MODELING POST-CRP LAND USE

FOR OPTIMUM ENVIRONMENTAL BENEFITS

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INTRODUCTION AND LITERATURE REVIEW

The Conservation Reserve Program

In Title XII of the Food Security Act of 1985, the US Congress established the Conservation Reserve Program (CRP). The CRP is a voluntary, long-term cropland retirement program administered by the United States Department of Agriculture (USDA) in conjunction with the Natural Resources Conservation Service (NRCS), the Farm Service Agency (FSA), and the Commodity Credit Corporation (CCC) (Ohlenbusch and Watson 1995, Zinn 1994, Johnson 2005).

The CRP is designed to improve the nation's natural resource base by reducing soil erosion, improving water quality, reducing surplus production of farm produce, improving fish and wildlife habitats, and reducing sedimentation in fields and waterways (Feather et al. 1999). The CRP generates a number of benefits including improved water quality, air quality, wildlife habitat, and soil productivity (Ribaudo 1989, Johnson 2005).

Under the CRP, landowners and the USDA enter into a contract to enroll severely eroding or other environmentally sensitive land for approximately 10 to 15 years. During the CRP period, the land is planted with either trees or grass (Ribaudo 1989, Ohlenbusch and Watson 1995). Landowners receive annual payments as rentals for their land and payments for up to 50% of the cost for establishing conservation practices. The initial goal of the CRP was to remove 40 to 45 million acres of highly erodible cropland from production by 1990 (Ribaudo 1989). The 2002 Farm Bill authorized the USDA to maintain a CRP enrollment of 39.2 million acres. In 2002, 34 million were enrolled in the CRP contracts, 1.5 million of these contracts expired by September 30 2003 (FSA 2003). Currently there are about 216,088 acres enrolled into the CRP in Texas County, Oklahoma. These contracts are scheduled to expire on 30 September 2007 (111,900.5 acres), 2008 (35,036.4 acres), 2009 (68,652.7 acres), and 2013 (498.9 acres) (USDA-FSA 2006).

"Highly erodible" land erodes at a rate three times the soil loss tolerance level (T) or has an erodibility index (EI) higher than eight (Bennett and Vitale 2001, Ribaudo 1989). Cropland bordering lakes, streams, rivers, and estuaries is also eligible for enrollment even when the erosion rate is low (Ribaudo 1989). In recent sign-ups, eligibility was determined by using an Environmental Benefit Index (EBI). The EBI, based on 600 theoretical points, uses six environmental factors and a 200-point cost factor. The EBI considers wildlife habitat benefits, water quality benefits, and on-farm benefits from reduced wind and water erosion at 100 points each. Long-term benefits of certain practices that go beyond the contract period (establishing trees or rare and declining habitat) are awarded 50 points. Air quality benefits from reduced wind erosion and benefits in conservation priority areas are considered at 25 points each. Government cost of the contract is awarded 200 points (USDA-FSA. 2003a, USDA-FSA 2004). The focal point of EBI keeps changing at every sign-up (USDA-FSA 2003b, Ribaudo et al. 2001). Other qualifying criteria for the CRP enrollment include eligibility and suitability for use in conservation practices as riparian buffers, wildlife buffers, wetland buffers, filter strips, grass waterways, shelterbelts, living snow fences, contour grass strips, salt tolerant vegetation, and shallow water areas for wildlife (Hatchfield et al. 2003).

At the end of the contract period, the CRP land is returned to production under certain conditions (Johnson and Zidack 1997, Ohlenbusch and Watson 1995) that ensure continued CRP objectives. Conditions under which land can be returned to production are set out in the contract. The landowner has a choice on the use of the CRP tracts at the end of the contract. The choices include using the land for haying, grazing, crops with no tillage, crops with minimum tillage, and crops with tillage. The use of land contrary to FSA guidelines results in loss of benefits (Johnson and Zidack 1997, Ohlenbusch and Watson 1995). These benefits include market transition payments, federally subsidized crop insurance and tax advantages (e.g., counties in Indiana reduce land taxes) (Ohlenbusch and Watson 1995). The benefits are provided for officially classified conservation practices like wildlife, forest, or wetlands management, and the establishment of riparian filter strips, and windbreaks. With cost share practices, support payments are up to 75% of the cost of the conservation practices while practices like wetland restoration get 100% payment support. The payments come from the Environmental Quality Incentives Program (EQIP) which began in 1997 and was reauthorized in the Farm Security and Rural Investment Act (Farm Bill) of 2002 (USDA 1996, Johnson 1997).

Statement of Problem

Various land use practices applied to post-CRP land will have different effects on soil loss and, therefore, on the water quality of streams and rivers draining the affected land. The choices made will also have different impacts on wildlife habitats. The magnitude of the impact will depend on several factors including land use or land cover, land management practices, soil type, slope and hydrology (Tjaden and Waber 1998). Hence, it is important to determine how different land management practices of post-CRP will affect the environmental benefits gained from the CRP.

The USDA assumes that all CRP tracts can be returned to production while maintaining high water quality management and other CRP goals. The other assumption is that, in addition to high water quality standards, other environmental benefits can be maintained side by side with normal agricultural practices. How we determine the specific type of land management that supports those goals on any given tract, however, remains to be answered. The question is important because not all management practices will ensure high water quality and wildlife benefits considering the multitude of factors that influence the rate of erosion from an area and the area's vegetation dynamics. Therefore, we need to look at the CRP benefits in new ways and to assess success of the CRP in a field where EBI changes over time as goals of the CRP change (Ribaudo et al. 2001). Studies have been carried out on methods of handling post-CRP lands (e.g., Ohlenbusch and Watson 1995, Stiegler et al. 1995, Rickerl et al. 1999), and the best ways that the CRP can be carried out to maximize goals at minimum cost (e.g., Khanna et al. 2001) including methods of estimating success of the CRP (Egbert et al. 2002).

Post-CRP Land Options

A Geographic Information System (GIS) analysis is a useful tool for arriving at land use decisions following expiration of the CRP contracts. A GIS makes use of maps or themes of CRP tracts that may include wetlands, surficial aquifer, lakes, rivers, and other landscape features in a watershed that are overlaid and integrated with attribute data on the percentage of highly erodible land, soil type, vegetation, and land capability class maps and other criteria that has been developed. Selection of tracts suitable for various management goals, including protection of surface and groundwater resources, wildlife enhancement, and row-crop or grassland agriculture is possible. This allows selection of CRP tracts to meet different management goals (Rickerl et al. 1999).

A GIS can also be used to model cost-effective targeting of land retirement to improve water quality in an integrated framework that combines spatial and biophysical attributes of land with hydrologic and economic models to identify cropland at risk by determining sediment deposition coefficients, which will depend on land use patterns. Studies have shown that highly sloping land adjacent to water bodies is important for retirement. In one study, 20% sediment abatement was achieved at 39% lower cost than with productivity-based rental scheme (Khanna et al. 2003).

Land use options of post-CRP tracts include cropping with conservation compliance, cropping without conservation compliance, leaving tracts in permanent cover and harvest for hay, leave in permanent cover and graze livestock, leave in permanent cover for wildlife habitat, rent for crop production, grazing, haying, or land sale, among others. In deciding among different management goals, a conceptual framework to determine CRP land use after contract expiration is desirable to maintain CRP benefits (Ohlenbusch and Watson 1995). A conceptual framework should consider conservation compliance provisions for land returned to crop production. For instance, to be eligible for USDA programs, growing crops on highly erodible land is not allowed except where soil erosion prevention measures are put in place including the purchase of Catastrophic Crop Insurance by land owners with CRP contracts (Ohlenbusch and Watson 1995).

Ohlenbusch and Watson (1995) suggest a planning process for post-CRP land that questions land suitability for crop production, erosion abatement when land is cropped, productivity of the land for the intended use, availability of capital and labor. It is important for land owners to have a business program and know the level of investment required, debt to be incurred, the expected annual cash outflow, and expected annual and monthly cash inflow. To answer the questions, landowners need information on past cropping performance, costs and returns, trends in government farm programs, the cost investment, including future costs of production and expected returns. Historical profitability is a key consideration when evaluating CRP options because where overall gains have been negligible or negative, the land is only for possible government payments rather than returning it to cropping (Ohlenbusch and Watson 1995).

Even highly erodible CRP land can be returned to cropland and remain in compliance if proper land management schemes are put in place. For instance during crop production, sweep tillage or controlled burning is a good method of removing grass growth before planting a crop (Stiegler 1997). Good crop fields that result in high yields are possible with the use of disk tillage coupled with high application of fertilizer, but this is at the expense of both wind and water erosion and compromised water quality. In terms of conservation, a minimum till system like sweep tillage can be considered effective while no-till system provides the best solution for soil erosion control (Stiegler et al. 1997).

Measuring CRP Success

Environmental indicators can be employed to target public programs to provide a variety of benefits as suggested by experts (social and physical scientists) and politicians entrusted with the development of indicators that take into account perspectives of concerned citizens (Ribaudo et al. 2001). The environmental benefits index (EBI) reflects compromises between science and policy considerations. The index has been revised to suit the latest goals of the CRP influenced by better information on various components of the environment. The EBI has been adjusted before every sign-up since the introduction of the idea in 1991 (Ribaudo et al. 2001). In deciding on feasible environmental benefits, economic benefits should be considered as well. For instance, targeting soil erosion control for improved water quality should take into account potential economic benefits (e.g., reduced water treatment). It is also important to note that benefits that may be realized from one acre may be higher or lower than damage that may arise from that same acre (e.g., loss of water quality due to erosion from an acre) (Ribaudo 1989).

The CRP can have a positive effect on the environment at different levels. In a recent study in Texas County, Oklahoma, impacts of the CRP on soil loss and water quality were evaluated to determine relative yields of sediments, nitrogen, and phosphorus, in the Beaver River watershed. Results indicated that the CRP reduced soil erosion by an overall 30%, and dry land wheat accounted for 9.25 tons/ha/year accounting for 75% of the entire sediment yield. Furthermore, land under the CRP showed reduced wind and water erosion and a potential general improvement in quality of wildlife habitat by increased mean size of patches and reduced number of patches (Awawdeh 2004). Other authors (Feather et al. 1999, Ribaudo 1989) have noted improvements in water quality.

Studies on the use of post-CRP lands have been carried out including the effect of grazing and haying and these studies have shown that water quality standards meet Environmental Protection Agency (EPA) standards and these practices are compatible with water quality standards considering their effect on soil erosion (Boyles et al. 2001, Gilley et al. 1996). Studies done on post-CRP land involve factors used in deciding use of post-CRP land among enrollees (Johnson and Zidack 1997). Other studies have centered on the economics of post-CRP land management under various options (Boyles et al. 2001). Gilley (1996) showed that conservation tillage systems are the most suitable for former CRP tracts returned to cropland, an observation also made by Stiegler et al. (1997). In addition to water quality, some literature suggests that the CRP has benefited native birds through habitat restoration (Burger et al. 1989, Frawley 1989, Johnson and Igl 1995) and success has also been reported for non-game wildlife as well (Feather et al. 1999, Kantrud 1993, King and Savidge 1995).

Assessment Tools

A geographical information system (GIS) is a useful technology in assessing spatial problems. A GIS is computer based and capable of various data manipulations that include capturing, storing, querying, analyzing, and displaying data (Chang 2004). These tools include several GIS software like Leica Geosystems' ERDAS IMAGINE 8.7 (primarily used for image processing), Esri's ArcView, and ArcGIS with their extensions like Patch Analyst and ArcView Soil Water Analysis Tool (AVSWAT). Success of the CRP can be measured by comparing sediment and chemical yields before and after CRP practice by using the Soil and Water Assessment Tool (SWAT) developed by the USDA-ARS (Di Luzio et al. 2001). The tool is intended for predicting the effect of alternative agricultural practices on water, sediment and agricultural chemical yields in river basins (Zhou et al. 1995, Dutta 2003). The main components to run the model are topology, hydrology, soils, land use, farm cropping history, weather, soil temperature, and agricultural management (Di Luzio et al. 2002, Dutta 2003, Zhou et al. 1995).

Concerns about the impacts of farming on water quality can be addressed by developing methods and data for evaluating environmental consequences of alternative land management practices at the watershed scale (Heidenreich et al. 1996). When the main requirement for land use management is soil loss, the Universal Soil Loss Equation (USLE) developed by Wischmeier and Smith (1978) is a simple and efficient model, which can be applied to calculate soil loss in different management practices for different soil types (Mongkolsawat et al. 1994). Others are the Revised Universal Soil Loss Equation (RUSLE) which has been modified to permit more flexibility in estimating soil loss (Rao and Kumar 2004, Engel 2003, USDA 2003) and Modified USLE (MUSLE) by Williams and Berndt (1977). These models can be used together with a GIS to produce data for use in an optimization model and are capable of calculating soil loss at a regional level (Blaszczynski 2003, Yang et al. 2003). Soil loss values obtained can be used to determine suitable crops or farming practices that are suitable for the soil type found in the area. Remotely sensed data (e.g., satellite images) are also useful and can provide data to detect changes taking place in a landscape (Weirs et al. 2004).

Land use decisions can also be based on studies using optimization models with data derived from a GIS. Such results would provide support for any decisions made (Wang et al. 2002). The interest of a farmer lies in the profit that he or she will realize from farming. Hence, any consideration of sustainability of environmental benefits on post-CRP land should take into account how much it will cost the farmer to practice environmentally friendly farming practices. Use of optimum models in land use for enhancing environmental benefits is possible using linear programming and GIS tools (Guerra and Lewis 2002). One of the optimizing methods used is the Microsoft Excel Solver an add-in of Microsoft's Excel program. The Excel Solver uses a spreadsheet to build a model that will specify constraints, decision variables and the objective. The constraints define the amount of resources available while decision variables impose limits on those resources for a particular use. The last component of the model, the objective, is the quantity that will be maximized (Fylstra et al. 1998).

When optimizing for environmental benefits, some of the constraints or resources required are the land area available, total budget available for identified practices, or time that must be spent on various operations (e.g., farming a particular crop). Decision variables are limits on the use of resources for a particular task or operation. In the current study, this could mean the soil loss or acreage allocated for each land use activity. The aim of an optimization model is to find the optimal combination of land use for maximum profit. The decision of the farmer on land use will be based on profit from operations. Hence, in my model, profit will be the objective that will be maximized while optimizing land use for farming practices while maintaining environmental benefits, which is reduced soil loss in this case. The model will select a mixture of crops that maximizes profit while minimizing soil loss thereby promoting water quality.

CRP Success and Habitat Fragmentation

Studies have shown that the CRP makes significant contributions to wildlife management (Egbert et al. 2002, Awawdeh 2004). Human activities, including farming, have resulted in habitat fragmentation over the landscape and natural habitats for wildlife have been reduced in area and have become highly fragmented. The impact of the CRP on landscape structure and potential influence on wildlife populations can be studied by using multi-seasonal satellite imagery and Fragstats spatial pattern analysis program (McGarigal 2004, McGarigal and Marks 1994, McGarigal and Marks 1995) or patch analyst (Elkie et al. 1999). This enables calculation of total area, percentage area of pre- and post-CRP grassland, number of patches, mean patch size, patch density, edge density, mean shape index, nearest neighbor distance, and an interspersion/juxtaposition index. A study by Egbert et al. (2002) showed an increase in total grassland area, percentage area in grassland, and grass patch size but noticed relatively small changes in patch density, edge density, mean shape index, nearest neighbor index, and interspersion/juxtaposition index (Egbert et al. 2002).

Study Area

The study area was Texas County (figure 1.2). The county shares the boundary with Beaver to the East and Cimarron to the West and shares state borders with Kansas to the North and Texas to the South. In terms of climate, Texas County has a sub-humid climate found in the Central Plains (Doerr and Morris 1960).

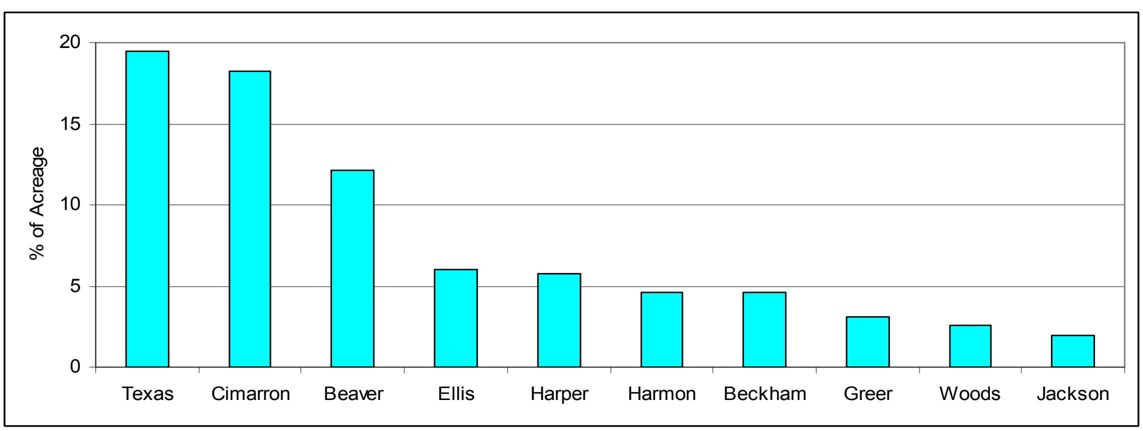

Figure 1.1: Percentage of CRP acreage by county in Oklahoma.

Figure 1.1 shows percentage of CRP acreage in Oklahoma, and Texas County has the highest number of the CRP activities, 19.44% (USDA-FSA 2006). The study is applicable to other counties with similar levels of CRP, i.e., Beaver County 12.11% and Cimarron County 18.22%.

Texas County forms part of the Great Plains, which is a physiographic region that extends from Central Canada to the Central United States. The plains are important for grain (wheat, sorghum, corn) production and livestock farming. Apart from grain, hay and soybeans are also important crops.

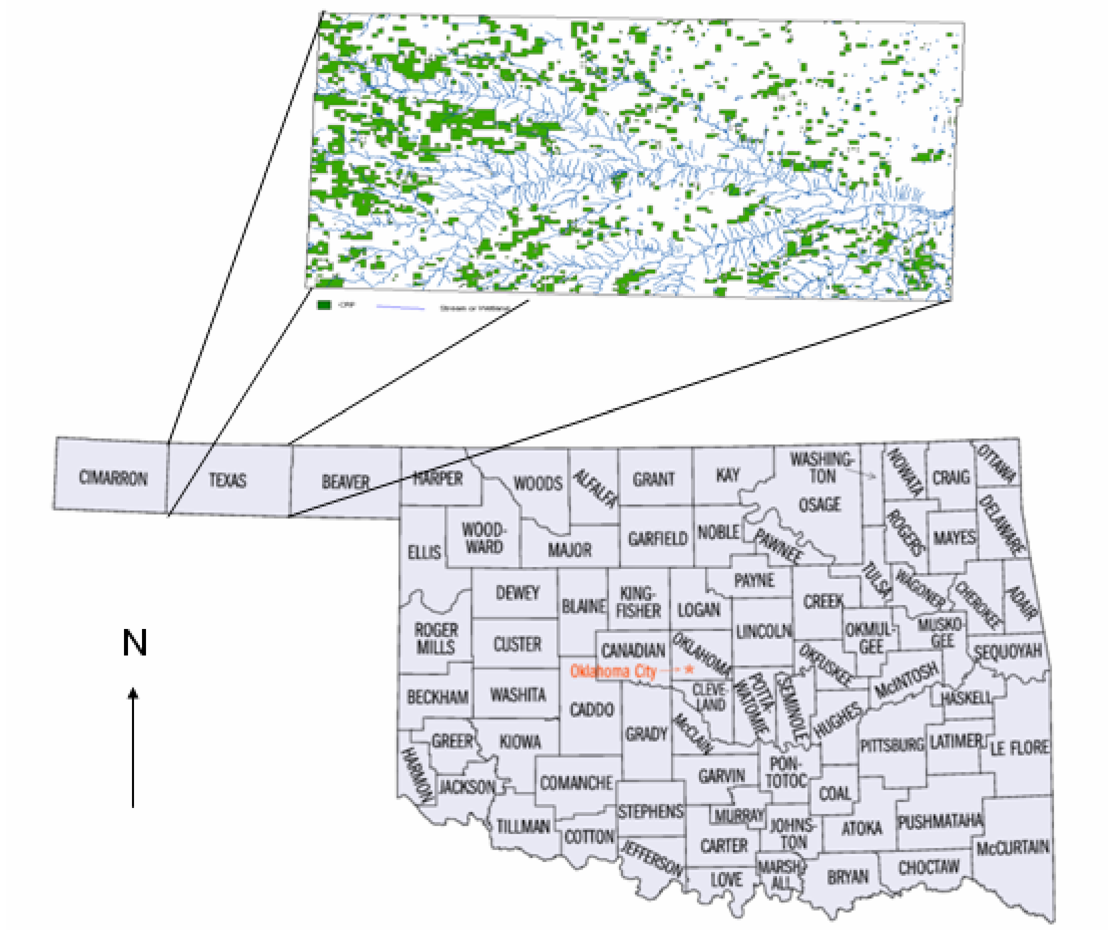

Figure 1.2: Study area – State of Oklahoma showing inset, Texas County, with the CRP tracts in green and streams in blue.

The Panhandle is shortgrass prairie with precipitation in the range of 250-500 mm (10-20 in) per annum and a shorter growing season of less than 180 days when compared to the rest of Oklahoma. Farming in the Panhandle is only possible under irrigation, fallow farming and residual management systems. The soil is sandy and high winds are a common occurrence. Farming and ranching operations occupy most of the panhandle with ranching dominating the drier western end.

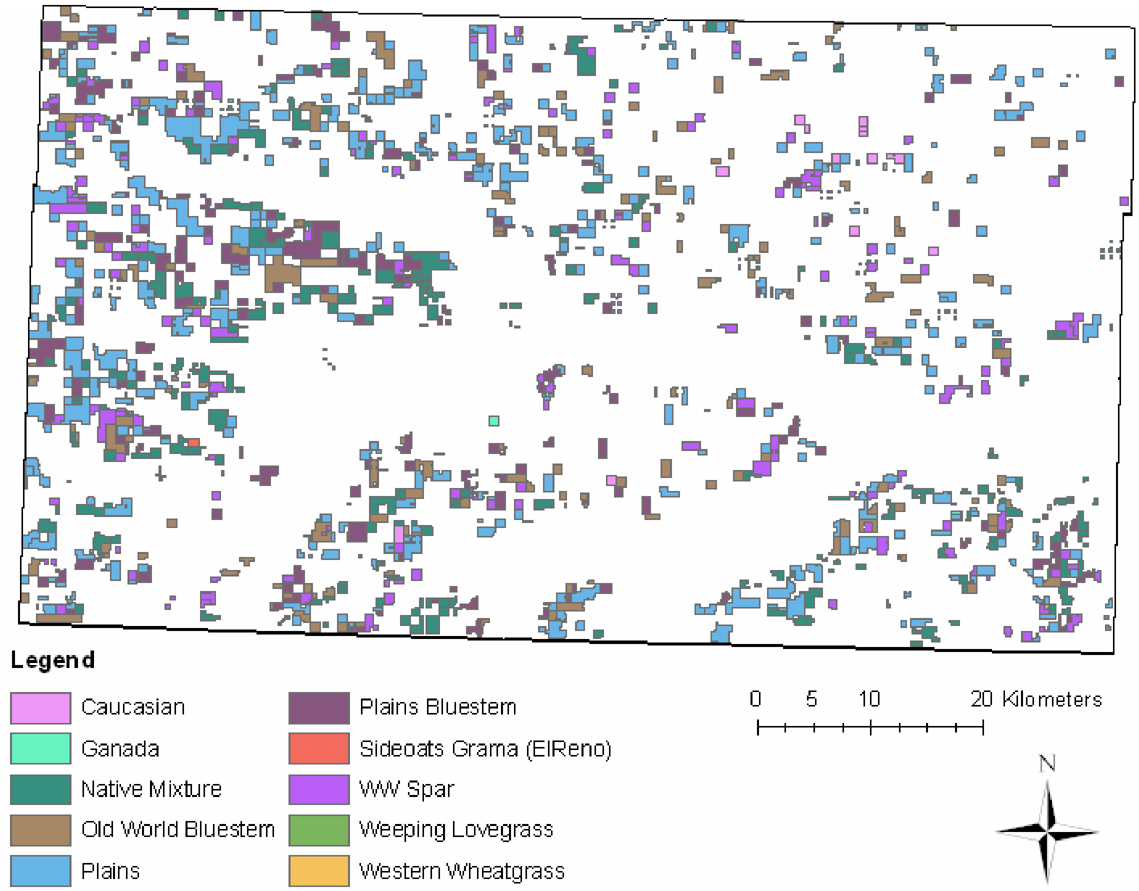

Figure 1.3: Distribution of CRP tracts in Texas County showing grass species planted between 1986 and 1991.

The CRP reference map (as shown in figure 1.2 – insert, and figure 1.3) obtained from the Center for the Applications of Remote Sensing (CARS) lab, Geography Department, Oklahoma State University, shows that the CRP grass plantings took place between 1986 and 1991. The program planted ten grass types (figure 1.3) in Texas County: old world bluestem, plains, WW–Spar, native mixture, plains bluestem, ganada, caucasian bluestem, western wheatgrass, sideoats grama, and weeping lovegrass (FSA 2000).

Objectives

Numerous studies have been carried out on the effect of the CRP on landscape structure and function both at the local scale and regional scale. Some studies have been done at the landscape level in Texas County (e.g., Awawdeh 2004) but have not examined methods of maintaining the wide range of environmental benefits gained from the CRP such as improved water quality, wildlife habitat, and reduced soil erosion. The overall goal of this study is to provide recommendations for use of post-CRP lands to ensure maximum environmental benefits. Specific objectives include: (1) quantifying changes in the Texas County landscape due to the CRP, (2) quantifying changes in potential wildlife habitat for native species, (3) modeling land use for protection of environmental benefits, and (4) applying an optimization model for achieving maximum production returns while maintaining optimum environmental benefits.

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CHAPTER II

QUANTIFYING LANDSCAPE CHANGE ON POST-CRP TRACTS IN TEXAS COUNTY, OKLAHOMA

Introduction

Farming causes a variety of environmental problems including habitat fragmentation, wildlife habitat loss, and general decline in environmental quality (Green et al. 2004). Land conversion and fragmentation degrade environmental quality of landscapes (Wu 2004) and clearance of vegetation compounds the problem. In addition, plowing causes soil loss and reduced water and air quality. Long-term land retirement is a useful tool for addressing such problems. Land retirement or land diversion policy in the United States started in the early 1930s with the idea of adjusting production to demand by withdrawing cropland from production. The policy was expanded in the late 1930s to include conservation through a compensation program to entice farmers from soil-depleting to soil-building crops (Johnson and Clark 2002). In 1985 the Conservation Reserve Program (CRP), was enacted by the United States Congress in Title XII of the Food Security Act of 1985 and implemented in 1986 (Ohlenbusch and Watson 1995, Feather et al. 1999, Ribaudo 1989).

The CRP's expectations are to reverse changes that have been brought about by farming practices in farming areas. Hence, it is important to study these landscape changes because landscape layout and composition are closely associated with what occurs at the landscape level in terms of the function of landscape elements and the processes that occur in the landscape (Turner 1989, Gustafson 1998, Klug et al. 2005). Studies have shown that the CRP makes significant contributions to wildlife conservation benefiting both game animals (e.g., ring-necked pheasant, bobwhite, scaled quail, mourning dove, lesser prairie chicken, wild turkey, and white-tailed deer) and non-game animals including songbirds (Lutz et al. 1994, Egbert et al. 2002). A study by Egbert et al. (2002) shows that the CRP increases the total grassland area, percentage area in grassland, and grass patch size. The CRP contributes to wildlife habitat quality and this is important because wildlife abundance and distribution are a "function of habitat quality, and the CRP provides needed loafing, nesting, and escape cover (especially associated with edges)" for wildlife (Miller 1994).

Studying the effects of long-term land retirement on the Texas County landscape can help in relating the impacts of conservation programs such as the CRP on landscape structure and on the potential influence on wildlife populations. This can be accomplished by using categorical maps and Patch Analyst program (Elkie et al. 1999). Landscape metrics quantify the degree of fragmentation and other landscape changes by using proportion, patch density, size, shape, and connectivity (McGarigal and Marks 1994, McGarigal and Marks 1995, Gustafson 1998, McGarigal 2000). We can link landscape patterns observed to habitat quality because the pattern of landscape elements strongly influences ecological processes (McGarigal 2004). Quantifying landscape change is an important step in understanding possible effects of landscape alteration emanating from land retirement programs like the CRP.

In this study, I used landscape metrics to better understand the effect of the CRP on the Texas County landscape in general. I also investigated the question of whether the CRP has targeted the intended tracts for natural resource conservation in terms of soil erosion and water quality in Texas County.

Methods

I analyzed the pre- and post-CRP Texas County landscape. The difference between the pre-CRP landscape and the post-CRP landscape is that the post-CRP landscape has CRP tracts in which grass was planted between 1986 and 1991 while the pre-CRP landscape does not have any CRP tracts. To analyze changes that have taken place, I first obtained a national land cover database (NLCD) of 1992 from United States Geological Service (USGS) (USGS 2003). I also obtained Texas County CRP reference map of 1994 prepared by NRCS from the Center for the Application of Remote Sensing (CARS) lab of the Geography Department, Oklahoma State University. The CRP reference map was projected in UTM 14N and datum NAD_1983.

I converted the NLCD raster map to a shape file. To create the pre-CRP LULC theme, I needed to remove grassland that had CRP tracts. Some of the grassland cover areas in the 1992 NLCD layer were wrongly identified as grassland when the tracts were already under CRP. I exported the grassland cover from the 1992 NLCD to a new layer. I clipped this layer using the CRP map to process only grassland that was in the CRP. I reclassified the clipped layer to row crops, small grains, fallow, and pasture/hay based on other polygons close by. I used the NLCD to identify the correct cover to assign. I used ArcInfo to edit the layer and changed the cover type in the attribute table. Using ArcInfo, I erased from the NLCD the extent of the classified layer and merged the reclassified layer to the processed NLCD layer using ArcView. This formed the pre-CRP LULC without any CRP.

To create the post-CRP layer, I first reclassified the CRP reference map by assigning all individual CRP grass types as CRP by editing with ArcView, and then I dissolved the CRP polygons using ArcView. I erased the extent of the CRP tracts from the NLCD using ArcInfo and merged the reclassified CRP reference layer to the processed NLCD layer using ArcView. The resulting layer was a post-CRP LULC theme. The pre-CRP LULC theme had 19 classes (small grains, row crops, grassland, pasture/hay, shrubland, mixed-forest, wetlands, low intensity residential, commercial, grassy wetlands, fallow, urban, bare rock/sand/clay, forest-evergreen, deciduous-forest, transitional, high intensity residential, quarries, and woody-wetlands). The post-CRP theme had 20 classes (i.e., all pre-CRP land classes plus CRP).

In my analysis of landscape metrics, I was mostly interested in six land cover classes, i.e., small grains, row crops, grassland, pasture/hay, grassy wetland, and fallow because CRP tracts are established on previously cropped land and other environmentally sensitive lands. The CRP cover has different characteristics from grassland as the management of the two land cover types differ in both composition and management and the CRP land cover originates from a mixture of seed (Mayer 1998), which may or may not be similar to the surrounding grassland. Again, CRP land undergoes weed management and is not hayed or grazed except during periods of extreme draught (Egbert et al. 2002).

I applied Patch Analyst 3.1 (Elkie et al. 1999) an extension of ArcView 3.3 to the pre- and post-CRP LULC theme to calculate landscape metrics at the landscape and class level. Figure 2.1 shows the methodology used in calculating the landscape metrics.

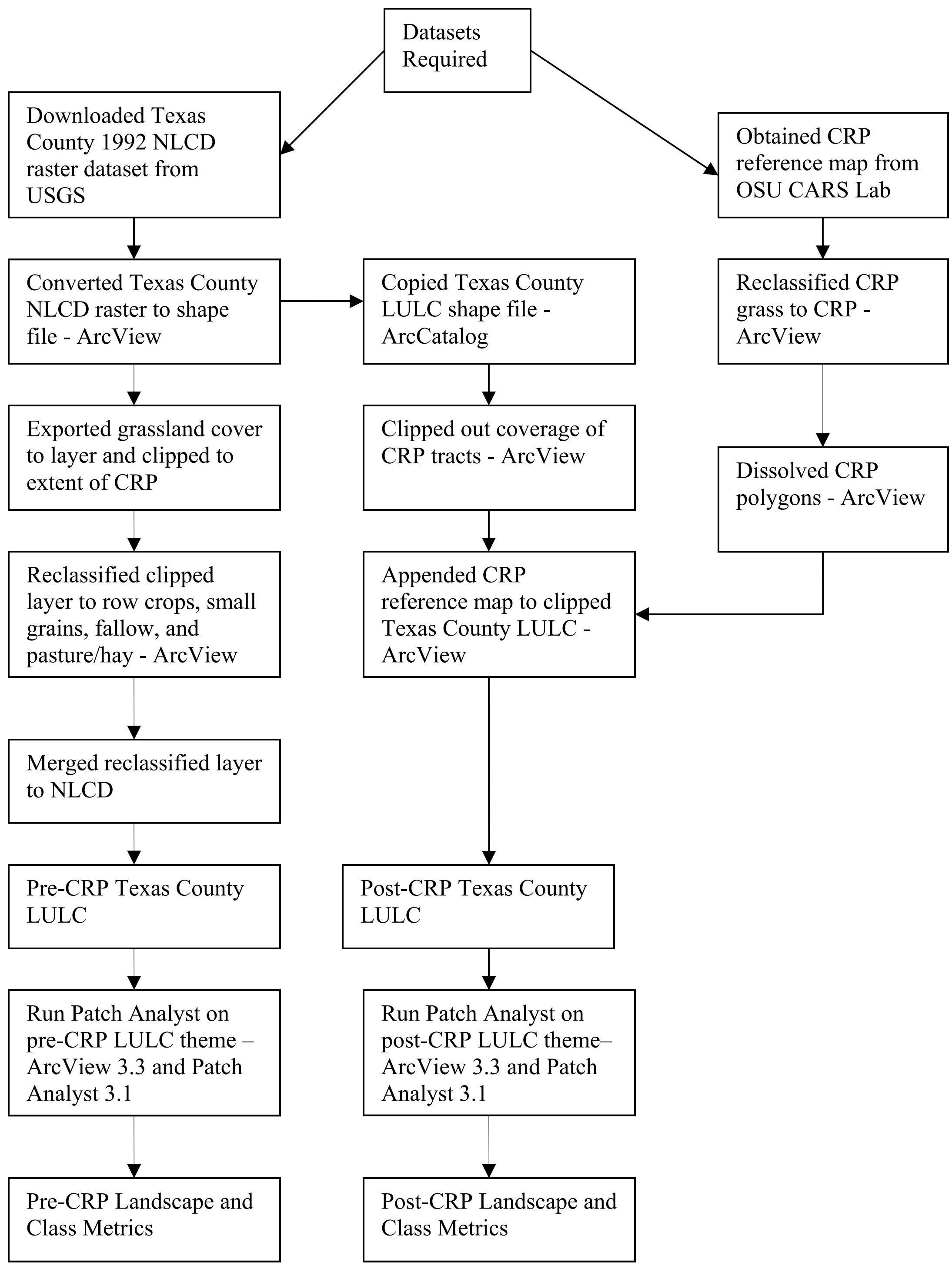

Figure 2.1: Methodology flow chart for calculating pre- and post-CRP landscape metrics for Texas County, Oklahoma.

Results

At the landscape analysis level (see table 2.1 in the appendix), I observed a reduction in the number of patches (NUMP), patch size standard deviation (PSSD), patch size coefficient of variation (PSCOV), total edge (TE) and edge density (ED), area-weighted mean shape index (AWMSI), and area-weighted mean patch fractal dimension (AWMPFD). However, there was an increase in mean patch size (MPS), mean patch edge (MPE), mean shape index (MSI), mean patch fractal dimension (MPFD), mean perimeter-area ratio (MPAR), Shannon's diversity index (SHDI) and Shannon's evenness index (SHEI). There was no change in the median patch size (MEDPS) between the pre-CRP and post-CRP landscapes.

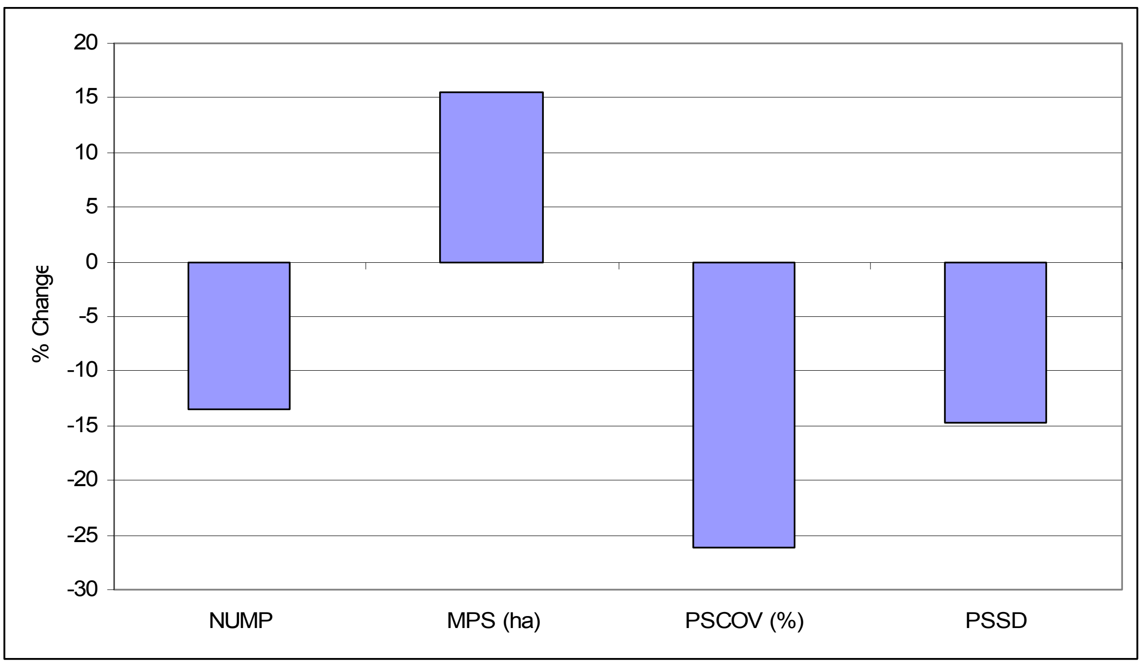

Figure 2.2: Percentage change (pre- to post-CRP) in number of patches (NUMP); mean patch size (MPS); patch size coefficient variation (PSCOV); and patch size standard deviation (PSSD) at landscape level in Texas County, Oklahoma.

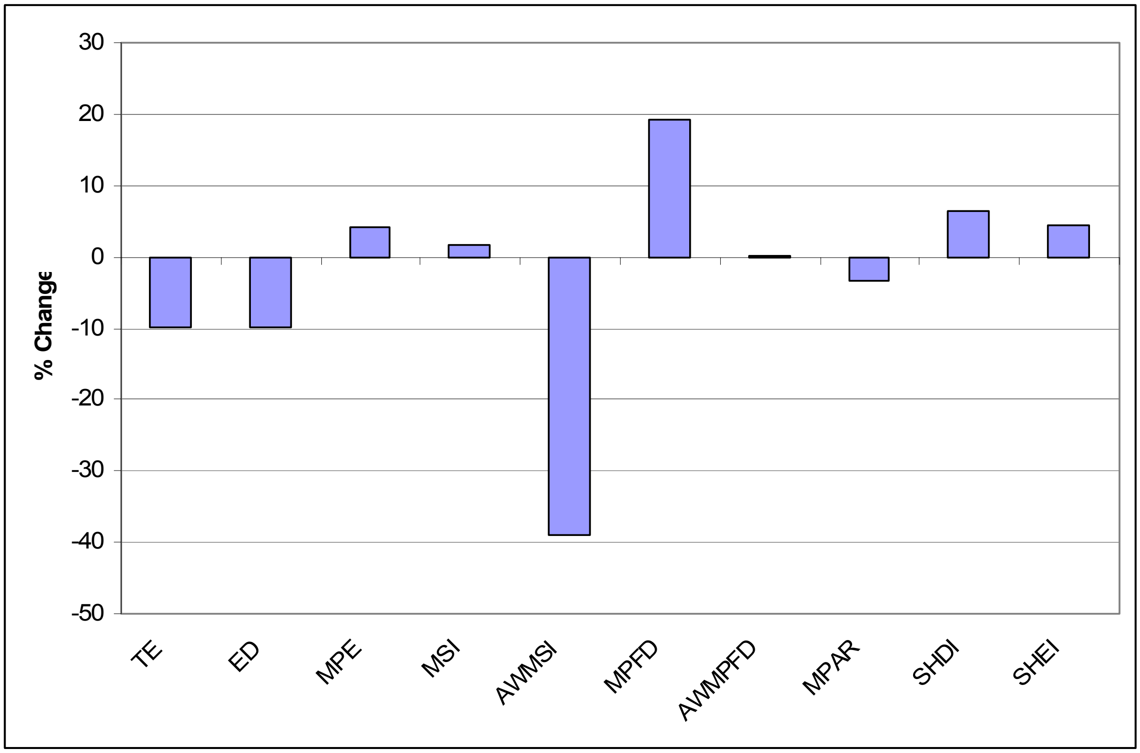

Figure 2.3: Metrics at the landscape level, Texas County, Oklahoma: edge (total edge – TE, edge density – ED, mean patch edge - MPE); shape – (mean shape index - MSI, area weighed mean shape index – AWMSI, mean patch area ratio – MPAR); and diversity (Shannon's diversity index – SHDI, Shannon's evenness index).

Land use cover class area (CA) between pre- and post-CRP reduced in all the classes I investigated with the highest reduction in the row crops land cover class and least in the grassland category (figure 2.5 and table 2.1). Contribution to total CRP cover type acreage was highest from row crops and least from grassland (figure 2.4).

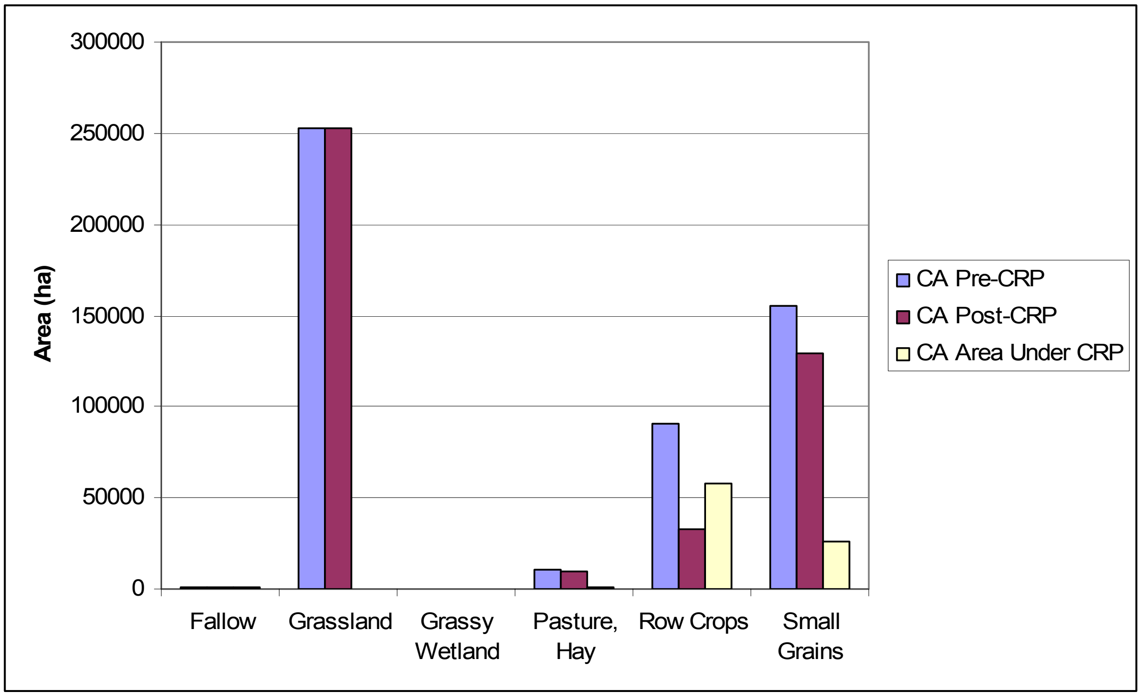

Figure 2.4: Pre- and post-CRP class area (CA) and area contributed to CRP tracts by different land cover classes in the pre- and post-CRP Texas County, Oklahoma.

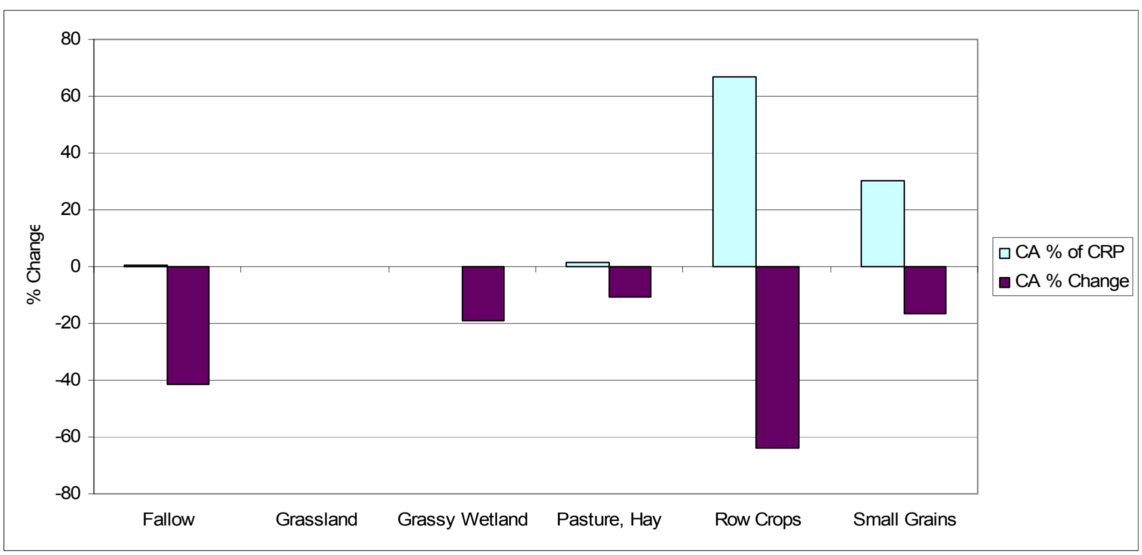

Figure 2.5: Percentage of cover area (CA) under the CRP and percentage change of cover area for different land cover classes in the pre- and post-CRP Texas County, Oklahoma.

The number of patches (NUMP) at class level also reduced in all classes studied except for grassland which increased by 3.89%. Mean patch size (MPS) reduced in all classes except pasture/hay, small grains and grassy wetland. I also observed a reduction in total edge (TE) and edge density (ED) in all land cover classes studied (figure 2.3).

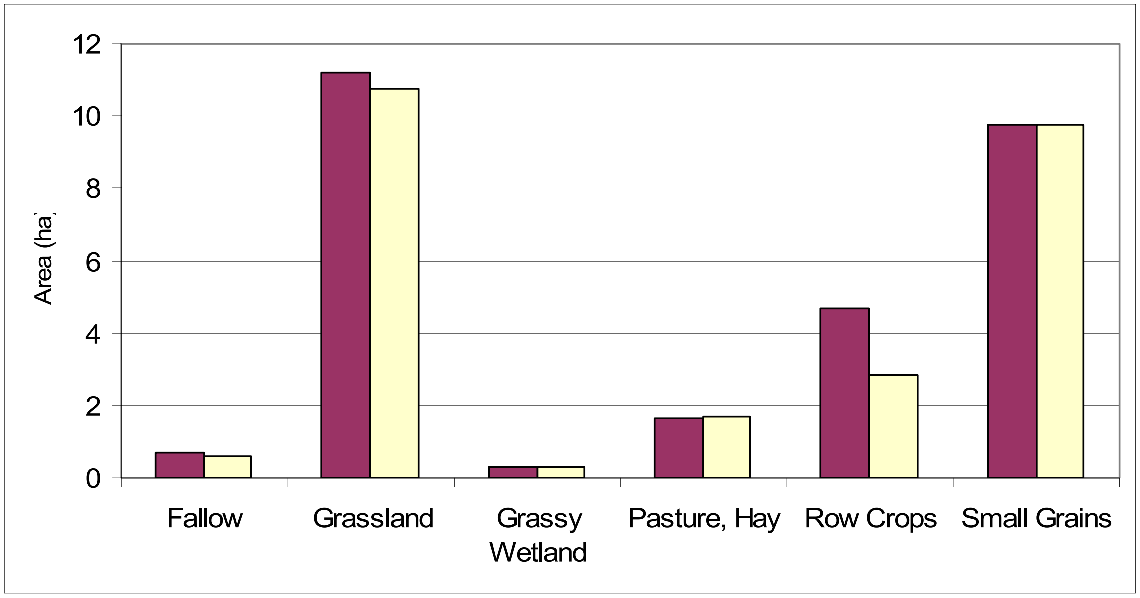

Figure 2.6: Class patch metrics showing mean patch size (MPS) for the pre- and post-CRP Texas County, Oklahoma.

The results obtained show that the CRP class has the highest MPS at 149.7 ha and the smallest PSCOV of 39.45% (table 2.1). When I compared the amount of class area contributed to CRP cover I found that row crops contributed the highest amount (5770 ha, 67%) while grassland contributed the least amount (143 ha, 0.17%) (see figure 2.5).

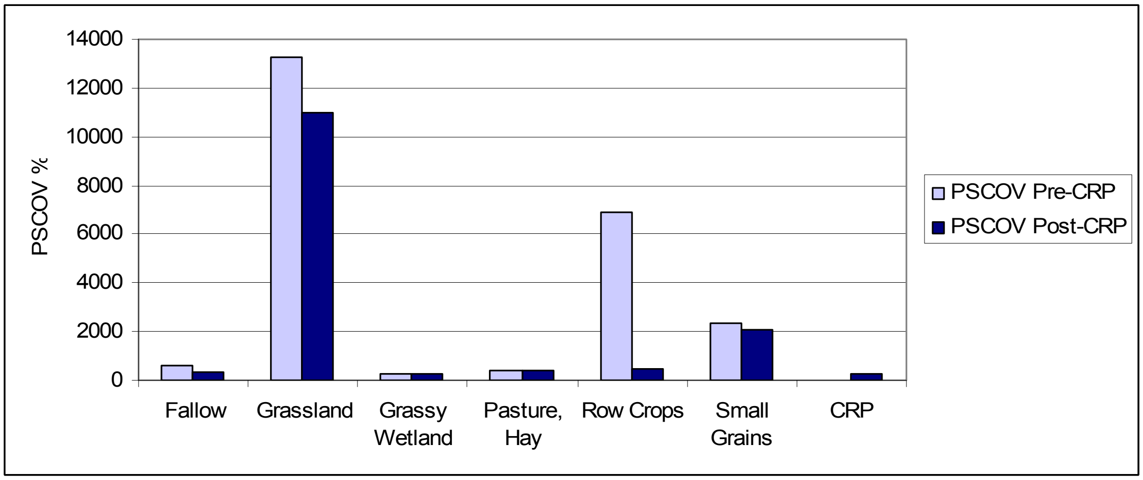

Figure 2.7: Patch size coefficient of variation (PSCOV) for the pre- and post-CRP Texas County, Oklahoma.

The interspersion juxtaposition index (IJI) increased both at the landscape level and among all classes investigated (figure 2.8). Small grains cover type showed the highest percentage change. Grassy wetland and grassland cover type showed the highest IJI in the post-CRP landscape. Other landscape metrics obtained are given in tables 2.1 in the appendix.

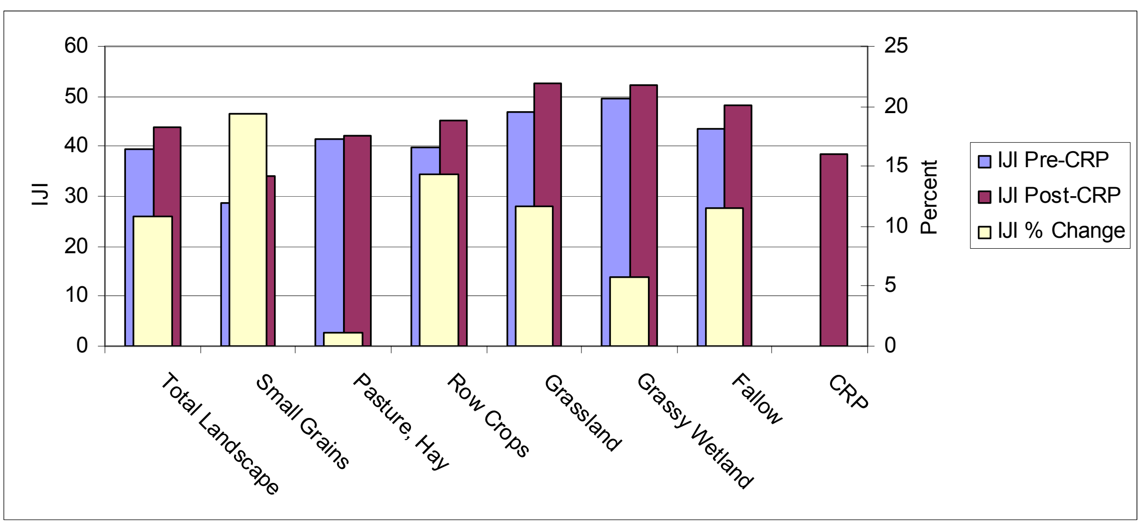

Figure 2.8: Landscape and class interspersion and juxtaposition index (IJI), and percentage change in Texas County, Oklahoma.

Discussion

This study has revealed that there is change that is attributed to the CRP in the Texas County landscape. At the landscape level, I observed the effect of the CRP in the reduction of number of patches. Reduction in number of patches has resulted in an increase in mean patch size and reduction in patch size coefficient of variation (reduced variability means mostly large patches in post-CRP compared to the pre-CRP landscape) (McGarigal and Marks 1995, Elkie et al. 1999, McGarigal 2004). I attribute the reduction in the number of patches at the landscape level to the consolidation of farmland fields into large CRP tracts. In addition, farm fields that may have belonged to different land use classes (e.g., fallow, row crops, and small grains) are grouped together under a single CRP tract. The increase in mean patch size to large patches is a result of consolidation small patches to form CRP tracts. Reduction of total edge resulted from reduction in number of patches because for the same area numerous small patches will have a larger total edge than a single large patch (Elkie et al. 1999, McGarigal and Marks 1995, McGarigal 2004). The reduction in edge is also supported by mean patch edge. Reduced edge has an effect on habitat quality on edge sensitive species. The mean shape index did not change significantly. In a similar study Egbert et al. (2002) attributes low levels of change in the mean shape index to the CRP tracts retaining the pre-existing geometric shape of the pre-CRP farm fields.

The IJI metric shows that the CRP has resulted in an increase in the intermixing of patch classes as shown by an increase in the IJI metric after the CRP at both the landscape and class levels (figure 2.8). At the class level the IJI is a measure of relative interspersion of each class, i.e., how patches are intermixed relative to other patches. A higher value of IJI shows that patches are equally interspersed (McGarigal and Marks 1994).

At the land-cover class level, I found important changes, which I attribute to the CRP. The CRP targets lands that have been in use for at least five years on highly erodible farm fields (Ribaudo 1989, Bennet and Vitale 2001). The area that was actually used in farming (small grains, row crops, and fallow) reduced in total area from the pre-CRP to post-CRP period by about 64% (row crops), 42% (fallow), 17% (small grains), and pasture/hay (10.51%). About 19% of grassy wetland also came under the CRP.

The creation of large patches is significant for wildlife because large patches provide habitat for loafing, nesting and for escape (Miller 1994). The increase in patch size is also an indication of less fragmentation of habitat in the post-CRP landscape. The effect of producing large patches is that there is reduced total edge (TE) in the post-CRP landscape (Elkie et al. 1999, McGarigal and Marks 1995, McGarigal 2004). Reduction in edge has an effect on habitat quality for edge sensitive species. The introduction of the CRP in the landscape has resulted in more cover for some species (e.g., pheasant, bobwhite, white-tailed deer) but the reduction of cropland has reduced feeding habitat for those species (NRCS 1999, Messenger 2005) and for mourning doves (Ostrand 1996).

This study indicates that the CRP has targeted areas that will contribute to natural resource conservation in farming areas. This study further points out that the CRP has generally benefited wildlife in Texas County. However, this depends on the habitat requirements of particular species. While the CRP may provide increased wildlife habitat for cover, foraging habitat (e.g., cropland) has been reduced for some species like pheasant, white-tailed deer, wild turkey, and eastern cotton-tail (Messenger 2005, Miller 1994). This is an important consideration for wildlife managers who should take stock of the effects of the CRP when making management decisions.

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Appendix

Table 2.1: Pre- and Post-CRP landscape and class metrics[*] for Texas County, Oklahoma

Metrics	Period and Change	Landscape	Fallow	Grassland	Grassy Wetland	Pasture, Hay	Row Crops	Small Grains	CRP
CA	Pre-CRP		1171	253188	241	10505	90587	155452	
	Post-CRP		684	253045	195	9401	32881	129304	86051
	% Change		-41.62	-0.06	-19.17	-10.51	-63.70	-16.82	
NUMP	Pre-CRP	85588	1629	22606	812	6342	19277	15964	
	Post-CRP	74054	1151	23485	651	5558	11654	13276	575
	% Change	-13.48	-29.34	3.89	-19.83	-12.36	-39.54	-16.84	
MPS	Pre-CRP	6.20	0.72	11.20	0.30	1.66	4.70	9.74	
	Post-CRP	7.17	0.59	10.77	0.30	1.69	2.82	9.74	149.65
	% Change	15.52	-17.37	-3.80	0.81	2.12	-39.96	0.12	
MEDPS	Pre-CRP	0.12	0.12	0.09	0.09	0.12	0.12	0.12	
	Post-CRP	0.12	0.12	0.10	0.09	0.12	0.13	0.12	64
	% Change	0	-1.15	16.22	0	0	2.18	0	
PSCOV	Pre-CRP	12690.02	633.05	13295.26	286.02	423.96	6926.06	2356.42	
	Post-CRP	9375.71	366.80	10961.96	299.95	409.02	479.16	2090.06	247.15
	% Change	-26.12	-42.06	-17.55	4.87	-3.52	-93.08	-11.30	
PSSD	Pre-CRP	787.12	4.55	1489.08	0.85	7.02	325.47	229.46	
	Post-CRP	671.82	2.18	1181.12	0.90	6.92	13.52	203.56	369.87
	% Change	-14.65	-52.13	-20.68	5.72	-1.48	-95.85	-11.29	
TE	Pre-CRP	55449089	481838	19092849	167584	2511122	12206017	14680848	
	Post-CRP	49988388	320648	19083781	134127	2194568	6462056	12678499	3136350
	% Change	-9.85	-33.45	-0.05	-19.96	-12.61	-47.06	-13.64	
ED	Pre-CRP	104.45	0.91	35.97	0.32	4.73	22.99	27.65	
	Post-CRP	94.20	0.60	35.96	0.25	4.14	12.18	23.89	5.91
	% Change	-9.81	-33.42	0	-19.93	-12.57	-47.03	-13.60	
MPE	Pre-CRP	647.86	295.79	844.59	206.38	395.95	633.19	919.62	

Metrics	Period and Change	Landscape	Fallow	Grassland	Grassy Wetland	Pasture, Hay	Row Crops	Small Grains	CRP
	Post-CRP	675.03	278.58	812.59	206.03	394.85	554.49	954.99	5454.52
	% Change	4.19	-5.82	-3.79	0-0.17	-0.28	-12.43	3.85	
MSI	Pre-CRP	1.37	1.32	1.37	1.28	1.34	1.39	1.40	
	Post-CRP	1.40	1.38	1.40	1.31	1.36	1.42	1.45	1.38
	% Change	1.77	4.20	1.92	1.80	1.35	2.44	2.95	
AWMSI	Pre-CRP	33.19	1.92	56.60	1.52	1.82	19.76	8.72	
	Post-CRP	20.24	1.76	37.05	1.54	1.76	2.28	7.53	2.07
	% Change	-39.01	-8.45	-34.54	1.18	-3.44	-88.49	-13.56	
MPAR	Pre-CRP	1416.04	1221.30	1624.26	1344.57	1199.95	1482.37	1282.65	
	Post-CRP	1686.91	2349.05	1859.50	2090.85	1512.82	1540.35	1831.75	78.38
	% Change	19.13	92.34	14.48	55.50	26.07	3.91	42.81	
MPFD	Pre-CRP	1.42	1.41	1.43	1.42	1.41	1.42	1.42	
	Post-CRP	1.43	1.44	1.43	1.43	1.42	1.42	1.43	1.24
	% Change	0.23	1.63	0.16	0.53	0.78	0.08	0.51	
AWMPFD	Pre-CRP	1.44	1.35	1.49	1.37	1.31	1.41	1.38	
	Post-CRP	1.39	1.35	1.46	1.37	1.31	1.32	1.37	1.25
	% Change	-3.23	0.23	-1.91	-0.01	-0.31	-6.28	-0.85	
SDI	Pre-CRP	1.63							
	Post-CRP	1.74							
	% Change	6.36							
SEI	Pre-CRP	0.55							
	Post-CRP	0.58							
	% Change	4.5							

* **Landscape and class metrics (units):** NP, Number of patches (#); MPS, Mean patch size (ha); PSSD, Patch size standard deviation (ha); PSCOV, Patch size coefficient of variation (%); MEDPS, Median patch size (ha); TE, Total edge (m); ED, Edge density (m/ha); MPE, Mean patch edge (m); MSI, Mean shape index; AWMSI, Area-weighted mean shape index; MPFD, Mean patch fractal dimension; AWMPFD, Area-weighted Mean patch fractal dimension; MPAR, Mean perimeter-area ratio (m/ha); SHDI, Shannon's diversity index; SHEI, Shannon's evenness index; IJI, Interspersion and Juxtaposition Index.

CHAPTER III

EFFECTS OF THE CRP ON POTENTIAL WILDLIFE HABITAT IN TEXAS COUNTY, OKLAHOMA

Introduction

Anthropogenic land use threatens wildlife habitats the world over. One of the causes of habitat loss and degradation is habitat fragmentation (Green et al. 2004, Wu 2000). Habitat fragmentation results in discontinuities in an organism's habitat. Human activities, compared to natural changes, result in a faster rate of fragmentation owing to land conversion by clearing natural vegetation for agriculture and other development activities, threatening biodiversity (Colline 1996).

Habitat fragmentation results in reduction in habitat total area, increase in edge, reduction in interior habitat, isolation of habitats, increase in number of patches, and reduction in patch size (McGarigal and Marks 1994). Habitat fragmentation eventually leads to habitat destruction, overcrowding and increased intraspecific and interspecific competition among the inhabitants of such habitats. This may also lead to stress and reduced resistance to disease. Habitat loss can result in some species becoming endangered because fragmentation affects distribution of species; it also affects migration patterns and rates among populations, including the sizes of local populations (Lomolino and Smith 2001).

An increasing number of species all over the world are threatened by habitat loss (Baillie et al. 2004). One example is the prairie dog (*Cynomys ludovicianus*) which was previously common as a native grassland species but was reduced by 98%, occupying less than 5% of its previous territory and occupying about 1% of the presettlement area (Lomolino and Smith 2001, Miller et al. 1994). There has been decline in number of other species in recent years caused mainly by decline in habitat area and quality (Tyler and Shackford 2002, Fisher and Gregory 2001)

Habitat fragmentation and species decline are important issues given the rate of development and rate of land conversion for agricultural use. Problems brought about by land fragmentation can be reversed by deliberate reversal of current development patterns in farmland areas. In 1985, the US Congress established the Conservation Reserve Program (CRP) through Title XII of the Food Security Act. The CRP is a voluntary, long-term cropland retirement program administered by the United States Department of Agriculture (USDA) in conjunction with Natural Resources Conservation Service (NRCS) and the Farm Service Agency (FSA) which are part of the USDA (Ohlenbusch and Watson 1995).

The CRP is designed to improve the nation's natural resource base by reducing soil erosion, improving water quality, reducing surplus production of farm produce, improving fish and wildlife habitats, and reduction of sedimentation in fields and waterways (Feather et al. 1999). The program has improved wildlife habitat through habitat restoration in many areas including benefit to some native birds (Burger et al.

1989, Frawley 1989, Johnson and Igl 1995) and other non-game wildlife as well (Feather et al. 1999, Kantrud 1993, King and Savidge 1995).

Under the CRP, landowners and the USDA enter into a contract to enroll severely eroding or other environmentally sensitive land for approximately 10 to 15 years. During the CRP period, the land is planted with either trees or grass (Ribaudo 1989, Ohlenbusch and Watson 1995). Landowners receive annual payments as rentals for their land and payments of up to 50% of the cost for establishing conservation practices. The initial goal of the CRP was to remove 40 to 45 million acres of highly erodible cropland from production by 1990 (Ribaudo 1989). The 2002 Farm Bill authorized the USDA to maintain a CRP enrollment of 39.2 million acres. In 2002, 34 million were enrolled in CRP contracts, 1.5 million of these acres expired by September 30 2003 (FSA 2003).

I studied the effect of the CRP in Texas County, Oklahoma in reversing habitat loss. Texas County has the highest number of CRP activities, 212,708 acres about 20% CRP acreage in Oklahoma (USDA-FSA 2006). I examined how the CRP has benefited 12 indicator species indigenous to Texas County. My hypothesis is that some mammal and bird species benefited from the CRP while other species have not benefited as much.

Methods

I used a national land cover database (NLCD) of 1992 from United States Geological Service (USGS) (2003). I also obtained Texas County CRP reference map from the CARS lab of the Geography Department, Oklahoma State University. I used ArcGIS version 9 and ArcView version 3.3 with their extensions to prepare and process the datasets and drew on Chang (2004) and Price (2004) for some of the methods used. Figure 3.1 shows an outline of the methodology used.

The dataset covered the extent of Texas County. I converted the Texas County raster LULC theme to a shape file to create the pre-CRP LULC theme. The CRP reference map showed different grasses planted which included old world bluestem (*Bothriochloa ischaemum*), native mixture (sideoats grama and western wheat grass), weeping blue grass, ganada, plains bluestem, plains (*Stipa aristiglumis*), WW Spar, and caucasian bluestem. Plains bluestem, WW Spar and caucasian bluestem are all varieties of old world bluestem (USDA-NRCS 2007). I reclassified the CRP reference map by assigning all CRP grass types as CRP and merged a copy of LULC map with the CRP reference map to create another layer that included CRP tracts as the post-CRP LULC theme. The pre-CRP LULC theme had 19 classes (small grains, row crops, grassland, pasture/hay, shrubland, mixed-forest, wetlands, low intensity residential, commercial, grassy wetland, fallow, urban, bare rock/sand/clay, forest-evergreen, deciduous-forest, transitional, high intensity residential, quarries, and woody-wetlands).

I created two scenarios, i.e., the pre-CRP scenario and post-CRP scenario. The 1992 LULC map represented the pre-CRP scenario. The post-CRP scenario was created by clipping out the extent of the CRP coverage in the 1992 LULC map and merging the clipped map with the CRP reference map. The pre-CRP layer had 19 cover types while the post-CRP theme had 20 cover types. I then used the attribute table to select cover types that represent suitable habitat for each of the indicator species. I created buffers for secondary habitats (e.g., edge of crop field, forest edge) and merged them to the selected cover types (primary habitat).

The habitat models used in this study were drawn from literature that included the Oklahoma (Fisher and Gregory 2001), and the Kansas Gap Analysis vertebrate models (KS-GAP 2002). I included the models used in the Kansas Gap Analysis because of the similarity of the landscape in the southern part of Kansas to that found in the Panhandle of Oklahoma. To model the effect of the CRP on wildlife habitat, I selected habitat specialist and generalists species indigenous to Texas County, Oklahoma (Fisher and Gregory 2001).

Black-tailed jackrabbit (*Lepus californicus*)

The natural habitat for black-tailed jackrabbit is shrubland or grassland and the species prefers sagebrush (*Artemisa*) and heavily grazed grassland, especially mixed grass. Other preferred vegetation types are sand sage savanna, sand sage prairie and grama-buffalo grass prairie (Best 1996, Bronson and Tiemeier 1958). The species occurs mostly in arid, open country (shortgrass prairie with scattered thickets or shrub patches) but avoids thick woods (Best 1996) and is least abundant in mowed hay fields (suboptimal habitat). The black-tailed jackrabbit occupies shortgrass prairie and wheat fields at the same rate (Riegel 1941).

I selected shrubland, grassland, and small grains (sorghum and wheat fields) as habitat for black-tailed jackrabbit (Flinders and Hansen 1973).

Black-tailed prairie dog (*Cynomys ludovicianus*)

The black-tailed prairie dog occurs in grassland with shortgrass prairie, without heavy brush or tall grass. The prairie dog prefers areas that have short grass that allow them to see far in order to escape their enemies. Therefore, preference for colonization is given to close cropped grassland where blue grama and buffalo grass are the main grass species (Andersen and Fleharty 1967).

I selected all grassland as the habitat for black-tailed prairie dog.

Northern bobwhite (*Colinus virginianus*)

The northern bobwhite occurs in shrubland, grassland, and fallow and prefers more grass cover than bare ground in brushy areas. Other habitat areas include abandoned fields, grassland (primary long grass), cultivated lands, hedgerows, thickets, woodland margins, and open woodland (Casey 1995, Johnsgard 1973, Brenhan 1991). The northern bobwhite can also be found in wooded and cultivated areas of small rivers and streams. Bobwhite is an edge loving species found within 30 meters of all forests, woodland or shrubland next to grassland. The species is also found within 30 meters of cropland found next to grassland in which it occupies up to 210 meters from the edge (Brenhan 1991).

I selected grassland, shrubland and fallow to create bobwhite habitat theme and appended 30 meters edge of all forests and all cropland. I also selected CRP tracts for the post-CRP habitat (Rosebery and Sudkamp 1998).

Cassin's sparrow (*Aimophila cassinii*)

Cassin's sparrow preferred habitat is shrubland and open grasslands, short-grass plains with scattered bushes/shrubs, sage brush, mesquite or yucca and shinery oak preferred (Dunning et al. 1999, Manes 1984). Breeding for Cassin's sparrow occurs in grassland with ground or near ground nesting (Dunning et al. 1999).

I selected grassland and shrubland for both the pre- and post-CRP period but included CRP tracts in the post-CRP period.

Eastern cotton-tail (*Sylvilagus floridanus*)

The eastern cotton-tail is commonly found in small grains agricultural fields and grassland. They occupy edges of all forests especially within 250-300 ft (approximately 76 to 90 meters) of corn, oats, or alfalfa fields where they are most numerous. The species also occupies riparian forest woodlots but is most abundant in undisturbed prairie and least in heavily grazed prairie. Eastern cotton-tail frequents a variety of mesic habitats as well (Choate 1967, Finch and Rainey 1956) and forests which it uses as winter forage.

I selected grassland, all forests and 90-meter buffer of small grains as habitat for eastern cotton-tail. I included CRP tracts for the pos-CRP habitat.

Lark sparrow (*Chondestes grammacus*)

The lark sparrow prefers shrubland, grassland, 30-meter edge of forest and successional habitats, breeding in succession scrub. Herbaceous or woody plants are an important cover in the lark sparrow habitat because they nest under them proving shed for the nests (Swanson 1998, Newman 1970). They are ground or near ground nesting and considered an edge species, preferring areas adjacent to selected open habitat or prairie (Faanes 1987). In Oklahoma, nests are built on the ground more often than above ground (Zimmerman 1993, McNair 1985).

As habitat, I selected shrubland and grassland, and appended a 30-meter buffer of all forests.

Lesser prairie chicken (*Tympanuchus pallidicinctus*)

The lesser prairie chicken is found in shrubland, grassland, and CRP tracts and within 990 m of agriculture fields. They prefer sand sage brush and tall grass (bluestem) and arid grassland with brushy vegetation, e.g., sagebrush shinery oaks, scrub oaks, and wild plums. Sand sage brush and sand bluestem are important cover types for lesser prairie chicken habitat as well (Crawford and Stormer 1980, Crawford 1980). Leks are located in mosaics of native prairie, agriculture fields and CRP tracts (Leslie 1999) and are numerous in areas with many CRP tracts (Rodgers 2000).

I selected shrubland and grassland for both pre- and post-CRP but included CRP tracts for the post-CRP habitat theme. For the secondary habitat portion, I appended a 990-meter buffer around agricultural fields.

Scaled quail (*Callipepla squamata*)

Scaled quail occupies shrubland, grassland, and low intensity residential areas where they use shelterbelts, machinery, and post piles as winter cover (Schemnitz 1994). Shrub vegetation and manmade structures are essential components of scaled quail habitat. More scaled quail will be found in areas with more forbes than grasses (Snyder 1967). They are generally found near sandy soils, with sagebrush, shinnery oak, mesquite grassland, and also pinyon pine and juniper habitats. Scaled quail prefers cactus and bare ground, mesquite, and juniper savannah. The species also occupies the more xeric uplands, tributary canyons, and mesa slopes as well (Schemnitz 1994).

The scaled quail habitat theme was created by selecting shrubland, grassland, and low residential areas.

Swift fox (*Vulpes velox*)

The preferred habitat for swift fox is both short and mixed grass prairie (Hines and Case 1991, Egoscue 1979). Swift fox is also found in shrubland and open rolling grassland habitats with little or no shrubs in short-grass prairie and semi-desert plains, especially weedy uplands (Kilgore 1969). Areas near cultivated fields are also preferred (Matlack et al. 2000, 2001). To create a swift fox habitat theme I selected shrubland and grassland cover types.

White-tailed deer (*Odocoileus virginianus*)

White-tailed deer utilizes shrubland, grassland, and CRP tracts within 2 km of cropland as habitat. Deciduous forests along streams serve as habitat islands while riparian areas serve as corridors allowing for the movement of white-tailed deer (Smith 1991). The presence of habitat islands and corridors lead to high productivity of white-tailed deer in riparian vegetation adjacent to cropland (Dusek et al. 1988, Smith 1991, Menzel 1984). Year round cover includes marshes, thickets, and river bottom. White-tailed deer can occupy a variety of habitats, mostly in edges, clearings in woodlands, and deciduous riparian areas. They occupy riparian areas and shrub during day and agricultural fields during the night (Dusek et al. 1991).

I selected shrubland, deciduous forests, and appended a 2-kilometer buffer of agricultural land to create a white-tailed deer habitat theme. For the post-CRP habitat theme, I included CRP tracts in the selection.

Wild turkey (*Meleagris gallopaus*)

Wild turkey is frequently found in deciduous forests, row crops, pasture, and low intensity residential areas. A 120-meter edge of row crops is also part of their preferred habitat (Badyaev 1995). Edge is an important part of wild turkey habitat in terms of food and nesting (Johnson 1965). The species also prefers habitats with a 50:50 mix of mast producing forests, <15% open land with row crops. Wild turkey's optimum habitat will include 40-60% forest cover; row crops 25-35%; pasture 10-15%; human development <10% (Schroeder 1985, Gustafson et al. 1994). Wild turkey prefers a minimum habitat area of 900 ha that is open deciduous or deciduous coniferous forests (especially mountainous regions). In Oklahoma this is mostly in river bottom forests or oak forests along edges and openings.

I identified wild turkey habitat by selecting deciduous forests, 120-meter edge of row crops, pasture, and low intensity residential areas (Badyaev 1995, Day et al. 1991).

Yellow warbler (*Dendroica petechia*)

Yellow warbler uses a wide range of habitat types but prefers shrubland (open deciduous shrubs), low intensity residential areas (orchards and bushes around rural houses), and deciduous forest within 30 meters of water edge (Collins et al. 1982). They also use woody upland adjacent to selected forest or woodland as habitat including willow thickets along streams, lakes and ponds. They are found in both moist (bogs, edges of swamps, marshes) and dry (roadside thickets, open scrub, second growth, farmlands, gardens) habitats. Yellow warbler breeds in disturbed and early successional habitats and fallow (Whitney and Thackson 2003).

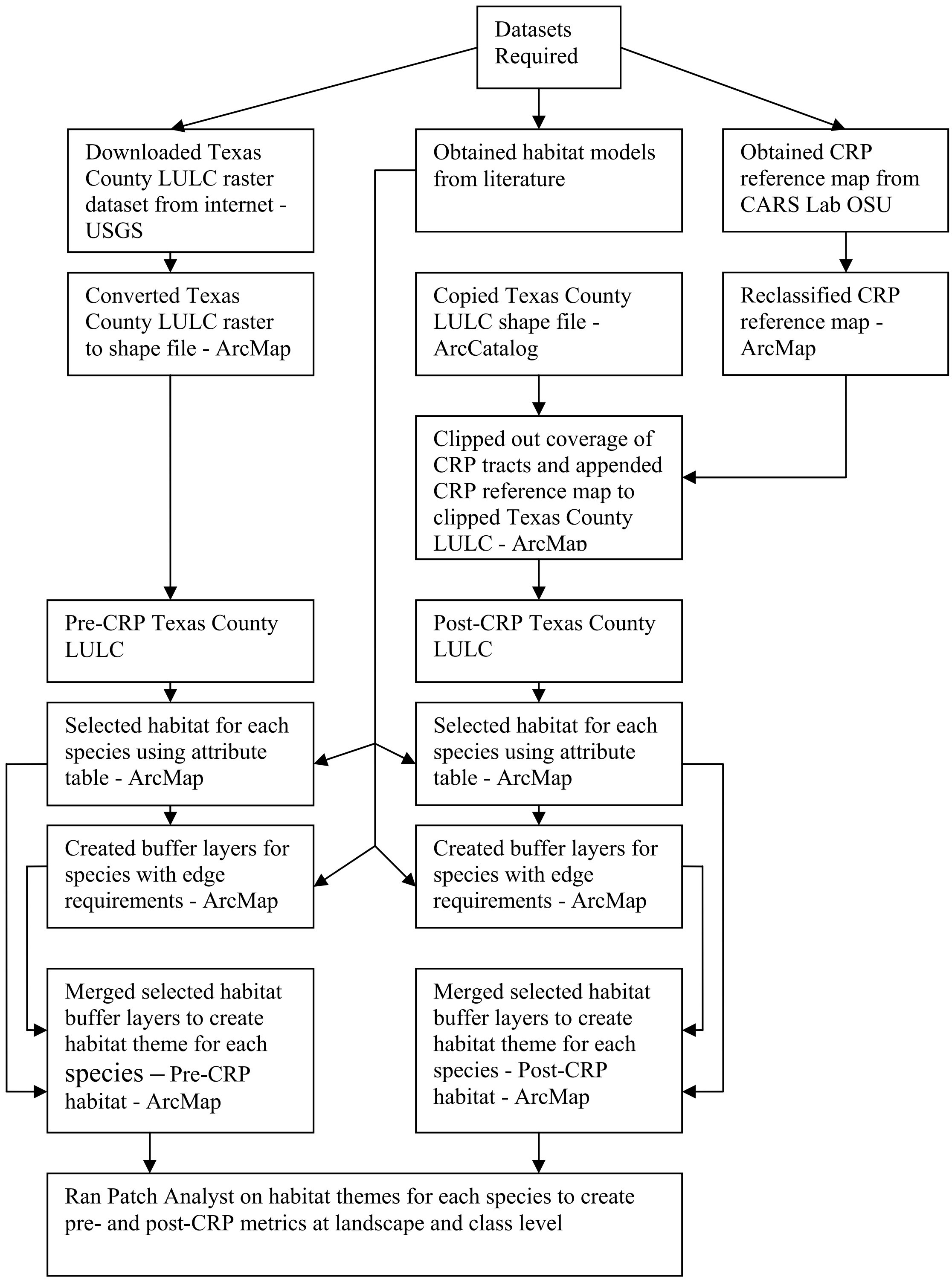

Figure 3.1: Methodology flow chart for determining possible habitat for studied species in Texas County, Oklahoma.

To identify yellow warbler habitat I selected shrubland, low intensity residential areas, and deciduous forest, and appended a buffer of 30 meters around the wetland cover type to the selection.

After creating habitat themes for all the species under study, I used ArcView 3.3 and Patch Analyst 3.1 an extension of ArcView. I calculated landscape metrics on each habitat theme. Metrics obtained include total habitat area (TLA), area occupied by each cover type (CA), number of patches (NUMP), mean patch size (MPS), total edge (TE), and mean shape index (MSI) for both pre- and post-CRP habitats.

Results

Table 3.1: Pre- and post-CRP habitat area for species in the study and percentage change of each habitat identified in Texas County, Oklahoma.

Habitat	Pre-CRP (Hectares)	Post-CRP (Hectares)	% Change
Cassin's sparrow	269145	354649	31.77
Lark sparrow	269569	355059	31.71
Eastern cotton-tail	337287	412765	22.38
Northern Bobwhite	337223	399629	18.51
White-tailed deer	274060	274115	0.02
Black-tailed prairie dog	253188	253188	0
Lesser prairie chicken	526861	526777	-0.02
Scaled quail	269868	269324	-0.02
Swift fox	269145	268607	-0.02
Wild turkey	1172	1167	-0.38
Yellow warbler	17909	17347	-3.14
Black-tailed jackrabbit	424597	397974	-6.27

Table 3.1 shows change in habitat area between the pre- and post-CRP landscape in Texas County, Oklahoma and tables 3.2 to 3.14 shows details of all metrics calculated. Black-tailed jackrabbit's selected habitat reduced by 6% in area and the number of patches reduced by approximately 9%. Total edge reduced by about 6% while mean patch size increased by about 3%.

Total selected habitat area for black-tailed prairie dog remained unchanged from the pre-CRP levels. The only change observed was in total edge which increased marginally by 0.03%.

Cassin's sparrow total selected habitat increased by 32%, NUMP reduced by more than 1% while TE and MPS increased by 12 and 34% respectively.

In the case of eastern cotton-tail selected habitat increased by 22% from the pre-CRP size while NUMP reduced by 7% while MPS and TE increased by 11 and 2%, respectively.

Lark sparrow's total selected habitat increased by 32% from the pre-CRP levels while MPS and TE increased by 34 and 12% respectively. There was however a reduction in NUMP by more than 1%.

Habitat area for lesser prairie chicken reduced by less than 1%. NUMP and TE also showed significant reduction of 14 and 10% respectively. There was an increase in MPS of about 17%.

Northern bobwhite habitat showed an increase of 17% (Figure 3.32 and 3.36). TE showed a reduction of 18% (Figure 3.32 and 3.36) while MPS increased by 44% (table 3.8). However, I observed a decrease in NUMP of about 18% (Figure 3.24 and 3.28).

I observed a reduction in almost all scaled quail's landscape metrics for the selected pre- and post-CRP habitats. Total habitat reduced by less than 1%, NUMP (3%) (table 3.9), MPS increased by 3%, and TE reduced by 1%, (see figure 3.16, 3.20, 3.24, 3.28, 3.32, 3.36 and table 3.9).

Swift fox experienced an increase in MPS of less than 1%, there was reduction in other metrics like TLA (0.02%), NUMP (3%), NUMP (3%) (table 3.10) while TE reduced by less more than 1%.

In the case of white-tailed deer there was increase in TLA (0.02%) and MPS (27%). However there was a reduction in TE (22%) and NUMP (22%) (see table 3.11).

Wild turkey selected habitat registered a reduction in all the calculated landscape metrics except for MPS which increased by 2%. TLA reduced by about 1%%, NUMP reduced by 2%, and TE reduced by about 1% (table 3.12).

The selected habitat area for yellow warbler showed some decrease of 3%, NUMP and TE reduced by 7 and 5% respectively. There was, however, an increase in MPS by 5% (see table 3.13).

The post-CRP MSI increased slightly in all selected habitats with the highest increase being observed for lesser prairie chicken (1.88%), (see table 3.4) and white-tailed deer (1.81%), (see table 3.11) and northern bobwhite (1.53%). For the rest of the selected habitats there was an average change in MSI of less than 1%. Detailed results of the analysis are given in the appendix section of this chapter.

Discussion

Compared to pre-CRP conditions, less habitat was available for black-tailed jack rabbit and lesser prairie. The reduction in habitat area for black-tailed jackrabbit is mainly due to loss of small grains to CRP. For lesser prairie chicken is due to loss of small grains, row crops, pasture and fallow to CRP.

Cassin's sparrow, lark sparrow, eastern cotton-tail, and northern bobwhite made major gains in habitat area due to the CRP which made up part of their habitat in the post-CRP Texas County landscape. Although white-tailed deer utilizes CRP tracts as habitat there is no increase in habitat area because the same agricultural field that formed part of the pre-CRP habitat have been enrolled into the CRP.

Although CRP land is planted with various types of grass species, not all wildlife species will find CRP tracts a suitable habitat. The main reasons could be that the grasses planted are not native (e.g., old world bluestem) or they are native but not present in the pre-agricultural habitat (e.g., big bluestem in shortgrass prairie).

The number of patches was reduced in all cases (except for white-tailed deer and lesser prairie chicken), which I attribute to a general reduction in the number of patches by conversion of grassland cover to CRP tracts and consolidation of smaller patches (e.g., small grains, row crops) into CRP tracts. The number of patches for white-tailed deer and lesser prairie chicken post-CRP habitat increased due to agricultural fields or cropland that was subdivided by CRP tracts. Increase in number of patches is an indication of a fragmented habitat (McGarigal and Marks 1994).

The mean patch size increased in all selected habitats and there was highest increase in Cassin's sparrow, eastern cotton-tail, lark sparrow, lesser prairie chicken, and northern bobwhite. These species have CRP tracts included as part of their habitat. The reduction in mean patch size is due to augmentation of small cover types into CRP tracts. The trend from small mean patch size to large mean patch size is a good indication of improved wildlife habitat. However, the trend from small mean patch size to large mean patch size was not pronounced in habitats that did not include CRP cover as part of the habitat.

Total edge reduced in all selected habitats except for black-tailed prairie dog, Cassin's sparrow, eastern cotton-tail, and lark sparrow which showed an increase. The highest reduction in total edge was seen in lesser prairie chicken, northern bobwhite, and white-tailed deer. This may be an indication of reduced fragmentation in those habitats especially where there is reduction in number of patches and increase in mean patch size.

Taken as a whole, I can say that the effect of the CRP has been an increase in habitat area for those species that are capable of using CRP cover as part of their habitat. For species that do not utilize CRP tracts as habitat, there a reduction in habitat area. In as much as cover may have increased, some species have lost foraging area in terms of agricultural fields that have been converted to CRP fields. The CRP is good for wildlife since it has increased habitat area, patch size, reduced the number of patches thereby reducing fragmentation.

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Appendix

Table 3.2: Black-tailed jackrabbit's habitat landscape (entire habitat) and class metrics, Texas County, Oklahoma.

COVER	CA			% of Total Habitat			NUMP		
	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change
Entire Habitat	424597	397974	-6.27	100	100	0.00	51142	46715	-8.66
Grassland	253188	253188	0.00	59.63	63.62	6.69	22606	22606	0.00
Shrubland	15957	15418	-3.38	3.76	3.87	3.09	12572	11523	-8.34
Small Grains	155452	129367	-16.78	36.61	32.51	-11.21	15964	12586	-21.16
COVER	**MPS**			**TE**			**MSI**		
	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change
Entire Habitat	8.30	8.52	2.61	38294081	36052074	-5.85	1.38	1.38	0.60
Grassland	11.20	11.20	0.00	19092849	19099436	0.03	1.37	1.37	0.00
Shrubland	1.27	1.34	5.42	4520384	4254970	-5.87	1.34	1.35	0.71
Small Grains	9.74	10.28	5.56	14680848	12697668	-13.51	1.40	1.43	1.93

Table 3.3: Black-tailed prairie dog's habitat landscape (entire habitat) and class metrics, Texas County, Oklahoma.

COVER	CA			% of Total Habitat			NUMP		
	Pre-CRP	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**
Entire Habitat	253188	253188	0.00	100	100	0.00	22606	22606	0.00
Grassland	253188	253188	0.00	100	100	0.00	22606	22606	0.00
COVER	**MPS**			**TE**			**MSI**		
	Pre-CRP	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**
Entire Habitat	11.20	11.20	0.00	19092849	19099436	0.03	1.37	1.37	0.00
Grassland	11.20	11.20	0.00	19092849	19099436	0.03	1.37	1.37	0.00

Table 3.4: Habitat landscape (entire habitat) and class metrics for Cassin's sparrow, Texas County, Oklahoma.

COVER	CA			% of Total Habitat			NUMP		
	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change
Entire Habitat	269145	354649	31.77	100	100	0.00	35178	34704	-1.35
Grassland	253188	253188	0.00	94.07	71.39	-24.11	22606	22606	0.00
Shrubland	15957	15418	-3.38	5.93	4.35	-26.67	12572	11523	-8.34
CRP		86042						575	
COVER	**MPS**			**TE**			**MSI**		
	Pre-CRP	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**
Entire Habitat	7.65	10.22	33.57	23613233	26490550	12.19	1.36	1.37	0.30
Grassland	11.20	11.20	0.00	19092849	19099436	0.03	1.37	1.37	0.00
Shrubland	1.27	1.34	5.42	4520384	4254970	-5.87	1.34	1.35	0.71
CRP		149.64			3136144			1.38	

Table 3.5: Eastern cotton-tail's habitat landscape (entire habitat) and class metrics, Texas County, Oklahoma.

COVER	CA			% of Total Habitat			NUMP		
	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change
Entire Habitat	337287	412765	22.38	100	100	0.00	39844	37218	-6.59
Deciduous Forest	388	383	-1.15	0.11	0.09	-19.22	1067	1043	-2.25
Evergreen Forest	75	67	-10.59	0.02	0.02	-26.94	343	312	-9.04
Grassland	253188	253188	0.00	75.07	61.34	-18.29	22606	22606	0.00
Mixed Forest	7	7	-5.43	0.00	0.00	-22.72	99	96	-3.03
Small Grains	83629	73078	-12.62	24.79	17.70	-28.60	15729	12586	-19.98
CRP		86042						575	

COVER	MPS			TE			MSI		
	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change
Entire Habitat	8.47	11.09	31.01	39453262	40136092	1.73	1.42	1.43	0.55
Deciduous Forest	0.36	0.37	1.13	249717	245445	-1.71	1.32	1.32	0.13
Evergreen Forest	0.22	0.21	-1.71	65879	59176	-10.18	1.29	1.30	0.16
Grassland	11.20	11.20	0.00	19092849	19099436	0.03	1.37	1.37	0.00
Mixed Forest	0.07	0.07	-2.47	11937	11359	-4.84	1.28	1.28	0.28
Small Grains	5.32	5.81	9.20	20032880	17584532	-12.22	1.49	1.53	2.82
CRP		149.64			3136144			1.38	

Table 3.6: Lark sparrow's habitat landscape (entire habitat) and class metrics, Texas County, Oklahoma.

COVER	CA			% of Total Habitat			NUMP		
	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change
Entire Habitat	269569	355059	31.71	100	100	0.00	36693	36156	-1.46
Forest Edge	424	410	-3.08	0.16	0.12	-26.42	1515	1452	-4.16
Grassland	253188	253188	0.00	93.92	71.31	-24.08	22606	22606	0.00
Shrubland	15957	15418	-3.38	5.92	4.34	-26.64	12572	11523	-8.34
CRP		86042						575	
COVER	**MPS**			**TE**			**MSI**		
	Pre-CRP	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**
Entire Habitat	7.35	9.82	33.67	23975631	26840659	11.95	1.36	1.37	0.30
Forest Edge	0.28	0.28	1.12	362398	350108	-3.39	1.35	1.36	0.30
Grassland	11.20	11.20	0.00	19092849	19099436	0.03	1.37	1.37	0.00
Shrubland	1.27	1.34	5.42	4520384	4254970	-5.87	1.34	1.35	0.71
CRP		149.64			3136144			1.38	

Table 3.7: Lesser prairie chicken's habitat landscape (entire habitat) and class metrics, Texas County, Oklahoma.

COVER	CA			% of Total Habitat			NUMP		
	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change
Entire Habitat	526861	526777	-0.02	100	100	0.00	78390	67246	-14.22
Fallow	1171	684	-41.62	0.22	0.13	-41.61	1629	1151	-29.34
Grassland	253188	253045	-0.06	48.06	48.04	-0.04	22606	23485	3.89
Pasture, Hay	10505	9401	-10.51	1.99	1.78	-10.49	6342	5558	-12.36
Row Crops	90587	32881	-63.70	17.19	6.24	-63.70	19277	11654	-39.54
Shrubland	15957	15412	-3.42	3.03	2.93	-3.40	12572	11547	-8.15
Small Grains	155452	129304	-16.82	29.51	24.55	-16.81	15964	13276	-16.84
CRP		86051						575	
COVER	**MPS**			**TE**			**MSI**		
	Pre-CRP	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**
Entire Habitat	6.72	7.83	16.55	53493058	48127285	-10.03	1.38	1.40	1.88
Fallow	0.72	0.59	-17.37	481838	320648	-33.45	1.32	1.38	4.20
Grassland	11.20	10.77	-3.80	19092849	19083781	-0.05	1.37	1.40	1.92
Pasture, Hay	1.66	1.69	2.12	2511122	2194568	-12.61	1.34	1.36	1.35
Row Crops	4.70	2.82	-39.96	12206017	6462056	-47.06	1.39	1.42	2.44
Shrubland	1.27	1.33	5.15	4520384	4251384	-5.95	1.34	1.35	0.70
Small Grains	9.74	9.74	0.02	14680848	12678499	-13.64	1.40	1.45	2.95
CRP		149.65			3136350			1.38	

Table 3.8: Northern bobwhite's habitat landscape (entire habitat) and class metrics, Texas County, Oklahoma.

COVER	CA			% of Total Habitat			NUMP		
	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change
Entire Habitat	337223	399629	18.51	100	100	0.00	73677	60769	-17.52
Fallow	1971	684	-65.30	0.58	0.17	-70.72	3258	1138	-65.07
Grassland	253188	253188	0.00	75.08	63.36	-15.62	22606	22606	0.00
Row Crops	28031	13777	-50.85	8.31	3.45	-58.53	19277	11653	-39.55
Shrubland	15957	15418	-3.38	4.73	3.86	-18.47	12572	11523	-8.34
Small Grains	38076	30519	-19.85	11.29	7.64	-32.36	15964	13274	-16.85
CRP		86042						575	
COVER	**MPS**			**TE**			**MSI**		
	Pre-CRP	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**
Entire Habitat	4.58	6.58	43.68	68953890	56860680	-17.54	1.54	1.56	1.53
Fallow	0.61	0.60	-0.65	1074882	320744	-70.16	1.38	1.38	-0.28
Grassland	11.20	11.20	0.00	19092849	19099436	0.03	1.37	1.37	0.00
Row Crops	1.45	1.18	-18.69	18991631	9482129	-50.07	1.67	1.79	6.67
Shrubland	1.27	1.34	5.42	4520384	4254970	-5.87	1.34	1.35	0.71
Small Grains	2.39	2.30	-3.60	25274144	20567257	-18.62	1.80	1.90	5.44
CRP		149.64			3136144			1.38	

Table 3.9: Scaled quail's habitat landscape (entire habitat) and class metrics, Texas County, Oklahoma.

COVER	CA			% of Total Habitat			NUMP		
	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change
Entire Habitat	269868	269324	-0.20	100	100	0.00	35597	34547	-2.95
Grassland	253188	253188	0.00	93.82	94.01	0.20	22606	22606	0.00
Low Intensity Residential	722	717	-0.71	0.27	0.27	-0.51	419	418	-0.24
Shrubland	15957	15418	-3.38	5.91	5.72	-3.18	12572	11523	-8.34
COVER	MPS			TE			MSI		
	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change
Entire Habitat	7.58	7.80	2.83	23848152	23588184	-1.09	1.36	1.37	0.28
Grassland	11.20	11.20	0.00	19092849	19099436	0.03	1.37	1.37	0.00
Low Intensity Residential	1.72	1.72	-0.47	234919	233777	-0.49	1.39	1.39	0.01
Shrubland	1.27	1.34	5.42	4520384	4254970	-5.87	1.34	1.35	0.71

Table 3.10: Habitat landscape (entire habitat) and class metrics for swift fox, Texas County, Oklahoma.

COVER	CA			% of Total Habitat			NUMP		
	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change
Entire Habitat	269145	268607	-0.20	100	100	0.00	35178	34129	-2.98
Grassland	253188	253188	0.00	94.07	94.26	0.20	22606	22606	0.00
Shrubland	15957	15418	-3.38	5.93	5.74	-3.18	12572	11523	-8.34
COVER	MPS			TE			MSI		
	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change
Entire Habitat	7.65	7.87	2.87	23613233	23354406	-1.10	1.36	1.37	0.28
Grassland	11.20	11.20	0.00	19092849	19099436	0.03	1.37	1.37	0.00
Shrubland	1.27	1.34	5.42	4520384	4254970	-5.87	1.34	1.35	0.71

Table 3.11: White-tailed deer habitat landscape (entire habitat) and class metrics, Texas County, Oklahoma.

COVER	CA			% of Total Habitat			NUMP		
	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change
Entire Habitat	274060	274115	0.02	100	100	0.00	56851	44804	-21.19
Deciduous Forest	388	383	-1.15	0.14	0.14	-1.17	1067	1043	-2.25
Fallow	1171	684	-41.62	0.43	0.25	-41.63	1629	1151	-29.34
Pasture, Hay	10505	9401	-10.51	3.83	3.43	-10.52	6342	5558	-12.36
Row Crops	90587	32881	-63.70	33.05	12.00	-63.71	19277	11654	-39.54
Shrubland	15957	15412	-3.42	5.82	5.62	-3.44	12572	11547	-8.15
Small Grains	155452	129304	-16.82	56.72	47.17	-16.84	15964	13276	-16.84
CRP		86051						575	
COVER	**MPS**			**TE**			**MSI**		
	Pre-CRP	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**
Entire Habitat	4.82	6.12	26.91	34649926	29288950	-15.47	1.37	1.40	1.81
Deciduous Forest	0.36	0.37	1.13	249717	245445	-1.71	1.32	1.32	0.13
Fallow	0.72	0.59	-17.37	481838	320648	-33.45	1.32	1.38	4.20
Pasture, Hay	1.66	1.69	2.12	2511122	2194568	-12.61	1.34	1.36	1.35
Row Crops	4.70	2.82	-39.96	12206017	6462056	-47.06	1.39	1.42	2.44
Shrubland	1.27	1.33	5.15	4520384	4251384	-5.95	1.34	1.35	0.70
Small Grains	9.74	9.74	0.02	14680848	12678499	-13.64	1.40	1.45	2.95
CRP		149.65			3136350			1.38	

Table 3.12: Wild turkey habitat landscape (entire habitat) and class metrics, Texas County, Oklahoma.

COVER	CA			% of Total Habitat			NUMP		
	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change
Entire Habitat	1172	1167	-0.38	100	100	0.05	1215	1191	-1.98
Deciduous Forest	388	383	-1.15	33.06	32.82	-0.72	1067	1043	-2.25
Low Intensity Residential	371	371	0.00	31.69	31.83	0.43	26	26	0.00
Pasture, Hay	267	267	0.00	22.75	22.85	0.43	68	68	0.00
Row Crops	146	146	0.00	12.45	12.51	0.43	54	54	0.00
COVER	**MPS**			**TE**			**MSI**		
	Pre-CRP	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**
Entire Habitat	0.96	0.98	1.63	439259	434987	-0.97	1.35	1.35	0.16
Deciduous Forest	0.36	0.37	1.13	249717	245445	-1.71	1.32	1.32	0.13
Low Intensity Residential	14.29	14.29	0.00	93859	93859	0.00	2.12	2.12	0.00
Pasture, Hay	3.92	3.92	0.00	60738	60738	0.00	1.49	1.49	0.00
Row Crops	2.70	2.70	0.00	34945	34945	0.00	1.38	1.38	0.00

Table 3.13: Yellow warbler's habitat landscape (entire habitat) and class metrics Texas County, Oklahoma.

COVER	CA			% of Total Habitat			NUMP		
	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change	Pre-CRP	Post-CRP	% Change
Entire Habitat	17909	17347	-3.14	100	100	0.00	14685	13598	-7.40
30 m Wetland Edge	842	829	-1.61	4.70	4.78	1.58	627	614	-2.07
Deciduous Forest	388	383	-1.15	2.16	2.21	2.06	1067	1043	-2.25
Low Intensity Residential	722	717	-0.71	4.03	4.13	2.51	419	418	-0.24
Shrubland	15957	15418	-3.38	89.10	88.88	-0.25	12572	11523	-8.34
COVER	**MPS**			**TE**			**MSI**		
	Pre-CRP	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**	**Pre-CRP**	**Post-CRP**	**% Change**
Entire Habitat	1.22	1.28	4.61	5594607	5314401	-5.01	1.37	1.38	0.74
30 m Wetland Edge	1.34	1.35	0.47	589586	580208	-1.59	2.04	2.04	0.16
Deciduous Forest	0.36	0.37	1.13	249717	245445	-1.71	1.32	1.32	0.13
Low Intensity Residential	1.72	1.72	-0.47	234919	233777	-0.49	1.39	1.39	0.01
Shrubland	1.27	1.34	5.42	4520384	4254970	-5.87	1.34	1.35	0.71

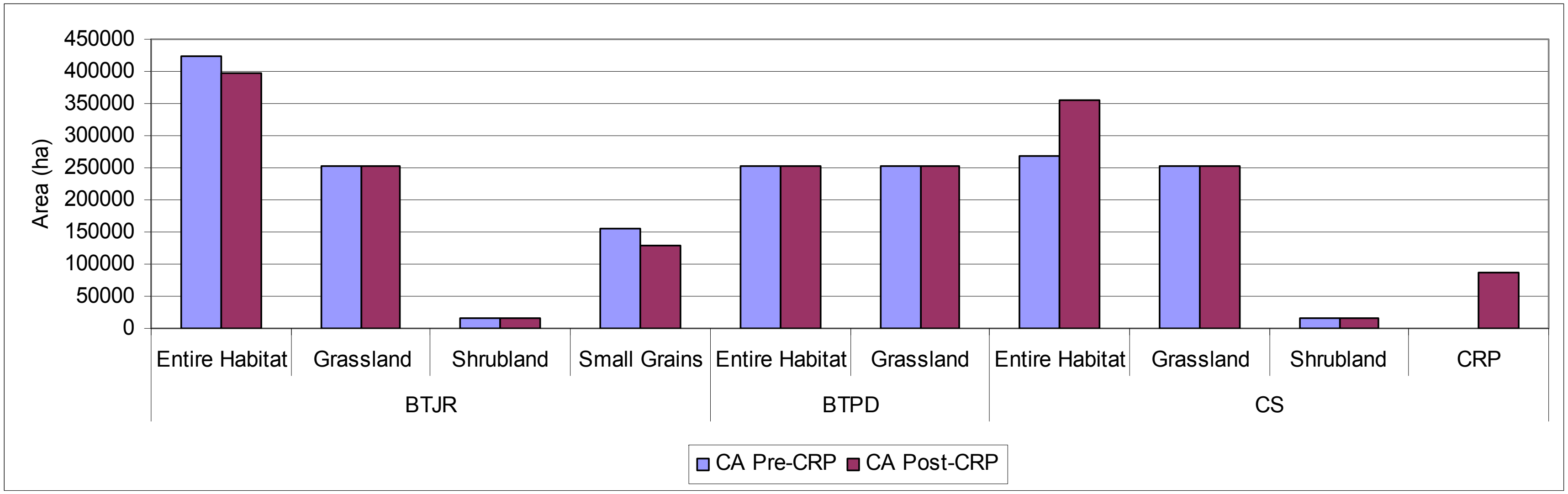

Figure 3.2: Class area (CA) for black-tailed jack rabbit (BTJR), black-tailed prairie dog (BTPD), and Cassin's sparrow (CS) habitats in Texas County, Oklahoma.

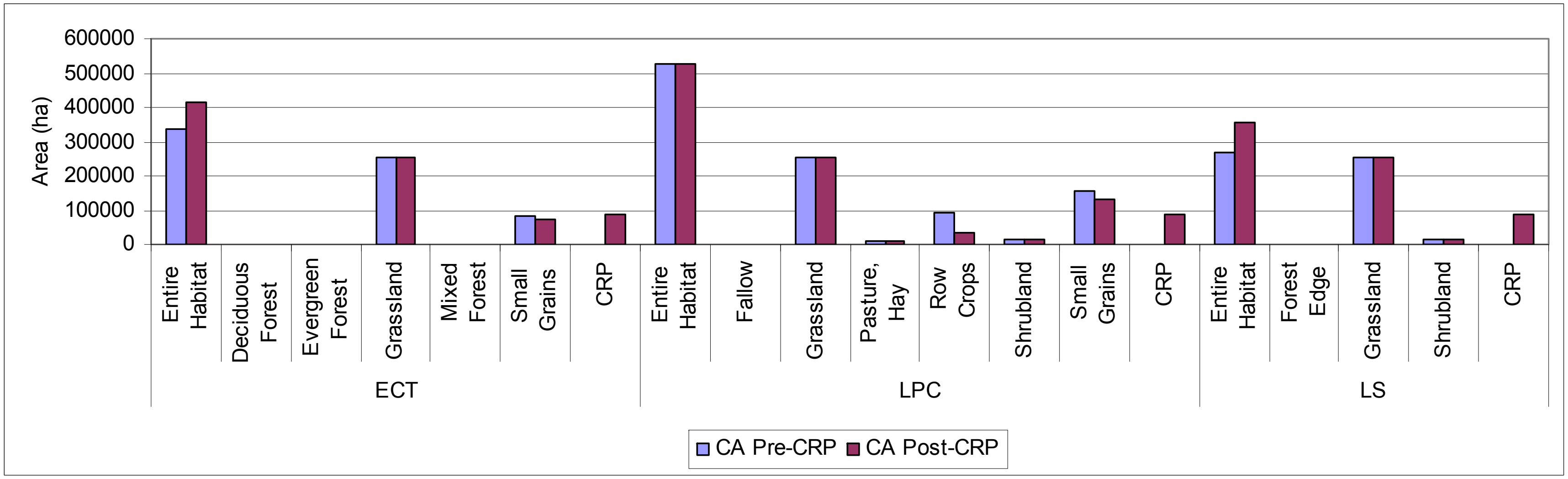

Figure 3.3: Class area (CA) for eastern cotton-tail (ECT), lesser prairie chicken (LPC), and lark sparrow (LS) habitats in Texas County, Oklahoma.

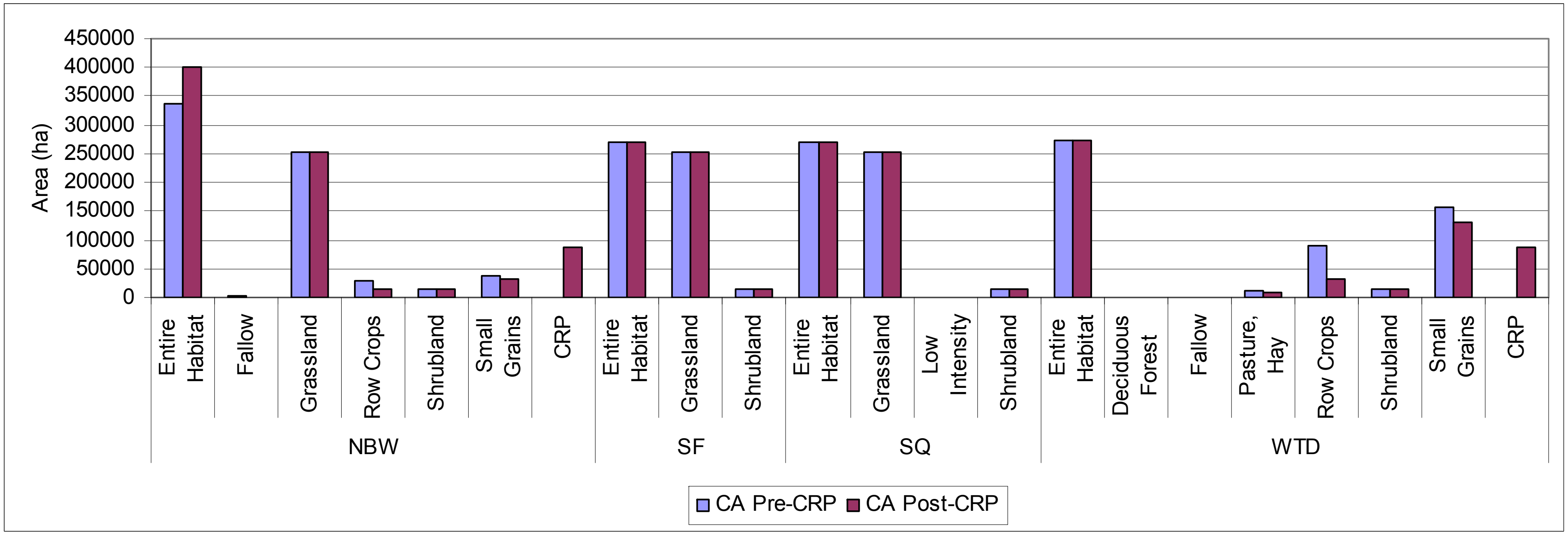

Figure 3.4: Class area (CA) for northern bobwhite (NBW), swift fox (SF), scaled quail (SQ), and white-tailed deer (WTD), habitats in Texas County, Oklahoma.

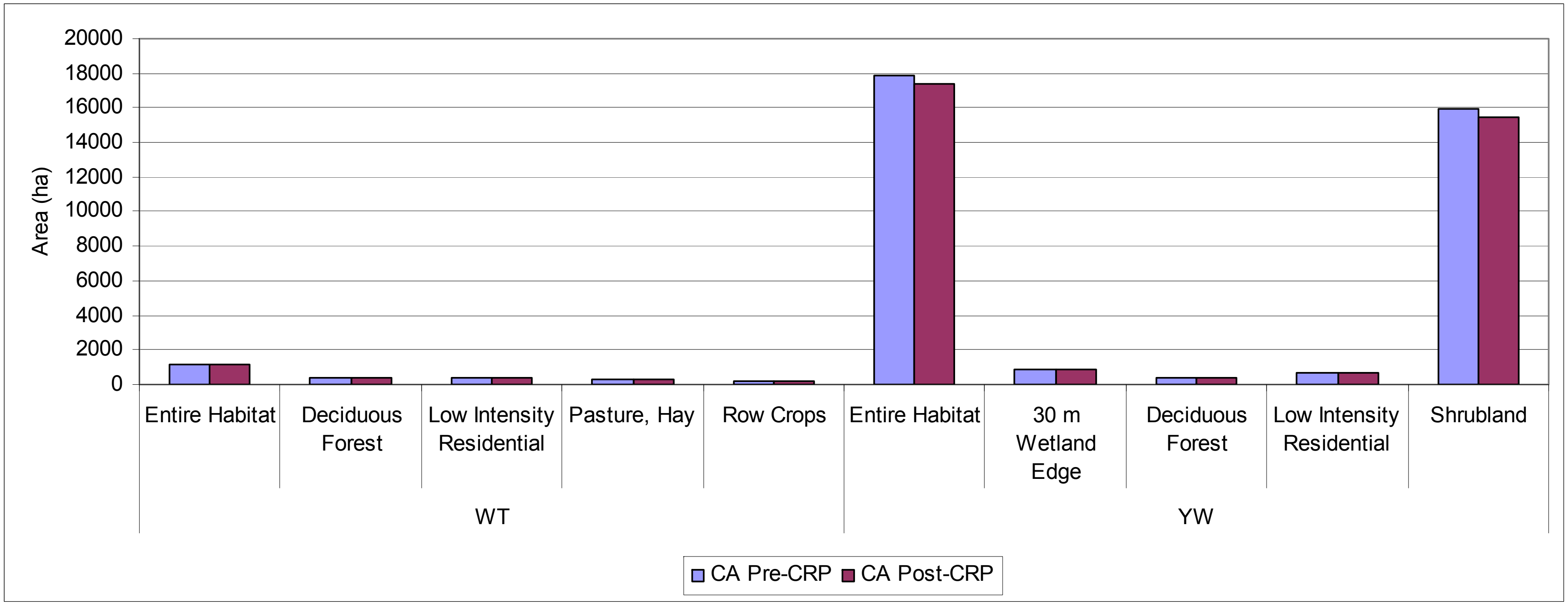

Figure 3.5: Class area (CA) for wild turkey (WT) and yellow warbler (YW) habitats in Texas County, Oklahoma.

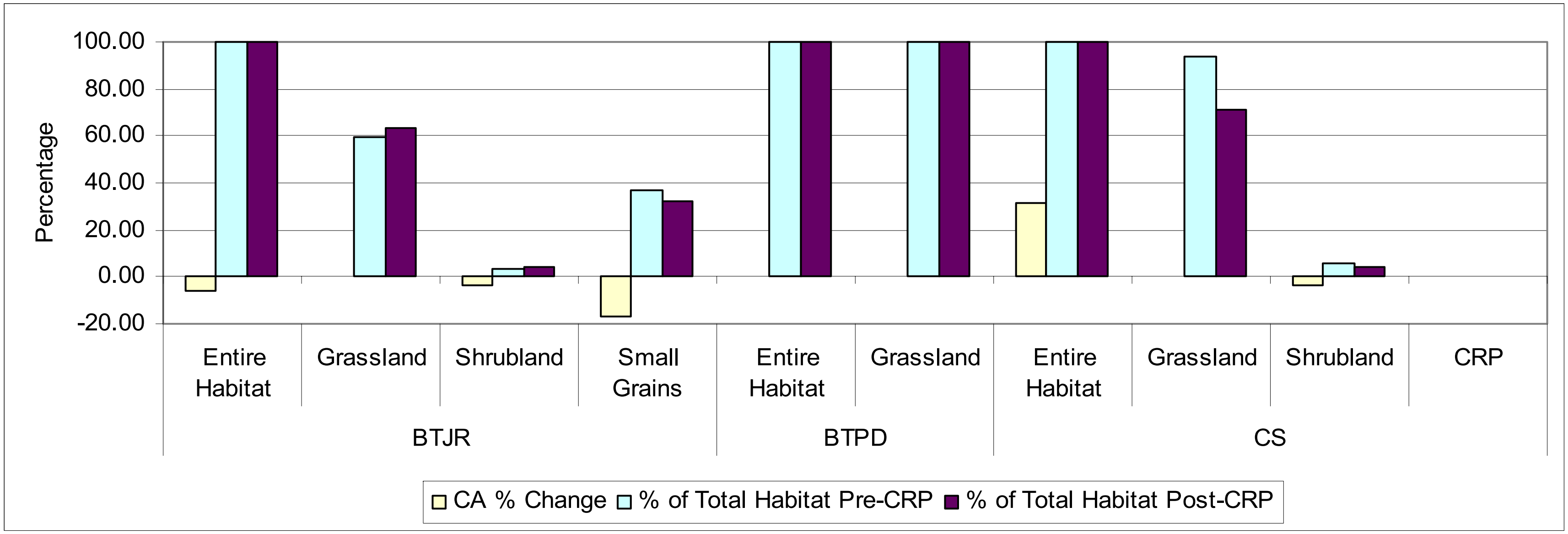

Figure 3.6: Percentage class area (CA %) and percentage of total habitat for black-tailed jackrabbit (BTJR), black-tailed prairie dog (BTPD), and Cassin's sparrow (CS) habitats in Texas County, Oklahoma.

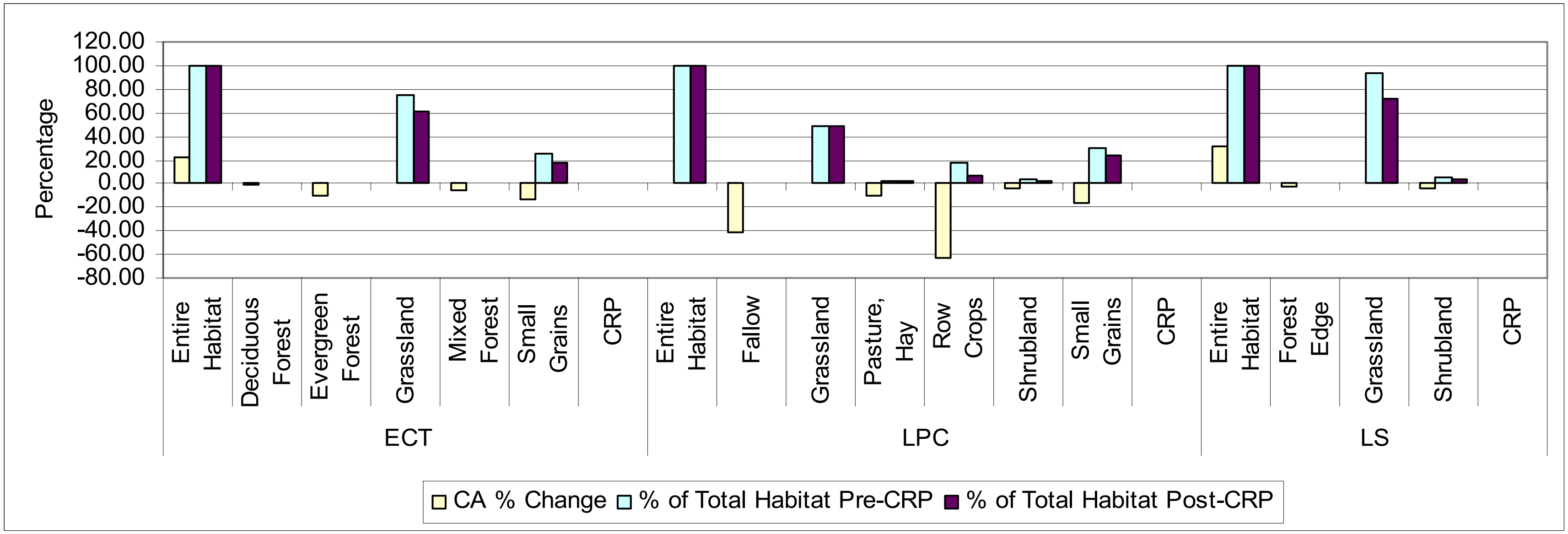

Figure 3.7: Percentage class area (CA %) and percentage of total habitat for eastern cotton-tail (ECT), lesser prairie chicken (LPC), and lark sparrow (LS) habitats in Texas County, Oklahoma.

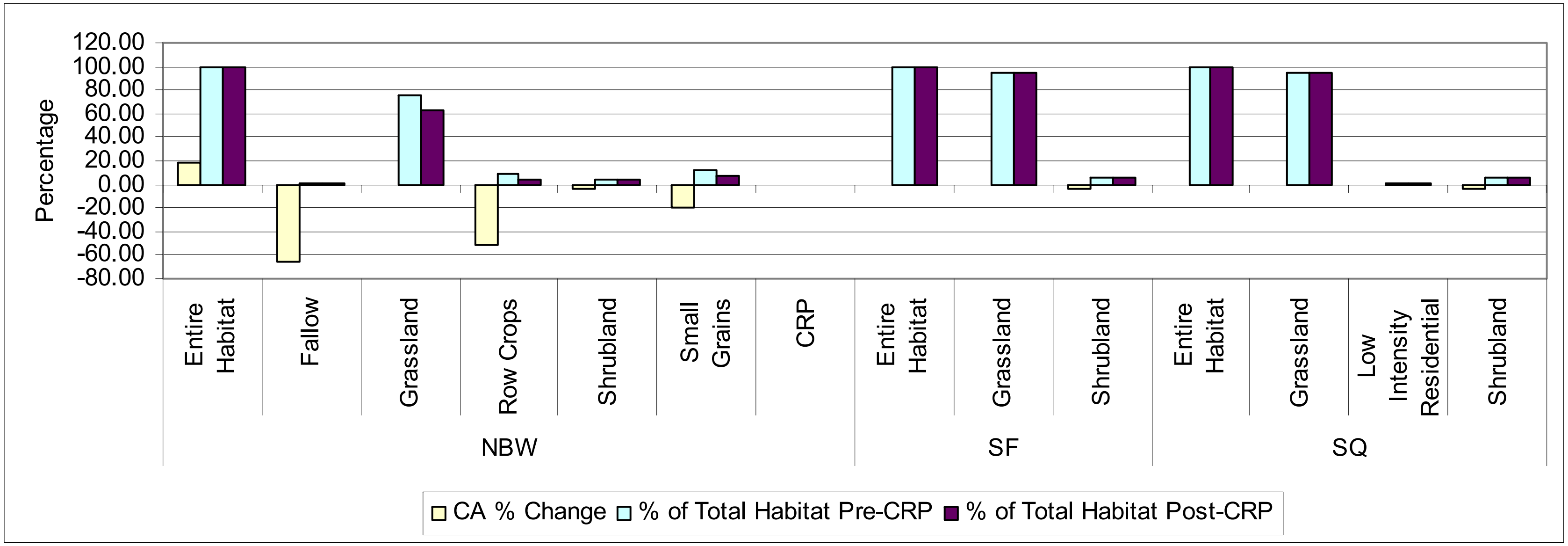

Figure 3.8: Percentage class area (CA %) and percentage of total habitat for northern bobwhite (NBW), swift fox (SF), and scaled quail (SQ) habitats in Texas County, Oklahoma.

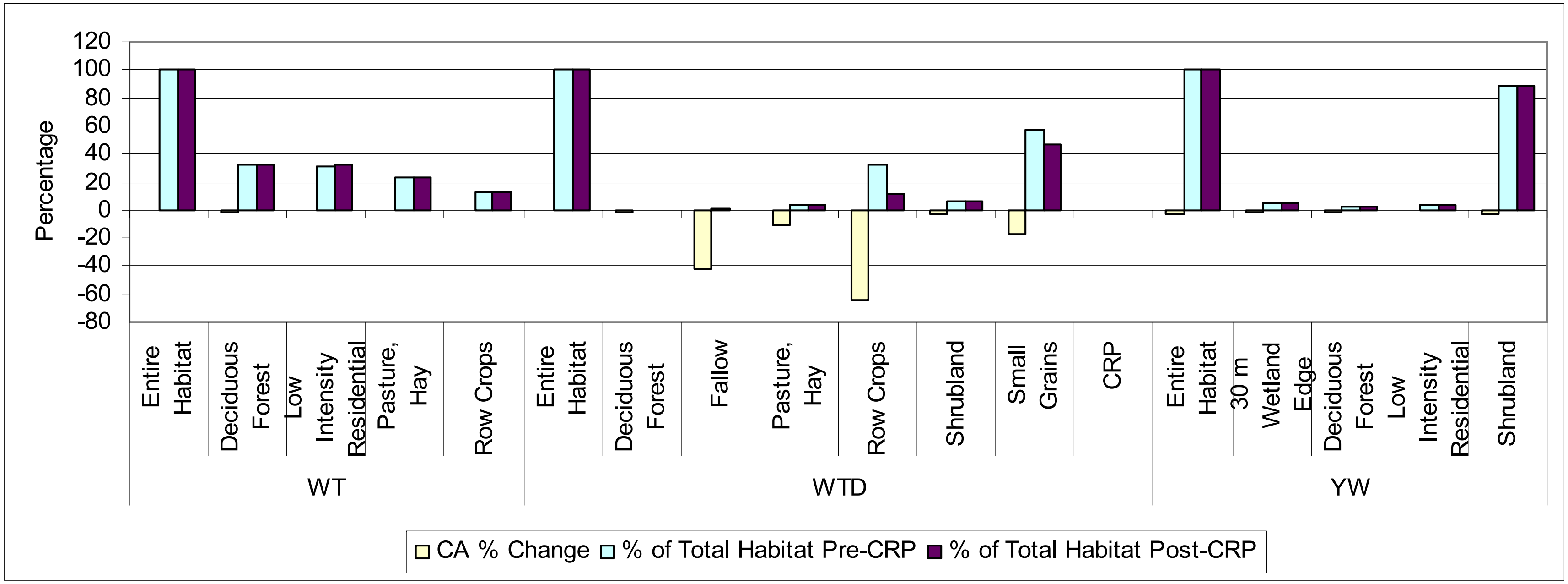

Figure 3.9: Percentage class area (CA %) and percentage of total habitat for white-tailed deer (WTD), wild turkey (WT), and yellow warbler (YW) habitats in Texas County, Oklahoma.

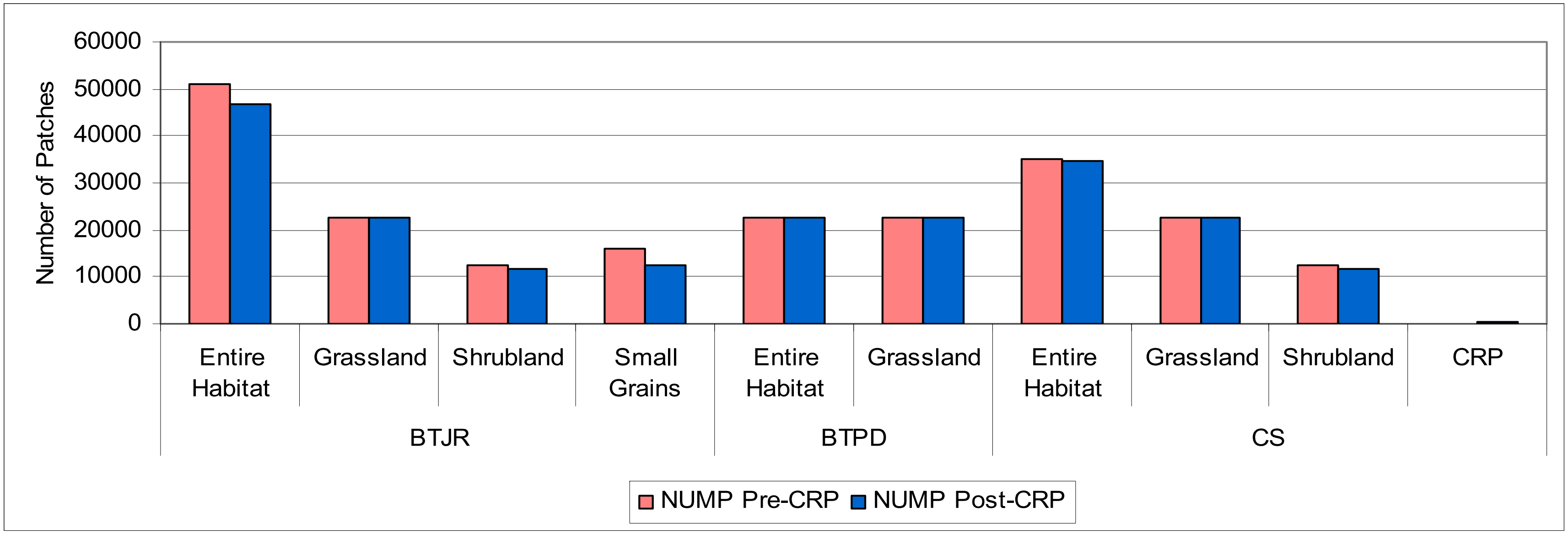

Figure 3.10: Number of patches (NUMP) for pre- and post-CRP black-tailed jackrabbit (BTJR), black-tailed prairie dog BTPD), and Cassin's sparrow (CS) habitats in Texas County, Oklahoma.

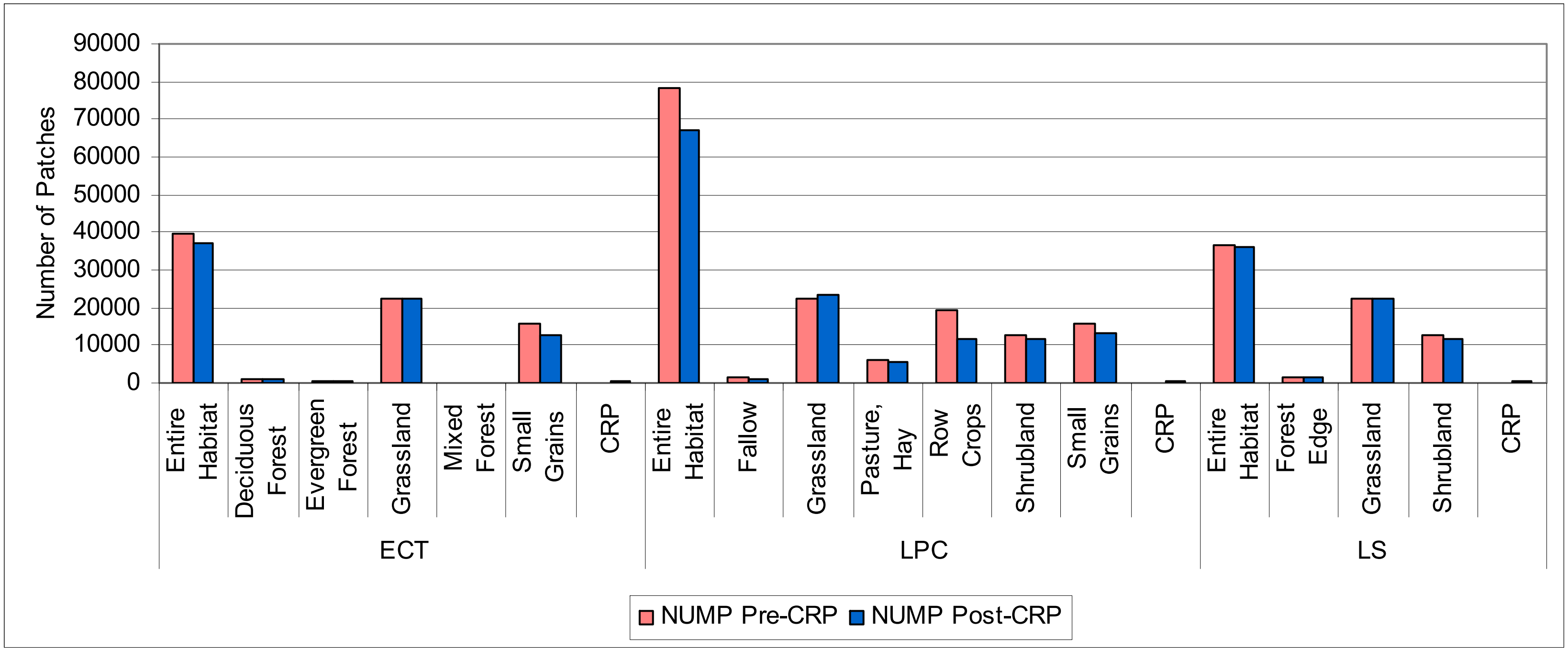

Figure 3.11: Number of patches (NUMP) for pre- and post-CRP eastern cotton-tail (ECT), lesser prairie chicken (LPC), and lark sparrow (LS) habitats in Texas County, Oklahoma.

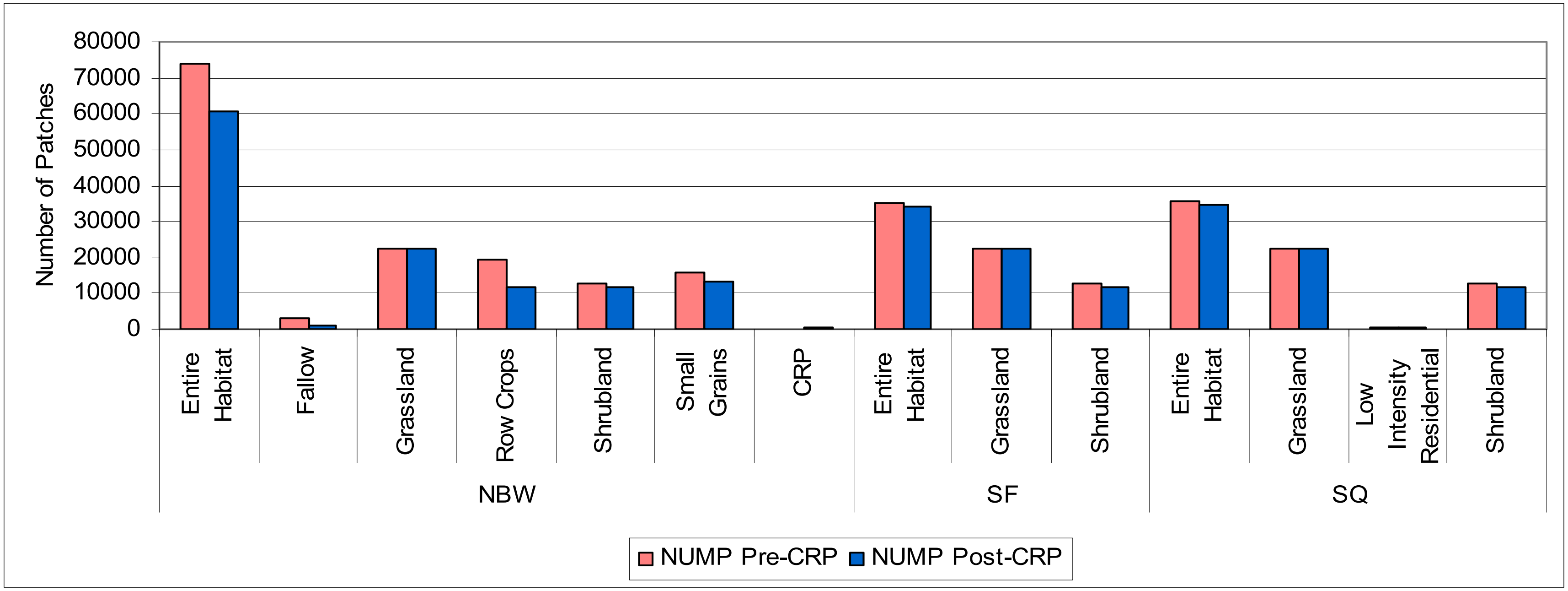

Figure 3.12: Number of patches (NUMP) for pre- and post-CRP northern bobwhite (NBW), swift fox (SF), and scaled quail (SQ) habitats in Texas County, Oklahoma.

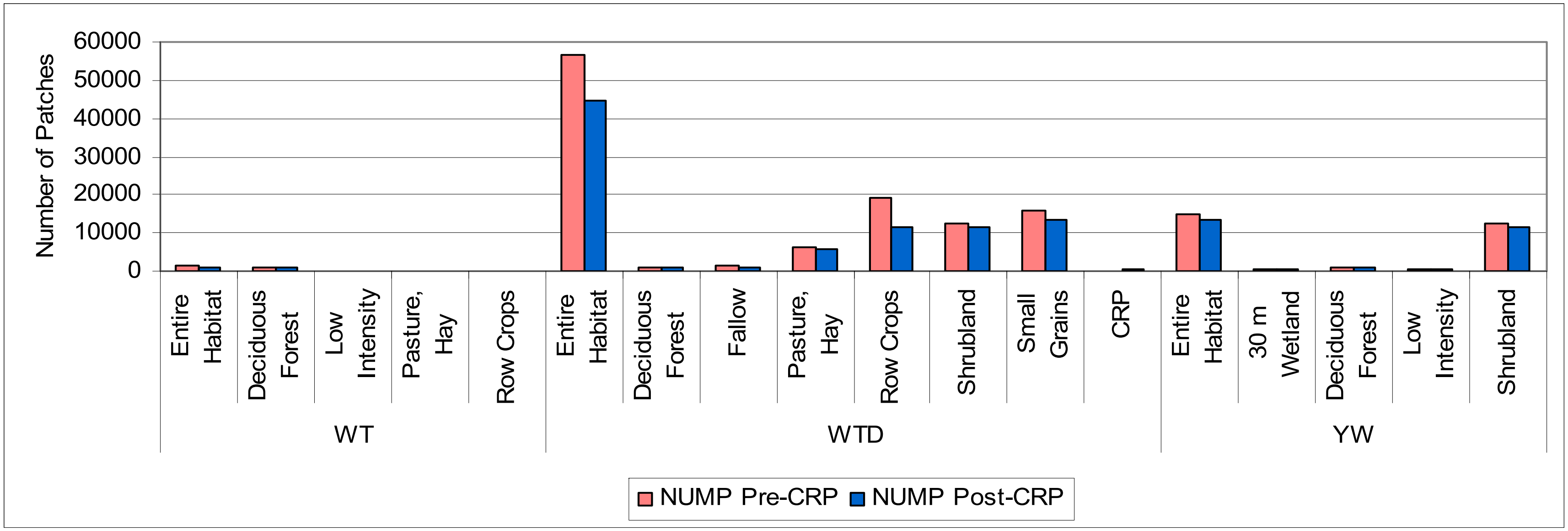

Figure 3.13: Number of patches (NUMP) for pre- and post-CRP wild turkey (WT), white-tailed deer (WTD), and yellow warbler (YW) habitats in Texas County, Oklahoma.

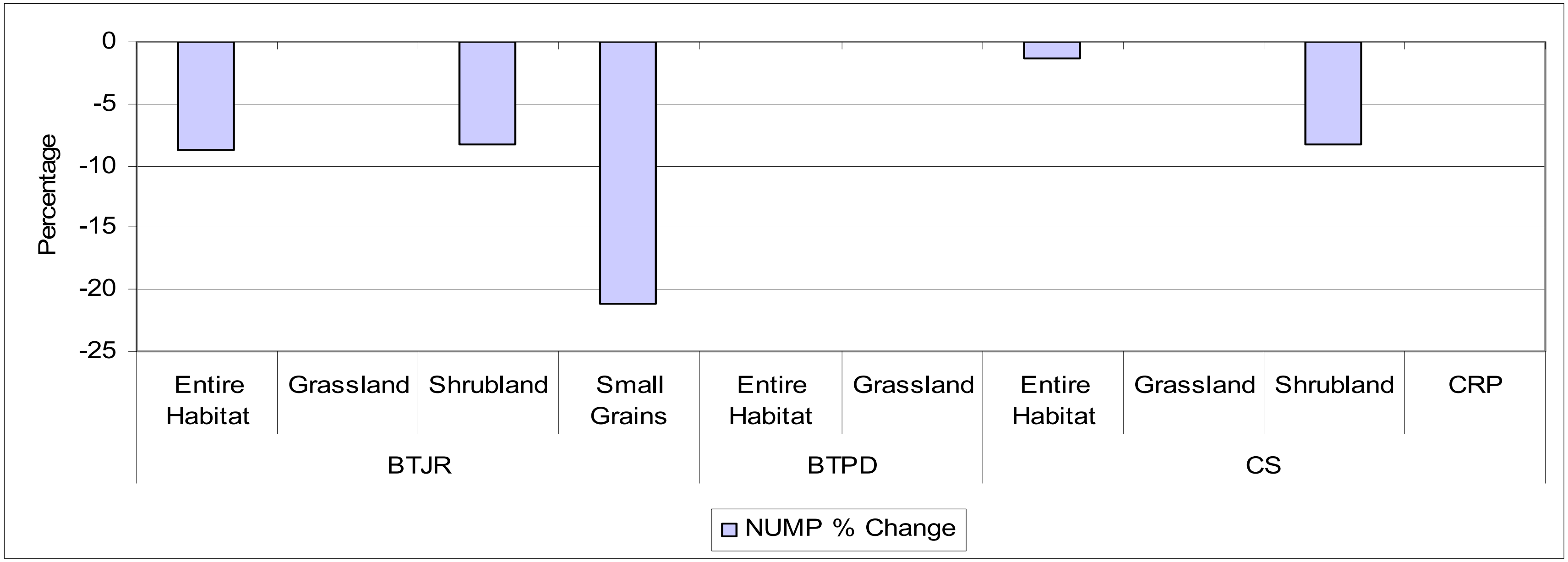

Figure 3.14: Percentage change in number of patches (NUMP % change) for pre- and post-CRP black-tailed jackrabbit (BTJR), black-tailed prairie dog (BTPD), and Cassin's sparrow (CS) habitats in Texas County, Oklahoma.

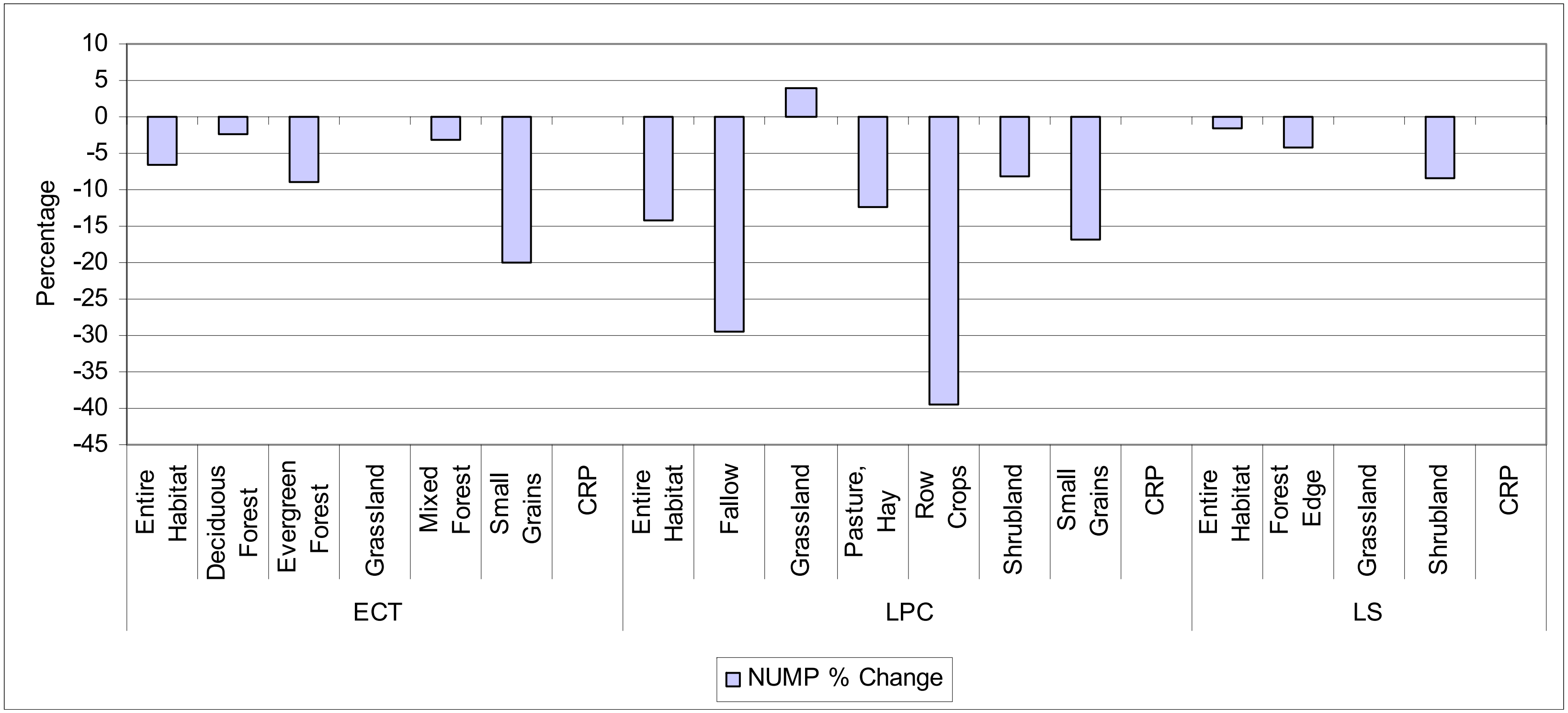

Figure 3.15: Percentage change in number of patches (NUMP % change) for pre- and post-CRP eastern cotton-tail (ECT), lesser prairie chicken (LPC) and lark sparrow (LS) habitats in Texas County, Oklahoma.

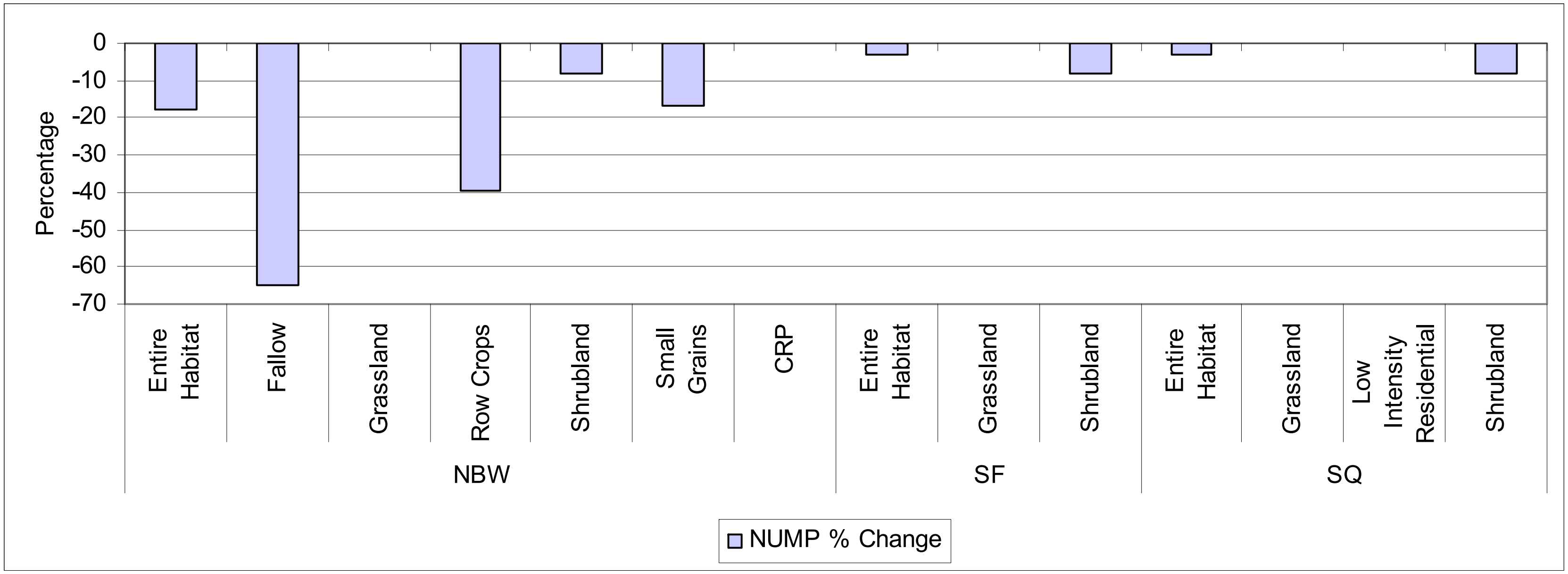

Figure 3.16: Percentage change in number of patches (NUMP % change) for pre- and post-CRP northern bobwhite (NBW), swift fox (SF), and scaled quail (SQ) habitats in Texas County, Oklahoma.

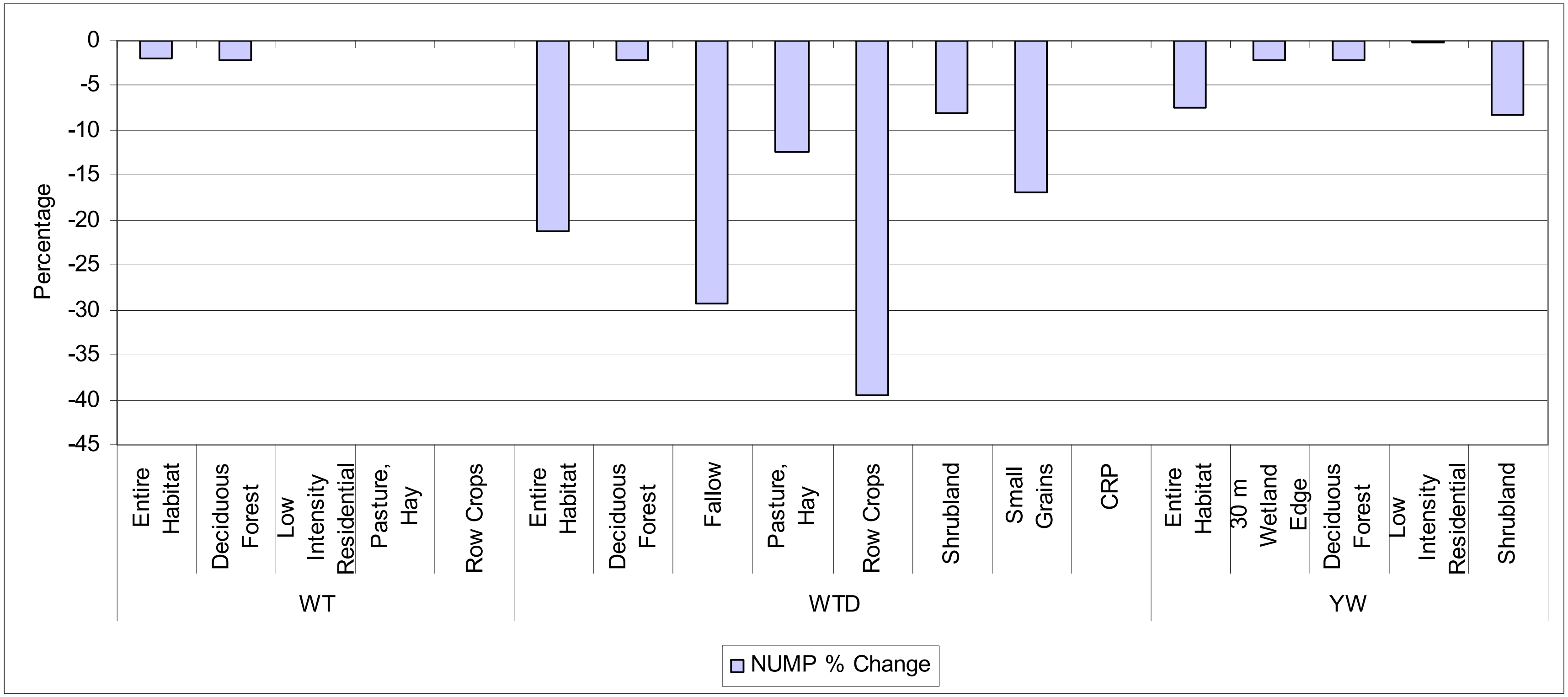

Figure 3.17: Percentage change in number of patches (NUMP % change) for pre- and post-CRP wild turkey (WT), white-tailed deer (WTD), and yellow warbler (YW) habitats in Texas County, Oklahoma.

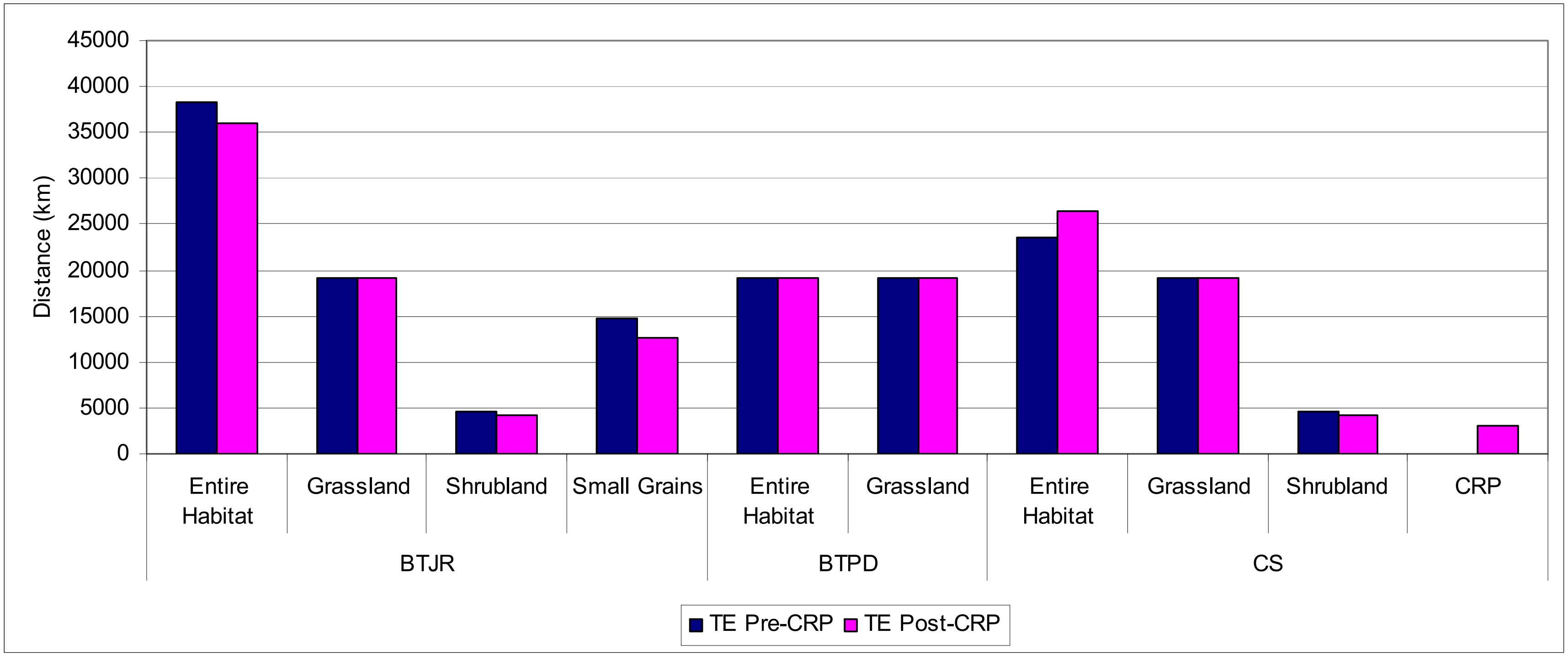

Figure 3.18: Total edge (TE) for pre- and post-CRP black-tailed jackrabbit (BTJR), black-tailed prairie dog (BTPD), and Cassin's sparrow (CS) habitats in Texas County, Oklahoma.

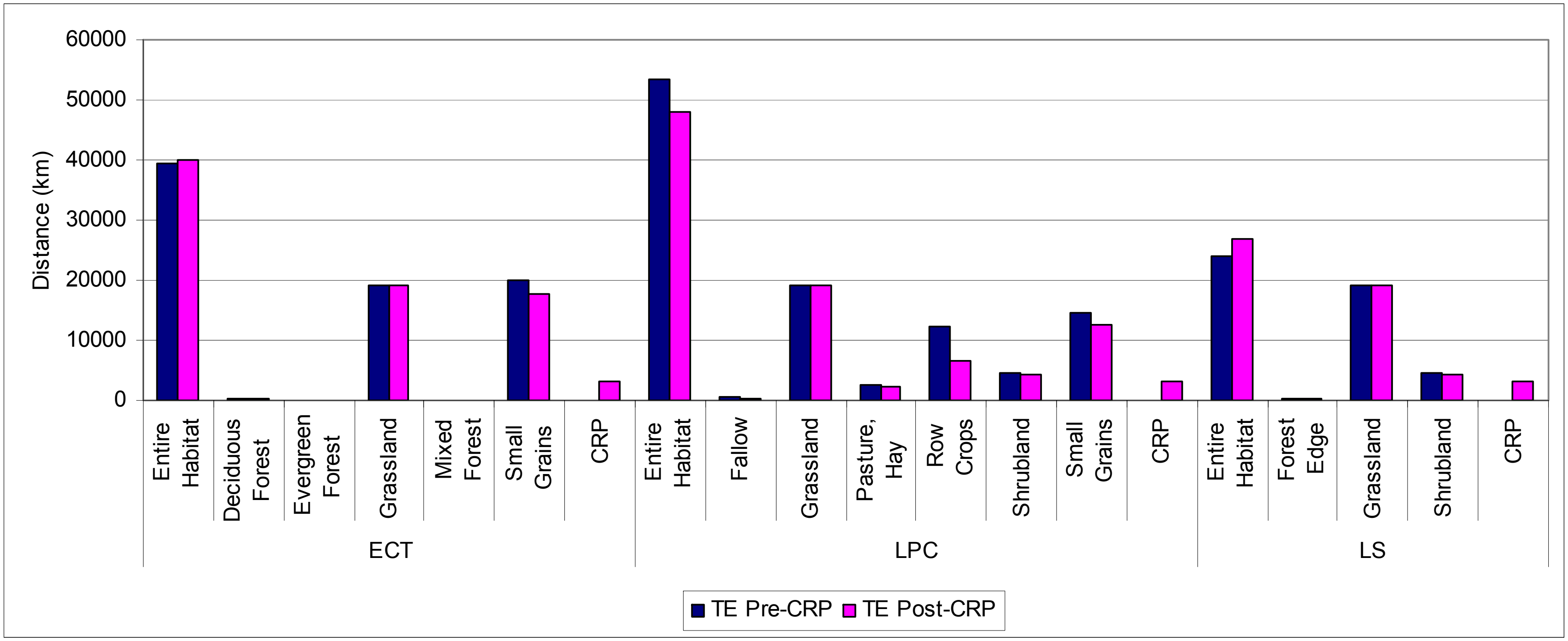

Figure 3.19: Total edge (TE) for pre- and post-CRP eastern cotton-tail (ECT), lesser prairie chicken (LPC), and lark sparrow (LS) habitats in Texas County, Oklahoma.

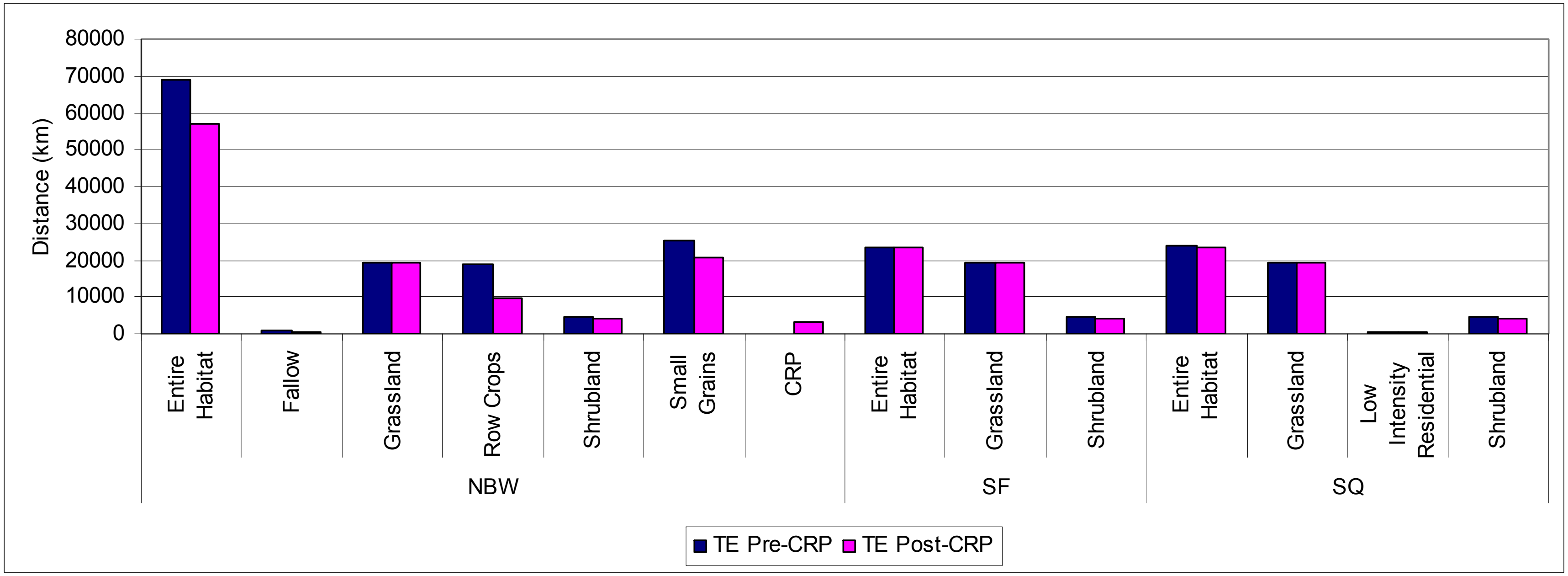

Figure 3.20: Total edge (TE) for pre- and post-CRP northern bobwhite (NBW), swift fox (SF), and scaled quail (SQ) habitats in Texas County, Oklahoma.

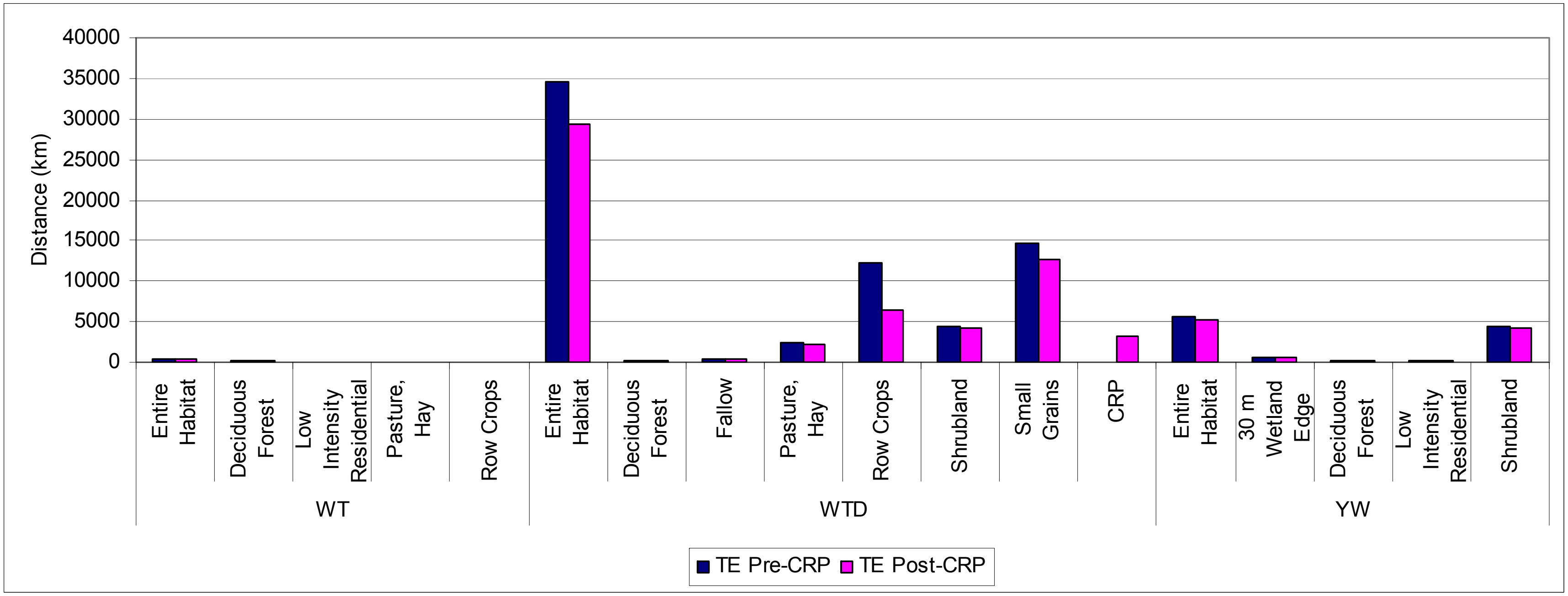

Figure 3.21: Total edge (TE) for pre- and post-CRP white-tailed deer (WTD), wild turkey (WT), and yellow warbler (YW) habitats in Texas County, Oklahoma.

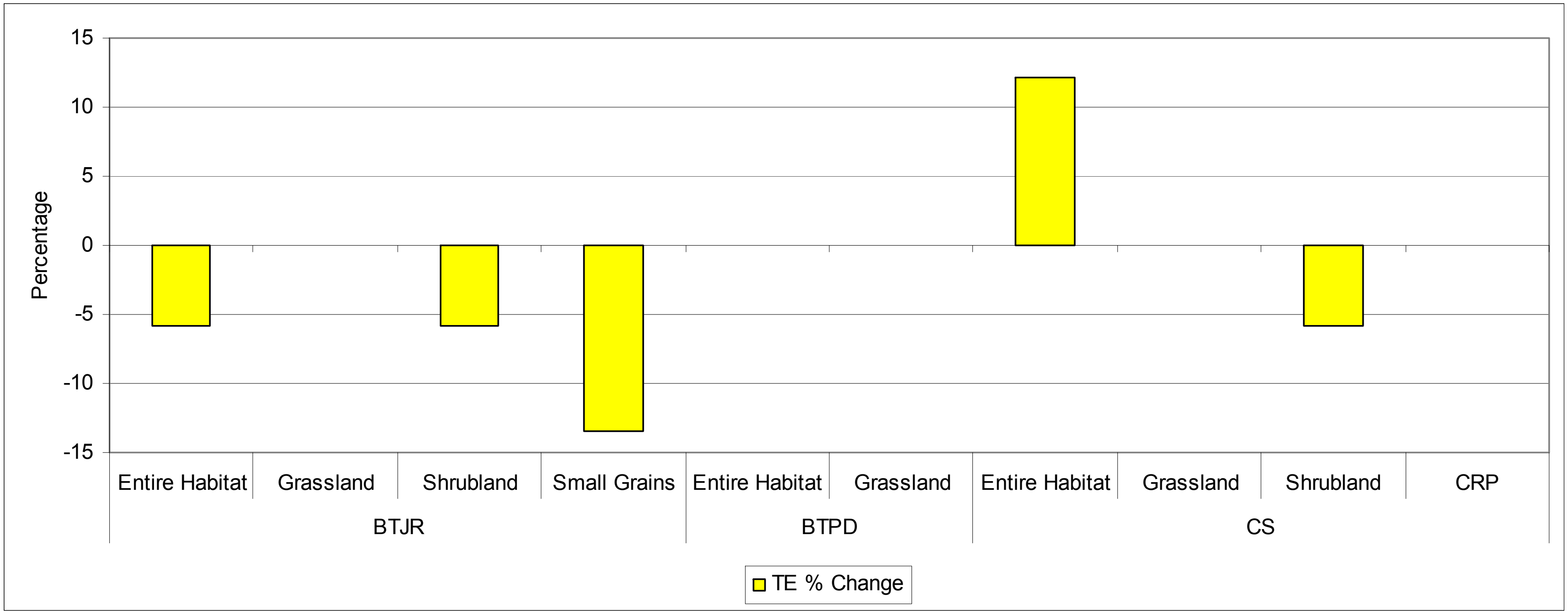

Figure 3.22: Percentage change in total edge (TE % change) for pre- and post-CRP black-tailed jackrabbit (BTJR), black-tailed prairie dog (BTPD), and Cassin's sparrow (CS) habitats in Texas County, Oklahoma.

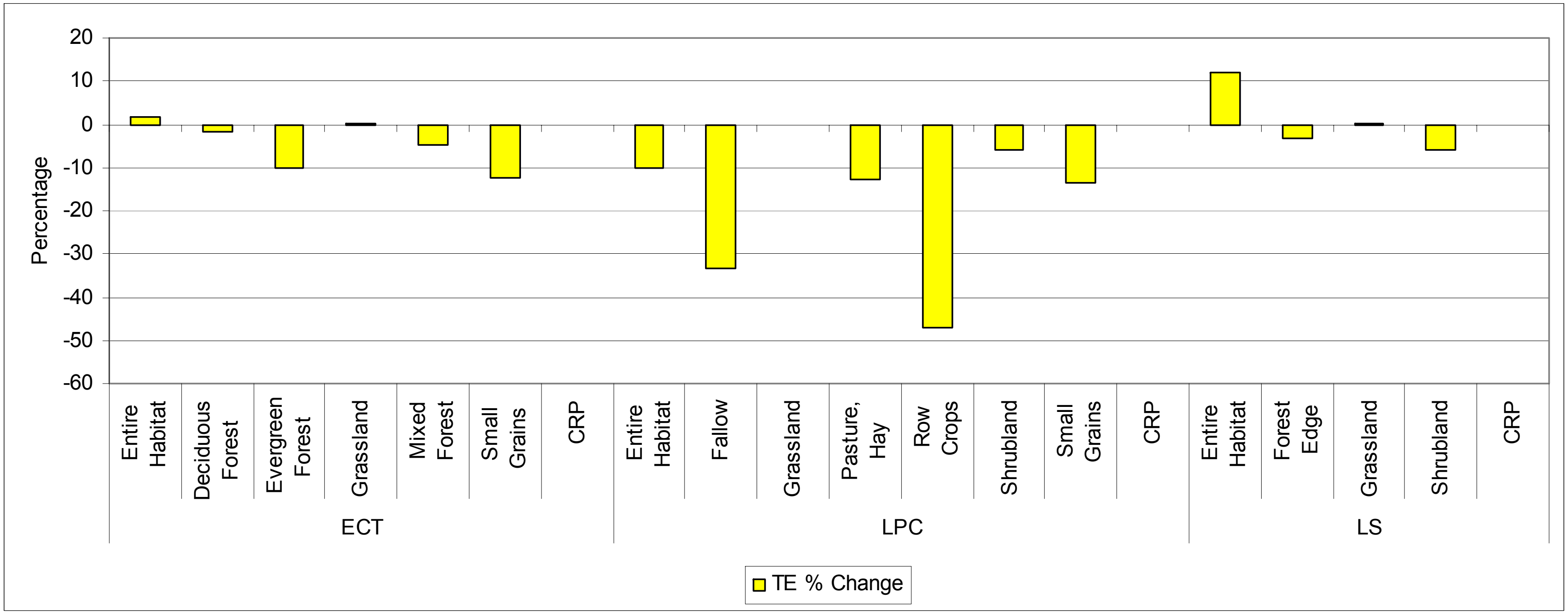

Figure 3.23: Percentage change in total edge (TE % change) for pre- and post-CRP eastern cotton-tail (ECT), lesser prairie chicken (LPC) and lark sparrow (LS) habitats in Texas County, Oklahoma.

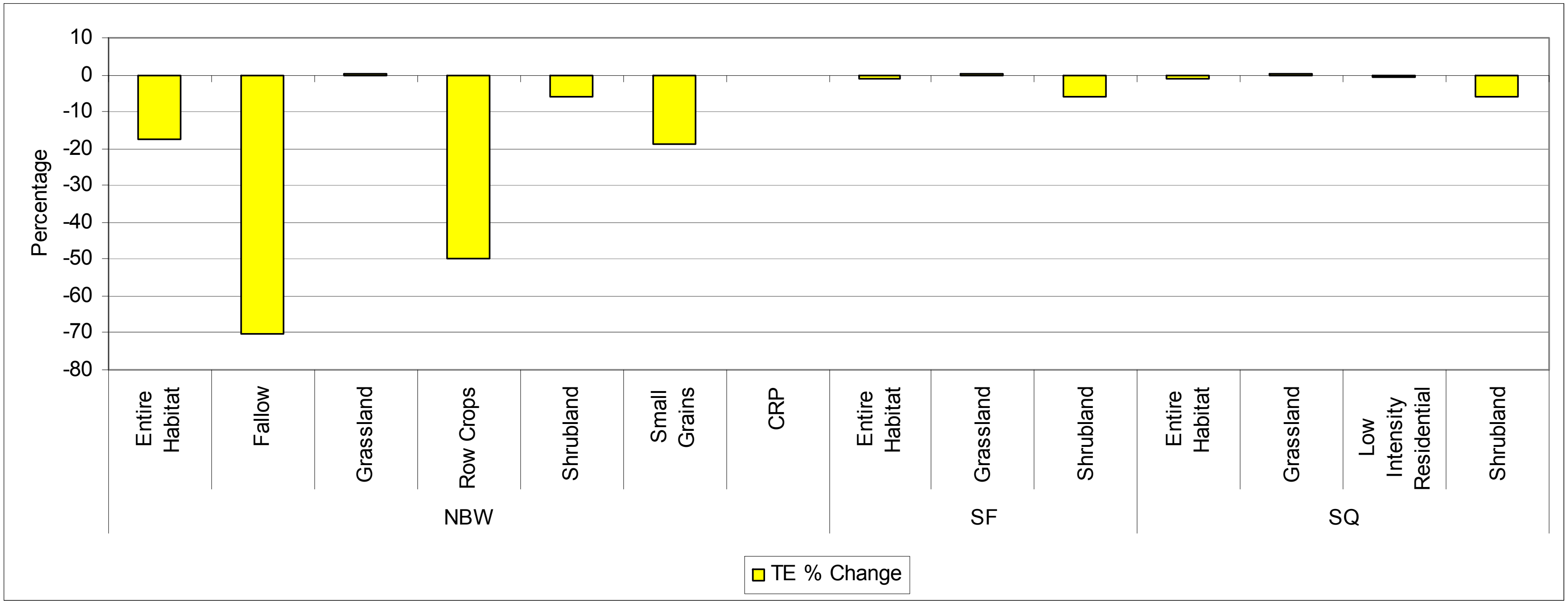

Figure 3.24: Percentage change in total edge (TE % change) for pre- and post-CRP northern bobwhite (NBW), scaled quail (SQ), and swift fox (SF) habitats in Texas County, Oklahoma.

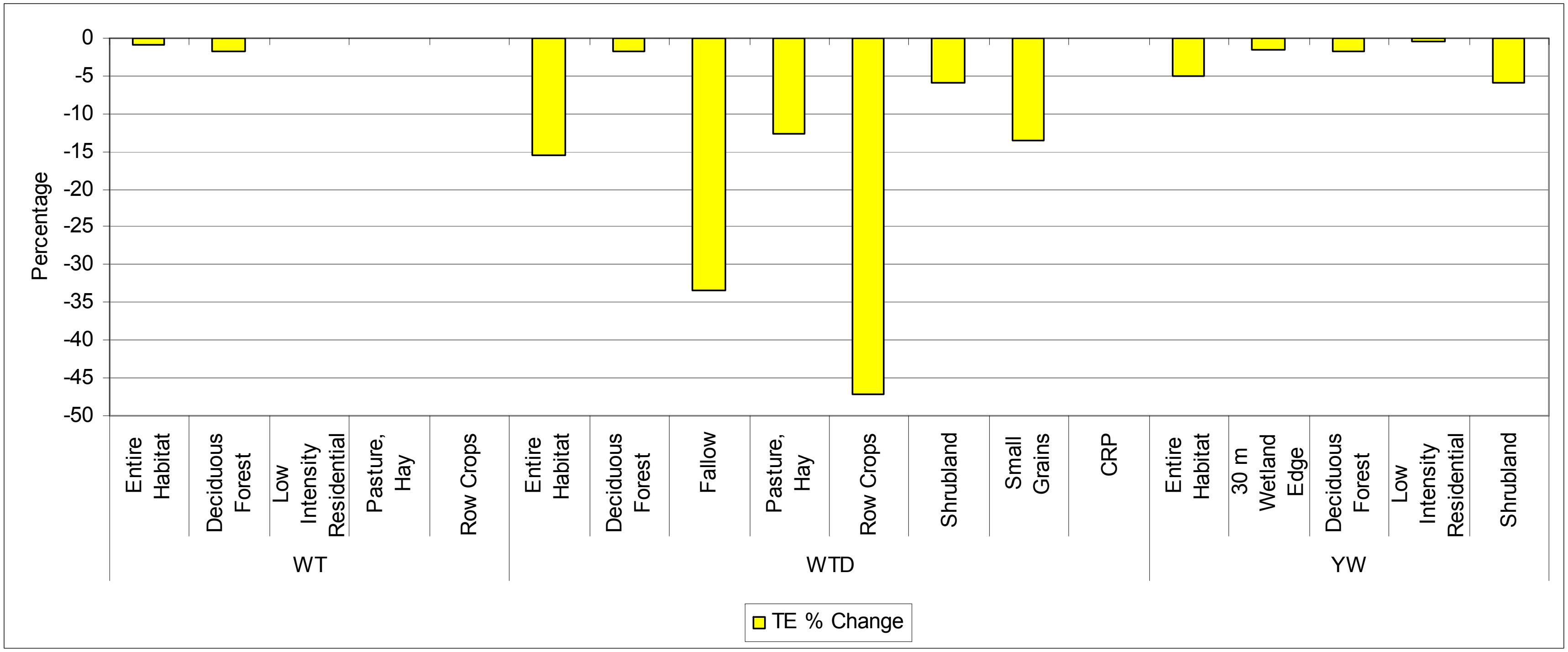

Figure 3.25: Percentage change in total edge (TE % change) for pre- and post-CRP wild turkey (WT), white-tailed deer (WTD), and yellow warbler (YW) habitats in Texas County, Oklahoma.

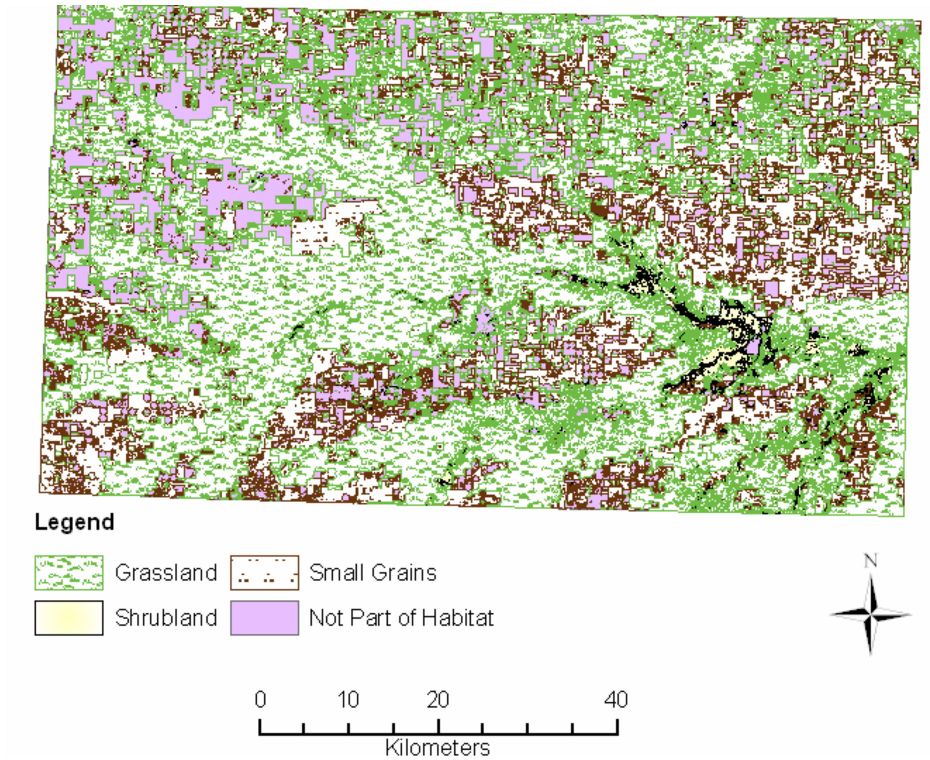

Figure 3.26: Selected potential black-tailed jackrabbit pre-CRP habitat in Texas County, Oklahoma.

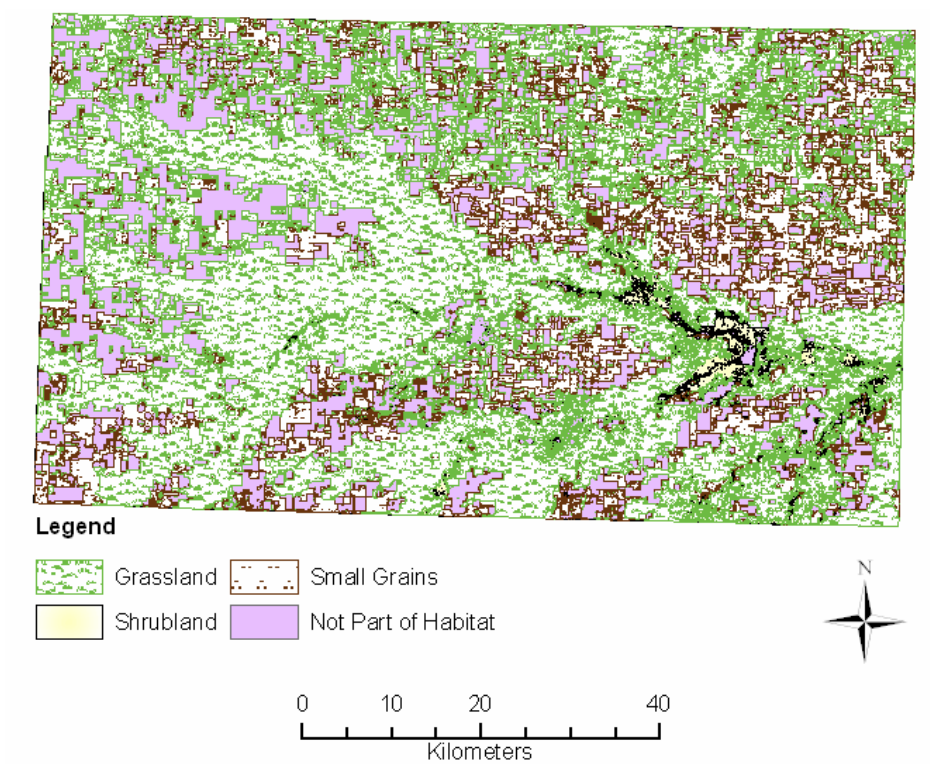

Figure 3.27: Selected potential black-tailed jackrabbit post-CRP habitat in Texas County, Oklahoma.

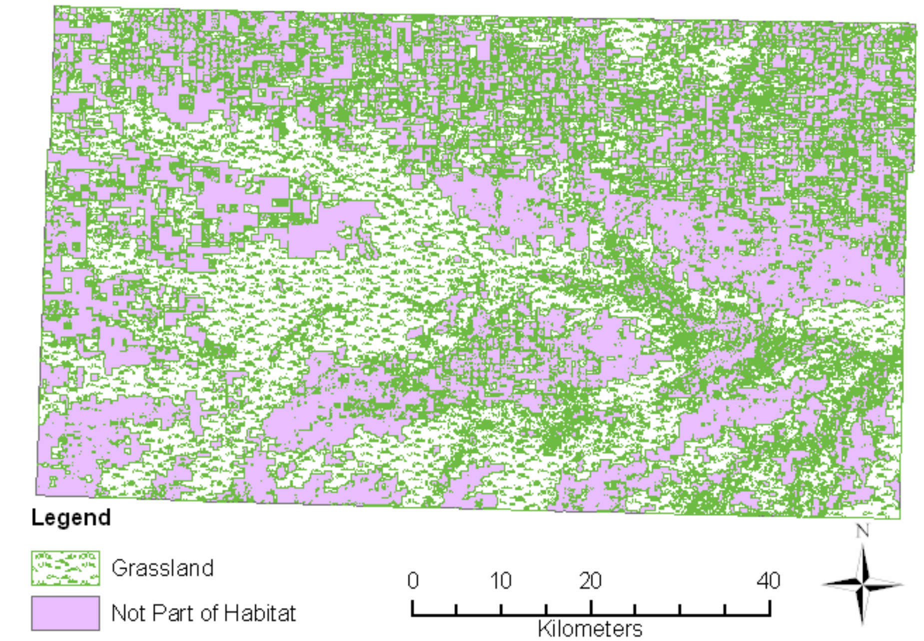

Figure 3.28: Selected potential black-tailed prairie dog pre-CRP habitat in Texas County, Oklahoma.

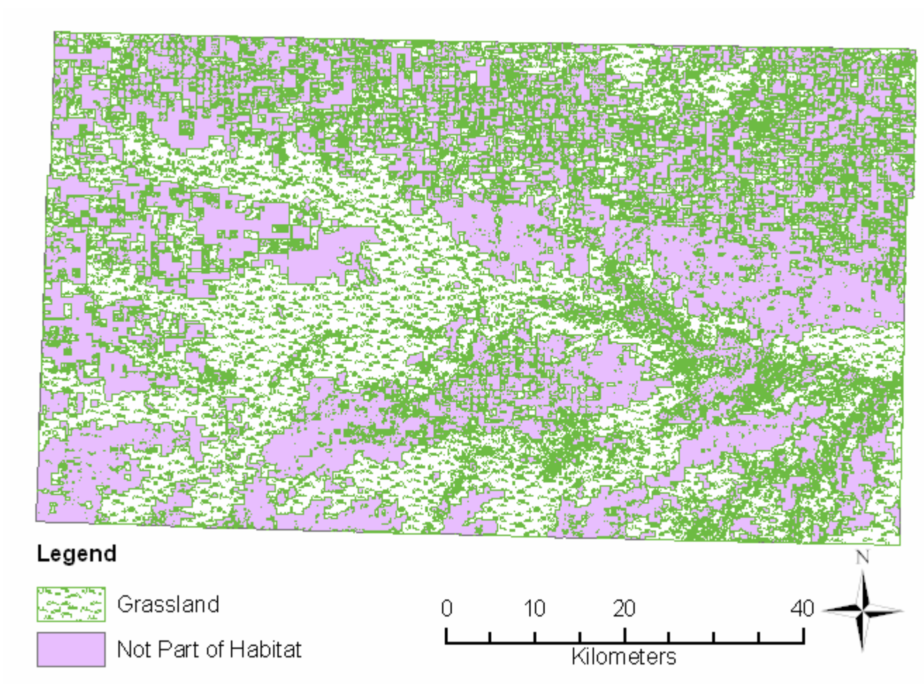

Figure 3.29: Selected potential black-tailed prairie dog post-CRP habitat in Texas County, Oklahoma.

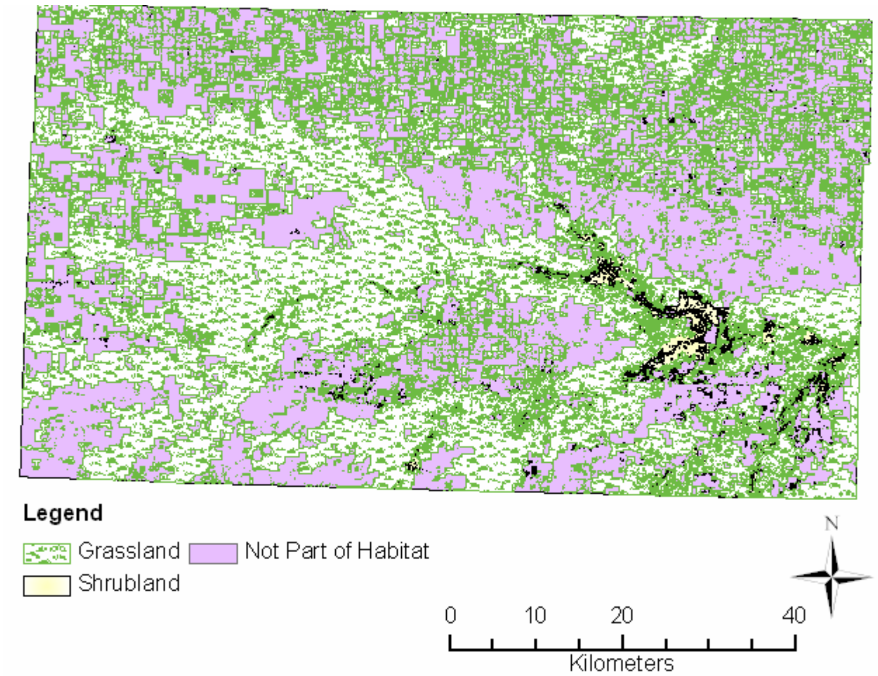

Figure 3.30: Selected potential Cassin's sparrow pre-CRP habitat in Texas County, Oklahoma.

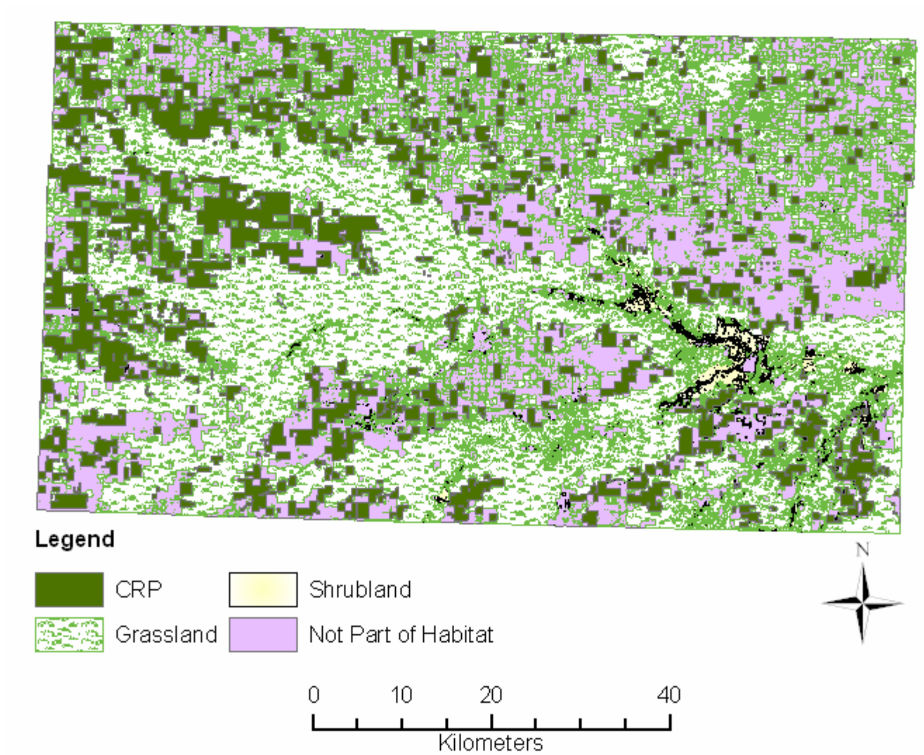

Figure 3.31: Selected potential Cassin's sparrow post-CRP habitat in Texas County, Oklahoma.

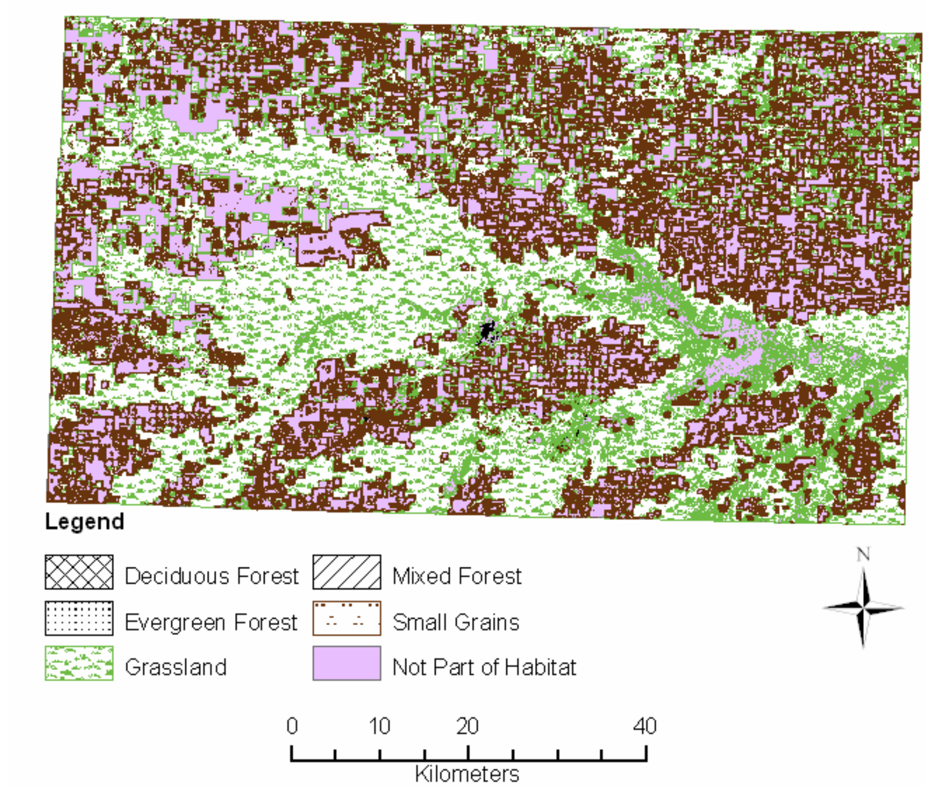

Figure 3.32: Selected potential eastern cotton-tail pre-CRP habitat in Texas County, Oklahoma.

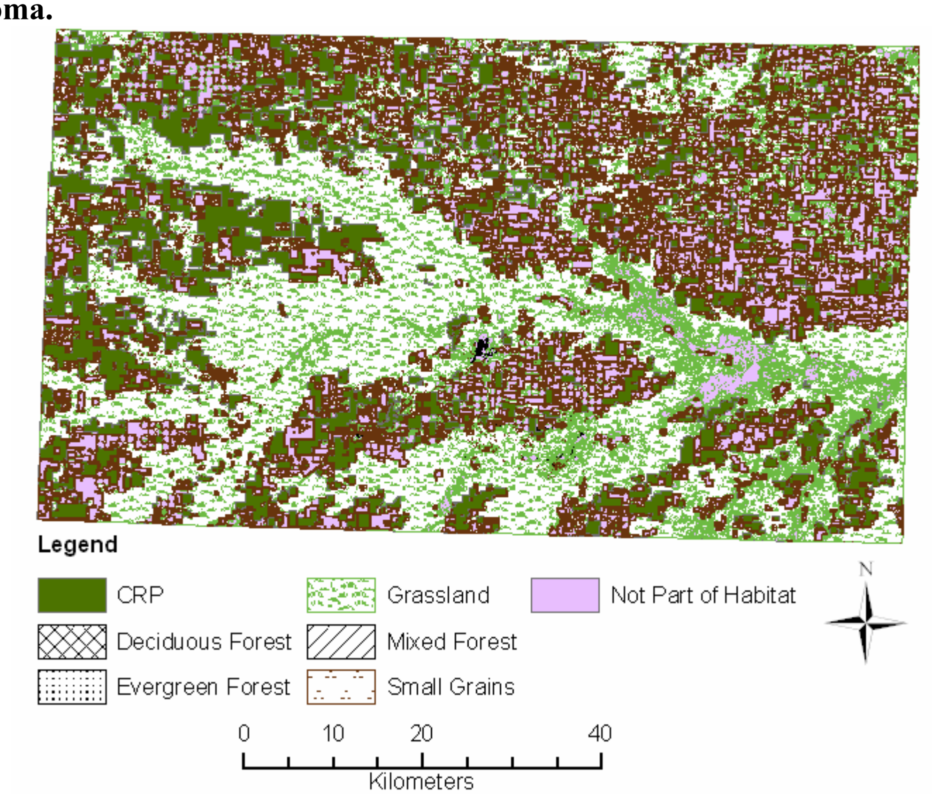

Figure 3.33: Selected potential eastern cotton-tail post-CRP habitat in Texas County, Oklahoma.

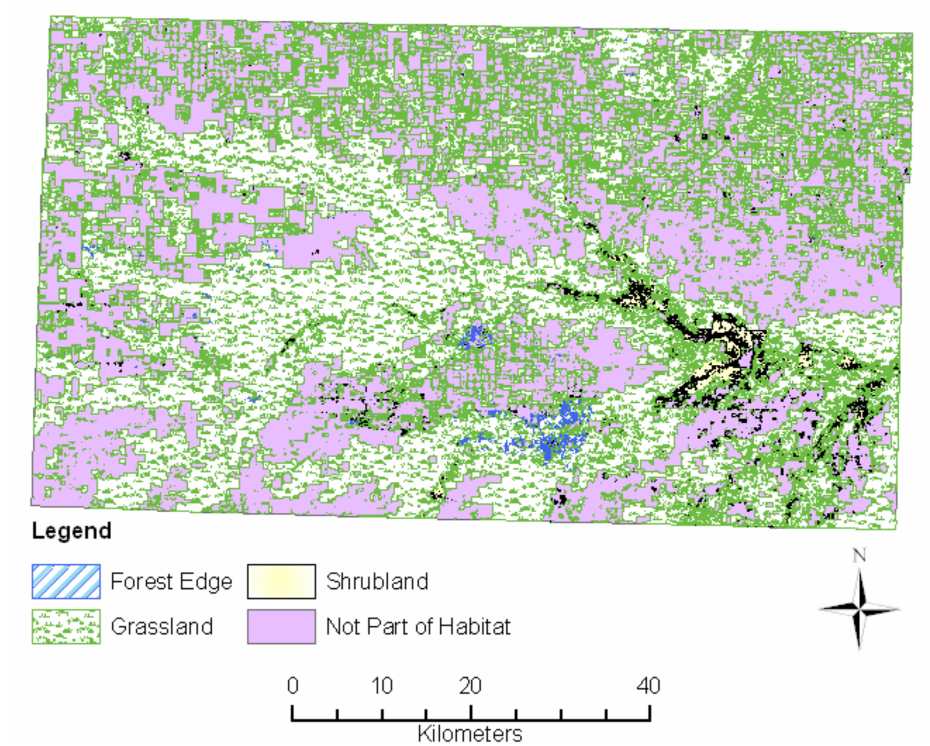

Figure 3.34: Selected potential lark sparrow pre-CRP habitat in Texas County, Oklahoma.

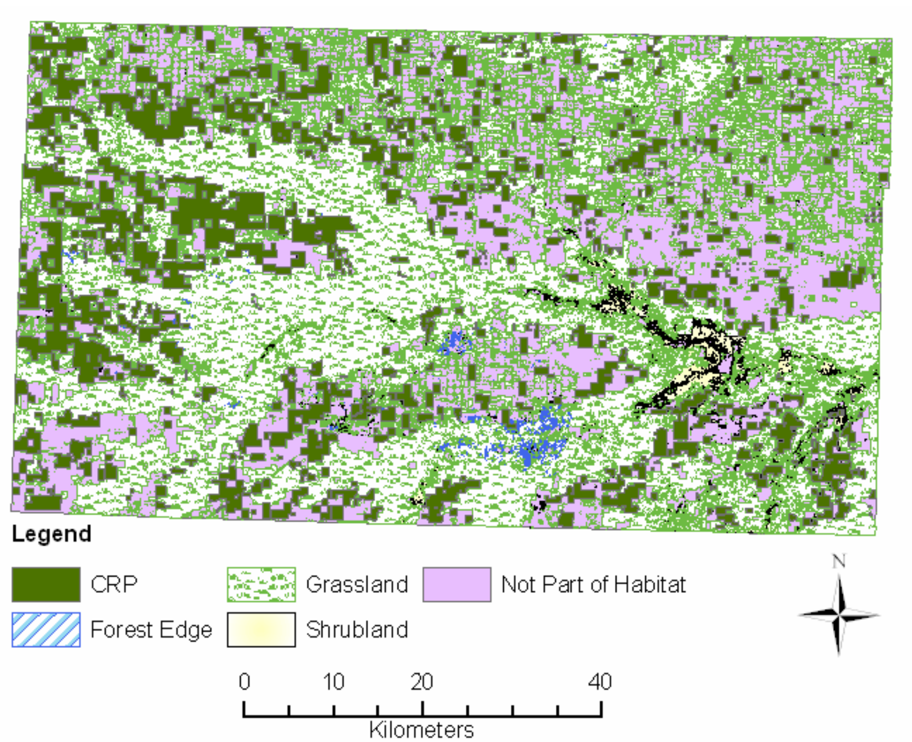

Figure 3.35: Selected potential lark sparrow post-CRP habitat in Texas County, Oklahoma.

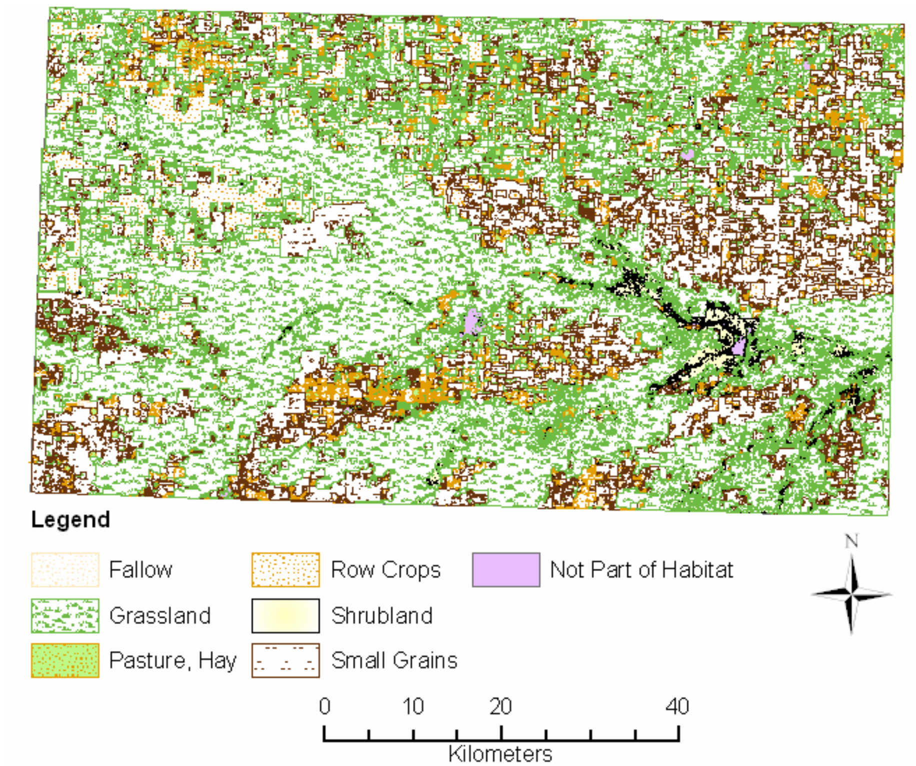

Figure 3.36: Selected potential lesser prairie chicken pre-CRP habitat in Texas County, Oklahoma.

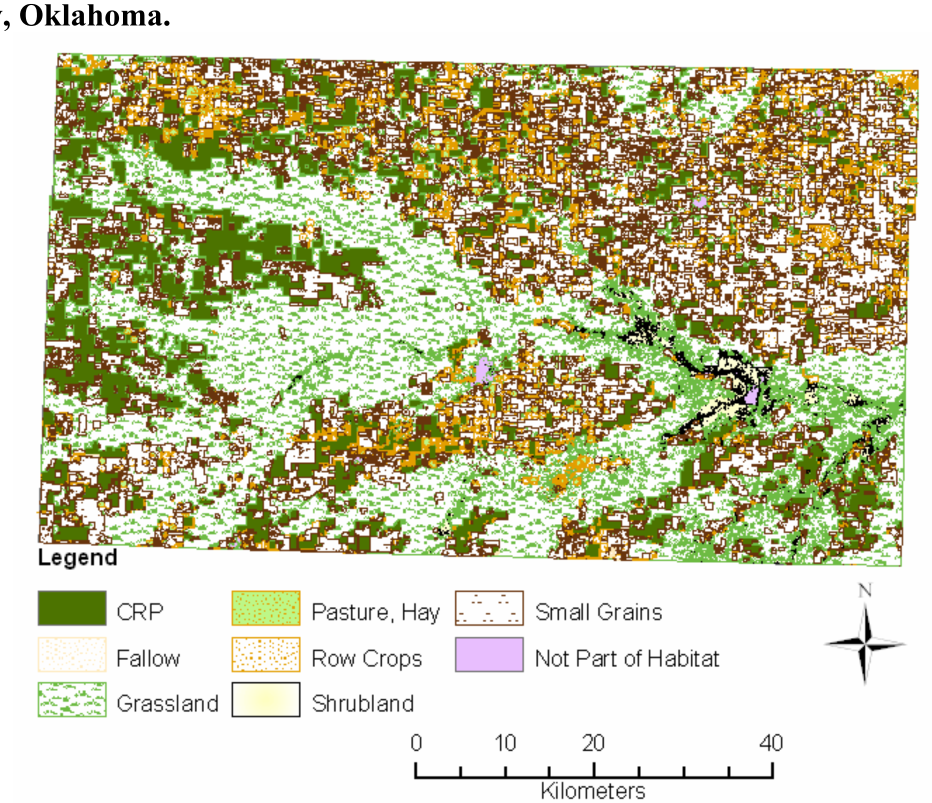

Figure 3.37: Selected potential lesser prairie chicken post-CRP habitat in Texas County, Oklahoma.

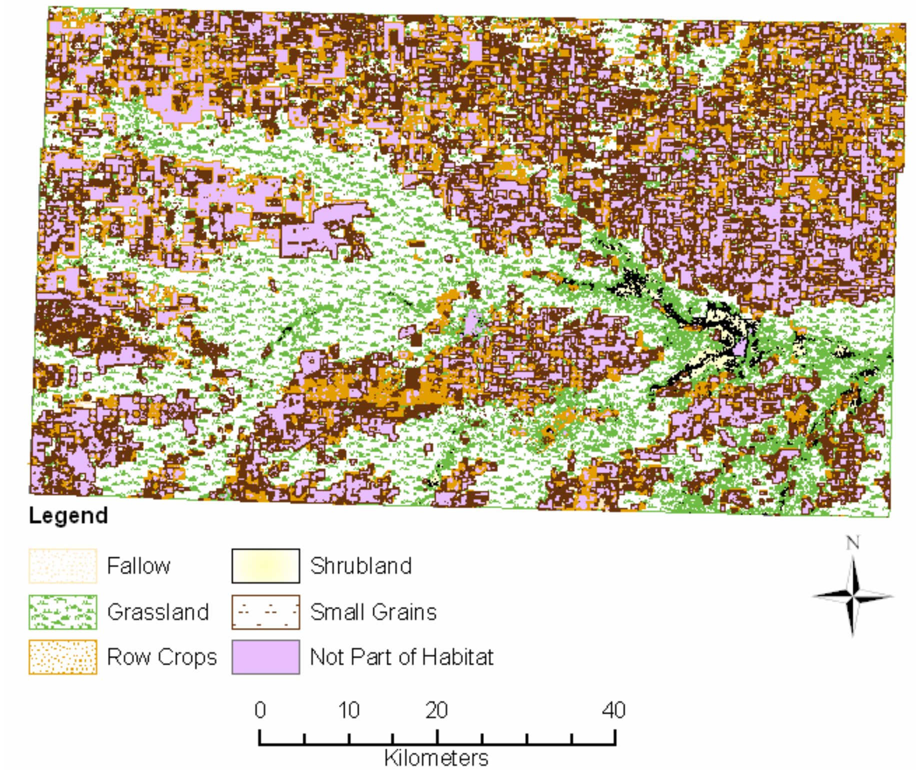

Figure 3.38: Selected potential northern bobwhite pre-CRP habitat in Texas County, Oklahoma.

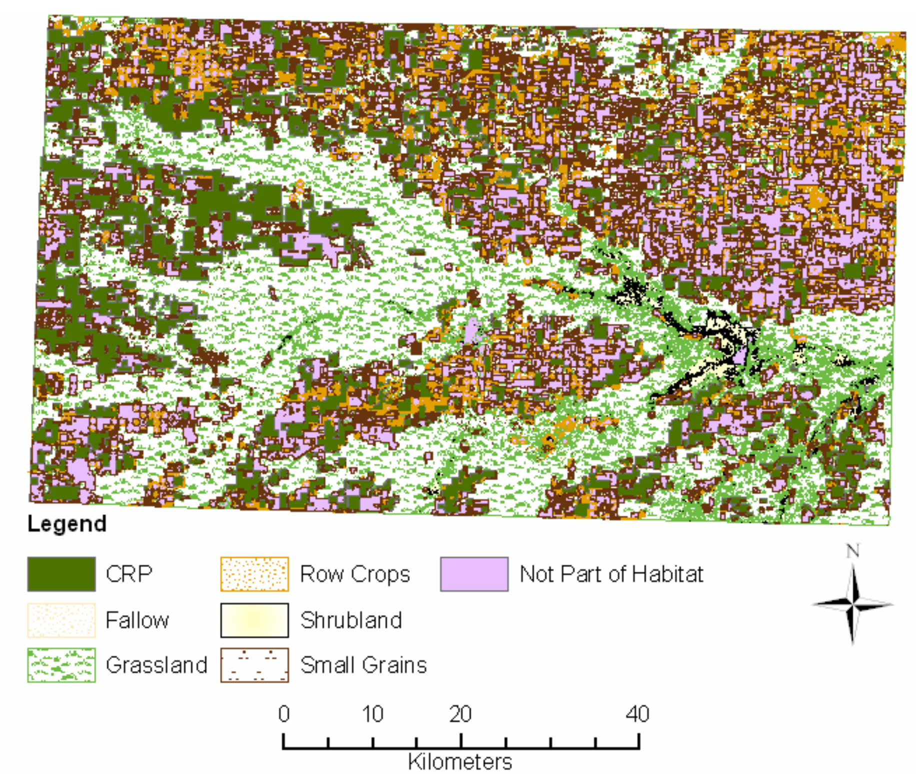

Figure 3.39: Selected potential northern bobwhite post-CRP habitat in Texas County, Oklahoma.

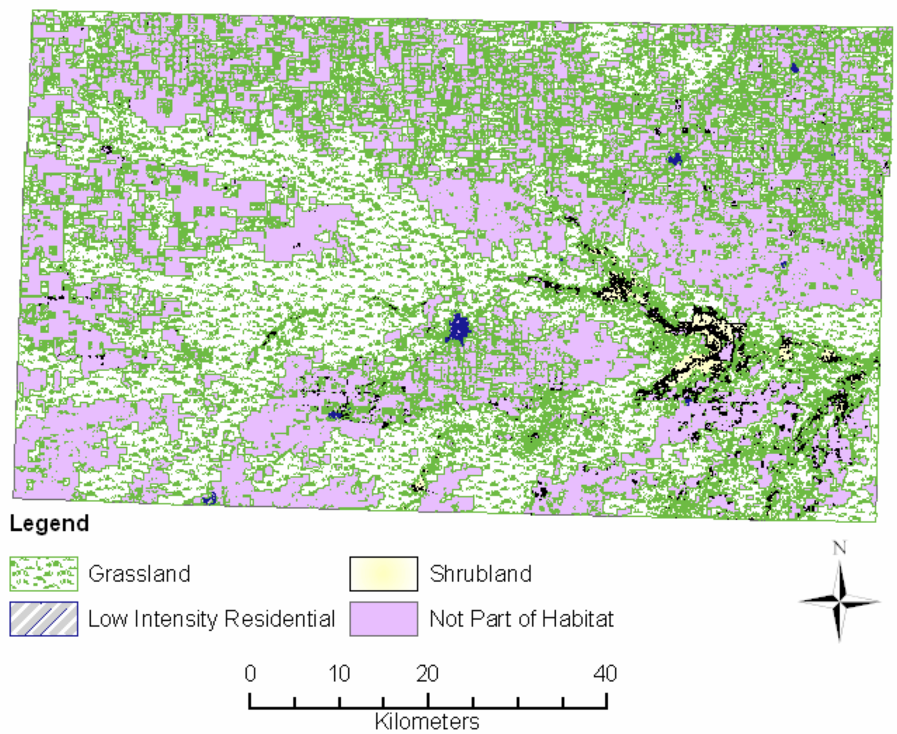

Figure 3.40: Selected potential scaled quail pre-CRP habitat in Texas County, Oklahoma.

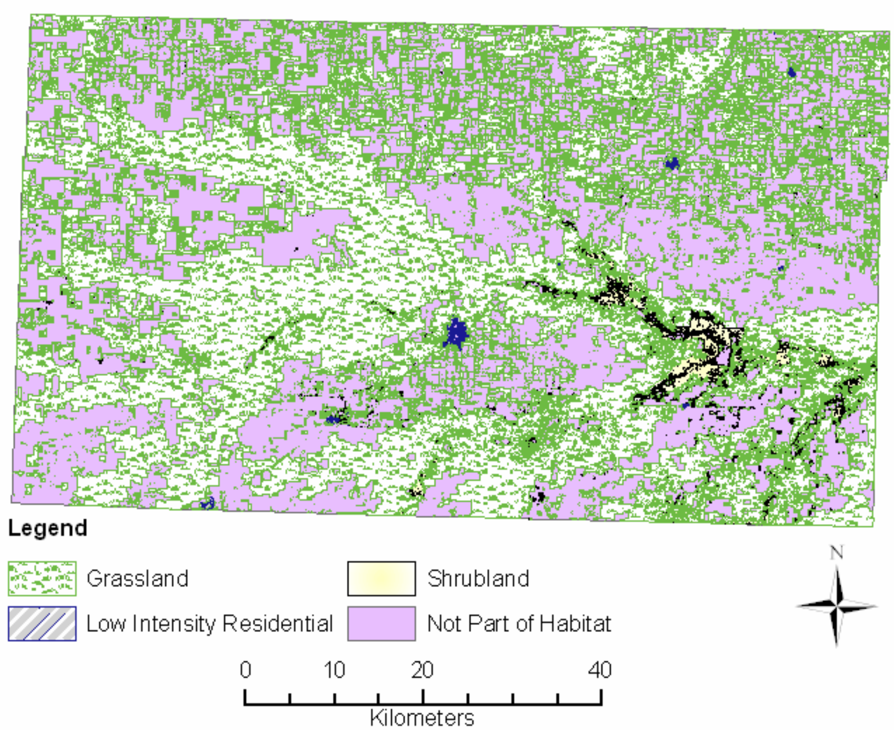

Figure 3.41: Selected potential scaled quail post-CRP habitat in Texas County, Oklahoma.

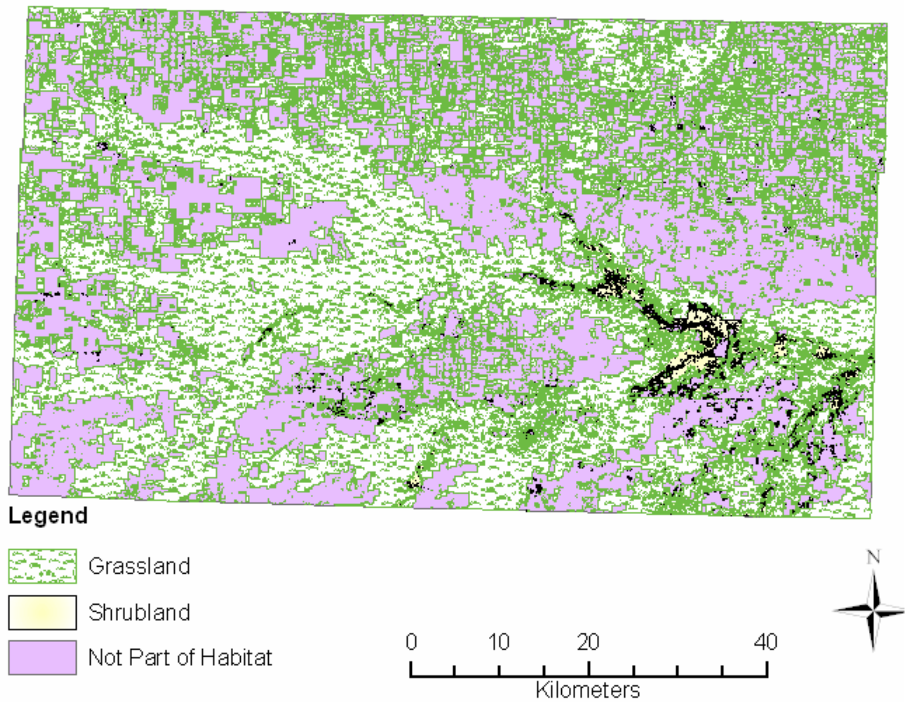

Figure 3.42: Selected potential swift fox pre-CRP habitat in Texas County, Oklahoma.

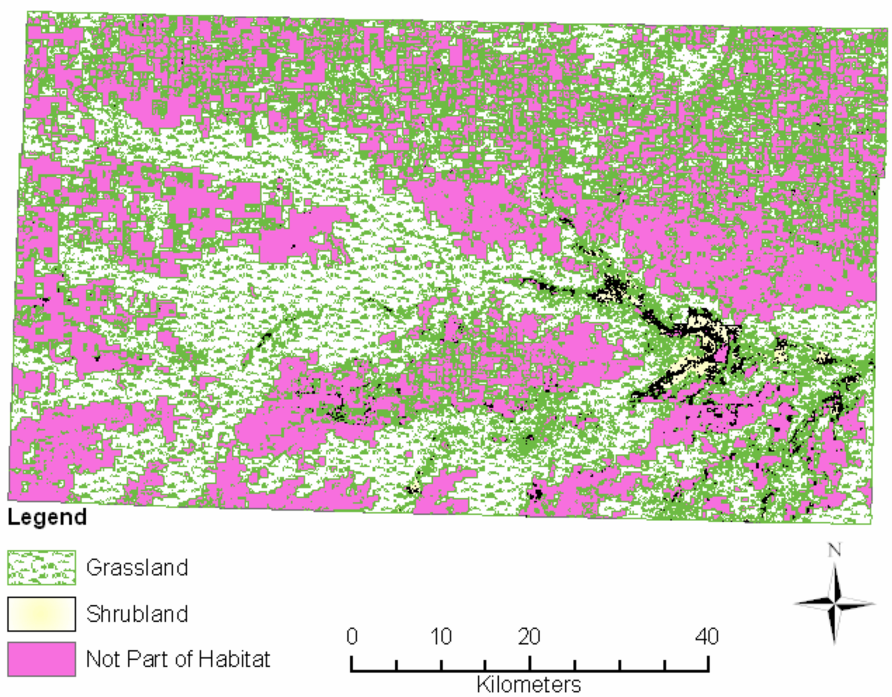

Figure 3.43: Selected potential swift fox post-CRP habitat in Texas County, Oklahoma.

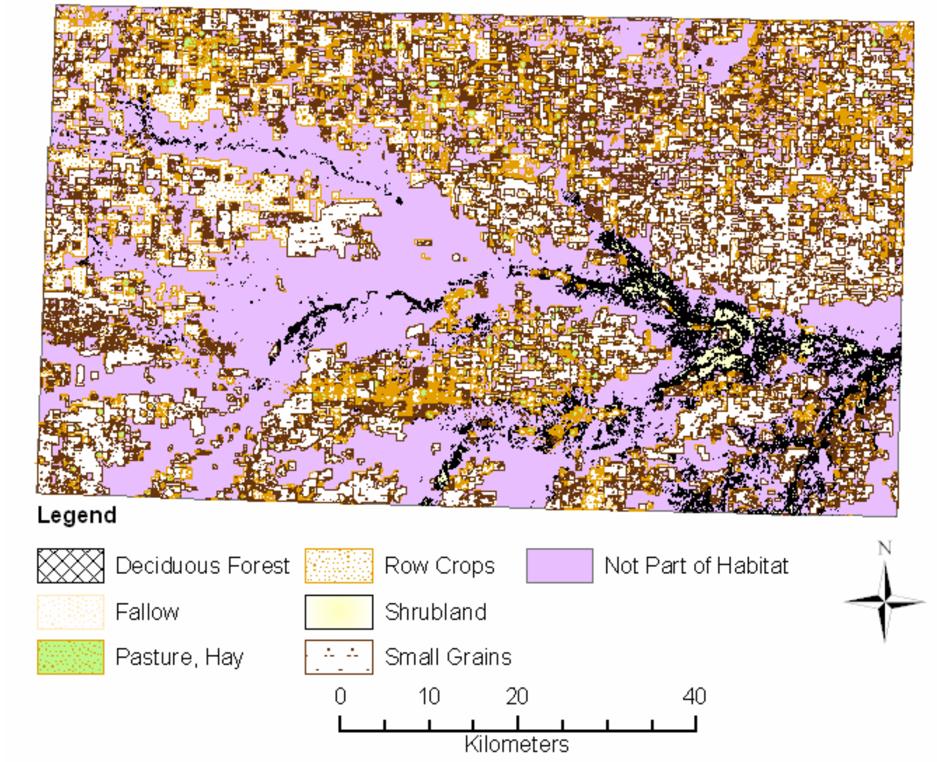

Figure 3.44: Selected potential white-tailed deer pre-CRP habitat in Texas County, Oklahoma.

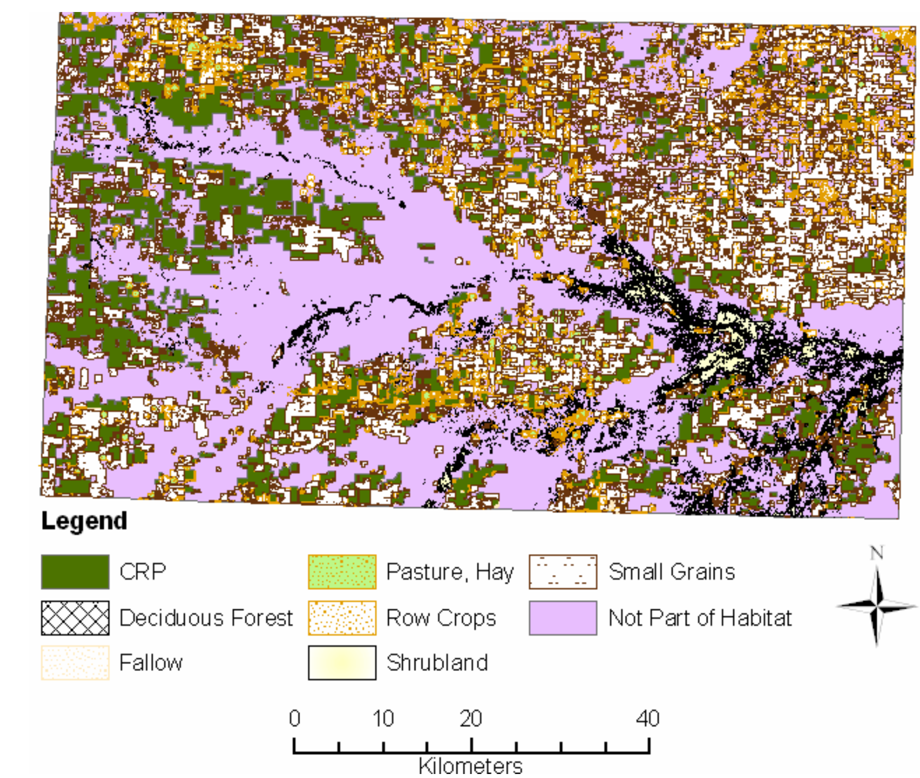

Figure 3.45: Selected potential white-tailed deer post-CRP habitat in Texas County, Oklahoma.

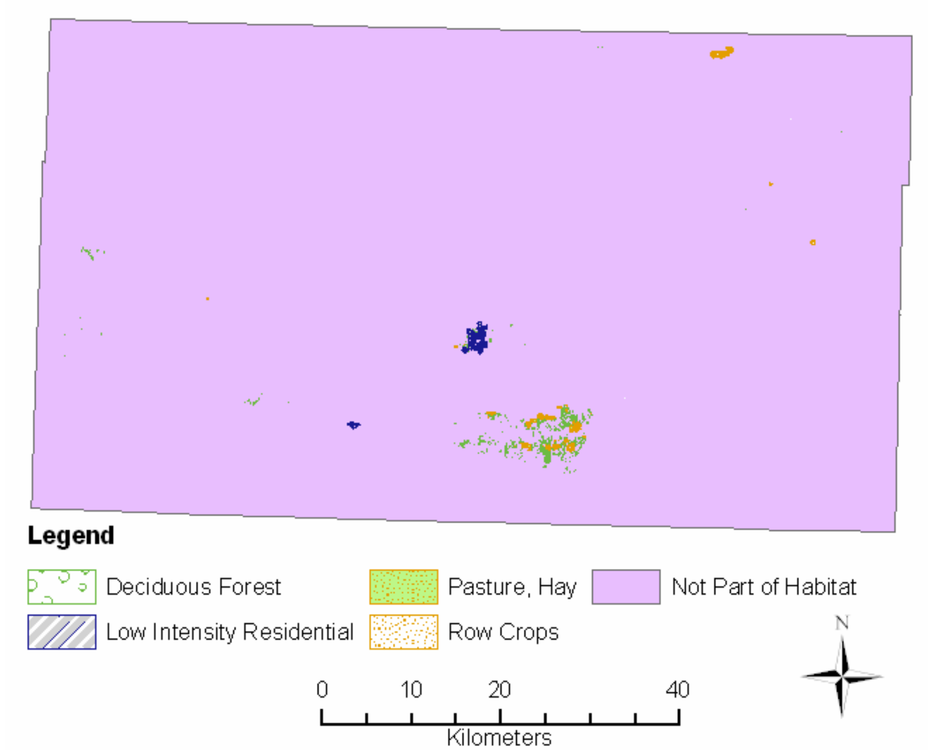

Figure 3.46: Selected potential wild turkey pre-CRP habitat in Texas County, Oklahoma.

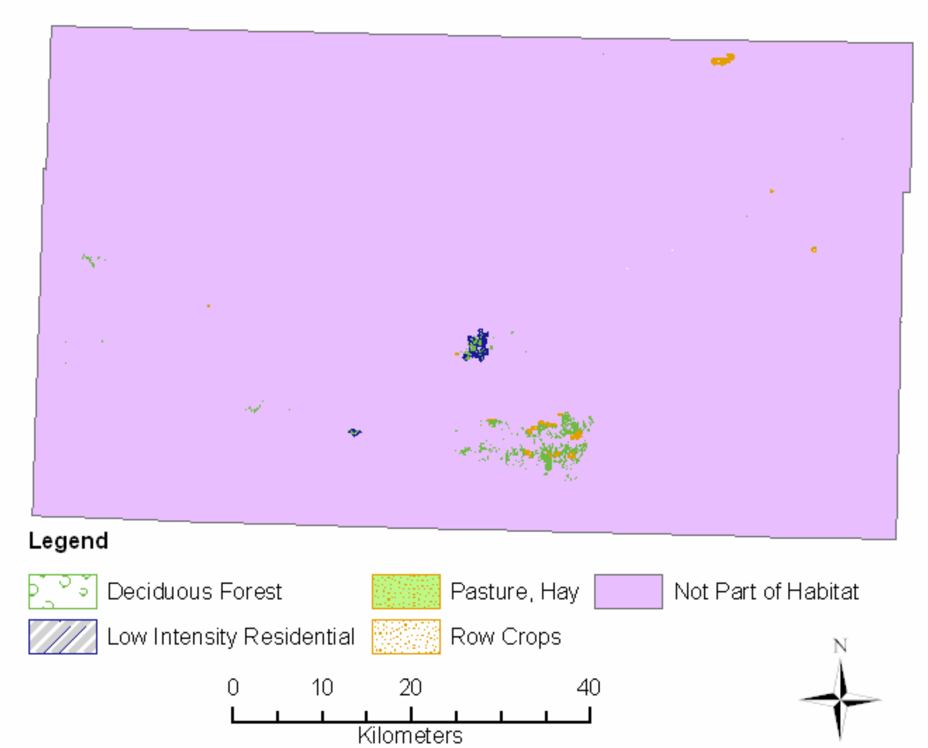

Figure 3.47: Selected potential wild turkey post-CRP habitat in Texas County, Oklahoma.

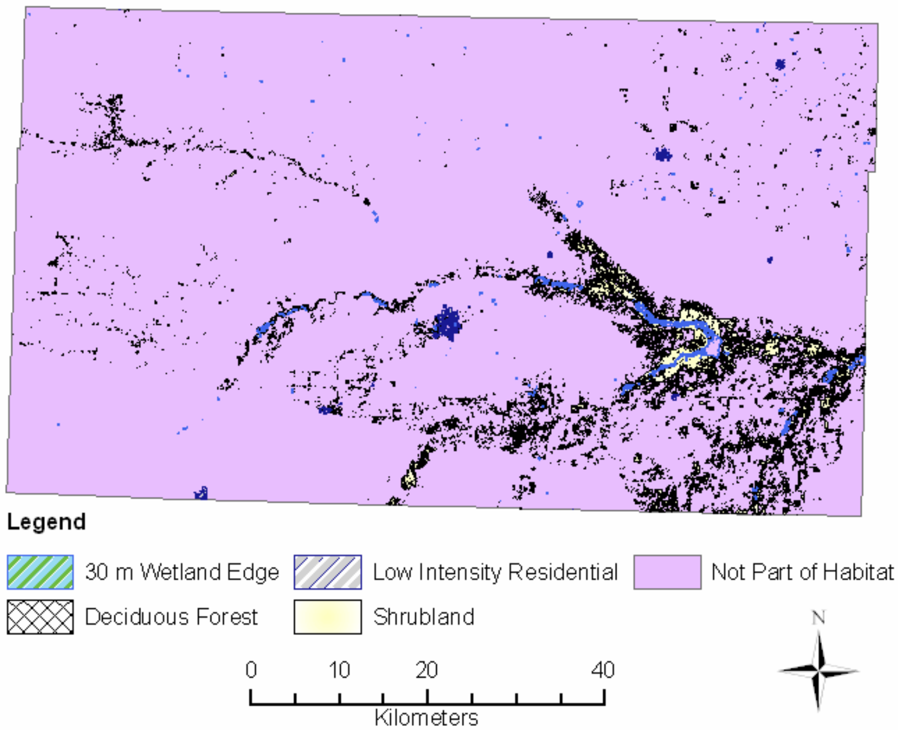

Figure 3.48: Selected potential yellow warbler pre-CRP habitat in Texas County, Oklahoma.

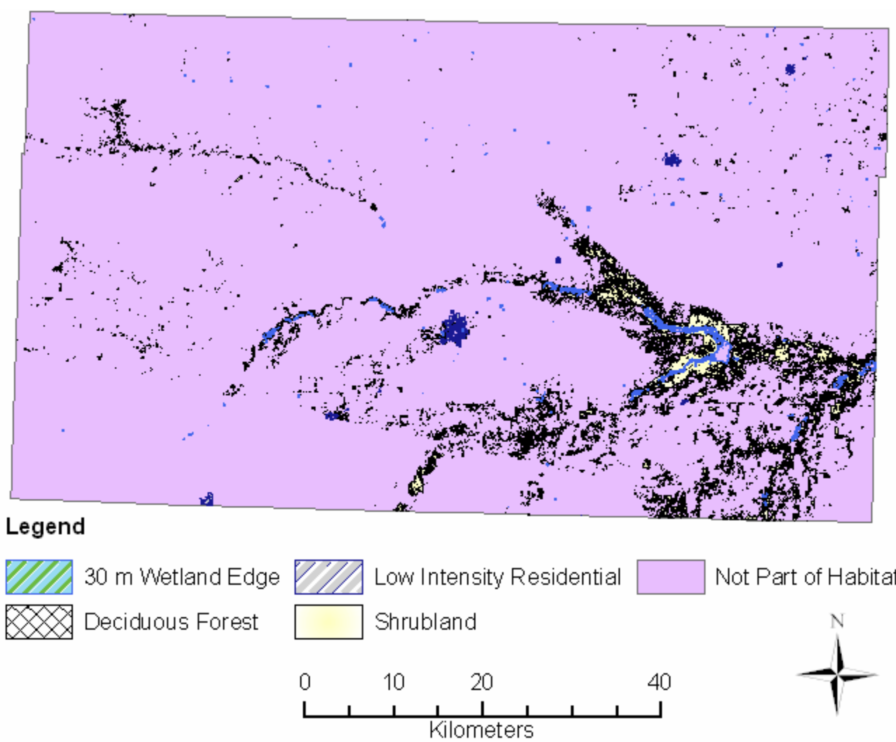

Figure 3.49: Selected potential yellow warbler post-CRP habitat in Texas County, Oklahoma.

CHAPTER IV

CHOICE ANALYSIS IN POST-CRP LAND USE FOR SUSTAINED ENVIRONMENTAL BENEFITS IN TEXAS COUNTY, OKLAHOMA

Introduction

The Conservation Reserve Program (CRP) has created considerable environmental benefits that include increased water quality and wildlife habitat compared to the pre-CRP era (Ribaudo 1989, Feather et al. 1999, Zinn 1997). The CRP is a sequel to the land retirement programs first started in the 1930s with the objective of reducing production to march demand by removal of croplands from production. In the late 1930s, the objectives were expanded to include soil conservation by encouraging production of soil building crops. However, during the Second World War there was emphasis on increased production. In the mid-1950s, the objectives of the retirement program were changed to curtail over production by reducing commodity stocks and emphasizing resource conservation. In the 1970s, cropland pulled out of production was returned to production until 1983 when, due to over production, the decision was reversed (Zinn 1997).

The current land retirement program was enacted in 1985 and has been in operation since 1986 during which a total of 86080 hectares (212708 acres) has been enrolled in Texas County, Oklahoma (USDA-FSA 2006, Zinn 1997). The primary objective was to reduce soil erosion while the secondary objectives were long-term capacity for food and fiber production, reduction of sedimentation, creation of fish and wildlife habitats, reduction of surplus crop production, and providing for farm income support. The program was re-authorized by the Food, Agriculture, Conservation, and Trade Act of 1990; the Federal Agriculture Improvement Act of 1996, and the Farm Security and Rural Investment Act of 2002. Through all these authorizations, the emphasis has been placed on reducing soil erosion, protecting long-term capacity to produce food, reduce sedimentation, improving water quality, creating and enhancing fish and wildlife habitats, and reducing surplus production of farm produce. The main goals have remained the same although the emphasis has changed and of late there has been a shift towards more involvement by landowners or operators in conservation issues. This is most apparent with the Farm Security and Rural Investment Act of 2002 whose mandate extends to the end of the year 2007 (USDA 2004).

The CRP enrolls identified highly erodible or sensitive tracts and land owners participating in the program enter into a contract with USDA. Land enrolled into the CRP is removed from production for 10 to 15 years and planted with either trees or grass (Ribaudo 1989, Ohlenbusch and Watson 1995). Land owners or operators are paid rentals an additional 50% for the cost of establishing conservation practices. (Ribaudo 1989, FSA 2003).

The amount of farmland to be removed from production by the 2002 farm bill was 39.2 million acres although the initial goal was 40 to 45 million acres as set out by the 1995 Farm Bill. In 2002, 34 million acres were enrolled in the CRP contracts; contracts of 1.5 million of these acres expired by September 30 2003 (FSA 2003).

The Texas County CRP tracts were planted with various species of grasses that included old world bluestem (*Bothriochloa ischaemum*), (14.4%), native mixture (18.9%), plains bluestem (52.9%) WW Spar (12.5%), and caucasian bluestem (1%). Each of the species ganada, weeping love grass, sideoats and western wheat grass were planted at less than 1% of the total grasses planted (FSA 1992). Ganada is originally from Turkestan (Wolfe et al. 1982), plains bluestem, composed of more than 30 closely associated bluestems, originates from about six countries. WW Spar is among the first varieties developed from plains bluestem, while caucasian bluestem is a closely related variety of old world bluestem (*B. ischaemum*). Another non-native grass is weeping lovegrass (*Eragrostis curvula)*, which originated from South Africa. The native mixture is made up of a number of native species like blue grama (*Bouteloua gracilis*), buffalo grass (*Buchloe dactyloides*), little bluestem (*Schizachyrium scoparium*), switch grass (*Panicum virgatum*), sideoats grama (*Bouteloua curtipendula*), Indian grass (*Sorghustrum mutans*), sand bluestem (*Andropogon halli*), and sandlove grass (*Eragrostis trichodes*). Mixtures were done at between 5-30% of each species and planted according to plant-soil affinity (USDA-NRCS 2002, USDA-NRCS 2006).

It is now two decades since the inception of the CRP. Some of the CRP tracts have been returned to production, mainly as pasture fields, and about 5% has been returned to crop production (Messenger 2005). The program has met the intended objectives by reducing soil erosion, improving water quality, improving fish and wildlife habitats and reducing sedimentation in fields and waterways (Ribaudo 1989, Johnson 1995). It is desirable to maintain these benefits after the expiration of the CRP contracts to achieve the intended long-term goals of the CRP, such as reducing soil erosion, protecting long-term capacity for food production, improving water quality, and creating fish and wildlife habitats. Neglecting benefits that have accrued from the CRP would nullify the program's intensions. Post-CRP land options are desirable so that CRP tracts can be selected to meet different management goals (Rickerl et al. 1999). Not all CRP tracts can be returned to their previous use without compromising environmental gains that have been the result of the CRP, however, CRP tracts can be targeted in a way that can ensure cost effective re-enrollment where continued CRP is desirable (Khanna et al. 2003). Consideration should also be given to favorable practices after the CRP (Ohlenbusch and Watson 1995). Farming practices that allow consideration of soil type in the area can promote continued environmental benefits accrued from the CRP (Stiegler et al. 1997).

A number of studies on post-CRP land use have been carried out (Rickerl et al. 1999, Khanna et al. 2003, Ohlenbusch and Watson 1995, Stiegler et al. 1995, Stiegler et al. 1997) with varying emphasis. These studies have centered on small areas or have targeted limited environmental issues. The best approach to study post-CRP land use issues is one that examines multiple uses of CRP tracts, targets a number of environmental benefits, and has a regional approach.

Among other benefits of the CRP, the program has brought benefits to ground and surface water. Groundwater is affected by activities in the vicinity of recharge points which are normally wetlands (Tjaden and Waber 1998a). Protection of wetlands can ensure that groundwater quality is not compromised. Wetlands are important for the recharge and filtration of groundwater. Water quality of streams and rivers is affected by activities near to the water courses (Tjaden and Waber 1998a, 1998b) and need to be protected to protect surface water quality. Row crops have the highest capacity for soil erosion among agricultural crops (Lal 1991). Row crops production will be most suitable on soils with the least potential for soil erosion. Erosion of soil by water is associated with the combined effect of rainfall, runoff, and infiltration on soil loss. Areas more susceptible to erosion can be identified by erodibility index of the soil in the area. Soil erodiblity is the potential for sheet or rill erosion. Soil erodiblity is influenced by slope, slope length, runoff, soil tolerance factor, and soil erodibility factor. Wind erosion is a larger problem than erosion by water because of the dry sandy soils and windy conditions in the area (Doerr and Morris 1960). The wind erosion index (WEI) is a factor used in calculating soil loss by wind. Soils with a high wind erosion index are more susceptible to wind erosion than those with a low WEI. Wildlife has different habitat requirements according to species but in deciding whether a particular CRP tract is suitable the minimum habitat size should be the most representative of the wildlife that may possibly use that habitat (Rickerl et al. 1999, USEPA 1999, Johnson and Zidack 1997).

The objective of this study was to examine possible use of post-CRP tracts at a regional level in Texas County, Oklahoma, with a view towards maintaining environmental benefits gained from the CRP. I examined: 1) use of certain tracts for ground and surface water protection, 2) suitability of some tracts as pasture, 3) use of tracts for row crop production, 4) tracts for use by wildlife as habitat, and finally 5) tracts important in abatement of soil and wind erosion.

Methods

The process of determining the ideal use of the post-CRP tracts to help uphold environmental benefits gained from the CRP involved the use of four data sets, i.e., the national land cover database (NLCD), CRP reference map, soil database, and the national wetland inventory (NWI). I downloaded the NLCD from the United States Geological Service web site (USGS) (2003). I obtained the CRP reference map from the Center for the Applications of Remote Sensing (CARS) lab, Geography Department, Oklahoma State University. The CRP reference map showed CRP tracts and the types of grasses planted. I downloaded the soil database, Soil Survey Geographic (SSURGO) from the National Resources Conservation Service (NRCS) website (NRCS 2005). The soil database shows soil types and their characteristics. The third data set, NWI, was downloaded from the U. S. Fish and Wildlife Service website. The NWI layer shows streams and wetlands in Texas County. All the data sets were projected to a Universal Transverse Mercator (UTM 14) coordinate system. Figure 4.2 gives an outline of the methodology used in selecting CRP tracts for different management objectives.

The NWI dataset had two types of data I required: wetlands and streams data. I extracted the data and prepared two separate layers one showing wetlands and the other showing streams. I reclassified the CRP reference map to show polygons as CRP tracts by grouping all grass types grouped together under CRP. The soil database did not have a column in the attribute table that could be used to establish the amount of erosion in the CRP tracts. I created the column and calculated the erosion index (EI) by using the Universal Soil Loss Equation (USLE) equation EI=R*K*LS/T developed by Wischmeier and Smith (1978) (Lee and Goebel 1986, Park and Egbert 2005). In the equation, R is the rainfall and runoff factor, K is susceptibility of the soil to water erosion, LS is the effects of slope and length to soil erosion, and T is the soil tolerance value, i.e., the maximum annual amount of soil that can be removed before long-term productivity is affected (IWR 2002, Lee and Goebel 1986). I calculated LS using the formula: LS = [0.065 +

$0.0456(\text{slope}) + 0.006541(\text{slope})^2]$ [slope length/22.1] ^{NN}. The value for NN was obtained from tables of literature (e.g. Blaszczynski 2003, IWR 2002) and I used the slope and slope length values included in the attribute table of the soil database. The values for the R, C, and P factors where obtained from the Texas County. I used values of K and T that I found in the attribute table of the soil database. The calculated EI ranged between 11-96 tons per acre per year. Figure 4.1 shows Texas County classified into three erosion index (IE) classes.

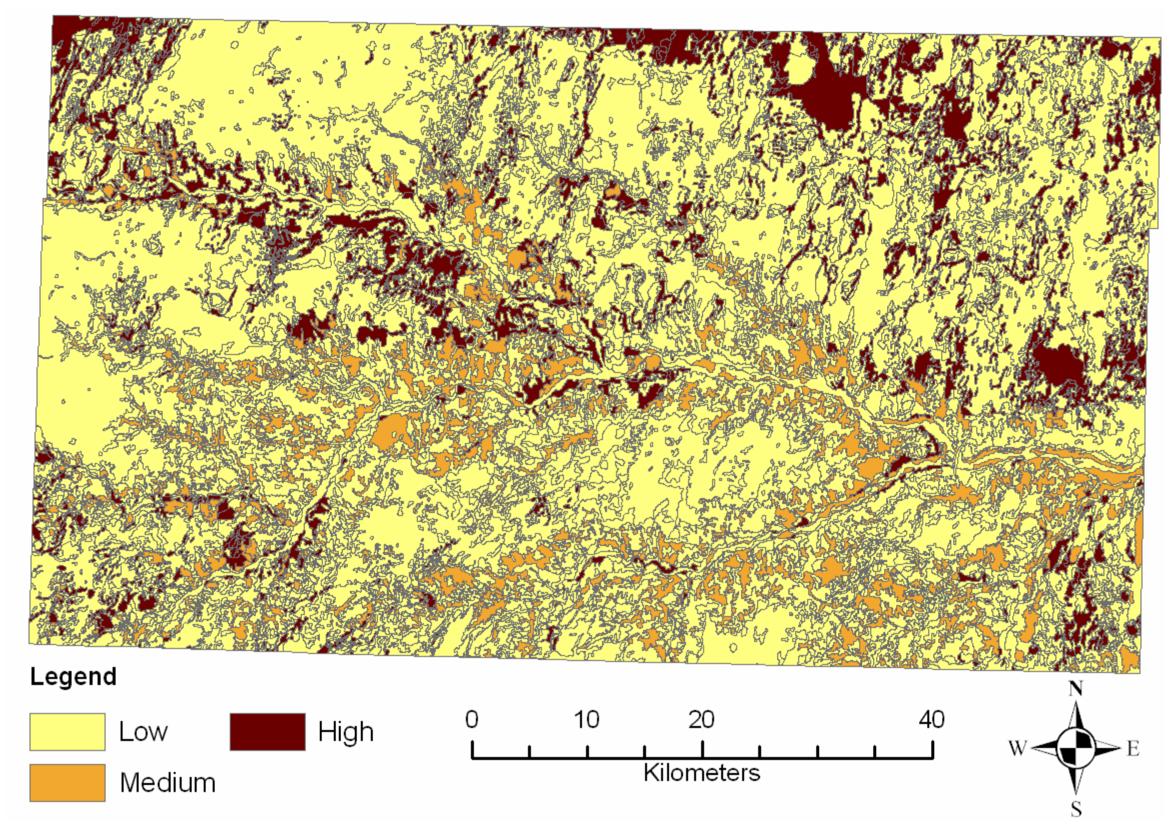

Figure 4.1: Erosion index (EI) for Texas County, Oklahoma showing low hazard (0-39), medium hazard (40-67), and high hazard (68-96). Units are in tons per acre per year.

I overlayed the CRP reference map, the soil database, and the streams, and wetlands layers to identify the post-CRP tracts for various uses that would not compromise environmental benefits gained from the CRP (Chang 2004, Price 2004).

I first identified CRP tracts that had been used for row crops in the pre-CRP period by overlaying the pre-CRP LULC layer with the CRP reference map and selecting all the tracts that had row crops cover and created a new layer (figure 4.2). I then selected from this new layer CRP tracts suitable for row crops production by overlaying with the soil database layer and making the selection based land capability class and erosion index. I selected tracts that fall within the land class capability of two and EI of 15 or less (Rickerl et al. 1999, Johnson and Zidack 1997).

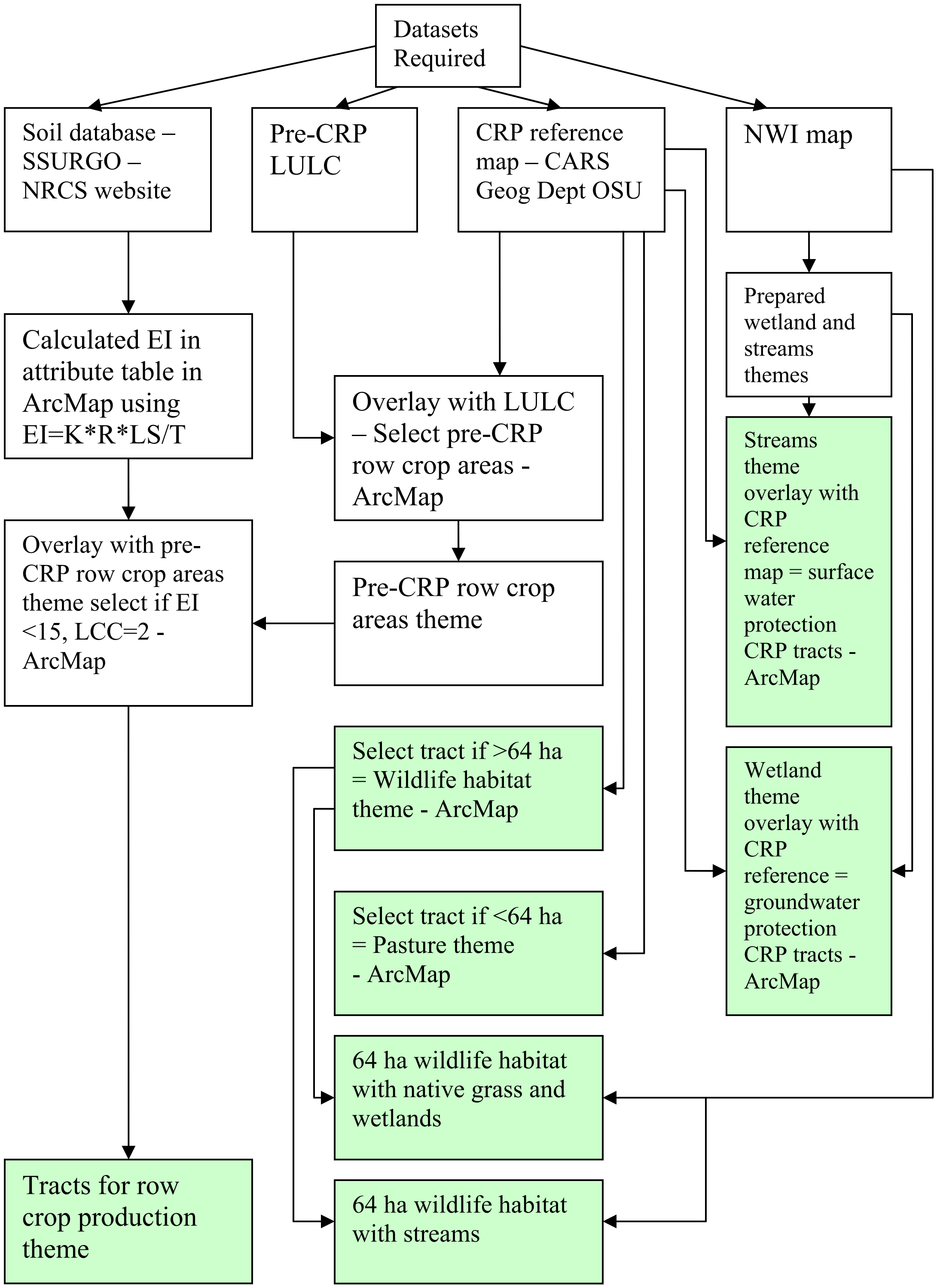

Figure 4.2: Methodology flow chart for selection of CRP tracts for different management options in post-CRP Texas County, Oklahoma showing final themes (shaded).

I then considered all the tracts not selected for row crop production as possible wildlife habitats at three levels: minimum area of 64 ha, minimum area of 64 ha with native grass, minimum area of 64 ha with wetland, minimum area of 64 ha with both native grass and wetland. I also considered tracts of 64 ha and more with native grass and having both wetlands and streams for wildlife use. The choice of using minimum 64 ha as habitat was based on the minimum parcel size that must be suitable for a number of species (Rickerl et al. 1999, USEPA 1999, Johnson and Zidack 1997).

The CRP tracts not selected for row crop production or wildlife habitat were assigned as pasturelands. These tracts have land class capability of three and below and have an erosion index of 15 or more tons per acre per year (Rickerl et al. 1991, Johnson and Zidack 1997).

I used the EI I had calculated to identify tracts within the CRP that should be considered in soil erosion protection. I selected CRP tracts with three EI ranges as hazard levels, i.e., low 11-39, medium 40-68, and high 69-96. In the case of selecting tracts important for wind erosion abatement I used the wind erosion index (WEI) value from the soil database layer to identify CRP tracts at different levels of risk from soil erosion. I selected CRP tracts with WEI of 48-115 low, 116-183 medium, and 184-250 high.

To select CRP tracts important for groundwater protection, I overlaid the CRP reference map and wetlands layer and selected CRP tracts containing wetlands or wetland polygons touching CRP tracts. In the case of surface water protection, I identified the CRP tracts by overlaying the CRP reference map and the streams layer and selected all tracts having a stream passing through the CRP tract.

I exported the selected tracts to new layers and calculated the total area and percentage of areas of CRP tracts selected for each of the layers.

Results

Table 4.1 shows selected categories of land use for environmental benefits in the pre-CRP land use. The results show that about 71% of CRP tracts (60,988 ha) were used for row crop production in the pre-CRP period (table 4.1 and figure 4.13) and of these 19,112 ha (22% of total CRP) were selected as suitable for row crop production in the post-CRP period (table 4.1 and figure 4.13).

Table 4.1: Selected categories of land use for environmental benefits.

Land Use/Selection	Area (Ha)	% of CRP
Not considered for row crops	66,968	77.80
History of row cropping	60,988	70.85
Wildlife	59,936	69.63
Surface water protection	53,524	62.18
Wind erosion 0-115 low	48,600	56.46
Soil erosion 0-39 low	45,524	52.89
No history of row cropping	25,092	29.15
Soil erosion 69-96 high	21,316	24.76
Suitable for row cropping	19,112	22.20
Wildlife streams wetland	18,300	21.26
Wildlife native grass	12,028	13.97
Groundwater protection	11,636	13.52
Pasture	7,032	8.17
Soil erosion 40-68 medium	6,444	7.49
Wind erosion 116-183 medium	5,488	6.38
Wildlife native streams wetland	4,528	5.26
Wildlife wetland	2,184	2.54
Wildlife native grass wetland	364	0.42
Wind erosion 184-250 high	260	0.30

Figure 4.14 in the appendix shows distribution of characteristics of selected wildlife habitat. Out of the remaining 66,968 ha, 59,936 ha met the minimum 64 ha and qualified as wildlife habitat (figure 4.6) and the rest 7,032 ha (about 8.17% of total CRP) were

considered for pasture use (figure 4.5). About 20% of the area selected as wildlife habitat has native grass types (see figure 4.6 and table 4.2) while about 8% has native grass types, streams and wetland areas (figure 4.9). The area that has only streams and wetland is about 31% (figure 4.7 and table 4.2) and 3.64% has only wetland areas (see table 4.2).

Table 4.2: Selected wildlife area types

Selection	**Area (ha)**	**% of CRP**	**% Total Wildlife Habitat**
Wildlife	59,936	69.63	100
Wildlife streams wetland	18,300	21.26	30.53
Wildlife native grass	12,028	13.97	20.07
Wildlife native streams wetland	4,528	5.26	7.55
Wildlife wetland	2,184	2.54	3.64
Wildlife native grass wetland	364	0.42	0.61

In the case of tracts identified for wind erosion control 56.46% were selected at low wind erosion hazard, 6.38% at medium wind erosion hazard, and 0.30% at high wind erosion hazard (table 4.1). This represented an area of 48,600, 5,488, and 260 ha respectively. Areas identified for water erosion hazard comprised 52.89, 7.49, and 24.76% of total CRP at low, medium, and high hazard levels respectively (see table 4.1 and figure 4.11). Low erosion index level has the highest acreage 48,600 ha (table 4.1 and figure 4.13).

The CRP tracts identified for groundwater protection make up 13.5% (11,636 ha) of the total CRP area while for surface water protection the area selected is higher (53,524 ha) representing 62.2% of the CRP tracts (see table 4.2).

Discussion

Land use planning that considers perpetuation of environmental benefits gained from the CRP should take into account the resource to be protected and the nature of the environment in which the resource resides. Historical use of land is also important in determining any future use of a parcel of land (Ohlenbusch and Watson 1995).

About 19,112 ha of CRP tracts were identified as suitable for row cropping representing about 22% of total CRP tracts. These are the tracts identified from a total of 60,988 ha that were used for row crops before the CRP was established. Of the remaining CRP tracts, 7,032 ha are suitable for pasture because they were less than 64 ha, one of the criteria used to select wildlife habitat.

The highest percentage of CRP tracts is suitable for wildlife habitat based mainly on the minimum 64 ha area requirement. The use of CRP tracts as wildlife habitat would serve a dual purpose of reducing soil erosion through farming practices and as wildlife habitat for native species. The most suitable are those providing both native grass and wetlands and represent 0.42% of total CRP tracts and would be the most ideal as habitat for a variety of native species because of the presence of wetlands.

Sensitive areas of the CRP need to be monitored. About 25% of CRP tracts are highly vulnerable to soil erosion by water and need to be monitored while a smaller portion of the CRP tracts (0.3%) is considered highly vulnerable to erosion by wind having a wind erosion index of between 184 and 250.

Only a small portion of the CRP tracts is important for monitoring for groundwater protection because Texas County is not extensively covered with wetlands. In the case of surface water protection, a larger percentage of the CRP is important and will need monitoring, a larger area than for groundwater because of the extensive nature of the stream network in Texas County. To protect groundwater, tracts that have wetlands should not be cultivated closer to wetlands than 30 meters to protect wetlands from sedimentation and contamination by agricultural chemicals. A minimum 30-meter buffer is also required to protect surface water (Tjaden and Weber. 1998a).

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Appendix

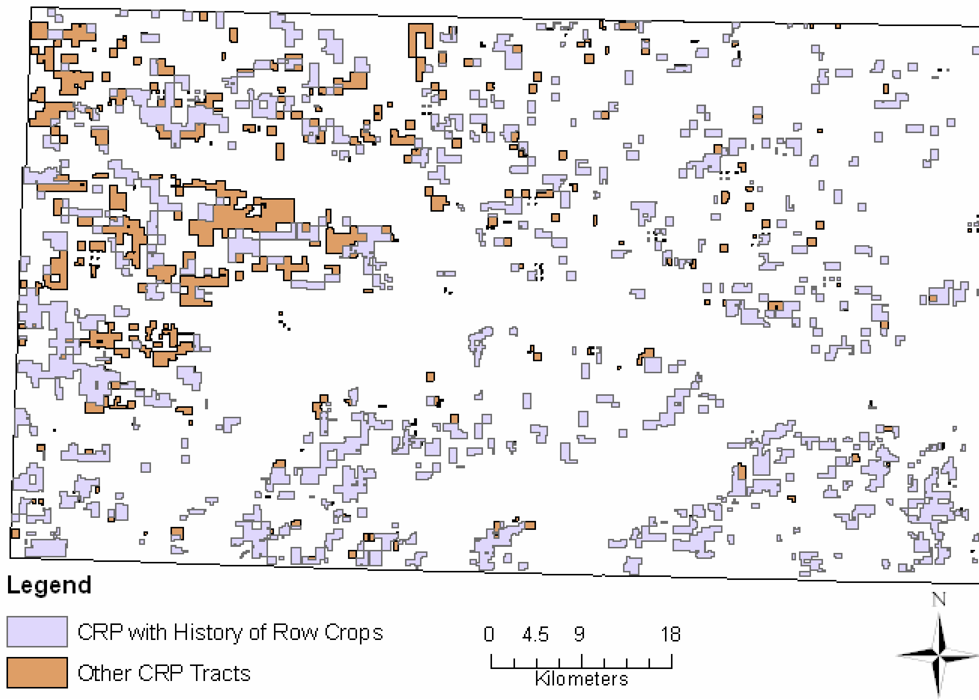

Figure 4.3: CRP tracts used for row crop production before the CRP in Texas County, Oklahoma.

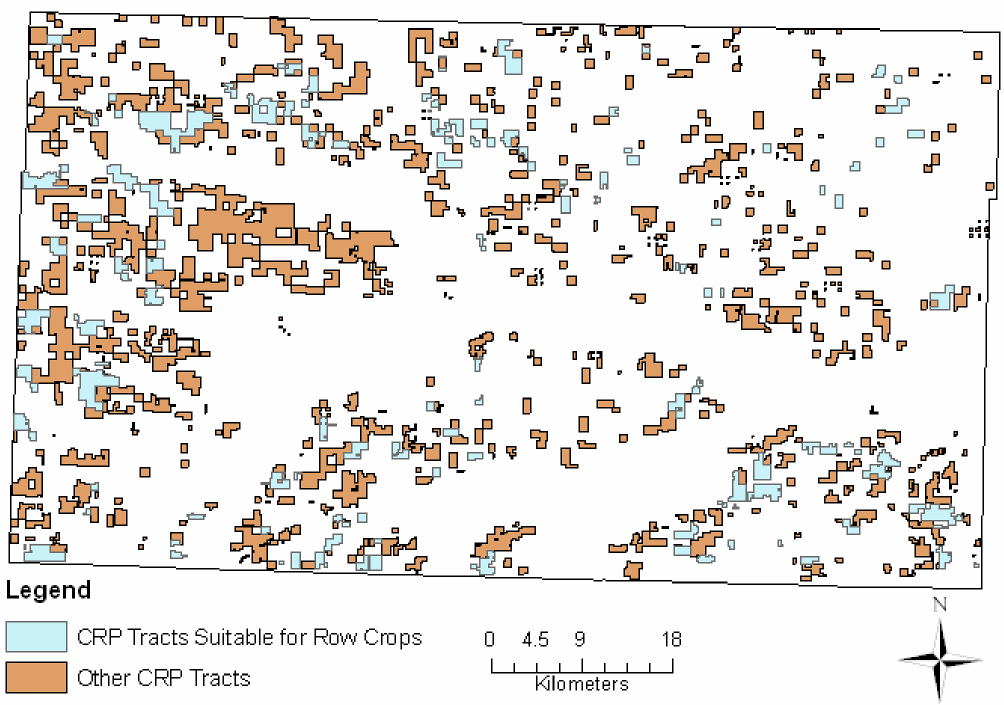

Figure 4.4: CRP tracts selected for row crop production with land class capability 2 and erosion index (EI) 15 or less in Texas County, Oklahoma.

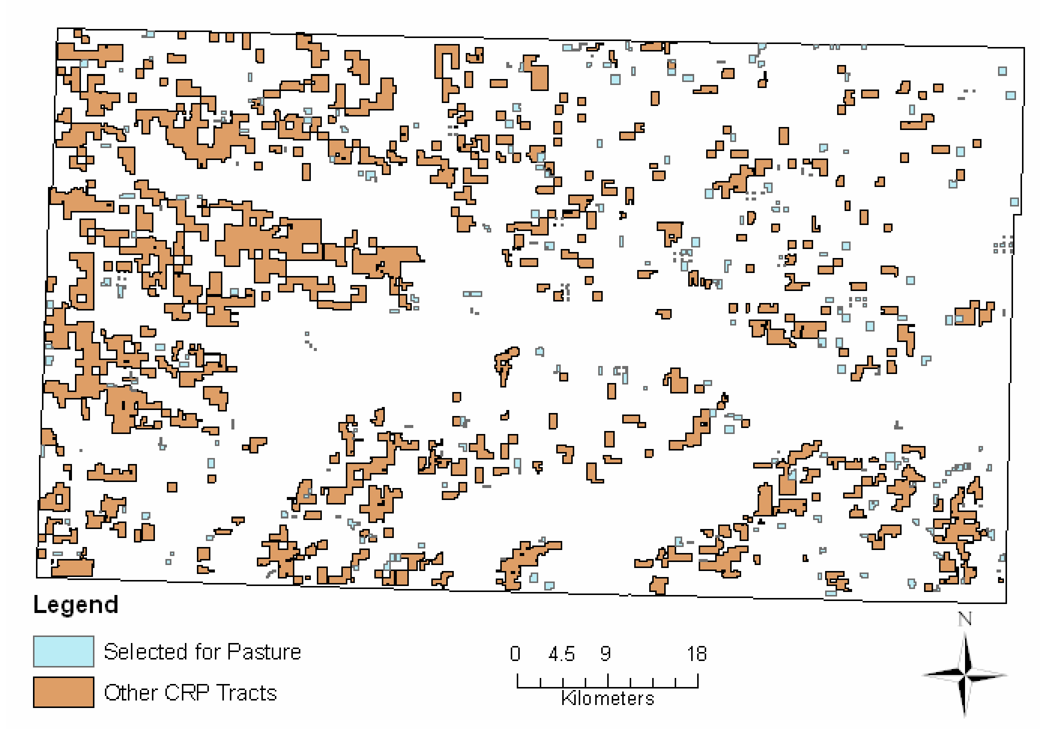

Figure 4.5: CRP tracts selected for use as pasture in Texas County, Oklahoma.

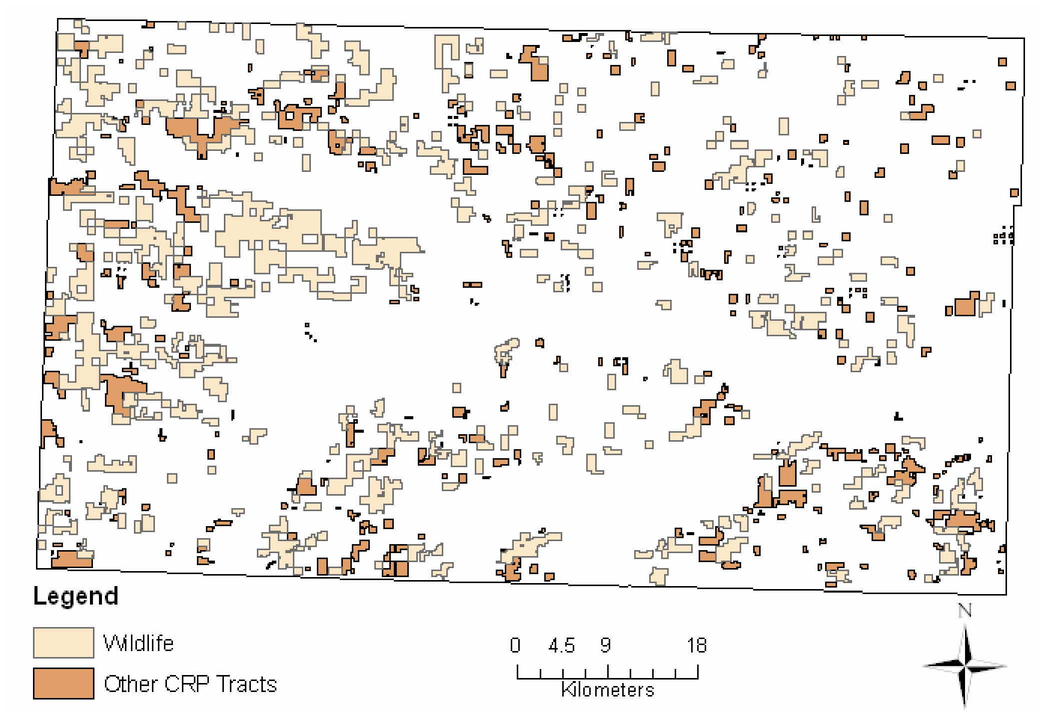

Figure 4.6: CRP tracts selected for wildlife habitat with minimum 64 ha in Texas County, Oklahoma.

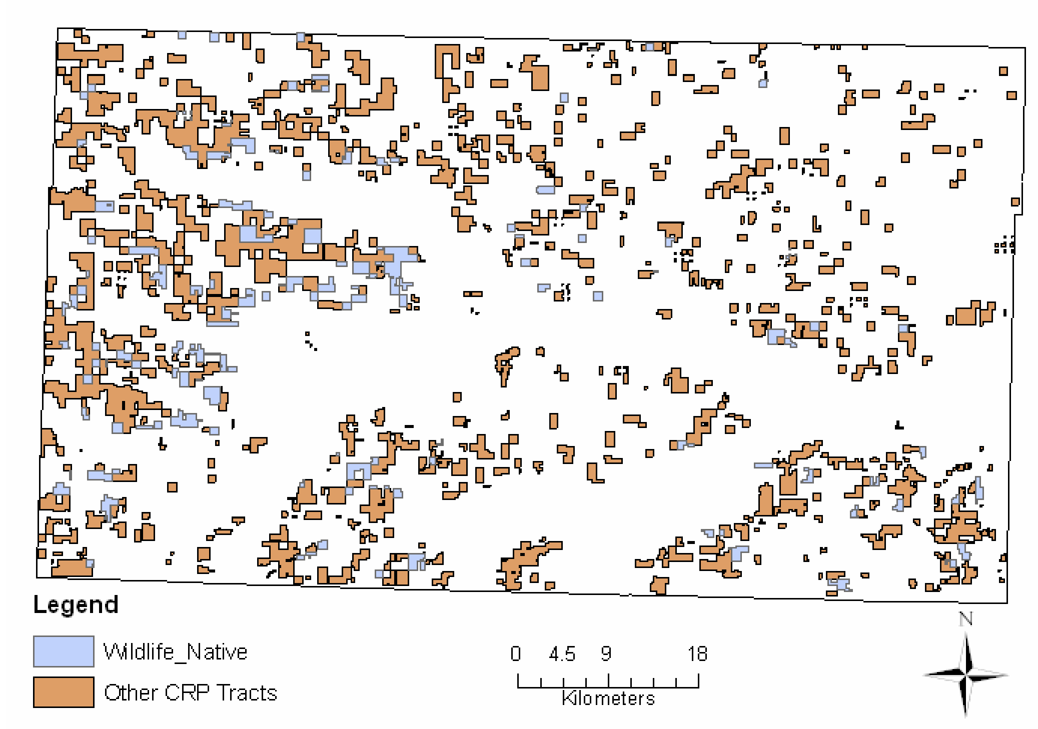

Figure 4.7: CRP tracts selected for wildlife habitat having minimum 64 ha and native grass in Texas County, Oklahoma.

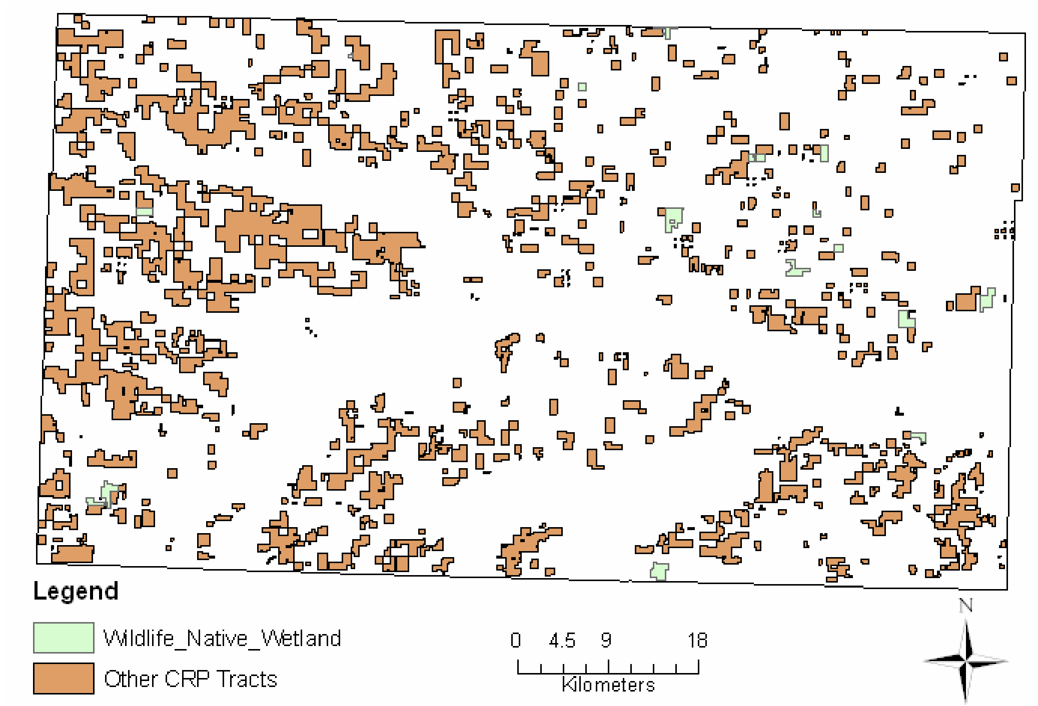

Figure 4.8: CRP tracts selected for wildlife habitat having minimum 64 ha with native grass and wetlands in Texas County, Oklahoma.

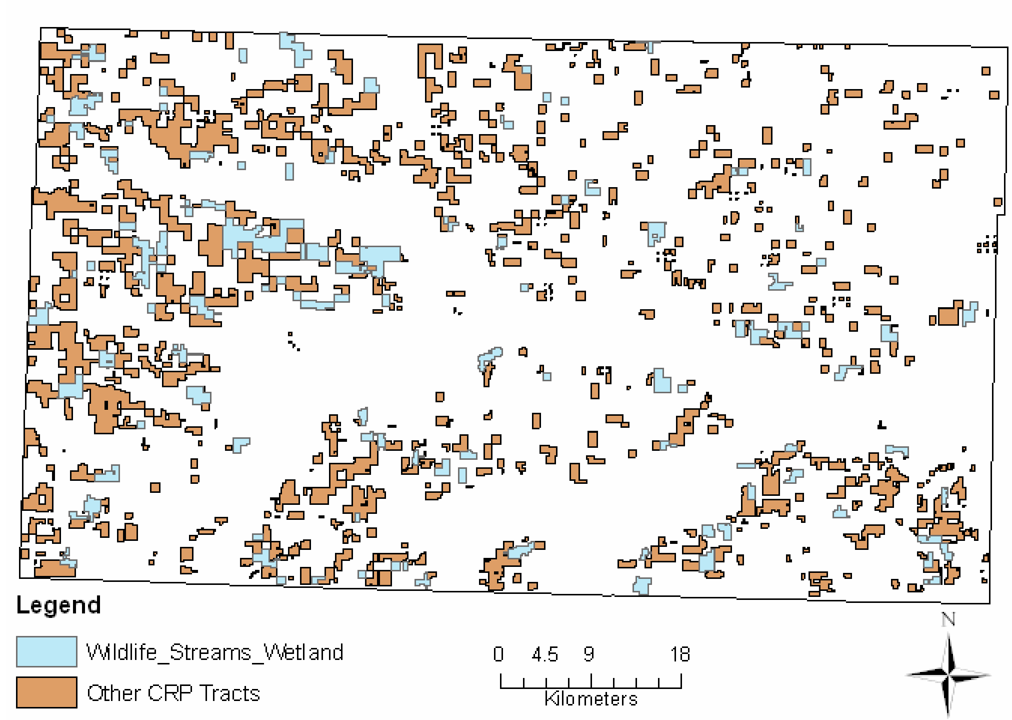

Figure 4.9: CRP tracts selected for wildlife habitat having minimum 64 ha with streams and wetland in Texas County, Oklahoma.

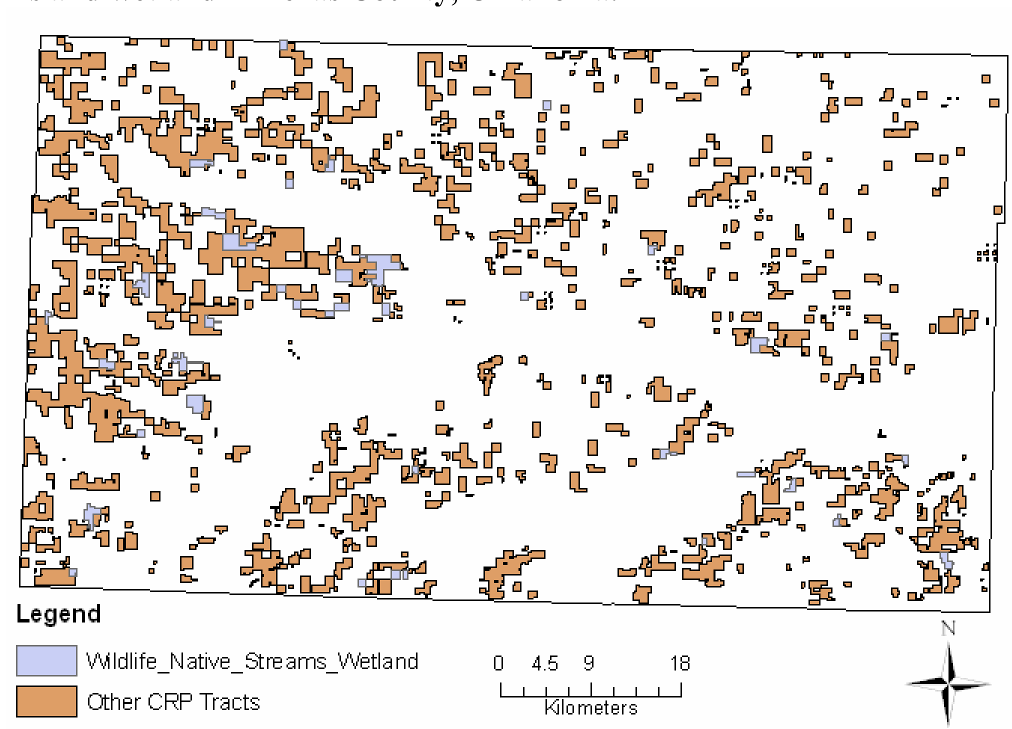

Figure 4.10: CRP tracts selected for wildlife habitat having minimum 64 ha with native grass, streams and wetland in Texas County, Oklahoma.

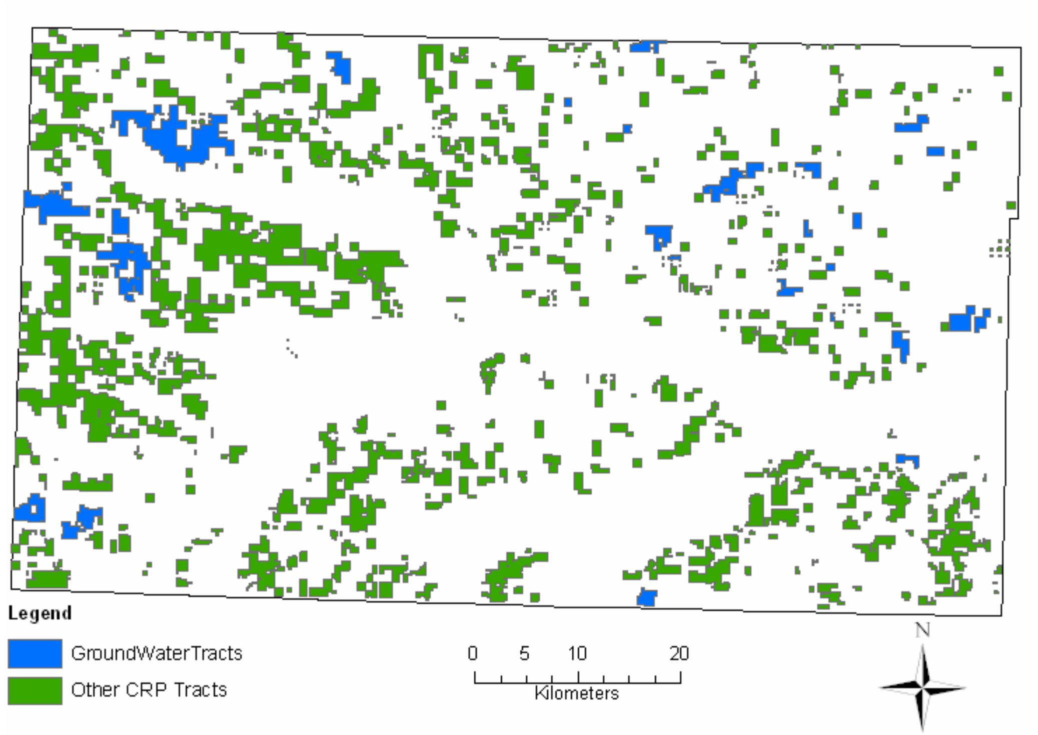

Figure 4.11: CRP tracts selected for groundwater protection in Texas County, Oklahoma.

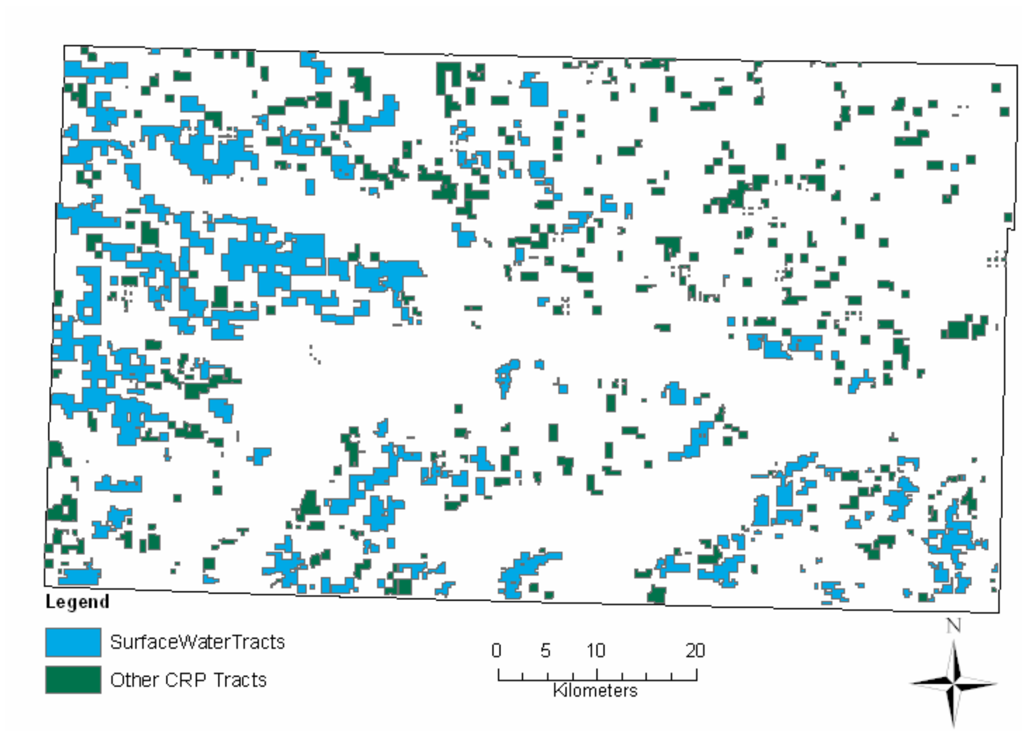

Figure 4.12: CRP tracts selected for surface water protection in Texas County, Oklahoma.

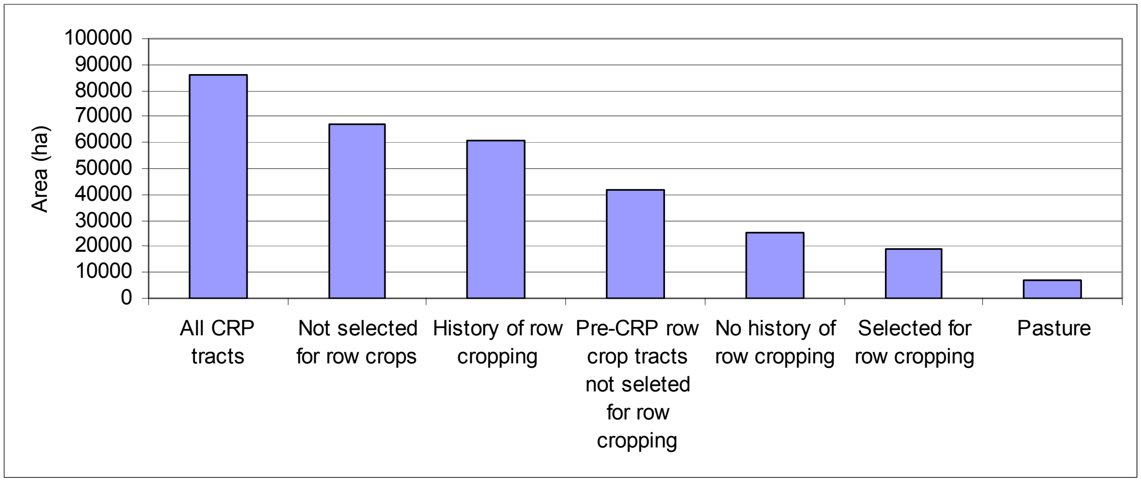

Figure 4.13: CRP tracts showing row cropping and pasture, including pre-selection acreage in Texas County.

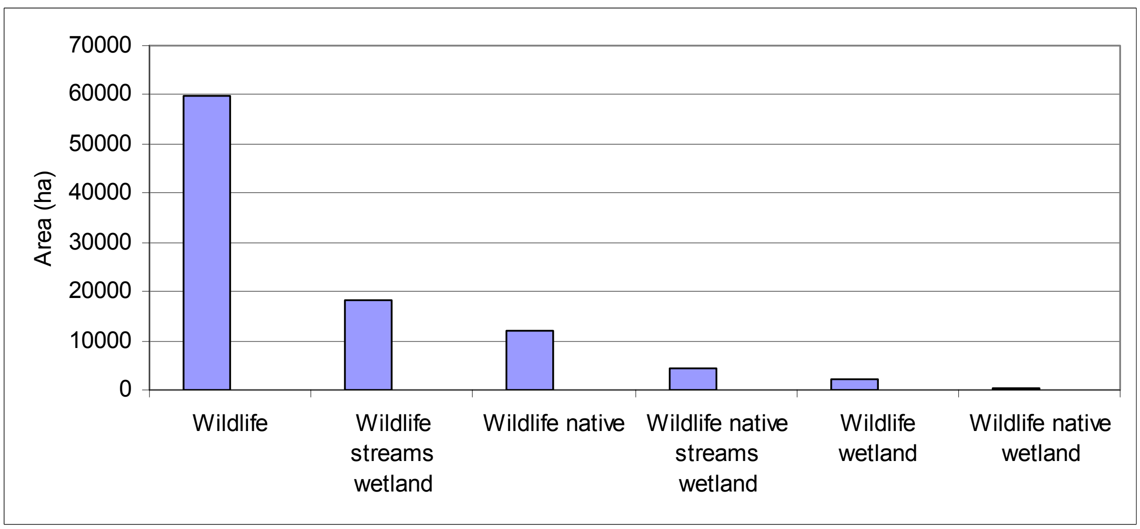

Figure 4.14: Area of CRP tracts identified for wildlife habitat in Texas County.

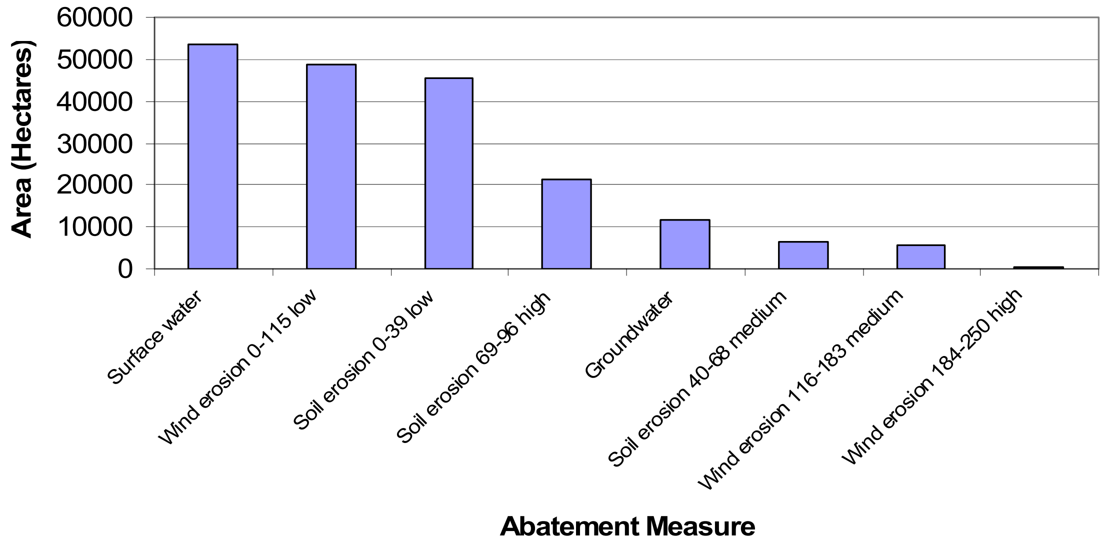

Figure 4.15: Acreage of CRP identified for monitoring water quality (ground and surface), soil erosion by water and wind in Texas County.

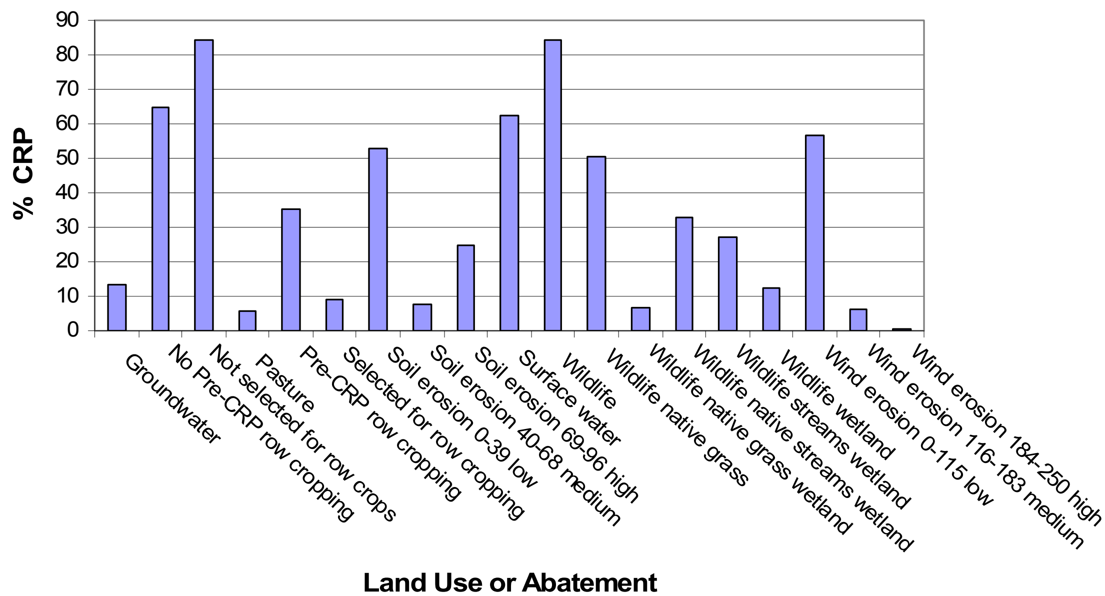

Figure 4.16: Percentage of CRP tracts under different considerations in Texas County's CRP Tracts.

CHAPTER V

MODELING POST-CRP LAND FOR CROP USE WITH OPTIMUM ENVIRONMENTAL BENEFITS IN TEXAS COUNTY, OKLAHOMA

Introduction

The Conservation Reserve Program (CRP) was enacted in 1985 through the Farm Bill Title XII. The CRP is the largest private land retirement program in the history of the US. The CRP is a voluntary program offering rental payments together with 50% cost sharing assistance for conservation practices for 10 to 15 years to land owners to establish plant cover on highly erodable farmland. The planting of trees or grass reduces soil erosion resulting in improvement of soil and water quality. The CRP also improves wildlife habitats (Beckwith II et al. 1997, Zinn 1994, Johnson 2005).

Administration of the CRP is through the United States Department of Agriculture (USDA). This is done in conjunction with the Farm Service Agency (FSA) responsible for contract development, the Commodity Credit Corporation (CCC) which has the responsibility for payments, and the Natural Resources Conservation Service (NRCS) which offers technical assistance (fieldwork, soil productivity, and erodibility) (Beckwith III et al. 1997, Zinn 1994, Johnson 2005).

The maximum annual rental payment for parcels of land offered for the CRP is determined by the area's soil productivity, and prevailing local cash equivalent for rental rates. An additional amount is offered at 50% maintenance costs for conservation activities on the CRP land. The landowner makes a bid based on income that would be lost by converting his land to the CRP practices and the cost of proposed conservation practices. The USDA rejects all bids that exceed their maximum per acre annual rental offer. Accepted bids are examined for amounts offered and types of environmental benefits proposed before final acceptance (Johnson and Zidack 1997).

When the CRP contracts expire, landowners follow approved conservation plans and comply with federal, state, and local environmental laws in relation to wetland, endangered species, and other conservation requirements (Ohlenbusch and Watson 1997).

The 2002 Farm Bill authorized the CRP to enroll a total of 39.2 million acres up to 2007 but currently there are about 34 million acres enrolled. The CRP has reduced soil erosion by 440 million tons per year on the acres enrolled in the program (Johnson 2005). Other benefits include carbon sequestration of over 16 million metric tons annually and over 3.2 million acres of wildlife habitat established (Johnson 2005). Where trees have been planted, the operation has been described as unprecedented with over 2.7 million acres planted using federal government funding (Johnson 2005).

The CRP in Texas County Oklahoma was planted with both native and non-native grasses over an area of more than 212708 acres between 1986 and 1990. In the past twenty years since the establishment of the first CRP tracts, some CRP contracts have come to a close and land owners have either extended their contracts or have returned their land to production. About 5% of the CRP tracts in Texas County have been returned to crop production while the rest remain under grass either continued in the CRP or used in grazing or haying (Messenger 2005). The decision to return CRP land to crop production depends on how much producers would get for their CRP lands compared to crop production. Decisions made depend on commodity prices such that fewer CRP tracts would be devoted to crop production if crop prices were lower but more land would be devoted to cropland if crop prices were higher (Zinn 1994).

Growing crops that do not have deep roots or do not provide mulch cover would result in more soil erosion because the soil would be more exposed to soil erosion by water and wind. For instance, growing row crops (soybeans or corn) can result in more erosion than keeping land under grass (meadow or hay). Thus, producing crops that maintain soil stability can go a long way in maintaining some of the environmental benefits gained from the CRP. The aim of this study was to determine the profitable use of post-CRP tracts without losing the benefits gained from the CRP in terms of soil erosion abatement. To achieve this I determined (i) soil loss by different crops and management practices, (ii) maximum profit at optimum soil abatement, and (iii) crops most suitable at various soil loss levels.

Methods

To determine out the best management or land use for post-CRP tracts in Texas County I determined the types of farm practices in terms of crops grown and modeled different rotation combinations. Information on crops grown in Texas County was obtained from the National Agricultural Statistics Service (NASS) (USDA-NASS 2006). I also used soil database Soil Survey Geographic (SSURGO) obtained from Natural Resources Conservation Service (NRCS) (NRSC 2005).

I calculated soil loss for each crop and management practice by using the (Universal Soil Loss Equation) USLE equation, A = K*R*LS*C*P, where A is the soil erosion loss (tons/acre/year), R is the rainfall factor, K is the soil erodibility factor, LS is the slope-length factor, C is the crop or management factor, and P is the erosion control practice factor. The K is included in the soil database layer while the LS factor was calculated from the equation $LS = [0.065 + 0.0456(slope) + 0.006541(slope)^2]\ [slope\ length/22.1]^{NN}$. The value for NN was obtained from tables of literature (e.g. Blaszczynski 2003, IWR 2002). The values for the R, C, and P factors where obtained from the Texas County NRCS office and literature. The value of the rainfall factor is 120 for Texas County. The values of the other factors are given in tables 5.1 and 5.2 below. I used ArcMap to solve for the LS factor and A in the attribute table using the field calculator.

Table 5.1: Crop or cover ('C') factors used in the study.

'C' (Crop) Factors:	Conventional Till	Minimum Till	No Till
Alfalfa			0.07
CCGM	0.16	0.09	0.05
CCSb	0.40	0.12	0.06
CCSbGM	0.20	0.09	0.05
Corn	0.37	0.07	0.06
CRP			0.036
CSbGM	0.16	0.09	0.05
Grain Sorghum	0.36	0.14	0.05
Meadow/Hay	0.03	0.02	0.01
Soybeans	0.49	0.33	0.29
Wheat	0.20	0.16	0.04

Source: Wischmeier and Smith (1978); NRCS office, Texas County; Terry 1997.

Table 5.2: Support practice ('P') factors used in the study.

Slope %	Contour Cropping	Strip Cropping
1-2	0.60	0.30
3-5	0.50	0.25
6-8	0.50	0.25
9-12	0.60	0.30
13-16	0.70	0.45
17-20	0.80	0.40
21-25	0.90	0.45

Source: Wischmeier and Smith (1978); NRCS office, Texas County; Terry 1997.

I obtained production costs for the crops grown in Texas County from various sources (Duffy and Smith 2006, Foreman 2001, McBride 2003, Johnson and Falconer 2001, Anderson 2005, Ali 2002, Linda and Livezey 2002) (figure 5.2). Production costs are only estimates and do not represent production costs for any particular farm because production costs are highly variable and are influenced by a multiplicity of factors (Duffy and Smith 2006, Johnson and Falcorner 2001, Anderson 2005). To arrive at the production cost reflecting different farming practices the average cost of plowing and contouring was added to the production cost (table 5.3). The price paid to the farmer was estimated from NAS Agricultural Prices publications (2001-2006) (table 5.1) (NASS 2006a). I calculated the average crop prices using figures from publications of the years 2001 to 2005. Yield estimates were calculated from farm production data also obtained from the National Agriculture Statistics Service (NASS) (USDA-NASS 2006b). I calculated the average crop production or yield using data for the years 2001 to 2005.

I used Microsoft Excel Solver to calculate maximum profit from the 212708 acres of CRP tracts that I treated as one farming unit. I used soil loss calculations, crop productions costs, and average crop prices as inputs in the Solver equation. I maximized profit from all the CRP tracts and set constraints in terms of total farmable area (212708 acres) – the extent of the CRP in Texas County, total budget ($60,000,000 – enough to cover the cost of production of the most expensive crop, corn). I also used crop ratio (a measure of the ratio of production of a particular crop in Texas County) (figure 5.4) as a decision variable in the optimization process to allow for a wide range of crops to be selected by the model. The crop ratio was determined by comparing crop production ratios between the 2001 and 2006 crop-marketing seasons. I varied soil loss to see which crops can be grown at different soil loss levels while maximizing profit. Figure 5.1 shows steps taken in the analysis.

Table 5.3: Average crop price (based on 2001 – 2006 commodity prices)

Commodity	Corn/ Bushel	Hay All/Ton	Hay Alfalfa/Ton	Hay Other/ Ton	Sorghum Grain/Bushel	Soybeans/ Bushel	Wheat All/ Bushel	Wheat Winter/ Bushel
Price	$2.11	$93.25	$99.78	$74.88	$3.63	$5.73	$3.34	$3.27

Table 5.4: Crop production costs per acre

Commodity	Corn	Hay All	Hay Alfalfa	Sorghum Grain	Soybeans	Wheat All
Production Cost/Acre	$257.81	$61.29	$239.18	$86.26	$128.63	$99.58

Table 5.5: Management practice cost ($)

Management	Till	Minimum Till	No Till	Contour	Strip
Tractor/Acre	$1.83	$1	$0	$0.50	$0
Herbicide	$0.50	$1.15	$1.50		
Total	$1.83	$1.65	$1	$0.50	$0

Table 5.6: Harvested acreage of crops grown in Texas County, Oklahoma.

Commodity	Harvested Acres	Ratio of Harvested Acres
Soybeans	3680	1
Hay Alfalfa (Dry)	8800	2
Hay Other (Dry)	17250	5
Sorghum For Grain	57000	15
Corn For Grain	71300	19
Wheat All	183000	50

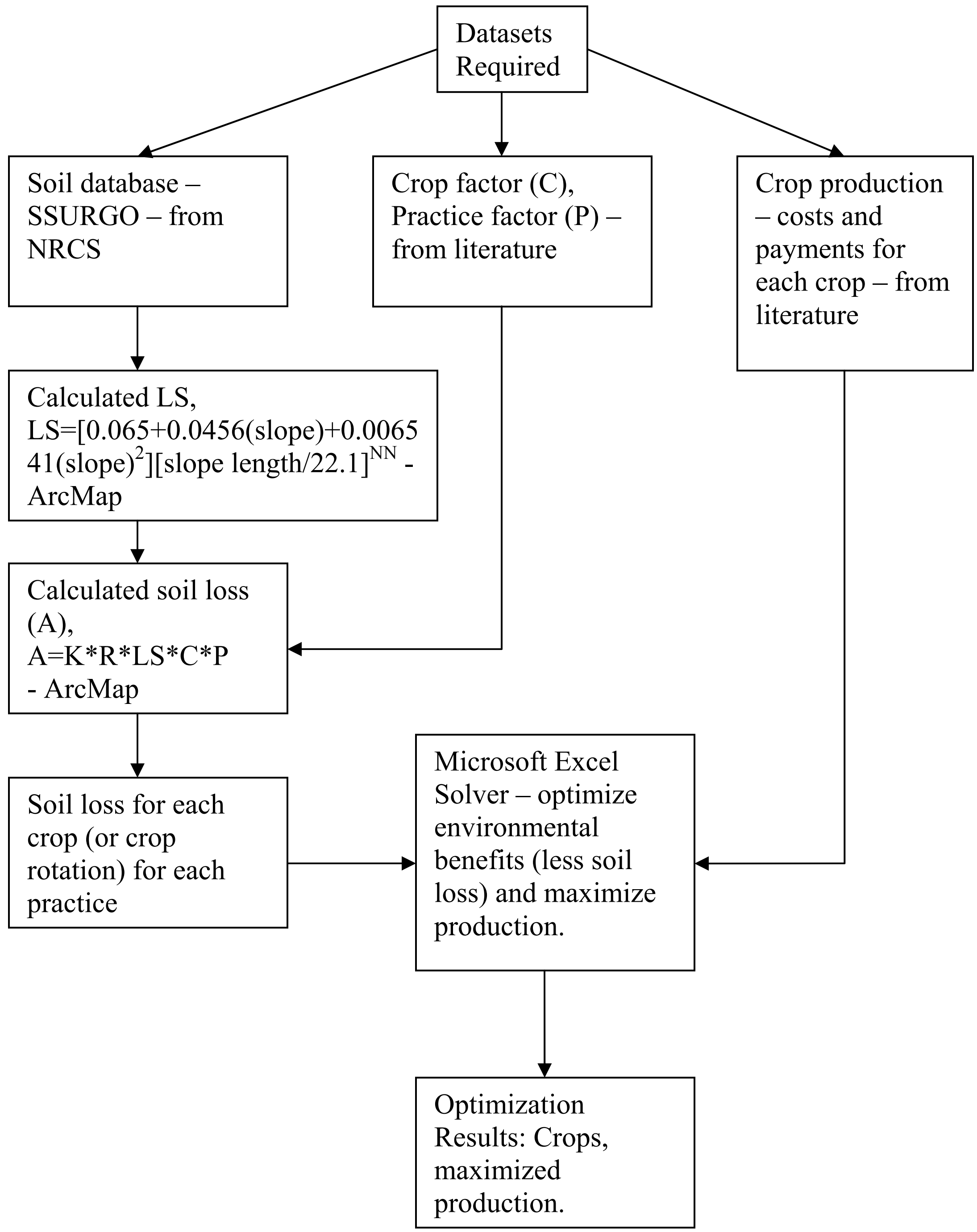

Figure 5.1: Methodology flow chart for determining suitable crops to maintain environmental benefits in post-CRP Texas County, Oklahoma.

Results

Soil loss calculations for single crop farming practices showed a range of 25.11 tons/acre/year for no-till alfalfa to 529.02 tons/acre/year for soybeans when used with conventional till (table 5.5). Farming using no-till produces the lowest soil loss for any of the crops used in the model. Average mean soil loss ranges from 1.50 tons/acre/year for soybeans down to 0.05 tons/acre/year for CRP cover (see table 5.5 and figure 5.2).

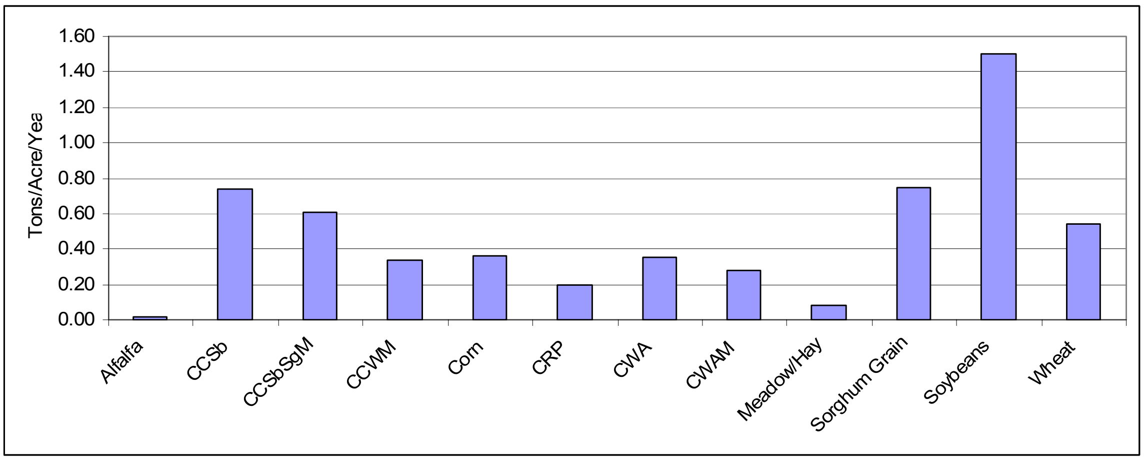

Figure 5.2: Average mean soil loss for crops and crops in rotation for Texas County soils: Alfalfa, CCSb (corn-corn-soybeans), CCSbSgM (corn-corn-soybeans-sorghum-meadow), CCWM (corn-corn-wheat-meadow), corn, CRP, CWA (corn-wheat-alfalfa), CWAM (corn-wheat-alfalfa-meadow), meadow/hay, sorghum, soybeans, and wheat.

In the case of crop cover in rotation, soil loss levels range from 168.93 tons/acre/year for corn-wheat-alfalfa with no-till farming to 3,597.34 tons/acre/year for corn-corn-soybeans with conventional tillage.

Within one crop using the same crop management practice, there are variations in soil loss over the whole CRP tracts under study. The lowest variation is with alfalfa strip cropping with no-till (0.018) while the highest variation (4.134) is found with soybeans contour conventional tilling method (table 5.5). Different crops produced under a combination of management practices result in different rates of soil erosion (Figures 5.3 – 5.6).

Optimization results obtained using the Microsoft Solver show higher profit with increasing soil loss. A solver like Microsoft Excel Solver is a software tool used to find best ways of using a scarce resource. The solver in this case is trying to maximize production while limiting soil loss. The optimum solution will depend on (i) decision variables, i.e., the amount of resources available, (ii) the objective function, in this case the objective function is to maximize production and minimize soil loss, and (iii) constraints, i.e., limits set on the model in terms of what should be possible (Fylstra et al. 1998). For instance, at the lowest soil loss level (2.13 tons per year) the production level is $53,133 with a net profit of $1,868. The area used for production is 212.71 acres. At the highest soil loss level of 95,719 tons per year the realized production level is $75,250,025 with a net profit of $19,927,572 using 212,708 acres. The highest maximized production level is $75,250,026 with a net profit of $20,062,504 and is obtained with a soil loss of 21,270.80 tons per year cultivating crops over an area of 212,708 acres (table 5.7). Comparable net profit levels of close to $20 million are obtained with soil loss levels of 85,083.20 and 95,718.60 tons per year respectively.

The crop selected by the solver equation at the lowest soil loss level of 2.13 tons/acre/year is alfalfa using strip cropping with no till. At the highest soil loss level all crops or cover are selected except for alfalfa, CRP, and soybeans. However, at the highest maximized production level only corn is selected.

When total soil loss is varied, crops are produced at different ratios (Figures 5.7 to 5.23). The highest soil loss that can be processed by the optimization model is 95,718.60 tons per year. Any additional increase in soil loss used in the model does not produce any new results, i.e., the model reaches its optimum soil loss level at that point. Details of results obtained can be found in the appendix section of this chapter.

Discussion

This study shows that a mixture of crops having different soil erosion potential can be suggested for Texas County CRP tracts through modeling by choosing different levels of total soil loss. Alfalfa offers the least soil loss especially when no till cultivation is used. The crop that causes most soil loss is soybeans seconded by corn. The level of soil loss is reduced when these crops are grown in rotation with other crops such as sorghum, wheat, and alfalfa. No till cultivation offers the least soil loss when used with any of the crops that were used in the Microsoft Excel Solver Modeling. The CRP tracts when returned to production would ensure that environmental benefits of reduced soil erosion are maintained by employing no-till cultivation. Additionally, planting crops in rotation between soil conserving crops like alfalfa, hay, and wheat with crops that cause increased soil loss like soybeans and corn would also greatly enhance soil benefits accrued from the CRP.

The model also suggests that profitable farming is possible with maximized production as much as $75,250,026 and a net profit of $20,062,504 that is obtained at the soil loss level of 0.1 tons per acre per year. This amount of soil loss translates into total soil loss of 21270.8 tons per year over the entire CRP tracts of Texas County. Comparable profit margins can be obtained at increased soil loss (0.4 and 0.45 tons/acre/year) but corn is the only crop selected by the model at these levels. A mixture of crops can be grown at lower levels of net profit using different soil loss levels.

Corn grown alone or grown in rotation with other crops gives a higher net profit due to the selling price of corn and the number of acres produced. The model does not select soybeans where there is high net profit because of high levels of soil loss caused by soybeans, net returns compared to corn, and the comparable ratio of production of the crop (the acres of soybeans grown are less than any other crop in Texas County).

At low soil loss levels, few acres are used and high erodability crops, e.g., soybeans, are not selected. Soybeans are selected when grown in rotation with other crops like corn, sorghum, or hay. This suggests that few acres should be cultivated to allow for low soil losses when producing crops in Texas County's CRP tracts.

Crop production in Texas County can be carried out up to maximum soil level of 0.45 tons/acre/year with a net profit of $19,927,572 growing a variety of crops using 212,708 acres. The model suggests that all of the CRP tracts can be put into crop production with an average of 0.45 tons/acre/year soil loss. Nonetheless, allowing very low levels of soil loss results in low production levels as shown by the low productivity of $53,133 obtained at the total soil loss level of 2.13 tons per year. Allowing high levels of soil loss in the model does not allow for higher production levels because soil loss levels off at 0.45 tons/acre/year.

The study also shows that amount of soil loss using a particular crop/crop management combination is not uniform over the whole CRP tracts as shown in table 5.1. The variation in soil loss means that results obtained are only a general guide and the model must be tried at the local or farm level. This will allow more realistic projected production levels.

The optimization model used in this study can be used to plan for farm practices for CRP tracts returned to production with a view of maintaining soil stability and water quality. The model can also be used to plan for production of certain crops and appropriate rotation programs that would ensure environmental benefits gained. Results of studies like the current study must be applied on a local level rather than applied uniformly throughout a region because better results will be obtained if findings are applied at a local scale (Yang et al. 2003).

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Appendix

Table 5.7: Soil loss using single crop cultivation in CRP Tracts in Texas County, Oklahoma

Crop/ Cover	Management	Total soil loss from 2467 polygons	Mean soil loss tons/acre/year from 2467 polygons	Minimum soil loss/acre/year	Maximum soil loss/acre/year	Standard deviation
Alfalfa	Contour_No Till	55.52	0.02	0.01	0.41	0.033
	Stripcropping_No Till	25.14	0.01	0.00	0.20	0.018
Corn	Contour_Conventional Till	2130.62	0.86	0.25	16.22	1.350
	Contour_Minimum Till	1068.31	0.43	0.12	8.11	0.675
	Contour_No Till	395.91	0.16	0.05	3.04	0.253
	Stripcropping_Conventional Till	1068.31	0.43	0.12	8.11	0.675
	Stripcropping_Minimum Till	529.44	0.21	0.06	4.05	0.338
	Stripcropping_No Till	199.02	0.08	0.02	1.52	0.127
CRP	Contour_No Till	476.76	0.19	0.06	8.65	0.305
	Stripcropping_No Till	242.44	0.10	0.03	1.82	0.151
Hay	Contour_Conventional Till	395.91	0.16	0.05	2.36	0.248
	Contour_Minimum Till	263.90	0.11	0.03	2.03	0.170
	Contour_No Till	133.01	0.05	0.02	1.01	0.084
	Stripcropping_Conventional Till	199.02	0.08	0.02	1.52	0.127
	Stripcropping_Minimum Till	133.01	0.05	0.02	1.01	0.084
	Stripcropping_No Till	69.32	0.03	0.01	0.51	0.043
Sorghum Grain	Contour_Conventional Till	4799.75	1.95	0.56	36.48	3.038

Crop/ Cover	**Management**	**Total soil loss from 2467 polygons**	**Mean soil loss tons/acre/year from 2467 polygons**	**Minimum soil loss/acre/year**	**Maximum soil loss/acre/year**	**Standard deviation**
	Contour_Minimum Till	1868.02	0.76	0.22	14.19	1.182
	Contour_No Till	666.78	0.27	0.08	5.07	0.421
	Stripcropping_Conventional Till	2398.07	0.97	0.28	18.24	1.519
	Stripcropping_Minimum Till	938.06	0.38	0.11	7.09	0.590
	Stripcropping_No Till	332.02	0.13	0.04	2.53	0.211
Soybeans	Contour_Conventional Till	6529.02	2.65	0.76	49.66	4.134
	Contour_Minimum Till	4395.47	1.78	0.51	33.44	2.780
	Contour_No Till	3861.45	1.57	0.45	29.39	2.450
	Stripcropping_Conventional Till	3266.58	1.32	0.38	24.83	2.067
	Stripcropping_Minimum Till	2195.70	0.89	0.26	16.72	1.393
	Stripcropping_No Till	1931.58	0.78	0.23	14.70	1.223
Wheat	Contour_Conventional Till	2660.30	1.08	0.31	20.27	1.688
	Contour_Minimum Till	2130.62	0.86	0.25	16.22	1.350
	Contour_No Till	529.44	0.21	0.06	4..05	0.338
	Stripcropping_Conventional Till	1333.55	0.54	0.16	10.13	0.844
	Stripcropping_Minimum Till	1068.31	0.43	0.12	8.11	0.675
	Stripcropping_No Till	263.90	0.11	0.03	2.03	0.170

Table 5.8: Soil loss using crop rotation cultivation in CRP Tracts in Texas County, Oklahoma

Crop/ Cover	Management	Total soil loss from 2467 polygons	Mean soil loss tons/acre/year from 2467 polygons	Minimum soil loss/acre/year	Maximum soil loss/acre/year	Standard deviation
CCWM	Contour_Conventional Till	1840.31	0.75	0.21	13.99	1.164
	Contour_Minimum Till	1132.54	0.46	0.13	8.61	0.718
	Contour_No Till	375.77	0.15	0.04	2.84	0.236
	Stripcropping_Conventional Till	918.27	0.37	0.11	6.99	0.583
	Stripcropping_Minimum Till	569.47	0.23	0.07	4.31	0.358
	Stripcropping_No Till	186.70	0.08	0.02	1.42	0.119
CWA	Contour_Conventional Till	1868.02	0.76	0.22	14.19	1.180
	Contour_Minimum Till	1236.96	0.50	0.14	9.43	0.784
	Contour_No Till	332.02	0.13	0.04	2.53	0.211
	Stripcropping_Conventional Till	938.06	0.38	0.11	7.09	0.590
	Stripcropping_Minimum Till	617.85	0.25	0.07	4.71	0.392
	Stripcropping_No Till	168.93	0.07	0.02	1.27	0.105
CWAM	Contour_Conventional Till	1503.85	0.61	0.18	11.45	0.954
	Contour_Minimum Till	1002.97	0.41	0.12	7.60	0.633
	Contour_No Till	279.68	0.11	0.03	2.13	0.177
	Stripcropping_Conventional Till	755.12	0.31	0.09	5.73	0.475
	Stripcropping_Minimum	504.77	0.20	0.06	3.80	0.316

Crop/ Cover	Management	Total soil loss from 2467 polygons	Mean soil loss tons/acre/year from 2467 polygons	Minimum soil loss/acre/year	Maximum soil loss/acre/year	Standard deviation
	Till					
	Stripcropping_No Till	136.15	0.06	0.02	1.03	0.088
CCSb	Contour_Conventional Till	3597.34	1.46	0.42	27.36	2.278
	Contour_Minimum Till	2175.43	0.88	0.25	16.52	1.375
	Contour_No Till	1556.26	0.63	0.18	11.86	0.988
	Stripcropping_Conventional Till	1798.70	0.73	0.21	13.68	1.139
	Stripcropping_Minimum Till	1087.61	0.44	0.13	8.26	0.688
	Stripcropping_No Till	775.81	0.31	0.09	5.93	0.494
CCSbSgM	Contour_Conventional Till	3202.04	1.30	0.37	24.32	2.024
	Contour_Minimum Till	1731.30	0.70	0.20	13.18	0.098
	Contour_No Till	1096.02	0.44	0.13	8.31	0.692
	Stripcropping_Conventional Till	1599.94	0.65	0.19	12.16	1.021
	Stripcropping_Minimum Till	861.80	0.35	0.10	6.59	0.549
	Stripcropping_No Till	549.87	0.22	0.06	4.16	0.345

Table 5.9: Solver optimization results of crop production in CRP Tracts in Texas County, Oklahoma

Average Soil loss Tons/Acre/Year	Total Soil loss (Tons)	Acres Used	Maximized Production ($)	Budget ($)	Maximized Profit ($)
0.00001	2.13	213.00	53,132.85	51,264.84	1,868.01
0.00010	21.27	85.00	21,179.23	15,661.75	5,517.48
0.00100	212.71	850.35	211,802.26	156,624.86	55,177.40
0.01000	2,127.08	8,503.00	2,117,788.28	1,566,076.87	551,711.41
0.02500	5,317.70	212,59.17	5,294,901.62	3,915,499.27	1,379,402.35
0.05000	10,635.40	425,18.35	10,589,804.46	7,830,999.48	2,758,804.98
0.07500	15,953.10	637,77.51	15,884,704.00	11,746,497.15	4,138,206.84
0.10000	21,270.80	212,708.00	75,250,026.39	55,187,522.83	20,062,503.56
0.12500	26,588.50	121,818.64	31,522,361.39	22,921,511.01	8,600,850.38
0.17500	37,223.90	116,076.46	29,674,972.86	21,595,431.01	8,079,541.88
0.20000	42,541.60	118,061.23	29,907,617.04	21,683,171.82	8,224,445.22
0.22500	47,859.30	212,708.00	72,402,302.20	53,325,992.52	19,076,309.68
0.25000	53,177.00	212,708.00	72,505,447.08	53,403,301.02	19,102,146.06
0.27500	58,494.70	191,513.60	54,881,837.43	39,755,611.15	15,126,226.28
0.30000	63,812.40	212,708.00	72,700,552.13	53,550,940.69	19,149,611.44
0.32500	69,130.10	212,708.00	66,875,677.56	49,298,294.27	17,557,383.28
0.35000	70,617.88	212,708.00	67,618,261.40	49,870,112.07	17,748,149.33
0.37500	74,447.88	212,708.00	69,057,674.78	50,881,807.06	18,175,867.72
0.40000	85,083.20	212,708.00	75,249,859.34	55,324,847.58	19,924,984.76
0.45000	95,718.60	212,708.00	75,250,024.73	55,322,452.60	19,927,572.13

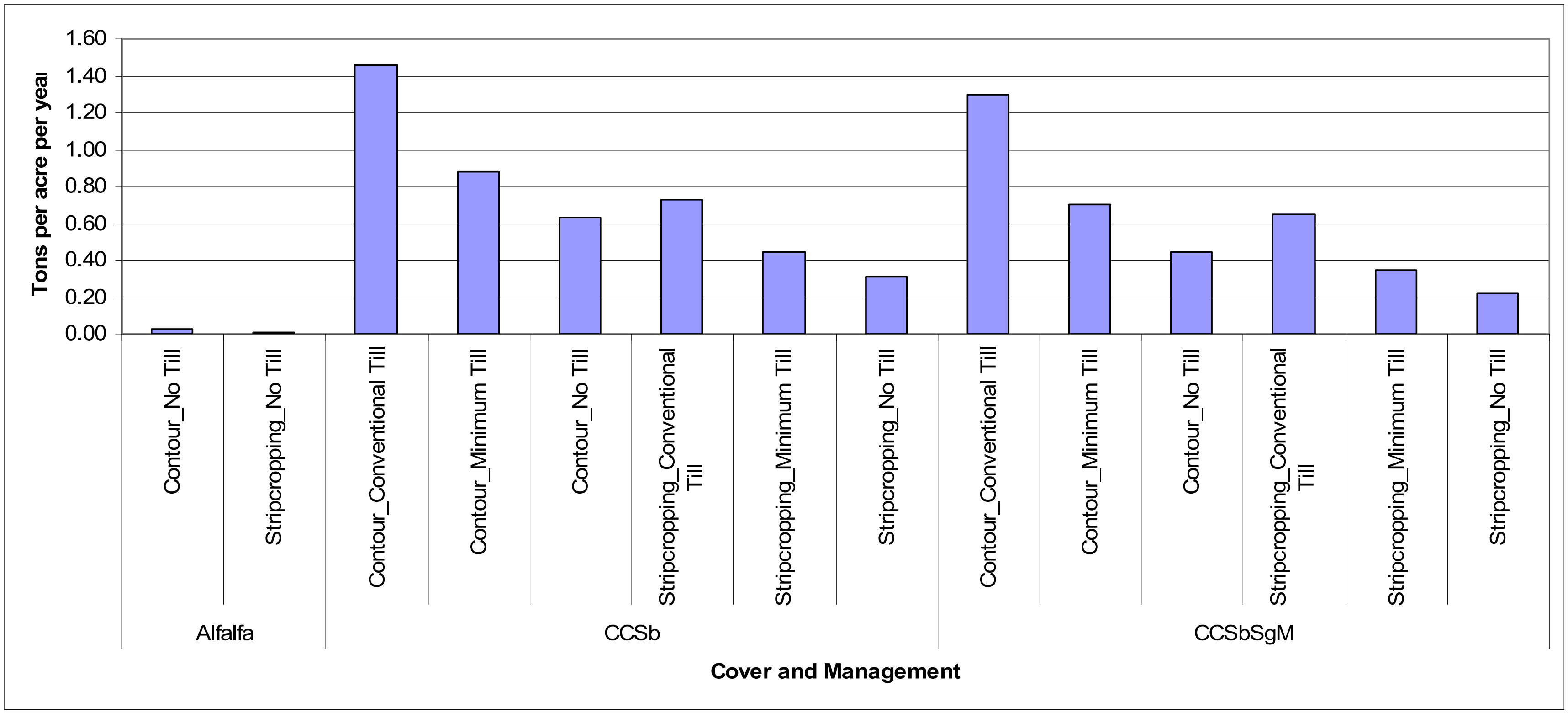

Figure 5.3: Soil loss under different crop and management system – Continuous alfalfa; corn, corn, and soybeans (CCSb) rotation; and corn, corn, soybeans, sorghum and meadow/hay (CCSbSgM) rotation.

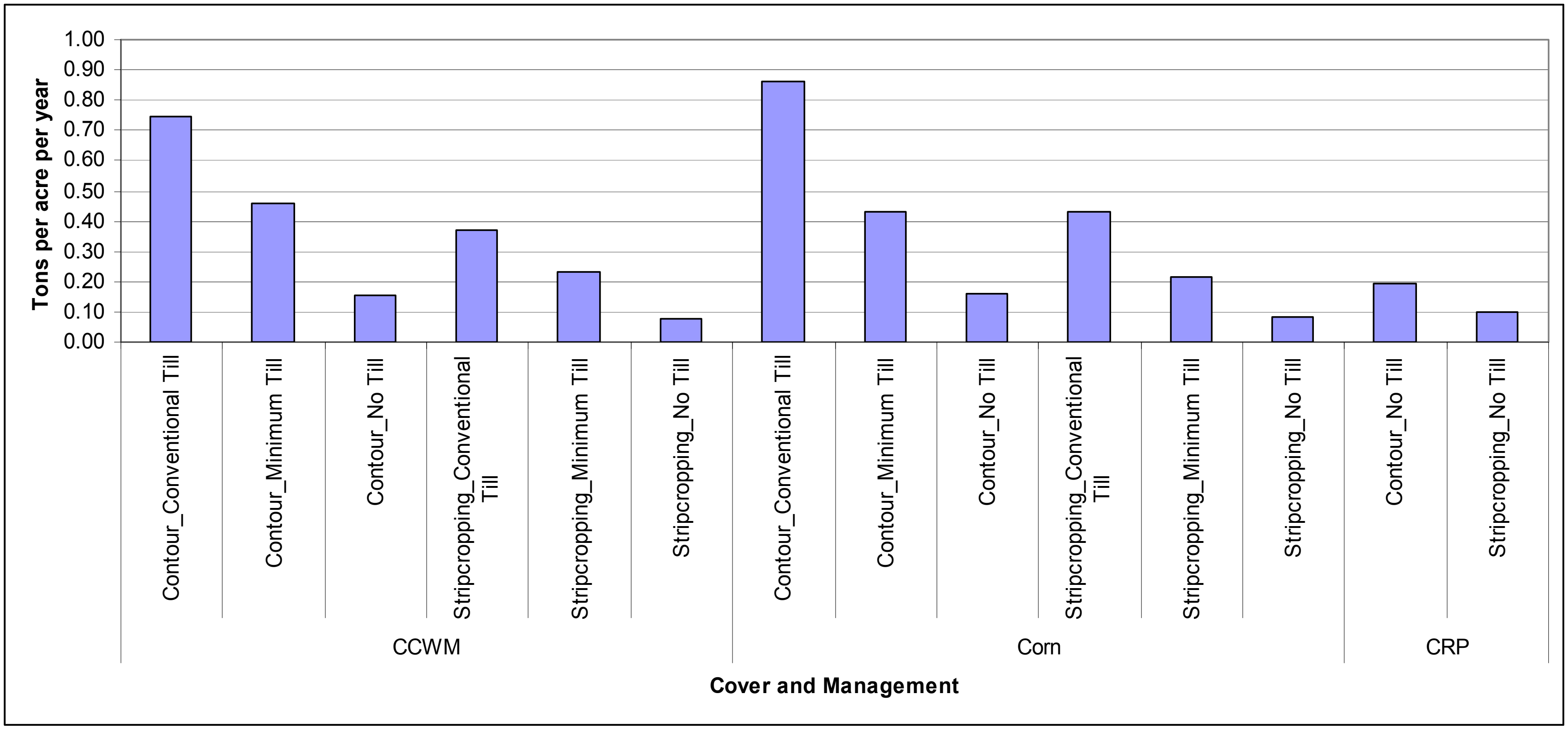

Figure 5.4: Soil loss under different crop and management system – Corn, corn, wheat and meadow/hay (CCWM) rotation; continuous corn; and continuous CRP cover.

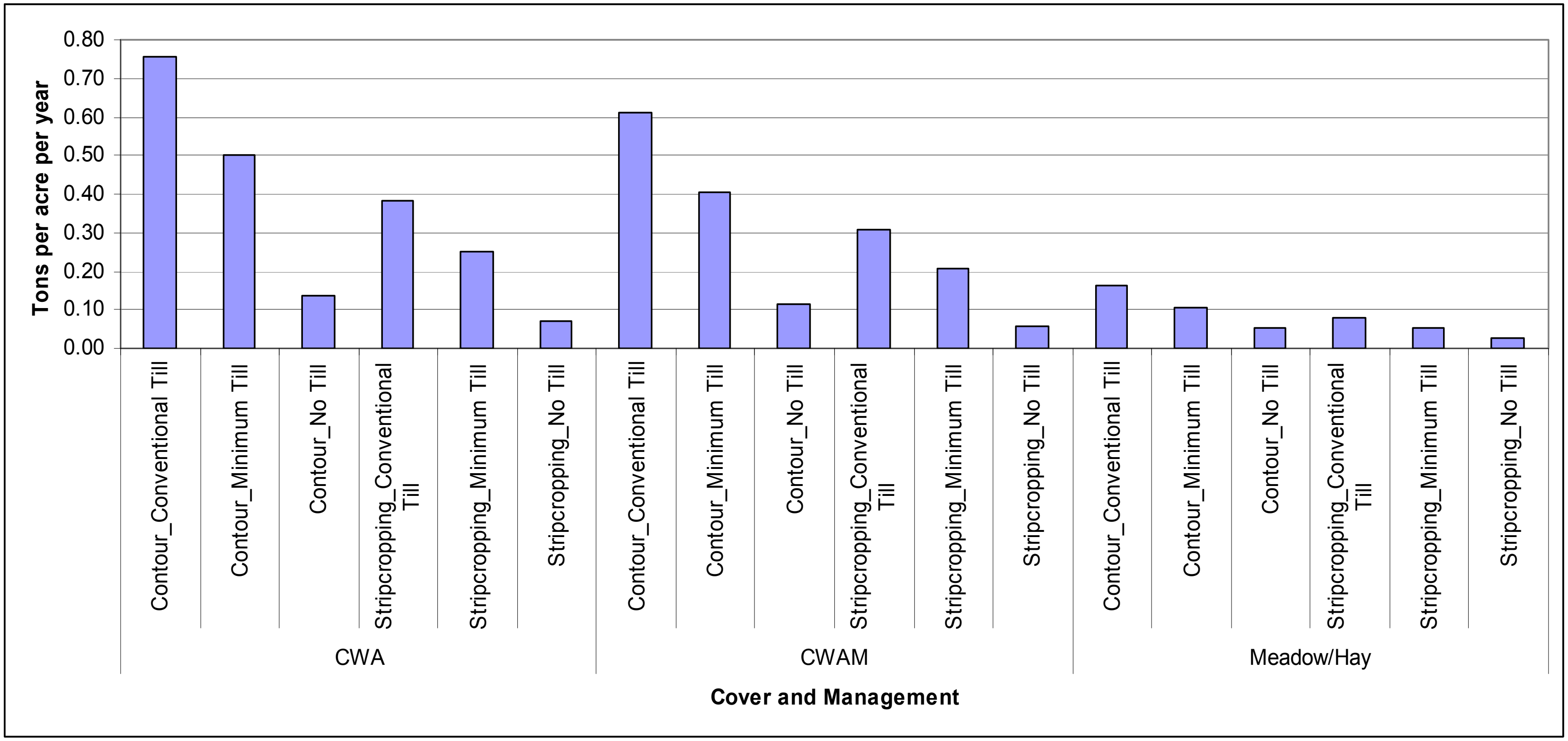

Figure 5.5: Soil loss under different crop and management system – Corn, wheat, and alfalfa (CWA) rotation; and corn, wheat, alfalfa, and meadow/hay (CWAM) rotation; and continuous meadow/hay.

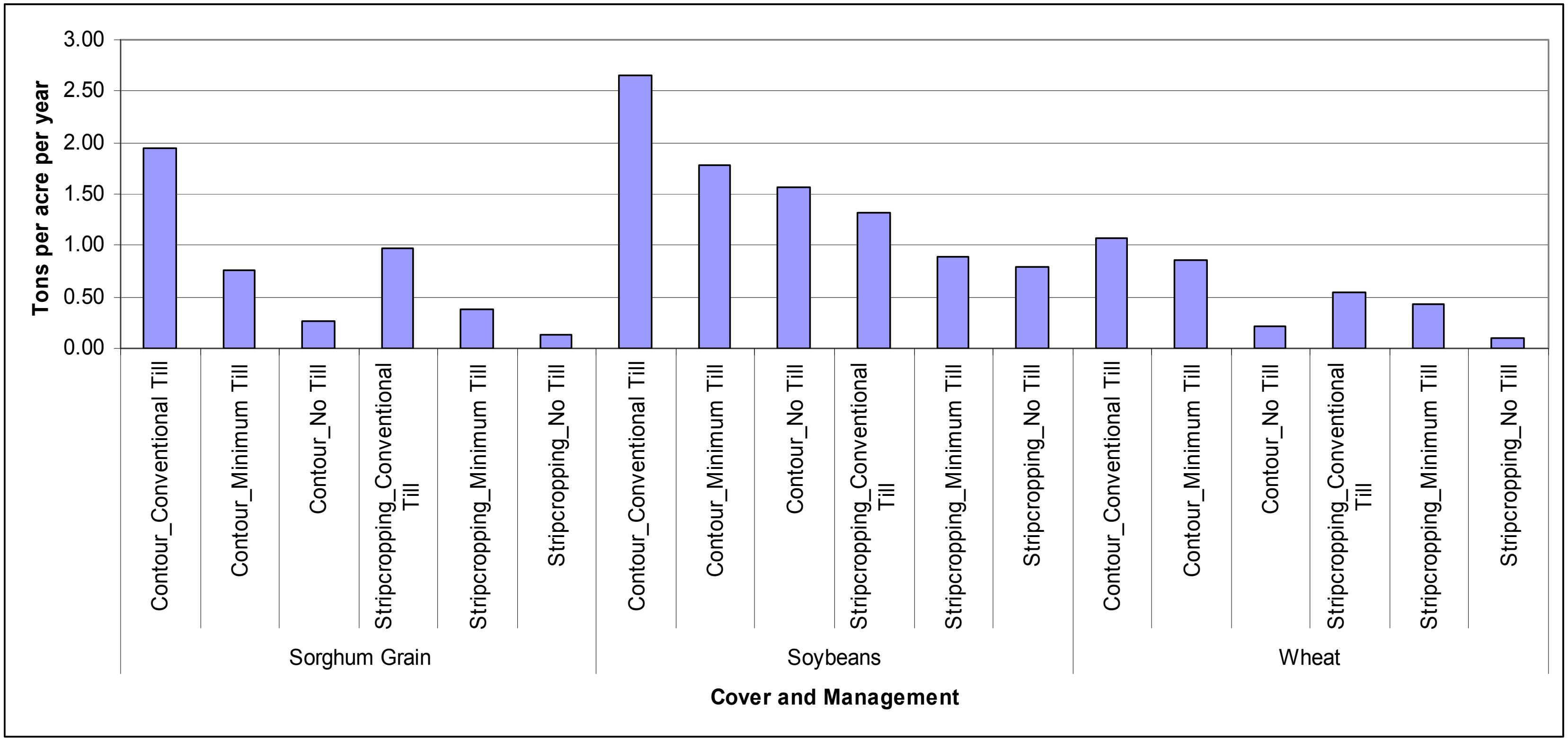

Figure 5.6: Soil loss under different crop and management system – Continuous sorghum; continuous soybeans; and continuous wheat.

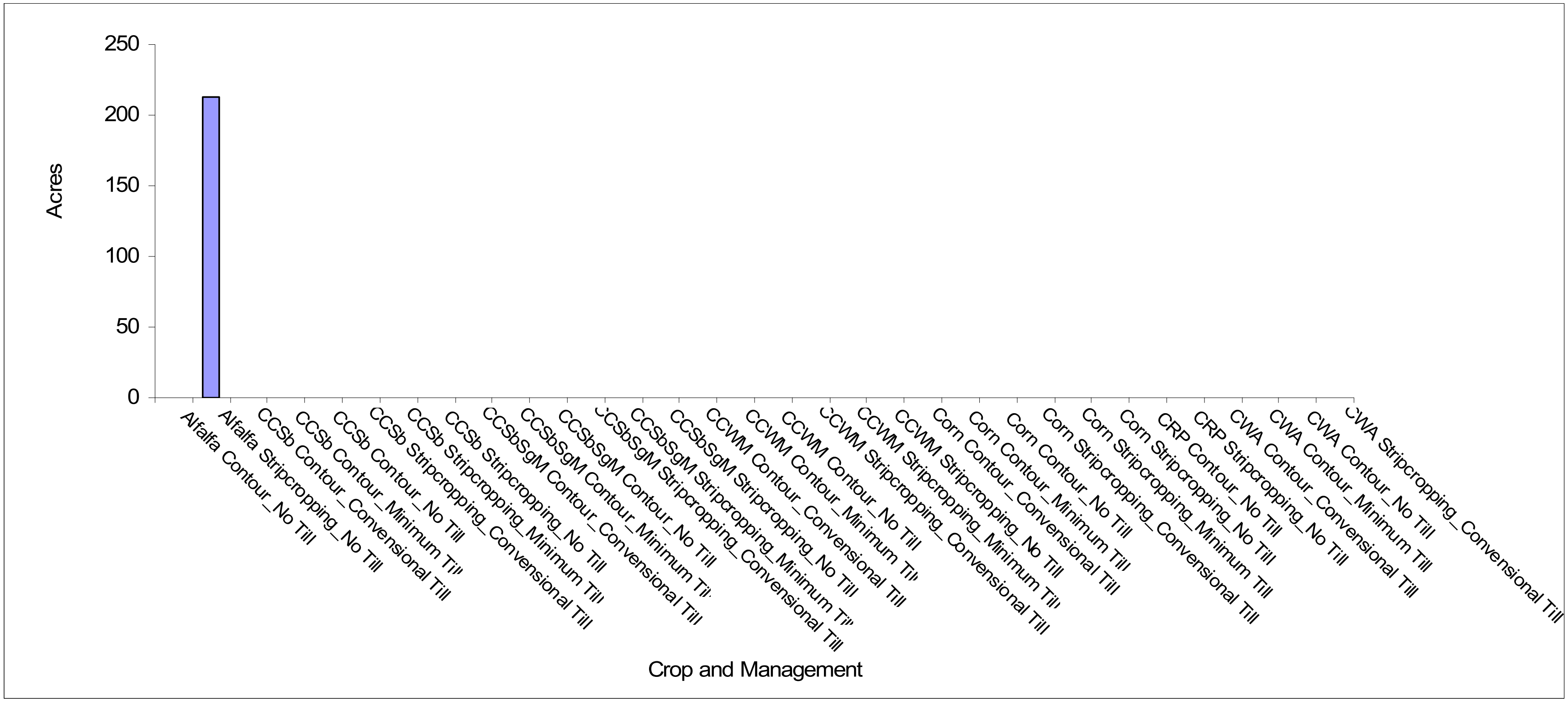

Figure 5.7: Acreage of crops produced using total soil loss of 2.13 tons per year in Texas County, Oklahoma.

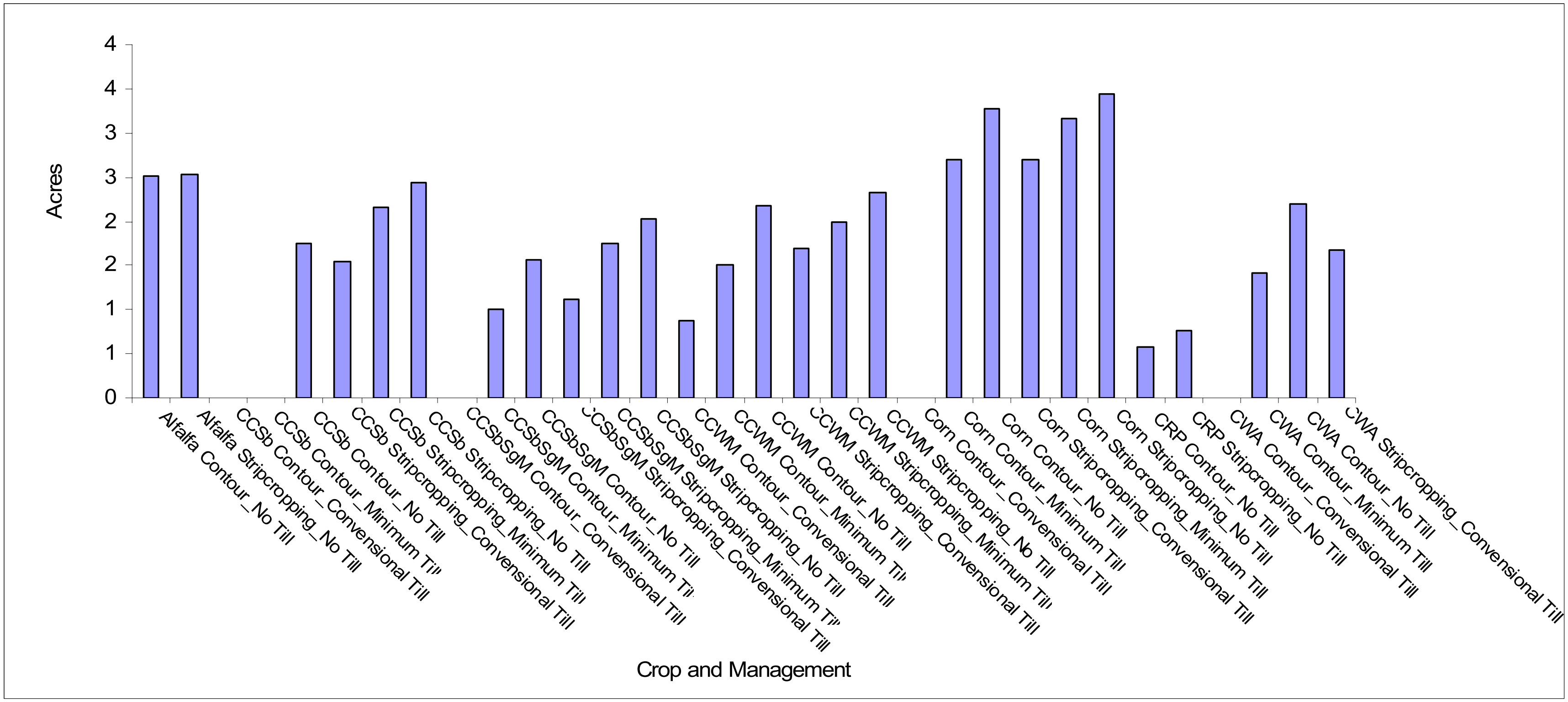

Figure 5.8a: Acreage of crops produced using total soil loss of 21.27 tons per year in Texas County, Oklahoma.

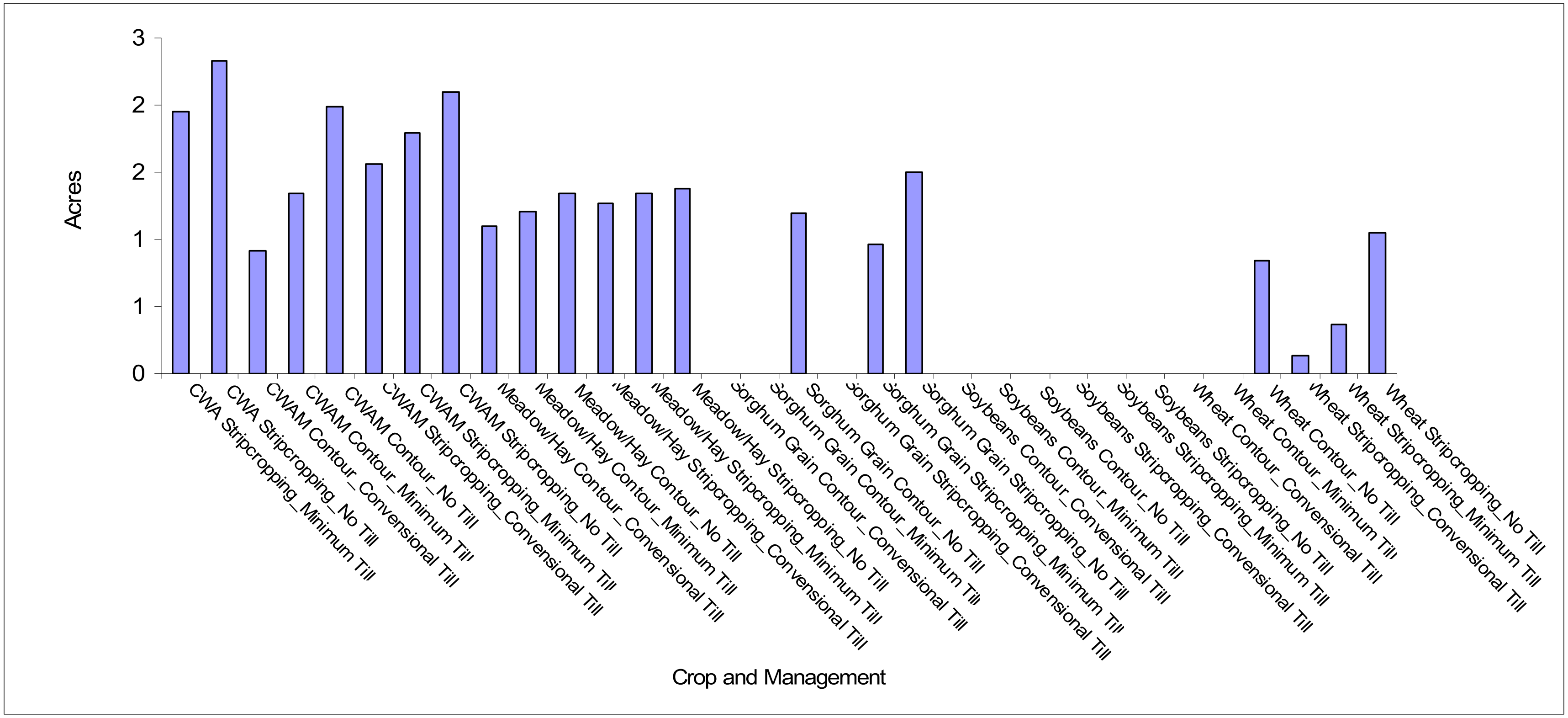

Figure 5.8b: Acreage of crops produced using total soil loss of 21.27 tons per year in Texas County, Oklahoma.

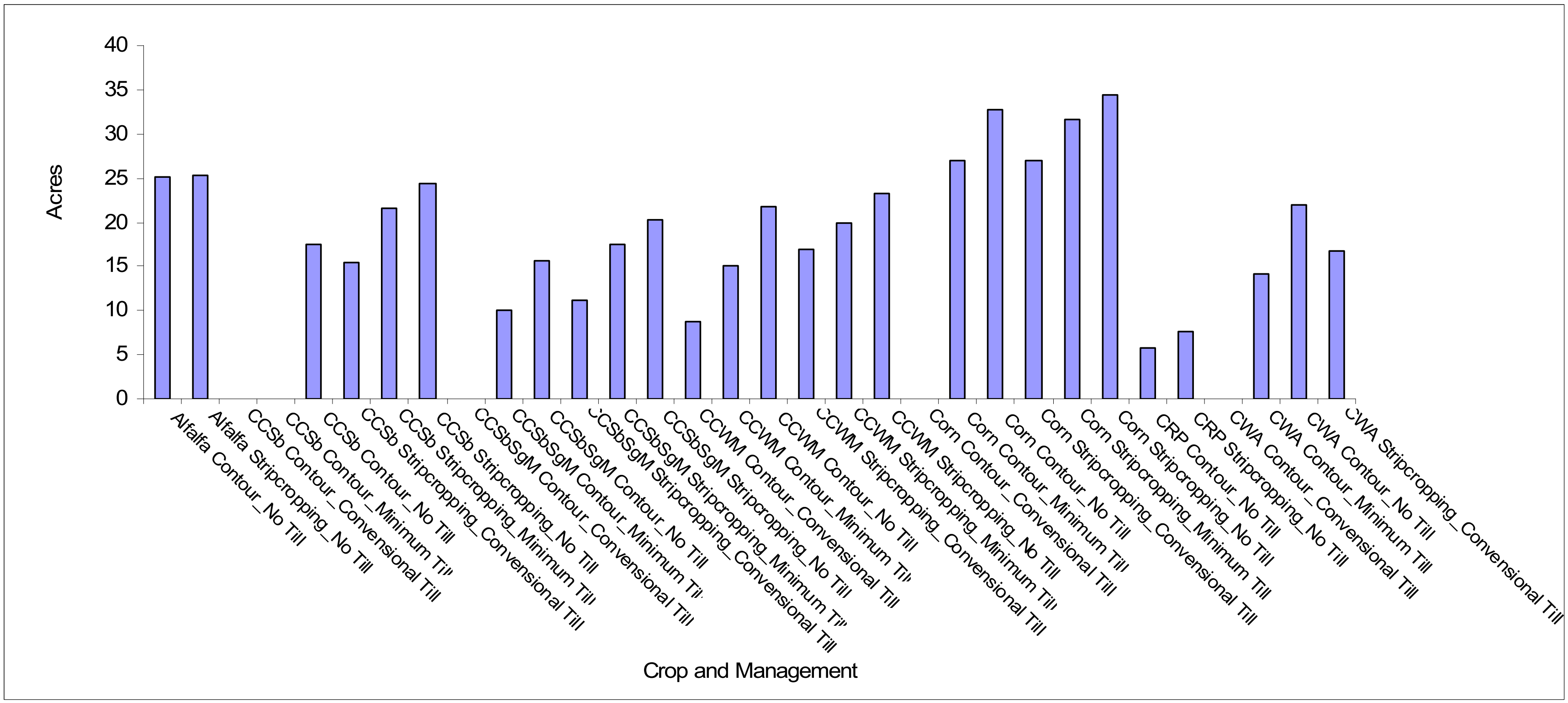

Figure 5.9a: Acreage of crops produced using total soil loss of 212.71 tons per year in Texas County, Oklahoma.

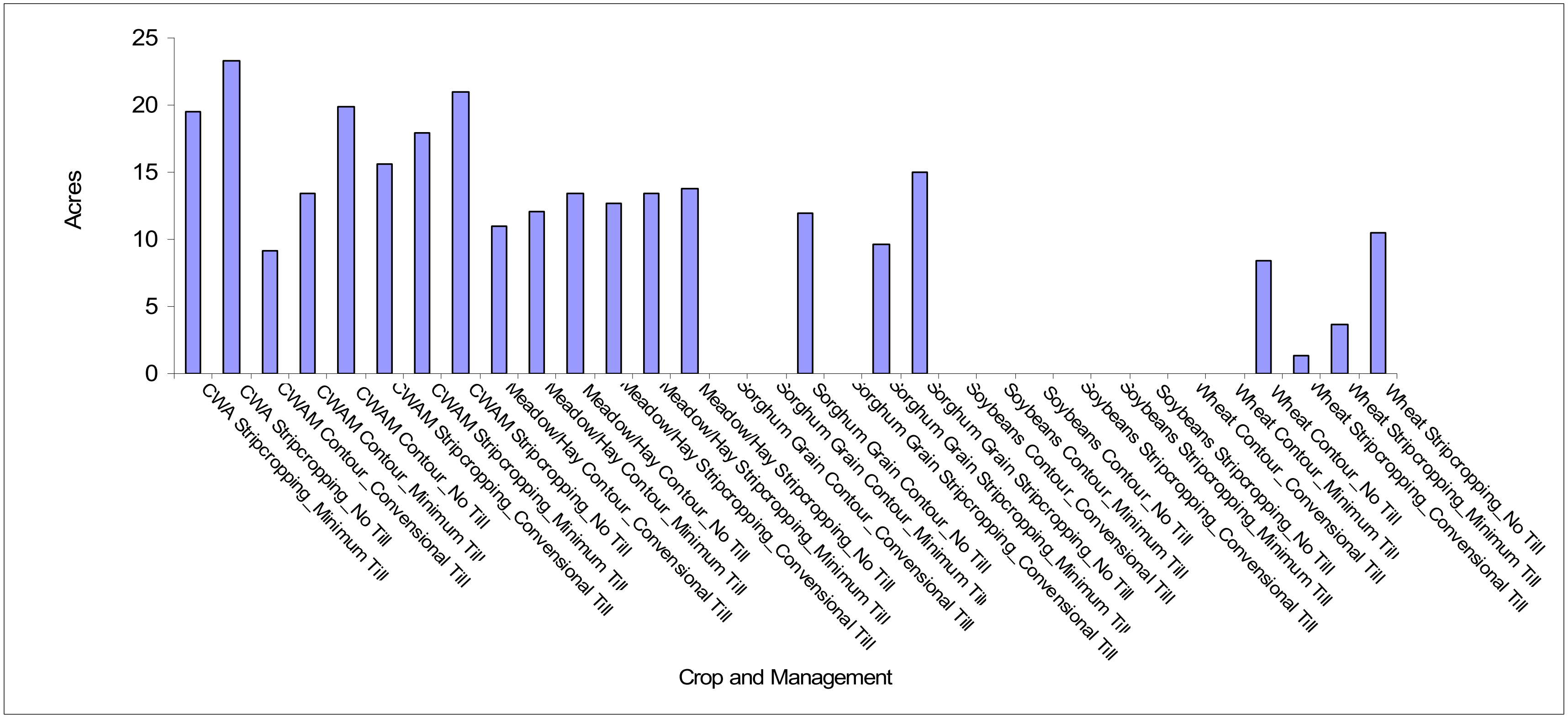

Figure 5.9b: Acreage of crops produced using total soil loss of 212.71 tons per year in Texas County, Oklahoma.

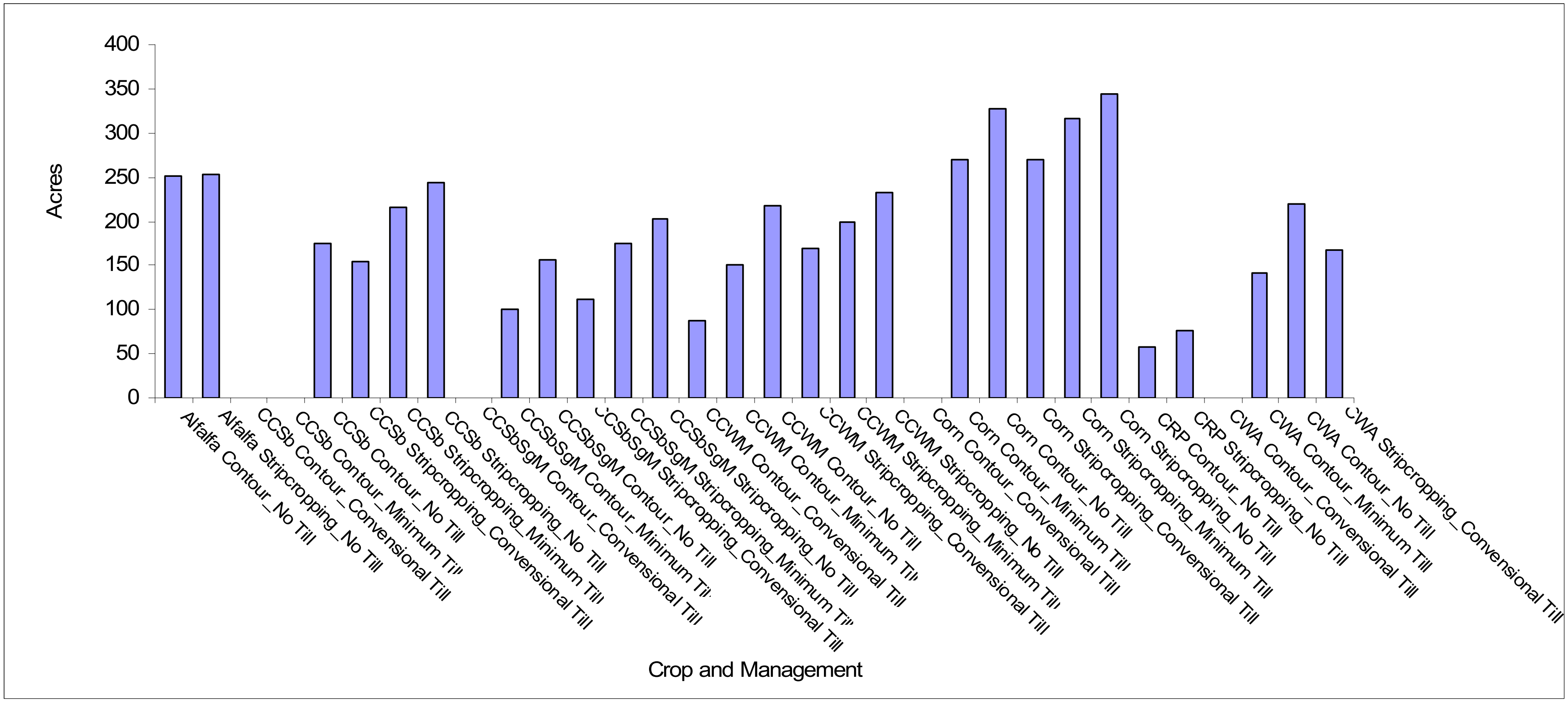

Figure 5.10a: Acreage of crops produced using total soil loss of 2,127.08 tons per year in Texas County, Oklahoma.

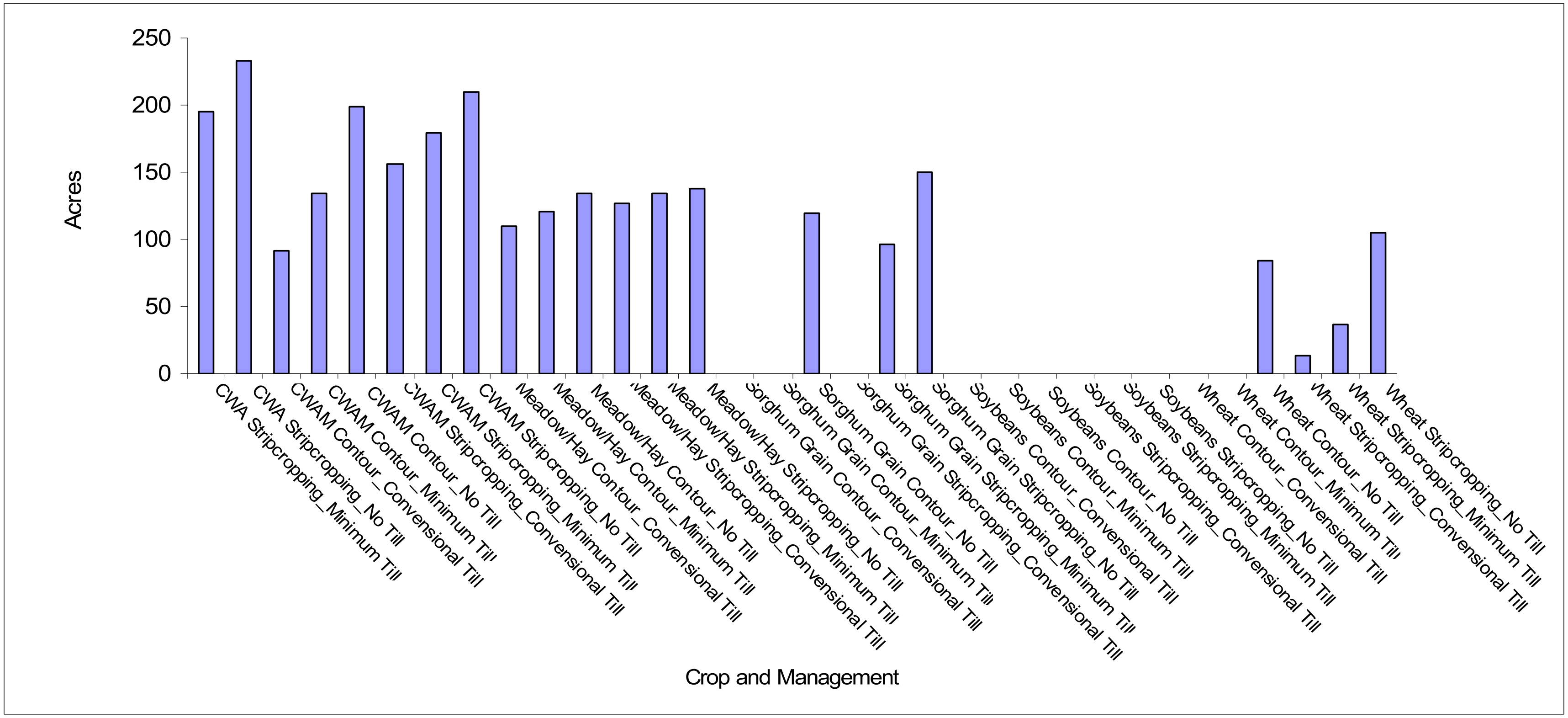

Figure 5.10b: Acreage of crops produced using total soil loss of 2,127.08 tons per year in Texas County, Oklahoma.

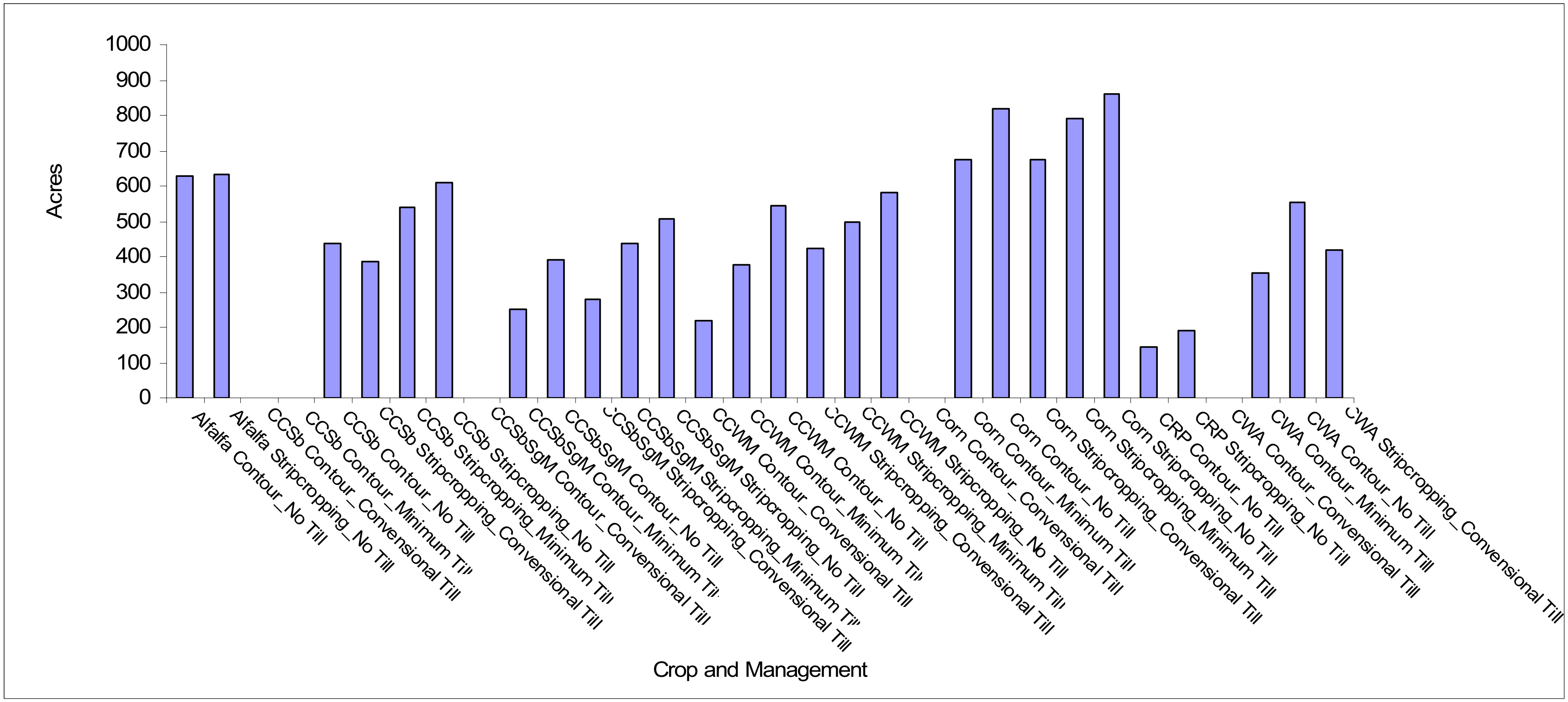

Figure 5.11a: Acreage of crops produced using total soil loss of 5,317.70 tons per year in Texas County, Oklahoma.

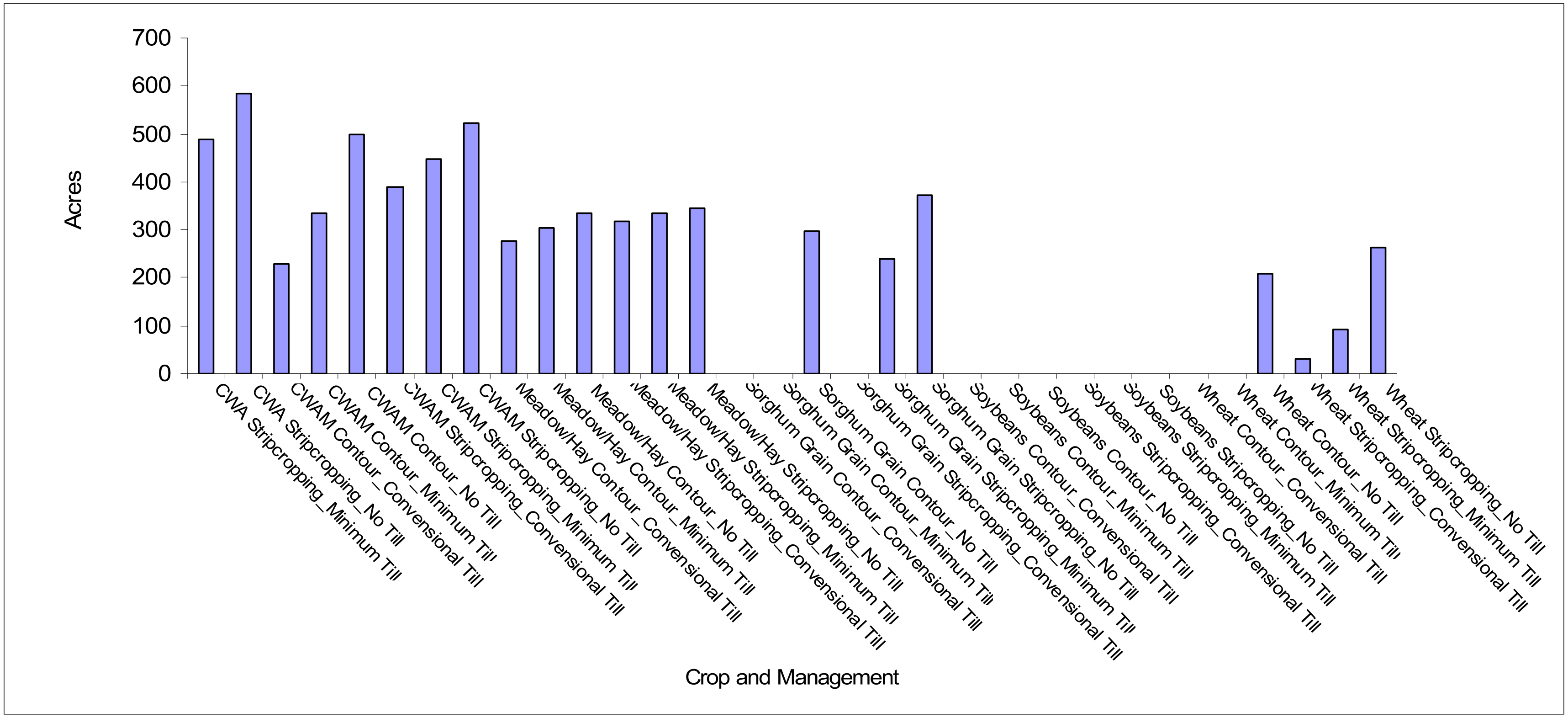

Figure 5.11b: Acreage of crops produced using total soil loss of 5,317.70 tons per year in Texas County, Oklahoma.

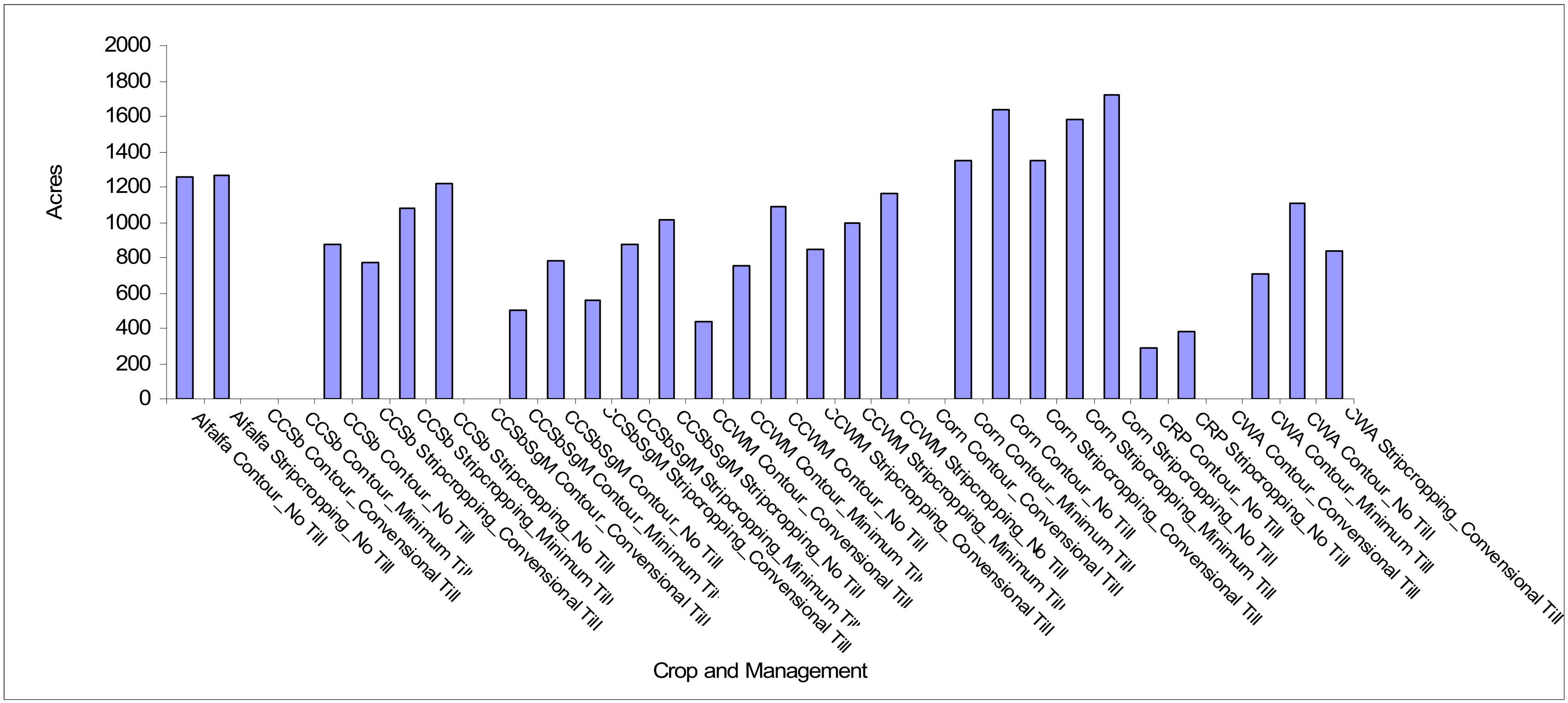

Figure 5.12a: Acreage of crops produced using total soil loss of 10,635.4 tons per year in Texas County, Oklahoma.

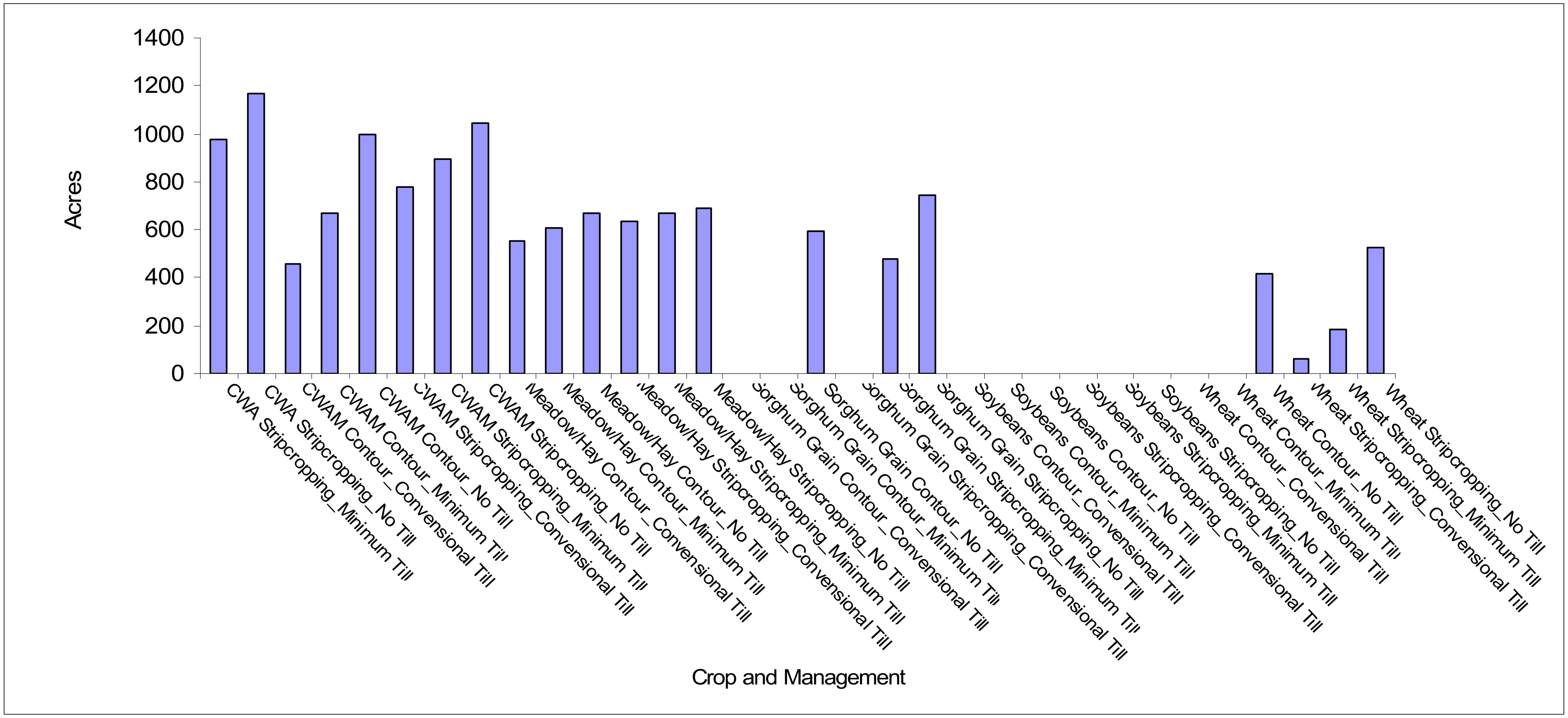

Figure 5.12b: Acreage of crops produced using total soil loss of 10,635.4 tons per year in Texas County, Oklahoma.

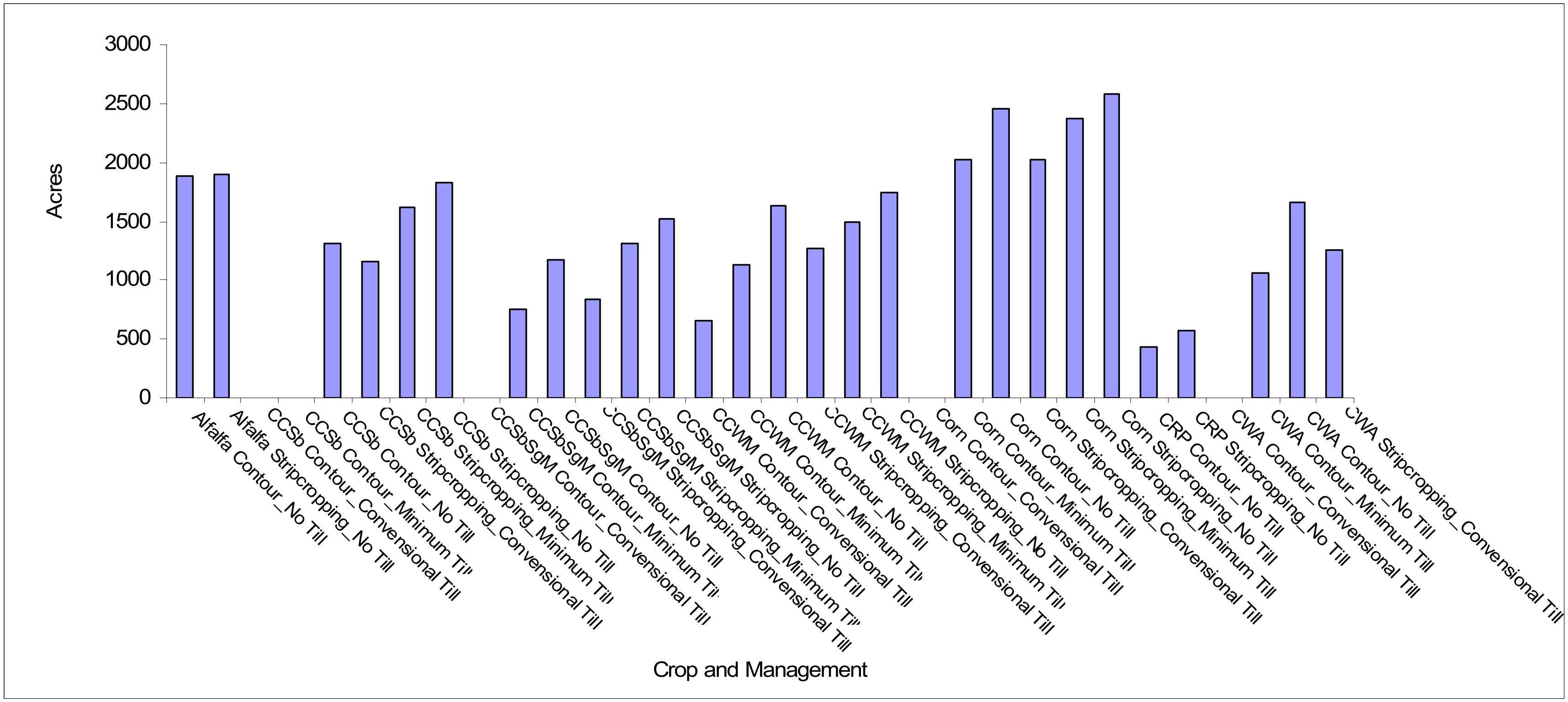

Figure 5.13a: Acreage of crops produced using total soil loss of 15,953.10 tons per year in Texas County, Oklahoma.

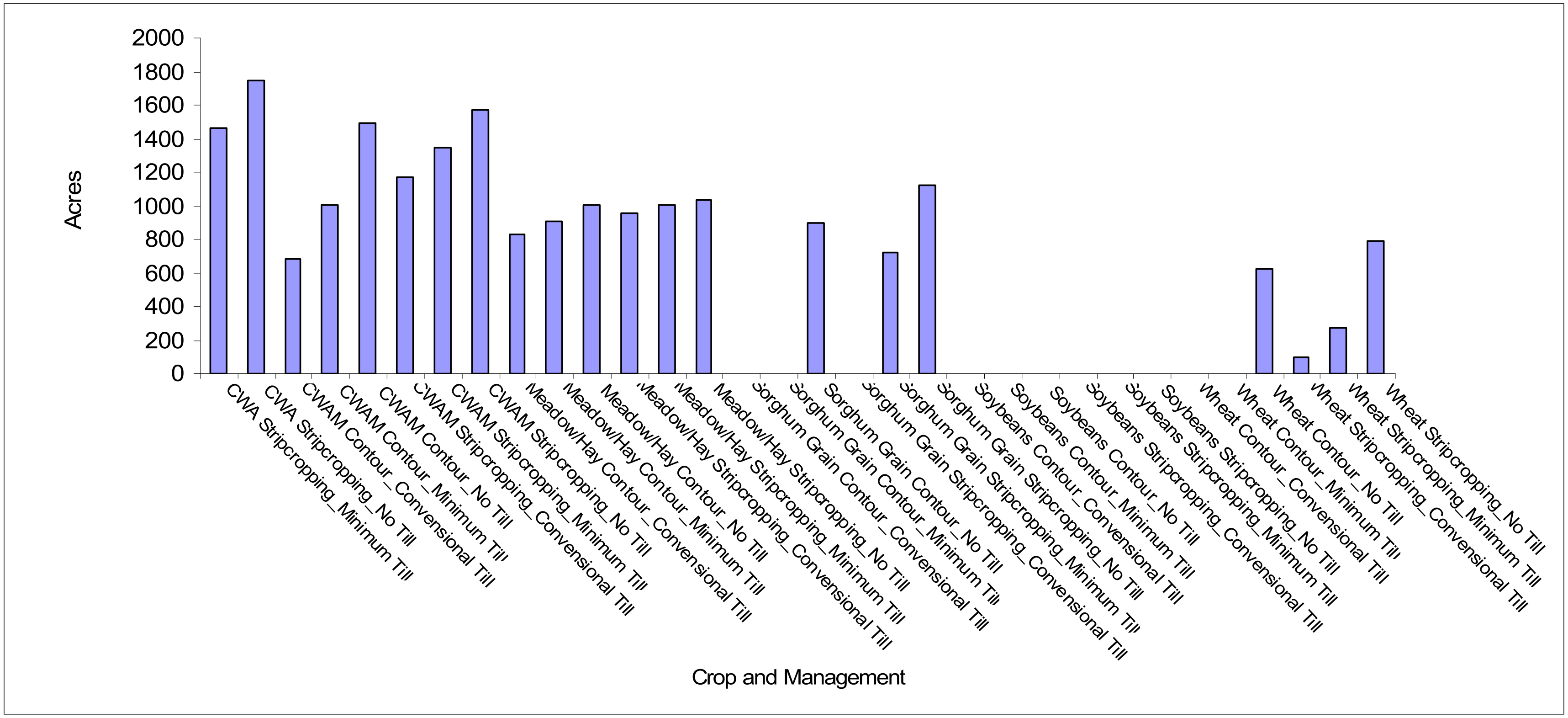

Figure 5.13b: Acreage of crops produced using total soil loss of 15,953.10 tons per year in Texas County, Oklahoma.

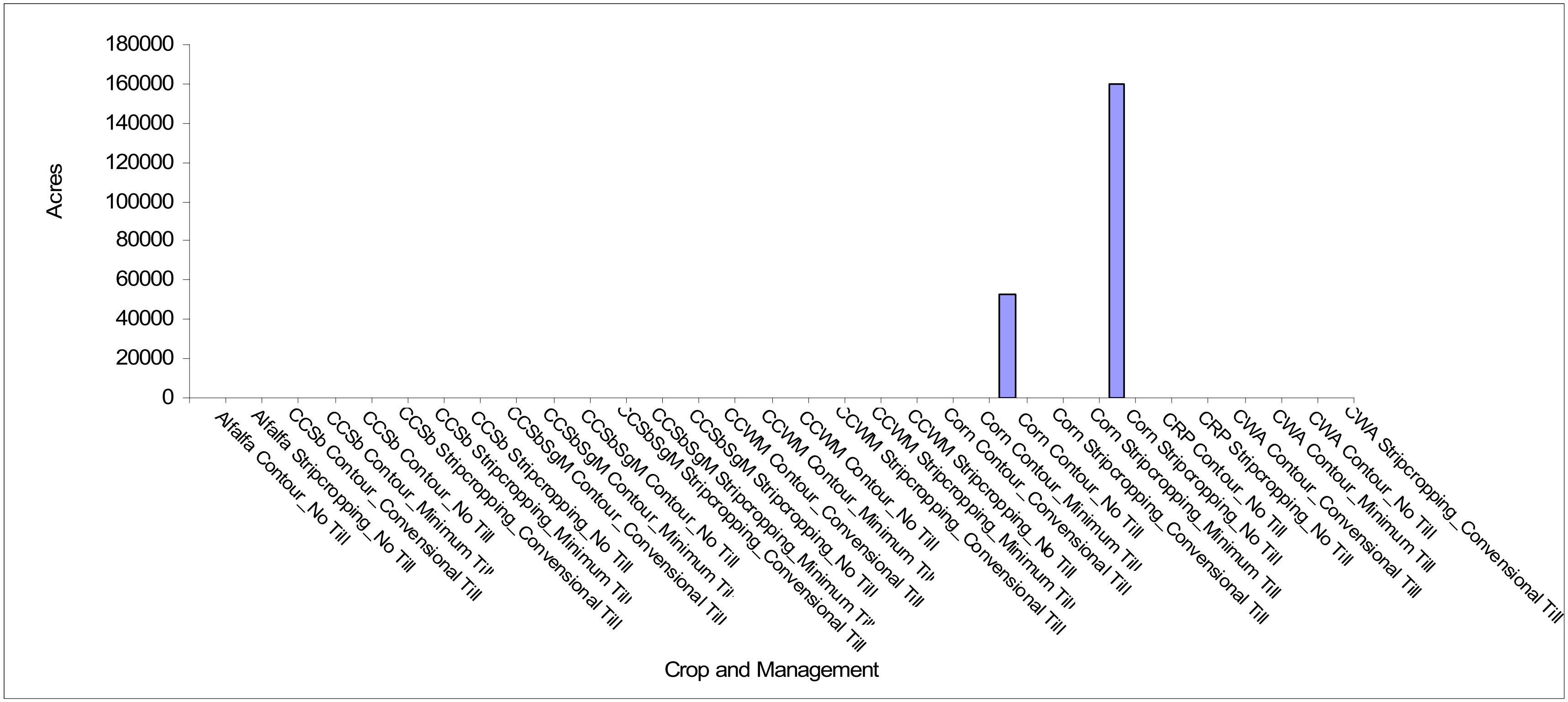

Figure 5.14a: Acreage of crops produced using total soil loss of 21,270.80 tons per year in Texas County, Oklahoma.

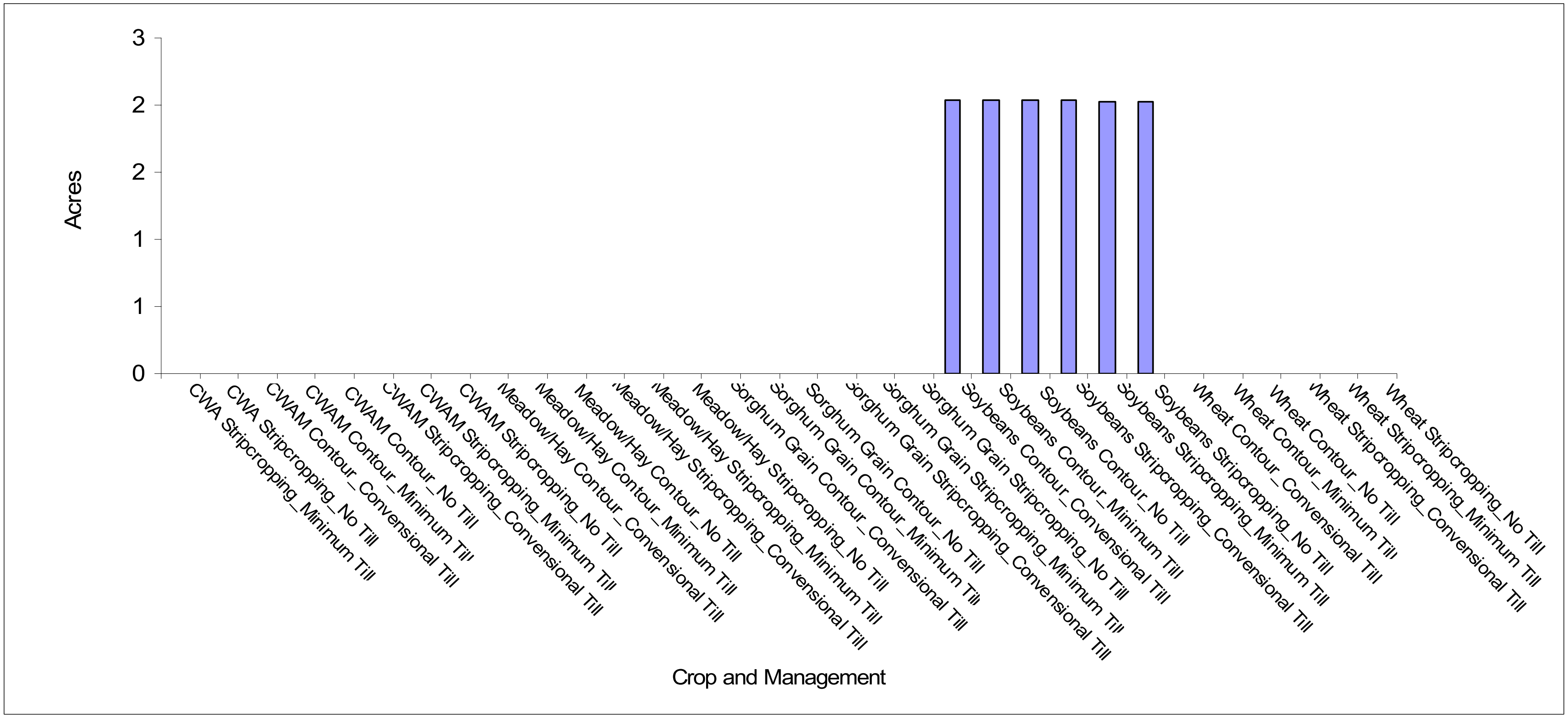

Figure 5.14b: Acreage of crops produced using total soil loss of 21,270.80 tons per year in Texas County, Oklahoma.

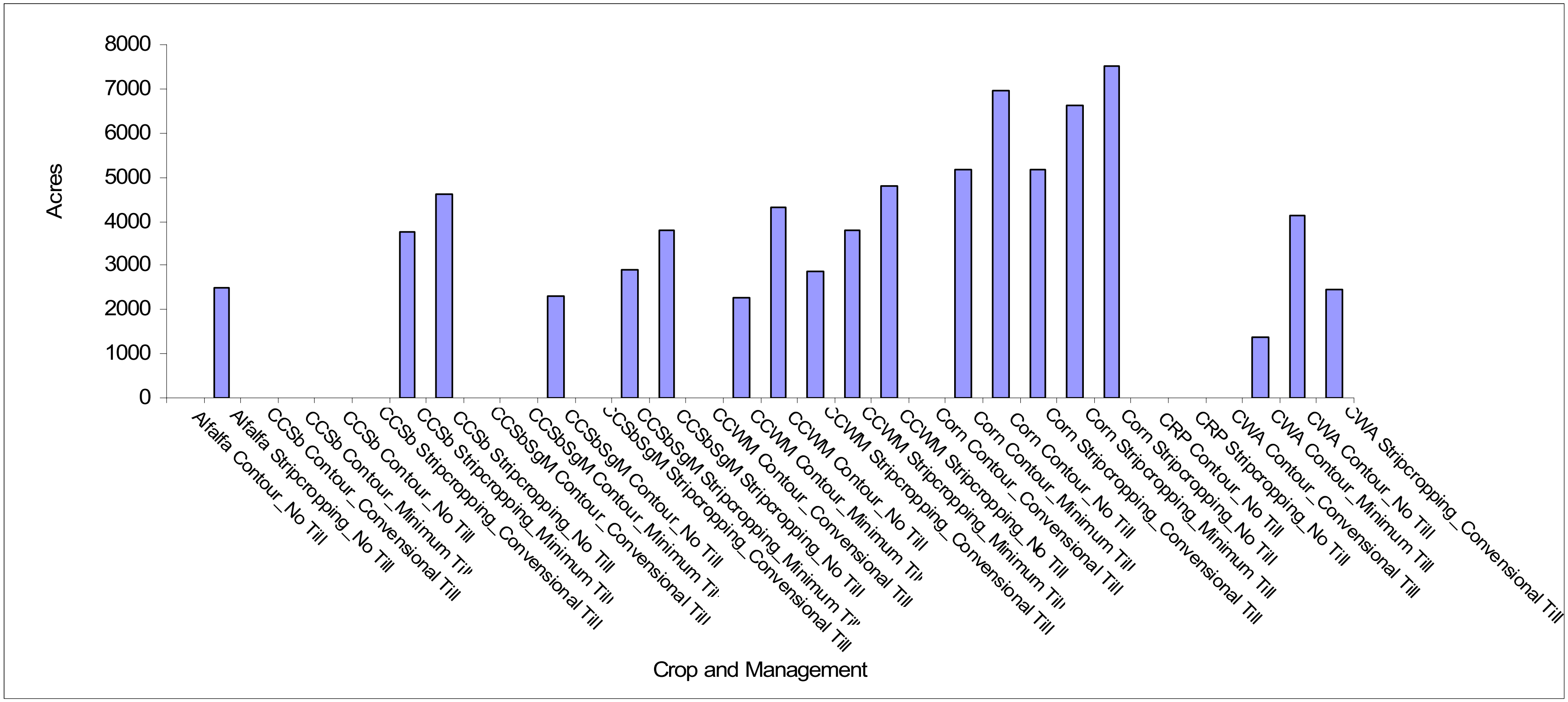

Figure 5.15a: Acreage of crops produced using total soil loss of 26,588.50 tons per year in Texas County, Oklahoma.

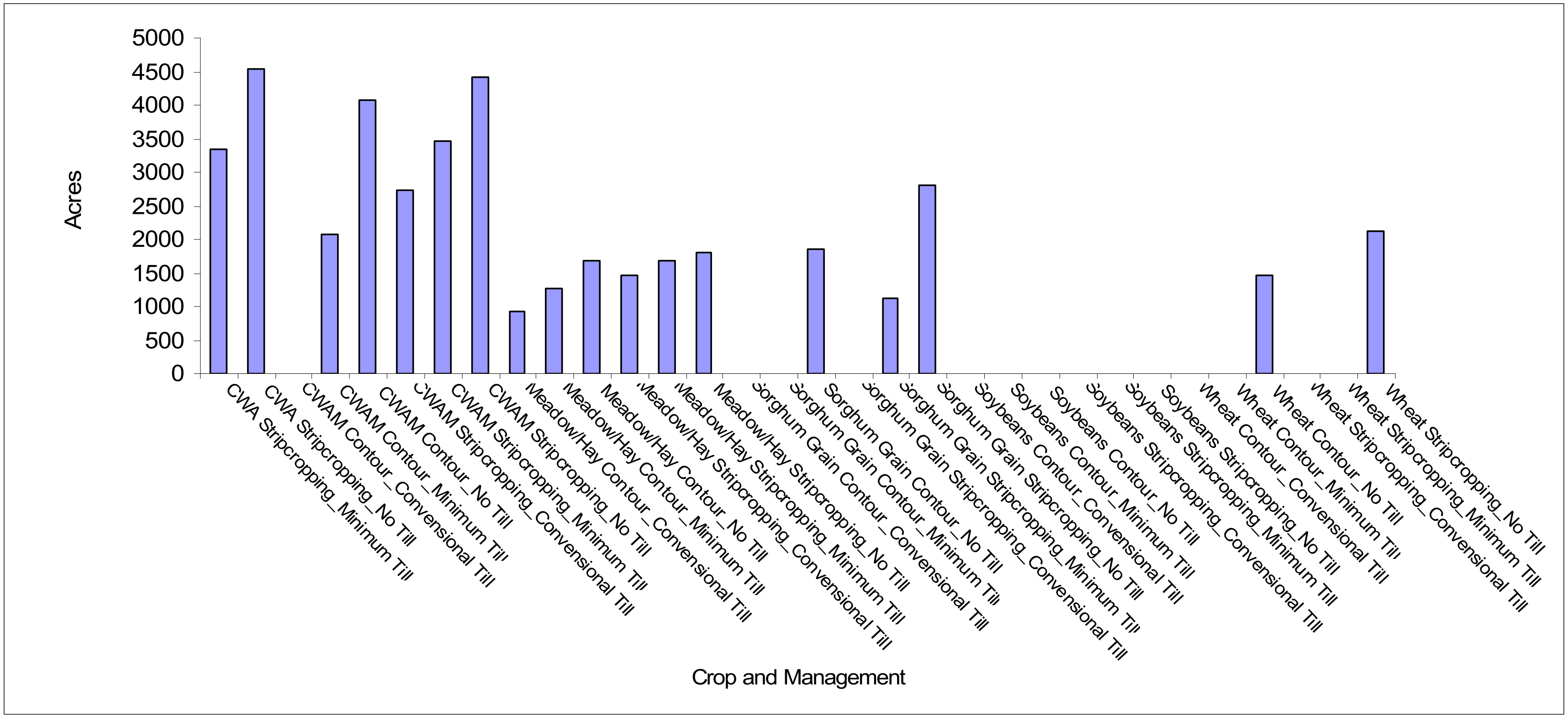

Figure 5.15b: Acreage of crops produced using total soil loss of 26,588.50 tons per year in Texas County, Oklahoma.

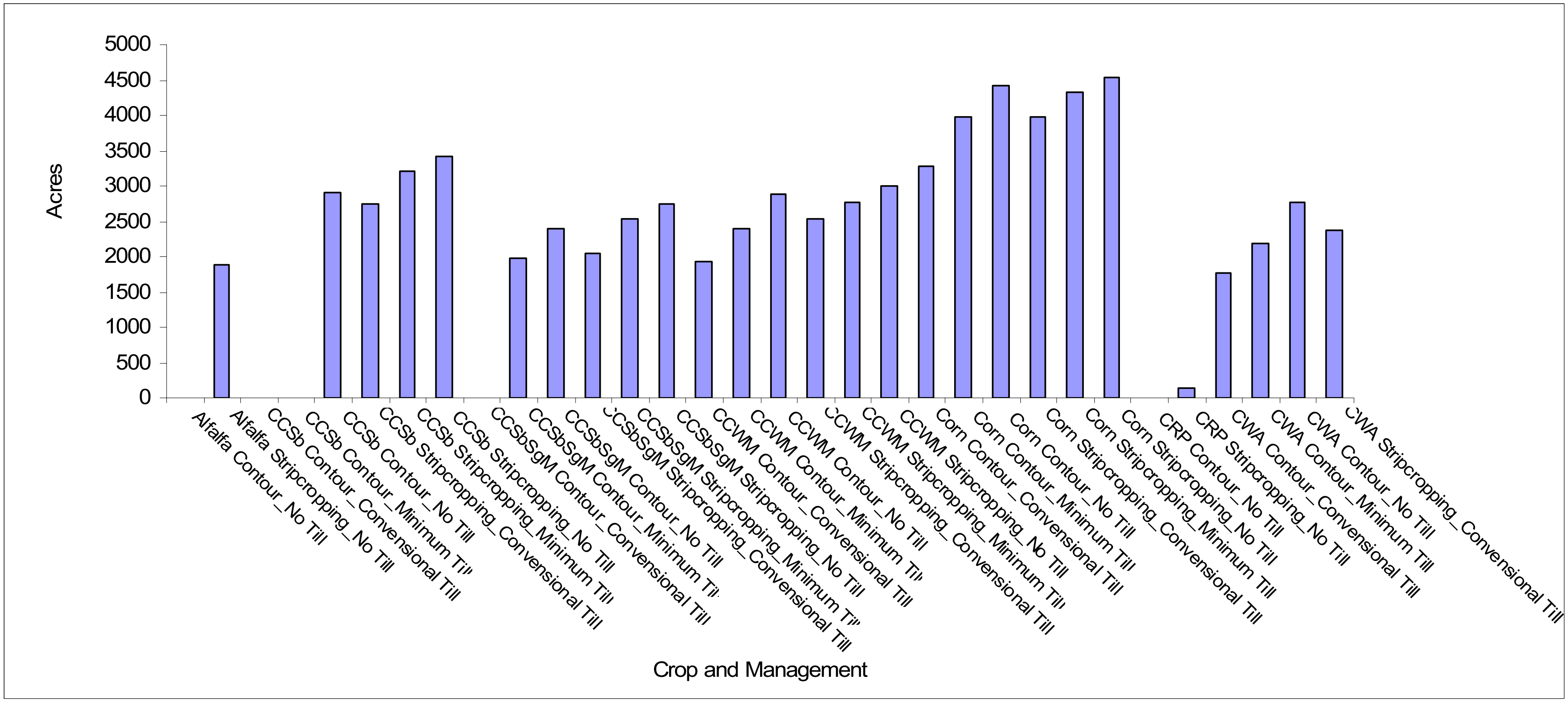

Figure 5.16a: Acreage of crops produced using total soil loss of 37,223.90 tons per year in Texas County, Oklahoma.

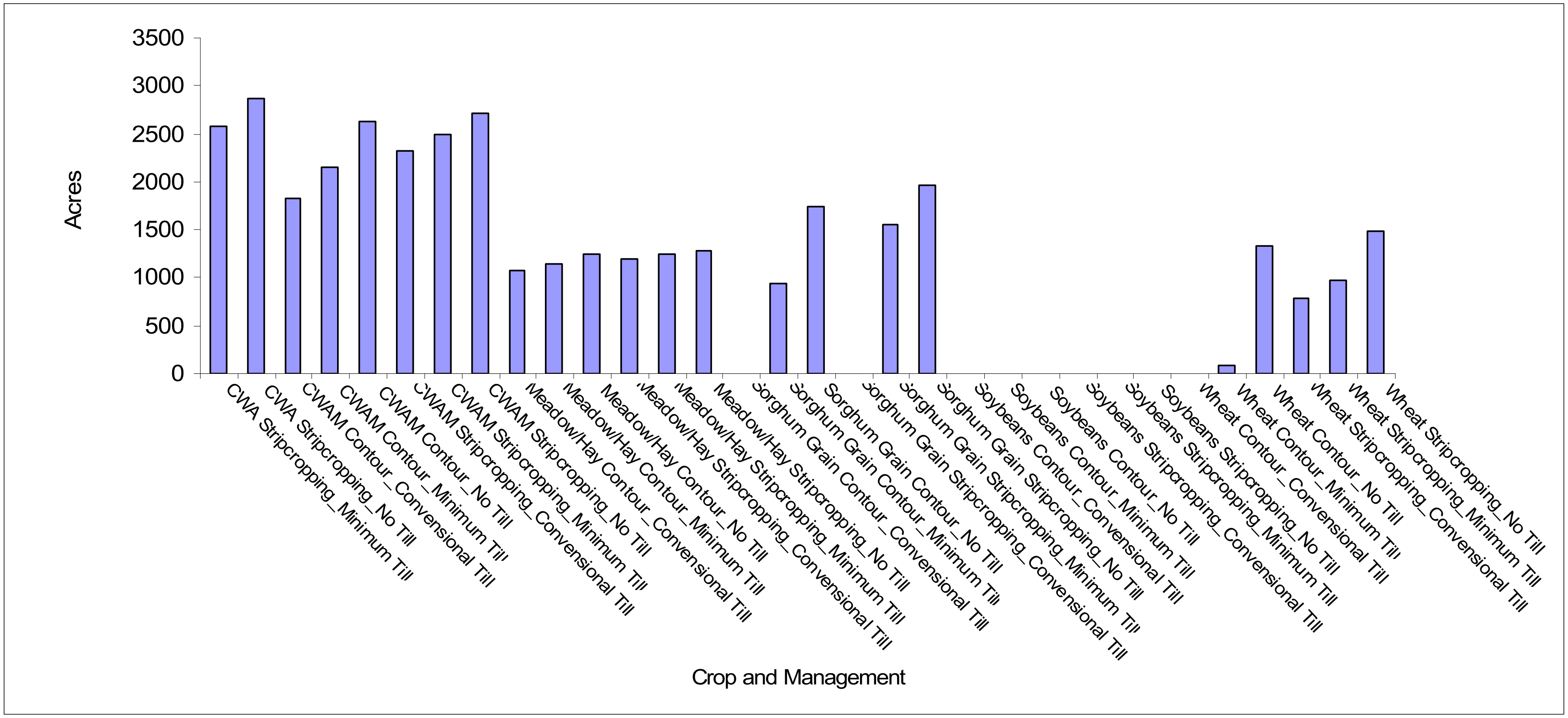

Figure 5.16b: Acreage of crops produced using total soil loss of 37,223.90 tons per year in Texas County, Oklahoma.

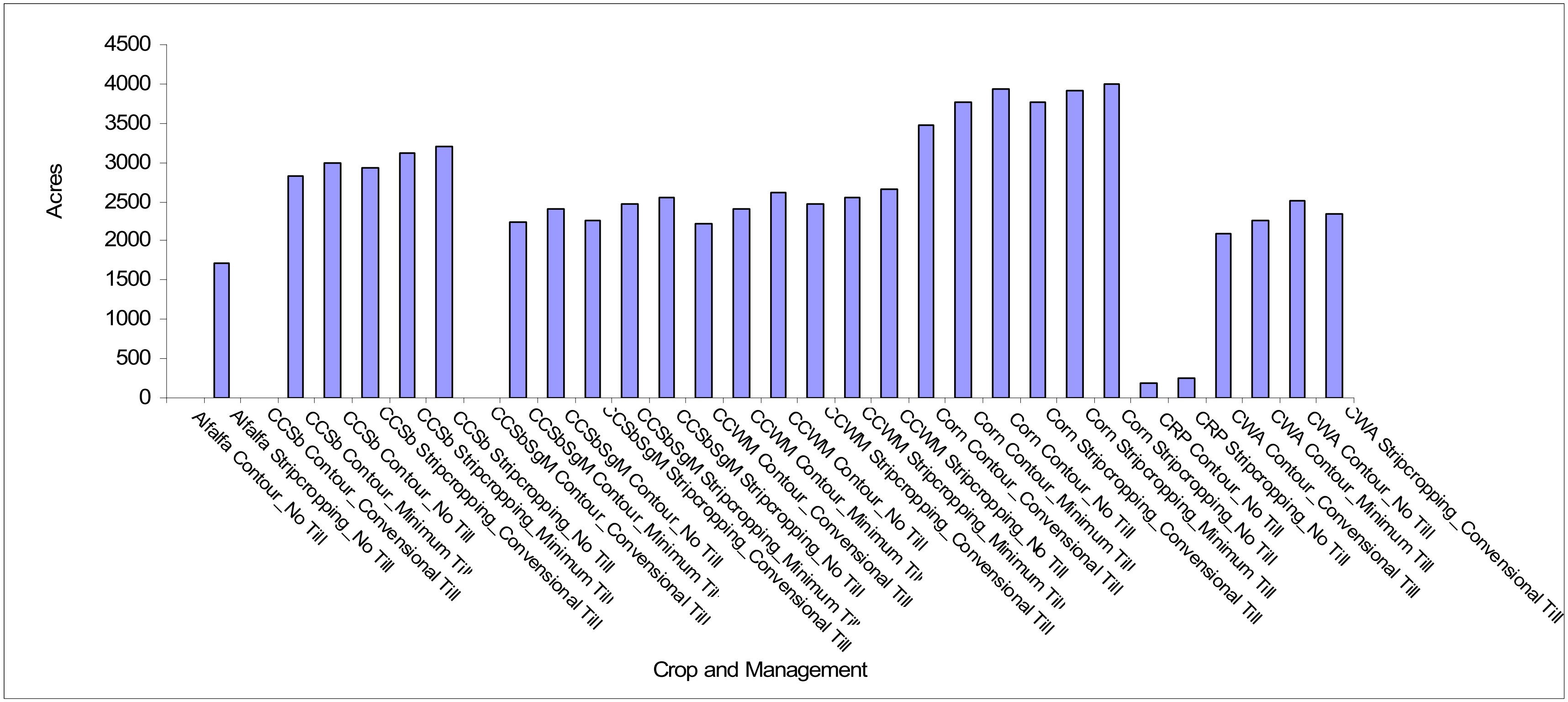

Figure 5.17a: Acreage of crops produced using total soil loss of 42,541.60 tons per year in Texas County, Oklahoma.

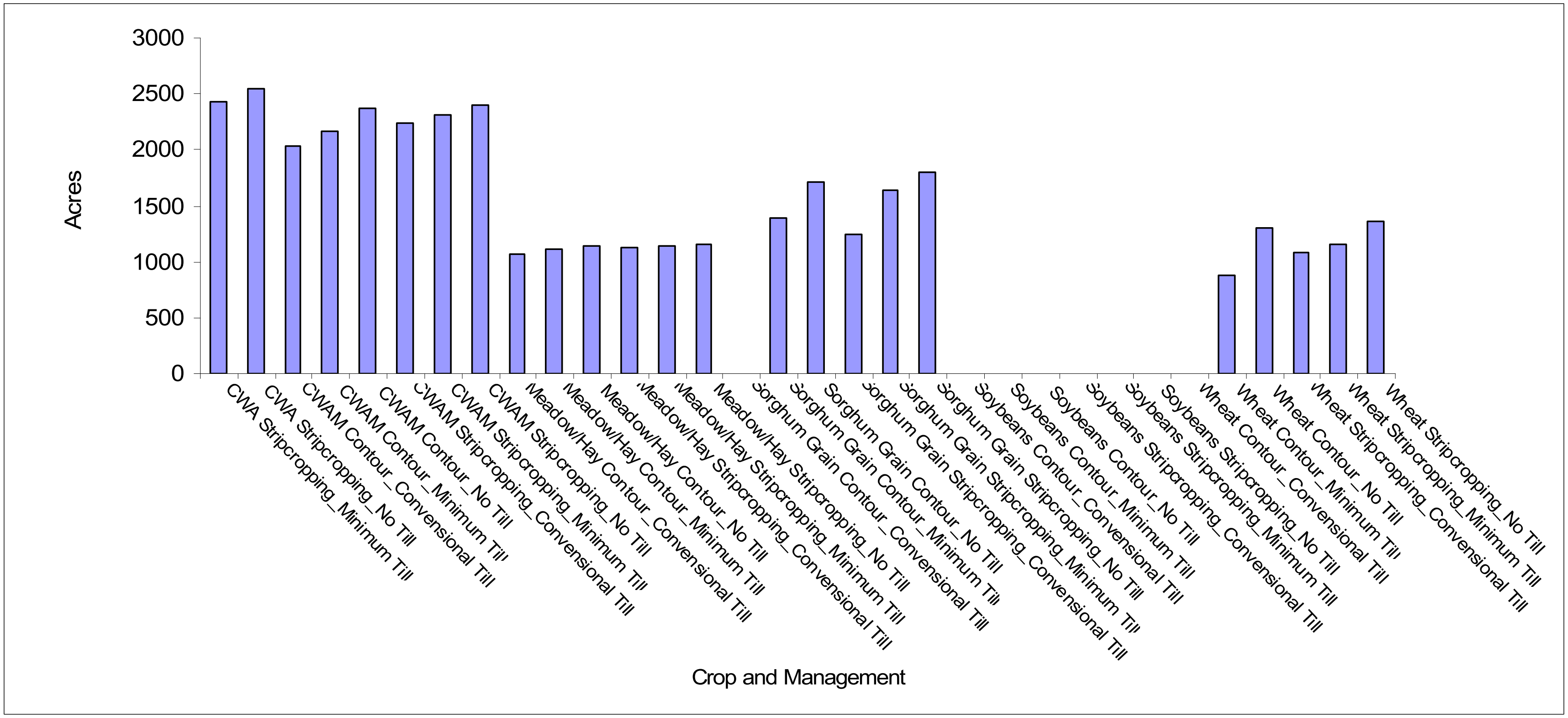

Figure 5.17b: Acreage of crops produced using total soil loss of 42,541.60 tons per year in Texas County, Oklahoma.

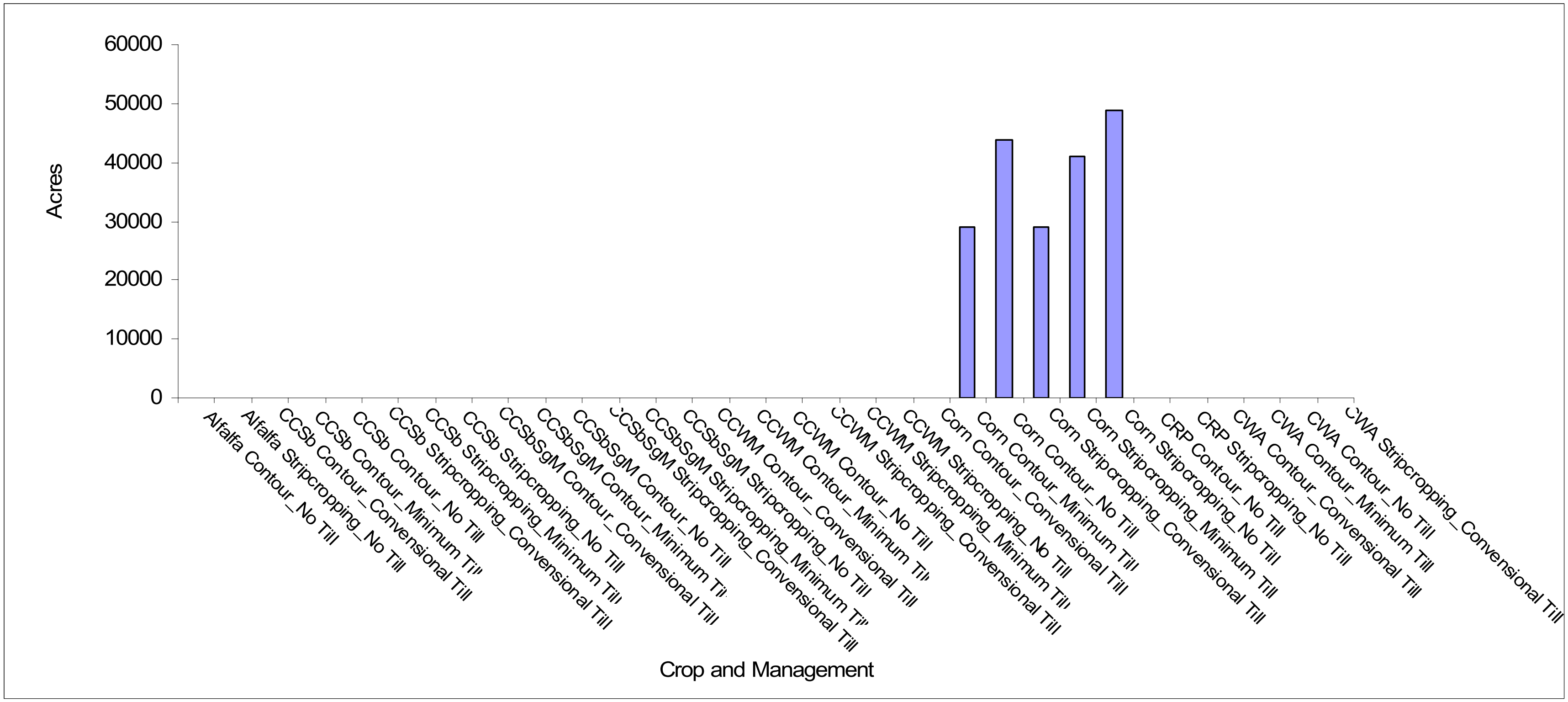

Figure 5.18a: Acreage of crops produced using total soil loss of 47,859.30 tons per year in Texas County, Oklahoma.

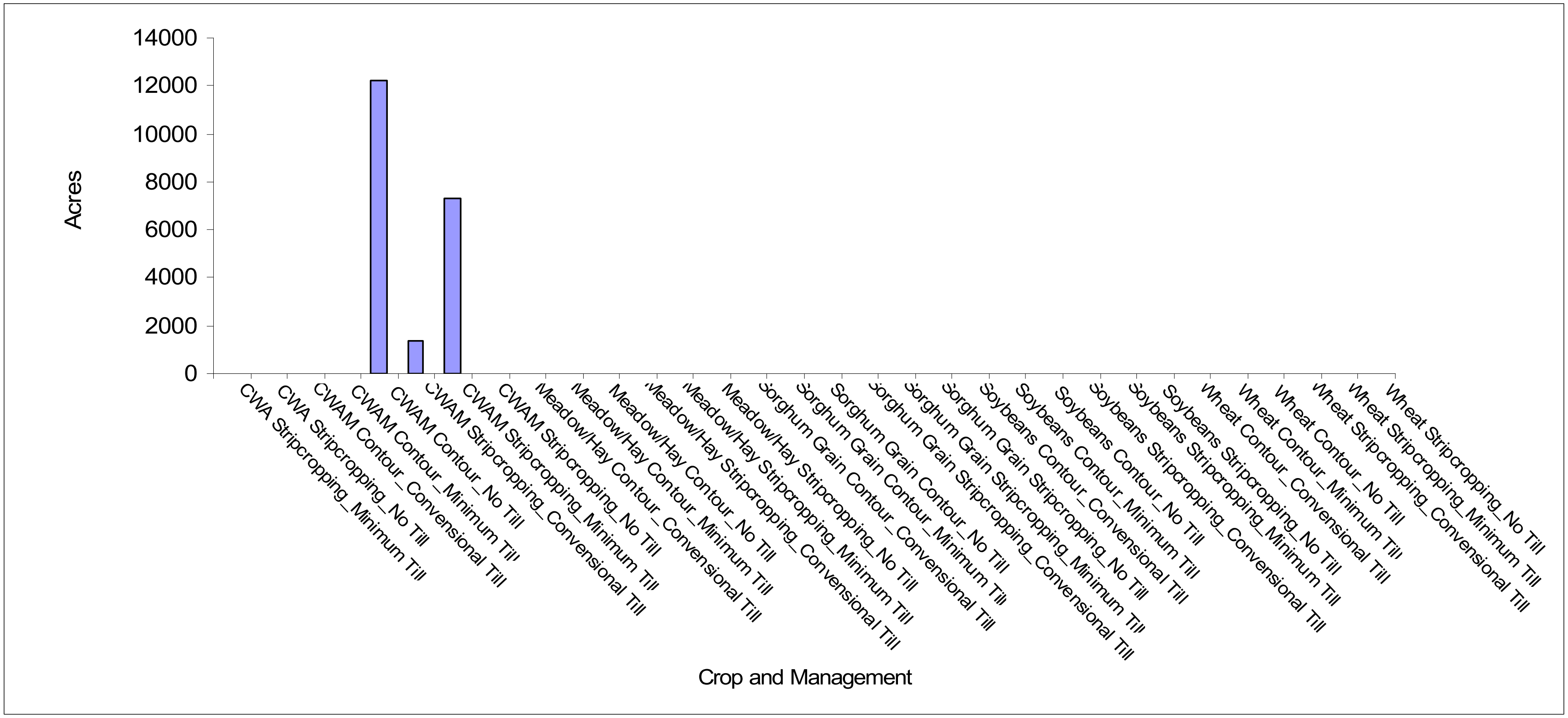

Figure 5.18b: Acreage of crops produced using total soil loss of 47,859.30 tons per year in Texas County, Oklahoma.

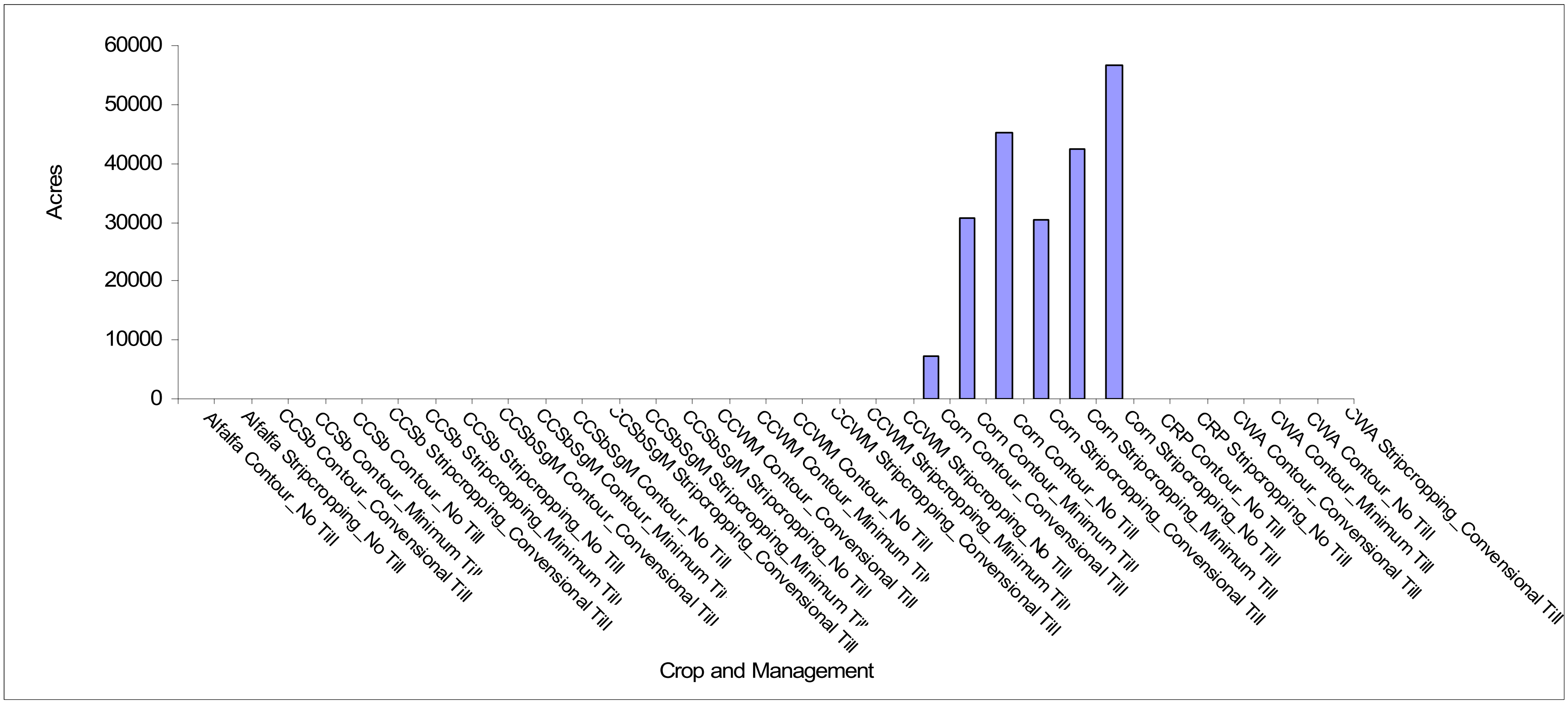

Figure 5.19: Acreage of crops produced using total soil loss of 53,177 tons per year in Texas County, Oklahoma.

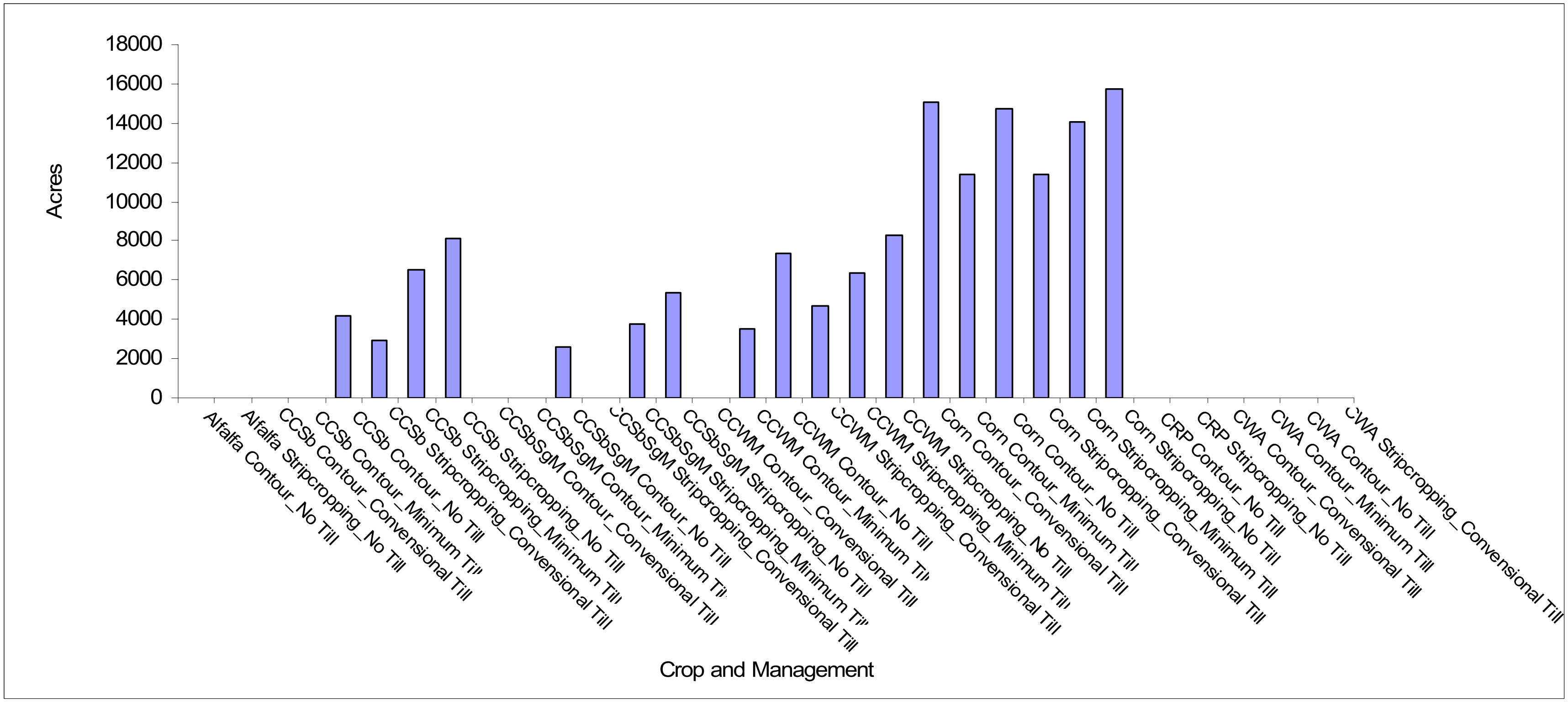

Figure 5.20a: Acreage of crops produced using total soil loss of 58,494.70 tons per year in Texas County, Oklahoma.

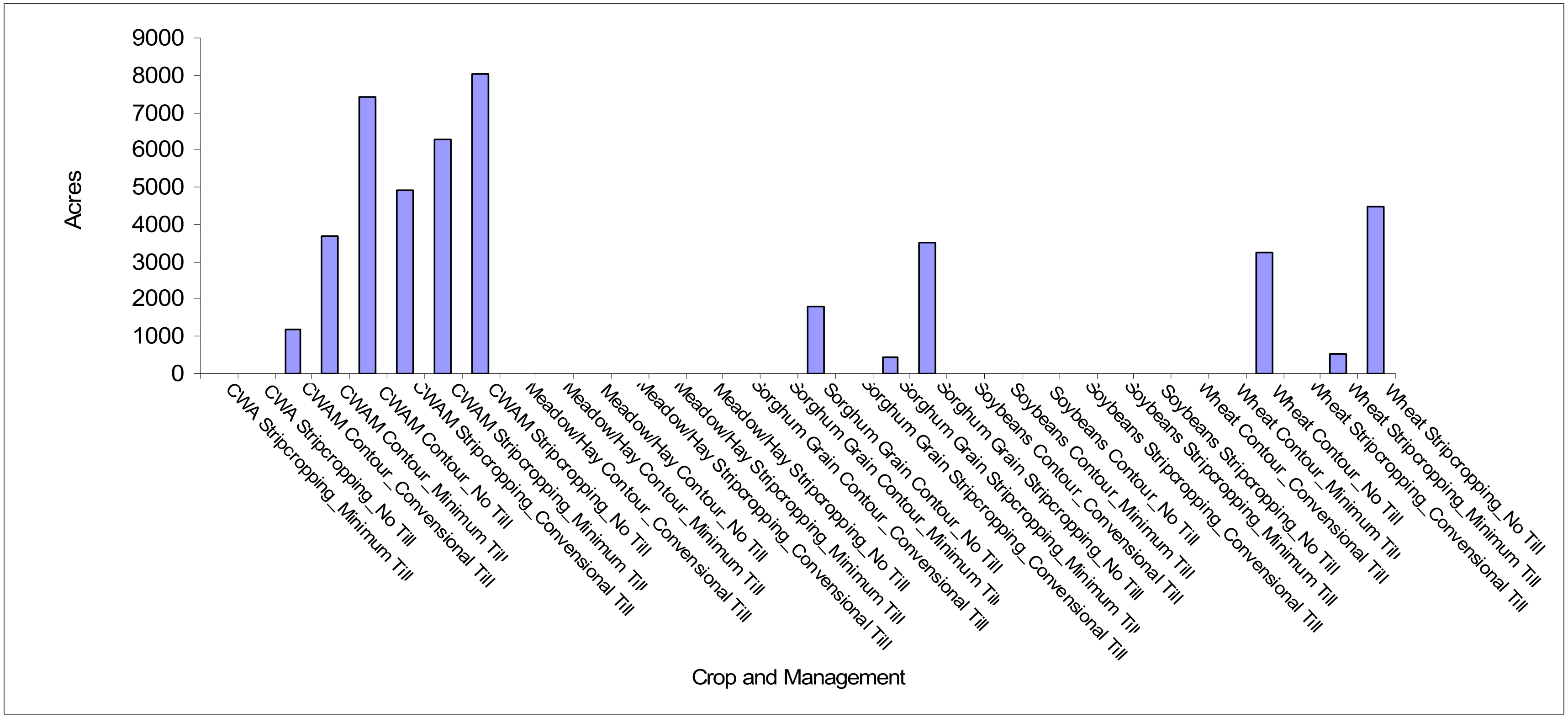

Figure 5.20b: Acreage of crops produced using total soil loss of 58,494.70 tons per year in Texas County, Oklahoma.

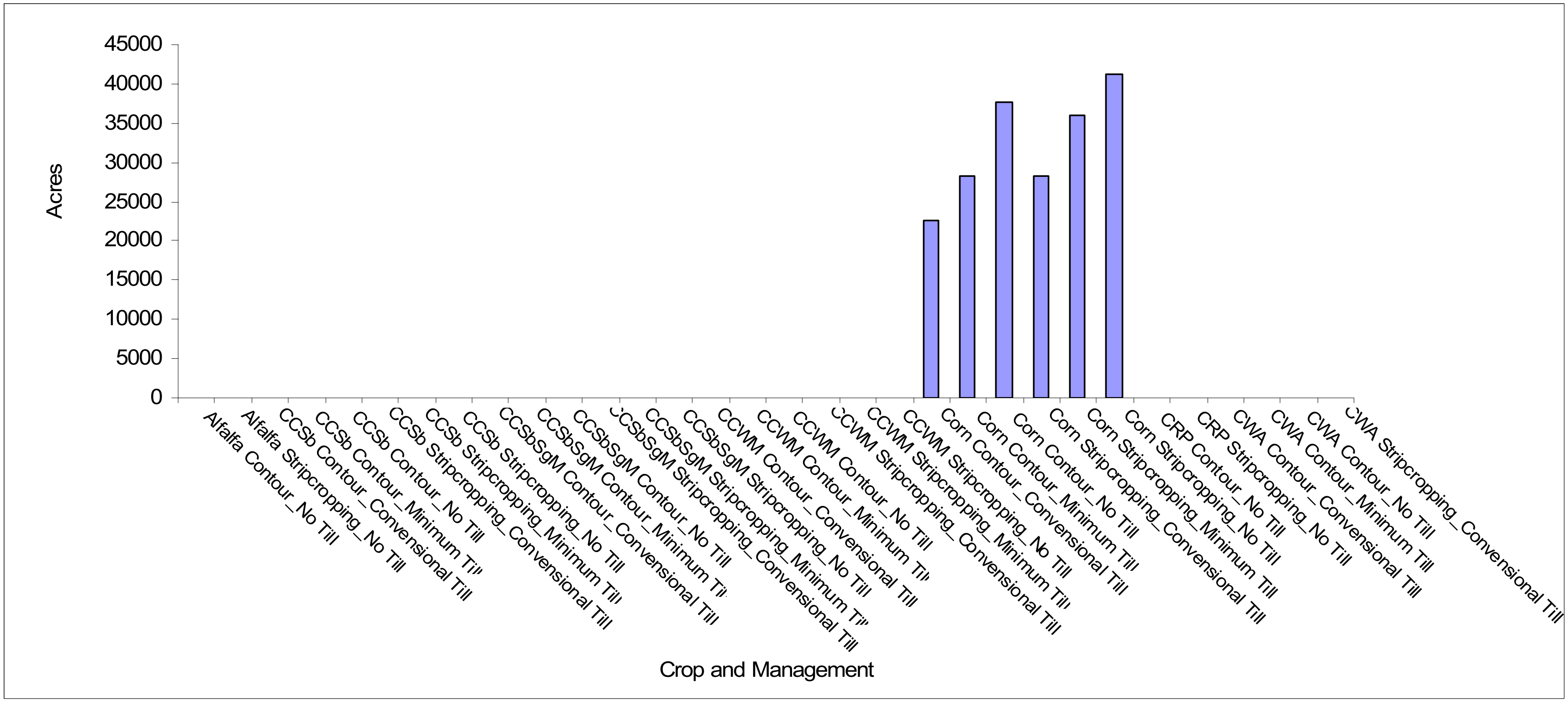

Figure 5.21a: Acreage of crops produced using total soil loss of 63,812.40 tons per year in Texas County, Oklahoma.

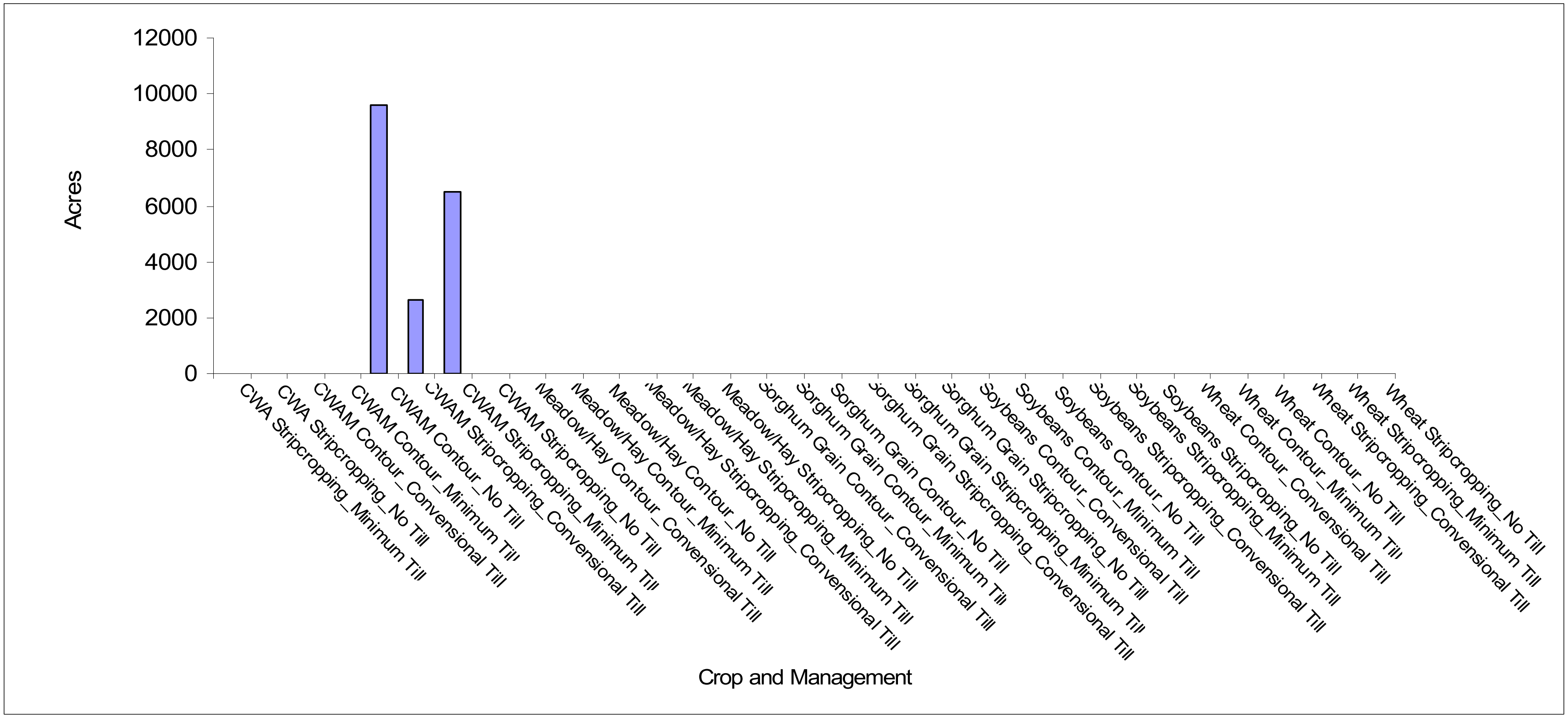

Figure 5.21b: Acreage of crops produced using total soil loss of 63,812.40 tons per year in Texas County, Oklahoma.

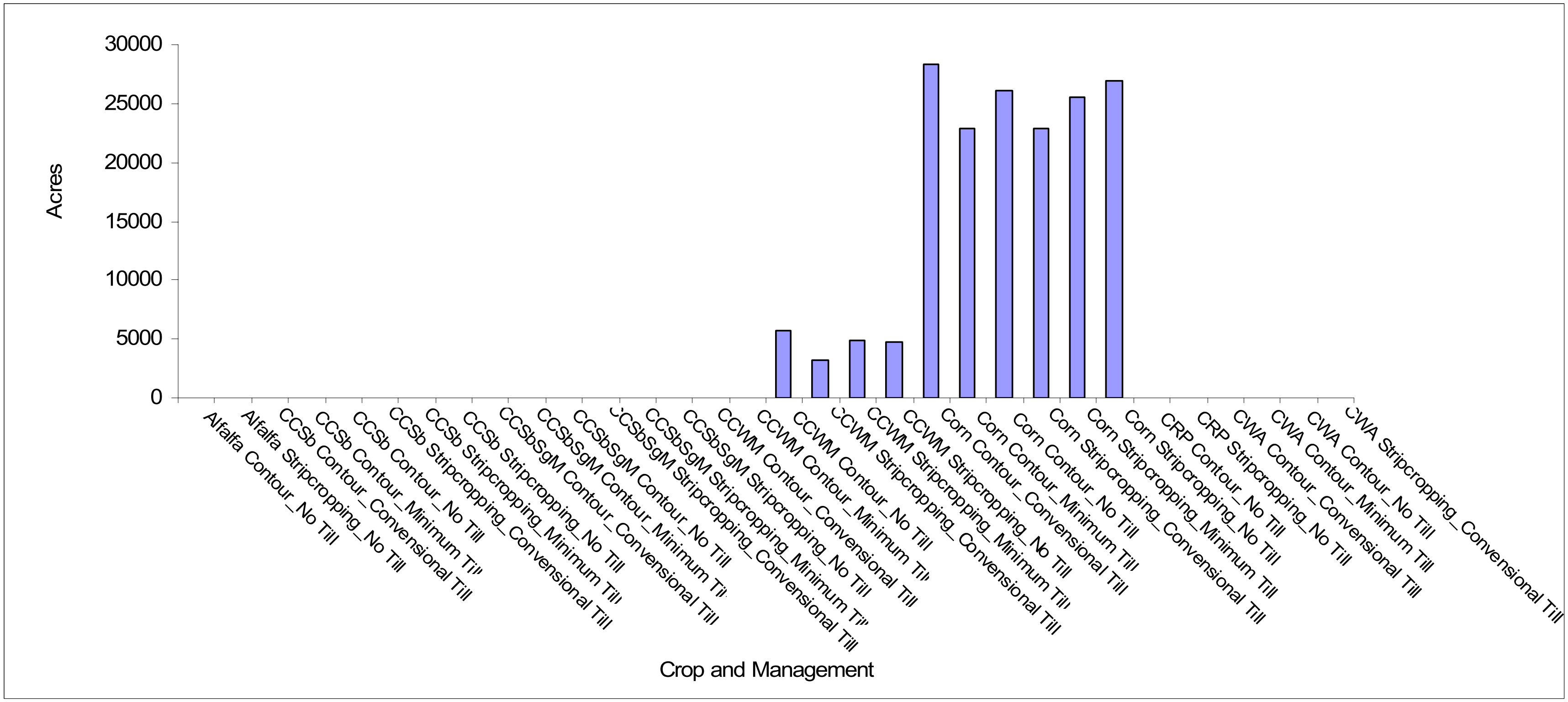

Figure 5.22a: Acreage of crops produced using total soil loss of 69,130.10 tons per year in Texas County, Oklahoma.

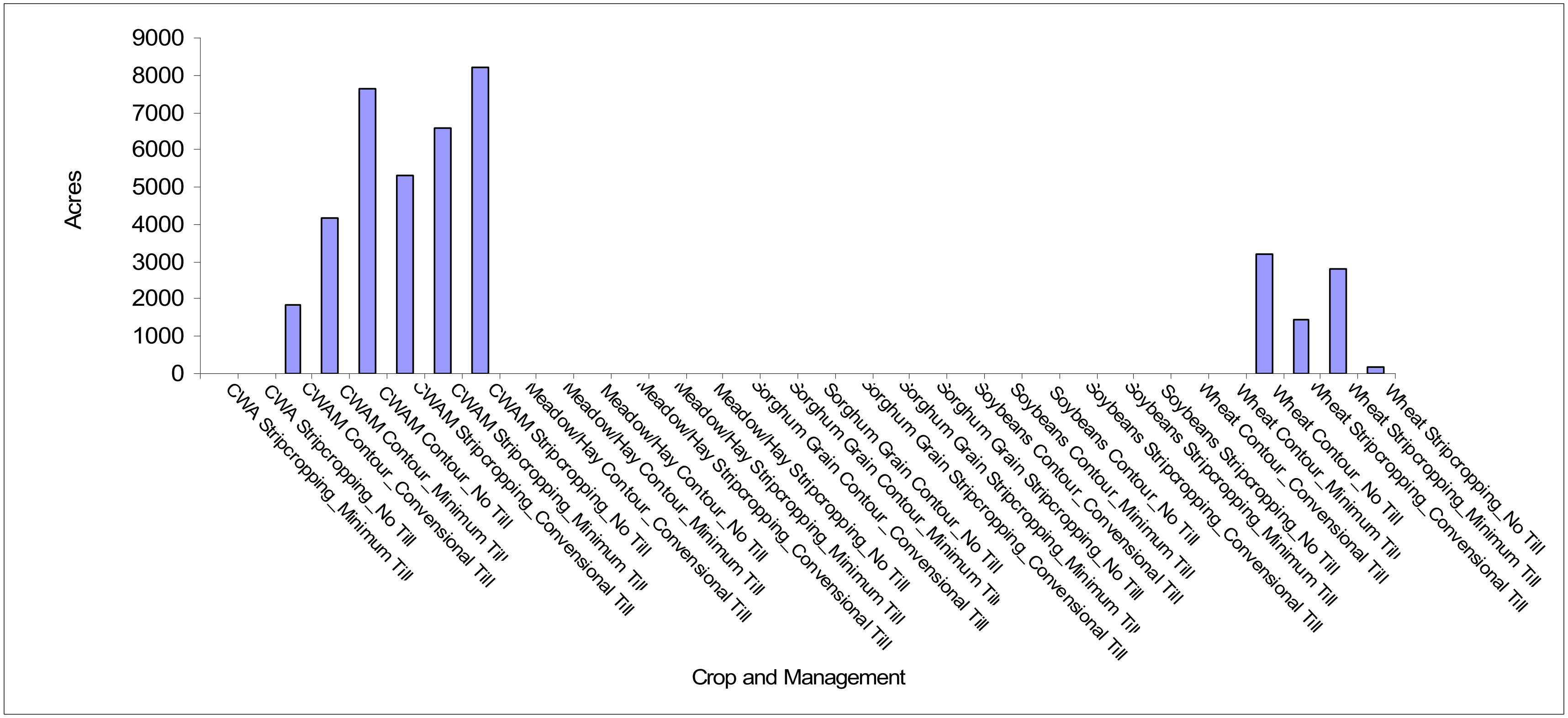

Figure 5.22b: Acreage of crops produced using total soil loss of 69,130.10 tons per year in Texas County, Oklahoma.

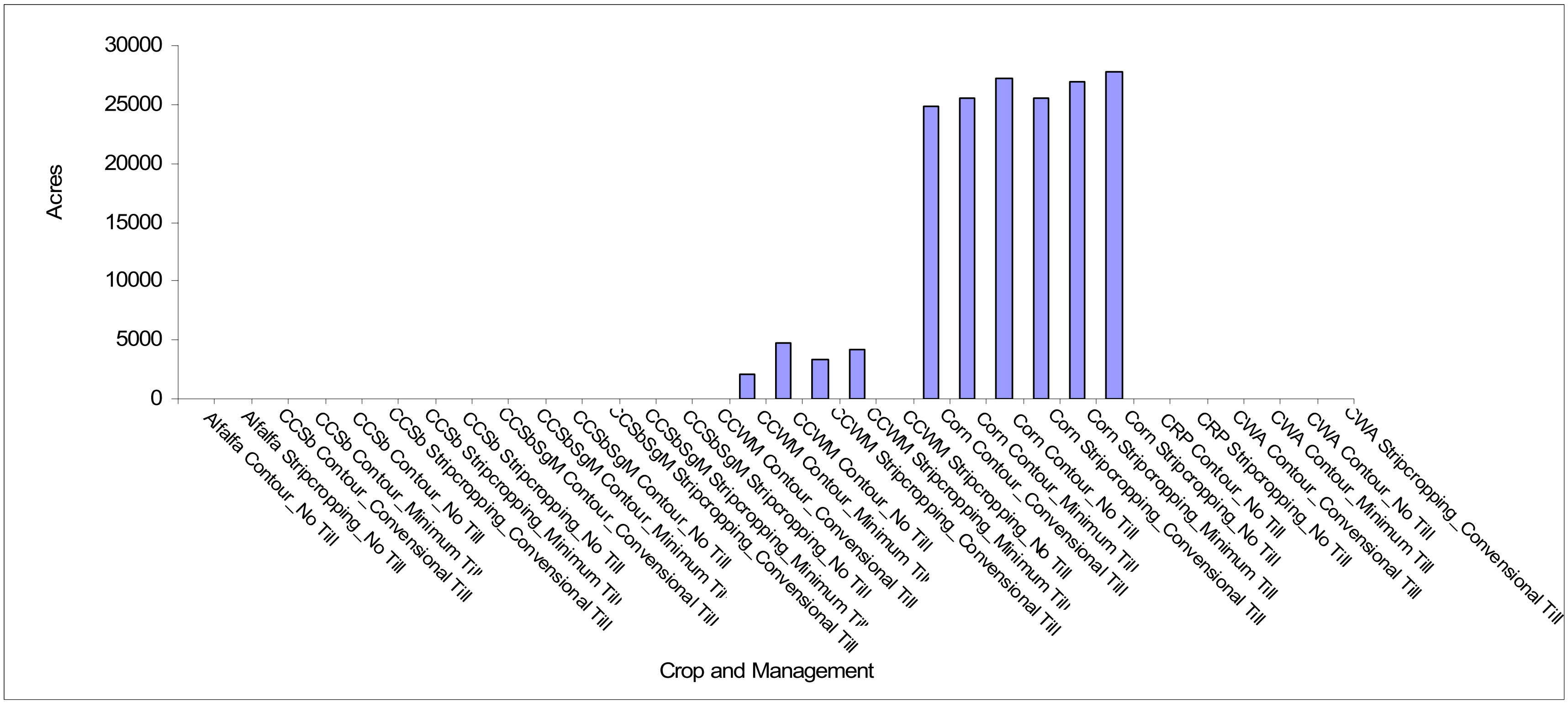

Figure 5.23a: Acreage of crops produced using total soil loss of 70,617.88 tons per year in Texas County, Oklahoma.

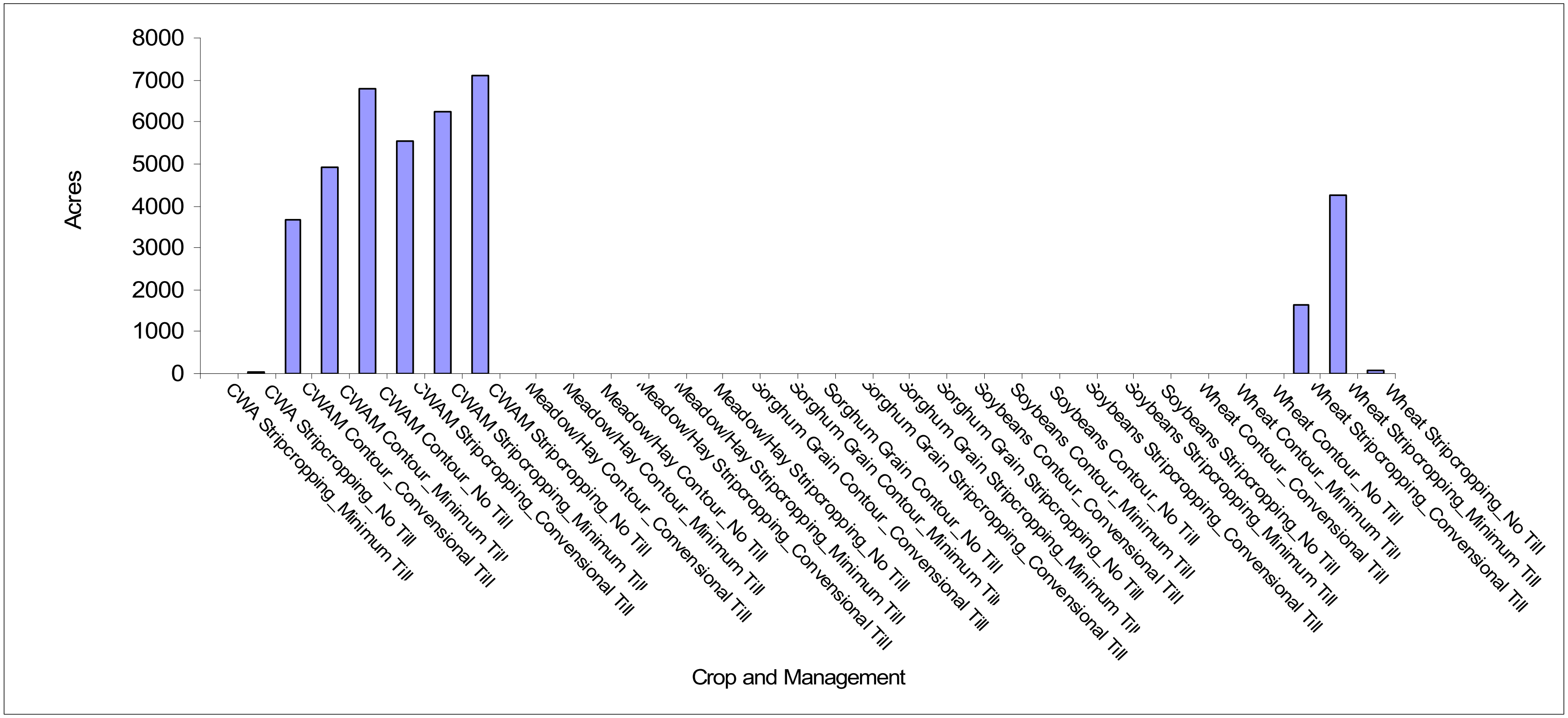

Figure 5.23b: Acreage of crops produced using total soil loss of 70,617.88 tons per year in Texas County, Oklahoma.

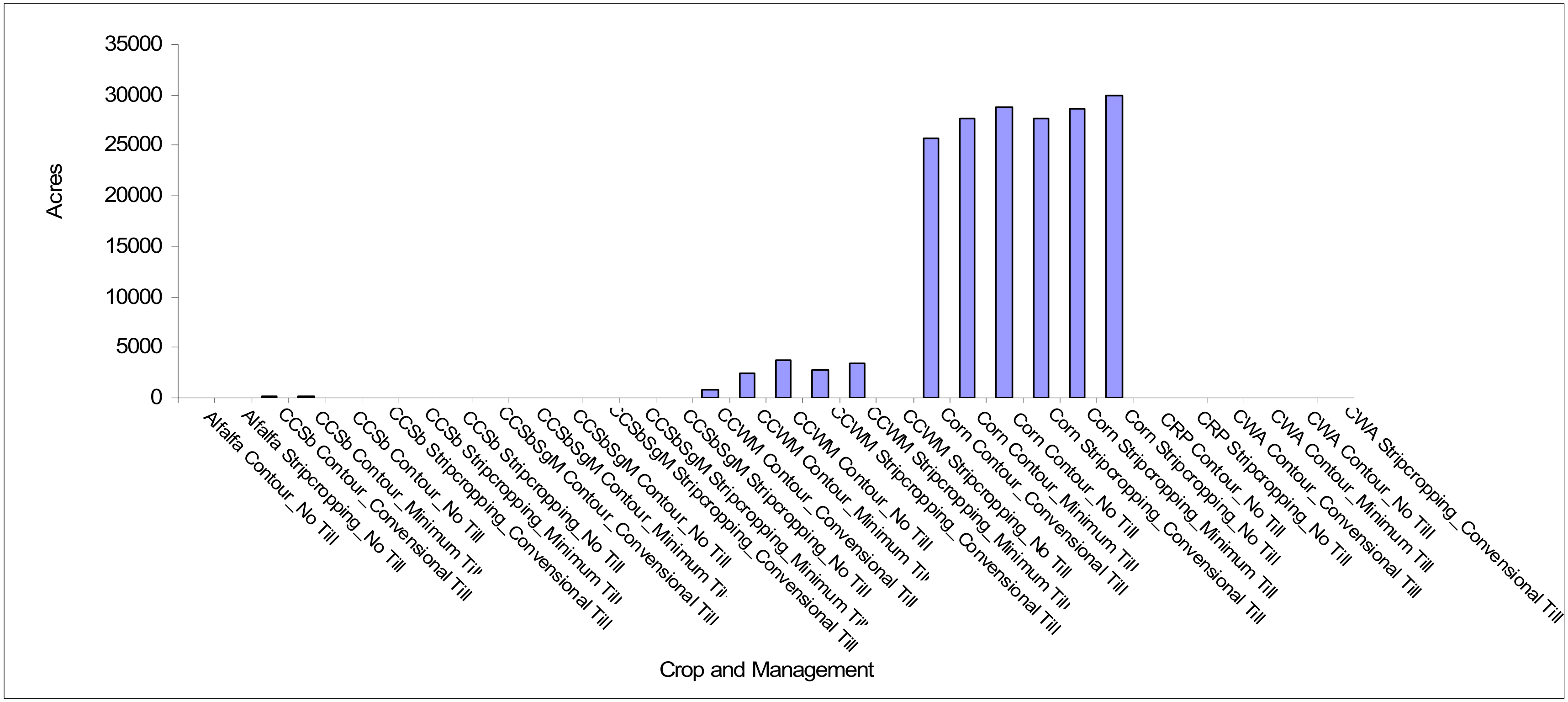

Figure 5.24a: Acreage of crops produced using total soil loss of 74,447.88 tons per year in Texas County, Oklahoma.

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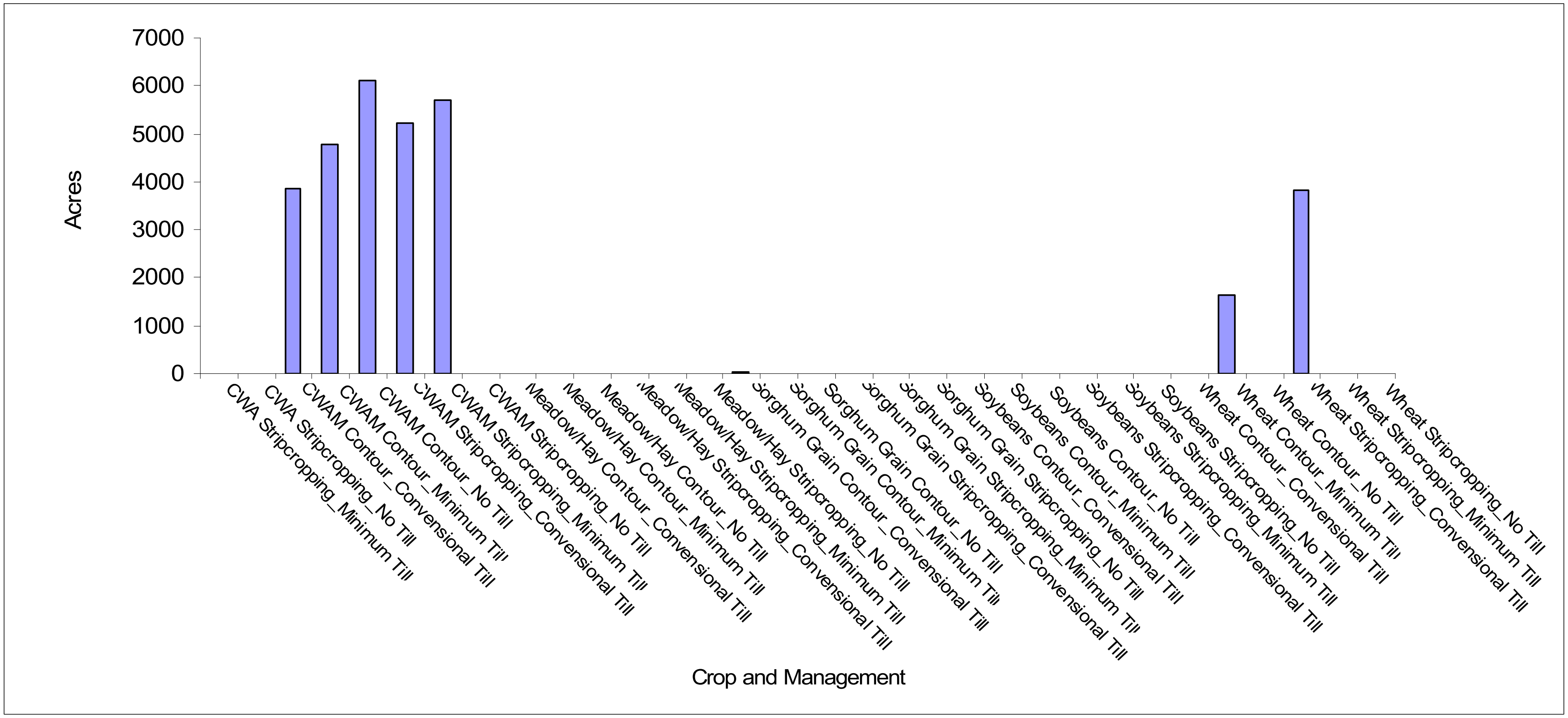

Figure 5.24b: Acreage of crops produced using total soil loss of 74,447.88 tons per year in Texas County, Oklahoma.

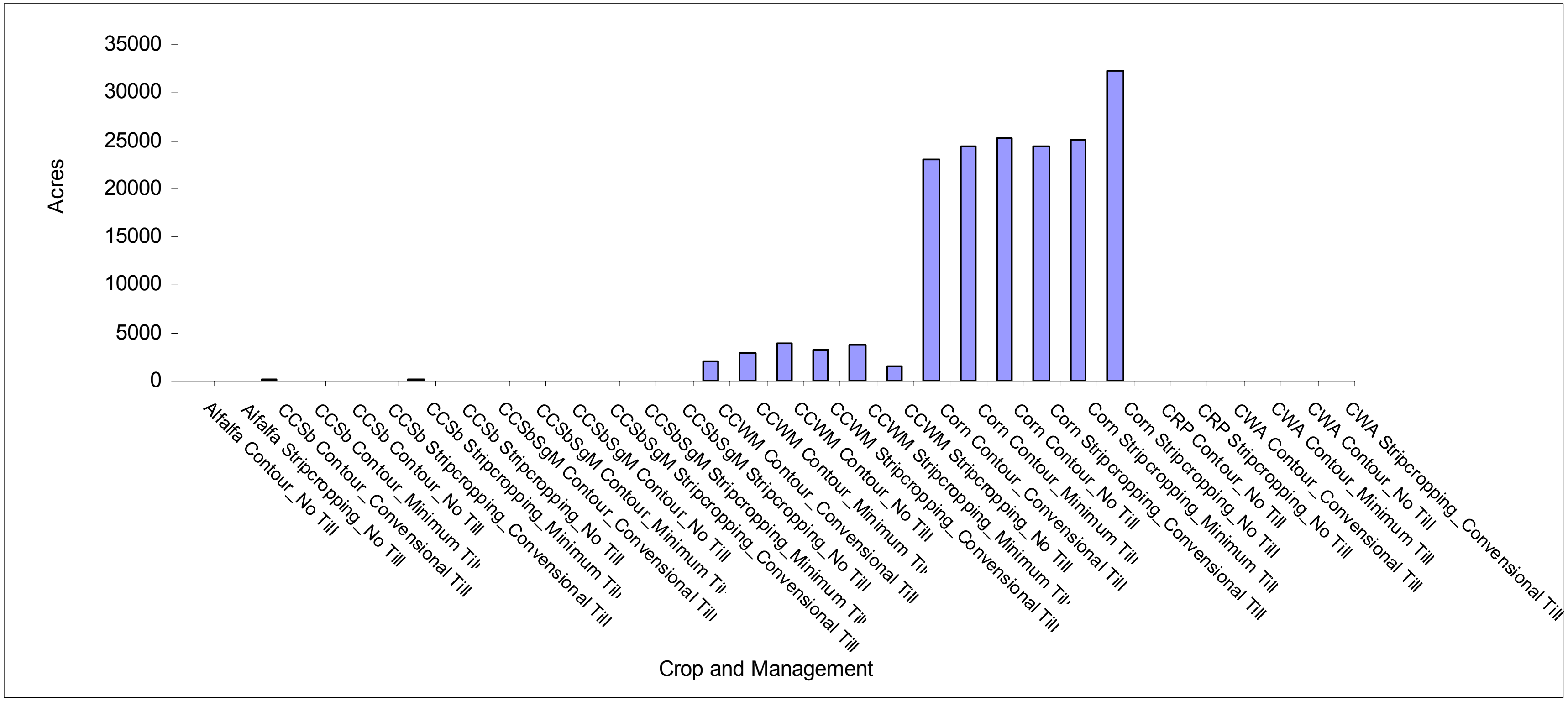

Figure 5.25a: Acreage of crops produced using total soil loss of 79,765.5 tons per year in Texas County, Oklahoma.

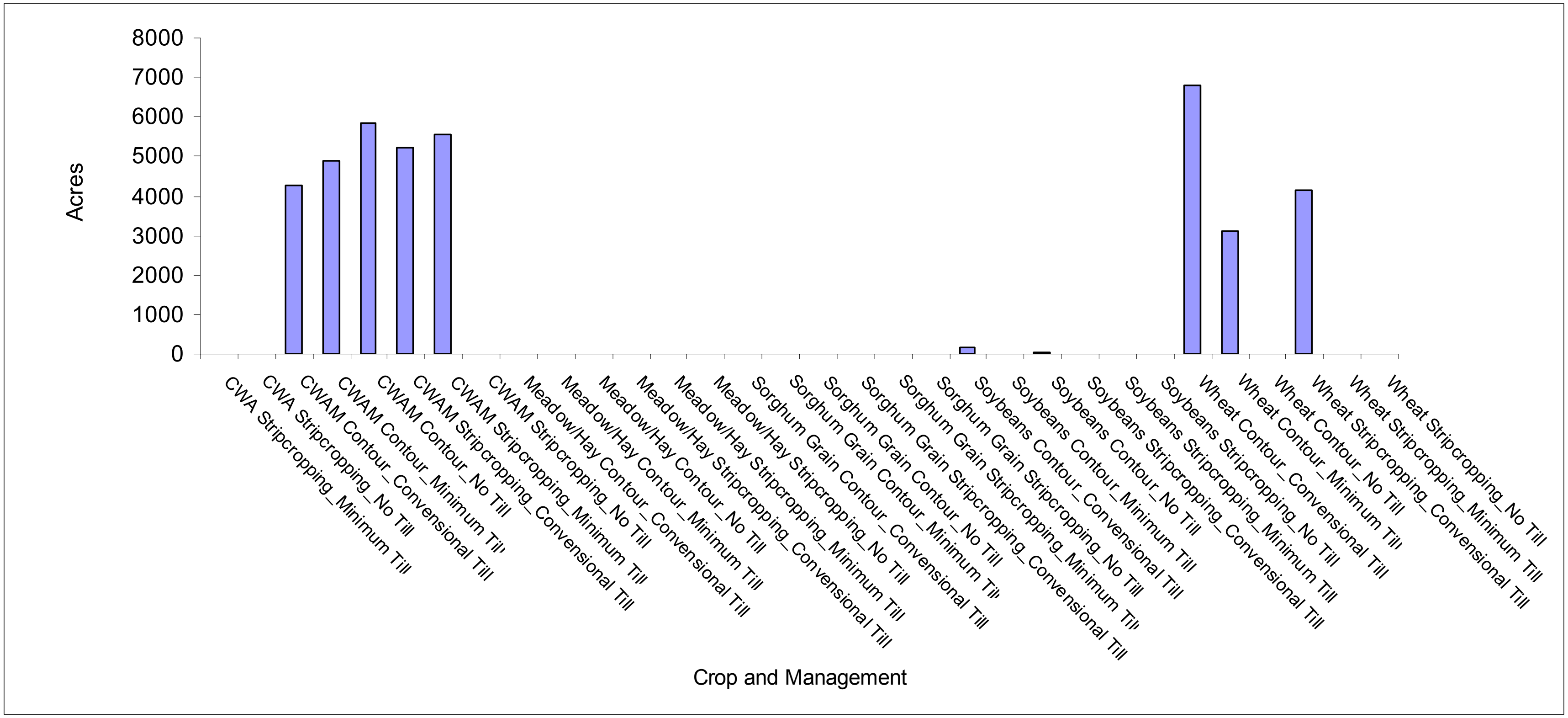

Figure 5.25b: Acreage of crops produced using total soil loss of 79,765.5 tons per year in Texas County, Oklahoma.

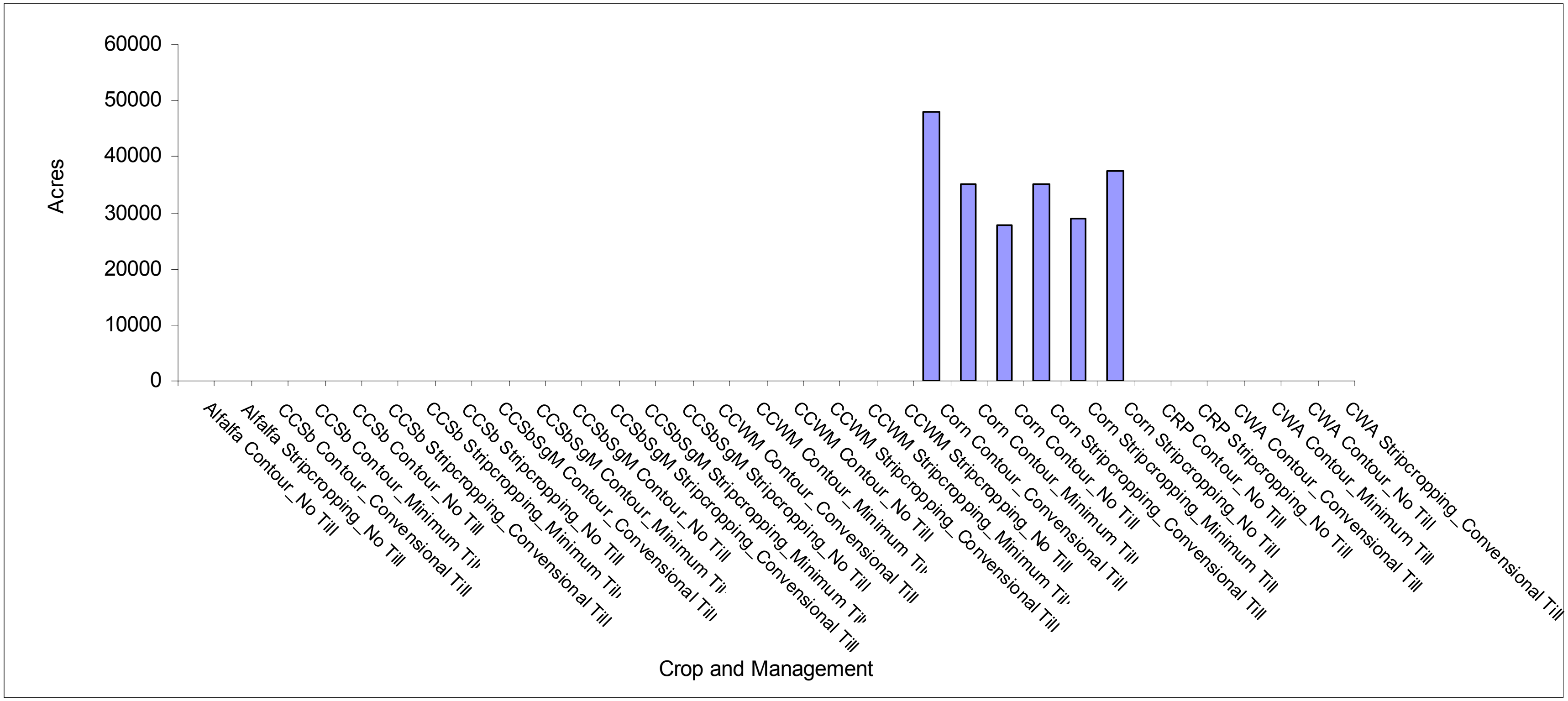

Figure 5.26a: Acreage of crops produced using total soil loss of 85,083.2 tons per year in Texas County, Oklahoma.

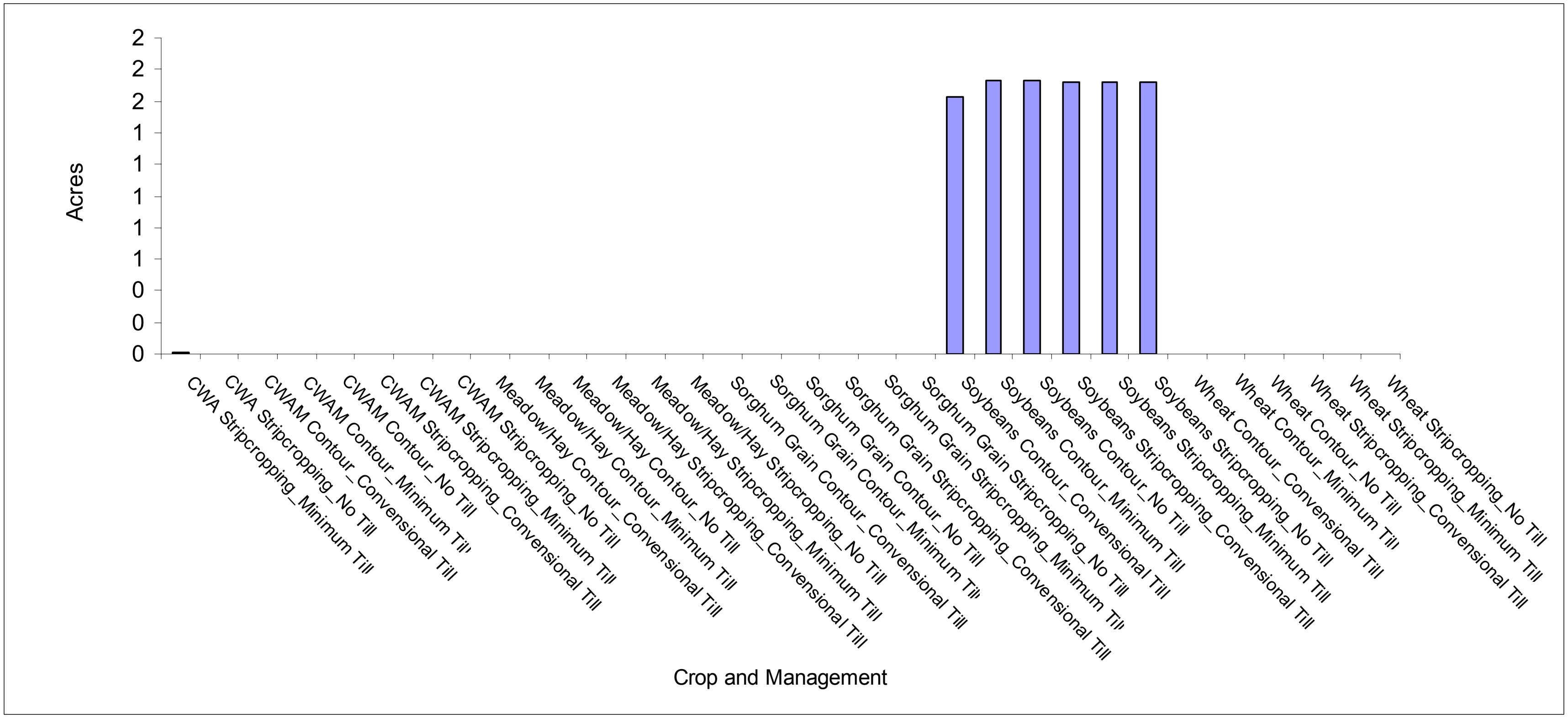

Figure 5.26b: Acreage of crops produced using total soil loss of 85,083.2 tons per year in Texas County, Oklahoma.

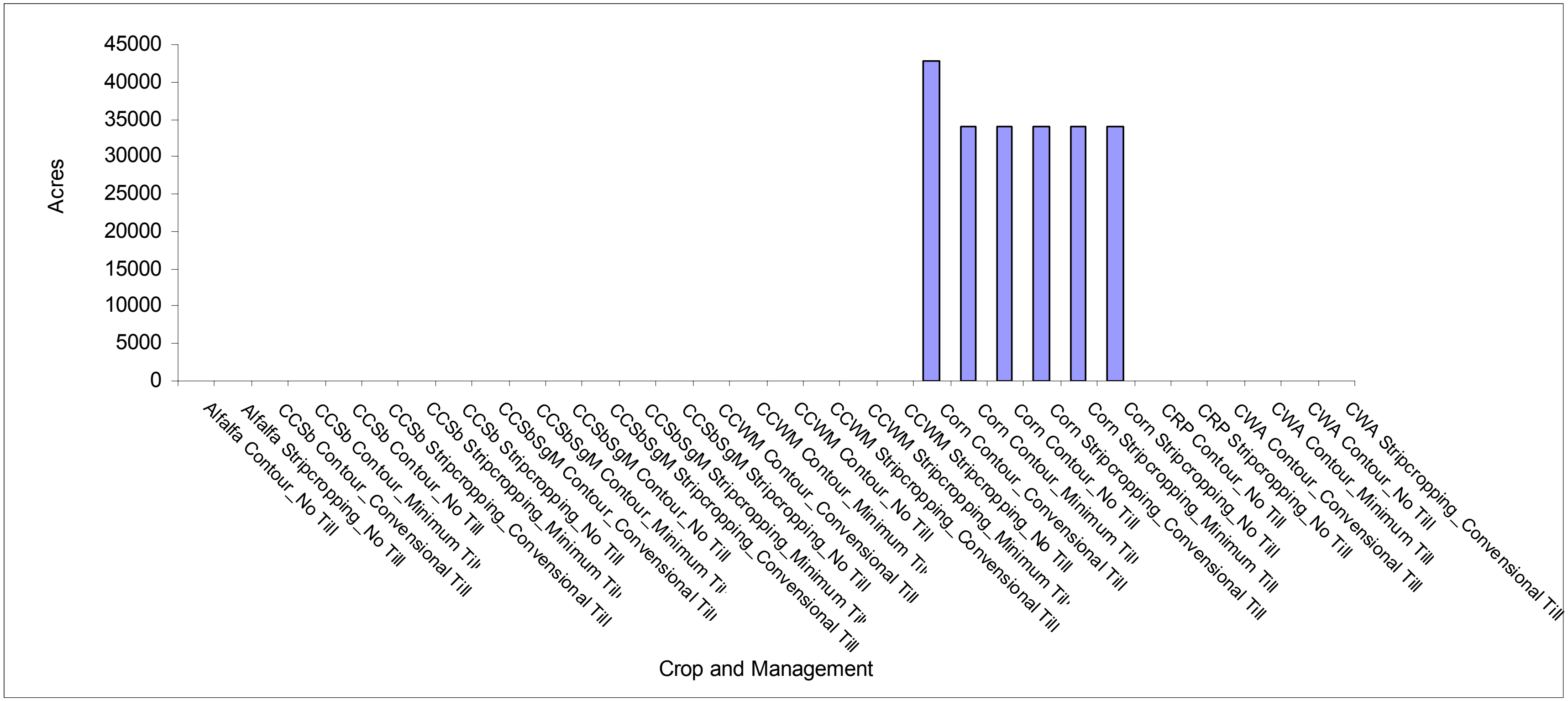

Figure 5.27a: Acreage of crops produced using total soil loss of 95,718.6 tons per year in Texas County, Oklahoma.

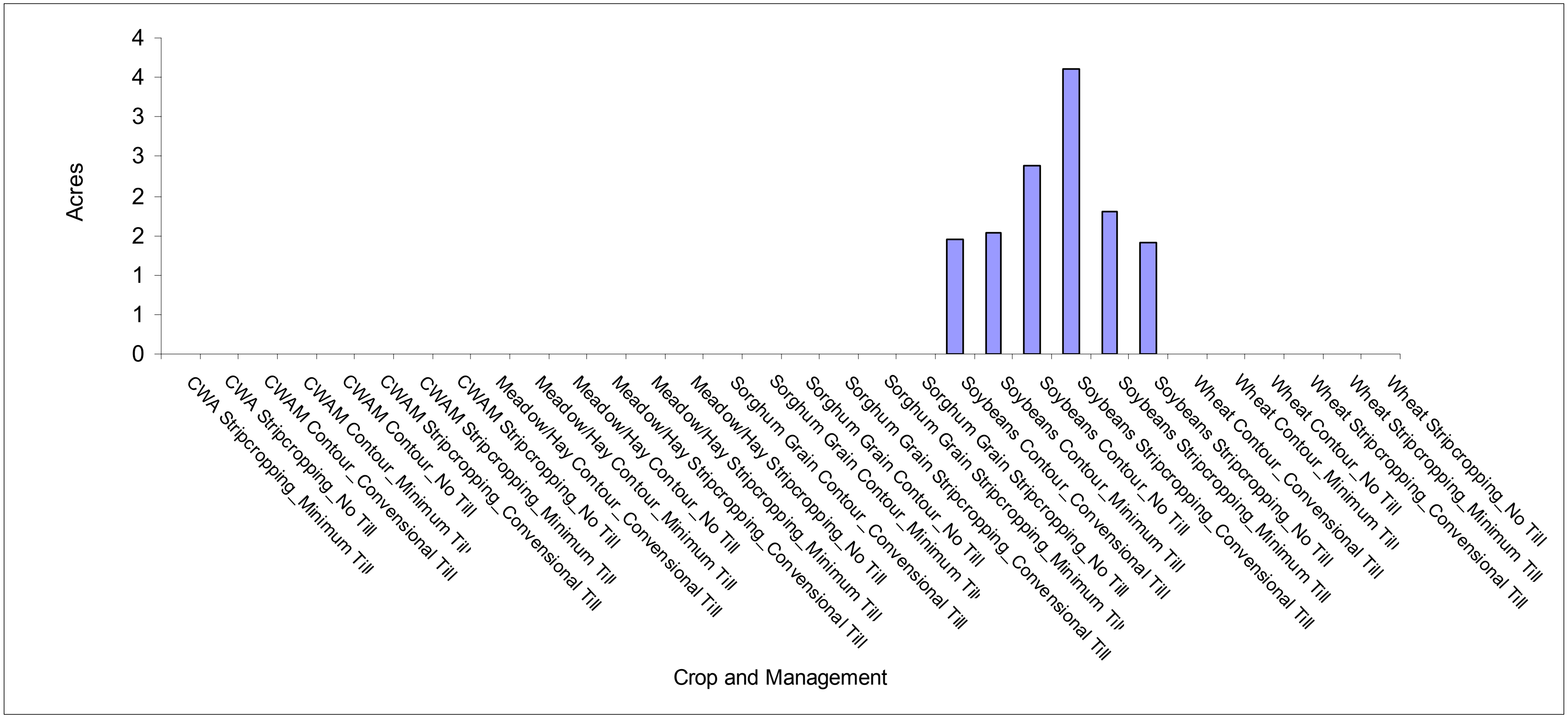

Figure 5.27b: Acreage of crops produced using total soil loss of 95,718.6 tons per year in Texas County, Oklahoma.

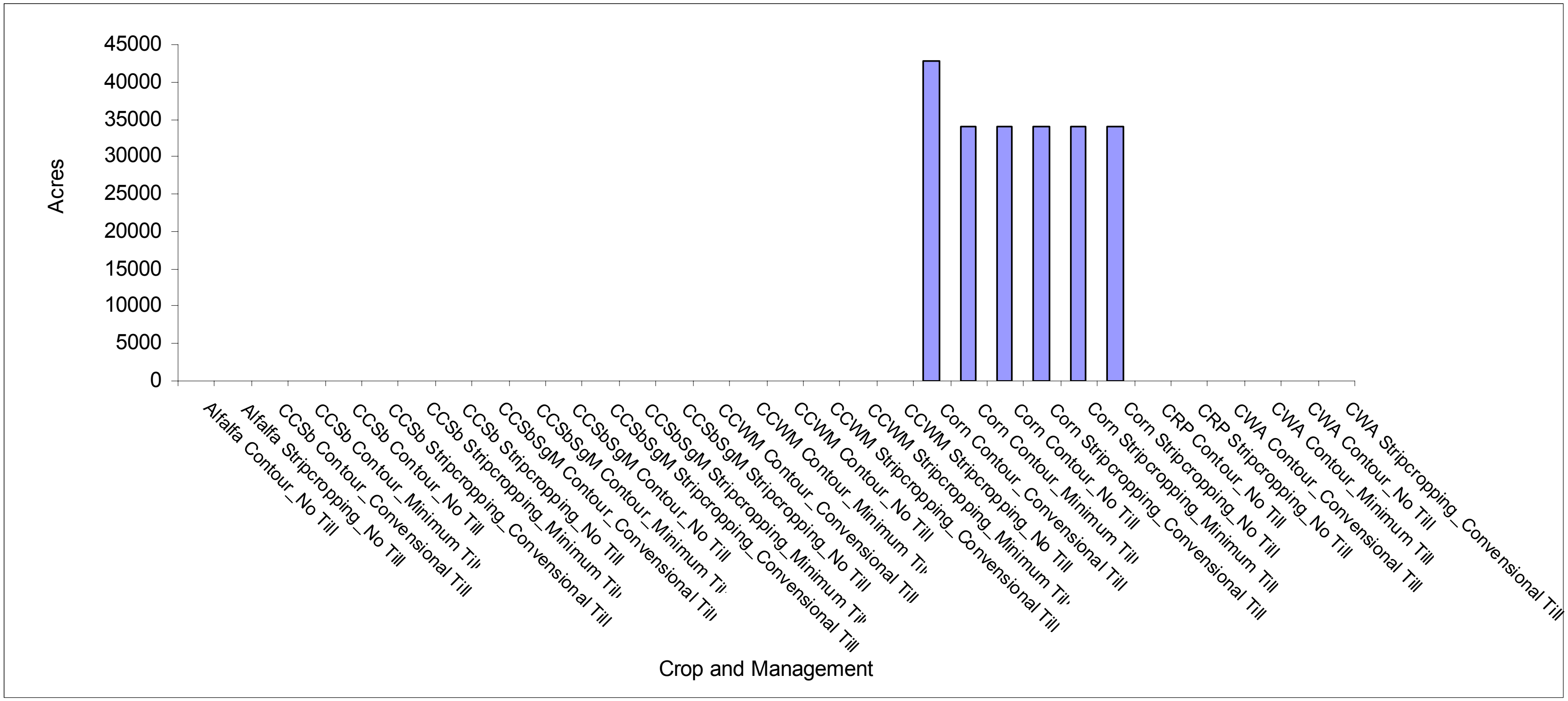

Figure 5.28a: Acreage of crops produced using total soil loss of 101,036.3 tons per year in Texas County, Oklahoma.

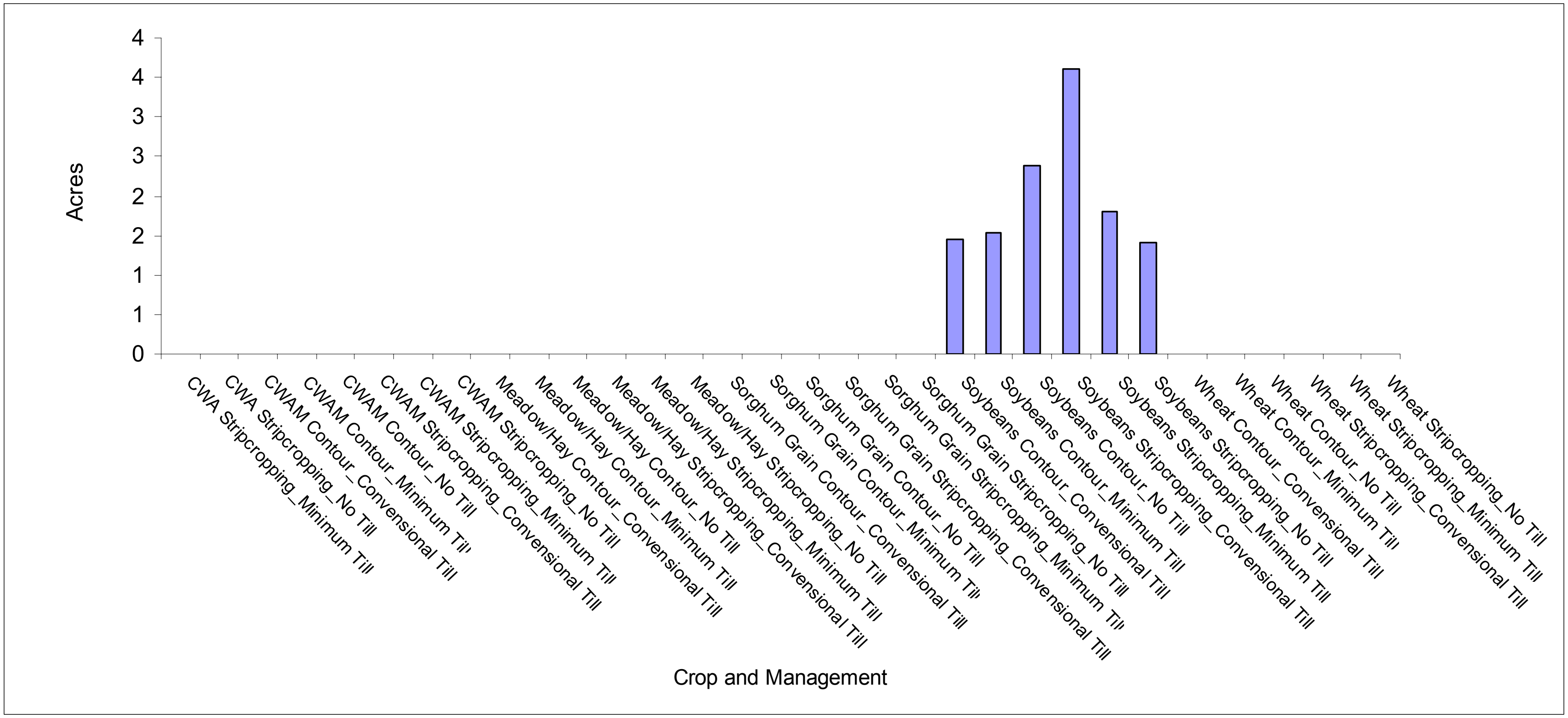

Figure 5.28b: Acreage of crops produced using total soil loss of 101,036.3 tons per year in Texas County, Oklahoma.

CHAPTER VI

SUMMARY AND RECOMMENDATIONS

Summary

The Conservation Reserve Program (CRP) has brought change on the Texas County landscape, which has resulted in a number of environmental benefits. At the landscape level, there has been a reduction in the number of patches resulting in an increase in mean patch size. There has been a reduction in patch size standard deviation and coefficient of variation resulting from the increased patch sizes of the post-CRP compared to the pre-CRP landscape. The large patches are due to the consolidation of farmland fields into large CRP tracts, i.e., fields used for growing different crops have been grouped together into a few CRP tracts. Reduction of total edge was an additional result of the reduction in the number of patches in Texas County. Reduced edge has an effect on habitat quality of edge sensitive species. The mean shape index did not change significantly because the CRP tracts retained the shape of pre-CRP farm fields.

Fields in multiple land uses, e.g., small grains, row crops, and fallow were converted to CRP. More row crops acreage, however, was converted to CRP than any other land use. The creation of large patches is significant for wildlife because large patches provide habitat for loafing, nesting and for escape. The increase in patch size is also an indication of less fragmentation of habitat in the post-CRP landscape.

The CRP has targeted areas that will contribute to natural resource conservation in farming areas and this is demonstrated by reducing row crops by 64% and small grains by 17%. Some fallow (42%) and wetland (19%) has also been placed under the CRP. The CRP has generally benefited wildlife in Texas County although this depends on the habitat requirements of particular species. While the CRP may provide increased wildlife habitat for hiding, foraging habitat has been reduced for some species by taking out cropland from their habitat (Messenger 2005).

Wildlife managers should take stock when making management decisions because the effect of the CRP on habitat preference is not the same on all species. Although the CRP is said to benefit wildlife in general, Klute et al. (2006) found that numbers of grassland birds (dickcissels, grasshopper sparrows, meadowlarks, brown-headed cowbirds, and upland sandpippers) were higher in pasture than in the CRP because of differences in habitat structure between the CRP and pasture. Additionally, the CRP may be used differently depending on the vegetation structure of the CRP. Schroeder and Haegen (2006) found that mule deer, jackrabbits and cotton-tails used the CRP fields differently depending on the CRP vegetation structure and landscape.

Habitat area has declined for some of the species tested (black-tailed jackrabbit, yellow warbler, and wild turkey). There was a marginal reduction in the habitat of swift fox, scaled quail, and lesser prairie chicken. But other species made major gains in habitat area (eastern cotton-tail, lark sparrow, lesser prairie chicken, and northern bobwhite) because CRP tracts form part of their habitat. Not all wildlife species will find CRP tracts as suitable habitat because in some cases the grasses planted are not native grass types (e.g., old world bluestem). Additionally, long grass (e.g., big bluestem) in shortgrass prairie, may not be suitable though native in areas where there was originally only short grass.

The number of patches for selected habitats reduced in all cases except for white-tailed deer and lesser prairie chicken habitat where the number of patches increased due to agricultural fields or croplands, which were subdivided by CRP tracts (Egbert 2002). Increase in number of patches may be an indication of a fragmented habitat.

The mean patch size reduced in all habitats for species where CRP cover does not make part of their habitat model. Reduced mean patch size has an effect of contributing to fragmented habitats for those species. Species in this category include black-tailed jackrabbit, black-tailed prairie dog, Cassin's sparrow, scaled quail, swift fox, and wild turkey. The trend from small mean patch size to large mean patch size was not observed in habitats that did not include CRP cover as part of habitat.

Total edge reduced in all selected habitats (except for lark sparrow, eastern cotton-tail, lesser prairie chicken, northern bobwhite, and white-tailed deer), which is an indication of increased patch size in those habitats. Generally, the effect of the CRP has been an increase in habitat area for those species that are capable of using CRP cover as part of their habitat but species that do not utilize CRP tracts as habitat experienced a reduction in habitat area.

I identified about 19,112 ha of CRP tracts as suitable for row cropping, representing 22% of total CRP tracts. These are the tracts identified from a total of 60,988 ha that were used for row crops before the CRP was established. CRP tracts that did not meet either the row crop or wildlife habitat criteria, i.e., 7,032 ha (8%) were reserved for pasture.

A high percentage of CRP tracts is suitable for wildlife habitat based on the minimum 64 ha polygon size (70%) but tracts providing native grass account for 14% while those providing both native grass and wetlands account for less than 1% of total CRP tracts. Tracts having both wetland and native grass would be the most ideal habitat for native species as such habitat caters for a wide range of habitat needs. The use of CRP tracts as wildlife habitat would serve a dual purpose of reducing soil erosion and serve as wildlife habitat for native species.

Sensitive areas of the CRP need to be monitored to maintain environmental benefits gained from the CRP. About 25% of CRP tracts are highly vulnerable to soil erosion by water while a smaller portion of the CRP tracts (0.3%) is highly vulnerable to erosion by wind. Only a small portion of the CRP tracts is important for monitoring for groundwater protection (13%) while for surface water protection a larger percentage of the CRP is important (62%). Protection of surface water is still desirable even though soil erosion by water is not as important as wind erosion in Texas County (Doerr and Morris 1960).

To maintain environmental benefits accrued from the CRP when tracts are returned to crop production, the solver model I used suggest a mixture of crops having different erosion potential that can be grown in Texas County CRP tracts. The crops are selected by using different levels of soil loss. Alfalfa offers the least soil loss especially when no till cultivation is used. Soybeans cause the most soil loss followed by corn. The level of soil loss is reduced when high erosive crops are grown in rotation with less erosive crops such as sorghum, wheat and alfalfa. No till cultivation offers the least soil loss when used with any of the crops that were used in the Microsoft Excel Solver Modeling.

Profitable farming is possible with maximized production of as much as $75,250,026 and a net profit of $20,062,504 obtained at the soil loss level of 0.1 tons per acre per year, a total soil loss of 21,270.8 tons per year over the entire CRP tracts of Texas County. Comparable profit margins can be obtained at increased soil loss (0.4 and 0.45 tons/acre/year) but corn and soybeans are the only crops selected by the model at all these levels. A mixture of crops can be grown at lower levels of net profit using different soil loss levels.

Corn grown alone or grown in rotation with other crops gives a higher net profit. The model does not select soybeans where there is high net profit because of high levels of soil loss caused by soybeans and low net returns compared to corn.

The model uses few acres at low soil loss levels when high erodability crops, e.g., soybeans are grown, and the crop is not selected except when grown in rotation with other crops like corn, sorghum, or hay. This may suggest that few acres should be cultivated to allow for low soil losses when producing crops in Texas County’s CRP tracts but allowing very low levels of soil loss results in low production levels. Nonetheless, allowing the highest levels of soil loss does not necessarily translate into higher production levels.

Crop production in Texas County can be carried out up to maximum average soil level of 0.45 tons/acre/year with a net profit of $19,927,572 growing a variety of crops using about 212,708 acres meaning, the total area of the CRP tracts, with an average of 0.45 tons/acre/year soil loss.

The amount of soil loss using a particular crop/crop management combination is not uniform over the whole CRP tracts; hence, the results obtained are only a general guide and the model should be applied at the local or farm level to allow for more realistic projected production levels.

The optimization model used in this study can be used to plan for farm practices for CRP tracts returned to production with a view of maintaining soil stability and water quality. The model can also be used to plan for production of certain crops and appropriate rotation programs that would ensure environmental benefits gained.

The CRP Policy

The performance of the CRP is viewed differently by various sectors of the population in terms of benefits, efficiency of the program, and post-CRP land use (Ohlenbusch and Watson 1995, Feather et al. 1999, Ribaudo 1989). Some of these views question the fairness of the CRP policy including legitimacy of the program. Policy legitimacy refers to the degree of acceptance of a policy by the people for whom it has been designed and a good policy must satisfy conditions of legitimacy that include technical effectiveness, economic efficiency, legal compliance, political feasibility, and whether the policy is administratively implementable (Stern and Fineburg 1996).

The CRP has addressed the problems it was intended to solve which include improvement in water quality (Feather et al. 1999), a reduction in soil erosion (Boyles et al. 2001, Gilley et al. 1996) and an increase in quality and number of habitats (Egbert et al. 2002). This means that the CRP policy is technically effective because it solves intended problems.

The CRP does not seem to be economically efficient because studies have shown that less money on water quality improvement would have been spent if the CRP had targeted more specific areas, i.e., steeper slopes and buffer strips along streams and rivers as suggested by Khanna et al. (2003) in their study. They demonstrated that CRP achieved 20% sediment abatement but at 75% higher cost than necessary (Khanna et al. 2003). Value of water quality is considered the same in areas where water is in high demand like in urban areas and where water demand is less. Targeting areas where treated water is in high demand would translate into higher savings because of the reduced cost of treatment of good quality water but similar savings cannot be realized in a rural area with low demand for treated water (Ribaudo 1989). There is also overlap with some other land retirement programs like the Wetland Reserve Program (WRP) and the Wildlife Habitat Incentives Program (WHIP) (NRCS-FSA 2006, Lovejoy and Doering 2002).

Violation of contract provisions leads to loss of incentives to carry out or maintain conservation practices, i.e., violation does not lead to fines or prison terms but may lead to loss of benefits (Johnson and Zidack 1997, Ohlenbusch and Watson 1995). Such laxity in the policy may attract violation of the contract where benefits of not complying with contract conditions are more than what can be gained if in compliance. It is difficult to monitor compliance because of the vast acreage involved in the CRP operation which may be approximately 40 million acres (FSA 2003); however, the technique for automated monitoring using GIS is available (Cherian et al. 2004, Song et al. 2005).

The CRP has not been widely accepted; it enjoys more support in scientific circles but does not have much support among the general public. One group with strong objections is businesses that sell farm products and equipment because retiring cropland “reduces local demand for farm inputs, marketing services, and labor” (Sullivan et al. 2004). The other group consists of environmentalists who feel that the program would have achieved more in environmental benefits if attention was directed to particular areas, rivers or wildlife habitats and convince farmers to enroll large tracts into the program (Zinn 1997). Farmers might also enroll just to get rid of areas of their farm they do not really need to use or put into production. The National Grain Marketers Association has also condemned the CRP for removing land from production, hence reducing the amount of available grain on the market and making the USA an importer of grain (KAWG 2002, NOPA 2004, Charles 2005).

Politically the CRP has wide acceptance because changes to the program are supported even when a lot more money is required for the program. This is demonstrated in the recent voting on the CRP budget in Congress when a larger budget than the 1996 Farm Bill was passed. Higher goals have also been added moving from “no-net-loss” of wetlands to restoration, improvement and protection of about 3 million acres of wetland alone in the next 5 years (The White House 2004).

There is still much that needs to be done to make the CRP policy more legitimate for widespread acceptance and smooth implementation. All concerns of stakeholders, i.e., farmers, environmentalists, and traders must be addressed. Future CRP policy formulation is likely to follow procedures that would impart more legitimacy to the program by following the democratic process that has become the norm in policy formulation procedures (Rowe and Frewer 2000). Such policy-making procedures include moral justification of policy results (Trachtenberg and Focht 2005). A lot of lessons have been learnt in the past two decades that the CRP has been in operation, lessons that stakeholders can draw on. Hence, for the policy to be most effective, producers, legislators, budget overseers and other stakeholders will need to participate in formulating CRP policy because "policy output effectiveness" will be higher where stakeholders voice their own opinion (Focht and Trachtenberg 2005). Formulation of policy should not be left to a few technocrats (Rowe and Frewer 2000) because technocrats have a limited view of issues under consideration which may not reflect the views of the affected public. The local stakeholders may have more insight into the problem. Additionally, local participation is very important when considering trade-offs in policy formulation and implementation.

Risks in the CRP Policy

Any program or policy that is implemented has some inherent risk that may result in negative outcomes due to activities of the program in policy implementation. Risk can be defined as exposure to harm or possibility of loss of value and such a risk will be proportional to the expected losses. The risks associated with an activity depend on probability of threat, probability of susceptible elements in the system, and the impact such a risk will create.

The USDA has invested a lot in conservation programs with the aim of restoring the natural resource base of the country, with about 2 billion dollars per annum for the CRP alone. But what are the risks that can arise from the CRP? The risks that may arise from this program are three fold: social, financial, and environmental.

Socioeconomic effects of the CRP include the rise in crop prices because some cropland is removed from production (Young and Osborn 1990, Barbarika and Langly 1992, USDA-FSA 1997). Smith (2000) predicted that as a result of the CRP there would be an increase in the price of wheat (12%), corn (12%) and soybeans (15%). This is confirmed by the commodity price history which shows a price increase of 30% (wheat), 18% (corn) and 13% (soybeans) for Illinois while for Oklahoma the increase is 65% (wheat), 76% (corn) and 36% (soybeans) using 1986 and 2006 average crop prices (NASS 2007, Farmdoc 2007). However, there are fluctuations in both monthly and yearly averages of commodity prices from year to year.

The other socioeconomic effect of CRP is that the program removes money from the local farm economy, an important local asset base in rural areas. This leads to loss of population resulting in less tax and consequently less capacity to provide services like schools to the local community (Hodur et al. 2001, Woods and Sanders 1987).

Slippage is another socioeconomic consequence that may result from the CRP. Slippage occurs when a landowner with a CRP contract increases crop production on some other land (usually marginal) to compensate for the acreage that has been enrolled into the CRP (Wu 2000). The landowner may do this because of higher commodity prices or because of steady income from CRP so that the landowner is prepared to take risks on marginal land (Wu 2000). Slippage has been estimated at 20% countrywide and about 30% in the Corn Belt affecting the efficiency of the CRP (more money spent for less gain) because water quality benefits are reduced by as much as 5-10% (Wu 2000, Ribaudo 1989).

Environmental risks of the CRP include the planting of non-native species that result in a number of consequences. Non-native grass may not be suitable for native species because they are not adapted to those grass types. Swift foxes are reported to avoid non-native CRP tracts preferring native shortgrass prairie (Kamler 2002). Planting non-native species in CRP tracts can result in a multiplicity of problems that include competition with native species and possible marginal wildlife value of non-native species (Muir 2007).

Another environmental risk arising from the CRP is the risk of fires, especially during the drought season. The main cause is accumulation of a large fuel (biomass) because the CRP contract prohibits grazing or haying on CRP tracts except with permission during drought conditions. Old world bluestem has the highest potential as a fire hazard (Kraich 2006).

Recommendations

This study has found that the CRP has brought positive change to the Texas County landscape. This change has benefited wildlife, water quality and soil erosion. These benefits need to be maintained. Modeling results show that all CRP tracts can be used for production but only 22% is suitable for row cropping. Most of the CRP tracts are suitable for wildlife habitat (about 70%). I would recommend that not more than 22% of the CRP tracts be returned to row crop production. Additionally, 50% should be reserved for wildlife and 8% should be used as pasture land. The remaining 20% can be set aside for other uses including continuing in conservation programs like the Grassland Reserve Program (GRP) and the Conservation Reserve Enhanced Program (CREP).

Returning some CRP tracts to cropping would benefit wildlife in terms of increased forage areas which has been reduced for some species by turning crop land to CRP practices. No-till cultivation would ensure maintaining environmental benefits on CRP tracts when returned to production. Planting crops in rotation between soil conserving crops like alfalfa, hay, and wheat with crops that cause high soil loss like soybeans and corn would also greatly enhance soil benefits accrued from the CRP.

Again, maintaining most of the CRP tracts in wildlife and pasture would help maintain environmental benefits accrued because Texas County has a pastoral historical background. To allow for pasture and wildlife habitat the CRP contracts should be replaced by the Grassland Reserve Program (GRP) or the Wildlife Habitat Incentive Program (WHIP) contracts. A policy change is required for an effective conservation strategy from the current arrangement. Putting the current CRP contracts under the WHIP and the GRP would be most beneficial to Texas County because a balance between conservation and production would be realized (Lovejoy and Doering 2002).

Soil erosion and water quality were some of the first objectives of the CRP policy. Water quality as an objective of the CRP is still attainable with continued cropping as long as streams and rivers are protected by buffers strips. Buffer strips will give protections to streams and rivers while the land is cropped hence using very little acreage than at present when whole tracts may be devoted to stream protection. To protect groundwater, tracts that have wetlands should not be cultivated very close to the edge of wetlands but at a distance of at least 30 meters to protect wetlands from sedimentation and contamination by agricultural chemicals. A minimum of 30-meter buffer along streams and rivers is also required to protect surface water. Tracts that are highly prone to wind erosion can be protected with the use of windbreaks.

A policy change in the CRP is desirable so that the program can address specific issues and target specific target sites as seen in the Conservation Reserve Enhancement Program. The CRP should be directed more towards working lands programs like the GRP which serves both economic and conservation objectives. Conservation programs like the WHIP can also be modified so that they are operated under working lands programs like the GRP with the incorporation of tax incentives. Where continued farming practices would reverse accrued benefits from the CRP sensitive properties can be purchased for federal, state, or local management. Additionally, some areas can be turned into permanent wildlife areas that can be privately managed with the help of USDA, FSA and NRSC, as under the WHIP. The other option is turning those areas into permanent pasture under the GRP contacts. There should be continuous monitoring as in the case of the Conservation Effects Assessment Project (CEAP) by the use of SWAT for instance which has been in effect since 2003 (USDA 2006).

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VITA

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Scope and Method of Study: Modeling of the Conservation Reserve Program tracts to maintain environmental benefits in Texas County, Oklahoma by using GIS.

Findings and Conclusions: I used a Geographic Information System to study the effects of the Conservation Reserve Program (CRP) in Texas County Oklahoma. The CRP has brought change to the Texas County landscape resulting in a 16% increase in mean patch size, a 13% reduction in the number of patches, and a 10% reduction in total edge. The CRP has targeted areas important for natural resource conservation. This is illustrated by reduction in area of small grains (17%) and row crops (64%). Some fallow fields (42%) and wetland (19%) have also been placed under the CRP. However, conversion of agricultural land to the CRP has resulted in loss of habitat for some native species.

In terms of post-CRP land management, about 22% of total CRP tracts were identified as suitable to return to row cropping, 70% retained as wildlife habitat, and 8% managed as pasture. Some tracts were identified as being highly vulnerable to soil erosion by water (25%), and wind erosion (0.3%). About 13% of the CRP tracts should be monitored for groundwater quality and about 62% for surface water quality. Modeling results show that all the CRP tracts can be cultivated profitably with marginal soil loss through soil erosion by water.

My conclusion is that environmental benefits of the CRP can be maintained by limiting the amount of land returned to production agriculture. I recommend that most of the retiring CRP tracts should be devoted to wildlife habitat and pasture. I propose that about 22% of the CRP tracts can be returned to row crop production 50% should be retained as wildlife habitat; 8% managed as pasture, and 20% for other uses including conservation programs like the Grassland Reserve Program (GRP) and the Conservation Reserve Enhanced Program (CREP). There should be a policy change in the CRP to allow for commercial usage of conservation lands (e.g. the GRP) and tax incentives should be a component of future conservation policy.

ADVISER'S APPROVAL: Dr. Timothy O'Connell