Restoration Potential of Native Prairie on the J. Clark Salyer National Wildlife Refuge, North Dakota USA

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Keywords: Soil Type, Soil Moisture, Native Prairie, Topography, Belt Transect

Abstract

North American prairies are in steep decline. Much of this decline stems from conversion to agriculture and the invasion of exotic species. The goal of this study was to provide an interpolated layer of prairie vegetation and conduct a native prairie restoration potential analysis. The J. Clark Salyer National Wildlife Refuge, North Dakota USA was the focus of this analysis, but the analysis can be modified to provide results in other regions for other organizations. An IDW interpolation was used to derive a vegetation dominance surface from the sampling sites point data. The SSURGO soils layer was reclassified as either suitable or non-suitable for native prairie growth based on soil texture and drainage. Lidar elevation data were reclassified into suitable and non-suitable slope surfaces for native prairie growth. The reclassified soil and slope layers were then combined with the vegetation dominance layer using Esri's Raster Calculator. Based on soil and vegetation criteria, areas of high potential for native prairie restoration were located mainly in the southern portion of the refuge. The slope analysis revealed issues when compared to field observations. Overall, results provide a visualization of native prairie restoration potential and would be useful for management decision-making.

Introduction

Prairies have always been an important part of North American ecological systems. Prairies are the largest component of the vegetative provinces. The main component of native prairies is prairie grass, which has the greatest diversity of any plant group. Since the settlement of Europeans, the decline and degradation of prairies is greater than any other ecosystem. The decline of native prairie range has been as high as 99.9% in some areas of North America (Samson and Knopf, 1994).

Prairies are also key habitats for many endangered grasses and wildlife. In North America there are 55 endangered grassland species and 728 endangered grassland species candidates. One-third of the species of wildlife considered endangered in Canada depend on grassland prairies (Samson and Knopf, 1994).

These threatened and endangered species all depend on native prairie being restored and kept intact. Unfortunately, much of the native prairie has been destroyed or degraded through invasive species such as Kentucky bluegrass *(Poa pratensis)* and conversion to other land uses such as agriculture. Management practices, such as prescribed burning and grazing, have been implemented to reduce invasive species and encourage native plant growth (Grant, Madden, Murphy, Smith, and Nenneman, 2004).

The purpose of this study was to provide an interpolated layer of prairie vegetation on the J. Clark Salyer National

Bollinger, Keith. 2015. Restoration Potential of Native Prairie on the J. Clark Salyer National Wildlife Refuge, North Dakota USA. Volume 17, Papers in Resource Analysis. 9 pp. Saint Mary's University of Minnesota University Central Services Press. Winona, MN. Retrieved (date) from http://gis.smumn.edu

Wildlife Refuge (NWR), North Dakota USA. The second objective was to conduct a native prairie restoration potential analysis that would allow J. Clark Salyer NWR managers to identify areas where they should focus their prairie restoration practices; however, the methods of this study can be applied to other refuges in North Dakota. With some modifications, this analysis could also be applied to other states where native prairies are desired.

Methods

Study Area

The area of interest for this study was the J. Clark Salyer NWR. The J. Clark Salyer NWR is one of three refuges in the Souris River Basin Complex. The refuge is 58,700 acres in size, and it is the largest refuge in North Dakota. The refuge has a diversity of habitats including mixed grass prairies, marshes, river valleys, and mixed forests (United States Department of Interior, 2014).

The refuge was separated into four regions. These regions were the Drift Prairie, the Sandhills, McHenry Refuge, and the Grassland Trail. Study areas were established in each region, and these study areas held the sampling sites for the vegetation dominance data collection (Figure 1).

Criteria

According to Grant, Flanders-Wanner, Shaffer, Murphy, and Knutsen (2009), the frequency, duration, and intensity of disturbance events in native prairies varied with environmental conditions. These environmental conditions included temperature, precipitation, soils, slope, and aspect. This study focused on soil texture, drainage, slope, and vegetation dominance to determine which areas on the J. Clark Salyer National Wildlife Refuge would be suitable for native prairie restoration efforts.

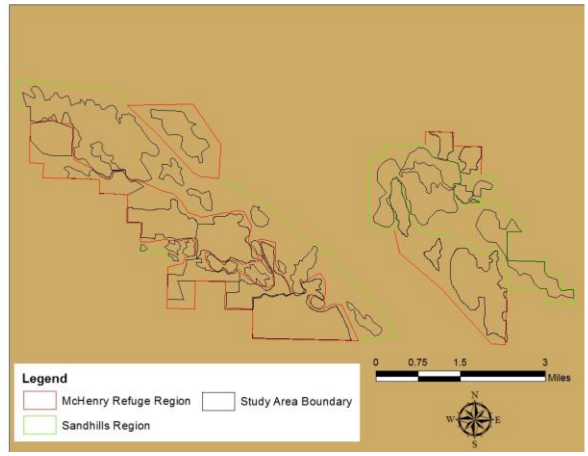

Figure 1.Two of the four regions in the southern part of the J. Clark Salyer NWR with their respective study boundaries. Depicted are the Sandhills and the McHenry Refuge regions in the southern part of J. Clark Salyer NWR.

The soil properties of interest were determined through evaluating research articles related to native prairies and soil properties. Barnes, Harrison, and Heinisch (1984) conducted research in the Nebraska sandhills and found the composition of the soil was an important factor in promoting growth of native prairie plants. Plants such as needle and thread grass (*Hesperostipa comat)*, little bluestem *(Schizachyrium scoparium)*, and other prairie plants require harsh soils, for instance soils with sand as the major component. The study found that as the percent of sand in the soil increased, the frequency of native prairie plants increased. These species were also found in areas of bare sand but with less frequency. The study found areas with about 15 percent clay and silt had the highest frequencies of native prairie plants (Barnes *et al*., 1984). Samson, Knopf, and Ostlie (2004) found that drought played a significant role in promoting native prairie growth. It was found that in years of severe drought, mass extinctions of annual forbs and grasses such as Kentucky bluegrass were probable. The study conducted by Barnes *et al*. (1984) also looked at soil moisture content. The study found that in conjunction with soil type, soil moisture was a key factor in the promotion of prairie plant growth. Barnes *et al*. (1984) indicated that as surface moisture storage increased, the frequency of prairie plants decreased, and for areas with the highest frequency of prairie plants, water retention was relatively low.

Based on the information from these various studies, soils with high amounts of sand and low soil moisture content and retention were selected as suitable soils to promote native prairie growth for this study.

Topography was the final component of the study. Barnes *et al*. (1984) also investigated the difference topography had on the frequency of native prairie plants. There were four areas Barnes *et al*. studied, which included: slope, swale, stable ridge, and eroded ridge. Barnes *et al*. found of the four areas, slope and ridges had the greatest diversity.

Similarly, a study in Kansas evaluating invasion of woody plants in bluestem prairies found the native prairies were able to resist growth of woody plants in level upland, upper-slopes, and ridge-tops (Bragg and Hulbert, 1976).

Another study in the sandhills of Nebraska described similar conditions. Steep upper slopes were established as having a slope greater than 17 percent (Potvin, 1993).

In addition to evaluated literature, first-hand field experience combined with subject matter expertise with biologists of J. Clark Salyer NWR supported the findings in the literature. First-hand experience revealed native prairie plants were able to out-compete invasive grasses when the growing conditions were very harsh. The characteristics of harsh conditions were high sand content, low water retention or high drainage, and steep slopes.

Based on the information derived from these research articles, a slope of 17 percent or greater was used as the definition of suitable conditions for native prairie growth.

Preparation of Data

Transect Point Creation

There were three transect lengths used in the vegetation data collection: 10 meters, 25 meters, and 100 meters. Data collection records were obtained at half meter intervals along each transect. The number of half meter entries collected depended on the length of the transect line; however, the standard was that the number of collection entries should be double the length of the transect line (Grant *et al*., 2004). The vegetation data used categories to record each plant species present and the percent coverage the species occupied. For example, plant category '51' was 95 percent or greater dominated by Kentucky bluegrass.

Rather than using all data collection entries for analysis, data were simplified using analysis points. Analysis points were placed at the beginning of the 10 meter and 25 meter transects. For the 100 meter transects, the analysis points were placed at the end of each transect, because sets of four 100 meter transects shared the same starting point (Figure 2). The XY event layer tool was used to create the analysis points for each transect.

Vegetation Dominance Reclassification

Each analysis point was assigned the most dominant plant category present along the transect. There were five classes established with 1 representing the highest potential with the least amount of management needed to restore native prairie and 4 representing the least potential with the most amount of management needed. A class for no analytical interest was represented by the value 0. The sites were reclassified using a Python script.

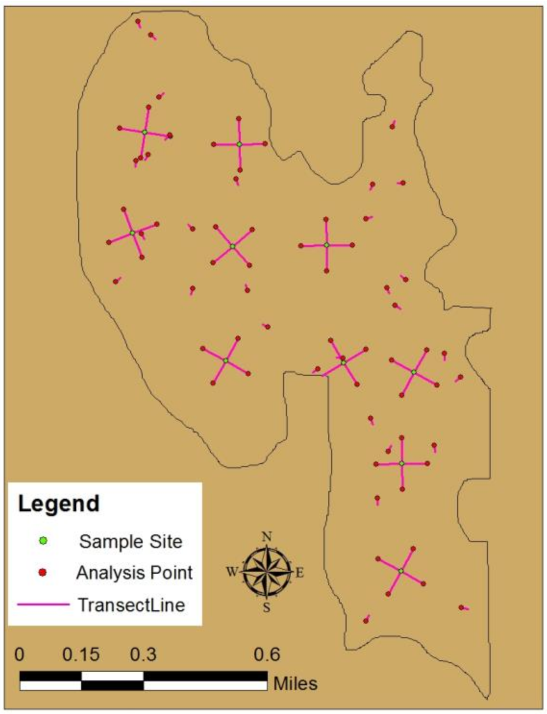

Figure 2. The sample sites and the analysis points for a study area within the McHenry Refuge region.

Plant categories were placed into one of the five classes based on the type of plant, followed by the percentage of coverage. Class 1 represented all categories where native prairie grasses were dominant. Class 2 represented all categories where Kentucky bluegrass was dominant. Class 3 represented all categories where smooth brome was dominant. Class 4 represented all categories where woody vegetation was dominant. Class 0 represented all other categories.

Vegetation Dominance Interpolation

For the interpolation of the vegetation dominance layer, the IDW tool was used with the output cell size set to 1 meter. This ensured the layer matched the digital elevation model (DEM) when the overlay analysis was conducted (Figure 3).

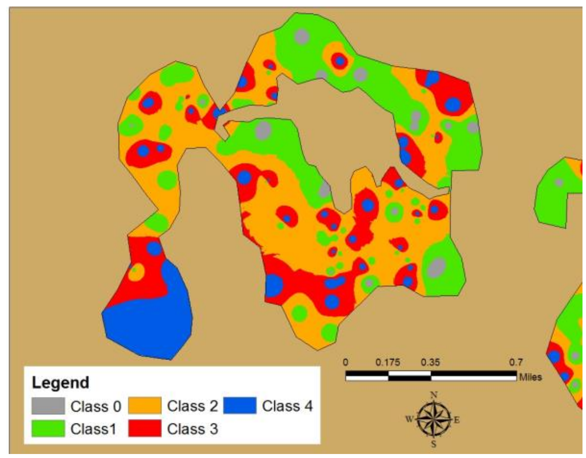

Figure 3. The interpolated layer created from IDW. The figure depicts the general composition of the vegetation classes within each study area.

Soil Properties Extraction/Raster Creation

The SSURGO soils layer was joined to four attribute tables to obtain the soil texture and drainage of all soils within the J. Clark Salyer NWR. The four tables included information about soil texture, drainage, and percent of sand, clay, and silt. The features suitable for native prairie growth were extracted to a shapefile. Soil polygons not suitable were extracted to a second shapefile. Soil textures that were selected as suitable included coarse sand, fine sand, fine sandy loam, loamy coarse sand, loamy fine sand, and sandy loam. The drainage attributes selected as suitable were excessively drained, moderately well drained, and somewhat excessively drained. Both the soil texture and the drainage classification had to be deemed suitable in order for the soil polygon to be classified as suitable for the analysis (Figure 4).

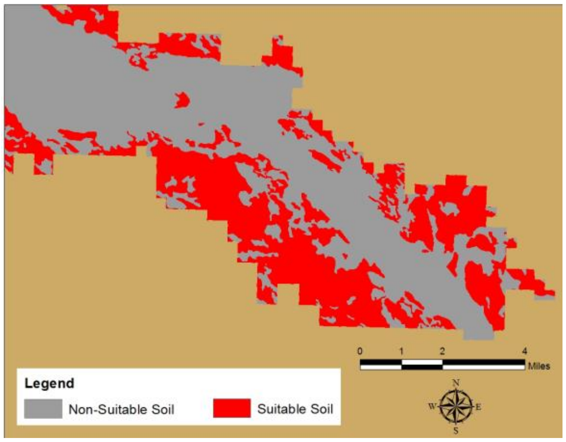

Figure 4. The suitable and non-suitable soils are depicted for the southern half of the J. Clark Salyer NWR.

Both shapefiles were converted to rasters with cell sizes of 1 meter. After the rasters were created, the mosaic tool was used to create a seamless raster for the analysis. The Extract by Mask tool was then used to extract all soil classifications within the study areas.

Topography Extraction/Raster Creation

A slope raster was derived from the area's DEMs. Each slope raster was reclassified with a value of 1 representing slopes of 17 percent or greater and 0 for slopes less than 17 percent. Once all the slope rasters were reclassified, the mosaic tool was used to create one seamless raster. The extract by mask tool was then used to extract all values within the study areas (Figure 5).

Analysis Procedure

The soil and slope suitability rasters for each study area were combined by multiplying the values of the soils and slope layers with the classified vegetation dominance raster using the Raster Calculator. This process produced two layers, one for soil and vegetation and a second for slope and vegetation. The layers displayed the restoration potential from the highest potential to the lowest potential on a scale of 0 to 4 (Figure 6 and 7).

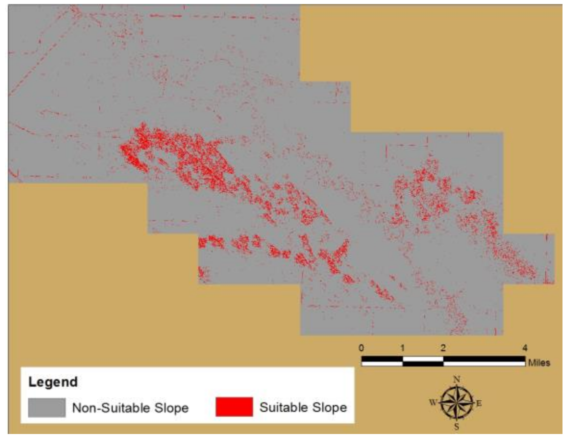

Figure 5. The suitable and non-suitable slopes are depicted for the southern half of the J. Clark Salyer NWR.

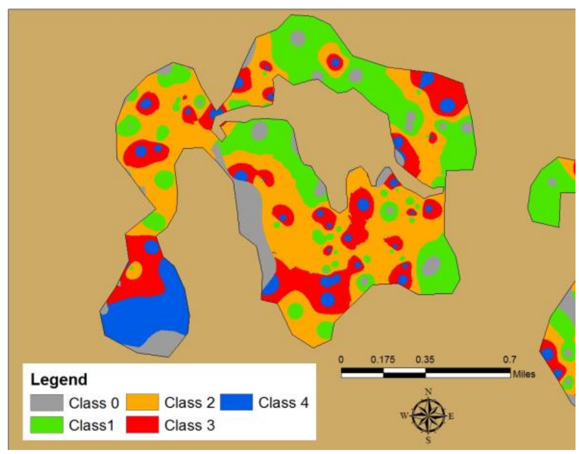

Figure 6. Overall suitability of the study areas considering both soils and vegetation. This example is in the Sandhills and McHenry Refuge regions.

Limitations

There were limitations to the methods and products of this analysis. One limitation was that cell counts from the Raster Calculator products were not readily available, which complicated the calculation of total area of the suitability classes.

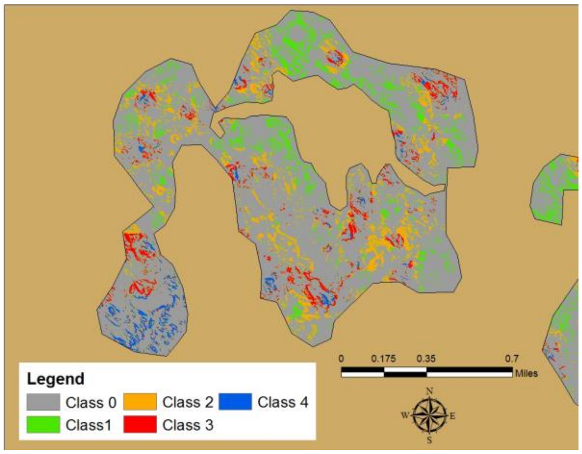

Figure 7. Overall suitability of the study areas considering both slope and vegetation. This example is in the Sandhills and McHenry Refuge regions.

Another limitation was with the interpolation, as there were areas where the interpolation could not be completed with a cell size of 1 meter. However, since the study was focused on visual representation and the cell sizes that were determined by the IDW tool were close to a 1 meter, this limitation was also minimized.

Results

Most of the areas that would require the least management effort to restore native prairie and have the highest potential for success based on all three factors were located in the Sandhills and McHenry Refuge regions.

Considering just the vegetation class composition for the analysis points in each region, the most suitable regions were the Sandhills and McHenry Refuge. Class 1 was the majority class for the analysis points for the Sandhills and McHenry Refuge regions. For the Drift Prairie region, class 3 made up the majority of analysis points. The analysis points within the Grassland Trail region were primarily classified in class 3 (Table 1).

For soil texture and drainage, the regions with the highest percentage of suitable locations were Sandhills and McHenry Refuge. The Drift Prairie and the Grassland Trail regions had the lowest percentage of suitable locations.

For slope, the region that had the highest percentage of suitable points was the Sandhills region. Drift Prairie, Grassland Trail, and McHenry Refuge had the lowest suitability. The McHenry Refuge region had the lowest percentage of suitability for slope (Table 2).

Discussion

Overall, the products of this study fulfilled project objectives. The vegetation dominance layer provides the J. Clark Salyer National Wildlife Refuge biologists with a visual representation of what vegetation is predominantly present in the study areas. Both the soil and slope layers depict a general location of areas

Table 1. Percentage of analysis points located in each of the five vegetation suitability classes. The table illustrates that certain regions are more suitable for restoration efforts than other regions.

Region	Class 0 Percent	Class 1 Percent	Class 2 Percent	Class 3 Percent	Class 4 Percent
Drift Prairie	15.62	15.92	20.42	40.54	7.51
Sandhills	13.64	48.27	1.52	0	36.58
McHenry Refuge	6.95	61.63	19.18	7.67	4.56
Grassland Trail	2.03	5.41	33.78	58.78	0

Table 2. Number of acres that fall under suitable or non-suitable classification for native prairie restoration. Class 0 is non-suitable cells and class 1 is suitable cells. The percent of suitable acres are also displayed to display the potential for native prairie restoration.

Region	Soil			Slope		
	Class 0 (Acres)	Class 1 (Acres)	Percent Suitability	Class 0 (Acres)	Class 1 (Acres)	Percent Suitability
Drift Prairie	2221.94	1401.89	39%	3317.41	272.26	8%
Sandhills	169.86	1779.82	91%	1789.51	812.80	31%
McHenry Refuge	345.45	3262.73	90%	3541.83	72.35	2%
Grassland Trail	875.24	56.72	6%	895.17	40.24	4%

suitable for promoting native prairie growth.

The Sandhills region was, not surprisingly, the most suitable region for prairie restoration. The Drift Prairie and Grassland Trail regions were, also not surprisingly, the lowest suitability. The McHenry Refuge region had high suitability for soils but the lowest percentage of suitable slope. The Sandhills and McHenry Refuge regions also had the highest percentage for class 1 vegetation. From these results, the Sandhills and McHenry Refuge appear to be the best options for where to focus native prairie restoration efforts.

The combined soils and vegetation suitability classification appears to provide a more realistic and accurate picture of actual prairie suitability. One reason is soil may be the primary factor that dictates if native prairie can be sustained. The soil data that was used in the study included multiple criteria, whereas the slope data only used one element, which was the percent rise. Having more restrictive requirements for the slope analysis could be more effective at representing what occurs in the field. With slope data, areas that may be unsuitable due to the nature of drainage and water retention would be included as suitable areas even though this is not accurate. With this in mind, if additional factors are added to the project, it would be beneficial to ensure that they have multiple attributes to potentially reduce the chance of errors occurring.

Also from first-hand field experience and biologist expertise of J. Clark Salyer NWR, the soil and vegetation combination appears to better closely match what occurs in reality. Observations revealed native prairie was more easily established and was better able to out-compete invasive grasses in areas where the soil had harsh growing conditions. Harsh conditions included high sand composition and low moisture content. Also, native prairie plants thrived on steep sloped areas and invasive grasses out-competed native plants in flat areas like the top and bottom of hills.

While the slope and vegetation layers do provide a good representation of trends, there are areas where the analysis does not match what actually occurs. One instance of this occurs in areas where gullies and valleys are present. In these situations, the soils layers did not indicate that these would be suitable for native prairie; however, the slope did indicate suitability even though the majority of gullies and valleys were heavily dominated by invasive grasses. The discrepancy between the slope analysis and what occurs was likely due to a significant presence of water in gullies and valleys. This allows Kentucky bluegrass and smooth brome to dominant native perennial grasses (Figure 8).

A way to alleviate this issue could be to conduct the slope analysis in a similar way as the soil analysis was conducted. Adding another factor may eliminate the false positive areas.

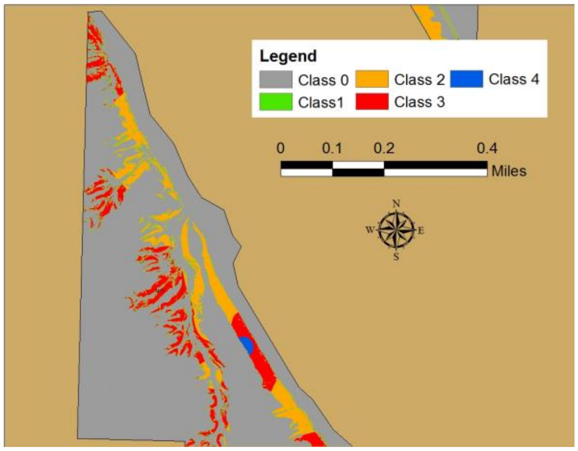

Figure 8. Errors with the slope analysis indicated gullies as suitable areas; however, field experience contradicts these results.

One factor that would be beneficial to the slope analysis would be aspect. Different aspects are associated with different temperatures, sunlight exposure, and water retention. Based on observation, in general, north and east aspects have cooler temperatures, less sunlight exposure, and higher water retention whereas south and west aspects have warmer temperatures, more sunlight exposure, and lower water retention. Pairing aspect with slope might eliminate areas where there are cooler temperatures, which allow for more water retention.

Overall, the analysis provided a good visualization of the suitability for promoting native prairie growth. The soils and vegetation layer seem to provide a better and more accurate representation than the slope. This analysis would be beneficial to other refuges for determining areas where native prairie restoration efforts should be focused.

The models and analysis procedures of the study could be modified depending on the needs of the user. The vegetation classes could be defined differently to better fit a different study area. The focus could also be shifted to evaluate the temporal change of vegetation classes as well as look at one specific invasive grass compared to all other vegetation classes to determine restoration suitability.

Acknowledgements

I would like to thank Todd Grant and the rest of the J. Clark Salyer NWR for providing the vegetation sampling data as well as field experience and direction for the analysis.

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