	---
Open Water	10	13	10	100.00%	76.92%	88.46%
Riparian Forest & Woodlands	54	42	41	75.93%	97.62%	86.78%
Wetlands	0	5	0	---	---	---
Other Ag. Land	0	0	0	---	---	---
Irrigated Sunflower	1	0	0	---	---	---
Summer Fallow	23	20	18	78.26%	90.00%	84.13%
Roads	0	0	0	---	---	---
Dryland Corn	71	99	48	67.61%	48.48%	58.05%
Dryland Soybeans	64	67	39	60.94%	58.21%	59.58%
Dryland Sorghum	53	33	31	58.49%	93.94%	76.22%
Dryland Dry Edible Beans	0	0	0	---	---	---
Dryland Alfalfa	38	25	16	42.11%	64.00%	53.06%
Dryland Small Grains	26	23	18	69.23%	78.26%	73.75%
Dryland Sunflowers	2	0	0	---	---	
Barren	0	0	0	---	---	
Totals	1142	1142	912			
Overall Classification Accuracy = 79.86%						
Overall Kappa Statistics = 0.7500						

Causes of Lower Accuracies and Sources of Error

Error can enter into a project during steps such as data acquisition, conversion, processing and analysis. While error matrices derive a percentage of classification accuracy, there are other sources of error they cannot measure.

Although certified FSA reporting records were the best available choice for ground truth on crop types, in some cases these records did not provide sufficient information. Often only one or two fields within each section were labeled and not all counties distinguished between fields as irrigated or non-irrigated fields. Due to the random selection of sections, not all crops may have been represented, or there may have been a minimal number of signatures available. This was the case for crops such as sunflowers, potatoes, dry edible beans, and sugar beets.

Although the classification techniques used were based on standard procedures (Jensen, 1996, Lillesand & Kiefer, 2000), error still remained a factor. An accuracy estimate is only as good as the ground or sampling information used to compare known land cover types to the results of the classification. Classification systems often fail to categorize mixed classes and transition zones. When dealing with mixed pixels or polygons in transition zones, labeling inconsistencies will occur with all classification systems (Lunetta et al, 1991). This introduces an element of error that is difficult to quantify. While all types of error cannot be controlled, it is important to note the limitations of one's final accuracy assessment and to document sources of error throughout the stages of the project.

1997 and 2001 Land Cover Comparisons

Overview of Change Detection Techniques

Change detection can be defined as the process of identifying differences in the state of an object or phenomenon by observing it at different times, and involves the ability to quantify temporal effects using multi-temporal data. Change detection techniques aim to detect changes in images over time. They rely upon differences in radiance values or spectral homogeneity. These differences may be due to an actual change in land cover, or differences in illumination, atmospheric conditions, vegetation phenology changes, ground moisture conditions and differences in the registration of the two classified images. (Singh, 1989). Remote sensing change detection techniques can be categorized into two basic approaches, pre-classification and post-classification.

The pre-classification approach incorporates the simultaneous analysis of multi-temporal data sets. There are a variety of methods used in this type of analysis, these including composite analysis, image differencing, principal component analysis, change vector, and spectral analysis methods (Lunetta & Elvidge 1998)

The most commonly used change detection approach is post-classification. This approach incorporates independently produced thematic classifications of imagery from different dates, followed by a comparison of the corresponding pixel (thematic) labels to identify areas where change has occurred. This was the method employed to determine the amount of change between 1997-2001 in the COHYST study area.

While the post-classification approach is the most common, one main disadvantage of this approach is that errors in classifications can have compounding effects (Pilon et al., 1988). One basic assumption in performing a post-classification change detection analysis is that the input classifications were generated using exactly similar methods. Another assumption is that the satellite images used to generate the classifications were not affected by differences in geometric rectification, atmospheric conditions, illumination and viewing angle, changes in precipitation, and soil moisture levels.

Land Cover Comparisons

The post-classification change detection approach was employed to determine the amount of change between 1997 and 2001 in the COHYST study area. The total acreage of each land cover class within each county and for the entire study area was compared using the two separate classified images for 1997 and 2001. Results for each land cover class are found in Table 17. Dryland Potatoes and Dryland Sugar Beets identified in the 1997 classification were merged into corresponding Irrigated Potatoes and Irrigated Sugar Beet class since it was noted after classification that these two crops are almost

Table 17. 1997 and 2001 Acreage Change Comparisons

Landcover Class	1997 Acres	2001 Acres	Acres Change	Change as a % of Study Area
Range, Pasture, Grass	9,066,471.87	10,060,999.07	994,527.20	5.31%
Irrigated Soybeans	431,108.77	869,423.77	438,315.00	2.34%
Irrigated Alfalfa	216,370.76	294,194.55	77,823.79	0.42%
Dryland Dry Edible Beans	25,962.26	45,369.46	19,407.20	0.10%
Dryland Corn	815,201.69	830,754.81	15,553.12	0.08%
Irrigated Dry Edible Beans	83,061.06	96,272.08	13,211.03	0.07%
Dryland Soybeans	244,494.77	250,016.50	5,521.73	0.03%
Irrigated Potatoes	1,934.06	5,169.26	3,235.20	0.02%
Irrigated Sunflower	14,064.81	13,708.94	-355.88	0.00%
Open Water	124,991.50	122,989.43	-2,002.07	-0.01%
Irrigated Small Grains	165,776.67	154,229.08	-11,547.59	-0.06%
Irrigated Sugar Beets	62,235.76	39,413.41	-22,822.35	-0.12%
Roads	68,998.85	45,583.11	-23,415.74	-0.12%
Urban Land	114,376.14	87,914.76	-26,461.37	-0.14%
Dryland Sunflower	69,295.15	40,297.09	-28,998.06	-0.15%
Irrigated Sorghum (Milo, Sudan)	76,963.18	41,085.48	-35,877.70	-0.19%
Riparian Forest and Woodlands	413,848.47	321,507.70	-92,340.77	-0.49%
Dryland Alfalfa	325,952.77	214,621.46	-111,331.31	-0.59%
Wetlands	379,004.10	255,247.34	-123,756.76	-0.66%
Summer Fallow	1,101,736.83	948,599.85	-153,136.97	-0.82%
Dryland Sorghum	327,852.92	126,737.39	-201,115.54	-1.07%
Other Ag. Land	249,736.25	40,139.61	-209,596.63	-1.12%
Dryland Small Grains	1,549,941.19	1,292,138.50	-257,802.69	-1.38%
Irrigated Corn	2,805,143.38	2,473,506.80	-331,636.59	-1.77%

always irrigated. The Barren class identified in 2001 but not in 1997 was left out of the analysis.

Based upon review of both classifications, changes identified within the agricultural classes tended to have more validity than those in non-agricultural classes. This was due to the fact that agricultural crops were classified using the same methods in 1997 and 2001, while non-agricultural areas, such as range, roads and urban areas were classified somewhat differently in the 1997 and 2001 classifications.

The greatest acreage change between 1997 and 2001 was in the Range/Pasture/Grass class. However, this increase in acreage does not necessary reflect that fields were take out of production. On the contrary, it mainly reflects differences in classification methods between the two years. More time was spent on the 2001 classification to remove mixed pixels in the range class, while the 1997 classification other crops such as small grains, alfalfa, summer fallow were mixed with the range class. For the 2001 classification, more effort was put in to remove these mixed pixels so that crops were not infringing as much on the range class.

The largest increase in crops acreage was found in Irrigated Soybeans (+438,315 acres), Irrigated Alfalfa (+77,823 acres), and Dryland Dry Edible Beans (+19,407 acres). The largest decrease in crop acreage was calculated for Irrigated Corn (-331,636 acres), Dryland Small Grains (-257,802 acres) and Dryland Sorghum (201,115 acres).

These changes were also identified by the Nebraska Agricultural Statistics Service (NASS). According to their records, in 2001,corn acreage across the state declined for the fourth straight year, while sorghum declined in eight of the last nine years. Areas with acreage decreases in corn, wheat, and sorghum saw corresponding increases in soybeans. Acres planted and harvested in soybeans set a record high in 2001 and dry edible beans had a record high yield in 2001. (Nebraska Agricultural Statistics Service, 2002).   These changes are further detailed in Table 18.

Open water and wetland acreage decreases could be attributed to changes in precipitation levels between 1997 and 2001. The entire study area was affected by the severe drought of 2000. Areas of open water and wetlands may be assumed to have not recovered to normal levels by 2001.

Table 18. 1997 and 2001 NASS Acreage Change Comparisons for Nebraska
(Nebraska Agricultural Statistics Service, 2002

Crop	1997 Acres	2001 Acres	Acreage Change
Irrigated Soybeans	1,070,000	2,220,000	1,150,000
Non-Irrigated Soybeans	2,530,000	2,730,000	200,000
Irrigated Alfalfa	335,000	440,000	105,000
Non-Irrigated Alfalfa	965,000	1,010,000	45,000
Non-Irrigated Corn	3,343,000	3,370,000	27,000
Irrigated Sorghum	32,000	49,000	17,000
Oats	160,000	155,000	-5,000
Sugar Beets	673,000.00	486,000.00	-187,000
Winter Wheat (Irr & non-irr)	2,000,000	1,750,000	-250,000
Non-Irrigated Sorghum	868,000	501,000	-367,000
Irrigated Corn	5,557,000	4,730,000	-827,000

Urban areas defined in 1997 were somewhat overestimated and included areas around airports. The change reflected in Table 17 does not necessarily mean urban areas decreased between 1997 and 2001. This again reflects differences in classification methods. More county roads were identified in the roads class in 1997 while the 2001 roads classification included only major roads. County roads, when dirt, were included in the Range class in the 2001 classification.

County Land Cover Comparisons

Changes in acreage of agricultural crops at the county level also reflected these trends. A majority of the counties which had a decrease in irrigated corn acreage saw a corresponding increase in irrigated soybean acreage. The counties that had the highest increases in irrigated soybean acreage between 1997 and 2001 included: Phelps (+88,252 acres), Kearney (+48,049 acres), Hamilton (+40,430 acres), Adams (+33,811 acres), and York (+33,348 acres). County acreage change totals for all crops are listed by county in Appendix C.

Counties that had an increase in irrigated corn acreage between 1997 and 2001 were mainly found in the western section of the study area. The counties with the largest increases included: Morrill (+10,374 acres), Box Butte (+7,844 acres), Cheyenne (+7,226 acres), and Kimball (+5,353 acres).

Irrigated alfalfa acreages also increased across the study area. The counties with the largest acreage increases included: Dawson (+8,207), Morrill (+7,363 acres), Lincoln (+6,234 acres), Merrick (+3,472 acres), Polk (+3,122 acres), and Garden (+3,145 acres) Counties.

In counties that had a decrease in sugar beet acreage, there was an equivalent increase in irrigated and non-irrigated dry edible beans. This was the case for Scotts Bluff, Box Butte, and Banner Counties. The county with the largest decrease in sugar beets acreage was Scotts Bluff County at 9,381 acres. Those acres were made up by irrigated and non-irrigated dry edible beans, which increased by 9,905 acres.

Irrigation Estimates and Comparisons 1997

Between 1997 and 2001 irrigation rates increased across the study area. Overall, the increase was estimated at 98,976 acres, representing less than one percent of the study area. Areas irrigated in 1997 were not always irrigated in 2001, as crop patterns change over time. Table 19 outlines the extent of the change in irrigated acres in the study area within the Nebraska border.

Table 19. 1997 and 2001 Irrigation Estimate Comparisons

Category	Acres	Percent of Study Area
Irrigated in 1997 but not in 2001	436,758.69	2.45%
Irrigated in 2001 but not in 1997	535,734.96	3.00%
Irrigated both in 1997 and 2001	3,374,869.33	18.89%
Total 1997 Irrigated Areas	3,811,628.02	21.34%
Total 2001 Irrigated Areas	3,910,604.29	21.89%
Irrigation Increase:	98,976.28	0.55%

The county that had the greatest increase in irrigated acres was Dawson County, (+20,947), followed by York (+13,531), Harlan (+11,337) and Hayes (+11,293) Counties. The counties that had the greatest decrease in irrigated acres was Hall county (-6,599) followed by Chase county (-4,731) and Merrick County (-4,113). Irrigation comparisons for all counties are listed in Table 20.

Table 20. 1997 and 2001 County Irrigation Comparisons

County	1997 Irrigated Acres	2001 Irrigated Acres	Acreage Change
Adams	179,591.99	183,149.90	3,557.92
Arthur*	9,516.03	7,915.78	-1,600.25
Banner	23,971.66	22,452.23	-1,519.44
Box Butte*	101,968.94	107,674.03	5,705.09
Buffalo*	200,600.98	199,565.64	-1,035.34
Chase*	120,389.96	115,659.42	-4,730.53
Cheyenne	47,739.20	49,609.91	1,870.70
Clay	184,188.46	178,340.73	-5,847.72
Custer*	48,128.22	48,507.37	379.15
Dawson	217,367.32	238,361.99	20,994.67
Deuel	19,439.82	18,725.33	-714.49
Franklin*	79,134.36	84,088.57	4,954.21
Frontier	51,420.37	60,783.36	9,362.99
Furnas*	20,389.78	25,116.30	4,726.52
Garden*	27,666.22	28,561.13	894.91
Gosper	75,596.62	78,661.10	3,064.48
Grant*	80.24	57.79	-22.45
Hall	193,735.86	187,199.78	-6,536.08
Hamilton	227,175.84	223,307.52	-3,868.32
Harlan*	49,690.35	61,027.70	11,337.35
Hayes*	39,460.90	50,738.62	11,277.73
Hitchcock*	15,160.73	15,379.60	218.86
Howard*	33,236.50	33,329.18	92.68
Kearney	197,172.22	195,789.20	-1,383.02
Keith	89,256.38	91,279.36	2,022.97
Kimball	24,066.00	27,082.45	3,016.46
Lincoln	195,319.26	205,236.22	9,916.96
Logan*	13,505.12	14,418.69	913.57
McPherson*	6,991.18	5,971.69	-1,019.49
Merrick	159,701.37	155,462.02	-4,239.35
Morrill	106,531.34	106,142.99	-388.35
Nance*	17,094.79	18,015.58	920.79
Nuckolls	38,628.75	48,171.33	9,542.58
Perkins	129,514.50	127,669.21	-1,845.29
Phelps	231,107.96	227,308.90	-3,799.06
Platte*	20,279.84	20,107.32	-172.52
Polk	128,267.49	136,704.99	8,437.50
Red Willow*	29,047.01	30,168.40	1,121.40
Scotts Bluff	165,640.39	166,006.56	366.17
Sheridan*	1,774.38	2,477.91	703.53
Sioux*	28,820.52	28,555.32	-265.20
Webster*	39,320.93	45,291.02	5,970.09
York	219,851.91	233,418.61	13,566.70

* Partial counties not completely within the COHYST boundary

PROJECT EXPOSURE

WWW Page

The Center for Advanced Land Management Information Technologies (CALMIT) has developed a web site for the COHYST Land Use Mapping project at : **http://www.calmit.unl.edu/cohyst/**. The web page provides information regarding the project's goals and methodologies, as well as allowing data sets and metadata to be downloaded over the Internet. The printed versions of the 2001 and 1997 land cover maps and reports can also be downloaded over the Internet. These maps and reports are in Adobe .PDF format. Internet mapping is also available for the COHYST study area. The land cover maps, digital orthphotography, and topographic maps are viewable through any web browser though a link on the above-mentioned web site.

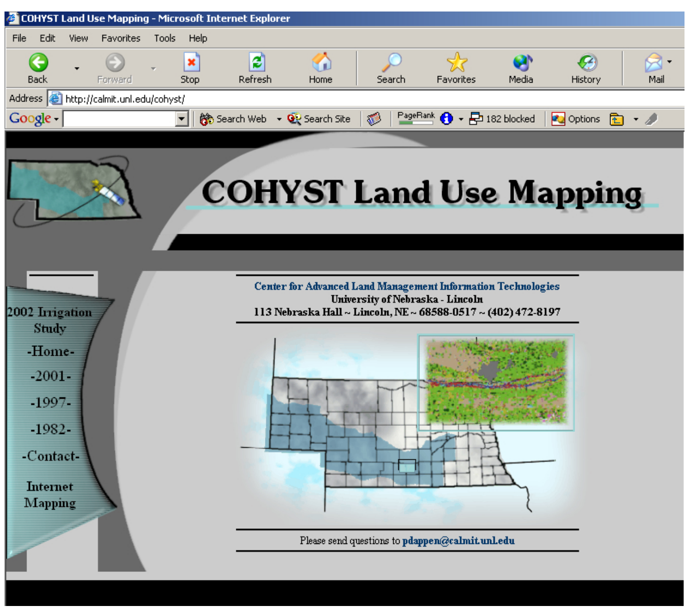


Figure 11. COHYST Land Use Mapping Web Page

(http://www.calmit.unl.edu/cohyst)

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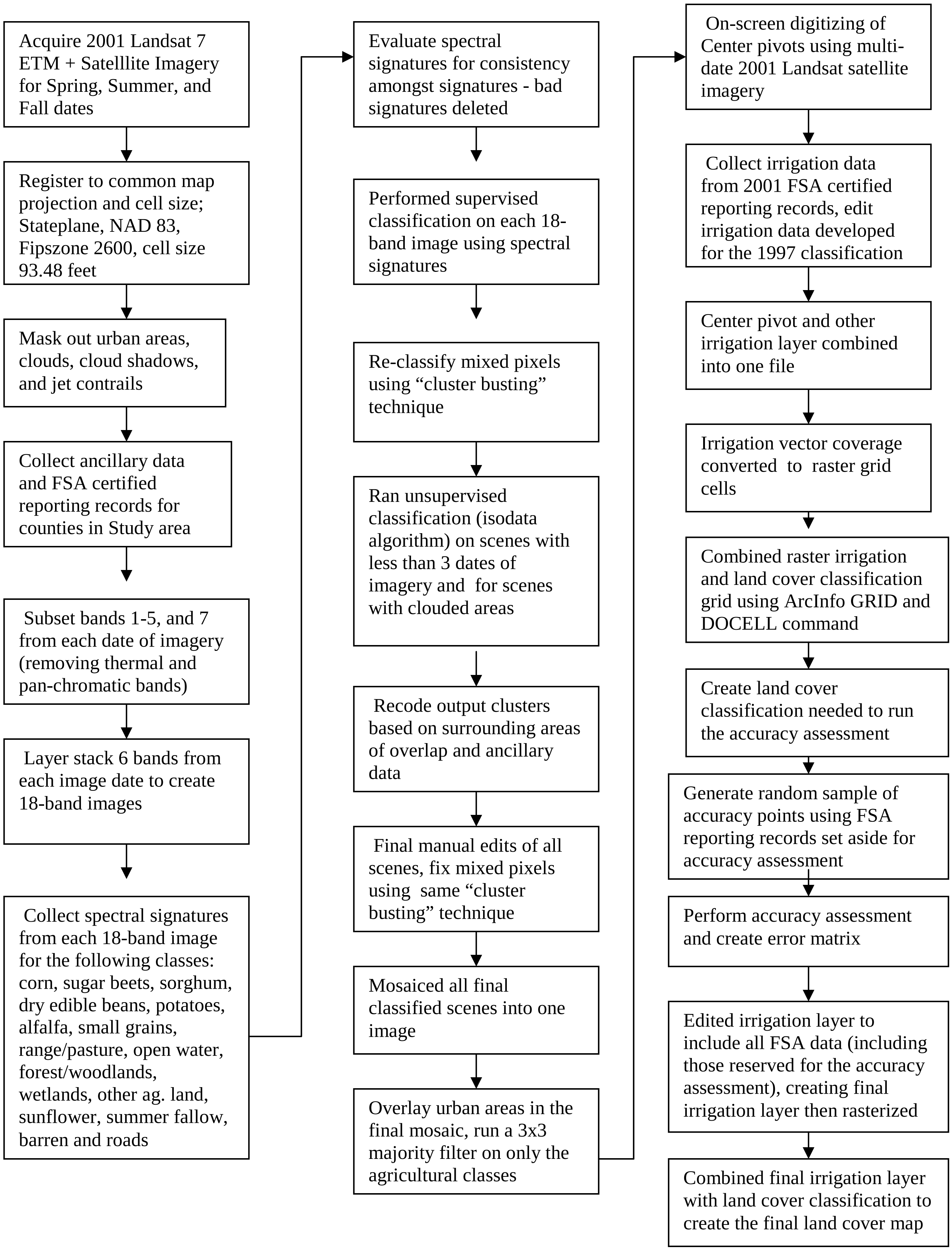
APPENDICES

Appendix A. Monthly Temperature and Precipitation of the Study Area

WEATHER STATION	PARAMETER	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Grand Island WSO AP	Monthly average temperature (F)	1999	25.08	37.36	39.15	48.90	60.34	68.10	78.73	72.76	62.72	52.98	45.80	32.56	52.04
Grand Island WSO AP	Monthly average temperature (F)	2000	28.10	34.72	42.47	50.05	64.10	70.25	76.11	77.73	67.45	55.11	29.05	17.06	51.02
Grand Island WSO AP	Monthly average temperature (F)	2001	26.31	20.64	35.65	53.68	62.94	71.62	79.05	75.85	64.75	52.90	46.78	32.17	53.65
Grand Island WSO AP	Monthly average temperature (F)	1961-90 normal	22.05	27.70	38.10	50.80	61.40	71.30	76.45	73.85	64.15	52.20	36.85	25.40	50.15
Grand Island WSO AP	Monthly total precipitation (In.)	1999	0.35	0.09	0.79	4.97	4.36	6.48	1.45	5.83	0.56	0.04	0.32	0.05	25.29
Grand Island WSO AP	Monthly total precipitation (In.)	2000	0.25	1.35	1.32	1.60	2.19	0.70	5.25	1.77	1.01	2.21	1.83	0.60	20.08
Grand Island WSO AP	Monthly total precipitation (In.)	2001	0.99	1.25	1.07	4.07	5.51	0.84	2.58	2.25	2.31	0.58	1.55	0.14	23.00
Grand Island WSO AP	Monthly total precipitation (In.)	1961-90 normal	0.53	0.82	1.87	2.51	3.74	3.80	2.93	3.04	2.59	1.43	1.02	0.76	25.03
Kearney 4 NE	Monthly average temperature (F)	1999	25.56	36.54	37.42	47.97	59.50	67.22	76.76	70.82	61.37	51.94	44.63	32.32	51.00
Kearney 4 NE	Monthly average temperature (F)	2000	28.39	33.45	41.18	48.62	62.24	68.42	74.85	76.77	65.43	53.52	27.02	17.47	49.78
Kearney 4 NE	Monthly average temperature (F)	2001	26.69	21.75	33.95	52.28	61.44	69.62	78.21	73.45	63.47	51.13	45.13	32.45	52.47
Kearney 4 NE	Monthly average temperature (F)	1961-90 normal	22.35	27.75	37.50	49.80	60.55	70.45	75.65	72.95	63.50	51.60	36.40	25.40	49.65
Kearney 4 NE	Monthly total precipitation (In.)	1999	0.34	0.14	0.54	4.20	5.35	8.23	2.78	6.67	0.87	0.02	0.08	0.15	29.37
Kearney 4 NE	Monthly total precipitation (In.)	2000	0.53	1.79	2.19	1.12	2.68	3.63	3.34	0.93	1.21	2.23	1.59	0.32	21.56
Kearney 4 NE	Monthly total precipitation (In.)	2001	1.02	1.03	0.86	3.55	4.18	0.84	4.62	3.16	4.36	1.15	1.50	0.24	26.27
Kearney 4 NE	Monthly total precipitation (In.)	1961-90 normal	0.49	0.75	1.81	2.33	3.66	3.90	3.45	2.82	2.44	1.56	0.94	0.72	24.87
North Platte WSO ARPT	Monthly average temperature (F)	1999	27.60	36.70	38.47	45.25	57.11	66.93	75.53	70.69	58.13	50.00	41.75	30.71	49.91
North Platte WSO ARPT	Monthly average temperature (F)	2000	27.29	33.91	40.90	47.97	60.69	67.85	76.42	77.42	63.58	51.08	24.62	21.56	49.44
North Platte WSO ARPT	Monthly average temperature (F)	2001	27.63	23.41	36.85	49.07	56.94	67.52	77.52	71.08	61.63	48.32	38.93	27.27	50.81
North Platte WSO ARPT	Monthly average temperature (F)	1961-90 normal	27.45	27.75	36.85	48.25	58.20	67.90	73.85	71.65	61.75	49.45	34.70	24.50	48.20
North Platte WSO ARPT	Monthly total precipitation (In.)	1999	0.34	0.26	0.64	2.83	1.92	5.32	0.93	5.49	1.20	0.22	0.14	0.05	19.34
North Platte WSO ARPT	Monthly total precipitation (In.)	2000	0.31	0.46	1.22	1.65	1.21	1.53	2.86	2.05	1.22	3.24	0.53	0.04	16.32
North Platte WSO ARPT	Monthly total precipitation (In.)	2001	0.48	0.40	0.60	5.94	2.19	1.71	2.52	5.26	2.76	0.80	0.96	0.07	23.62
North Platte WSO ARPT	Monthly total precipitation (In.)	1961-90 normal	0.38	0.51	1.23	1.91	3.37	3.42	2.93	1.87	1.60	0.99	0.63	0.50	19.33
Scottsbluff WSO AP	Monthly average temperature (F)	1999	31.53	37.75	40.37	43.55	55.85	66.68	75.18	72.40	57.62	49.92	43.05	32.97	50.57
Scottsbluff WSO AP	Monthly average temperature (F)	2000	29.84	35.78	40.03	47.15	59.55	67.10	76.27	75.76	62.55	49.92	26.77	23.84	49.55
Scottsbluff WSO AP	Monthly average temperature (F)	2001	28.89	25.59	38.89	47.58	56.81	67.67	76.58	73.73	64.38	48.98	38.70	29.84	51.62
Scottsbluff WSO AP	Monthly average temperature (F)	1961-90 normal	24.90	30.25	37.45	47.30	57.10	67.45	74.00	71.45	61.50	49.45	35.50	26.35	48.70
Scottsbluff WSO AP	Monthly total precipitation (In.)	1999	0.07	0.22	1.03	3.47	1.45	3.70	1.71	2.34	2.40	0.06	0.24	0.13	16.82
Scottsbluff WSO AP	Monthly total precipitation (In.)	2000	0.48	0.89	1.04	2.80	1.48	0.68	1.70	0.33	2.31	2.47	0.37	0.24	14.79
Scottsbluff WSO AP	Monthly total precipitation (In.)	2001	0.28	0.29	0.42	3.03	2.22	1.70	2.79	0.04	1.01	0.94	0.30	0.00	13.02
Scottsbluff WSO AP	Monthly total precipitation (In.)	1961-90 normal	0.53	0.55	1.07	1.63	2.76	2.55	1.96	1.25	1.07	0.83	0.61	0.53	15.32

Appendix B. Flow Chart of Methodology



Appendix C. Crop Acreage Change By County 1997-2001

(Counties not completely within the COHYST boundary are listed as 'partial')

Adams County

Adams				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	59,780.52	25,968.53	33,811.99	9.37%
Dryland Soybeans	19,150.42	14,199.47	4,950.95	1.37%
Dryland Corn	38,511.68	36,085.55	2,426.13	0.67%
Irrigated Alfalfa	4,666.14	2,848.48	1,817.65	0.50%
Irrigated Potatoes	20.86	0.60	20.26	0.01%
Irrigated Sorghum	2,352.33	2,918.13	-565.80	-0.16%
Irrigated Small Grains	720.98	1,746.18	-1,025.20	-0.28%
Summer Fallow	1,735.86	4,416.64	-2,680.78	-0.74%
Dryland Alfalfa	4,033.42	9,976.72	-5,943.30	-1.65%
Dryland Small Grains	5,819.83	13,889.97	-8,070.14	-2.24%
Dryland Sorghum	3,560.39	15,833.45	-12,273.07	-3.40%
Irrigated Corn	115,609.07	146,110.05	-30,500.98	-8.45%

Arthur County (partial)

Arthur				
Class	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Alfalfa	5,392.34	2,621.94	2,770.39	0.67%
Irrigated Sorghum	1,019.09	1.00	1,018.08	0.25%
Dryland Sorghum	152.86	1.81	151.06	0.04%
Dryland Dry Edible Beans	0.00	11.64	-11.64	0.00%
Irrigated Dry Edible Beans	0.00	129.99	-129.99	-0.03%
Irrigated Sunflower	0.00	138.22	-138.22	-0.03%
Dryland Sunflower	0.00	164.10	-164.10	-0.04%
Irrigated Sugar Beets	0	197.40	-197.40	-0.05%
Dryland Soybeans	1.00	215.85	-214.85	-0.05%
Dryland Alfalfa	516.16	804.64	-288.47	-0.07%
Summer Fallow	560.70	898.72	-338.02	-0.08%
Irrigated Soybeans	46.14	432.31	-386.17	-0.09%
Irrigated Small Grains	365.91	1,057.00	-691.09	-0.17%
Dryland Small Grains	30.89	978.36	-947.47	-0.23%
Dryland Corn	76.83	1,319.80	-1,242.97	-0.30%
Irrigated Corn	1,092.31	4,946.59	-3,854.28	-0.93%

Banner County

Banner				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Corn	7,255.18	4,592.06	2,663.12	0.56%
Irrigated Dry Edible Beans	4,144.76	1,675.13	2,469.63	0.52%
Dryland Sunflower	3,148.14	928.89	2,219.25	0.47%
Dryland Dry Edible Beans	1,954.52	394.60	1,559.92	0.33%
Dryland Corn	2,354.13	1,245.01	1,109.12	0.23%
Summer Fallow	50,422.37	50,342.02	80.35	0.02%
Irrigated Potatoes	3.81	21.07	-17.26	0.00%
Dryland Soybeans	94.89	626.22	-531.33	-0.11%
Irrigated Sugar Beets	983.18	1,627.76	-644.58	-0.14%
Irrigated Sunflower	164.50	1,148.27	-983.77	-0.21%
Irrigated Alfalfa	4,244.26	5,563.09	-1,318.84	-0.28%
Irrigated Small Grains	5,613.21	7,264.32	-1,651.11	-0.35%
Irrigated Soybeans	43.33	2,079.96	-2,036.63	-0.43%
Dryland Alfalfa	859.00	3,508.82	-2,649.82	-0.56%
Dryland Small Grains	59,499.07	70,349.05	-10,849.98	-2.27%

Box Butte County (partial)

Box Butte County				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Small Grains	29,398.27	21,553.70	7,844.57	1.79%
Dryland Dry Edible Beans	5,383.11	1,868.46	3,514.65	0.80%
Irrigated Corn	36,788.06	33,536.41	3,251.65	0.74%
Irrigated Dry Edible Beans	13,659.99	10,590.29	3,069.70	0.70%
Dryland Sunflower	1,543.88	79.04	1,464.84	0.33%
Irrigated Sunflower	1,437.96	71.82	1,366.14	0.31%
Irrigated Sorghum	574.14	0.00	574.14	0.13%
Irrigated Potatoes	1,254.80	726.20	528.60	0.12%
Dryland Sorghum	474.84	0.00	474.84	0.11%
Dryland Corn	6,029.87	5,696.26	333.61	0.08%
Irrigated Alfalfa	8,276.68	8,290.72	-14.04	0.00%
Dryland Soybeans	0.00	1,750.30	-1,750.30	-0.40%
Dryland Alfalfa	784.18	2,831.78	-2,047.60	-0.47%
Summer Fallow	35,126.22	39,002.77	-3,876.55	-0.88%
Irrigated Sugar Beets	16,284.14	20,268.61	-3,984.47	-0.91%
Dryland Small Grains	46,023.64	50,465.90	-4,442.26	-1.01%
Irrigated Soybeans	0.00	10,064.09	-10,064.09	-2.30%

Buffalo County (partial)

Buffalo				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	50,700.61	29,545.92	21,154.69	3.86%
Dryland Corn	36,182.22	23,009.71	13,172.51	2.40%
Dryland Soybeans	13,108.11	6,623.47	6,484.65	1.18%
Irrigated Small Grains	2,047.80	1,468.85	578.95	0.11%
Irrigated Potatoes	444.55	3.01	441.54	0.08%
Summer Fallow	2,127.25	2,166.36	-39.12	-0.01%
Dryland Small Grains	7,640.75	7,843.16	-202.41	-0.04%
Irrigated Alfalfa	12,417.62	12,682.43	-264.80	-0.05%
Irrigated Sorghum	82.25	6,487.05	-6,404.81	-1.17%
Dryland Alfalfa	19,500.68	26,592.57	-7,091.89	-1.29%
Dryland Sorghum	371.93	14,951.50	-14,579.57	-2.66%
Irrigated Corn	133,872.81	150,414.32	-16,541.52	-3.02%

Chase County (partial)

Chase County				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Dryland Corn	17,215.16	13,048.73	4,166.42	1.07%
Irrigated Soybeans	5,593.15	1,831.55	3,761.60	0.96%
Irrigated Alfalfa	5,240.88	4,303.84	937.04	0.24%
Irrigated Sugar Beets	2,126.84	1,242.56	884.28	0.23%
Dryland Small Grains	33,364.69	32,750.43	614.26	0.16%
Irrigated Small Grains	9,104.99	8,604.47	500.52	0.13%
Dryland Dry Edible Beans	1,689.12	1,855.02	-165.90	-0.04%
Irrigated Sunflower	514.16	930.22	-416.06	-0.11%
Dryland Sunflower	265.81	1,061.01	-795.21	-0.20%
Dryland Soybeans	372.33	1,404.25	-1,031.93	-0.26%
Irrigated Dry Edible Beans	4,211.96	5,531.56	-1,319.60	-0.34%
Dryland Alfalfa	1,518.40	3,158.77	-1,640.37	-0.42%
Irrigated Sorghum	763.71	3,227.78	-2,464.07	-0.63%
Dryland Sorghum	1,394.42	5,380.90	-3,986.48	-1.02%
Irrigated Corn	88,103.74	94,723.59	-6,619.86	-1.69%
Summer Fallow	27,277.44	37,939.35	-10,661.90	-2.73%

Cheyenne County

Cheyenne				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Dryland Dry Edible Beans	8,267.65	1,041.29	7,226.36	0.94%
Irrigated Dry Edible Beans	5,386.92	1,604.48	3,782.44	0.49%
Dryland Corn	9,619.34	6,896.82	2,722.53	0.36%
Irrigated Corn	17,263.71	14,560.95	2,702.76	0.35%
Dryland Sorghum	2,537.89	7.63	2,530.26	0.33%
Irrigated Alfalfa	4,996.74	3,543.75	1,452.99	0.19%
Irrigated Sunflower	2,979.03	1,643.02	1,336.01	0.17%
Irrigated Sorghum	173.73	88.31	85.41	0.01%
Irrigated Potatoes	42.93	0.00	42.93	0.01%
Dryland Alfalfa	1,599.85	1,606.89	-7.04	0.00%
Irrigated Small Grains	17,944.37	17,971.22	-26.85	0.00%
Dryland Soybeans	84.05	1,659.47	-1,575.42	-0.21%
Irrigated Sugar Beets	333.81	2,662.43	-2,328.61	-0.30%
Summer Fallow	172,757.82	176,532.35	-3,774.53	-0.49%
Irrigated Soybeans	488.68	5,665.06	-5,176.37	-0.68%
Dryland Sunflower	8,730.05	15,788.90	-7,058.85	-0.92%
Dryland Small Grains	237,136.07	271,866.05	-34,729.98	-4.54%

Clay County

Clay				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	63,891.78	36,950.41	26,941.37	7.34%
Irrigated Alfalfa	5,356.83	2,161.45	3,195.38	0.87%
Irrigated Potatoes	54.16	0.00	54.16	0.01%
Irrigated Dry Edible Beans	7.42	0.00	7.42	0.00%
Irrigated Sunflower	6.82	0.00	6.82	0.00%
Irrigated Sugar Beets	6.22	0	6.22	0.00%
Dryland Dry Edible Beans	3.41	0.00	3.41	0.00%
Dryland Sunflower	0.20	0.00	0.20	0.00%
Summer Fallow	225.68	405.44	-179.75	-0.05%
Dryland Corn	31,878.59	32,550.84	-672.25	-0.18%
Irrigated Small Grains	732.22	1,797.16	-1,064.94	-0.29%
Dryland Alfalfa	5,718.12	7,432.91	-1,714.79	-0.47%
Irrigated Sorghum	4,648.68	7,608.74	-2,960.05	-0.81%
Dryland Soybeans	15,900.17	22,230.90	-6,330.73	-1.73%
Dryland Small Grains	4,150.58	12,937.80	-8,787.23	-2.39%
Dryland Sorghum	8,669.87	24,993.28	-16,323.41	-4.45%
Irrigated Corn	109,732.47	135,670.70	-25,938.23	-7.07%

Custer County (partial)

Custer				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Dryland Dry Edible Beans	6,593.78	662.81	5,930.97	1.48%
Irrigated Soybeans	6,890.68	2,359.95	4,530.73	1.13%
Dryland Soybeans	7,879.67	4,965.85	2,913.83	0.73%
Irrigated Small Grains	409.04	139.42	269.62	0.07%
Irrigated Sunflower	14.44	15.25	-0.80	0.00%
Irrigated Sugar Beets	0.00	3.61	-3.61	0.00%
Irrigated Dry Edible Beans	0.00	113.95	-113.95	-0.03%
Dryland Sunflower	111.94	243.14	-131.20	-0.03%
Irrigated Alfalfa	4,458.31	4,993.13	-534.82	-0.13%
Summer Fallow	3,699.01	4,632.44	-933.43	-0.23%
Irrigated Sorghum	258.98	1,263.63	-1,004.64	-0.25%
Dryland Corn	25,966.87	27,188.98	-1,222.10	-0.31%
Irrigated Corn	36,475.91	39,240.09	-2,764.17	-0.69%
Dryland Small Grains	72.22	6,508.92	-6,436.70	-1.61%
Dryland Sorghum	1,258.81	8,835.37	-7,576.56	-1.90%
Dryland Alfalfa	3,438.22	13,029.88	-9,591.66	-2.40%

Dawson County

Dawson				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	38,043.46	17,454.19	20,589.27	3.16%
Irrigated Alfalfa	30,640.84	22,433.02	8,207.82	1.26%
Dryland Soybeans	9,257.25	4,038.70	5,218.55	0.80%
Irrigated Small Grains	3,019.35	938.12	2,081.23	0.32%
Dryland Small Grains	6,480.23	5,888.25	591.99	0.09%
Summer Fallow	2,765.38	2,500.05	265.33	0.04%
Irrigated Potatoes	214.85	0.00	214.85	0.03%
Dryland Small Grains	0.00	0.20	-0.20	0.00%
Dryland Sunflower	0.00	0.20	-0.20	0.00%
Dryland Corn	28,525.23	32,457.71	-3,932.48	-0.60%
Irrigated Corn	166,366.45	171,412.03	-5,045.57	-0.77%
Irrigated Sorghum	77.03	5,129.96	-5,052.93	-0.77%
Dryland Sorghum	258.98	10,099.15	-9,840.17	-1.51%
Dryland Alfalfa	22,130.85	48,217.50	-26,086.65	-4.00%

Deuel County

Deuel				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Dryland Dry Edible Beans	8,134.25	388.58	7,745.67	2.75%
Summer Fallow	77,313.24	71,088.06	6,225.18	2.21%
Dryland Corn	9,471.50	3,342.43	6,129.06	2.17%
Irrigated Corn	12,831.28	11,525.60	1,305.67	0.46%
Dryland Sorghum	662.61	0.40	662.21	0.23%
Irrigated Sorghum	17.45	1.00	16.45	0.01%
Irrigated Small Grains	3,414.34	3,428.14	-13.79	0.00%
Irrigated Dry Edible Beans	557.09	578.05	-20.96	-0.01%
Dryland Alfalfa	236.12	321.34	-85.22	-0.03%
Dryland Soybeans	41.53	224.60	-183.07	-0.06%
Irrigated Alfalfa	1,161.72	1,371.86	-210.14	-0.07%
Irrigated Sugar Beets		514.42	-514.42	-0.18%
Irrigated Sunflower	554.08	1,154.89	-600.81	-0.21%
Irrigated Soybeans	189.37	865.87	-676.49	-0.24%
Dryland Sunflower	5,842.90	21,019.21	-15,176.31	-5.38%
Dryland Small Grains	72,399.96	90,007.84	-17,607.89	-6.25%

Franklin County (partial)

Franklin County 2001				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	31,820.41	11,679.19	20,141.22	6.93%
Dryland Soybeans	12,558.85	4,297.02	8,261.83	2.84%
Dryland Corn	27,988.60	23,056.26	4,932.34	1.70%
Irrigated Alfalfa	4,239.44	3,156.96	1,082.48	0.37%
Irrigated Small Grains	1,264.23	852.98	411.25	0.14%
Irrigated Potatoes	226.49	3.81	222.68	0.08%
Dryland Alfalfa	5,965.67	6,352.65	-386.97	-0.13%
Dryland Small Grains	13,218.45	15,179.59	-1,961.14	-0.67%
Irrigated Sorghum	94.49	2,499.77	-2,405.29	-0.83%
Summer Fallow	4,880.39	7,900.74	-3,020.35	-1.04%
Irrigated Corn	46,443.51	60,944.05	-14,500.53	-4.99%
Dryland Sorghum	1,104.15	19,202.38	-18,098.23	-6.23%

Frontier County

Frontier				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	11214.17655	3,651.13	7,563.05	1.21%
Irrigated Corn	38949.20775	35,684.73	3,264.48	0.52%
Irrigated Small Grains	3589.675949	2,271.84	1,317.83	0.21%
Irrigated Alfalfa	4992.726892	3,710.74	1,281.99	0.20%
Dryland Corn	38,150.19	37,400.81	749.38	0.12%
Dryland Soybeans	5,514.91	4,916.61	598.30	0.10%
Irrigated Potatoes	224.0789111	0.80	223.28	0.04%
Irrigated Sunflower	166.30	21.88	144.43	0.02%
Irrigated Sugar Beets	10.43160553	4.42	6.02	0.00%
Dryland Alfalfa	10,779.86	10,847.00	-67.14	-0.01%
Dryland Sunflower	273.83	366.50	-92.67	-0.01%
Irrigated Dry Edible Beans	24.67475923	120.83	-96.15	-0.02%
Dryland Dry Edible Beans	52.16	533.29	-481.13	-0.08%
Irrigated Sorghum	1612.08427	5,956.89	-4,344.80	-0.69%
Summer Fallow	40,031.89	46,388.02	-6,356.13	-1.01%
Dryland Small Grains	55,480.29	63,296.08	-7,815.79	-1.25%
Dryland Sorghum	7,727.81	32,190.56	-24,462.75	-3.90%

Furnas County (partial)

Furnas County				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	9,529.67	5,913.32	3,616.36	3.61%
Irrigated Alfalfa	2,294.95	1,099.53	1,195.42	1.19%
Irrigated Corn	12,608.80	12,073.98	534.82	0.53%
Dryland Soybeans	2,078.90	1,640.97	437.93	0.44%
Dryland Alfalfa	4,152.58	3,800.92	351.67	0.35%
Dryland Corn	10,125.48	9,954.96	170.52	0.17%
Irrigated Small Grains	648.36	547.06	101.31	0.10%
Irrigated Sorghum	34.50	755.89	-721.39	-0.72%
Dryland Small Grains	12,170.67	13,639.52	-1,468.85	-1.46%
Summer Fallow	5,508.89	7,545.26	-2,036.37	-2.03%
Dryland Sorghum	785.18	5,229.04	-4,443.86	-4.43%

Garden County (partial)

Garden				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Alfalfa	9,114.82	5,969.49	3,145.33	0.29%
Dryland Dry Edible Beans	3,552.76	450.97	3,101.80	0.28%
Dryland Sorghum	574.14	10.43	563.71	0.05%
Dryland Corn	8,717.41	8,433.15	284.26	0.03%
Irrigated Sorghum	307.13	30.69	276.44	0.03%
Irrigated Dry Edible Beans	657.39	518.37	139.02	0.01%
Irrigated Small Grains	4,216.78	4,161.41	55.37	0.01%
Irrigated Sunflower	213.65	238.12	-24.47	0.00%
Dryland Sugar Beets	0.00	336.22	-336.22	-0.03%
Dryland Soybeans	121.97	629.11	-507.14	-0.05%
Irrigated Sugar Beets	0.00	631.31	-631.31	-0.06%
Dryland Alfalfa	2,833.59	3,478.34	-644.75	-0.06%
Irrigated Soybeans	578.35	1,334.84	-756.49	-0.07%
Irrigated Corn	13,473.02	14,781.99	-1,308.97	-0.12%
Summer Fallow	44,968.24	47,115.95	-2,147.71	-0.20%
Dryland Small Grains	50,830.41	58,741.37	-7,910.97	-0.72%
Dryland Sunflower	2,631.77	12,448.12	-9,816.34	-0.90%

Gosper County

Gosper				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	27,422.28	7,595.09	19,827.20	6.69%
Dryland Corn	19,640.11	12,641.95	6,998.15	2.36%
Dryland Soybeans	5,016.40	1,221.93	3,794.47	1.28%
Irrigated Alfalfa	3,812.15	2,647.37	1,164.78	0.39%
Irrigated Small Grains	2,294.95	1,599.86	695.09	0.23%
Irrigated Potatoes	160.89	0.20	160.69	0.05%
Dryland Alfalfa	3,640.23	3,602.96	37.27	0.01%
Summer Fallow	9,755.56	12,652.59	-2,897.04	-0.98%
Irrigated Sorghum	213.45	3,968.65	-3,755.20	-1.27%
Dryland Small Grains	17,042.23	21,908.56	-4,866.33	-1.64%
Dryland Sorghum	1,561.13	15,230.92	-13,669.79	-4.61%
Irrigated Corn	44,910.27	59,785.45	-14,875.18	-5.02%

Grant County (partial)

Grant				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Alfalfa	57.78	18.66	39.12	0.05%
Irrigated Sunflower	0.00	0.40	-0.40	0.00%
Dryland Dry Edible Beans	0.00	0.80	-0.80	0.00%
Irrigated Soybeans	0.00	1.00	-1.00	0.00%
Dryland Sorghum	0.00	2.41	-2.41	0.00%
Dryland Sunflower	0.00	18.66	-18.66	-0.02%
Irrigated Corn	0.00	26.68	-26.68	-0.03%
Irrigated Small Grains	0.00	33.50	-33.50	-0.04%
Dryland Soybeans	0.00	35.11	-35.11	-0.04%
Dryland Small Grains	0.00	103.51	-103.51	-0.12%
Dryland Alfalfa	136.21	283.06	-146.84	-0.18%
Summer Fallow	0.00	208.83	-208.83	-0.25%
Dryland Corn	0.80	239.33	-238.52	-0.29%

Hall County

Hall				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	39,197.76	16,627.66	22,570.10	6.39%
Dryland Corn	20,012.03	17,345.61	2,666.43	0.76%
Irrigated Alfalfa	4,955.21	4,014.21	941.00	0.27%
Summer Fallow	795.01	316.72	478.29	0.14%
Irrigated Dry Edible Beans	187.17	0.00	187.17	0.05%
Dryland Soybeans	4,676.37	4,516.99	159.38	0.05%
Irrigated Potatoes	128.99	0.60	128.39	0.04%
Dryland Dry Edible Beans	24.47	0.00	24.47	0.01%
Irrigated Small Grains	615.26	1,395.34	-780.08	-0.22%
Dryland Small Grains	1,597.84	2,895.25	-1,297.41	-0.37%
Irrigated Sorghum	1,138.05	3,036.55	-1,898.50	-0.54%
Dryland Sorghum	779.56	5,458.12	-4,678.56	-1.33%
Dryland Alfalfa	6,987.77	15,126.95	-8,139.18	-2.31%
Irrigated Corn	140,977.33	168,661.49	-27,684.16	-7.84%

Hamilton County

Hamilton				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	68,454.20	28,323.67	40,130.53	11.46%
Irrigated Alfalfa	3,781.46	1,595.25	2,186.21	0.62%
Irrigated Potatoes	97.09	0.00	97.09	0.03%
Summer Fallow	83.85	19.87	63.98	0.02%
Irrigated Sunflower	13.64	0.00	13.64	0.00%
Irrigated Sugar Beets	12.64	0.00	12.64	0.00%
Irrigated Dry Edible Beans	10.23	0.00	10.23	0.00%
Dryland Sunflower	0.20	0.00	0.20	0.00%
Irrigated Sorghum	1,958.94	2,923.15	-964.21	-0.28%
Irrigated Small Grains	890.50	1,974.39	-1,083.89	-0.31%
Dryland Small Grains	1,753.91	3,680.83	-1,926.92	-0.55%
Dryland Alfalfa	2,520.44	4,815.85	-2,295.41	-0.66%
Dryland Sorghum	1,430.53	5,131.37	-3,700.83	-1.06%
Dryland Soybeans	9,299.78	13,077.10	-3,777.32	-1.08%
Dryland Corn	26,634.50	35,732.50	-9,098.00	-2.60%
Irrigated Corn	148,084.46	192,359.38	-44,274.92	-12.65%

Harlan County (partial)

Harlan				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	25,294.44	8,699.16	16,595.28	6.67%
Dryland Soybeans	9,089.94	4,132.12	4,957.82	1.99%
Irrigated Alfalfa	2,932.28	2,069.27	863.01	0.35%
Irrigated Small Grains	858.80	634.12	224.68	0.09%
Dryland Corn	29,421.94	29,314.22	107.73	0.04%
Summer Fallow	12,976.11	12,870.60	105.52	0.04%
Irrigated Potatoes	0.00	1.00	-1.00	0.00%
Irrigated Sorghum	38.52	1,466.44	-1,427.93	-0.57%
Dryland Alfalfa	5,253.32	7,033.31	-1,779.99	-0.72%
Dryland Small Grains	20,978.16	23,463.89	-2,485.73	-1.00%
Irrigated Corn	31,903.66	36,820.36	-4,916.70	-1.98%
Dryland Sorghum	1,283.69	18,931.76	-17,648.07	-7.10%

Hayes County (partial)

Hayes				
Class	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Corn	37,241.44	30,302.28	6939.17	1.58%
Irrigated Alfalfa	4,724.53	1,800.57	2923.95	0.66%
Irrigated Soybeans	2,763.98	1,381.69	1382.29	0.31%
Irrigated Sorghum (Milo, Sudan)	2,891.64	1,696.41	1195.23	0.27%
Irrigated Dry Edible Beans	1,117.96	481.71	636.25	0.14%
Irrigated Sunflower	393.39	121.03	272.36	0.06%
Irrigated Sugar Beets	4.62	1.40	3.21	0.00%
Dryland Alfalfa	5,302.17	5,521.15	-218.98	-0.05%
Dryland Dry Edible Beans	529.68	843.99	-314.31	-0.07%
Dryland Sunflower	510.41	857.84	-347.43	-0.08%
Dryland Sorghum	9,554.83	10,398.01	-843.19	-0.19%
Irrigated Small Grains	1,601.07	3,675.81	-2074.74	-0.47%
Dryland Soybeans	293.24	3,774.16	-3480.92	-0.79%
Dryland Small Grains	43,604.37	47,734.39	-4130.02	-0.94%
Dryland Corn	14,771.89	26,263.58	-11491.68	-2.61%
Summer Fallow	33,740.25	47,606.94	-13866.69	-3.15%

Hitchcock County (partial)

Hitchcock				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Corn	10,292.99	11,124.50	-831.52	-1.31%
Irrigated Sugar Beets	32.90	0.00	32.90	0.05%
Irrigated Soybeans	1,441.77	1,256.61	185.16	0.29%
Irrigated Sorghum (Milo, Sudan)	1,248.18	626.10	622.08	0.98%
Irrigated Dry Edible Beans	67.00	128.19	-61.19	-0.10%
Irrigated Alfalfa	1,175.56	853.39	322.18	0.51%
Irrigated Small Grains	1,051.99	1,137.05	-85.06	-0.13%
Irrigated Sunflower	69.21	34.91	34.30	0.05%
Summer Fallow	6,673.42	8,175.37	-1,501.95	-2.37%
Dryland Corn	2,486.53	4,589.71	-2,103.17	-3.32%
Dryland Soybeans	151.86	871.04	-719.18	-1.13%
Dryland Sorghum (Milo, Sudan)	2,049.01	1,587.41	461.60	0.73%
Dryland Dry Edible Beans	103.51	230.30	-126.78	-0.20%
Dryland Alfalfa	1,258.41	956.50	301.91	0.48%
Dryland Small Grains	10,154.57	9,167.17	987.39	1.56%
Dryland Sunflower	11.03	145.04	-134.01	-0.21%

Howard County (partial)

Howard				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Corn	23,591.88	22,662.06	929.82	0.84%
Irrigated Soybeans	3,966.82	6,559.07	-2,592.25	-2.34%
Irrigated Sorghum (Milo, Sudan)	1,174.36	206.02	968.33	0.87%
Irrigated Alfalfa	4,550.39	3,754.58	795.81	0.72%
Irrigated Small Grains	45.74	54.77	-9.03	-0.01%
Summer Fallow	908.75	0.40	908.35	0.82%
Dryland Corn	4,837.06	4,717.49	119.56	0.11%
Dryland Soybeans	773.54	3,040.01	-2,266.47	-2.04%
Dryland Sorghum (Milo, Sudan)	705.34	368.72	336.62	0.30%
Dryland Alfalfa	1,957.33	4,935.15	-2,977.82	-2.69%
Dryland Small Grains	109.13	164.50	-55.37	-0.05%

Kearney County

Kearney				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	68,208.26	20,159.17	48,049.09	14.49%
Dryland Corn	36,602.90	25,584.17	11,018.73	3.32%
Dryland Soybeans	15,200.86	5,774.64	9,426.21	2.84%
Irrigated Potatoes	1,610.28	600.33	1,009.95	0.30%
Irrigated Alfalfa	4,379.27	4,084.46	294.81	0.09%
Irrigated Small Grains	846.97	1,630.57	-783.61	-0.24%
Summer Fallow	4,087.18	6,136.12	-2,048.94	-0.62%
Dryland Alfalfa	4,455.50	7,189.45	-2,733.95	-0.82%
Dryland Small Grains	6,769.51	10,471.07	-3,701.56	-1.12%
Irrigated Sorghum	92.48	3,827.35	-3,734.87	-1.13%
Dryland Sorghum	505.73	12,386.05	-11,880.32	-3.58%
Irrigated Corn	120,651.95	166,870.35	-46,218.40	-13.93%

Keith County

Keith				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Dryland Corn	29,054.43	22,718.43	6,336.00	0.89%
Irrigated Soybeans	6,812.64	2,656.20	4,156.44	0.59%
Irrigated Corn	64,517.07	60,892.17	3,624.90	0.51%
Irrigated Alfalfa	8,896.96	7,829.32	1,067.64	0.15%
Irrigated Sugar Beets	1,218.09	1,014.79	203.30	0.03%
Irrigated Sunflower	1,282.89	1,461.77	-178.89	-0.03%
Dryland Dry Edible Beans	1,386.40	1,820.65	-434.24	-0.06%
Irrigated Sorghum	1,145.27	2,071.53	-926.26	-0.13%
Dryland Sunflower	2,460.25	3,511.03	-1,050.78	-0.15%
Dryland Soybeans	1,474.67	2,788.47	-1,313.80	-0.19%
Dryland Sorghum	2,312.81	4,089.08	-1,776.27	-0.25%
Irrigated Small Grains	6,079.42	8,689.56	-2,610.14	-0.37%
Irrigated Dry Edible Beans	1,327.02	4,641.03	-3,314.01	-0.47%
Dryland Alfalfa	3,312.84	7,215.95	-3,903.11	-0.55%
Dryland Small Grains	44,599.13	56,703.14	-12,104.01	-1.71%
Summer Fallow	36,817.35	50,912.64	-14,095.29	-1.99%

Kimball County

Kimbal				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Corn	11,175.86	5,822.41	5,353.45	0.88%
Dryland Small Grains	148,595.21	144,552.94	4,042.27	0.66%
Irrigated Alfalfa	5,918.93	4,753.23	1,165.71	0.19%
Irrigated Dry Edible Beans	2,006.28	983.88	1,022.40	0.17%
Dryland Sunflower	3,304.01	2,692.93	611.08	0.10%
Dryland Sorghum	227.69	2.01	225.68	0.04%
Irrigated Sorghum	11.23	8.03	3.21	0.00%
Irrigated Potatoes	1.20	0.00	1.20	0.00%
Irrigated Sunflower	424.69	574.03	-149.35	-0.02%
Dryland Dry Edible Beans	623.09	959.80	-336.71	-0.06%
Irrigated Sugar Beets	1,341.06	1,840.52	-499.45	-0.08%
Dryland Corn	2,534.08	3,933.32	-1,399.25	-0.23%
Dryland Soybeans	0.00	1,515.36	-1,515.36	-0.25%
Irrigated Soybeans	2.01	1,706.04	-1,704.03	-0.28%
Irrigated Small Grains	6,201.19	8,377.86	-2,176.67	-0.36%
Dryland Alfalfa	911.76	3,526.28	-2,614.52	-0.43%
Summer Fallow	97,946.96	126,460.29	-28,513.33	-4.68%

Lincoln County

Lincoln				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	23,755.17	10,295.25	13,459.93	0.82%
Irrigated Alfalfa	23,882.76	17,648.48	6,234.28	0.38%
Dryland Sunflower	1,048.58	481.30	567.27	0.03%
Irrigated Small Grains	4,788.11	4,347.59	440.52	0.03%
Irrigated Sunflower	637.93	344.02	293.91	0.02%
Irrigated Sugar Beets	28.29	17.86	10.42	0.00%
Irrigated Dry Edible Beans	535.82	1,311.64	-775.82	-0.05%
Irrigated Sorghum	3,349.35	5,501.48	-2,152.13	-0.13%
Dryland Dry Edible Beans	210.84	3,724.59	-3,513.75	-0.21%
Dryland Sorghum	8,296.14	12,522.33	-4,226.20	-0.26%
Dryland Soybeans	5,810.60	11,263.27	-5,452.67	-0.33%
Summer Fallow	22,050.21	28,793.13	-6,742.93	-0.41%
Irrigated Corn	148,258.79	155,852.95	-7,594.15	-0.46%
Dryland Alfalfa	31,760.83	40,256.92	-8,496.09	-0.52%
Dryland Small Grains	26,517.34	35,466.56	-8,949.22	-0.54%
Dryland Corn	40,865.61	63,448.42	-22,582.80	-1.37%

Logan County (partial)

Logan				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Corn	10,654.48	11,375.26	-720.78	-0.73%
Irrigated Sugar Beets	0.40	5.02	-4.62	0.00%
Irrigated Soybeans	1,642.78	785.38	857.40	0.87%
Irrigated Sorghum (Milo, Suda	353.67	66.40	287.27	0.29%
Irrigated Dry Edible Beans	1.60	180.55	-178.94	-0.18%
Irrigated Alfalfa	1,616.70	1,049.98	566.72	0.57%
Irrigated Small Grains	144.84	31.50	113.34	0.11%
Irrigated Sunflower	4.21	16.05	-11.84	-0.01%
Summer Fallow	2,657.65	2,778.02	-120.36	-0.12%
Dryland Corn	7,371.33	10,101.20	-2,729.87	-2.77%
Dryland Soybeans	3,037.60	2,081.11	956.50	0.97%
Dryland Sorghum	420.07	38.32	381.76	0.39%
Dryland Dry Edible Beans	28.69	818.28	-789.59	-0.80%
Dryland Alfalfa	1,788.62	3,570.42	-1,781.80	-1.81%
Dryland Small Grains	1,686.91	2,799.28	-1,112.37	-1.13%
Dryland Sunflower	123.78	74.43	49.35	0.05%

Merrick County

Merrick				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	42,029.74	27,094.52	14,935.22	4.80%
Irrigated Alfalfa	6,249.94	2,777.63	3,472.30	1.11%
Irrigated Sorghum	2,447.42	238.24	2,209.17	0.71%
Summer Fallow	637.93	1.40	636.53	0.20%
Irrigated Small Grains	679.46	112.00	567.46	0.18%
Dryland Sorghum	773.94	274.17	499.77	0.16%
Dryland Small Grains	448.56	187.06	261.50	0.08%
Dryland Corn	16,037.59	16,850.85	-813.26	-0.26%
Dryland Soybeans	5,393.14	9,107.04	-3,713.90	-1.19%
Dryland Alfalfa	2,095.35	6,688.28	-4,592.93	-1.47%
Irrigated Corn	104,055.47	129,478.98	-25,423.51	-8.16%

McPherson County (partial)

McPherson				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Corn	3,181.44	4,881.19	-1,699.75	-0.56%
Irrigated Sugar Beets		21.87	-21.87	-0.01%
Irrigated Soybeans	104.92	228.09	-123.17	-0.04%
Irrigated Sorghum (Milo, Sudan)	419.47	0.00	419.47	0.14%
Irrigated Dry Edible Beans	0.20	44.74	-44.53	-0.01%
Irrigated Alfalfa	2,124.24	1,569.15	555.08	0.18%
Irrigated Small Grains	141.03	213.05	-72.02	-0.02%
Irrigated Sunflower	0.40	33.10	-32.70	-0.01%
Summer Fallow	451.97	368.12	83.85	0.03%
Dryland Corn	177.14	1,946.30	-1,769.16	-0.58%
Dryland Soybeans	58.98	322.18	-263.20	-0.09%
Dryland Sorghum (Milo, Sudan)	40.32	0.40	39.92	0.01%
Dryland Dry Edible Beans	9.43	3.61	5.82	0.00%
Dryland Alfalfa	134.01	962.92	-828.91	-0.27%
Dryland Small Grains	28.69	708.15	-679.46	-0.22%
Dryland Sunflower	4.21	139.82	-135.61	-0.04%

Morrill County

Morrill				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Corn	57,286.77	46,911.88	10,374.89	1.13%
Irrigated Alfalfa	23,759.19	16,396.04	7,363.14	0.81%
Dryland Dry Edible Beans	4,847.09	1,008.37	3,838.72	0.42%
Dryland Corn	9,619.34	5,990.41	3,628.94	0.40%
Dryland Alfalfa	5,021.01	3,849.23	1,171.79	0.13%
Irrigated Sunflower	2,773.80	1,614.31	1,159.49	0.13%
Irrigated Dry Edible Beans	13,283.25	12,151.22	1,132.03	0.12%
Dryland Sorghum	1,049.58	3.81	1,045.77	0.11%
Dryland Sunflower	1,993.84	1,500.91	492.93	0.05%
Irrigated Sorghum	400.41	24.69	375.73	0.04%
Dryland Soybeans	78.24	1,549.69	-1,471.45	-0.16%
Irrigated Sugar Beets	461.00	4,758.04	-4,297.05	-0.47%
Irrigated Small Grains	7,919.80	12,770.41	-4,850.61	-0.53%
Irrigated Soybeans	258.78	11,904.74	-11,645.96	-1.27%
Summer Fallow	18,530.14	32,207.02	-13,676.88	-1.50%
Dryland Small Grains	26,835.91	48,118.55	-21,282.64	-2.33%

Nance County (partial)

Nance				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Corn	11,282.18	12,563.87	-1,281.68	-1.83%
Irrigated Sugar Beets	1.20	0.00	1.20	0.00%
Irrigated Soybeans	5,084.00	4,150.78	933.23	1.33%
Irrigated Sorghum (Milo, Suda	205.22	0.00	205.22	0.29%
Irrigated Potatoes	0.80	0.00	0.80	0.00%
Irrigated Alfalfa	1,381.59	379.55	1,002.04	1.43%
Irrigated Small Grains	60.58	0.60	59.98	0.09%
Summer Fallow	147.25	0.00	147.25	0.21%
Dryland Corn	7,644.96	8,401.25	-756.29	-1.08%
Dryland Soybeans	3,139.91	6,729.19	-3,589.27	-5.12%
Dryland Sorghum	262.80	0.00	262.80	0.38%
Dryland Alfalfa	1,071.05	2,306.39	-1,235.34	-1.76%
Dryland Small Grains	504.73	2.81	501.92	0.72%

Nuckolls County (partial)

Nuckolls				
Class	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	17,501.36	10,002.41	7,498.95	2.01%
Dryland Soybeans	27,123.62	23,294.27	3,829.36	1.02%
Dryland Corn	36,623.85	33,862.88	2,760.97	0.74%
Irrigated Alfalfa	1,721.90	291.43	1,430.46	0.38%
Summer Fallow	2,799.31	1,907.35	891.96	0.24%
Irrigated Corn	26,489.58	25,901.50	588.08	0.16%
Irrigated Sorghum (Milo, Sudan)	1,874.03	1,547.28	326.76	0.09%
Dryland Alfalfa	8,386.09	8,067.76	318.33	0.09%
Irrigated Small Grains	584.47	886.14	-301.67	-0.08%
Dryland Sorghum	40,066.64	47,734.99	-7,668.35	-2.05%
Dryland Small Grains	27,578.23	66,800.69	-39,222.45	-10.49%

Perkins County

Perkins				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Dryland Corn	57,697.81	34,766.68	22,931.13	4.05%
Irrigated Soybeans	11,296.43	3,536.92	7,759.50	1.37%
Dryland Alfalfa	4,945.18	2,895.45	2,049.73	0.36%
Dryland Sunflower	5,396.95	3,635.27	1,761.68	0.31%
Irrigated Alfalfa	5,075.98	3,401.64	1,674.34	0.30%
Irrigated Corn	98,331.12	97,668.36	662.76	0.12%
Irrigated Sunflower	1,073.65	907.41	166.24	0.03%
Irrigated Sugar Beets	775.35	996.93	-221.58	-0.04%
Dryland Soybeans	2,574.20	4,501.13	-1,926.94	-0.34%
Irrigated Sorghum	2,132.46	4,281.76	-2,149.30	-0.38%
Dryland Dry Edible Beans	1,299.54	3,825.14	-2,525.60	-0.45%
Irrigated Dry Edible Beans	1,672.87	5,319.63	-3,646.76	-0.64%
Irrigated Small Grains	7,311.35	13,401.84	-6,090.49	-1.08%
Dryland Sorghum	5,809.80	11,999.88	-6,190.08	-1.09%
Dryland Small Grains	109,101.55	119,794.89	-10,693.34	-1.89%
Summer Fallow	89,643.40	117,698.27	-28,054.87	-4.96%

Phelps County

Phelps				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	103,497.98	15,245.37	88,252.61	25.51%
Dryland Soybeans	13,776.34	3,467.88	10,308.46	2.98%
Dryland Corn	19,372.09	17,610.74	1,761.35	0.51%
Summer Fallow	3,075.52	1,916.59	1,158.93	0.33%
Irrigated Potatoes	187.37	670.77	-483.41	-0.14%
Irrigated Small Grains	628.30	1,216.51	-588.20	-0.17%
Irrigated Alfalfa	5,599.16	7,000.38	-1,401.22	-0.40%
Dryland Small Grains	2,790.45	4,756.84	-1,966.39	-0.57%
Dryland Alfalfa	4,324.10	8,170.73	-3,846.62	-1.11%
Irrigated Sorghum	49.15	4,516.59	-4,467.44	-1.29%
Dryland Sorghum	290.48	8,689.96	-8,399.48	-2.43%
Irrigated Corn	117,346.94	202,458.34	-85,111.40	-24.60%

Platte County (partial)

Platte				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Corn	14,522.20	16,064.07	-1,541.87	-2.76%
Irrigated Soybeans	3,645.85	3,834.22	-188.37	-0.34%
Irrigated Sorghum (Milo, Suda	227.89	0.00	227.89	0.41%
Irrigated Alfalfa	1,595.43	381.15	1,214.28	2.18%
Irrigated Small Grains	115.95	0.40	115.55	0.21%
Summer Fallow	290.68	0.00	290.68	0.52%
Dryland Corn	1,863.04	2,885.14	-1,022.10	-1.83%
Dryland Soybeans	336.62	1,794.64	-1,458.02	-2.61%
Dryland Sorghum	40.92	0.00	40.92	0.07%
Dryland Alfalfa	352.87	694.50	-341.64	-0.61%
Dryland Small Grains	132.00	0.00	132.00	0.24%

Polk County

Polk				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	48,081.88	32,190.16	15,891.72	5.64%
Irrigated Alfalfa	3,971.03	848.20	3,122.83	1.11%
Dryland Small Grains	435.72	67.64	368.08	0.13%
Irrigated Small Grains	166.10	9.03	157.07	0.06%
Dryland Corn	46,434.89	46,912.48	-477.59	-0.17%
Dryland Alfalfa	3,264.49	4,751.62	-1,487.13	-0.53%
Dryland Soybeans	22,063.65	30,769.33	-8,705.68	-3.09%
Irrigated Corn	84,485.97	95,220.10	-10,734.12	-3.81%

Red Willow County (partial)

Red Willow				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Corn	18,546.19	20,476.44	-1,930.25	-1.11%
Irrigated Sugar Beets	4.81	0.00	4.81	0.00%
Irrigated Soybeans	5,286.02	3,545.54	1,740.47	1.00%
Irrigated Sorghum (Milo, Suda	635.32	1,501.75	-866.43	-0.50%
Irrigated Dry Edible Beans	14.24	28.49	-14.24	-0.01%
Irrigated Potatoes	30.29	0.40	29.89	0.02%
Irrigated Alfalfa	3,290.57	2,263.86	1,026.71	0.59%
Irrigated Small Grains	2,352.73	1,226.32	1,126.41	0.65%
Irrigated Sunflower	8.22	4.21	4.01	0.00%
Summer Fallow	18,273.16	16,485.15	1,788.02	1.03%
Dryland Corn	14,844.38	16,217.94	-1,373.56	-0.79%
Dryland Soybeans	1,216.29	2,053.02	-836.74	-0.48%
Dryland Sorghum	1,706.17	8,051.59	-6,345.43	-3.64%
Dryland Dry Edible Beans	30.89	52.76	-21.87	-0.01%
Dryland Alfalfa	3,177.03	5,454.73	-2,277.70	-1.31%
Dryland Small Grains	27,401.82	25,939.19	1,462.63	0.84%
Dryland Sunflower	4.01	54.36	-50.35	-0.03%

Scotts Bluff County

Scottsbluff				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Corn	78,598.34	66,458.88	12,139.46	2.55%
Irrigated Dry Edible Beans	38,955.23	32,151.82	6,803.40	1.43%
Irrigated Small Grains	12,928.37	9,801.50	3,126.87	0.66%
Dryland Dry Edible Beans	5,125.73	2,022.76	3,102.97	0.65%
Dryland Corn	7,607.25	5,605.64	2,001.60	0.42%
Irrigated Alfalfa	27,340.03	26,641.11	698.92	0.15%
Irrigated Potatoes	70.61	0.20	70.41	0.01%
Dryland Sunflower	34.71	348.83	-314.13	-0.07%
Dryland Sorghum	11.84	1,111.74	-1,099.90	-0.23%
Dryland Small Grains	14,648.98	16,253.14	-1,604.16	-0.34%
Irrigated Sunflower	290.28	2,192.96	-1,902.68	-0.40%
Dryland Alfalfa	3,677.54	7,725.95	-4,048.41	-0.85%
Summer Fallow	7,934.04	12,050.06	-4,116.02	-0.86%
Irrigated Sugar Beets	7,757.30	17,138.47	-9,381.17	-1.97%
Irrigated Sorghum	66.40	11,255.45	-11,189.04	-2.35%

Sheridan County (partial)

Sheridan				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Corn	411.45	333.81	77.64	0.03%
Irrigated Sugar Beets	0.40	17.05	-16.65	-0.01%
Irrigated Soybeans	0.00	9.63	-9.63	0.00%
Irrigated Sorghum (Milo, Sudan)	2.01	0.00	2.01	0.00%
Irrigated Dry Edible Beans	118.56	53.16	65.40	0.03%
Irrigated Alfalfa	1,708.38	848.97	859.40	0.33%
Irrigated Small Grains	235.71	464.41	-228.69	-0.09%
Irrigated Sunflower	1.40	47.34	-45.94	-0.02%
Summer Fallow	93.88	1,448.39	-1,354.50	-0.52%
Dryland Corn	75.43	186.97	-111.54	-0.04%
Dryland Soybeans	0.00	146.84	-146.84	-0.06%
Dryland Sorghum (Milo, Sudan)	2.01	0.00	2.01	0.00%
Dryland Dry Edible Beans	25.28	3.41	21.87	0.01%
Dryland Alfalfa	427.29	677.05	-249.76	-0.10%
Dryland Small Grains	129.39	1,533.85	-1,404.46	-0.54%
Dryland Sunflower	1.00	5.42	-4.41	0.00%

Sioux County (partial)

Sioux				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Corn	13,493.28	12,025.84	1,467.45	0.29%
Irrigated Sugar Beets	1,329.23	1,694.94	-365.71	-0.07%
Irrigated Soybeans	0.00	1,211.27	-1,211.27	-0.24%
Irrigated Sorghum (Milo, Sudan)	6.62	0.00	6.62	0.00%
Irrigated Dry Edible Beans	3,116.24	3,492.58	-376.34	-0.07%
Irrigated Potatoes	0.40	0.60	-0.20	0.00%
Irrigated Alfalfa	8,104.35	6,930.00	1,174.36	0.23%
Irrigated Small Grains	2,387.43	3,003.70	-616.27	-0.12%
Irrigated Sunflower	117.76	461.60	-343.84	-0.07%
Summer Fallow	945.67	3,865.31	-2,919.65	-0.58%
Dryland Corn	1,471.66	728.61	743.05	0.15%
Dryland Soybeans	0.00	140.22	-140.22	-0.03%
Dryland Sorghum (Milo, Sudan)	10.43	0.00	10.43	0.00%
Dryland Dry Edible Beans	365.51	267.01	98.50	0.02%
Dryland Alfalfa	957.90	1,055.00	-97.09	-0.02%
Dryland Small Grains	877.46	3,014.13	-2,136.67	-0.42%
Dryland Sunflower	27.08	27.08	0.00	0.00%

Webster County (partial)

Webster				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Corn	24,659.71	28,729.64	-4,069.93	-1.37%
Irrigated Soybeans	15,042.78	7,099.91	7,942.87	2.68%
Irrigated Sorghum (Milo, Suda	1,347.88	826.91	520.98	0.18%
Irrigated Potatoes	375.34	0.40	374.94	0.13%
Irrigated Alfalfa	2,886.55	1,470.25	1,416.29	0.48%
Irrigated Small Grains	978.77	1,193.82	-215.05	-0.07%
Summer Fallow	6,719.56	9,889.76	-3,170.21	-1.07%
Dryland Corn	31,192.51	26,511.12	4,681.38	1.58%
Dryland Soybeans	10,818.98	9,345.31	1,473.66	0.50%
Dryland Sorghum	14,500.13	21,855.62	-7,355.49	-2.48%
Dryland Alfalfa	6,592.77	9,290.75	-2,697.97	-0.91%
Dryland Small Grains	21,433.54	41,325.01	-19,891.47	-6.71%

York County

York				
CLASS	2001 Acres	1997 Acres	Acres Change	% of County Change
Irrigated Soybeans	69,113.60	35,800.34	33,348.66	9.05%
Dryland Alfalfa	9,136.28	4,428.48	4,712.48	1.28%
Irrigated Alfalfa	5,001.95	893.76	4,110.75	1.12%
Irrigated Sorghum	4,394.31	2,599.20	1,797.36	0.49%
Summer Fallow	280.85	3.61	277.38	0.08%
Irrigated Small Grains	568.72	688.44	-119.42	-0.03%
Dryland Soybeans	22,030.75	22,425.39	-383.36	-0.10%
Dryland Small Grains	1,109.96	3,937.94	-2,827.41	-0.77%
Dryland Sorghum	2,266.47	6,129.90	-3,862.27	-1.05%
Dryland Corn	42,847.42	52,586.57	-9,717.20	-2.64%
Irrigated Corn	154,340.02	179,870.17	-25,451.10	-6.91%