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Quantifying Undisturbed Lands in MInnesota's Prairie Coteau and Lac qui Parle Valley Regions

Natural Resource Management Data Sets

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Quantifying Undisturbed Land in Minnesota's Prairie Coteau and Lac Qui Parle Valley Regions

Pete Bauman
South Dakota State University

Ben Carlson
South Dakota State University

Tanner Butler
South Dakota State University

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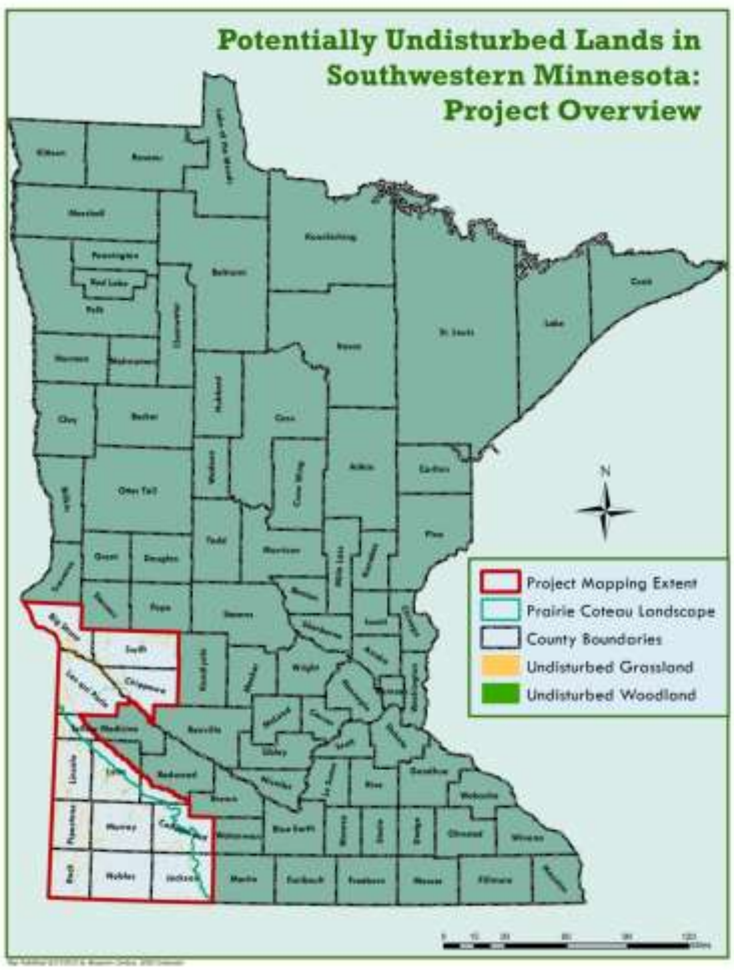
QUANTIFYING UNDISTURBED LAND IN MINNESOTA'S PRAIRIE COTEAU AND LAC QUI PARLE VALLEY REGIONS



8/27/2015

A report to The Minnesota Department of Natural Resources from South Dakota State University based on the Prairie Coteau and Lac Qui Parle boundaries as defined by the 10/31/14 State of MN Joint Powers Agreement No. 85003 (SDSU project 3X5641: Bauman-MNDNR - PRAIRIE COTEAU PH II [PHASE II: QUANTIFYING UNDISTURBED LAND AND MODELING GRASSLAND IMPACTS TO WATERSHEDS IN SOUTH DAKOTA AND MINNESOTA]).

SDSU Extension

Authors:
Pete Bauman, SDSU Extension Range Field Specialist, Watertown, SD.
Ben Carlson, SDSU Senior Agricultural Research Technician, Watertown, SD.
Tanner Butler, SDSU Agricultural Research Technician, Watertown, SD.

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Executive Summary:

We employed simple GIS methods utilizing the Minnesota Farm Service Agency's Common Land Unit (CLU) cropland data layer from 2013, along with 2013 USDA National Agriculture Imagery Program (NAIP) county mosaic aerial imagery, to evaluate over 5 million acres of land in 14 southwest Minnesota counties, including all or portions of 10 counties within the Minnesota portion of the Prairie Coteau region and the entirety of four counties in the Lac qui Parle region. We utilized the CLU cropland layer to first identify and remove any areas with a cropping history, regardless of current land use. We then analyzed the remaining land in approximately one mi^2 sections in order to identify and remove additional historic or current land disturbances. The remaining land tracts were then categorized as potentially 'undisturbed grassland' or 'undisturbed woodland' by simple reason of deduction. Finally, we removed all known water bodies $\geq$ 40 acres as defined by the Minnesota Department of Natural Resources Public Waters Basin Delineation.

Overall, 402,253 acres (8.0%) were designated as potentially undisturbed in the 5,055,319 evaluation area. Within the Lac qui Parle region of Minnesota, we estimate there are 147,409 acres of potentially undisturbed land remaining of the 1,694,414 acres we evaluated (8.7%). Within the Prairie Coteau landscape we estimate there are approximately 230,608 acres of potentially undisturbed land remaining of the 2,822,332 acres we evaluated (8.2%). Within the narrow 545,703 acre MN River Prairies landscape area we estimate there are approximately 25,469 acres (4.7%) of potentially undisturbed land remaining.

Of the total 5,055,319 acre analysis area, approximately 4,051,457 acres (80.1%) were deemed to have a cropping history in the FSA CLU data while 491,634 acres (9.7%) indicated some type of land disturbance other than a CLU crop code.

Within the total 5,055,319 acre evaluation area, only 290,412 acres (5.7%) were found to have some sort of permanent protection from conversion (some of these acres have a disturbance history). Only 104,169 acres (2.1%) of the evaluation area are both potentially undisturbed ***AND*** had some level of permanent conservation protection status.

Of the 1,517 wind turbines identified in the total analysis area, 96 (6.3%) were located adjacent to potentially undisturbed areas.

Finally, we evaluated disturbance histories on MN Department of Natural Resources Sites of Biodiversity Significance (SBS) and Native Plant Communities (NPC). Of the total 321,106 acres within MCBS SBS layer, 51,833 acres (16.1%) had a CLU crop designation while 35,373 acres (11.0%) were excluded due to some type of disturbance other than CLU crop codes. Of the 91,813 acres within the MCBS NPC layer, 3,737 acres (4.1%) had a CLU crop designation while 3,997 acres (4.4%) were excluded due to some type of disturbance other than CLU crop codes.

Contents

INTRODUCTION:

The Prairie Coteau and Lac qui Parle regions of southwest Minnesota are focal areas of Northern Tallgrass Prairie management for the MN Department of Natural resources. An essential component to managing this landscape is identifying the location and amount of remnant native (undisturbed) prairie. The Minnesota Prairie Conservation Plan (2011) identifies areas of primarily 'good' to 'excellent' native grasslands across the state of Minnesota as well as core areas of ecological significance. While the MN Prairie Conservation Plan reports on the status of high quality prairies, there is no data available that quantifies the total potential extent of intact remnant untilled or undisturbed grassland habitat, (regardless of ecological condition).

In 2014, South Dakota State University and The Nature Conservancy initiated a pilot project to analyze the extent of undisturbed land in the Prairie Coteau region of eastern South Dakota. The objective of that work was to develop a simple, systematic, repeatable, and cost-effective approach to estimate the location and total area of land tracts that are potentially undisturbed (i.e. native) grasslands or woodlands. The central component to that analysis was the utilization of the 2012 South Dakota Farm Services Agency's (FSA) Common Land Unit (CLU) cropland data layer. (For a comprehensive history of the South Dakota Prairie Coteau Landscape, see the initial pilot report: Bauman et al. 2014).

For this project, we employed similar (albeit more refined) methods for the analysis of the MN Prairie Coteau and Lac qui Parle regions, resulting in a very similar product. All of these data will be utilized as part of a larger project that seeks to quantify all undisturbed (native) land in South Dakota and southwestern Minnesota, as well as the number and locations of wind turbines in these areas. The methods and protocols established by this project will be published in the future so as to allow a continuation of this analysis within Minnesota and other states in the region.

Furthermore, understanding the protection status of potentially native habitats, especially the quantity and location of permanently protected undisturbed lands, is essential for developing future protection and conservation strategies. We were able to estimate the amount of protected undisturbed land in southwestern MN by intersecting the undisturbed layer produced by our initial analysis with a collection of ownership and easement boundaries acquired from a variety of conservation organizations and agencies.

Finally, we analyzed Minnesota County Biological Survey (MCBS) data by comparing the results of our undisturbed data layers against MCBS Sites of Biodiversity Significance and Native Plant Communities to determine the amount and location of lands in either of those categories that we deemed had been disturbed through interpretations of our data sources.

EFFORT

Counties	**14**
Acres	**5,055,319**
Mi^2	**7,898**
Total Hours	**~1,100**

METHODS

The contract for this project specified deliverables for two distinct areas known as the Laq qui Parle region and the Prairie Coteau landscape of southwestern MN. The former was defined for our project as the four counties surrounding the Lac qui Parle Valley (generally the Minnesota River Valley above Granite Falls, MN). The latter was defined as the Minnesota portion of the Prairie Coteau landscape. We utilized the Prairie Coteau ecoregion subsection boundary as defined by the MN DNR Ecological Classification System, which is consistent with the Prairie Coteau landscape boundary utilized by The Nature Conservancy in a 2010 report to the National Fish and Wildlife Foundation. We were also able to analyze a third area described here as the MN River Prairie landscape, which is essentially a buffer zone extending east of the primary Prairie Coteau landscape boundary for about five miles or to the nearest county boundary.

The entirety of Big Stone, Chippewa, Lac qui Parle, and Swift counties comprised the Lac Qui Parle region analysis while all or portions of Cottonwood, Jackson, Lac qui Parle, Lincoln, Lyon, Murray, Nobles, Pipestone, Redwood, Rock, and Yellow Medicine counties were analyzed as part of the Prairie Coteau and MN River Prairie landscapes.

We assessed the history of land use in this 14 county area via simple layering and data editing methods in ArcGIS in order to deduce the location and size of land tracts that are potentially remaining undisturbed (native) habitats - regardless of current vegetation type or quality. We utilized the Minnesota Farm Services Agency's (FSA) Common Land Unit (CLU) layer from 2013 along with 2013 USDA National Agricultural Imagery Program (NAIP) county mosaic aerial imagery (http://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/index) as our base data layers, projected on-screen at a scale no smaller than 1:8000 to analyze approximately 5,055,319 acres (~ 7,898 mi.^{2}). The 1:8000 minimum map scale was selected to allow technicians to view a full square mile section (640 acres) of land on a 9 inch by 11 inch computer map frame when evaluating land use. Greater scales ranging up to 1:800 were used on occasion for analyzing smaller tracts of land or to aid in the precision of polygon creation.

We defined undisturbed land as that which the soil has not been mechanically manipulated. Although it could be argued that Great Plains soils have a long history of localized 'tillage' through the historic habits of burrowing animals, hoof impact from large herbivores, and the agricultural practices of certain Native Americans, we consider modern cultivation, anthropogenic development, and use/extraction of natural resources as the general definition of disturbance. See table 1 for examples of land use types considered as 'disturbance'.

Conversely, 'undisturbed' areas generally include: native remnant grasslands, pastures, prairies, and other natural herbaceous plant communities including natural forests, woodlands, and shrublands as well as non-developed and non-farmed wetlands. Within these areas lie land tracts that may have been farmed or otherwise manipulated historically but which lack definitive indicators of such and therefore cannot be officially identified as 'disturbed' within the context of our analysis methods and criteria. For example, small wetlands, young forests, hayfields, pastures, and possibly non-native habitats often occur where historic disturbance is possible, but for which no aerial photography or CLU data was able to confirm disturbance. Therefore those areas are retained in the 'undisturbed' land classifications until additional data can prove a disturbance history.

Table 1. Disturbance categories and associated land use types considered to constitute disturbed land.

Disturbance Category	**Land Use Type Examples**
Agricultural Disturbance or Cultivation	▪ Currently cultivated cropland ▪ "Go-back" land, old fields, or former cropland reverted to semi-natural cover ▪ Former cropland planted or seeded to permanent cover (including hayfields) ▪ Permanently flooded former cropland ▪ Prairie restorations ▪ Wildlife food plots ▪ Cultivated or planted trees and shrubs for wildlife or conservation purposes ▪ Trees and shrubs planted for wind breaks, farm groves, and tree claims ▪ Large linear drainage ditches (when on the edge of undisturbed grasslands) ▪ Farm sites and associated buildings, wind breaks, farmyards, driveways, feedlots, manure storage, and animal pens ▪ Abandoned farm sites, when visible ▪ Feedlots and Concentrated Animal Feeding Operations
Residential Disturbance	▪ Municipal residential housing developments and built up areas ▪ Rural homesteads, building sites, and surrounding yards and driveways ▪ Recreational areas including: campgrounds, golf courses, historic sites, picnic areas, race tracks, boat launches, sports fields, shooting ranges, and associated roadways and parking areas ▪ Schools, churches, cemeteries, and town halls
Industrial Disturbance	▪ Highways, roads, streets, parking lots, and driveways ▪ Abandoned road grades (when built up or on the edge of undisturbed grasslands) ▪ Railways, including spurs and abandoned railway grades ▪ Artificial or otherwise impervious surfaces ▪ Gravel and sand pits ▪ Rock quarries ▪ Mechanically exposed earth ▪ Wind turbines, turbine pads, and access roads ▪ Large earthen dams and spillways ▪ Factories, power plants, and other built up industrial or commercial areas

Understanding the Common Land Unit Data

The Common Land Unit (CLU) is a geographic dataset developed and managed by the Farm Service Agency (FSA) to track agricultural land use across the United States. The CLU is based on FSA field boundary lines developed from actual agricultural 'use' lines such as agricultural field edges, tree plantings, fence lines, building sites, etc.

CLU data was established in 1998 and contains land use data tracked since the beginning of the Soil Bank program, which was initiated in 1956. It is reasonable to assume that some field boundaries identified in the early years of the Soil Bank program would have reflected historical agricultural land use, including fields specifically recorded by the Soil Conservation Service following the 1936 Soil Conservation Act. The CLU data layer contains many data fields, but two data fields in particular contain specific indicators that land has been cropped at some point in its management history: the CLU Classification Code and the 3-CM Cropland Indicator. The CLU Classification Code is designed to indicate only the most recently recorded land use whereas the 3-CM Cropland Indicator is designed to record *any* past cropping history for eligibility in USDA programs. Therefore, this analysis primarily utilized the 3-CM Cropland Indicator code.

The CLU data is not cataloged annually by FSA, rather it is a continuously updated data layer and therefore the current CLU layer cannot be compared to any past CLU data to analyze land use trends over time. 2013 was chosen as the static temporal extent since this is the most recent year that CLU and NAIP Aerial Imagery data coincide for the Minnesota project area.

The 2013 Minnesota Farm Service Agency Common Land Unit data layer was acquired via a Memorandum of Understanding between FSA and South Dakota State University. The terms of the MOU restrict SDSU access to personal landowner data as well as sharing or directly incorporating these data files into any product developed through this project.

The significance of CLU land use designations are described as follows:

Crop

Within the 'crop' designations are farm fields that have a history of being cropped. A farm field with a crop designation code provides significant historical perspective regarding where current or previous land tillage has occurred since approximately 1956 and thus the land tract can be safely removed from any estimation of native or undisturbed land. It is important to understand that the CLU crop layer does not necessarily include all land with a cropping history; rather it *only* represents cropland that was recorded by USDA programs since about the mid-1950s. Crop lands never enrolled in USDA programs were not recorded in the CLU layer. Additionally, there are instances where a CLU crop designation may have been removed or changed (see below). Therefore, it cannot be assumed that the CLU data alone represents the sum total of historic and current cropland in a given county.

Non-Crop

Within the 'non-crop' designation are all fields that are currently un-cropped or designated as a field where cropping: 1) has actually never occurred, 2) has not occurred under a USDA program since the 1950s, or 3) will no longer occur due to a change of ownership or use that impacts future use (see 'crop to non-crop' and 'removal of CLU data' sections below). An example of a non-crop designation would be a native pasture or woodland that has never been tilled for row crop agriculture. A second example would be a city or town that has existed for decades where cropping simply does not occur.

Non-Crop to Crop Reclassification

Generally, new crop fields will be re-classified in the CLU system from non-crop to crop if the farm or field is enrolled in any type of USDA program. For example, if a farm converts a previous non-crop designated area to crop and that farm has a USDA farm number, the Farm Service Agency would reclassify the field from non-crop to crop. When, in the case of land recently converted to cropland or crop fields that have been expanded but in either case not yet enrolled in any USDA program, the CLU cropland layer will not yet reflect this change. If the conversion occurred before the date of NAIP aerial imagery used in analysis, mapping technicians would still identify the disturbance using the aerial imagery.

Crop to Non-Crop Reclassification

Under the CLU system the 3-CM Cropland Indicator is intended to track cropland for eligibility in USDA programs. This indicator may change from a cropped to non-cropped designation in certain instances, such as when the tract is permanently taken out of possible future crop production. Examples of what might trigger a reclassification from crop to non-crop could include a crop field that is converted to residential, municipal, industrial, commercial, or farm site use. Under these scenarios, even though the land use designation is now non-crop, our analysis methodology would still easily identify the land as 'disturbed' via visible indicators in the NAIP aerial imagery (buildings, ground disturbances, etc.).

The 3-CM Cropland Indicator can also be changed from crop to non-crop when future land use is dictated by legal ownership or a status change, such as when purchased by a habitat, recreation, or conservation agency or when permanently encumbered by an easement that restricts row-crop agriculture (for the purposes of this report, we generally refer to these 'protected' lands as conservation lands). Under these circumstances, historic cropping may be much more difficult to identify, especially if significant time has passed for the land to have been converted (or in some cases reverted) to a more natural vegetative cover. Further complicating this reclassification is the fact that not all conservation land ownership necessarily restricts cropping, and thus cropping can continue even under a non-crop designation.

In Minnesota, private land conservation easements held specifically by the US Fish and Wildlife Service (FWS) and the MN Board of Water and Soil Resources (BWSR) are often changed from cropped to non-cropped by FSA offices if the easements restrict future tillage. Some land use history data does exist for FWS easements, but overall is very incomplete, and CLU data for FWS and BWSR easement lands are usually inconsistent. Thus many FWS and BWSR grassland easements may be incorrectly classified as undisturbed under our analysis methods and may require additional review, as discussed below.

Removal of CLU Data

In the instances described above the land is still recorded and tracked by USDA in the CLU system as non-crop. However, in some cases, land may be removed entirely from USDA programs (and subsequently FSA record keeping), such as with some conservation lands. These lands have no associated crop or non-crop data and are essentially 'holes' in the CLU data. Again, further complicating the issue with conservation lands is that reclassification and removal of CLU data is not consistent and is likely dependent on a variety of local and legal factors. Protocols and timing for removal of CLU data by county FSA offices are highly variable.

In any case, whether CLU data is changed or removed, we need other data sources to consistently confirm disturbance on conservation lands. In order to accomplish this, we acquired land use and vegetation cover data from specific conservation and habitat entities including the US Fish & Wildlife Service, MN Department of Natural Resources, and The Nature Conservancy.

While both the general crop and non-crop codes are fair indicators of major land use trends across a broad region, because of the nuances associated with the CLU crop and non-crop codes, they simply cannot provide an accurate indication of the sum total of either disturbed or undisturbed lands.

Analysis Procedures

Note: For further technical descriptors regarding the development of specific data layers, see metadata files associated with each GIS dataset listed in table 2 of the Results section of this report.

Step 1: Interpreting CLU Data

Mapping technicians, working at a scale of 1:8000 or greater, analyzed base layers including 2013 NAIP aerial imagery and 2013 Common Land Unit data. The CLU data was symbolized to show which fields have a cropping or tillage history indicator. This first-level analysis allowed us to define areas without a recorded cropping history (non-crop) for additional analysis using aerial photography and other land use history data.

We 'accepted' FSA crop data as accurate measured data, regardless of certain anomalies that occasionally indicated a tract may be potentially misclassified regarding actual land use history. Indications of cropping history misclassification were extremely rare and in no case did we include a tract with a cropland indicator in our undisturbed data layer, even if we suspected that the cropland indicator may have been erroneously applied to the tract by FSA. A correction of this nature would require an on-site visit to the tract by a qualified person, and on-the-ground confirmation of land use history was not part of this analysis. Conversely, we did consider land with a 'non-crop' CLU code to be 'disturbed land' if there was evidence of a cropping history. This is necessary in our protocol because of the previously discussed issues with FSA re-classifying previous crop to non-crop under certain circumstances, such as when a tract of land came under the control of a conservation organization or conservation program such as permanent easements restricting future cropping of the tract.

Step 2: Interpreting 'Other' Disturbances

Technicians then began the deductive process of identifying potentially undisturbed (native) grasslands and woodlands by evaluating remaining land tracts for indicators of historic or current disturbance (see table 1 above). Once identified, these disturbed areas were permanently removed from further analysis and were not tracked or mapped categorically; they were simply cut out during on-screen digitizing.

Within step two, a number of additional tools were utilized to assist in the evaluation of the landscape including 1990's Digital Ortho Quarter Quad (DOQQ) County Mosaic Imagery and topographic composite maps, both originally produced by the US Geological Survey and published by the USDA.

We gathered and applied land use history data from conservation entities during this step in the evaluation process as well. Often, agency specific management data would include several tracts of land where historic or current land use indicated disturbance such as cropping but which were not indicated in the CLU data, making the agency data a valuable resource in ensuring accuracy of land use. In addition, technicians utilized web-based mapping programs such as Google Earth to investigate historic use on land tracts where past disturbances were suspected. Once all land with cropping or other disturbances were removed, the remaining land tracts were, by default, considered to be 'potentially undisturbed' and were retained for further classification as undisturbed grassland or woodland.

Step 3: Designating Potentially Undisturbed Woodlands and Grasslands

Classification of potentially undisturbed woodlands is intended to capture remnant oak savanna and eastern hardwood forests which typically occur in wooded ravines, glacial hills, river valleys, and along lake shores and other watercourses. Any tract appearing to be an oak savanna or eastern hardwood remnant forest approaching a closed or mature canopy visible with the 2013 NAIP aerial imagery was classified as undisturbed woodland. Often, trees growing in and around small wetlands are classified as undisturbed woodlands, which may include willow brush or cottonwood stands. Since no measurements were taken on actual canopy cover, the commission and omission of woodlands is often a subjective judgment made by the mapping technician. The mapping of the woodland-grassland classification may have a precision of +/- 2.2 - 22.5 meters, depending on which scale it was mapped at, which is acceptable given the oftentimes ecotonal nature of these areas.

Trees planted for soil, water, or habitat conservation or as farm shelterbelts and groves were not mapped as undisturbed woodlands. Closed canopy or newly planted conifer/willow/shrub stands were removed from the woodland layer and considered disturbed land if it was obvious the stand was greater than a single row and planted in a pattern for wind protection or wildlife habitat (as is typical in this region). Sometimes, it is difficult to discern whether trees classified as potentially undisturbed woodland are planted or natural, especially in the case of farmsteads adjacent to wooded riparian areas or old tree claim plantings near wetlands with no adjacent farmstead.

Undisturbed land tracts not designated as potentially undisturbed woodlands were, by default, retained in the analysis as potentially undisturbed grasslands. Acres covered with scattered deciduous trees remained in the native 'undisturbed' grassland layer as long as they did not appear to be planted and did not approach a closed or mature canopy.

Figure 1 below provides an example of a section of land where the CLU 'crop' layer has been removed (black) and where various other disturbances were removed via on-screen digitizing, leaving only those areas determined to be 'potentially undisturbed' woodlands and grasslands.

Step 4: Error Analysis and Accuracy Review

As technicians progressed through the data, decisions on land use classifications became less objective and more subjective. For example, removal of land with a CLU cropping history is an objective process requiring no visual interpretation. Additionally, removal of obvious disturbances such as buildings, gravel pits, and municipalities is a subjective process utilizing interpretation of aerial imagery. Removal of 'obvious' disturbances is fairly straightforward and the primary issue of subjectivity is not so much in relation to the disturbance type but rather in relation to the decision on where the most practical boundary should be drawn that defines the disturbance.

As technicians proceed through the analysis process, subjective decisions become more necessary, especially in regard to interpretation of landscape indicators such as previous tillage scars or classifications of small or linear habitats. It is at this point where technician experience becomes invaluable, as experienced and well trained technicians begin to build rigorous mental search images as they evaluate each tract of land against cumulative knowledge gained from previous assessments of similar tracts.

In order to ensure accuracy of final 'potentially undisturbed' grassland and woodland data, each section (square mile) in the project extent was analyzed and reviewed independently by two qualified mapping technicians using the aforementioned process steps. Once each county was initially digitized by a mapping technician, the second technician would review the work of the first to address any uncertain data interpretations and correct any omission or commission errors. Any remaining uncertainties in interpreting or analyzing the source data were flagged and discussed at a later point in a group setting with the project coordinator, at which point they were rectified or explained in the notes field of the GIS layer data attribute tables. Additionally, a series of 36 random points were established within the project extent and evaluated by both technicians and the project coordinator to assess accuracy of mapping and source data interpretation (16 for the Lac qui Parle region and 20 for the Prairie Coteau and MN River Prairie landscapes).

Step 5: Lakes and Wetlands

Once the extent of potentially undisturbed grassland and woodland areas was determined, we then applied additional measures to further refine the data. Unique challenges were associated with the classifications for wetlands and lakes. Because of the integration of water bodies throughout the disturbed and undisturbed layers, and because the separation of waters from native habitats is at best an arbitrary decision, we elected to retain all water bodies less than 40 acres in the final undisturbed layers (as defined by the MN Public Waters Basin Delineation dataset) if those water bodies were within or adjacent to potentially undisturbed lands. These smaller water bodies were not removed because, although water bodies are not grassland or woodland per se, they are essentially a part of the functioning landscape, especially in larger blocks of undisturbed land. Larger water bodies, on the other hand, may artificially inflate the amount of undisturbed land if retained in the final layer. Furthermore, we were not satisfied with the omission or commission of smaller water bodies in the Public Waters dataset, so a conservative standard size of 40 acres (1/16 square mile) was chosen for water bodies to remove.

Figure 1: Image at left depicts an area of Big Stone County, MN during initial analysis. Areas in black represent fields with a CLU 'crop' indicator code that were removed, leaving all non-blacked out areas requiring further analysis. Areas with hash marks represent a CLU 'non-crop' designation, indicating those tracts were potentially undisturbed. Other areas owned by the state of MN had no CLU data. Technicians analyzed all non-crop and no-data areas for indicators of past disturbance. In this case, several tools were employed to identify and remove areas of current and historic disturbance such as the MN DNR cover type and land use data (colored areas, left) and historic 1991 NAIP imagery (right) to further evaluate the lands. Ultimately, based on all known factors, final potentially undisturbed land tracts are identified and cataloged in the database as seen in the right image (grasslands [green] and woodlands [red]).

Step 6: Evaluation of Undisturbed Land Protection Status

Of primary interest was the relative overlap of undisturbed grasslands and woodlands with records of permanent conservation protection, which was derived by compiling the most up-to-date protection data available. The 'protection' layer compiled for analysis *only* includes fee title and permanent conservation easement data from the: US Fish and Wildlife Service, National Park Service, Natural Resources Conservation Service, MN Department of Natural Resources, MN Board of Water and Soil Resources, The Nature Conservancy (TNC), Minnesota Historical Society (MHS), and The Minnesota Land Trust (MLT). Protection layers were acquired through direct contact with organizations holding the fee title to the property or the easement.

Additional potentially protected lands (fee title or easements) occur throughout Minnesota and are held by a variety of state, county, or private entities. Unless specifically listed in the previous paragraph, it can be assumed that we were not able to acquire reliable boundary data for these areas. For example we were not able to acquire data from MN DNR Trails and Waterways, county parks, or other small independent land trusts. Data from these organizations may be incorporated into the 'protected lands' layer in future analysis.

Information on fee title ownership and easement holdings was collected and merged into a single aggregate layer, which was then clipped to the project extent. This protected lands layer was then intersected with the potentially undisturbed grasslands and woodlands layer produced by our initial analysis, which resulted in a final 'protected undisturbed' data layer. Because some land ownership data is sensitive or proprietary (i.e. TNC, MLT, and MNDNR easements), aggregating protected land data into a single layer with no identifying information was crucial for gaining permission to utilize the data while ensuring protection of the sensitive information. In this manner, it is still possible to determine the amount of total protected land that is either disturbed or undisturbed, which was the primary intent of the analysis.

Step 7: Identification of Wind Turbines

Creation of the wind turbine layer occurred coincidental to the creation of the potentially undisturbed lands layer. Mapping technicians, working at a scale of 1:8000, analyzed the 2013 NAIP Aerial Imagery base layer during this mapping process. While turbine pads and access roads were considered 'disturbed land' and were removed during analysis, a point was created and placed on individual wind turbines that were identified from the aerial imagery.

Step 8: Evaluation of Disturbances MCBS Land Classifications

The final portion of our analysis included evaluating the relative amount of potentially undisturbed land within the Minnesota County Biological Survey (MCBS) Sites of Biodiversity Significance (SBS). Within the SBS lie MN DNR Native Plant Communities (NPC), which are a subset of MCBS data defined as being the highest quality sites surveyed.

Once the potentially undisturbed lands layer was complete, it was overlaid with the MCBS SBS and NPC data to arrive at two layers representing SBSs and NPCs that are known to have a disturbance history. The MCBS polygons were then overlaid with CLU cropland data and Public Waters Basin Delineations data to further determine whether an SBS and/or an NPC land tract was excluded from the potentially undisturbed lands layer due to either CLU crop history, the presence of a large water body ($\geq$40 acres), or some other type of disturbance as determined by our methodology. This disturbance data will help to both refine or correct MCBS data and streamline future MCBS plant community survey activities.

RESULTS

Overall, we developed six specific GIS feature classes as we evaluated the occurrence of potentially undisturbed land within the southwest Minnesota regions discussed in this report. Names and descriptions of those files can be found in table 2 below. Table 3 includes specific data for all landscapes evaluated.

Table 2. GIS feature classes developed by South Dakota State University for the analysis of southwest Minnesota regions.

Filename and Descriptor	Details
mn_pudl_cntyextent: MN Potentially Undisturbed Lands Project Extent	Polygon feature class representing the portion of those counties in southwestern Minnesota that were analyzed as part of the SD & MN Potentially Undisturbed Lands project
mn_pudl: Potentially Undisturbed Lands in Southwestern Minnesota	Polygon feature class representing grasslands and woodlands mapped at a scale of 1:8,000 that did not contain any apparent indicators of agricultural, industrial, or residential disturbance prior or current to the end of the 2013 growing season
mn_pudl_protected: Potentially Undisturbed Lands in Southwestern Minnesota with Permanent Protection	Polygon feature class representing undisturbed grasslands and woodlands (from the Potentially Undisturbed Lands layer) that have permanent protection status through fee title or easement holdings by a conservation entity
mn_windturbines: Wind Turbines in Southwestern Minnesota	Point feature class representing the location of wind turbines mapped at a scale of 1:8,000 using aerial photography from July 2013
mn_mcbs_sites_disturbed: Disturbed Areas within MN DNR MCBS Sites of Biodiversity Significance	Polygon feature class representing areas within Minnesota County Biological Survey Sites of Biodiversity Significance that contained an apparent indicator of disturbance, defined as those areas within survey sites that were not common to undisturbed grasslands and woodlands in the Potentially Undisturbed Lands layer
mn_npc_disturbed: Disturbed Areas within MN DNR Native Plant Communities	Polygon feature class representing areas within Minnesota County Biological Survey Native Plant Communities (highest ranking survey areas from the Sites of Biodiversity Significance) that contained an apparent indicator of disturbance, defined as those areas within Native Plant Communities that were not common to undisturbed grasslands and woodlands in the Potentially Undisturbed Lands layer

Potentially Undisturbed Lands

Overall, we evaluated 5,055,319 acres (7,898 mi^2) within 14 southwestern Minnesota counties within the Lac qui Parle, MN Prairie Coteau, and MN River Prairie landscapes. Counties assessed include all of Big Stone, Swift, Lac qui Parle, and Chippewa counties within the Laq qui Parle region and all or portions of Yellow Medicine, Lincoln, Lyon, Redwood, Pipestone, Murray, Cottonwood, Rock, Nobles, and Jackson counties in the Prairie Coteau and MN River Prairie landscapes (Lac qui Parle county also harbors a very small portion of the Prairie Coteau landscape). Overall, 402,253 (8.0%) of the acres evaluated were designated as potentially undisturbed in the project areas. For complete landscape statistics, see table 3 below.

Lac qui Parle Region and Landscape Results

Within the total county boundaries of the four-county Lac qui Parle region of Minnesota, we estimate there are 147,409 acres of potentially undisturbed grasslands and woodlands remaining of the 1,694,414 acres we evaluated (8.7%). Of these total acres of remnant undisturbed lands, 122,346 acres (83.0%) are classified as 'undisturbed grasslands' and 25,063 acres (17.0%) are classified as 'undisturbed woodlands'.

Within the Lac qui Parle region lie portions of two distinct landscapes. The Lac qui Parle landscape comprises 99% of the four county region while the Prairie Coteau landscape makes up 1% of the region (located in the extreme southwest corner of Lac qui Parle County). There are only 1,233 acres of potentially undisturbed land in this portion of the Prairie Coteau landscape within Lac qui Parle County, and those acres are comprised predominantly of grasslands (91.5% [8.5% are woodlands]). The remaining 146,176 acres of potentially undisturbed land in this four county region are included in the Lac qui Parle landscape of which 82.9% are grasslands and 17.1% are woodlands.

Figure 2: Lac qui Parle region: General extent of potentially undisturbed lands.

Prairie Coteau Landscape Results

Within the Prairie Coteau landscape of Minnesota (as defined by The Nature Conservancy's 2010 report to the National Fish and Wildlife Foundation using MN DNR Ecological subsection boundaries), we estimate there are approximately 230,608 acres of potentially undisturbed grasslands and woodlands remaining of the 2,822,332 acres we evaluated (8.2%). Of these undisturbed acres, 207,161 acres

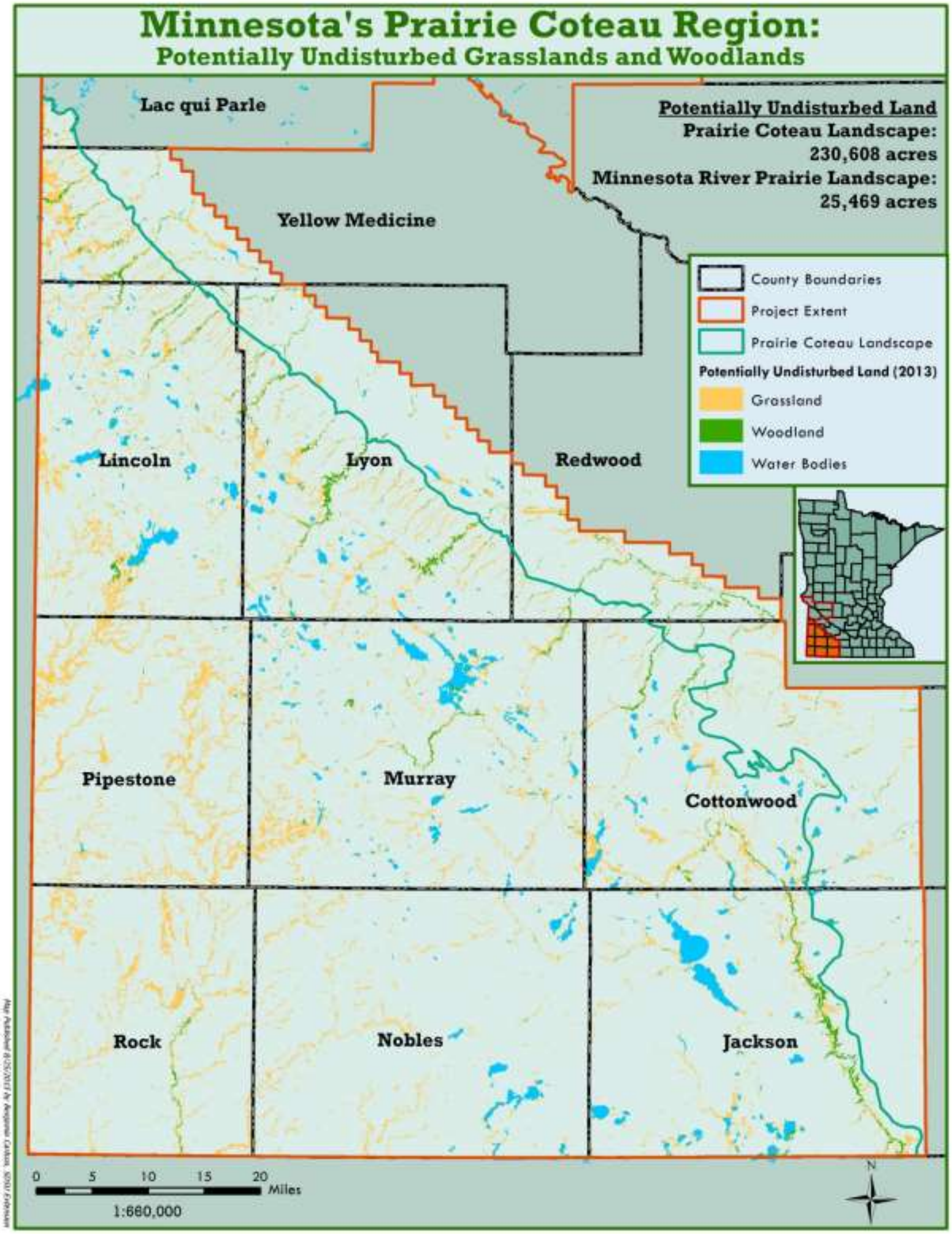
(89.8%) are classified as undisturbed grasslands and 23,446 acres (10.2%) are classified as undisturbed woodlands.

MN River Prairie Landscape Results

While not initially a landscape we were commissioned to evaluate, we were able to extend our analysis east of the Prairie Coteau landscape (more or less described as a 5 mile 'buffer' across six counties in the area between the eastern edge of the Prairie Coteau and the eastern edge of the individual counties). We labeled this area as the MN River Prairie landscape and evaluated the status of undisturbed lands therein. Within this narrow 545,703 acre area, we estimate there are approximately 25,469 acres (4.7%) of potentially undisturbed land remaining. Of these undisturbed acres 19,925 acres (78.2%) are classified as undisturbed grasslands and 5,544 acres (21.8%) are classified as undisturbed woodlands.

It is important to note that within our undisturbed layers there is a possibility that certain individual tracts could have a historic cropping or tillage history that is not detectible with the imagery or with other land use data. These areas are commonly known as 'go back' pasture or hay land. An example would be a land tract that might have been farmed or a tillage attempt made decades ago. These tracts may not have been enrolled in any type of government farm program and thus may not have been tracked through any formal system. The condition and vegetative cover of these areas today is unpredictable, and they may be vegetated with varying degrees of quality, structure, and diversity of native, tame and exotic species. Overall, we believe that our 'potentially undisturbed' grassland and woodland layers may harbor several hundred acres with a disturbance history, but we do not feel the impacts of such will significantly alter the overall evaluation of acres/area within these landscapes.

Figure 3: Prairie Coteau region: General extent of potentially undisturbed lands (includes project extension into the MN River Prairie landscape).



CLU Cropland and Other Disturbed Lands

Across the total 5,055,319 acre analysis area comprising the Lac qui Parle, Prairie Coteau, and MN River Prairie landscapes, approximately 4,051,457 acres (80.1%) were shown to have a cropping history in the FSA CLU data while 491,634 acres (9.7%) indicated some type of land disturbance other than a CLU crop code. More specifically, within individual landscapes, CLU data alone indicated the following cropping rates: Lac qui Parle 78.5%, Prairie Coteau 80.1%, and MN River Prairie 85.4%. In regard to 'other' disturbed areas not represented in the CLU crop codes (see table 1), the Lac qui Parle landscape rate was 9.7%, the Prairie Coteau was 9.8%, and the MN River Prairie areas was 9.4%.

Protection Status of Undisturbed Lands

A key element to assessing the current and future role of these potentially undisturbed tracts in the landscape is evaluating their susceptibility to conversion to other uses. As stated above, of the total 5,055,319 total acres evaluated here, only 402,253 acres (8.0%) were deemed potentially undisturbed (grasslands and woodlands). Also, within the total evaluation area, only 290,412 acres (5.7%) have some sort of permanent protection from conversion (although some of these acres have a disturbance history). So, the ratio of land that is undisturbed AND protected is very important when evaluating the 14 county region: only 104,169 acres (2.1%) of the evaluation area were both potentially undisturbed ***AND*** had some level of permanent conservation protection status. At 3.6%, the Lac qui Parle landscape scored highest in this regard (Prairie Coteau landscape [1.3%] and the MN River Prairie landscape [1.0%]).

When evaluating the level of protection status against the potentially undisturbed acres, the Lac qui Parle landscape ranks highest with 60,663 acres of total 146,176 undisturbed acres under some sort of protection status (41.5%). Figure 4 below shows the extent of *all* protected lands overlaid on potentially undisturbed grasslands and woodlands, while figure 5 highlights lands that are *both* undisturbed and protected within the Lac qui Parle region.

Figure 4: Lac qui Parle region: Extent of all protected lands and all undisturbed lands.

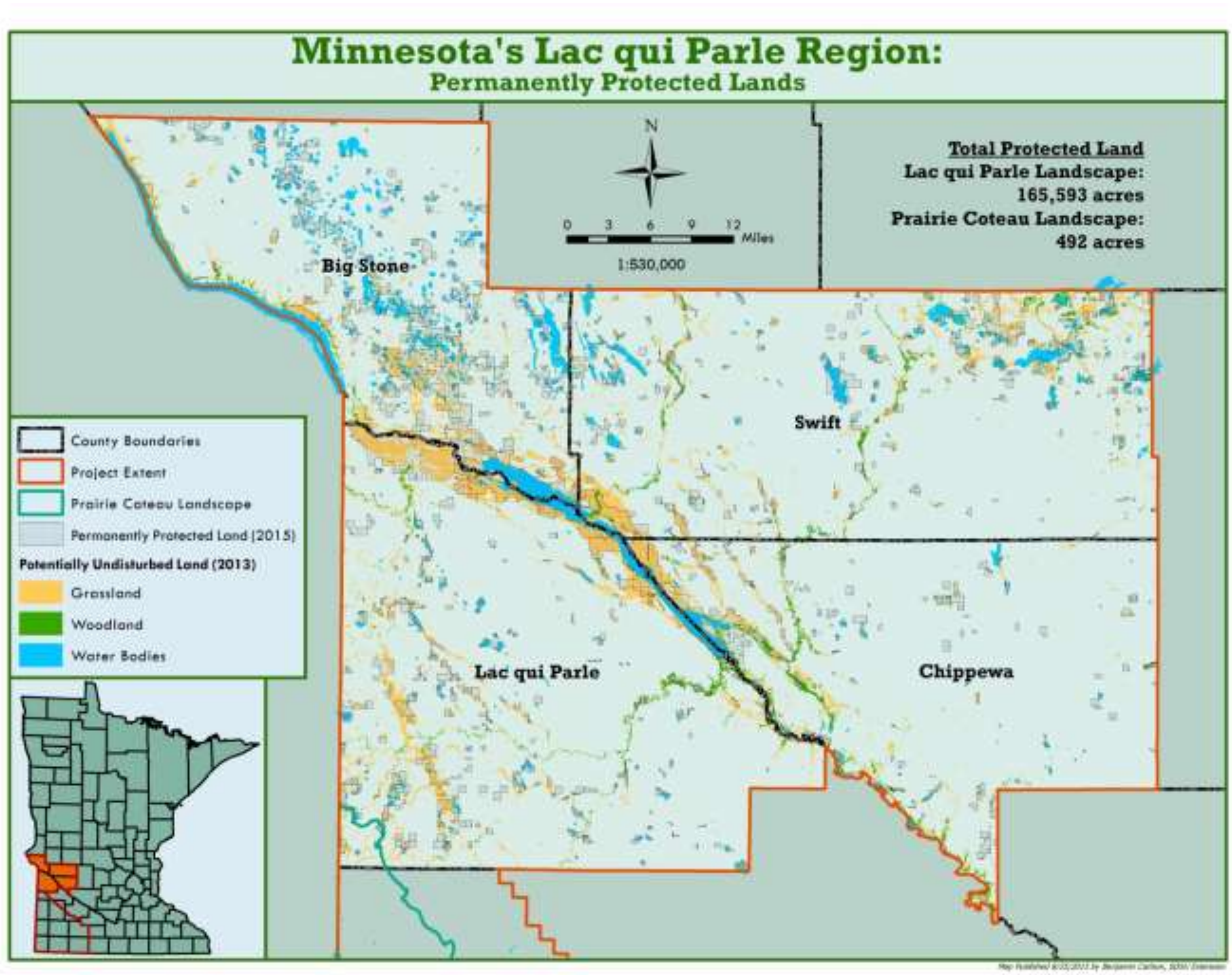


Figure 5: Lac qui Parle region: Extent of all undisturbed lands with protected undisturbed lands highlighted.

The Prairie Coteau and MN River Prairie landscapes have far less of their potentially undisturbed lands under permanent protection at 16.5% and 21.9%, respectively. Figure 6 below shows the extent of *all* protected lands overlaid on potentially undisturbed grasslands and woodlands, while figure 7 highlights lands that are *both* undisturbed and protected within the Prairie Coteau region.

Figure 6: Prairie Coteau region: Extent of all protected lands and undisturbed lands.

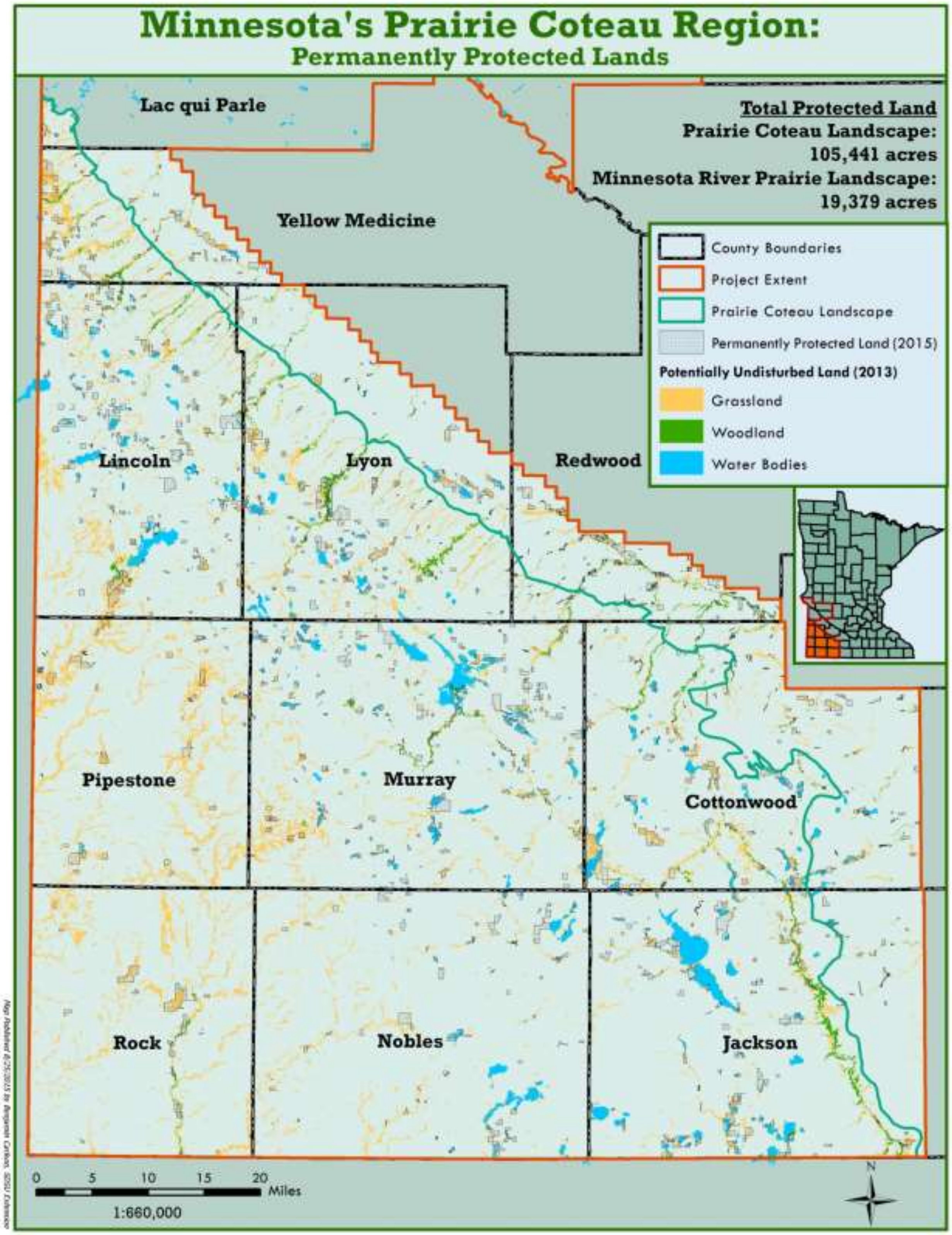
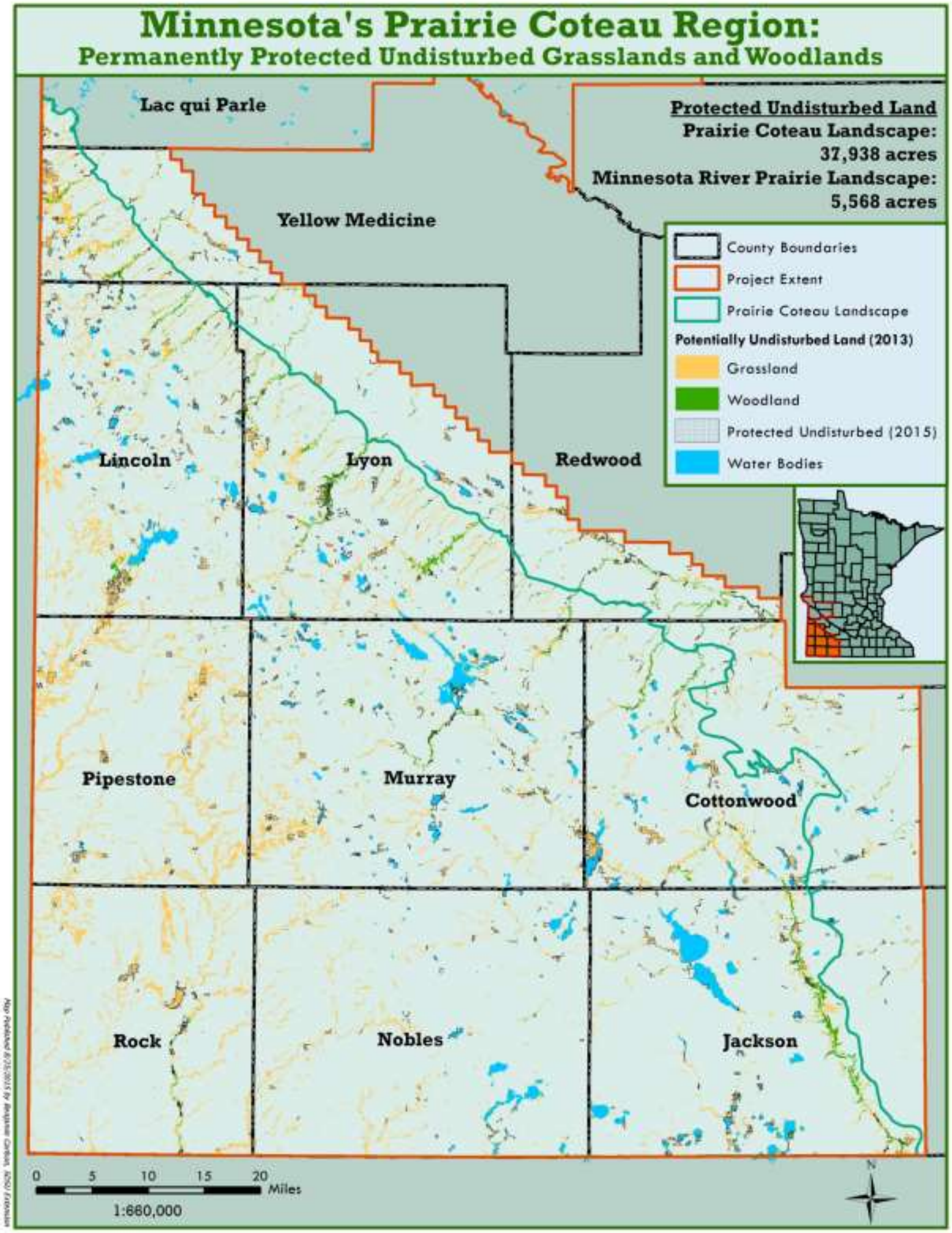


Figure 7: Prairie Coteau region: Extent of all undisturbed lands with protected undisturbed lands highlighted.



Lakes and Wetlands

The methodology for the removal of lakes $\geq$ 40 acres was described in detail in the methods section of this report. Although only 42% of the individual Public Waters Basin water bodies within the project extent were greater than 40 acres, those same water bodies represented 89% of the total water surface area. Stated another way, 11% of water surface area was retained within the potentially undisturbed grassland and wetland data within the total project extent.

Understanding that no data layer is perfect, it is worth noting that some larger 'water bodies' have been removed from the potentially undisturbed grassland classification that likely could remain, such as the 'lake' in the Lower Antelope Valley WMA in Yellow Medicine County. Likewise, Marsh Lake within the Big Stone National Wildlife Refuge was not included in the Public Waters Basin Delineation layer when it likely should have been removed from the Potentially Undisturbed layer. Regardless, the MN DNR Public Waters Basin Delineations have been accepted as measured geometric data, thus no editing or commission/omission decisions beyond the 40 acres threshold have been performed.

Table 3: Full landscape statistics.

Potentially Undisturbed Land - County and Landscape Statistics Within the MN Regions and Landscape Areas

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
County	Landscape	Total County Area (mi²) [1]	Total County Area (Acres) [1]	Area (Acres) included in Analysis (by Landscape) [2]	Percent of Area included in Analysis (E/D)	Cropland Acres Within Analysis Area [3]	Other Disturbed Acres Within Analysis Area [4]	Acres of large water bodies (≥ 40 Acres) Within Analysis Area [5]	Potentially Undisturbed Grassland Acres Within Analysis Area [6]	Potentially Undisturbed Woodlands Acres Within Analysis Area [6]	Total Potentially Undisturbed (Grasslands and Woodlands) Acres Within Analysis Area [6]	Percent of Potentially Undisturbed Land Classified as Grasslands (J/L)	Percent of Potentially Undisturbed Land Classified as Woodlands (K/L)	Percent of Analysis Area Classified as Undisturbed (Grasslands and Woodlands) (L/E)	Total Acres With 'Protected' Status Within Analysis Area [7]	Undisturbed Acres *With* 'Protected' Status Within Analysis Area [8]	Percent of 'Protected' acres Within Analysis Area that are Undisturbed (Q/P)	Percent of Total Undisturbed *With* 'Protected' Status Within Anaylsis Area (Q/L)	Percent of Total Acres With 'Protected' Status Within Analysis Area (P/E)	Percent Classified as 'Undisturbed' *And* 'Protected' Status Within Analysis Area (Q/E)
Big Stone	Lac qui Parle	528	338,162	338,162	100%	241,165	37,161	26,423	30,310	3,103	33,413	90.7%	9.3%	9.9%	55,682	16,464	29.6%	49.3%	16.5%	4.9%
Chippewa	Lac qui Parle	588	376,280	376,280	100%	312,338	35,467	4,196	15,806	8,473	24,279	65.1%	34.9%	6.5%	23,950	8,571	35.8%	35.3%	6.4%	2.3%
Lac qui Parle	Lac qui Parle			491,201	99%	387,707	43,415	9,862	43,809	6,407	50,216	87.2%	12.8%	10.2%	52,114	22,762	43.7%	45.3%	10.6%	4.6%
	Prairie Coteau			7,130	1%	5,401	496	0	1,128	105	1,233	91.5%	8.5%	17.3%	492	276	56.1%	22.4%	6.9%	3.9%
	Total	779	498,319	498,331	100%	393,108	43,911	9,863	44,936	6,512	51,449	87.3%	12.7%	10.3%	52,606	23,039	43.8%	44.8%	10.6%	4.6%
Swift	Lac qui Parle	753	481,641	481,641	100%	383,023	47,064	13,285	31,294	6,975	38,268	81.8%	18.2%	7.9%	33,847	12,865	38.0%	33.6%	7.0%	2.7%
4-County Lac qui Parle Region Totals		**2,648**	**1,694,402**	**1,694,414**	**100%**	**1,329,635**	**163,603**	**53,767**	**122,346**	**25,063**	**147,409**	83.0%	17.0%	**8.7%**	**166,085**	**60,940**	**36.7%**	**41.3%**	**9.8%**	**3.6%**
Cottonwood	Prairie Coteau			236,604	57%	190,232	21,482	5,944	15,798	3,148	18,946	83.4%	16.6%	8.0%	14,724	5,546	37.7%	29.3%	6.2%	2.3%
	MN River Prairie			178,668	43%	154,405	14,540	1,367	7,055	1,301	8,356	84.4%	15.6%	4.7%	4,413	1,365	30.9%	16.3%	2.5%	0.8%
	Total	649	415,278	415,271	100%	344,636	36,022	7,311	22,853	4,449	27,302	83.7%	16.3%	6.6%	19,137	6,911	36.1%	25.3%	4.6%	1.7%
Jackson	Prairie Coteau			364,435	79%	288,247	40,572	14,836	15,239	5,541	20,779	73.3%	26.7%	5.7%	15,099	4,683	31.0%	22.5%	4.1%	1.3%
	MN River Prairie			95,834	21%	87,140	6,846	447	1,227	174	1,401	87.6%	12.4%	1.5%	945	233	24.7%	16.6%	1.0%	0.2%
	Total	719	460,422	460,269	100%	375,387	47,418	15,284	16,465	5,715	22,180	74.2%	25.8%	4.8%	16,044	4,916	30.6%	22.2%	3.5%	1.1%
Lincoln	Prairie Coteau			347,184	99%	269,303	33,434	9,518	31,983	2,946	34,929	91.6%	8.4%	10.1%	19,943	6,682	33.5%	19.1%	5.7%	1.9%
	MN River Prairie			4,114	1%	3,372	406	0	180	155	335	53.7%	46.3%	8.1%	278	97	34.8%	28.9%	6.8%	2.4%
	Total	549	351,300	351,298	100%	272,675	33,841	9,518	32,162	3,102	35,264	91.2%	8.8%	10.0%	20,221	6,779	33.5%	19.2%	5.8%	1.9%
Lyon	Prairie Coteau			251,864	55%	192,640	27,141	4,519	21,996	5,567	27,563	79.8%	20.2%	10.9%	12,151	4,491	37.0%	16.3%	4.8%	1.8%
	MN River Prairie			115,498	25%	94,945	15,161	870	3,326	1,196	4,522	73.6%	26.4%	3.9%	4,427	1,447	32.7%	32.0%	3.8%	1.3%
	Total	722	461,941	367,362	80%	287,585	42,302	5,389	25,323	6,763	32,086	78.9%	21.1%	8.7%	16,578	5,938	35.8%	18.5%	4.5%	1.6%
Murray	Prairie Coteau	720	460,675	460,675	100%	374,711	40,808	12,716	29,703	2,736	32,439	91.6%	8.4%	7.0%	20,606	6,541	31.7%	20.2%	4.5%	1.4%
Nobles	Prairie Coteau	723	462,475	462,362	100%	394,236	45,005	5,427	17,247	447	17,694	97.5%	2.5%	3.8%	7,437	1,352	18.2%	7.6%	1.6%	0.3%
Pipestone	Prairie Coteau	467	298,592	298,581	100%	231,698	30,613	151	36,025	94	36,119	99.7%	0.3%	12.1%	5,475	3,120	57.0%	8.6%	1.8%	1.0%
Redwood	Prairie Coteau			21,051	4%	17,688	1,927	0	1,054	382	1,436	73.4%	26.6%	6.8%	306	32	10.3%	2.2%	1.5%	0.2%
	MN River Prairie			88,469	16%	73,441	8,111	0	4,590	2,327	6,917	66.4%	33.6%	7.8%	6,632	1,470	22.2%	21.3%	7.5%	1.7%
	Total	881	563,984	109,520	19%	91,129	10,038	0	5,645	2,709	8,353	67.6%	32.4%	7.6%	6,938	1,502	21.6%	18.0%	6.3%	1.4%
Rock	Prairie Coteau	483	309,292	309,384	100%	252,863	30,531	0	25,114	876	25,991	96.6%	3.4%	8.4%	4,456	2,435	54.6%	9.4%	1.4%	0.8%
Yellow Medicine	Prairie Coteau			63,063	13%	44,289	5,136	160	11,874	1,604	13,478	88.1%	11.9%	21.4%	4,751	2,780	58.5%	20.6%	7.5%	4.4%
	MN River Prairie			63,120	13%	52,613	6,317	252	3,547	391	3,938	90.1%	9.9%	6.2%	2,683	955	35.6%	24.3%	4.3%	1.5%
	Total	764	488,798	126,183	26%	96,902	11,453	412	15,421	1,995	17,416	88.5%	11.5%	13.8%	7,434	3,735	50.2%	21.4%	5.9%	3.0%
10 County Prairie Coteau Region Totals		**6,676**	**4,272,757**	**3,360,905**	**79%**	**2,721,822**	**328,031**	**56,208**	**225,959**	**28,886**	**254,844**	88.7%	11.3%	**7.6%**	**124,327**	**43,229**	**34.8%**	**17.0%**	**3.7%**	**1.3%**
Landscape Totals	Lac qui Parle [9]			**1,687,284**	**33%**	**1,324,234**	**163,107**	**53,767**	**121,218**	**24,958**	**146,176**	82.9%	17.1%	**8.7%**	**165,593**	**60,663**	**36.6%**	**41.5%**	**9.8%**	**3.6%**
	Prairie Coteau [10]			**2,822,332**	**56%**	**2,261,308**	**277,145**	**53,272**	**207,161**	**23,446**	**230,608**	89.8%	10.2%	**8.2%**	**105,441**	**37,938**	**36.0%**	**16.5%**	**3.7%**	**1.3%**
	MN River Prairie [11]			**545,703**	**11%**	**465,915**	**51,382**	**2,937**	**19,925**	**5,544**	**25,469**	78.2%	21.8%	**4.7%**	**19,379**	**5,568**	**28.7%**	**21.9%**	**3.6%**	**1.0%**
	Total			**5,055,319**	**100%**	**4,051,457**	**491,634**	**109,975**	**348,304**	**53,949**	**402,253**	**86.6%**	**13.4%**	**8.0%**	**290,412**	**104,169**	**35.9%**	**25.9%**	**5.7%**	**2.1%**

[1] Calculated using GIS from US Census Bureau 2002 county boundary data published by the Natural Resources Conservation Service (2009)

[2] Area extent as per South Dakota State University GIS analysis. May differ from column D due to discrepencies between US Census Bereau data and interpretation of Common Land Unit geometry by SDSU

[3] 2013 Farm Service Agency Common Land Unit data layer: cropland

[4] All non-CLU cropland and disturbed lands including but not limited to: other identified cropland, buildings sites, planted shelterbelts, municipalities, gravel pits, feedlots, roadways, large drainage ditches, railways, etc

[5] MN Department of Natural Resources Public Waters Basin Delineation layer selected for water bodies ≥40 acres

[6] South Dakota State University Potentially Undisturbed Lands Analysis: 2015. Includes all land tracts with no apparent disturbance (may include land tracts with historic disturbance that cannot be detected by SDSU analysis methodology. Example: go-back grasslands)

[7] Includes fee title property and/or permanent easements held by: US Fish and Wildlife Service , National Park Service, Natural Resources Conservation Service, MN Dept. of Natural Resources, MN Board of Water and Soil Resources, MN Historical Society, The Nature Conservancy, and the MN Land Trust

[8] South Dakota State University Undisturbed Lands Analysis: 2015. GIS intersection of protected lands (column N) and total undisturbed lands (column L)

[9] Four-County Lac Qui Parle region excluding the portion of the Prairie Coteau Landscape

[10] Prairie Coteau landscape boundary defined by 2010 National Fish and Wildlife Foundation/The Nature Conservancy Business Plan (inlcudes portions of Lac qui Parle County)

[11] Portions of the 10-County Prairie Coteau Region excluding the Prairie Coteau Landscape (approximately a 5-mile buffer area within listed counties)

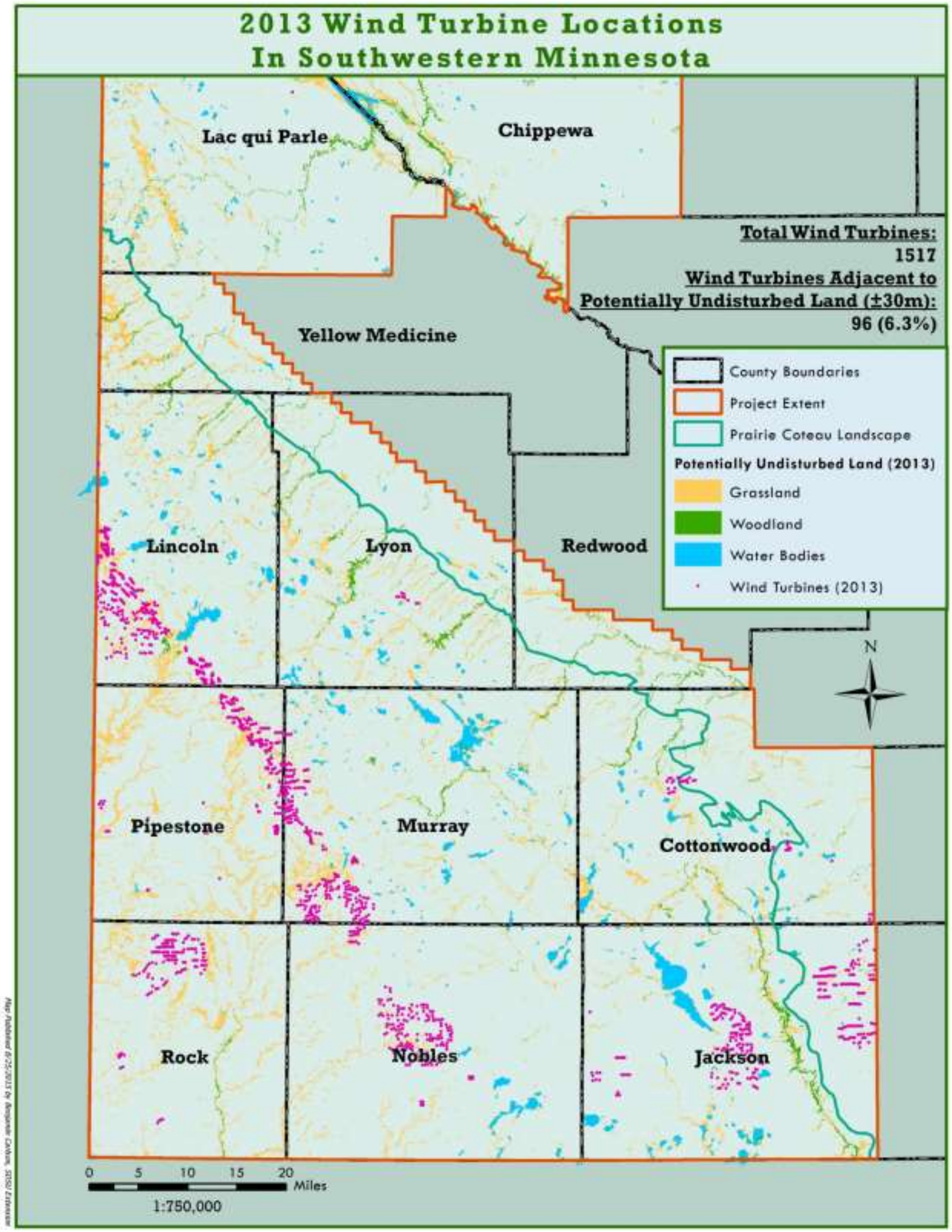
Wind Turbines

Of the 1517 wind turbines (as of 2013) identified in the total analysis area, 96 (6.3%) were located within potentially undisturbed areas (using a search distance parameter of 30 meters to compensate for disturbance due to turbine pads and access roads). While no wind turbines were found within potentially undisturbed areas with permanent protection, 23 turbines were located specifically within the MCBS NPC regions. Figure 8 depicts the general location of all wind turbines identified during analysis, and table 4 lists the number of wind turbines found in each county.

Table 4: Wind turbines per county as of 2013.

County	Wind Turbines (2013)
Big Stone	0
Chippewa	0
Cottonwood	38
Jackson	296
Lac qui Parle	2
Lincoln	377
Lyon	9
Murray	253
Nobles	183
Pipestone	229
Redwood	0
Rock	130
Swift	0
Yellow Medicine	0
Total	1,517

Figure 8: Locations of all wind turbines identified during analysis (as per 2013 imagery).



Disturbance of Minnesota County Biological Survey (MCBS) lands

Here we performed a comparative analysis between the potentially undisturbed lands layer and the MN Department of Natural Resources Sites of Biodiversity Significance (SBS) layer, which is a product of the Minnesota County Biological Survey (MCBS) showing individual tracts of land that have been surveyed and ranked by the MCBS based on biodiversity of native plant communities. This comparison seeks to identify which SBS areas have a disturbance history. This data may assist in future management of MCBS data and streamline future MCBS plant community survey activities.

The MCBS SBS layer totals 321,106 acres within the three landscapes. Of that total, 51,833 acres (16.1%) had a CLU crop designation while 35,373 acres (11.0%) were excluded due to some type of disturbance other than CLU crop codes (see table 1). Additionally, 26,074 acres (8.1%) coincided with water bodies ≥40 acres.

In addition to evaluating the MCBS SBS data layer, we also evaluated the MN DNR's Native Plant Communities (NPC) layer and performed a comparative analysis between the potentially undisturbed lands layer and the NPC layer. The NPC land tracts have been surveyed and ranked by the MCBS as having the highest quality native plant communities remaining *within* MCBS's Sites of Biological Significance (SBS). This comparison seeks to identify which NPC areas have a disturbance history.

The MCBS NPC layer totals 91,813 acres within the three landscapes. Of that total, 3,737 acres (4.1%) had a CLU crop designation while 3,997 acres (4.4%) were excluded due to some type of disturbance other than CLU crop codes (see table 1). Additionally, 3,160 acres (3.4%) coincided with water bodies ≥40 acres.

DISCUSSION

The last several years have yielded great interest from researchers and policy makers regarding land conversion and many popular, semi-technical, and technical papers have been published on the topic. The most notable papers providing background on the status of land conversion in the Northern Great Plains and the Prairie Pothole Region (generally including southwest Minnesota) include: Wright and Wimberly (2013), Johnston (2013, 2014), Faber et al. (2012), Cox and Rundquist (2013), Decision Innovation Solutions (2013), and Reitsma et al. (2014). While none of these reports were specific to the landscape boundaries or counties we evaluated in this report, they do indicate trends in shifting land use from grasslands to cropland or other uses across the Northern Great Plains region, and likely provide adequate indications of trends of grassland loss.

In addition to the papers mentioned above, many papers discuss the relative importance of intact native vegetation and the consequences of land conversion in general including Stephens et al. (2008) and Rashford et al. (2010). Several authors have also addressed similar concerns regarding the loss of wetlands including Cox and Rundquist (2013), Johnston et al. (2013), Blann et al. (2009), Werner et al. (2013), Voldseth et al. (2007, 2009), and Doherty et al. (2013).

Caution should be applied when utilizing any of the data mentioned in the papers above for evaluating land use changes within the Lac qui Parle, Prairie Coteau, or Minnesota River Prairie landscapes, specifically because, while likely a reasonable estimate for the regions sampled, these data do not differentiate between native grasslands and several types of non-native grass or grass-like vegetation and thus cannot provide an accurate indication of occurrence or loss of truly native (undisturbed) habitats. That said, the trend in grassland and wetland loss indicated in all the aforementioned reports obviously does include some percentage of native grasslands and wetlands and the overall loss of all grassland habitat types, native or otherwise, can have significant impacts on the general use and distribution of grassland-dependent species.

While it would be simple to assume current land use or rates of conversion for the Prairie Coteau, Lac qui Parle, or MN River Prairie landscapes are similar to others included in these reports, the geology of the landforms themselves are highly variable with some areas lending themselves to an increased threat of conversion to farmland (i.e. MN River Prairie) while other areas remain topographically challenging even with today's modern farm equipment, such as the upper slopes and steep valleys of the Prairie Coteau. In addition, because of the prevalence of conservation work in the region, 60,663 acres in the Lac qui Parle, 37,938 acres in the Prairie Coteau, and 5,568 acres in the MN River Prairie landscapes are considered both undisturbed and are under some type of permanent protection from land conversion due to conservation easements or agency ownership.

Further complicating any analysis of land use change is the fact that some areas of the Minnesota landscapes we evaluated for this report were historically farmed only to be allowed to re-vegetate naturally (more or less). These tracts, if identified, are often referred to as 'go-back' pastures, indicating they were allowed to 'go-back' or re-vegetate naturally. The conversion and subsequent natural reclamation of these tracts occurred primarily prior to the onset of the heavy use of agricultural herbicides, thus vegetation diversity and quality can be variable, and at times can resemble a truly native site. While nearly impossible to confidently categorize from aerial imagery, the land use history of many of these tracts can be determined by future on-the-ground evaluation of physical and ecological indicators such as tillage furrows, rock piles, and simple plant communities infested with exotic species. Classifying land use history solely based on plant community composition where physical indicators may be limited and where native plant diversity is high is very difficult, but this is a very rare occurrence.

MANAGEMENT IMPLICATIONS

Future Data Refinement and Analysis of Conservation Lands

> *When one land use expands, it is always at the expense of another"*
>
> - Johnston (2014)

Classification of potentially undisturbed land is difficult and requires a deductive process to remove all disturbed land from consideration. Anything less would not arrive at an accurate depiction of undisturbed land. For instance, simple quantification of land tracts under conservation easement or ownership by agencies would not be an accurate indication of undisturbed lands because many 'go back' tracts are included in conservation lands. Further, many native tracts remain in private ownership as working farms and ranches and are not under formal protection (i.e. easements). Thus, any quantification of native sod based solely on protection status or conservation lands would be a gross underestimate.

We believe the data produced by this project to be the most comprehensive and inclusive estimation of undisturbed (likely native) grassland and woodland habitat in the prairie landscape of southwestern Minnesota. However, the accuracy and completeness of our dataset is limited by that of the source data used in analysis. Data sources acquired or analyzed henceforth may improve the analysis of potentially undisturbed lands. In any event, because of the conservative nature of our analysis, it is unlikely that there would be a situation that would constitute a positive change or increase of lands from disturbed to undisturbed.

Certain issues relating to the quality of the FSA Common Land Unit (CLU) layer and its cropland indicators are discussed at length above. At specific issue is the fact that permanently protected grassland conservation easements often drive reclassification from a cropland to a non-cropland status on easement tracts. This is especially problematic for our analysis since there is no way to tell from the CLU data whether a non-cropland tract is truly undisturbed or simply reclassified historic cropland due to an easement. Further complicating the issue is that this reclassification varies between easement types and county FSA offices. Usually, reclassified farms are not dissolved, meaning a reclassified cropland tract will remain as an individual polygon distinct from neighboring tracts within a given easement property, only with a non-cropland status instead of the former cropland status. Fortunately, through our overlay of permanently protected lands, we can tell if a tract has a permanent conservation easement and adjust our analysis accordingly. Sometimes, the interpretation of historic USGS DOQQ aerial imagery or even more current 2013 NAIP imagery can provide insights into easement tracts that contain possible go-back fields or those that were still cropped at the time of the 1990's DOQQ images. More often, though, aerial photos may not show clear disturbance indicators for conservation easement tracts with a non-crop indicator. This all means, then, that the easement classification itself pre-empts a fair or consistent interpretation of the CLU data, which poses a real problem for the integrity of our analysis because it creates a situation where the easement itself drives the non-crop classification.

This problem certainly pertains more to conservation easement lands as opposed to fee title lands owned by conservation entities because historic land use data often exists for fee title lands, but not so much for easement holdings. Future re-analysis may then need to focus specifically on gathering historical (pre-1990's) land use and/or land cover data for conservation easement lands. If data can be acquired and georectified properly, disturbances identified in that data may be used to properly reclassify easement lands currently classified as undisturbed. Ideally, information on FSA cropland to non-cropland reclassification history could also serve to refine our analysis, however we are unaware of any practically accessible dataset that would contain this history. Such data may exist as archived CLU data or individual farm or tract data files within FSA county offices.

Some agencies and organizations have begun internal land cover classification projects on easement holdings, such as the Fish and Wildlife Service and the Minnesota Board of Water and Soil Resources (Reinvest in Minnesota easements), but the coverage of these data is often incomplete or unreliable. For example, FWS easement land cover data was used in our analysis, but only covered a fraction of total FWS grassland easements. A similar MN BWSR easement land use data project was abandoned, thus could not be used for our analysis. We urge conservation agencies and organizations to consider conducting on-the-ground surveys, along with historical research, to determine disturbance history on conservation easement lands.

Additionally, historic aerial photography exists for much of Minnesota dating to the late 1930's and early 1950's through the 1960's. These photos are sometimes the same ones used by the early Soil Conservation Service for tracking farm fields, and they often very clearly show historic tillage that has since reverted to grassland. In general, these historic aerial photographs could not be used in this analysis because they are not georectified, and doing so would add considerable time and effort. Accurately georectifying these historic photos can be accomplished, albeit with considerable investment, which could further inform undisturbed land classification in the future.

Future refinement of the potentially undisturbed lands dataset will focus on updating and reclassifying undisturbed land polygons that have since been altered by new acts of disturbance. However, future refinement of this dataset will also reflect reclassifications based on new interpretations of historic disturbance through the utilization of different data sources. One requirement of such future refinement and reclassification is that all changes to the potentially undisturbed land dataset be tracked through the use of a separate layer containing the reclassified tract and a note indicating the reason it was reclassified as disturbed. In this manner, reclassification due to recent disturbance and discovery/reinterpretation of historic disturbance may be kept separate, which is critical for computing statistics on both rates of land conversion and relative accuracy of the dataset over time.

Understanding Native Grasslands

Within all previous reports on land use trends, conversion of native grassland is included as an unquantified portion of total grassland loss. The remainder of grassland conversion reported is better described as grass 'crop' acres, such as Conservation Reserve Program (CRP) acres, small grains, alfalfa, tame grass, or even historic crop fields that have actively or passively re-vegetated with some semblance of native and exotic vegetation. Use of these previously tilled acres and the type of crop they produce (including grasses) may ebb and flow, and these typically simplified planted habitats can be destroyed and re-created over time and space. The conversion of these grass 'crop' acres can have social, economic, and ecological benefits and detriments, but they are not suitable surrogates for evaluation of the loss of truly native grassland acres (Doherty et al. (2013).

Native habitats, on the other hand, cannot be re-created over time and space. Once the soil is physically disrupted, the native habitat is gone forever. Converted native grassland and woodland acres can eventually be re-cropped with grass and grass-like covers and or woody species that may provide some of the social, economic, and ecological values provided by the original native habitat, but it is impossible to re-create all values inherent in native habitats and undisturbed soils, thus the cumulative ecological, social, and economic impacts of conversion of these acres is difficult to measure.

Conversion of remnant native grassland requires a cost/benefit analysis that acknowledges true loss of an irreplaceable ecosystem. Perhaps Doherty et al. (2013) captures the argument for the cumulative effects of time on grassland conversion and conservation policy more thoroughly than any other report, calling for the identification and protection of high-diversity remnant areas as a critical step in conservation planning in relation to timing (i.e. sooner than later).

Because no baseline exists for unprotected native or undisturbed sod in the regions evaluated, we cannot provide a reasonable estimate of land use change over time that can support or refute trends reported by others. However, with our methodology, we were able to quantify all areas that are likely native untilled sod (as of 2013) to a degree of accuracy never before attempted. Our methodology provides a 'road map' to future analysis that will provide a baseline of reasonable potential areas of native sod based on known measured data. Analysis of the quality of these tracts can only be quantified by evaluating these sites for objective physical or ecological indicators to determine what is truly 'native' sod and the quality of the ecological communities therein.

As grasslands continue to be one of the most threatened ecosystems on the planet, the northern Great Plains is a focal area for grassland conversion. Our methodology not only provides a model for mapping potentially undisturbed land for the remainder of Minnesota, it can be applied to identification and mapping of potential remaining native habit in other states. While there is still a degree of subjectivity involved, our techniques provide a reasonable estimate of native untilled sod with a far greater degree of local accuracy at a usable scale than do previous estimates.

Our native grassland and native woodland results establish a simple base data layer for future analysis. Because of the clarity provided by the USDA-NAIP imagery, new cropping/conversion or disturbances are quite obvious through on-screen analysis. By utilizing GIS technology to overlay our 2013 grassland and woodland layer results on future USDA-NAIP aerial imagery, analysis of additional land disturbances within our polygons will allow researchers to estimate an accurate rate of conversion for this region while also allowing continual refinement of the undisturbed grassland and woodland layers over time.

Unfortunately, the total acres of undisturbed native grassland can only remain constant or decrease over time. However, there is potential for the woodland portion of the undisturbed layer to increase if volunteer native woody vegetation infiltrates native grasslands and achieves a density that would indicate closed canopy cover. That measure is somewhat subjective and we believe that significant change in the native woodland layer would be required in order to accurately detect change through short term analysis.

In addition to expansion of native woody cover, the Prairie Coteau and Lac qui Parle regions will likely be subject to increasing invasions of exotic and/or invasive native woody species such as Eastern redcedar (*Juniperus virginiana*). This situation may pose a particular challenge in future analysis of the undisturbed grassland layer, as these woody invaders can eventually achieve a dense canopy appearance. Our suggestion would be that these areas continue to be classified as undisturbed grasslands unless or until the density of trees is such that the canopy reflects that of undisturbed woodlands, at which times they should be reclassified as such. In Minnesota, an example of transition from undisturbed grassland to woodland was found in the glacial hills region of northeastern Swift County and was due primarily to the invasion of Eastern redcedar.

Overall, our methodology and subsequent results will allow for improved analysis of the quality of the remaining undisturbed portions of the landscape by providing a baseline for researchers to target their efforts to quantify overall undisturbed grassland biological diversity and habitat potential. As stated previously, there is a certain percentage of our undisturbed grassland and woodland layers that are likely 'go back' pasture that is relatively low in diversity. Those areas cannot be quantified without some sort of improved evaluation through ground truthing. The same need for ground truthing holds true for identifying the highest quality areas already identified by the Minnesota County Biological Survey.

In conclusion, we believe our mapping methods will allow assessment of future land use change for previously undisturbed or native tracts that have occurred after 2013 and that such results will allow conservation and management organizations such as the MN Department of Natural Resources and others to target evaluation and conservation specifically aimed at the protection of undisturbed grasslands and woodlands.

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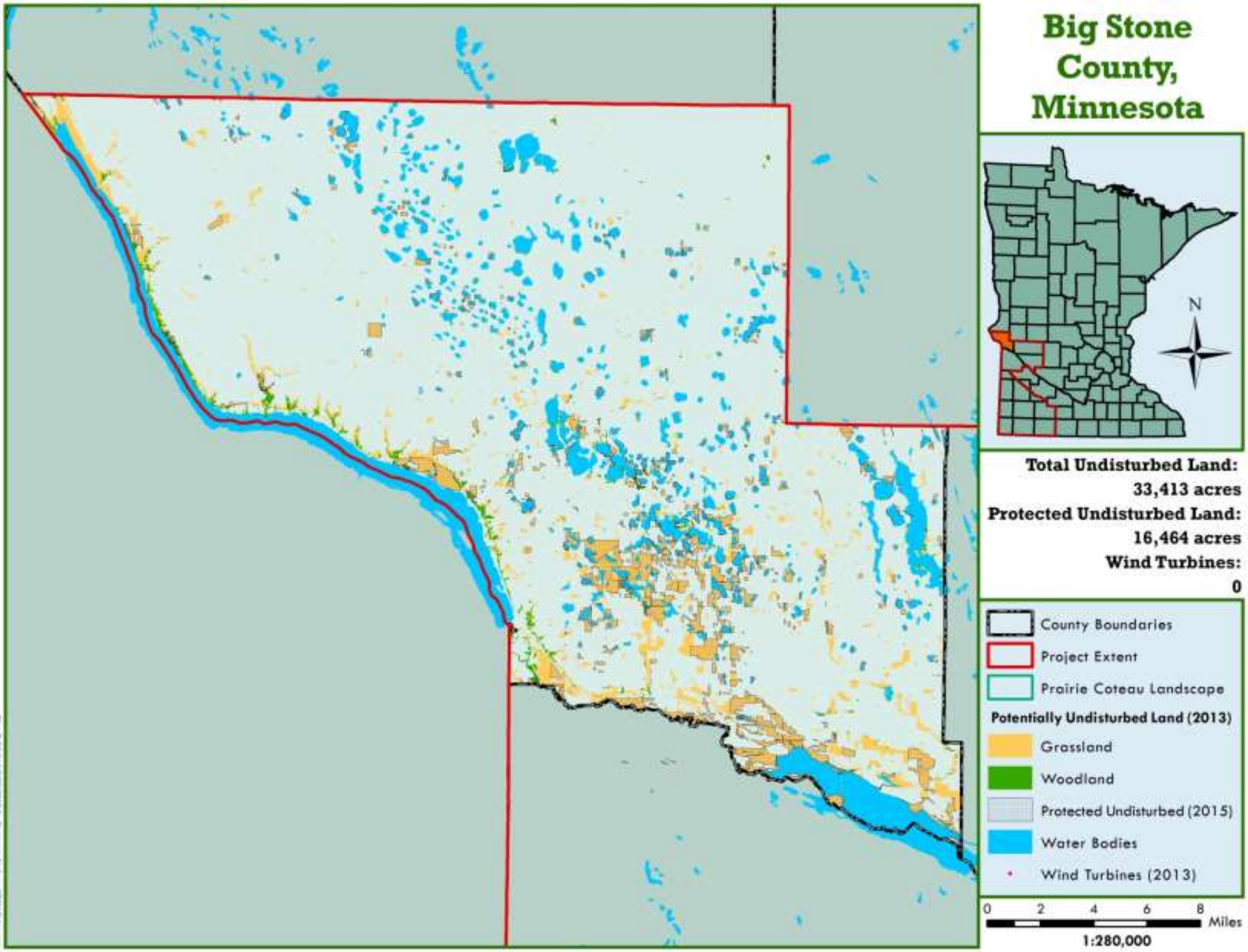
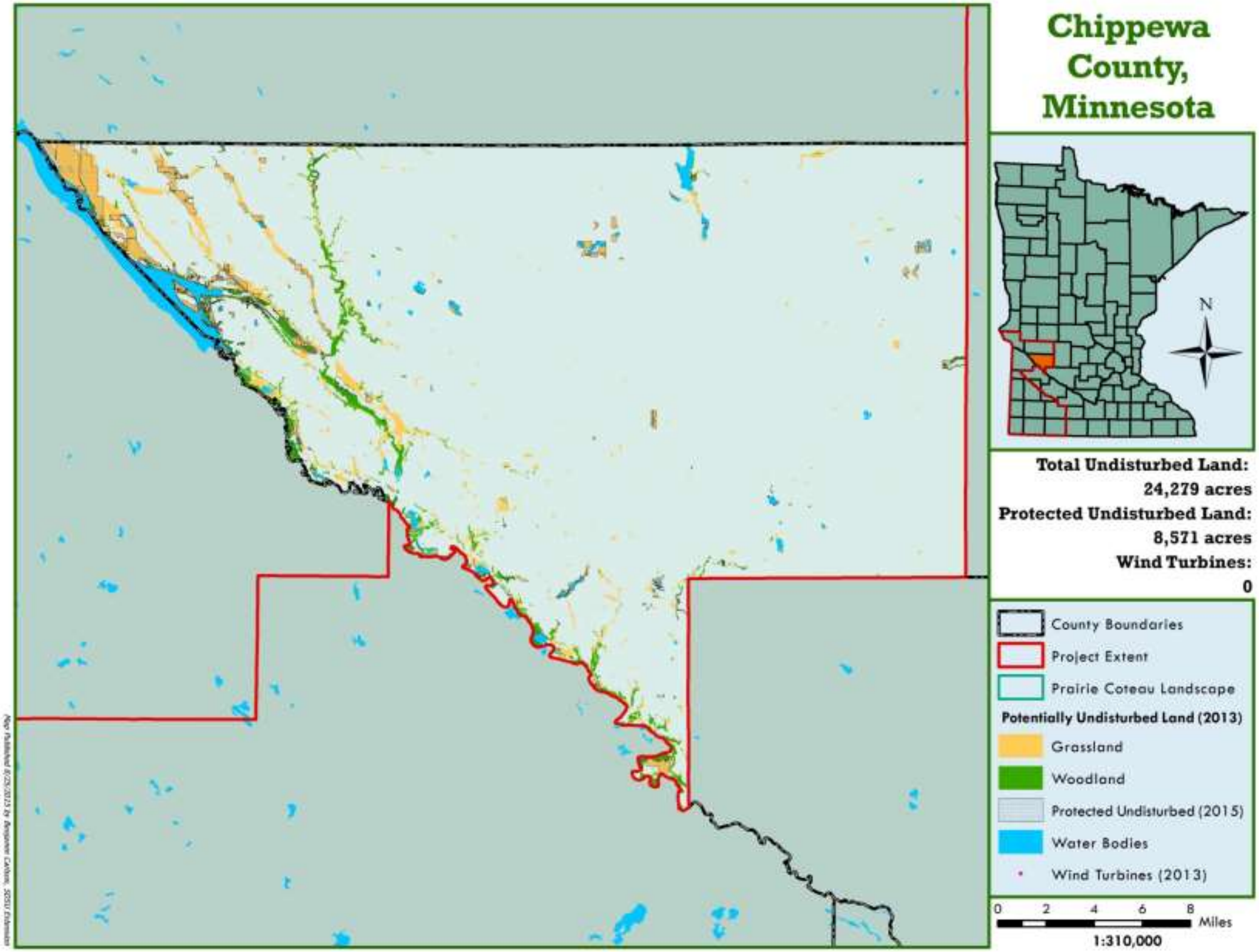
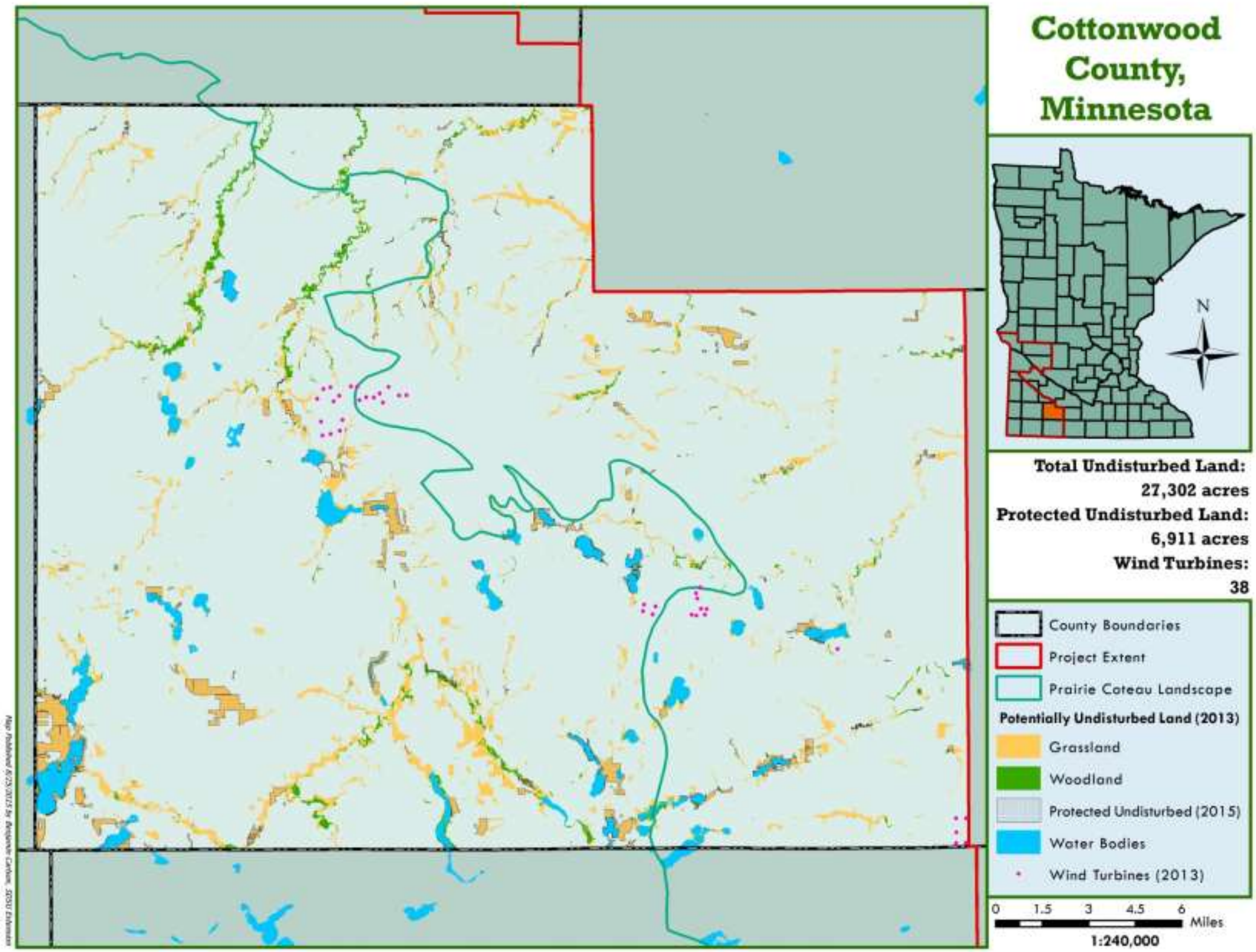
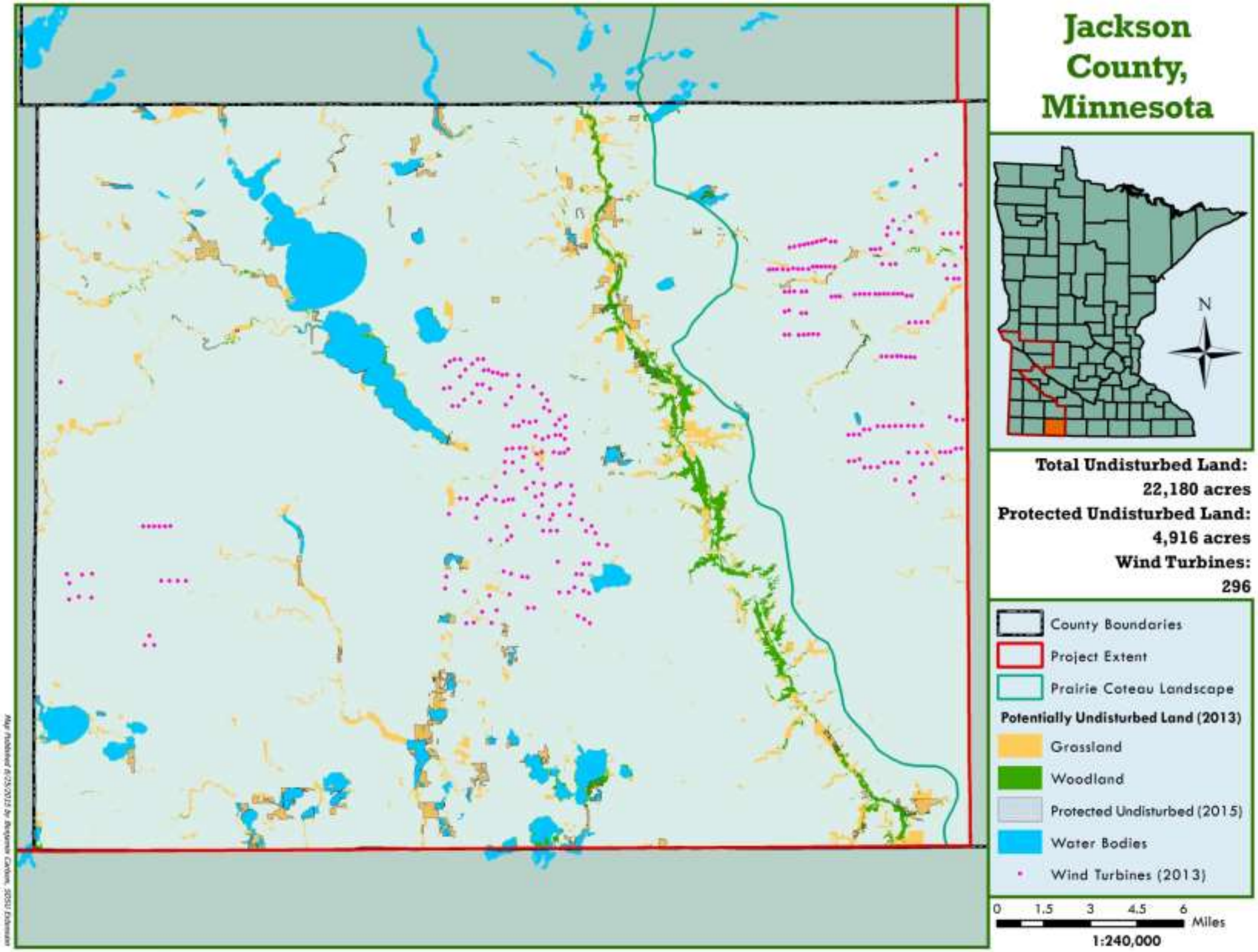
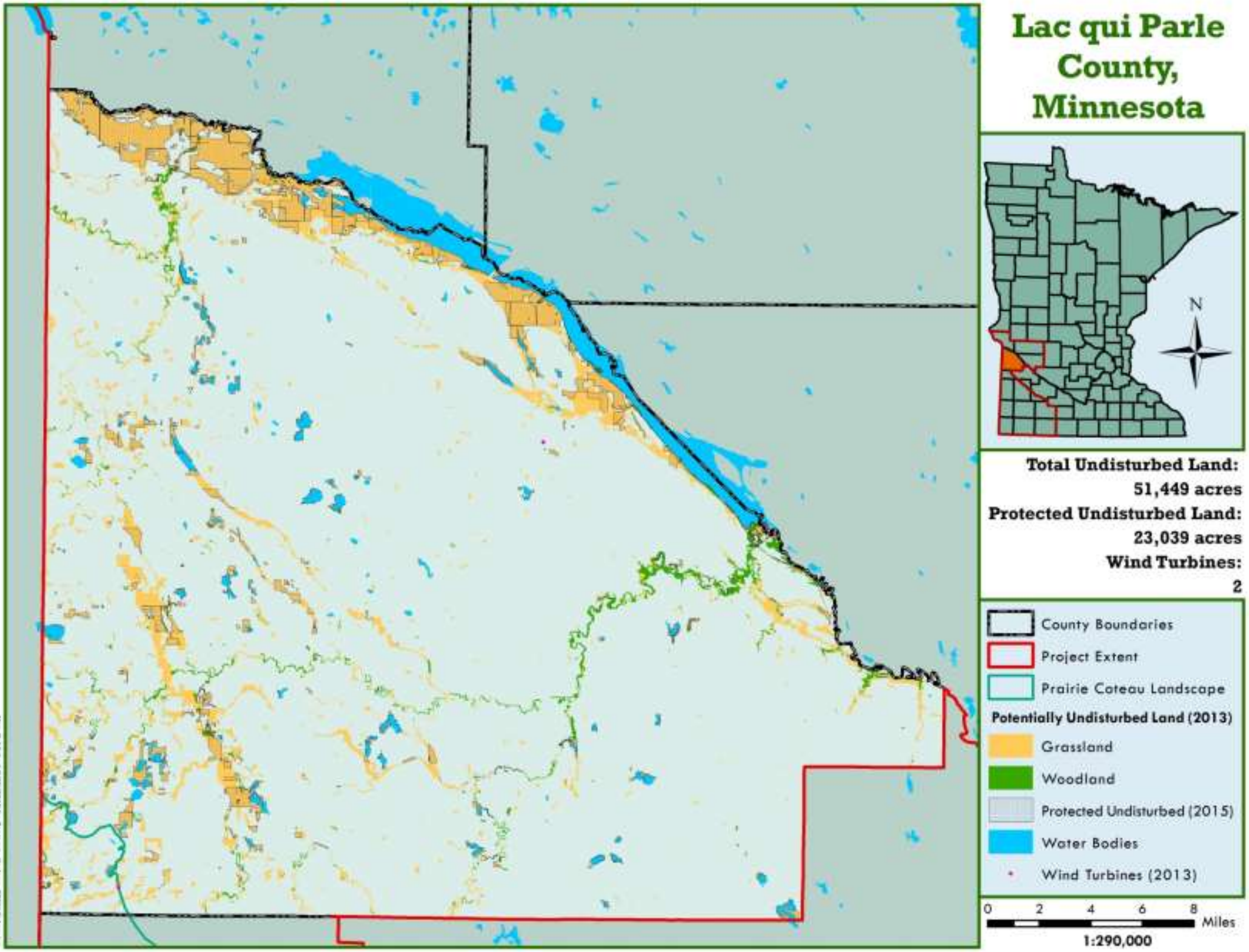
APPENDIX A: SOUTHWEST MN COUNTY MAPS

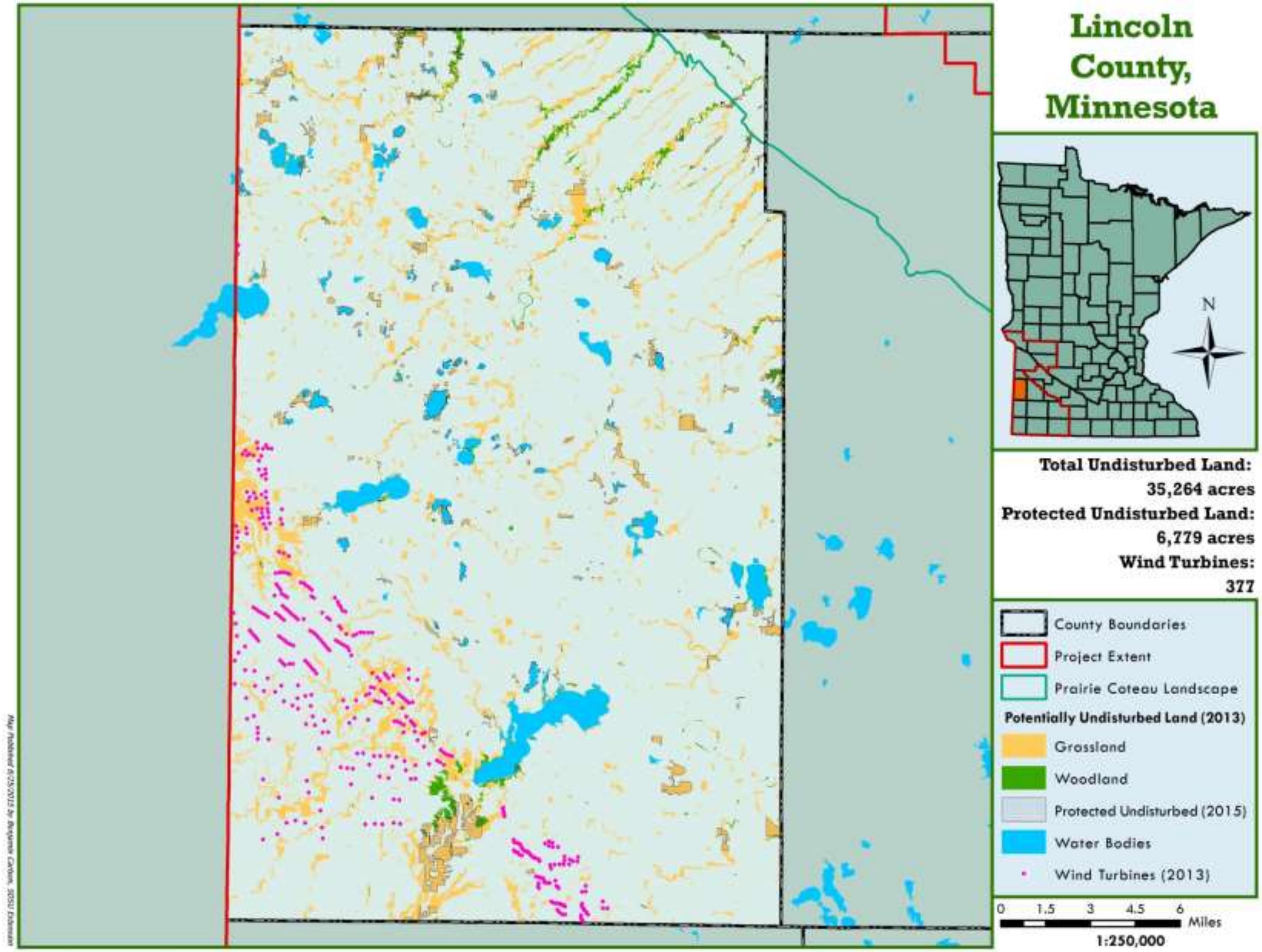

Big Stone County, Minnesota
N
Total Undisturbed Land:
33,413 acres
Protected Undisturbed Land:
16,464 acres
Wind Turbines:
0
County Boundaries
Project Extent
Prairie Coteau Landscape
Potentially Undisturbed Land (2013)
Grassland
Woodland
Protected Undisturbed (2015)
Water Bodies
Wind Turbines (2013)
0 2 4 6 8 Miles
1:280,000

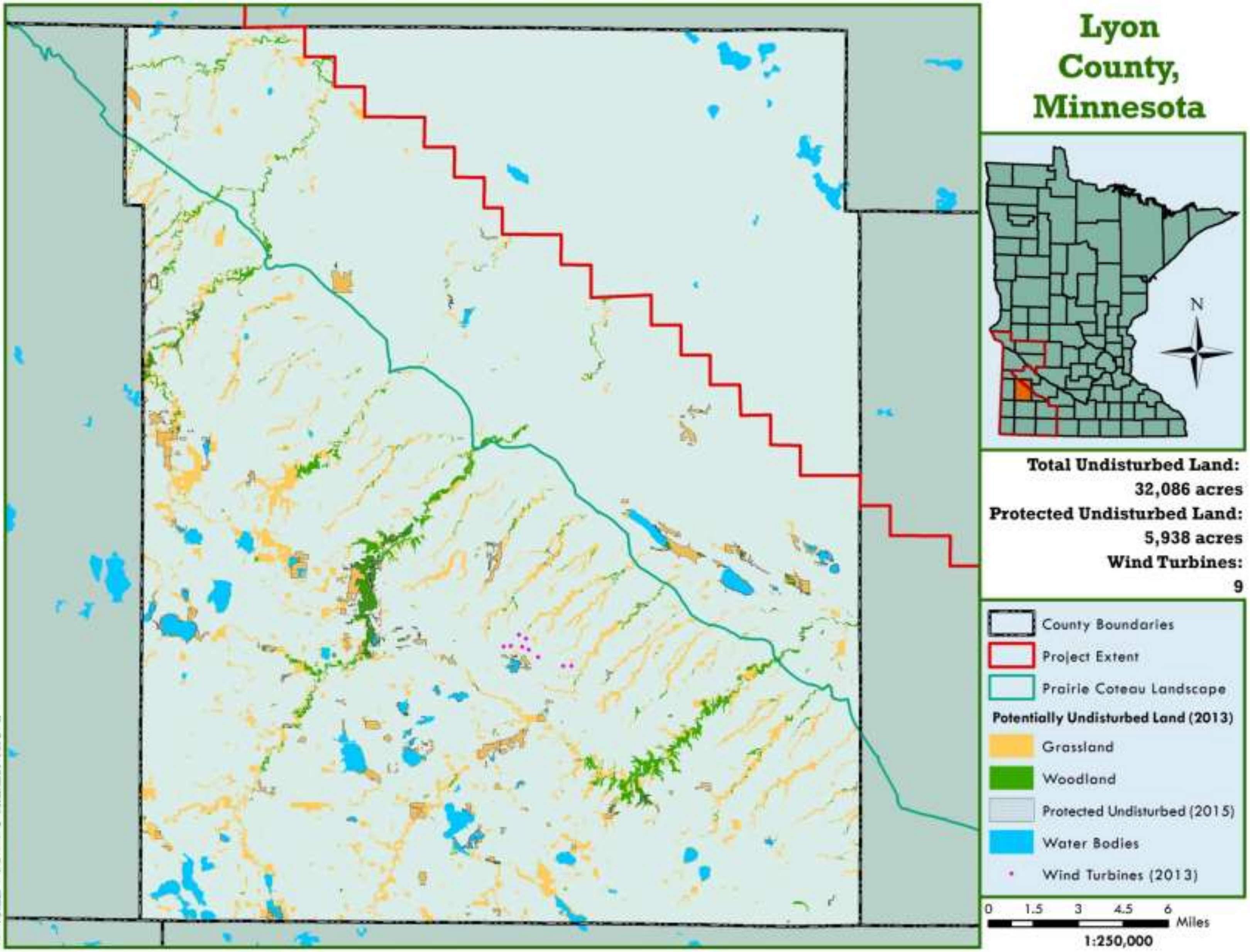

Chippewa County, Minnesota
N
Total Undisturbed Land: 24,279 acres
Protected Undisturbed Land: 8,571 acres
Wind Turbines: 0
County Boundaries
Project Extent
Prairie Coteau Landscape
Potentially Undisturbed Land (2013)
Grassland
Woodland
Protected Undisturbed (2015)
Water Bodies
Wind Turbines (2013)
0 2 4 6 8 Miles
1:310,000

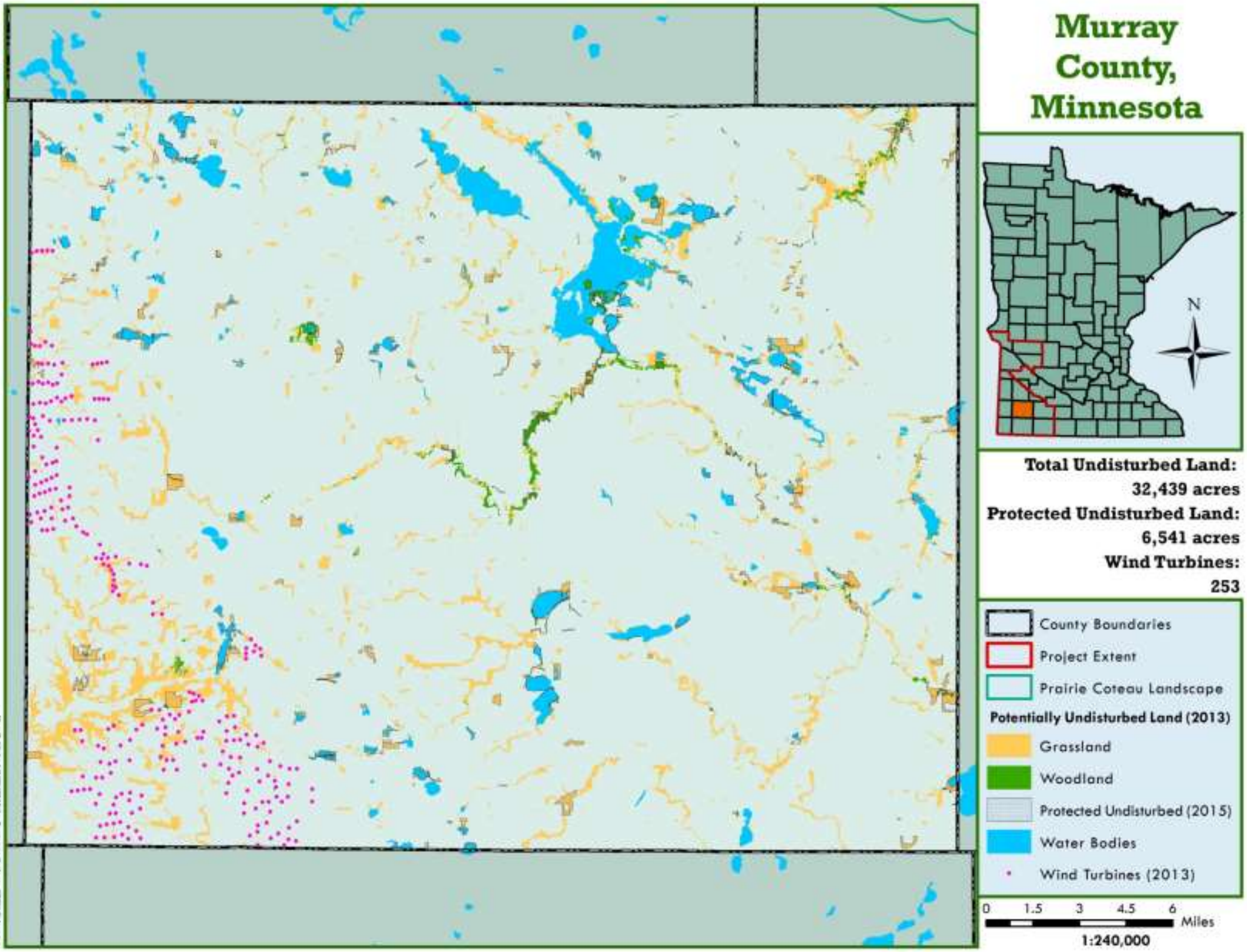

Cottonwood County, Minnesota
N
Total Undisturbed Land:
27,302 acres
Protected Undisturbed Land:
6,911 acres
Wind Turbines:
38
County Boundaries
Project Extent
Prairie Coteau Landscape
Potentially Undisturbed Land (2013)
Grassland
Woodland
Protected Undisturbed (2015)
Water Bodies
Wind Turbines (2013)
0 1.5 3 4.5 6 Miles
1:240,000

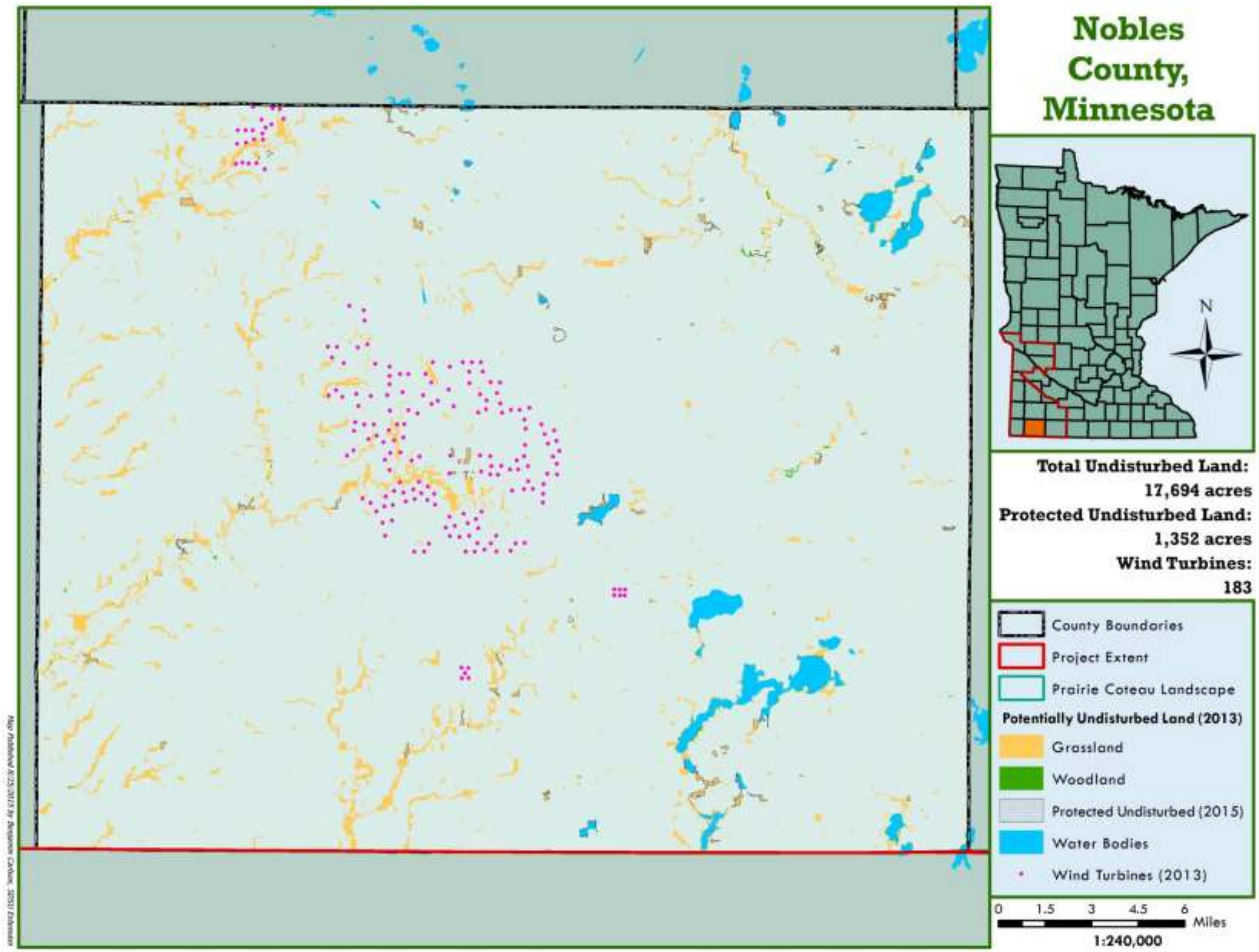

Jackson County, Minnesota
N
Total Undisturbed Land: 22,180 acres
Protected Undisturbed Land: 4,916 acres
Wind Turbines: 296
County Boundaries
Project Extent
Prairie Coteau Landscape
Potentially Undisturbed Land (2013)
Grassland
Woodland
Protected Undisturbed (2015)
Water Bodies
Wind Turbines (2013)
0 1.5 3 4.5 6 Miles
1:240,000

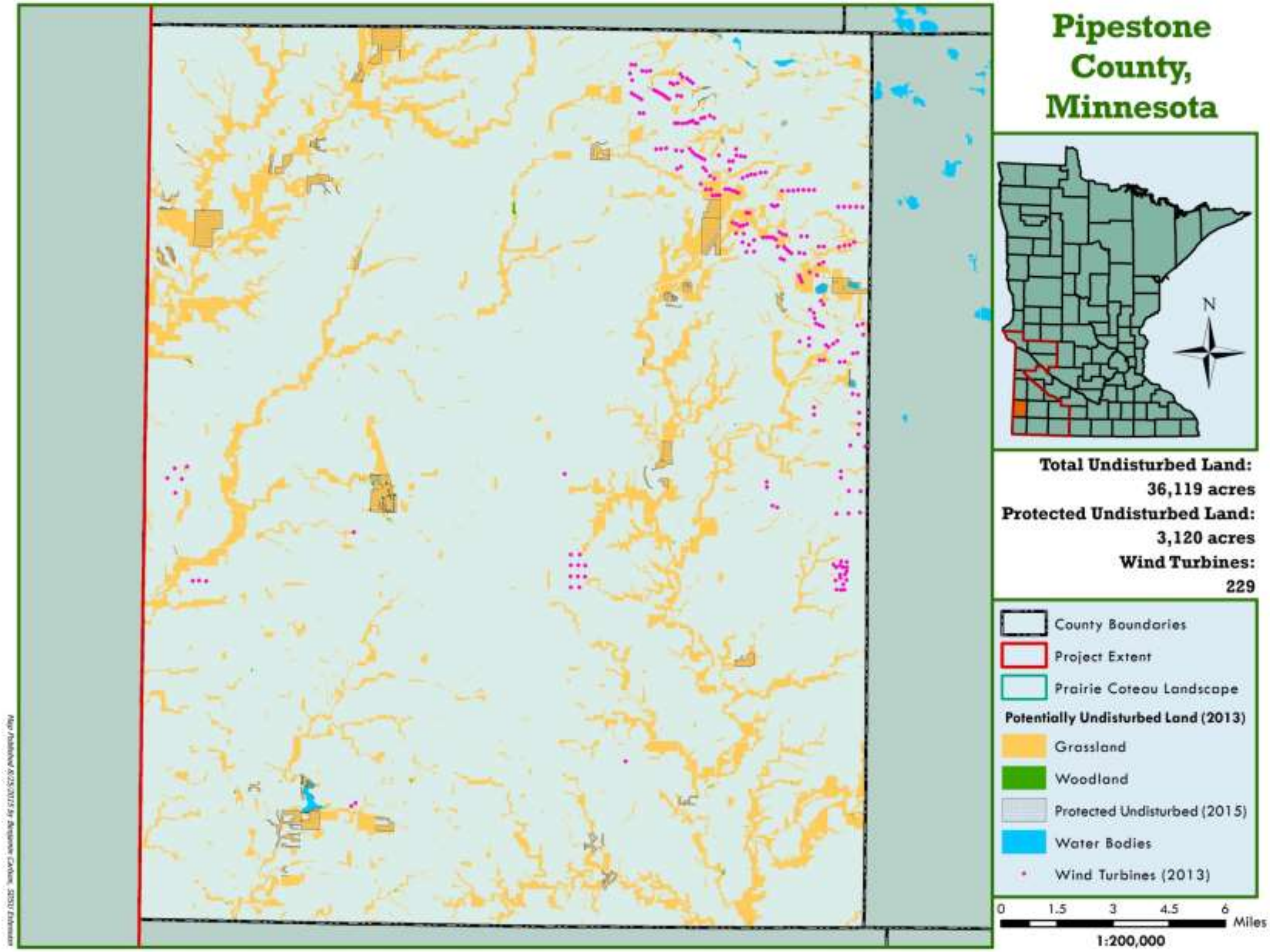

Lac qui Parle County, Minnesota
N
Total Undisturbed Land:
51,449 acres
Protected Undisturbed Land:
23,039 acres
Wind Turbines:
2
County Boundaries
Project Extent
Prairie Coteau Landscape
Potentially Undisturbed Land (2013)
Grassland
Woodland
Protected Undisturbed (2015)
Water Bodies
Wind Turbines (2013)
0 2 4 6 8 Miles
1:290,000

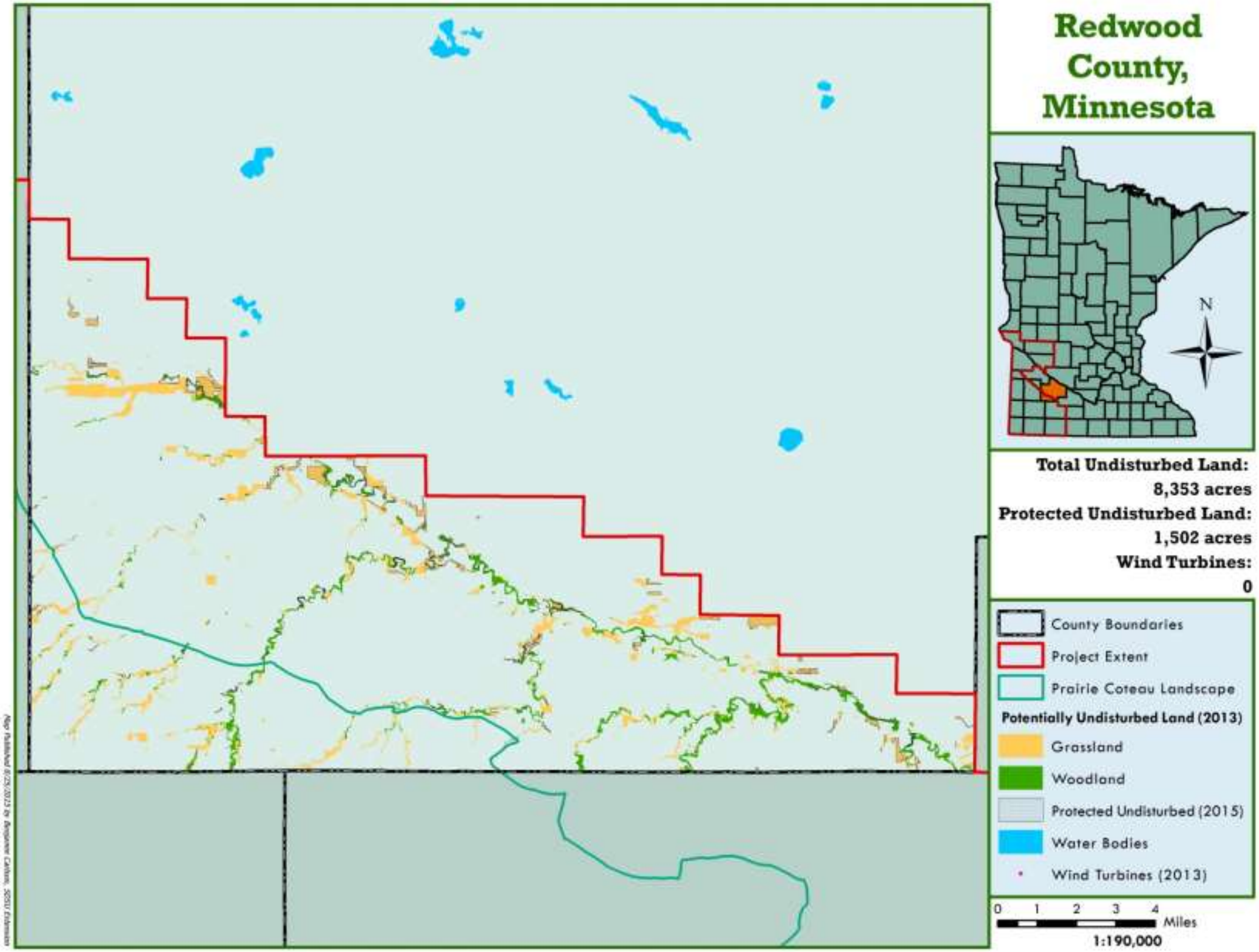

Lincoln County, Minnesota
N
Total Undisturbed Land:
35,264 acres
Protected Undisturbed Land:
6,779 acres
Wind Turbines:
377
County Boundaries
Project Extent
Prairie Coteau Landscape
Potentially Undisturbed Land (2013)
Grassland
Woodland
Protected Undisturbed (2015)
Water Bodies
Wind Turbines (2013)
0 1.5 3 4.5 6
Miles
1:250,000

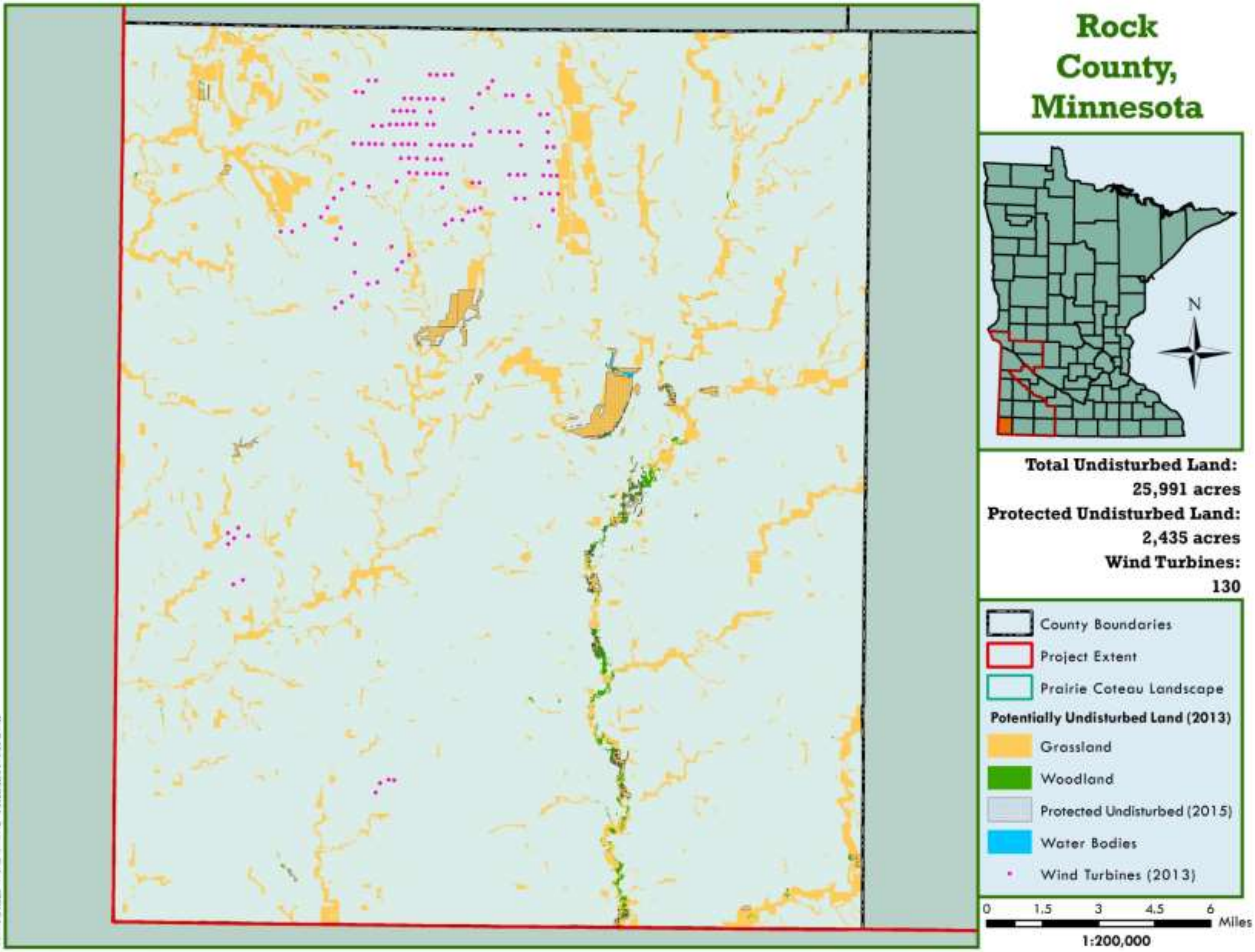

Lyon County, Minnesota
N
Total Undisturbed Land:
32,086 acres
Protected Undisturbed Land:
5,938 acres
Wind Turbines:
9
County Boundaries
Project Extent
Prairie Coteau Landscape
Potentially Undisturbed Land (2013)
Grassland
Woodland
Protected Undisturbed (2015)
Water Bodies
Wind Turbines (2013)
0 1.5 3 4.5 6 Miles
1:250,000

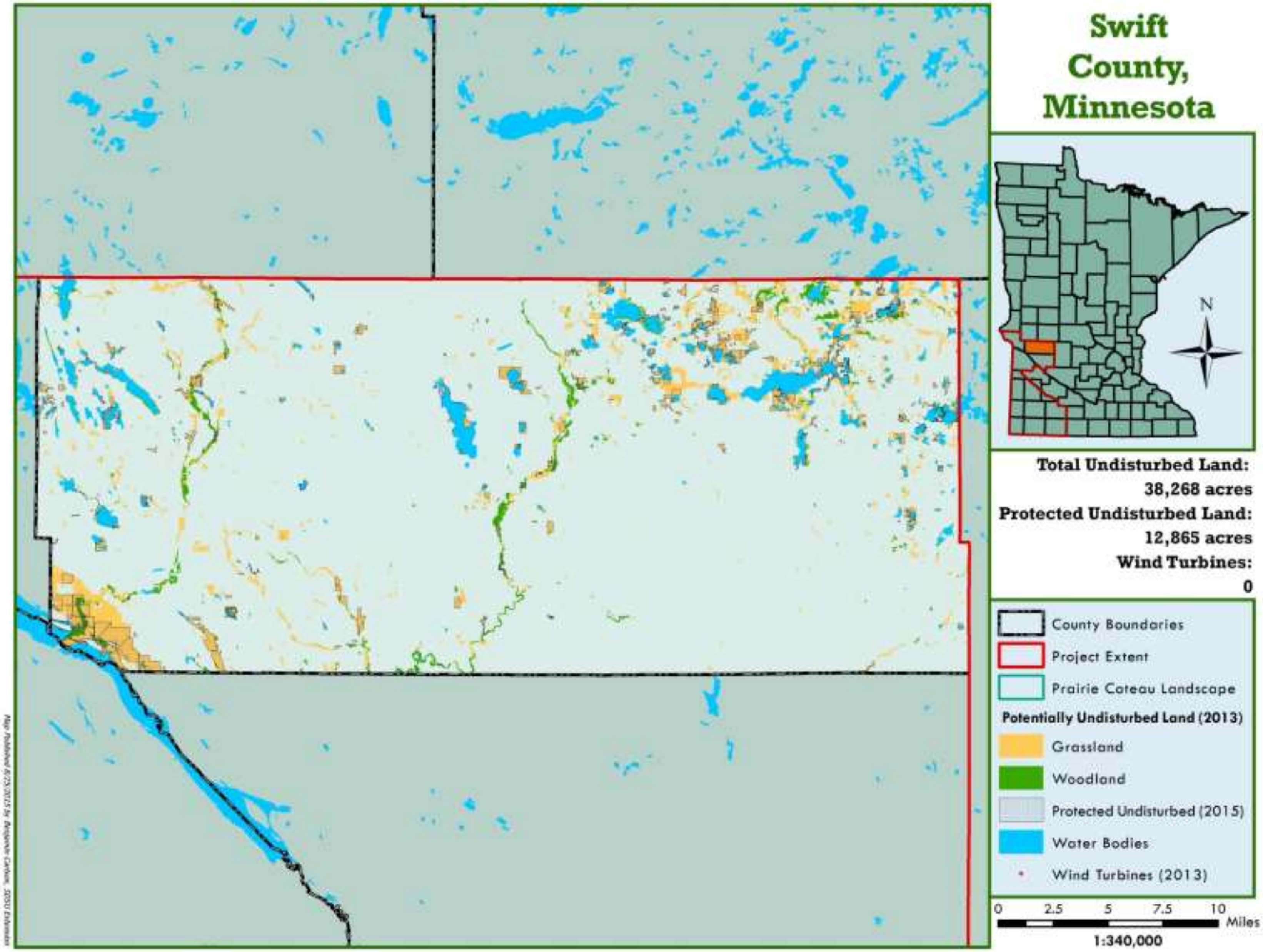

Murray County, Minnesota
N
Total Undisturbed Land:
32,439 acres
Protected Undisturbed Land:
6,541 acres
Wind Turbines:
253
County Boundaries
Project Extent
Prairie Coteau Landscape
Potentially Undisturbed Land (2013)
Grassland
Woodland
Protected Undisturbed (2015)
Water Bodies
Wind Turbines (2013)
0 1.5 3 4.5 6
Miles
1:240,000


Nobles County, Minnesota
N
Total Undisturbed Land: 17,694 acres
Protected Undisturbed Land: 1,352 acres
Wind Turbines: 183
County Boundaries
Project Extent
Prairie Coteau Landscape
Potentially Undisturbed Land (2013)
Grassland
Woodland
Protected Undisturbed (2015)
Water Bodies
Wind Turbines (2013)
0 1.5 3 4.5 6 Miles
1:240,000
Map Published 8/25/2015 by Benjamin Carlson, SDSU Extension


Pipestone County, Minnesota
N
Total Undisturbed Land:
36,119 acres
Protected Undisturbed Land:
3,120 acres
Wind Turbines:
229
County Boundaries
Project Extent
Prairie Coteau Landscape
Potentially Undisturbed Land (2013)
Grassland
Woodland
Protected Undisturbed (2015)
Water Bodies
Wind Turbines (2013)
0 1.5 3 4.5 6
Miles
1:200,000


Redwood County, Minnesota
N
Total Undisturbed Land:
8,353 acres
Protected Undisturbed Land:
1,502 acres
Wind Turbines:
0
County Boundaries
Project Extent
Prairie Coteau Landscape
Potentially Undisturbed Land (2013)
Grassland
Woodland
Protected Undisturbed (2015)
Water Bodies
Wind Turbines (2013)
0 1 2 3 4
Miles
1:190,000


Rock County, Minnesota
N
Total Undisturbed Land:
25,991 acres
Protected Undisturbed Land:
2,435 acres
Wind Turbines:
130
County Boundaries
Project Extent
Prairie Coteau Landscape
Potentially Undisturbed Land (2013)
Grassland
Woodland
Protected Undisturbed (2015)
Water Bodies
Wind Turbines (2013)
0 1.5 3 4.5 6 Miles
1:200,000


Swift County, Minnesota
N
Total Undisturbed Land:
38,268 acres
Protected Undisturbed Land:
12,865 acres
Wind Turbines:
0
County Boundaries
Project Extent
Prairie Coteau Landscape
Potentially Undisturbed Land (2013)
Grassland
Woodland
Protected Undisturbed (2015)
Water Bodies
Wind Turbines (2013)
0 2.5 5 7.5 10 Miles
1:340,000

REPORT SUGGESTED CITATION

Bauman, P. J., B. Carlson, and T. Butler. 2015. Quantifying Undisturbed Land in Minnesota's Prairie Coteau and Lac qui Parle Valley Regions. A report to The Minnesota Department of Natural Resources from South Dakota State University. MN Joint Powers Agreement No. 85003. 51 pp.