

# The Shrinking Prairies of the Great Plains: An Analysis on the Trends

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## **I. Problem**

The prairies of the Great Plains are one of the most vulnerable environments in the world. Much of the Great Plains have been overtaken by agriculture and urban development beginning the 17<sup>th</sup> century. Acts such as the Homestead Act of 1862 encouraged more migration into the Great Plains thus increasing agriculture and home development. Agriculture has removed much of the native grass and replaced with other non-native species. For example, the woody juniper is one species introduced via agriculture and has become invasive in the Great Plains. Many states once had swaths of grasslands but now have either completely vanished or barely remain. These areas support some of the richest biodiversity in the world, especially vegetation which include wildflowers important to pollinators and many species of natural grasses. The goal of this project is to observe how much has disappeared since the start of the 21<sup>st</sup> century. I hypothesize that there is a significant negative trend from human activity in the Great Plains and the amount of coverage is approximately inversely proportional. By utilizing land use data of various years, I can compare the change in area as well as determine the rate grasslands are shrinking. As a side note, the term prairie and grassland are similar with only slight ecological differences, so I will use them interchangeably in this project.

## **II. Data Collection and Preprocessing**

Just about every piece of data is in a different coordinate systems, so I chose WGS 1984 as it is a geographic coordinate system and conversion was straightforward. As I was searching for data, I was surprised to find the lack of grassland/prairie specific data prior to 2010 and outside of the Land Cover Database, so I had to frequently adjust what data to use in the later processing stage. Sources are listed below.

Great Plains Landscape Conservation Cooperative shapefile boundary

<https://www.sciencebase.gov/catalog/item/4f4e4769e4b07f02db47e0f4>

National Land Cover Database 30 m rasters from 2001-2019, five year intervals

<https://www.usgs.gov/centers/eros/science/national-land-cover-database>

North American Grassland PCAs 2010 shapefile

<https://www.sciencebase.gov/catalog/item/4fb54fa1e4b04cb937751d8e>

North America Lakes and Rivers shapefile

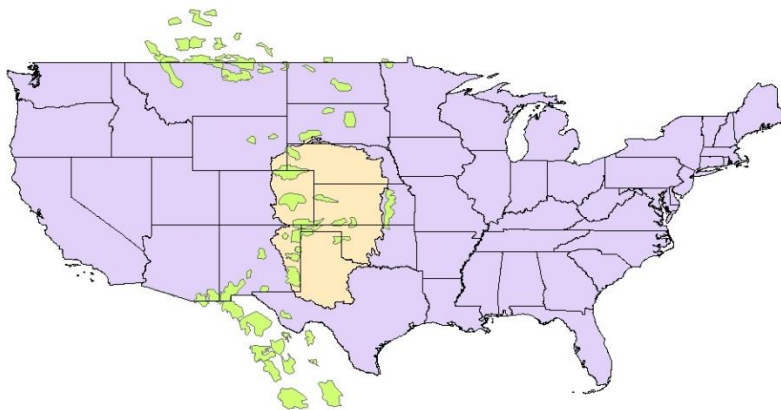
<https://www.sciencebase.gov/catalog/item/4fb55df0e4b04cb937751e02>

USA Major Cities shapefile

<https://hub.arcgis.com/datasets/esri::usa-major-cities/explore?location=39.629833%2C-113.479736%2C4.70>

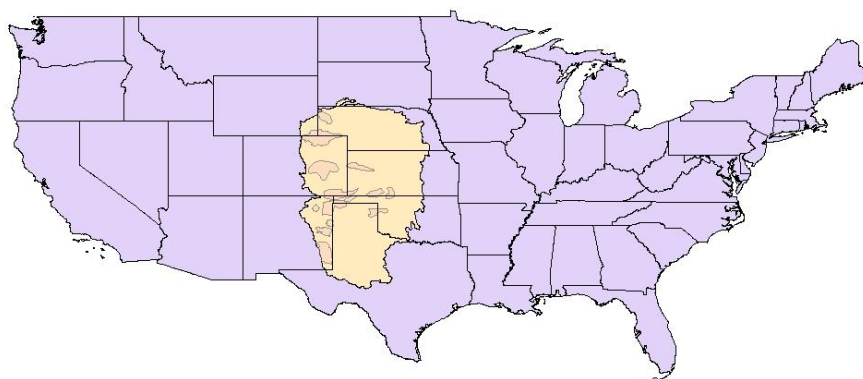
### **III. Data Processing**

First, I need to determine an area to work with as the Great Plains cover a large area. Courtesy of the USGS, I found a Great Plains LCC (Landscape Conservation Cooperative), containing a shapefile encompassing several central U.S. states. In addition to the boundary, I have also included PCAs (Priority Conservation Areas) based on data from 2010 where I hope to analyze the rate they are shrinking. I then collect shapefiles to outline the U.S. and the states.



*Figure 1* Unclipped PCA shape files over the Great Plains LCC and state shapefiles.

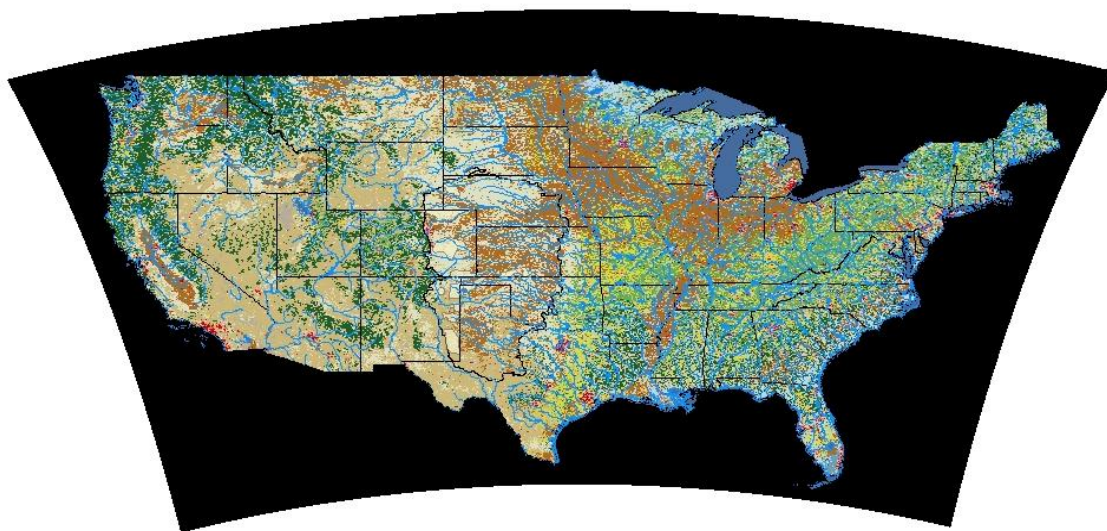
Since I am observing the data in the Great Plains LCC area, the PCA shapefile must be clipped. This is done by the Clip tool in the “Spatial Analysis” toolbox as it is not a raster. After that, I now have an area to work with.



*Figure 2* Now clipped PCA shapefiles with 30% transparency.

Most of the data I will use comes from the National Land Cover Database which is remotely sensed data containing 28 types of land cover, though the rasters I am using have 15 classes. These rasters come from the 2001-2019 surveys in five-year increments. As depicted in Figure 3, this dataset covers the entirety of conterminous U.S. and needs to be clipped. Seeing that there

are distinct hydrological environments, I included a shapefile of North American river systems that also needs to be clipped within the boundary. A problem now arises: the rasters are massive with each being around 15.68 GB and having a 30 m resolution. The “Extract by Mask” tool often failed, therefore, I opted to use the “Clip” tool in “Data Management,” using the Great Plains LCC as a boundary. I repeat this for all five rasters and repeat another five times by clipping them to the PCA shapefile. The LCC clipped rasters are now 1.28 GB and much more workable though the computer still struggles to load them.



*Figure 3* Unclipped land cover raster with river shapefiles. The rasters have a 30 m resolution and are 15.68 GB.

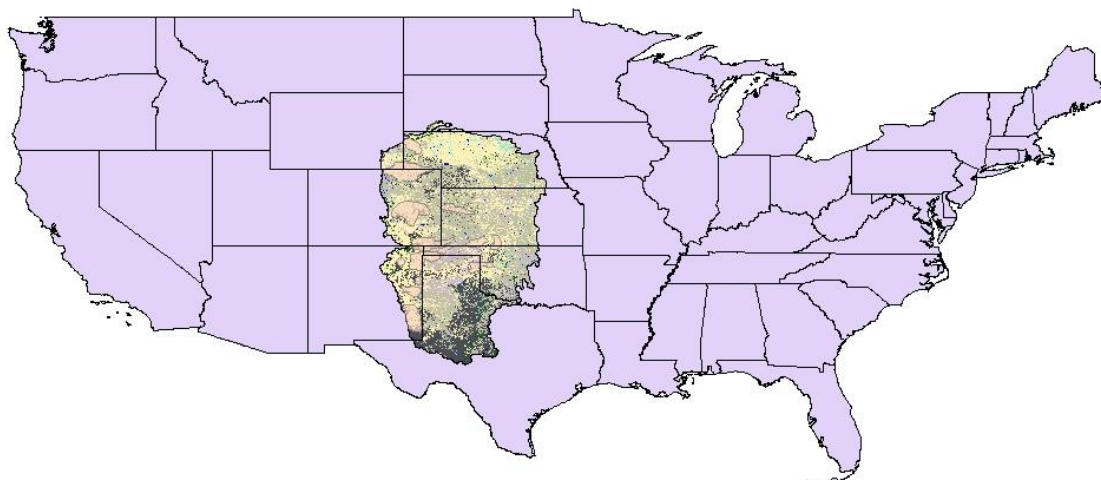


Figure 4 Clipped land cover raster.

Since I want to observe the changes in grasslands over time, I want to group the data into four classes: (1) grassland (2) agriculture (3) developed and (4) other natural features. This is done by the “Reclassify” tool in “Spatial Analysis” (Figure 5). This simplifies the data by making it much easier to analyze and visualize. Since there is a “Developed” class, I also include a shapefile marking major cities which are clipped to the LCC boundary and symbolized by 8 pt red dots. I have also labeled the states to show where the LCC covers. All the rasters appear similar, so I have chosen to feature the 2019 raster in the final map. The colors are little dark, so I also change the color of the river shapefile to a lighter blue for better contrast. I then export the VAT of all five rasters and convert the files into Excel with the “Table to Excel” tool in “Conversion.”

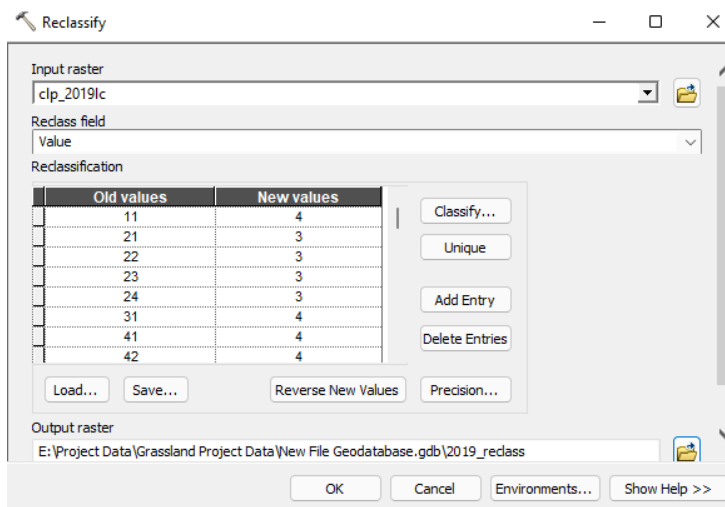


Figure 5 Data is reclassified into four groups with the "Reclassify" tool in "Spatial Analysis". They are (1) grasslands (2) agriculture (3) developed and (4) other natural features.

- Woody Wetlands
- Shrub/Scrub
- Open Water
- Mixed Forest
- Herbaceous
- Hay/Pasture
- Evergreen Forest
- Emergent Herbaceous Wetlands
- Developed, Open Space
- Developed, Medium Intensity
- Developed, Low Intensity
- Developed, High Intensity
- Deciduous Forest
- Cultivated Crops
- Barren Land
- Grassland
- Agriculture
- Developed
- Other Natural Features

Figure 6 Reclassified rasters into four classes.



### Land Use in the Great Plains in 2019

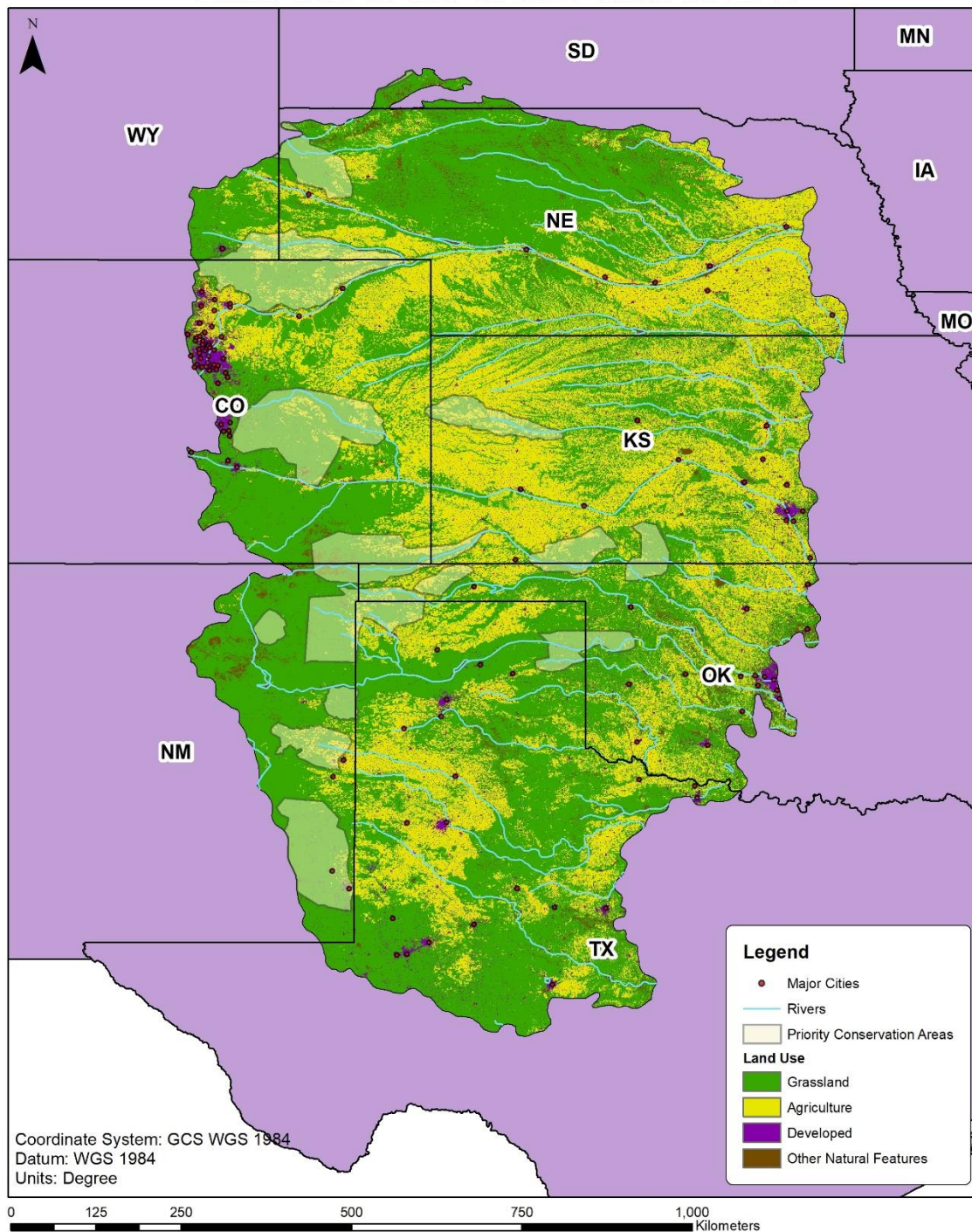


Figure 7 Final map with the four classes symbolized, the PCA, major cities, and river shapefile.



#### IV. Data Analysis

I place the COUNT attribute of all five rasters into one Excel file and proceed to complete a few simple calculations and analyze the attribute which contains the number of pixels for each class in the raster. First I calculate the percent change, comparing 2019 and 2001. Second, I calculate the percent coverage in the second half of Table 1 and 2, one for the overall region and the other for the PCA, respectively. Lastly, I proceed to make two graphs to depict the Great Plains LCC region and the smaller PCA.

Land Class	2001	2006	2011	2016	2019	% Change
Grassland	535060357	533297745	528907279	522310845	519782005	-2.855
Agriculture	275154294	276212878	279806563	285535114	287158818	4.363
Developed	29040352	29950334	30724059	31492217	31843720	9.653
Other Natural Features	29637301	29431347	29454403	29554128	30107761	1.587
Anthropogenic	304194646	306163212	310530622	317027331	319002538	4.868
<b>Total</b>	868892304	868892304	868892304	868892304	868892304	<b>Average % Coverage</b>
% Grassland	61.580	61.377	60.871	60.112	59.821	60.752
% Agriculture	31.667	31.789	32.203	32.862	33.049	32.314
% Developed	3.342	3.447	3.536	3.624	3.665	3.523
% Other	3.411	3.387	3.390	3.401	3.465	3.411
% Anthropogenic	35.009	35.236	35.739	36.486	36.714	35.837

Table 1 Calculations for the region done in Excel by using the COUNT attribute. The bottom half is % coverage. Anthropogenic is the sum of Agriculture and Developed and is not included in Total.

Land Class	2001	2006	2011	2016	2019	% Change
Grassland	82939026	82820573	82352290	81536035	81270182	-2.012
Agriculture	13852858	13951741	14376247	15147025	15381824	11.037
Developed	1866194	1907307	1952622	1994669	2007529	7.573
Other Natural Features	1410404	1388861	1387323	1390753	1408947	-0.103
Anthropogenic	15719052	15859048	16328869	17141694	17389353	10.626
<b>Total</b>	100068482	100068482	100068482	100068482	100068482	<b>Average % Coverage</b>
% Grassland	82.882	82.764	82.296	81.480	81.215	82.127
% Agriculture	13.843	13.942	14.366	15.137	15.371	14.532
% Developed	1.865	1.906	1.951	1.993	2.006	1.944
% Other	1.409	1.388	1.386	1.390	1.408	1.396
% Anthropogenic	15.708	15.848	16.318	17.130	17.377	16.476

Table 2 Calculations for the PCA done in Excel by using the COUNT attribute. The bottom half is % coverage. Anthropogenic is the sum of Agriculture and Developed and is not included in Total.

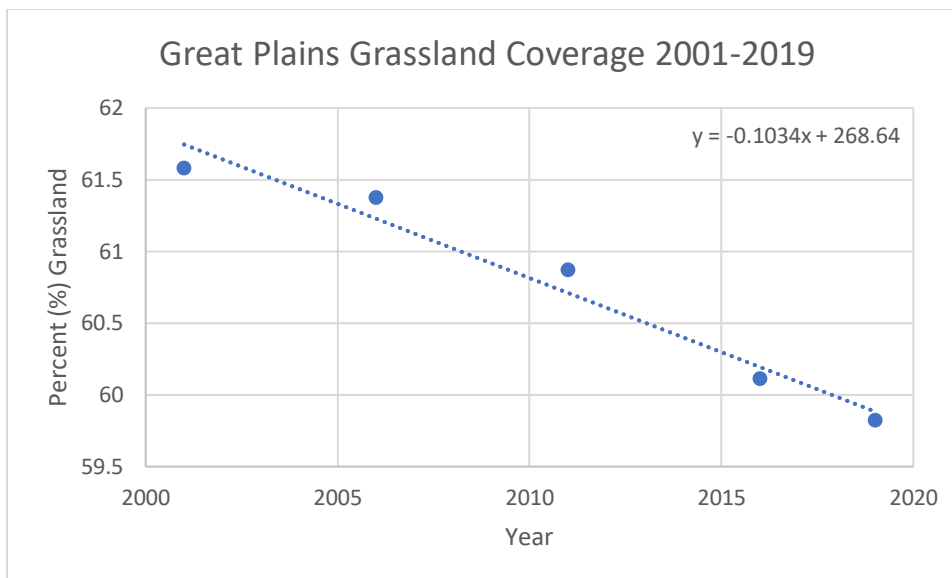


Figure 8 Percentages from five different years with a linear fit.

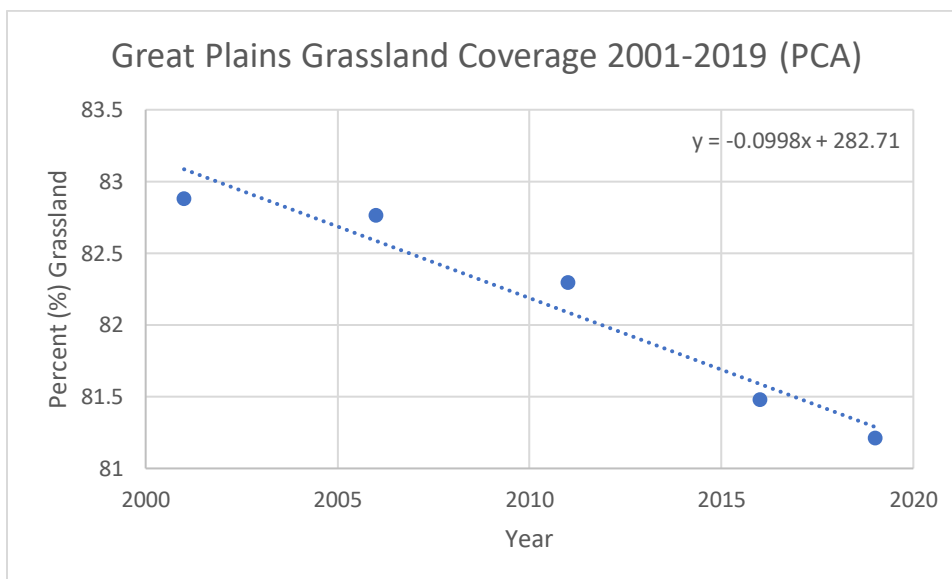


Figure 9 Percentages from five different years fitted to a linear trend in the Priority Conservation Areas (PCA).

Unsurprisingly, there is a negative linear trend in the data, but I did find it surprising how much agriculture has increased in the PCAs, yet grassland percent change is slightly less than the overall region. I initially hypothesized grassland coverage was inversely proportional to anthropogenic changes, but the data and visuals suggest otherwise. However, the anthropogenic changes are much higher than the others and is an important variable.

## **V. Conclusion**

Evidently, the Great Plains prairies have been shrinking in the past two decades. As shown in Tables 1 and 2, grasslands and prairies have decreased by only 2-3%, much less than I expected, but anthropogenic influences play a significant role. However, there are many limitations to analyzing the data in this project. I suspect increased conservation efforts has lowered the percent change compared to, for example, coverage in 1919, and historical data in this area prior to the 2001 land coverage is scarce. Additionally, I have excluded further in-depth analysis of anthropogenic factors and climate due to technological and time constraints, but if included, they will provide more insight into other factors causing the Great Plains to shrink.

## **VI. References**

Samson, F. B., Knopf, F. L., & Ostlie, W. R. (2004). Great Plains ecosystems: past, present, and future. *Wildlife Society Bulletin*, 32(1), 6-15.