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Quantifying Undisturbed (Native) Lands in Northwestern South Dakota: 2013

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NATURAL RESOURCE MANAGEMENT DEPARTMENT

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Note of thanks: Special thanks to Ben Carlson, our Lead Technician, for his extraordinary work refining a majority of the protocols for this ongoing project. Ben was overworked and underpaid, but his dedication to the task at hand was remarkable. Ben is retiring from the undisturbed land inventory project after 2.5 years. His steadfast presence will be missed as he furthers his career and his impact on conservation of our native resources. Good luck Ben!

Note to the Reader:

This interim report for northwestern South Dakota is a continuation of a statewide analysis to determine the location and extent of potentially undisturbed (native) land.

To assist the reader in identifying significant updates and new information, we have added light blue shaded boxes whenever there is a significant addition or modification to background, methods, data, sources, observations, or analysis techniques from previous reports.

This report is designed to be a stand-alone document for the northwestern region, but it will be superseded upon completion of western South Dakota, at which time the information herein may be updated and rolled into a comprehensive western South Dakota report. Even though this is an interim report, it is meant to fully inform the reader regarding all methods, data sources, observations, and analysis techniques used in this region. Therefore, a great deal of information is repeated from previous reports.

Northwestern South Dakota presented unique opportunities and challenges when applying our landscape evaluation methods developed for eastern South Dakota. As an example, the patterns and landscape indicators associated with several categories of go-back and rangeland manipulation found in northwestern South Dakota, while obviously present, have irregular shapes and less definable edges that often 'feather' into truly virgin sod areas. Thus, our team had to employ an interim technique of 'flagging' these areas for further analysis (see Methods section for a complete discussion on these issues).

Executive Summary:

We employed simple GIS methods primarily utilizing the South Dakota Farm Service Agency's Common Land Unit (CLU) data layers from 2013 and the 2012 United States Department of Agriculture (USDA) National Agriculture Imagery Program (NAIP) county mosaic aerial imagery to evaluate 7,347,812 acres of land in northwestern South Dakota. The analysis area includes: Harding, Perkins, and Butte counties along with portions of Lawrence and Meade counties outside of the Black Hills Core Highlands and Plateau Ecoregions.

We utilized the FSA CLU data layer queried to show current and former cropland to identify and remove any areas with cropping history regardless of current land use. We analyzed the remaining land in approximately one mi^2 sections to identify and remove additional historic or current land disturbances. The remaining land tracts were categorized as potentially 'undisturbed grassland' or 'undisturbed woodland' by simple reason of deduction. Finally, we removed all known water bodies larger than 40 acres as defined by the South Dakota Department of Game, Fish, and Parks' (SDGFP) Statewide Water Bodies layer to gain a more accurate interpretation of the remaining undisturbed grassland/ wetland complex.

Overall, 5,743,137 acres (78.2%) of the approximately 7.3 million-acre analysis area was designated as potentially undisturbed by our initial analysis (Figure 1). However, a portion of these undisturbed acres have certain indicators suggesting historical disturbance, thus 17,263 locations were flagged as potential 'go-back'

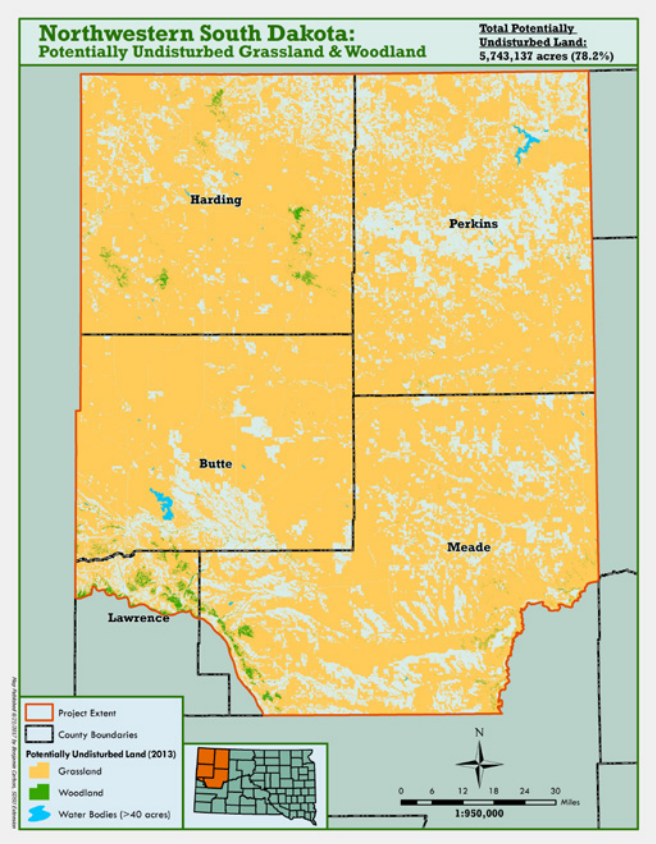

Figure 1: Northwestern South Dakota: Undisturbed land.

areas (see updated Methods section). In addition to go-back areas, we also identified over 300 locations with indicators of some type of native rangeland manipulation other than historic cropping.

Because of limitations evaluating historic land patterns with NAIP imagery, it was not possible to accurately calculate actual area estimates for these flagged locations. However, we were able to perform an initial area analysis of go-back sites using polygons in portions of Harding and northern Perkins Counties which suggests the combined impact of go-back fields and rangeland manipulations may impact about 10% of the undisturbed land layer. Therefore, we speculate the actual undisturbed (potentially native) land area for this region may be reduced from the current 78.3% down to roughly 68% if we can refine our methodologies to more accurately reflect these disturbances in the future. We anticipate future LiDAR analysis will aid in improving such accuracy.

To provide the reader with a better understanding of the distribution of these flagged disturbances, we analyzed the number of legal sections of land (as defined by the 2000 Public Land Survey) that had at least one indicator of disturbance against the total number of legal sections in the analysis area. We found that 7,558 out of 11,580 (65.3%) legal sections had at least one indication of disturbance within the section (either a go-back site or rangeland manipulation site within the undisturbed land layer).

Of the approximate 7.2-million-acre total analysis area, 1.4 million acres (19%) were deemed to have a cropping history according to the FSA CLU data. 193,570 acres (2.6%) were found to have some type of land disturbance not indicated by a CLU crop code. Totaling 1.59 million acres (21.7%) of all land with some type of proven disturbance history. Leaving roughly 5.7 million acres deemed undisturbed.

Within the approximate 7.2-million-acre total evaluation area, 12,315 acres (0.2%) were found to have some sort of permanent protection from conversion (some of these acres have a disturbance history). Only 10,835 acres of the approximately 5.7 million acres of undisturbed land (0.2%) had some level of permanent conservation protection status. The 10,835 acres of potentially undisturbed land that is officially protected from future conversion represents only 0.1% of the analysis area for the five northwestern South Dakota counties.

Within northwestern South Dakota we identified 298 oil wells, drill sites, and associated facilities/developments. These sites are primarily located in the Sagebursh Steppe Ecoregion of Harding County. Of the sites identified, 262 (87.9%) were located adjacent to undisturbed areas (within 250 feet, see Methods section).

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Introduction:

Northwestern South Dakota is one of the state's most iconic regions. Ancient geology and vast expanses of mid and short grass rangelands are managed primarily as private ranchland with large tracts of interspersed public land. To the casual observer, most of these open grasslands could be mistaken for undisturbed or native rangeland (those that have never been cultivated or mechanically disrupted for agriculture or other uses). However, vast swaths of this region have been subjected to mechanical manipulations and cannot be considered native grasslands. Understanding the location and extent of the remaining native habitats is an essential first step to ensure the future of these important natural resources.

In 2014, South Dakota State University and The Nature Conservancy initiated a pilot project to analyze undisturbed land in the 17-county Prairie Coteau region of eastern South Dakota (project Phase I). 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 of that analysis was the utilization of the 2013 South Dakota Farm Services Agency's (FSA) Common Land Unit (CLU) data layer.

Based on methodology developed during this initial pilot project, we employed similar (albeit more refined) methods for the analysis of southwestern Minnesota (Phase II) and the entire eastern South Dakota region during Phases III and IV (Figure 2) (Bauman et al.2014, 2016).

Understanding the land 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. In eastern South Dakota, we were able to estimate the amount of protected undisturbed land in the 44-county region by intersecting the undisturbed layer produced by our analysis with a collection of ownership and easement boundaries acquired from a variety of conservation organizations and agencies.

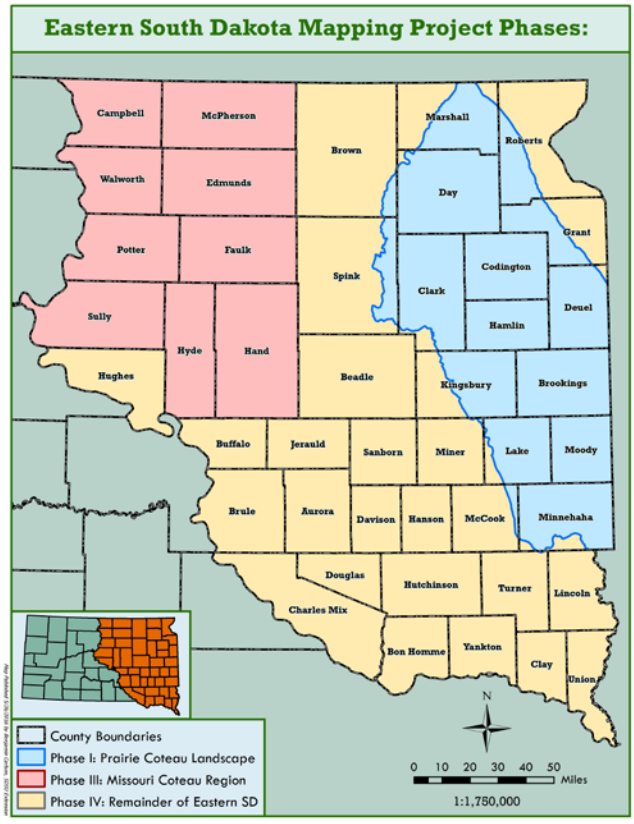

Figure 2: Eastern South Dakota: Geography of prior project phases.

Similarly, the information provided in this report will inform future management decisions for the northwestern South Dakota landscape, and will also serve as a baseline for which to compare the future status of native and non-native habitats in that region.

Methods

This northwestern South Dakota Report (Phase V-interim) is a continuation of the project methodology and reports previously completed for eastern South Dakota and southwest Minnesota. Therefore, the data sources and analysis protocols outlined below are largely similar to those covered in previous reports except where noted.

We assessed the history of land use in this five-county area via simple layering and data editing methods in ArcGIS to deduce the location and size of land tracts that are potentially undisturbed (native) habitats regardless of current vegetation type or quality. We utilized the South Dakota Farm Services Agency's (FSA) Common Land Unit (CLU) layer from 2013 along with 2012 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 1:8,000 to analyze approximately 7.3 million acres (11,481 mi.^{2}). The 1:8,000 minimum map scale was selected to allow technicians to view a full square mile section (640 acres) of land on a typical computer monitor when evaluating land use. Greater scales ranging up to 1:800 were used on occasion for analyzing smaller tracts of land to aid in the precision of polygon creation, and assist in accurately identifying sites of historic disturbance (i.e. go-back fields and range manipulation sites).

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 that fall under this 'disturbance' definition. Likewise, we define 'undisturbed' land as soil that has not been mechanically manipulated or has not experienced 'iron in the ground' practices. These 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.

However, to ensure source data was interpreted consistently and that only disturbed/manipulated sites were removed from our undisturbed land inventory, we required definitive proof in either vector data or aerial photography to consider any area as 'disturbed'. Therefore, within the lands classified as 'undisturbed' by our assessment, lie land tracts that may have been farmed or otherwise manipulated historically (including go-back fields and rangeland manipulation), but which lack definitive indicators and therefore cannot be systematically identified as 'disturbed' within the context of our analysis methods and criteria at this time. This includes many areas which contain indications that historic disturbance may have occurred, but no data (aerial photography or CLU data) was able to confirm disturbance, as well as areas where definitive indicators of tillage or disturbance were confirmed, but the extent (edge) of the disturbance could not be ascertained. (Note: we intend to re-assess these areas in the future via the use of LiDAR or other technology that will allow improved/definitive interpretation of these areas).

Unlike eastern South Dakota, where old field edges were often definitive (more or less), northwestern South Dakota's soils and natural geological patterns coupled with a variety of historic land use practices made defining old field edges and other disturbance patterns difficult. We did not want to risk the removal of truly undisturbed lands by using subjective interpretations, so we developed a more refined protocol for flagging these areas for future analysis using both points and polygons. This allowed us to retain these areas in the 'undisturbed' land classifications until additional data refinement can prove the presence or extent of a disturbance history. The types of possible disturbances that were flagged for future analysis are defined in Table 2.

Significant to the northwestern SD landscape is the use of rangeland manipulation practices that were rarely documented in eastern SD. These practices were conducted to improve rangeland production

Table 1: Disturbance Categories and Associated Land Use Types That Constitute Disturbed Land and That are Removed.

Agricultural Disturbance or Cultivation	• Currently cultivated cropland • 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 • Developed 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, maintained 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, scoria, and sand pits • Rock quarries • Mechanically exposed earth • Wind turbines, turbine pads, and access roads • Oil wells, drill sites, associated facilities, and access roads • Large earthen dams and spillways for reservoirs larger than 40 acres • Factories, power plants, and other built up industrial or commercial areas

over large areas and often involved some degree of mechanical manipulation to the soil, such as terracing and contour furrowing. Because the extent of these practices were often difficult to define and the areas subject to these practices were not completely disturbed; we elected to simply flag these areas in a manner similar to other possible historic disturbances. These rangeland manipulation practices are outlined in Table 2 as well.

Understanding the FSA Common Land Unit Data

The Common Land Unit (CLU) data layers are geographic datasets developed and managed by each Farm Service Agency (FSA) county office 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.

Common Land Unit data was established in 1998 and contains land use data tracked using paper maps since the beginning of the Soil Bank program 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 and tracked 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. These include 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. The 3-CM Cropland Indicator (instituted in 2012) 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 within South Dakota, rather it is a continuously updated data layer. However, South Dakota counties do annually report to the state FSA office which then provides an annual South Dakota dataset to the national FSA office, which is then archived in the USDA Aerial Photography Field Office. Because the 3-CM Cropland indicator has only been used since 2012, it is difficult to compare data for years prior to 2012. Therefore, the current CLU layer cannot readily be compared to any past CLU

data to analyze land use trends over time, although CLU data from 2005 was used to remove suspected old fields apparent in aerial imagery in cases where the 2013 CLU data was missing, removed, altered, or otherwise incorrect. CLU data for 2013 was chosen for this project since this was the most recent year that CLU and NAIP Aerial Imagery data coincided for the South Dakota project area at the commencement of the project. It is also the first year available for South Dakota in which the Cropland 3-CM indicator was used.

While both the general crop and non-crop codes are fair indicators of major land use trends across a broad region, the nuances associated with the CLU crop and non-crop codes cannot provide a precise measure of either disturbed or undisturbed lands.

The 2013 South Dakota 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 from accessing personal landowner data as well as sharing or directly incorporating these data files into any product developed through this project.

Several USDA FSA documents were referenced as we developed our methodologies for interpreting CLU data, especially concerning the interpretation of cropland and out-of-state CLU records. See FSA References section of this report for the list of specific documents pertaining to the creation and use of CLU records. From these documents, we have found several CLU land use designations. The significance of which are described as follows:

Crop

Within the 'crop' designations are farm fields that have a history of being cropped and are still considered eligible for USDA cropland programs (such as direct and counter-cyclical payments). 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 (although many of these fields were presumably cropped for many years prior). 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 of historic and current cropland in any given county. For a complete definition of 'cropland' as it applies to the 3-CM cropland indicator in the CLU dataset, see Subparagraph 25 B (page 2-6) in the FSA Handbook 3-CM (Revision 4): Farm, Tract, and Crop Data.

Non-Crop

Within the 'non-crop' designation are all land 'units' that are currently un-cropped or designated as a field where cropping: 1) has never occurred, 2) occurred prior to tracking by USDA programs (circa 1950s), or 3) will no longer occur due to a change of ownership or use that impacts future use or disqualifies the land from eligible cropland status in USDA programs (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 (i.e. conversion of native or virgin sod) 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 new field area 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 or recorded 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 our analysis, mapping technicians would still identify the disturbance using the aerial imagery and thus categorize the field as disturbed and remove it from the undisturbed land layer.

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 cropland to non-cropland designation in certain instances, such as when the tract is permanently taken out of possible future crop production due to a change in land use. 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.). This reclassification is allowed according to Subparagraph 25 J (page 2-8) in the FSA Handbook 3-CM (Revision 4).

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). If such a change makes a certain tract ineligible for cropland status under USDA programs, the tract may (but not always) be changed to non-crop. See Subparagraphs 25 H and I, and Paragraph 26 in FSA Handbook 3-CM (Revision 4) for a complete list of instances were conservation lands are either removed from or retained in the CLU cropland classification.

Under these circumstances, historic cropping may be much more difficult to identify, especially if significant time has passed for the land to have been actively converted, or in some cases passively 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 on conservation lands even under a non-crop designation. A food plot or hayfield on property owned by South Dakota Department of Game, Fish, and Parks is a good example of cropping on conservation land that may have been re-classified as non-crop at the time of purchase by the state.

In South Dakota, private land conservation easements held specifically by the US Fish and Wildlife Service (USFWS) or other conservation organizations can be reclassified from cropland to non-cropland 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 conservation lands are usually inconsistent. Thus, many grassland easements may be incorrectly classified as undisturbed under our analysis methods and may require additional review, as discussed below. Generally, reclassification due to this type of conservation easement is not found in western South Dakota.

Complete Removal of CLU Data Records

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. Although relatively rare, 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 across counties and is likely dependent on a variety of local 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 required other data sources to consistently confirm disturbance on conservation lands. To accomplish this, we acquired land use and vegetation cover data from specific conservation and habitat entities including the US Fish & Wildlife Service, South Dakota Department of Game, Fish, and Parks, Ducks Unlimited, The Nature Conservancy, and others.

USDA Allowance of Out-of-County Land Records

The USDA allows for county offices (such as FSA) to track all the properties owned by an individual landowner enrolled in USDA programs including lands that occur outside the county boundary or even in an adjacent state. The determination and allowances for transferring records between counties and states is described in Part 3 of FSA Handbook 3-CM (Revision 4). For example, Figure 3 depicts the distribution of 2013 CLU records for Brown County, SD, which includes lands recorded under Brown county that occur in 10 area counties as well as in North Dakota.

To address this issue, we were able to secure and

utilize FSA CLU data for all surrounding states (MN, IA, NE, WY, MT, and ND) via a multi-year, multi-state MOU, thus our analysis for northwestern SD includes complete FSA CLU data for all counties. Such CLU data for tracts administered by bordering states are necessary to create a complete coverage of CLU data in South Dakota.

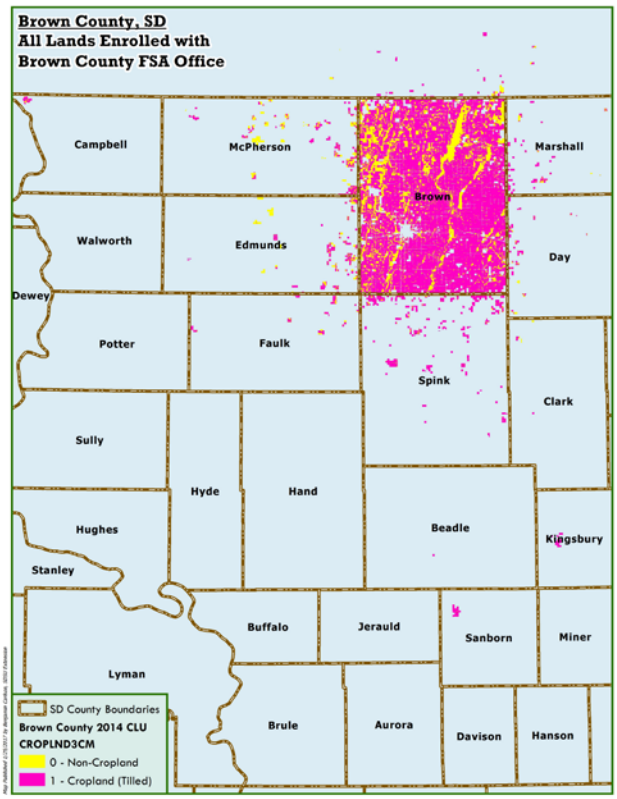

Figure 3: Geographical distribution of 2013 of Farm Service Agency Common Land Unit (CLU) data for Brown County, SD.

CLU Discrepancies Involving Cropland Misclassification or Spatial Errors

We accepted FSA CLU cropland indicators as measured data, and removed all lands with a cropping history based on this data. Although FSA CLU data is an excellent resource for our analysis, it is not without certain errors.

During our analysis of northwestern South Dakota, we occasionally encountered other discrepancies in the CLU Data. These discrepancies usually involved instances where we thought the "Cropland" classification was incorrect based on all available aerial imagery or else the CLU polygon boundaries did not match what we considered to be the appropriate field boundaries apparent in the imagery.

The first major discrepancy includes various edge errors, where the CLU field boundary simply does not match the field boundary shown on the current or historical aerial imagery. These can result from changes in aerial photo/source data quality, spatial data projection, or simply transcribing errors. In addition, some recent grassland conversions were mapped in the CLU to the edge of the property or section lines and not the actual field edge, which resulted in the removal of some native grasslands adjacent to crop fields from our undisturbed layer

The second major discrepancy is the misclassification of untilled or undisturbed land as cropland. These are likely simple human errors resulting from misinterpretation or poor information, in which case certain tracts were simply incorrectly coded with a value of "1" (crop) in the 3-CM Cropland Indicator field (Figure 4).

The third major discrepancy is land that appears tilled, but has no crop indicator in the 2013 CLU data, but does have a crop indication previous CLU data. We speculate these errors are simply due to FSA's recategorization of certain CLU parameters in 2011.

Because we accepted CLU layers as measured data and we could not systematically provide a review of all CLU polygons. We removed all tracts of land falling under CLU "Cropland" polygons regardless of our confidence in the accuracy of the CLU data. In some instances, we marked these discrepancies for future analysis, but an effort by individual county FSA offices would be necessary to systematically rectify CLU discrepancies in the future.

Deductive 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 3 of the Results section of this report.

Step 1: Interpreting CLU Data

Mapping technicians working at a scale of 1:8,000 or greater, analyzed base layers including 2012 NAIP aerial imagery and 2013 South Dakota FSA Common Land Unit data. The CLU data was queried and symbolized to show which fields have a cropping or tillage history indicator. This first-level analysis allowed us to identify areas without a recorded cropping history (non-crop) for additional analysis using aerial photography and other land use history data.

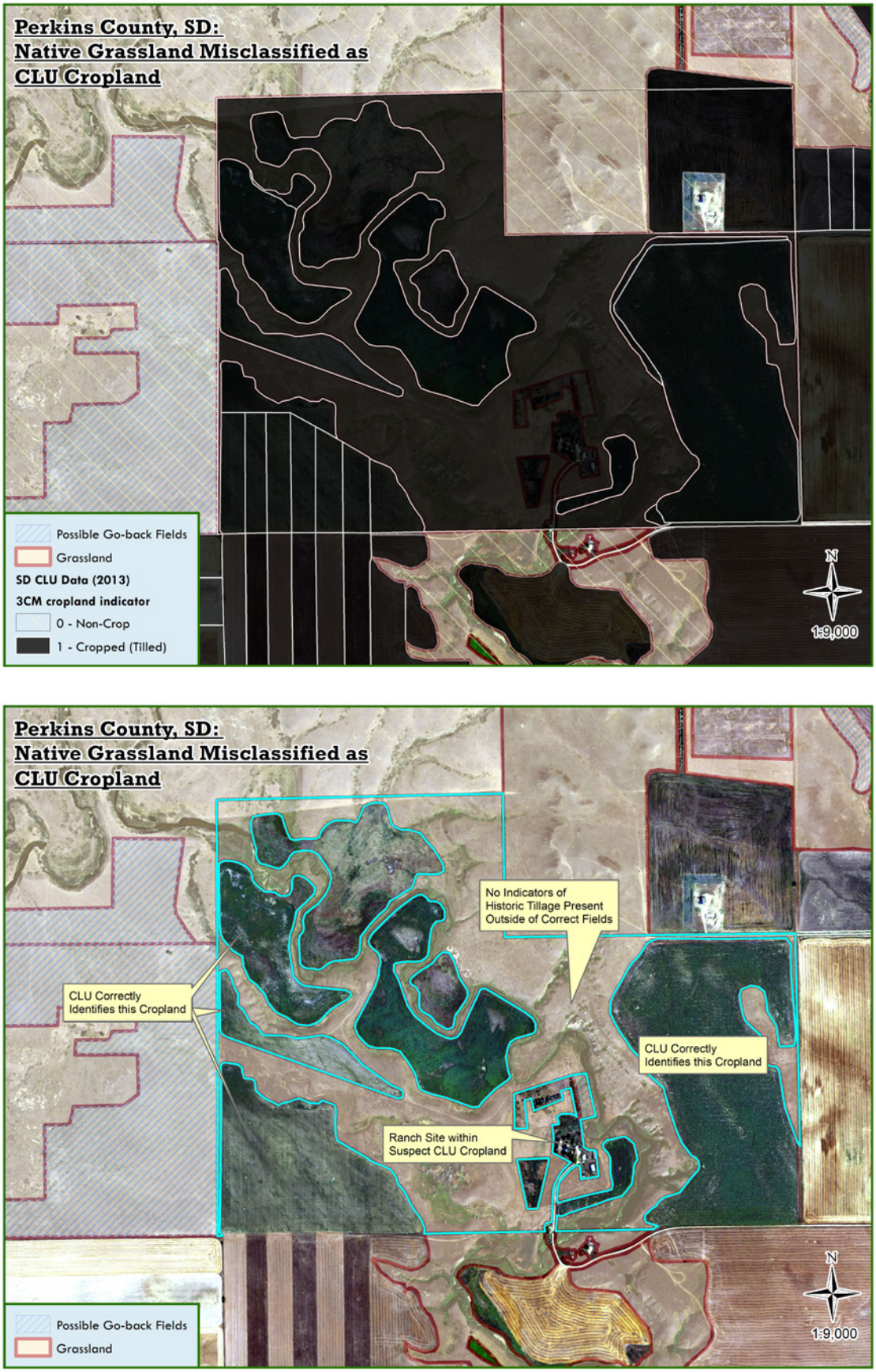

Figure 4: Northwestern South Dakota: Example of land tract portions misclassified by CLU data as cropland (top) with correction (bottom).

We 'accepted' FSA crop data as accurate measured data, regardless of certain anomalies that occasionally indicated a land unit may be potentially misclassified regarding actual land use history or else topologically or orthographically incorrect due to inconsistencies in digitizing by FSA offices (see section on Understanding the FSA CLU layer above and the Common Land Unit Cropland Results section below). Indications of cropping history misclassification were uncommon and in no case did we include a tract with a 3-CM 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 option 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

Interpreting the 'other disturbances' detailed in Table 1 comprised the primary focus of our work. After removal of the FSA CLU cropland, technicians then incorporated our deductive process of identifying potentially undisturbed (native) grasslands and woodlands by evaluating remaining land tracts for indicators of historic or current disturbance. Once identified, these disturbed areas were permanently eliminated from further analysis and were not tracked or mapped categorically. However, tracts that were suspected of having prior disturbance, but where disturbance could not be verified, were delineated and flagged as potential 'go-back' lands with an uncertain history, as discussed in step 3, below.

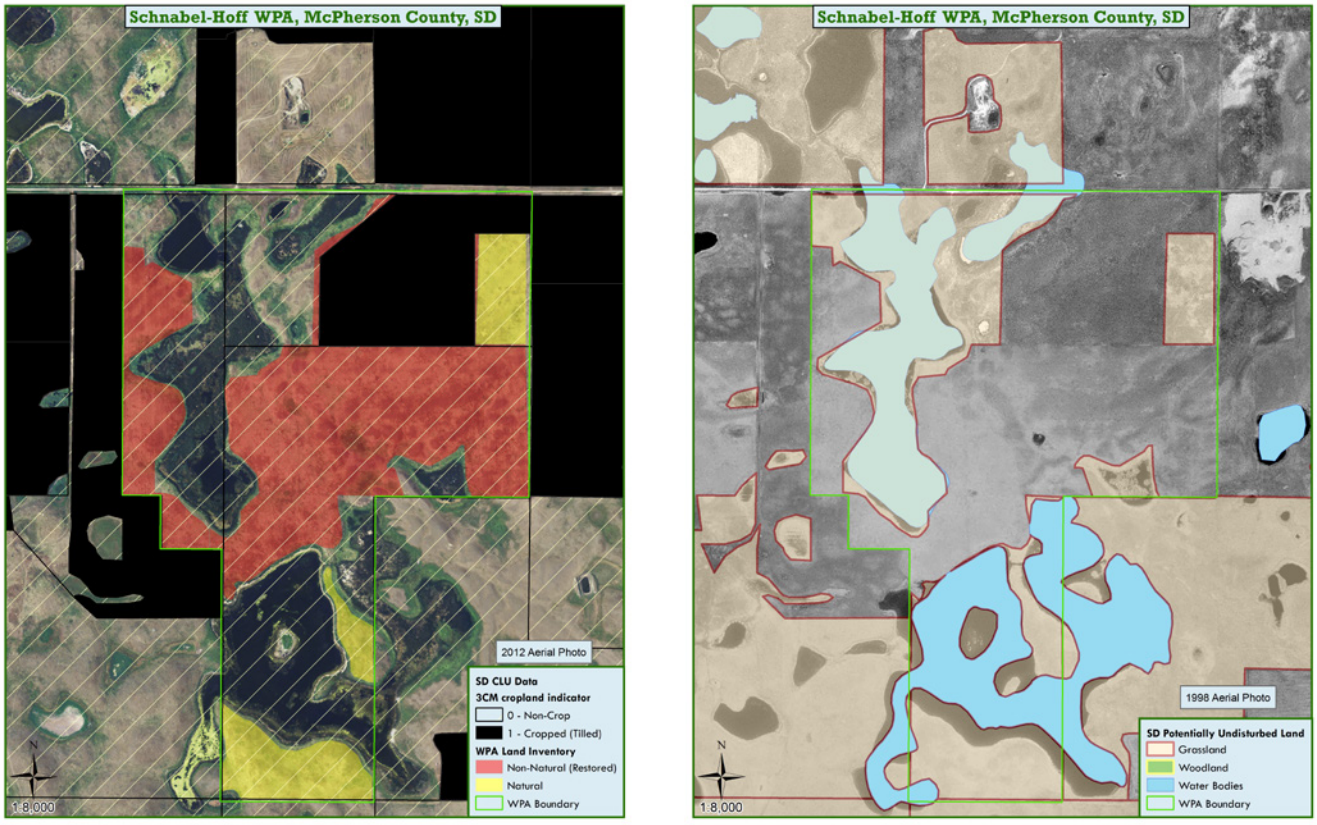

Figure 5: Example: Image at left depicts an area of McPherson County, SD, during initial analysis. Areas in black represent fields with a CLU 'crop' indicator code that were removed, leaving all non-blacked out areas (including 'non-cropland' designated CLU tracts, in cross-hash marks at left) to be further analyzed. 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 USFWS cover types (native prairie, grassland restorations, old hayfields, etc.), land use data (colored areas, left) and historic 1998 USGS imagery (right). Ultimately, based on all known factors, final potentially undisturbed land tracts are identified and cataloged in the database as seen in the image at right (grasslands [beige]).

To complete step two, several 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. Streaming aerial photography from the ESRI web map service and Google Earth were utilized to identify disturbances, along with indicators of possible go-back fields and rangeland manipulation sites, where the resolution of the 2012 aerial imagery and 1990's DOQQ imagery precluded such.

Figure 5 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.

We gathered and applied land cover and land use history data from state and federal agencies and conservation entities when available. 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 history categorization. The specific management data layers were queried and symbolized to show areas that were restored or historically disturbed.

It is important to note that small or isolated land manipulations that were difficult to identify at the mapping scale and that do not significantly impact the total acreage assessments usually remain in the final inventory of undisturbed lands. Examples include: pasture and field roads with no indicators of being excavated or built up, hay and forage storage yards, corals and other small livestock holding and feeding areas, abandoned homesteads not readily identified on aerial photographs, singular isolated buildings such as calving sheds and hunting cabins, unmaintained historic burial sites or abandoned pioneer cemeteries, single rows of planted trees, excavated or constructed wind breaks for cattle or along highways, livestock dams and dugouts and their associated spoil piles (when the reservoir is less than 40 acres), small or isolated irrigation or drainage ditches and terraces in grasslands, and small levies along stretches of otherwise un-manipulated prairie streams or rivers.

Once all land with a definitive cropping history or other disturbances was eliminated, the remaining land tracts were, by default, considered 'potentially undisturbed' and were digitized using simple manual editing techniques in ArcMap. These remaining potentially undisturbed lands were classified as either undisturbed grassland or woodland during the polygon creation process described in step 4. This systematic elimination of disturbed areas resulted in a map of potentially undisturbed land comprising the basis of our deductive analysis approach.

Step 3: Identifying Go-Back Land and Land with Uncertain Management History

Many potential signs of tillage or disturbance were identified using historical imagery or web map services. These indicators include rock piles, potential dead furrows, linear patterns, and changes in vegetation, all of which suggest historical tillage on fields that were either tilled and abandoned prior to FSA CLU tracking (now considered go-back pasture). Unlike eastern South Dakota, fields that were re-classified as non-crop due to coverage by a grassland easement were uncommon in the northwestern area (see 'Understanding Common Land Unit Data' section above).

Our protocol requires definitive indicators of disturbance when permanently removing land tracts. In rare cases, disturbance indicators found in historic (1990's DOQQ) imagery were clear enough to prove definitively that a particular field had undergone historical tillage, and thus that field was removed. In most cases, disturbance indicators were not clear enough to prove definitively that a particular field had undergone historical tillage (patterns resulting from annual hay mowing, rural water lines, historic fence lines, and even cattle trails may sometimes be mistaken for indicators of historic tillage). In other cases, the exact delineation of historical tillage could not be determined for the entire disturbance site (indicators may be apparent in only a portion of a particular go-back field). Go-back fields and other historic disturbances are rather common throughout this landscape. Homesteading efforts in the 1910's and 20's were widespread and short-lived. Therefore, they were not captured by predecessors to the current US Departments of Agriculture and Interior.

Go-back fields are particularly common in the Grand River National Grassland in Perkins County and constitute a large percentage of that land area. In most cases, a scale of 1:3000 was used to identify and/or map possible go-back fields, since many of the signs of historic tillage are difficult to ascertain at smaller scales.

Generally, land use patterns and landscape indicators in northwestern South Dakota were diverse and complex because many indicators, while obviously present, had poorly defined edges that often 'feathered' into truly virgin sod areas. Initially, our methodology called for technicians to define suspected disturbances by drawing polygons delineating the extent of the disturbance, but this proved difficult in the northwestern region, requiring a refinement of our methodology. In Harding County and the northern half of Perkins County, as well as scattered instances elsewhere, technicians used polygon delineation to roughly outline what appeared to be the extent of tillage and made a note of the potential disturbance in the Notes data field. In addition, these tracts were identified with a "1" attribute in the "Disturbance Uncertain" column of the data table. For the remainder of this project area (Meade, Butte, Lawrence, southern Perkins Counties), most possible go-back fields were signified using a newly-created point layer where each distinct area containing potential previous disturbances was flagged. The flag point was then categorized in the same manner as the polygon protocol. Some possible go-back fields were delineated as separate polygons in this portion of the project area, but most possible go-back fields were marked using the point method.

In addition to possible disturbances from historical tillage, many instances of soil manipulation due to historic rangeland 'improvement' practices were identified in these counties. Some of these practices included: contour furrowing, spreader ditches, harrowing, terracing, and hardpan subsoiling. These practices were initiated with the intent of improving grassland production, but nonetheless created mechanical disturbance over large acreages. Despite this level of disturbance, these areas were deemed relatively insignificant (compared to go-back fields) since they usually amounted to small furrows or

Table 2: Disturbance categories and associated land use types that constitute uncertain disturbances flagged for further analysis.

Uncertain Disturbance Category	Possible Disturbance Examples
1	• Possible disturbance with typical indicators of thorough/complete soil manipulation • "Go-back" fields, old fields, or former cropland reverted to semi-natural cover • Indicators of historical tillage including dead furrows, rock piles, and differences in soil texture • Hay fields with indicators of possible prior alfalfa planting • Former tree rows planted around abandoned homesteads or elsewhere • Possible abandoned gravel pits/mines with no definitive indicators of excavation
2	• Possible disturbance without any visible indicators of mechanical soil manipulation • Areas that appear to be sprayed with glyphosate but not mechanically disturbed • Hay fields containing possible disturbance indicators and delineated by CLU non-cropland polygons with or without native grass designations • Natural soil erosion patterns that appear to be soil manipulation • Also used as a temporary placeholder for points with unknown indicators or else needing review
3	• Possible disturbance with typical indicators of dispersed/incomplete soil manipulation • Furrowing/contour furrowing • Subsoiling, chiseling, trenching, deep ripping, and pitting • Terraces, spreader ditches/dams, and other water retention projects • Pasture harrowing
4	• Discrepancies in CLU cropland data • Missing/incomplete CLU records • Incorrectly classified cropland (3-CM code '1' instead of '0' • Inaccurately drawn CLU polygons • Discrepancies/changes between 2005 & 2013 CLU datasets

trenches with undisturbed grassland in between. When mapping these areas, the extent of a given soil manipulation practice was usually not defined since the edges were often highly irregular and difficult to ascertain. Thus, tracts containing these types of practices were flagged with a value of "3" in the "Disturbance Uncertain" field. Additionally, flag points were placed in these areas of soil manipulation along with a note in their attributes signifying the type of practice suspected. These flag points are contained in the same layer as other possible disturbances, but may be separated using the disturbance category attribute.

Flagged tracts should be the primary target for future ground-truthing or data refinement efforts. It is possible that data from historical land use maps, aerial photography, or Light Detection and Ranging (LiDAR) coverages could be used to ascertain potential disturbance indicators in the future for these and other tracts (for information on LIDAR data see http://oceanservice.noaa.gov/facts/lidar.html).

Table 2 provides examples of land use considered as likely 'disturbance' but categorically flagged and retained within the go-back land data.

An excellent example of likely historic go-back fields delineated through the uncertain disturbance protocol are those identified on the US Forest Service's Grand River National Grassland in Perkins County (Figure 6). Figures 7-9 depict how other disturbance categories such as terracing, rangeland manipulations, and irrigation have impacted the land to some extent but where the ramifications of the disturbance on native plant communities is difficult to assess.

Step 4: Designating Potentially Undisturbed Woodlands

Classification of potentially undisturbed woodlands is intended to capture remnant native woodlands. In the northwestern tier counties of South Dakota,

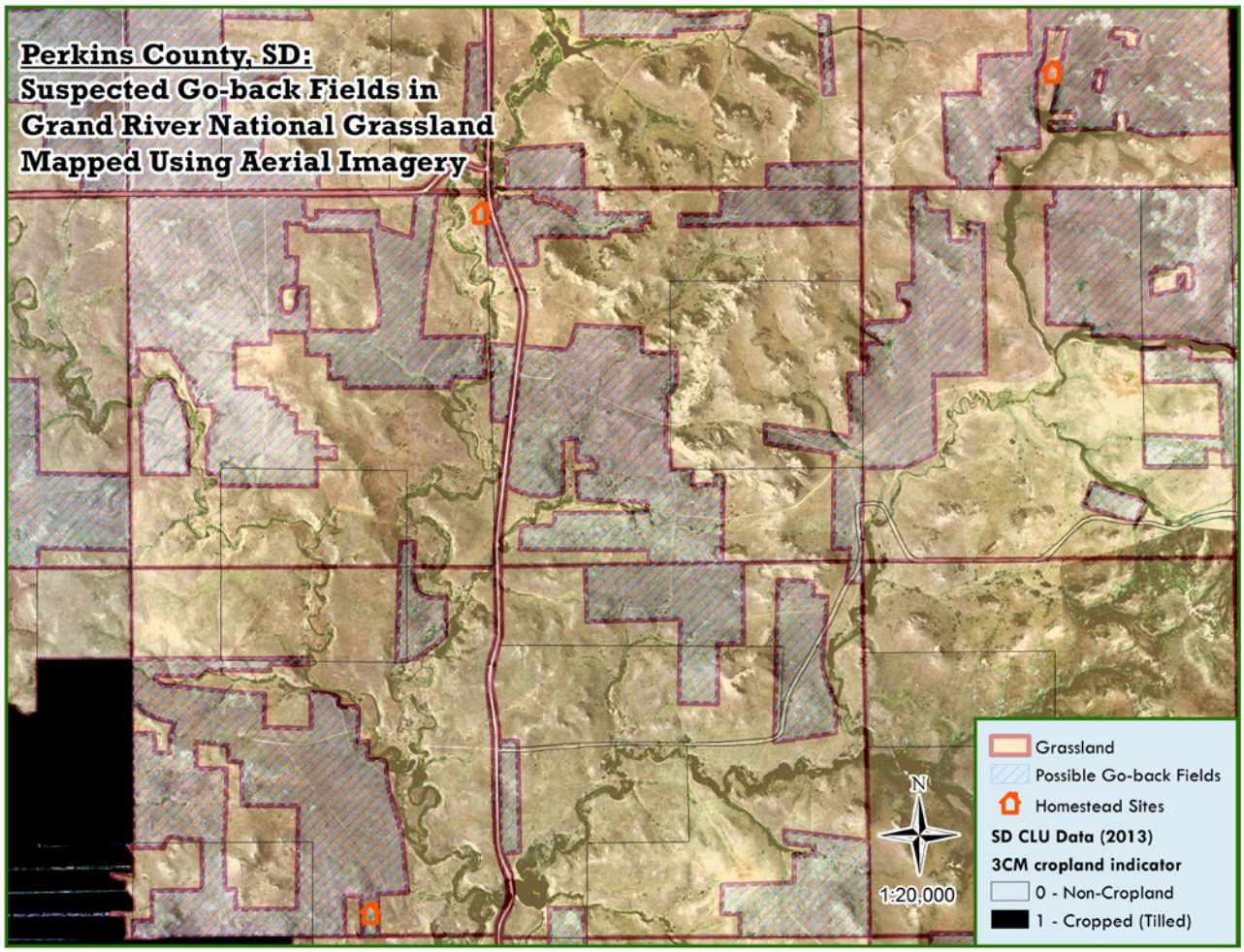

Figure 6: Example of go-back fields identified via drawing polygons on the US Forest Service's grand River National Grasslands in Perkins County, SD.

Figure 7: Example of terracing on otherwise undisturbed grassland without clear indiacations of historic cropping.

Figure 8: Aerial image of Contour furrowing in Northwestern South Dakota.

Figure 9: Examples of effects of rangeland contour furrowing over time. Initial impacts are sometimes drastic, with the range 'healing' over time (series of photos are not of the same field).

these woodlands that inhabit higher and dryer sites are primarily comprised of native and invading species of conifers including: pine, spruce, juniper, and cedar. Also included are the forested buttes of Custer National Forest in Harding County, and the pine forests of the Black Hills Foothills. Cottonwood, ash, willow, and other deciduous species also occur in relatively thin bands along valleys, small draws, and occasionally along the banks of rivers, streams, and wetlands.

Any stands of trees appearing to be native remnant woodland and if they were approaching a closed or mature canopy as visible with the 2012 NAIP aerial imagery were classified as undisturbed woodlands. Areas covered with scattered deciduous trees remained in the native 'undisturbed' grassland layer if they did not appear to be planted and did not approach a closed or mature canopy.

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, which we deemed acceptable given the 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 undisturbed 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.

It is important to note that woody cover can fluctuate in certain regions of northwestern South Dakota via natural and enhanced reductions and expansions. Where expansion is occurring, the encroachment is largely into grasslands, not croplands or other areas with heavy human use. While deciduous tree encroachment/expansion into grasslands does occur, it is likely that eastern redcedar encroachment and expansion into native rangelands accounts for a greater loss of open grasslands than does deciduous tree expansion.

Step 5: Error Analysis and Accuracy Review

As technicians progressed through the deductive analysis process for each section of land, decisions on land use classifications become less objective and increasingly subjective. For example, removal of land with a CLU cropping history is an objective process requiring no visual interpretation. Conversely, removal of obvious disturbances such as buildings, gravel pits, and municipalities is a subjective process utilizing interpretation of aerial imagery. However, removal of 'obvious' disturbances is 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.

Subjective decisions become more necessary when interpreting source data to identify disturbance indicators such as go-back tillage scars, farm sites, and other possible historic disturbances; also to correctly classify small or linear habitats. At this point, the technician's 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.

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. 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, commission, or topology 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.

We modified our random point analysis to include establishment of 30 random points (6 per county) in northwestern South Dakota (as opposed to 3 per county for eastern counties) due to the much larger average size of the counties. Random points were established and evaluated by both technicians and the project coordinator to assess protocol consistency along with accuracy of mapping and source data interpretation (Figure 10).

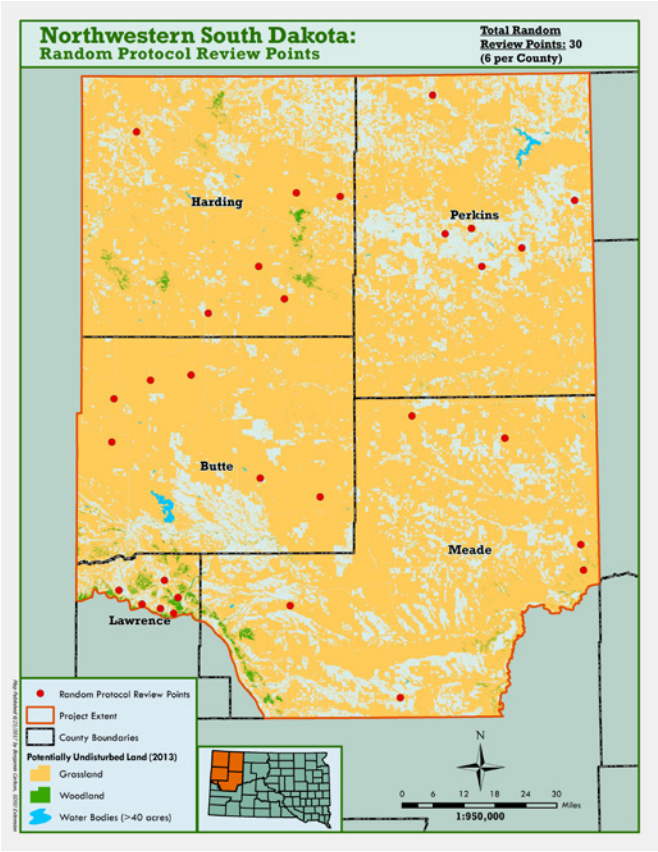

Figure 10: Northwestern South Dakota: Location of random review points.

Step 6: Lakes and Wetlands

Once the extent of potentially undisturbed grassland and woodland areas was determined, we applied additional measures to further refine these 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 South Dakota GFP Statewide Water Bodies layer) 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. Thus, a conservative standard size of 40 acres (1/16 square mile) was chosen for water bodies to remove.

Understanding that no data layer is perfect, it is worth noting that the SDGFP Statewide Water Bodies layer is an incomplete dataset. The SDGFP is actively creating water body delineations on a county-by county basis using aerial photo spectrometry to create highly precise delineations. However, counties that have not been completely analyzed using photo spectrometry utilize modified water body delineations from the National Wetland Inventory dataset for all or some of a given county's water bodies. In the northwestern South Dakota region, all counties have not had water bodies created by photo spectrometry, meaning most of the water bodies in these counties come from the modified NWI dataset. As the SDGFP Statewide Water Bodies layer becomes more complete, future refinements of this analysis will utilize the most up-to-date version of the Water Bodies layer available to remove lakes greater than 40 acres. Regardless, the SDGFP Statewide Water Bodies have been accepted as measured geometric data, thus no editing or commission/omission decisions beyond the 40-acre threshold have been performed.

Step 7: Evaluation of Undisturbed Land Protection Status

Of primary interest in our analysis 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. For the purposes of our analysis, we define the term 'protected' as land that cannot be converted from its current grassland or woodland state due to the policies of the agency or entity that owns the land in fee title (such as The Nature Conservancy, the US Fish and Wildlife Service, or the National Park Service) or as land that is legally encumbered through easements, deed restrictions, or other permanent or perpetual clauses that would restrict the land from being converted from the present natural state to some other use (which includes, but is not limited to, USFWS grassland easements and

NRCS Wetland Reserve Program (WRP) or Grassland Reserve Program (GRP) perpetual easements).

A variety of federal and state agencies own and manage property in northwestern South Dakota along with a few non-government organizations. These organizations and entities have individual operating procedures, protocols, or standards for how their properties are managed and utilized. However, not all of these management strategies specifically restrict the conversion of grasslands and woodlands to other uses (see below for examples). Therefore, the 'protected lands' layer compiled for this analysis only includes fee title lands and permanent conservation easements owned or held by organizations or entities that have a specific policy or legal encumbrance restricting the future conversion of grasslands and woodlands to other uses.

Specifically absent from the 'protected lands' layer are lands owned or generally managed by: SD School and Public Lands, SD Department of Game, Fish, and Parks, Tribal Trust and Reservation Lands, US Bureau of Indian Affairs, US Bureau of Land Management, and the US Forest Service. For these entities, as well as others, land use decisions are potentially influenced by interpretation, leadership decisions, reserved future multi-use, or else these lands are otherwise not permanently legally encumbered from conversion, regardless of current institutional philosophy. An excellent example is lands owned by SD School and Public Lands (SDSPL). Although there is a standing moratorium on conversion of current grazing lands held by SDSPL and the current administration has no interest in allowing these grasslands to be converted to cropland; there is no specific legal protection to ensure compliance with this philosophy. Thus, the commissioner of the SDSPL has the legal authority to grant exemptions and/or change the policy, even if highly unlikely (SDSPL Commissioner Ryan Brunner, pers. comm., Sept. 2015, November 2017).

Likewise, the SD Department of Game, Fish, and Parks lacks any policy restricting the conversion of native grasslands to other uses, such as wildlife food plot plantings or other recreational facilities. Therefore, lands owned and managed by SDGFP are also not included in the 'protected lands' layer in this analysis.

Protection and agency ownership data layers were acquired either through publicly accessible sources or through direct contact with organizations holding the fee title to the property or the easement. Source citations are listed in the metadata files associated with the feature classes listed in Table 3. Information on fee title ownership and easement holdings was collected and merged into single aggregate layers for both permanently protected land and state and federal agency land, which were then clipped to the project extent. These layers were then intersected with the potentially undisturbed grasslands and woodlands layers produced by our initial analysis, which resulted in a final 'protected undisturbed' and 'undisturbed with state and federal agency ownership' data layers. Because some land ownership data is sensitive or proprietary, aggregating and reporting the protected land data in a single layer with no identifying information was crucial for gaining permission to utilize these 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.

Additional potentially protected lands (fee title or easements) occur throughout South Dakota and are held by a variety of state, county, or private entities. Unless specifically listed in the previous paragraphs, it can be assumed we were not able to acquire reliable boundary data for these areas. Data from these organizations may be incorporated into the 'protected lands' layer in future analysis.

Step 8: Identification of Oil Industry sites

We tracked the general footprint of the oil industry in northwestern South Dakota using similar techniques to our wind turbine analysis in eastern South Dakota. Mapping technicians, working at a scale of 1:8,000, analyzed the 2012 NAIP Aerial Imagery base layer during this mapping process. While oil wells, drill sites, and access roads were considered 'disturbed land' and were removed during analysis, a point was created and placed on individual oil wells, drill sites, and associated facilities that were identified from the aerial imagery or USGS topographic maps. To calculate the impact of oil wells and other industry features on both potentially undisturbed and protected undisturbed lands, a spatial search query with a 250-foot radius was conducted to identify the number of oil features adjacent to these areas.

Results

Overall, we developed seven specific GIS feature classes as we evaluated the occurrence of potentially undisturbed land within the northwestern South Dakota region as discussed in this report. Names and descriptions of those files can be found in Table 3 below.

Potentially Undisturbed Land (Grasslands and Woodlands)

Overall, we evaluated 7,347,812 acres (11,481 mi^2), comprising the majority of five counties in northwestern South Dakota for potentially undisturbed land (Phase V of a multi-phase project). All or portions of Harding, Perkins, Butte, Meade, and Lawrence counties outside of the Black Hills Core Highlands and Plateau ecoregions were included in the analysis. County size and area was variable, and must be acknowledged when interpreting the impact of disturbed and undisturbed land at the county level. When compared against total county analysis area (land and water), Butte County ranked highest at 84.5% of its land base being likely undisturbed habitat. Lawrence County had the least percentage of undisturbed land within the analysis area (70.1) %.

Overall, 5,743,137 (78.3%) of northwestern SD were deemed to be potentially undisturbed land. Of this total acreage, 5,686,795 acres (99.0%) were categorized as undisturbed grassland while 56,342 acres (1.0%) were categorized as undisturbed woodlands (Figure 11). Counties with the greatest acreage of undisturbed land classified as grassland were Butte, Harding, Meade, and Perkins; all with over 98% of their undisturbed land classified as grassland, with actual acres ranging between 1.2 million and 1.6 million acres. The portion of Lawrence County included in the analysis was a slight anomaly with only about 82% of its undisturbed land comprised of grassland (105,207 acres) due to the proximity of this area to the northern Black Hills region. Undisturbed woodlands, while not as extensive as grasslands, were an important component of the total undisturbed land in Lawrence County, comprising over 17% of the portion of the county included in the analysis area (18,482 acres). However, Harding and Meade Counties offered similar total acres of

Table 3. GIS feature classes developed by South Dakota State University for the analysis of Northwestern South Dakota.

Filename and Descriptor	Details
NWSD_pudl_cntyExtent: Northwestern SD Potentially Undisturbed Lands Project Extent	Polygon feature class representing portions of those counties in the northwestern South Dakota region that were analyzed as part of the SD & MN Potentially Undisturbed Lands project.
NWSD_pudl: Potentially Undisturbed Lands in Northwestern South Dakota	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.
NWSD_pudl_Protected: Potentially Undisturbed Lands in Northwestern South Dakota 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 ownership or easement holdings by a conservation entity.
NWSD_pudl_OtherPublic: Non-protected Potentially Undisturbed Lands in Northwestern South Dakota Managed by State and Federal Agencies	Polygon feature class representing undisturbed grasslands and woodlands (from the Potentially Undisturbed Lands layer) that are owned by state or federal agencies and do not have permanent protection status through institutional policy or legal restrictions.
NWSD_OilFeatures: Oil Wells and Features in Northwestern South Dakota	Point feature class representing the location of oil wells, drill sites, and associated facilities mapped at a scale of 1:8,000 using aerial photography from July 2012.
NWSD_Homesteads: Homestead Sites Identified in Northwestern South Dakota	Point feature class representing the location homestead locations mapped at a scale of 1:8,000 using aerial photography from July 2012.
NWSD_Disturbance_pts: Possible Disturbance (Go-back) Sites in Northwestern South Dakota	Point feature class representing sites were signs of possible historic disturbance were identified in otherwise undisturbed grassland. These possible/uncertain disturbances include areas of possible complete mechanical soil manipulation (go-back fields), areas of possible incomplete mechanical soil manipulation (range manipulation), and other uncertain disturbance areas including possible CLU discrepancies.

woodland habitat with 14,232 acres and 17,527 acres respectively.

Evaluation of Go-Back and Rangeland Manipulation Indicators

It is important to note that within our undisturbed layers, there are individual tracts that have a historic disturbance or tillage history that is difficult to detect using aerial imagery alone. These areas are commonly known as 'go-back' pasture or old field acres. Examples include: a land tract that might have been farmed before the Great Depression or a tillage attempt made by homesteaders 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. In addition, 'rangeland improvement' practices, often promoted by government agencies, occurred where native grassland soils were mechanically manipulated in an attempt to improve water infiltration and/or forage production. Overall, the condition and vegetative cover of any go-back or rangeland manipulation area today is unpredictable, as they may be vegetated with varying degrees of quality, structure, and diversity of native, tame and exotic species.

In rare cases, old fields and other areas of uncertain disturbance are easily defined in historical imagery and can be confidently removed from the undisturbed layer. Generally, however, land with potential disturbances were delineated or flagged under several 'go-back' categories developed or refined during this phase of the statewide evaluation (see Methods). Initial evaluation of go-back acres using our method of digitizing visibly apparent old field boundaries was conducted in Harding and the northern half of Perkins Counties, and to a limited extent in areas of the remaining three counties. This proved excessively time consuming while not providing an adequate degree of accuracy due to the difficulty of establishing accurate field edges using available aerial imagery; even when some indicators of previous disturbance were clearly present in the imagery. Therefore, we elected to employ a more efficient method of 'flagging' go back areas using point features to mark sites of possible disturbance for future analysis.

Technicians drew field edges around 7,927 possible go-back fields primarily in Harding and northern Perkins Counties before switching to the flag point method. These polygons represented a total of 206,562 acres, and the average size represented by polygons was approximately 26 acres. Technicians then placed an additional 9,336 flag points on suspect go-back fields and disturbance sites within the remainder of the analysis area. It is impossible to know how much acreage these points represent. However, if we apply a 26-acre average to each point, the result is about 243,000 acres. In total, by applying the average acres represented by polygons to point locations and combining this with the total acreage of those polygons, there may be roughly 450,000 acres of possible go-back fields in this region (about 7.8% of the total undisturbed area). Of course, this is a rough estimate, but it does suggest a high degree of confidence in the estimate of actual undisturbed acres across the region (Figure 12).

It is also important to recognize the distribution of these go-back fields across the landscape. Of the 11,580 Public Land Survey designated legal sections of land in the analysis area, 7,242 (62.5%) had at least one polygon or point indicating one or more go-back fields or possible disturbance sites were present in the section.

In addition to go-back fields, we flagged areas with indicators of rangeland manipulation as described in the Methods section of this report. Individual manipulation areas can vary in size from several hundred to several thousand acres. Technicians placed several flag points in these areas, and often placed more than one point per disturbance to re-locate the area during future analysis. The number of points placed depended largely on the size, shape, and fragmentation of the manipulation areas in relation to the topography and extent of the site.

A total of 904 rangeland manipulation points were flagged, but since no acreage estimate could be established for rangeland manipulations, we evaluated how many sections of land intersected at least one rangeland manipulation flag point. Overall, 316 of 11,580 sections (2.7%) evaluated had one or more rangeland manipulation flag points, suggesting that, although this practice often occupied large individual areas, the total number of project areas is relatively low when compared to the rest of the landscape. Of the 904 flag points that indicate

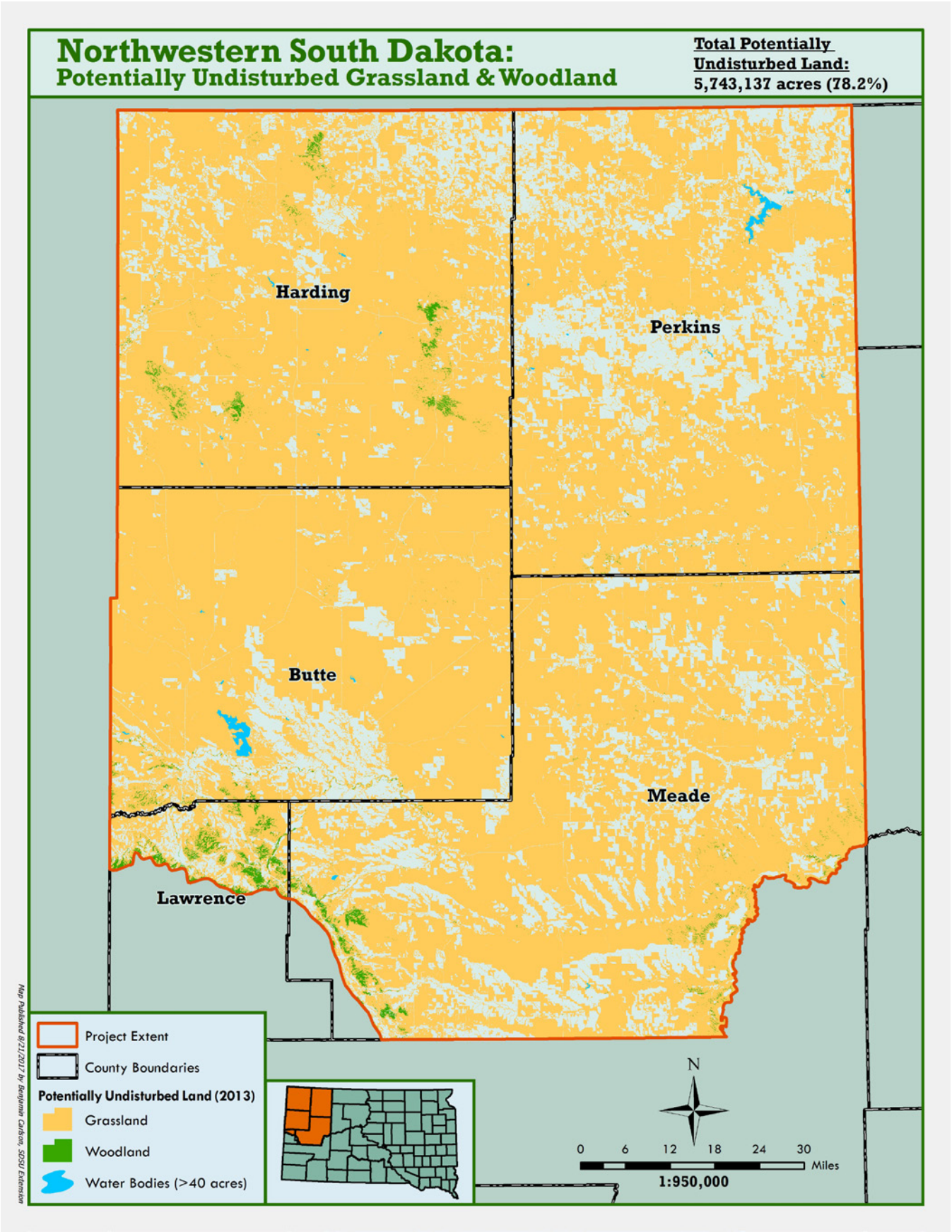

Figure 11: Northwestern South Dakota: General extent of potentially undisturbed lands as of 2013.

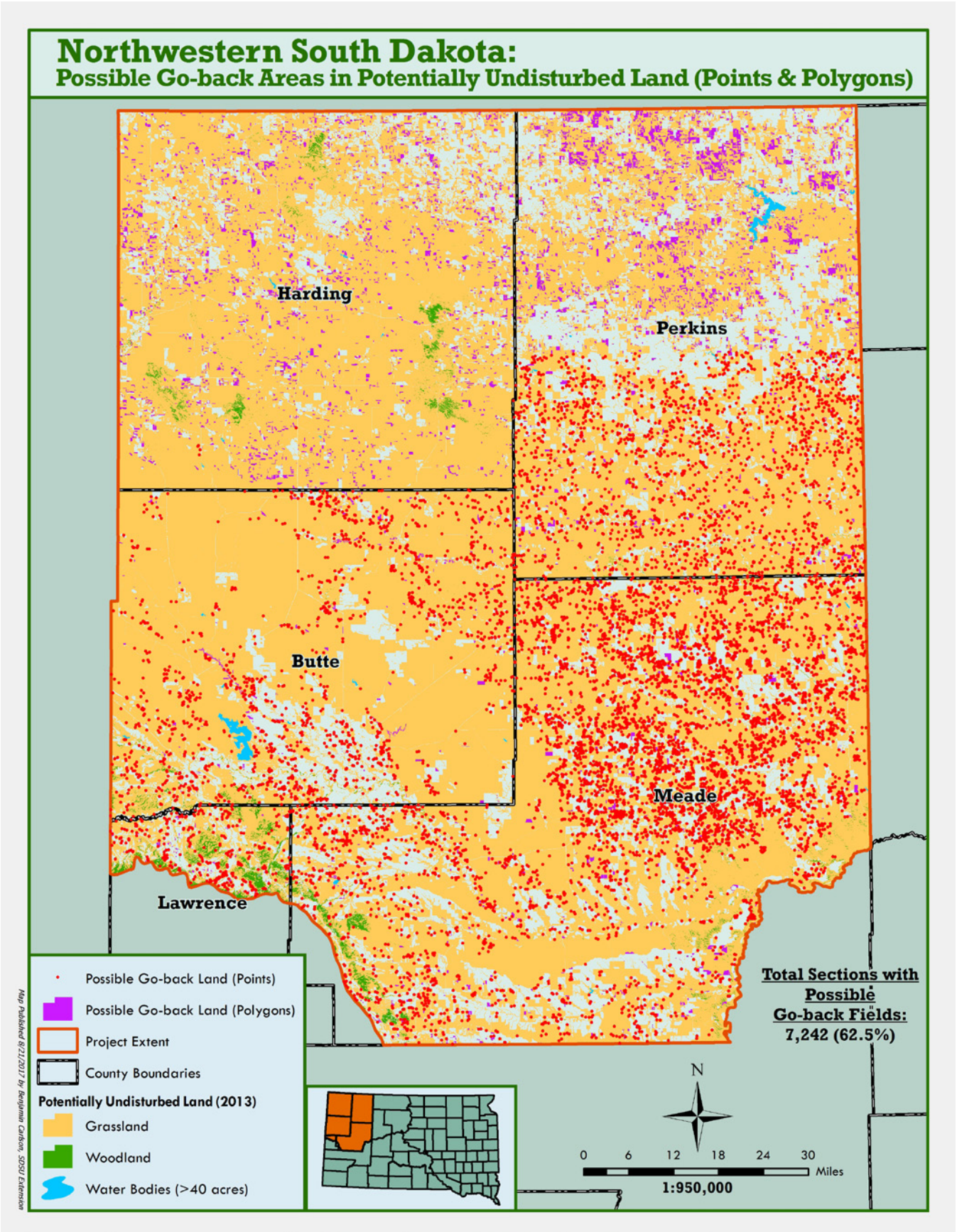

Figure 12: Northwestern South Dakota: General extent of Go back fields as of 2013.

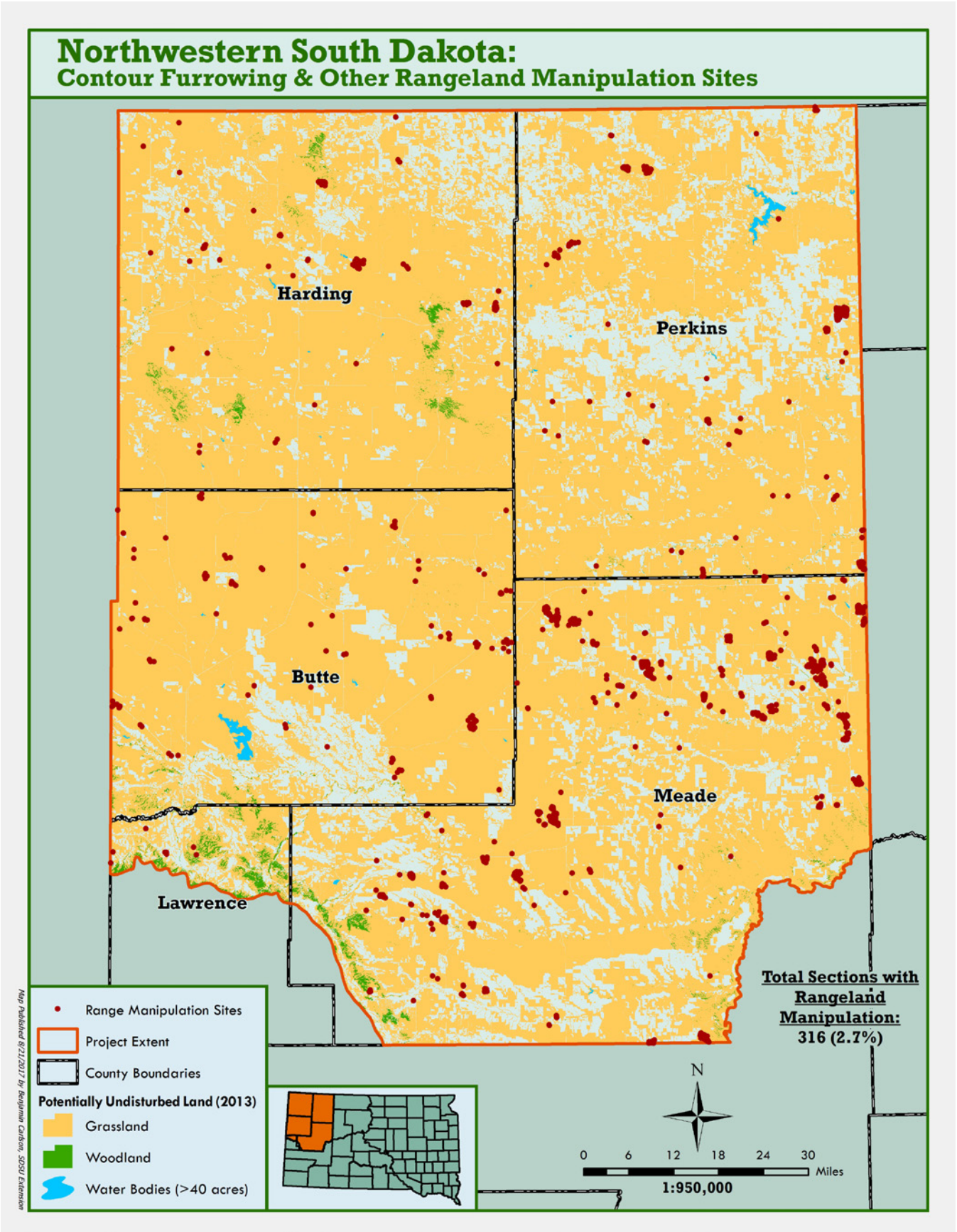

Figure 13: Northwestern South Dakota: General extent of Rangeland Manipulation projects as of 2013.

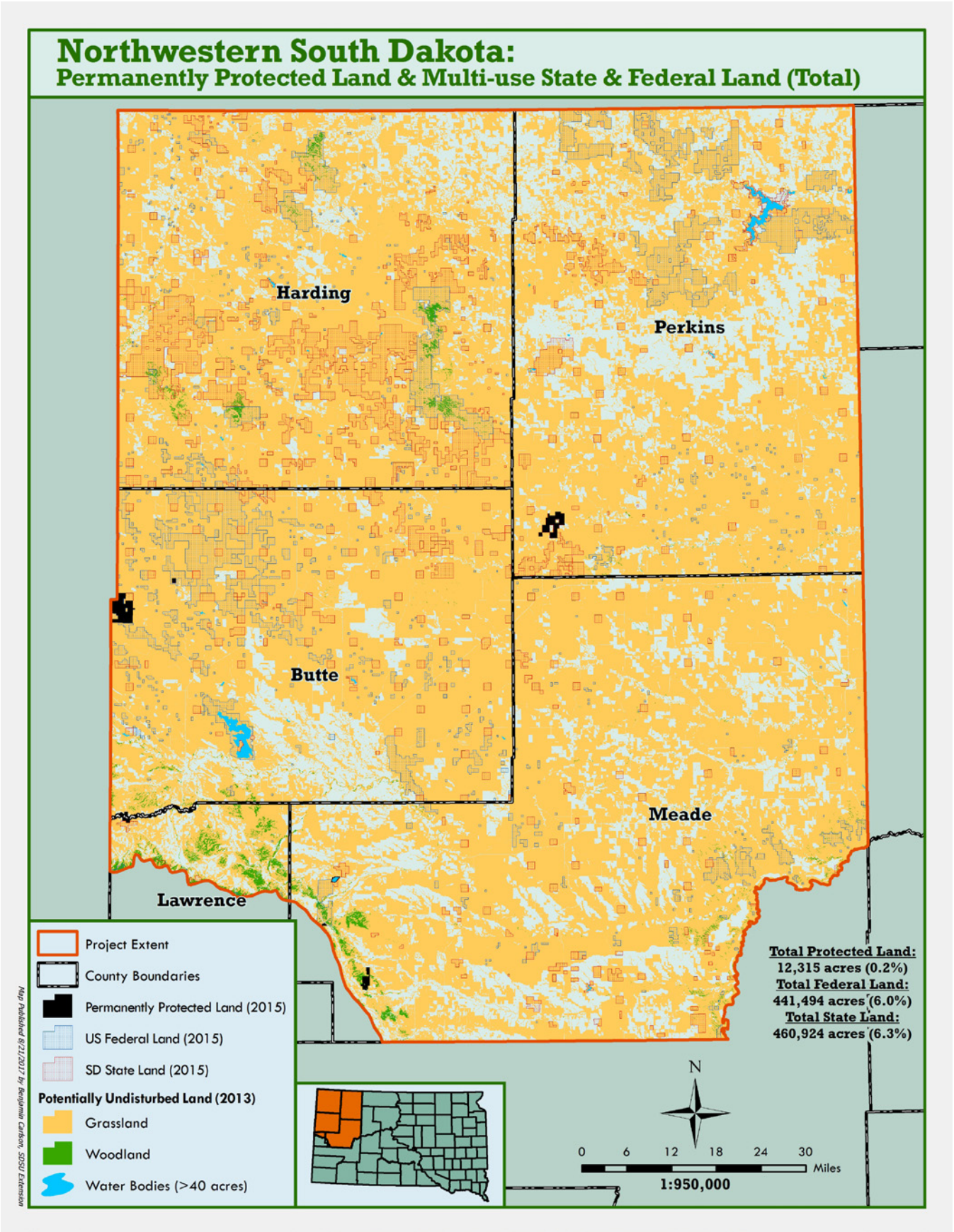

Figure 14: Northwestern South Dakota: General extent ofall protected land as of 2013.

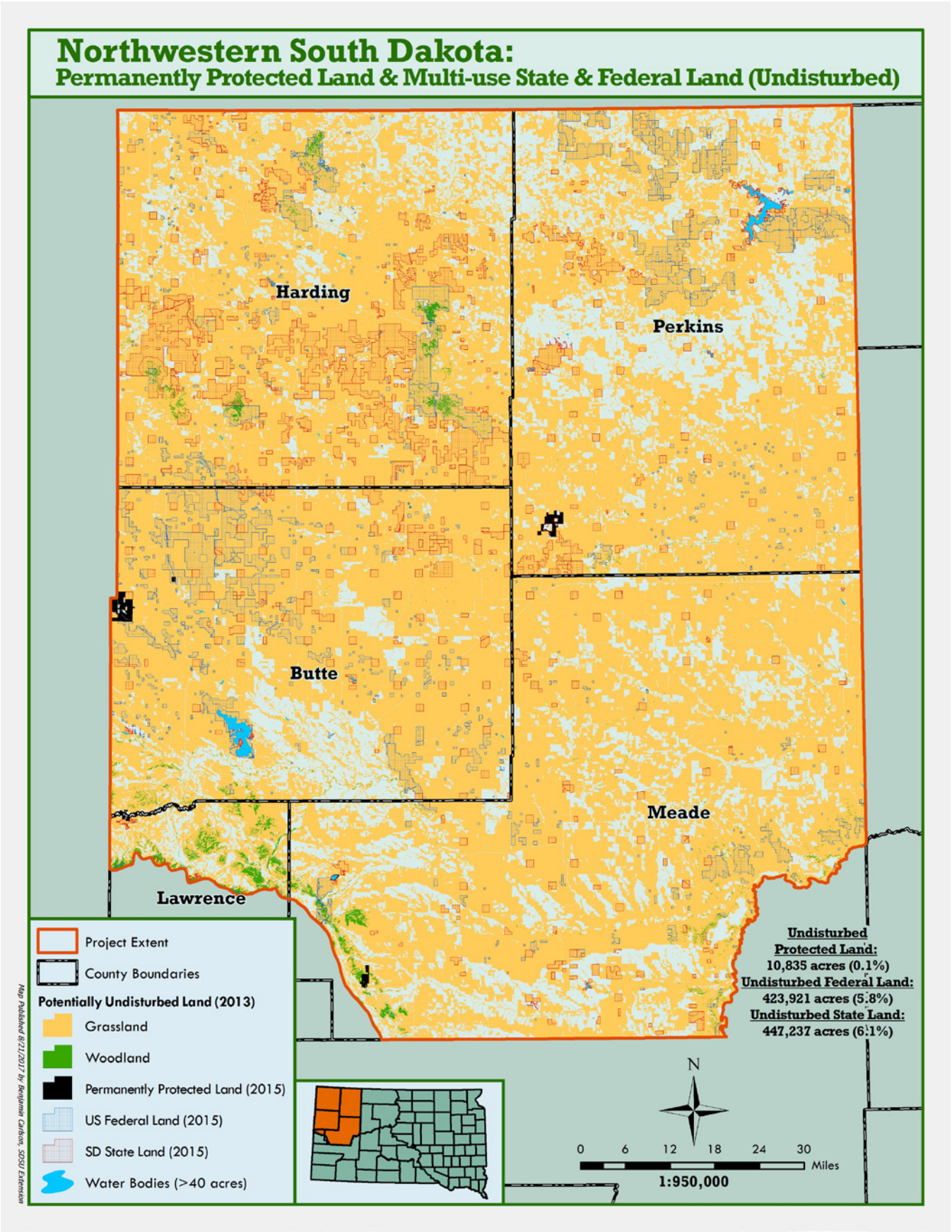

Figure 15: Northwestern South Dakota: General extent of all undisturbed and protected land as of 2013.

rangeland manipulation, 874 fell on privately owned land, with the majority on private land in Meade County. The remaining 30 points were on Bureau of Land Management properties (29 of which were on BLM land in Butte County) (Figure 13).

Protection Status of Undisturbed Lands

Within the 7.3 million-acre northwestern South Dakota evaluation area, approximately 5.7 million acres were identified as undisturbed grasslands and woodlands. Within this extensive analysis area, only 12,315 acres met our criteria as permanently protected (0.2%) (Figure 14). Consequently, only 10,835 of the 5.7 million acres classified as undisturbed were also classified as protected according to our criteria (0.2%). At over 5,700 acres, Butte County harbors over half of the protected undisturbed land in the region while Harding County harbors the least at only eight acres. In total, 88% of the protected acres in the region are likely undisturbed (native) land. Stated another way, nearly nine of every 10 acres that have 'protection' status in northwestern South Dakota are likely undisturbed habitat (Figure 15).

Protection of undisturbed land can vary greatly when evaluated at a county level due to federal, state, and NGO activity and overall landscape position. Permanent protection of land in this region according to our strict criteria is very low. However, because of the vast amount of public land ownership coupled with ranching being the primary private land use activity, conversion of land for other uses, while a threat in certain localities, is not as prevalent in this region as it is in the eastern portions of the state.

Impact of State and Federal Ownership

South Dakota School and Public Land (SDSP) and Department of Game, Fish, and Parks (SDGFP)

In total, the state of South Dakota owns and/or manages nearly 461,000 acres in the analysis area (6.3% of the total area). At nearly 443,899 acres, state ownership of land was dominated by South Dakota School and Public Lands (SDSPL) (96.3% of state land holdings), with the Department of Game, Fish, and Parks holding the remaining 17,026 acres (3.7% of state land holdings). Influence of state-owned land per county was highly variable, with over 250,000 acres of state land in Harding County and just over 2,500 acres in the portion of Lawrence County within the analysis area. Overall, 97% of all state-owned land in the region was deemed undisturbed (i.e. native) land, representing 7.8% of all undisturbed land in the analysis area (Figure 16).

Federal Land Holdings

Federal Land holdings were slightly less than state land holdings in the analysis area. In total, the federal government held approximately 441,494 acres of land in the region (6.0% of the total area), of which 423,921 acres were deemed to be undisturbed (96%). Certain federal agencies have a much larger footprint than others in certain counties. In some cases, undisturbed land may have go-back fields or rangeland manipulations that would reduce the overall undisturbed land totals upon further analysis. Nonetheless, the federal government's land holdings are dominated by undisturbed acres.

Bureau of Land Management (BLM)

The Bureau of Land Management (BLM) owns and manages approximately 223,446 acres in northwestern South Dakota of which 219,856 acres were considered undisturbed (98.4%). However, a small portion of the go-back and rangeland manipulation flag points occur on BLM land, indicating that the actual percentage of undisturbed land is likely lower (Figure 17).

United States Forest Service (USFS)

The United States Forest Service land is managed primarily by two distinct entities in the analysis area. The Grand River National Grasslands covers approximately 123,544 acres within northern Perkins County, of which 122,085 acres (98.8%) are deemed undisturbed. However, we identified approximately 35,524 acres of potential go-back land within the undisturbed portion of the Grand River National Grasslands (29.1%) (Figure 18). Additionally, the Custer National Forest occupies 74,000 acres in Harding County, of which 73,086 acres were classified as undisturbed in our analysis (98.8%). Again, we identified approximately 62 acres of potential go-back land within the undisturbed portion of the Custer National Forest (0.1%) (Figure 19).

United States Bureau of Reclamation (BOR)

United States Bureau of Reclamation land is minimal in this region, with only two counties having BOR land within the analysis area. At 13,963 acres, Harding County has the greatest amount BOR acres, of which 7,386 acres are deemed undisturbed (52.9%). Perkins

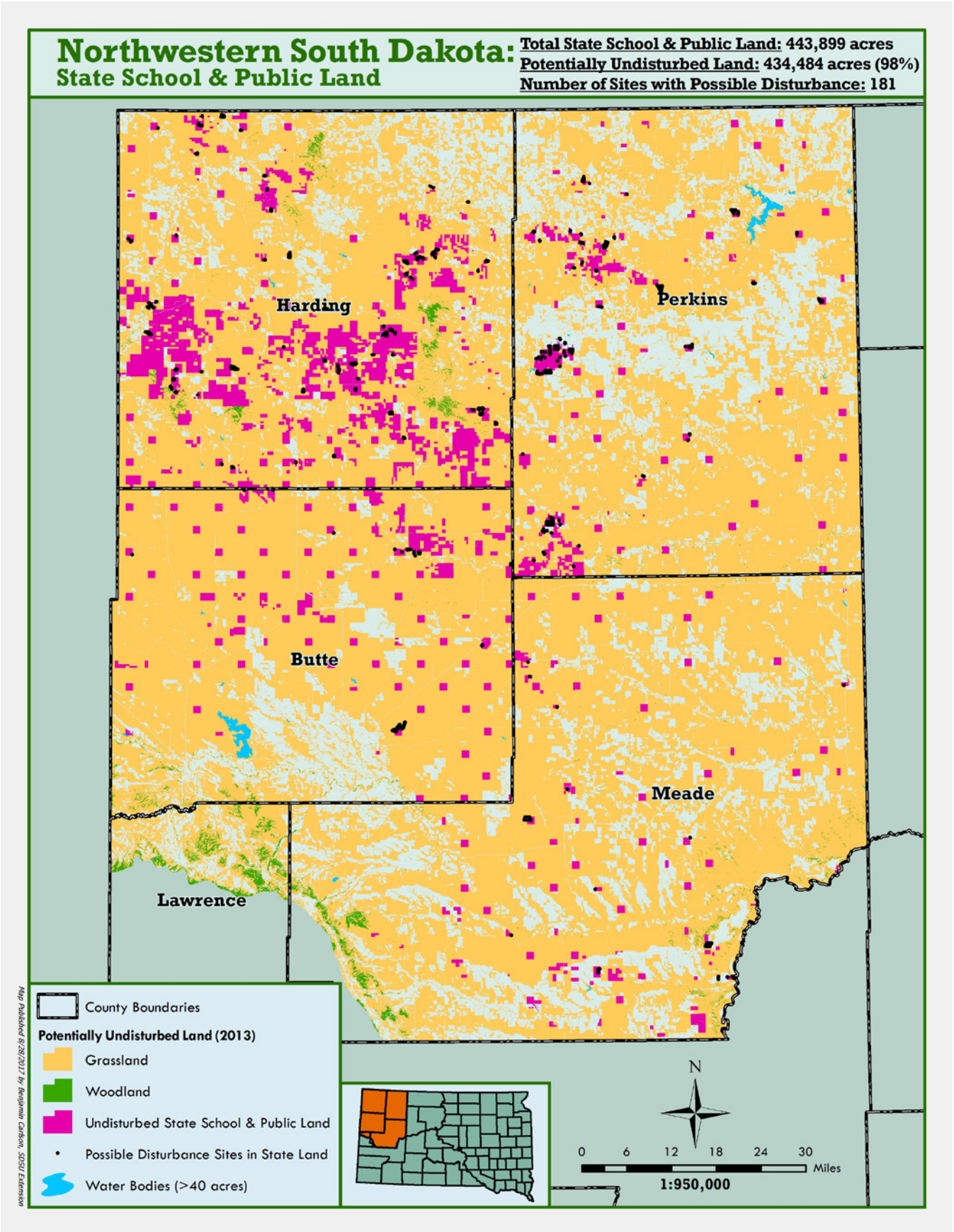

Figure 16: Northwestern South Dakota: South Dakota State School and Public Lands (SDSPL) property with overlay of possible go-back fields.

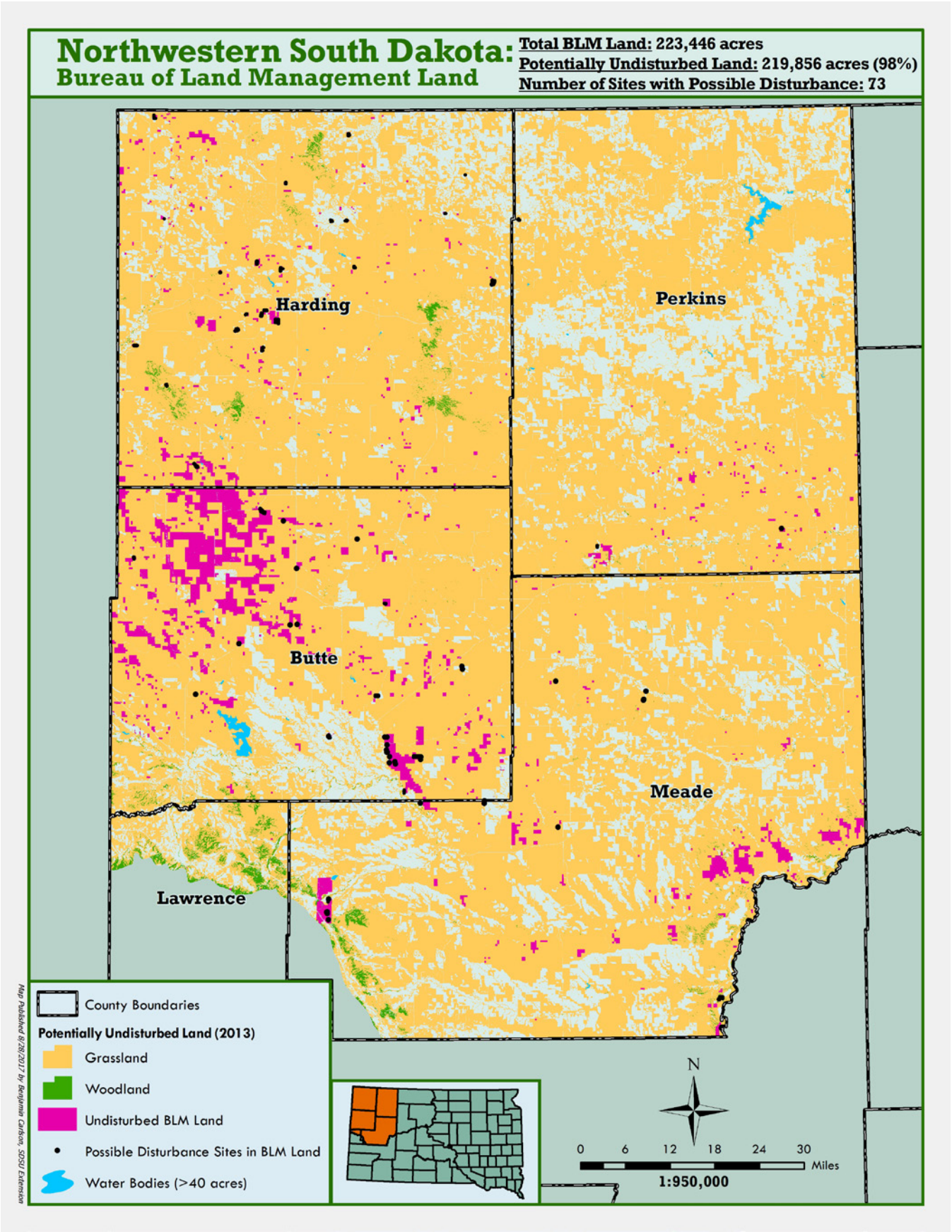

Figure 17: Northwestern South Dakota: United States Bureau of Land Management (BLM) Property with overlay of possible go-back fields.

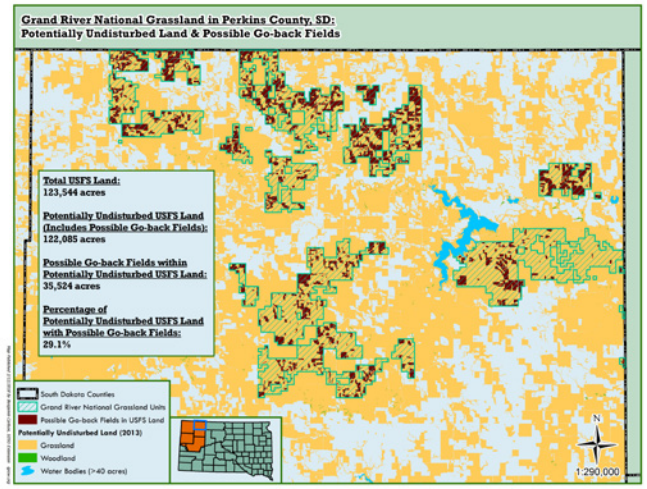

Figure 18: Northwestern South Dakota: United States Forest service (USFS)Property (Grand River National Grassland) with overlay of possible go-back fields.

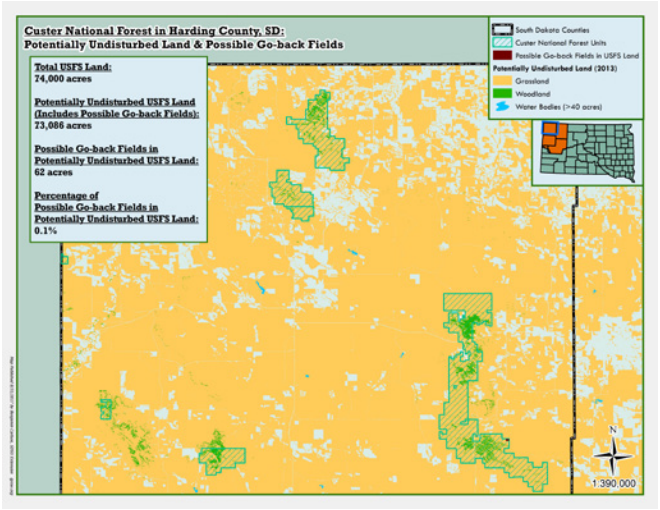

Figure 19: Northwestern South Dakota: United States Forest service (USFS)Property (Custer National Forest) with overlay of possible go-back fields.

County has 5,362 acres of BOR land, of which only 355 acres are deemed undisturbed (6.6%).

Farm Service Agency Common Land Unit Cropland and Other Disturbed Land Results

FSA CLU Designated Cropland

Land with a cropping history under the Farm Service Agency (FSA) Common Land Unit (CLU) criteria described in the Methods section of this report was identified and removed as we evaluated the landscape for undisturbed land. Within the approximately 7.2 million-acre analysis area, we identified nearly 1.4 million acres of land with a proven cropping history via the CLU-designated cropland designation codes, accounting for 19.1% of the total five county analysis area. Perkins County, with over 483,000 acres, and Meade County with nearly 463,000 acres, contained most cropland acres in the region.

Other Disturbance

Along with assessment of the FSA CLU cropping history, we assessed the landscape for additional disturbances (see Methods section, Table 1). Nearly 194,000 acres of additional disturbance were identified in northwestern South Dakota comprising a total of 2.6% of the total analysis area. Meade County had the most total 'other' disturbance with over 63,000 acres of additional disturbances. Lawrence county had the lowest total acres of additional disturbances at 14,635 acres, but the greatest percentage of any county with nearly 10% of the land in the analysis area impacted by other disturbances beyond CLU identified acres.

When FSA CLU cropping history and additional land disturbances were combined, the total land disturbance for northwestern South Dakota was nearly 1.6 million acres (21.7% of the land area). Based on initial analysis of go-back, rangeland manipulation, and other areas where disturbance is likely; the actual total disturbance in this region may be approximately 30% of the land area. Essentially, these acres are the crux of our analysis and they required the step by step landscape evaluation process described in Step 2 of the Methods section in this report (Figure 20).

We accepted FSA CLU data 'as is' and did not actively seek out or inventory all major errors. We did record errors if/when they were identified through our normal processes. Figure 21 provides an example of over 50 errors in the CLU data in northwestern SD to show the general distribution of these issues. While these issues do exist, we believe their overall impact on the area analysis is limited. However, the impact of these errors on analysis of individual land tracts could be significant.

Lakes and Wetlands

The methodology for the removal of lakes larger than 40 acres was described in detail in Step 6 in the methods section of this report. Only 13,605 acres of large water bodies were recorded in the analysis representing only 0.19% of the area. Nearly all of these water bodies are man-made impoundments for water retention, livestock water, and recreational purposes. Butte and Perkins County, both with significant water impoundments dominated the large water category

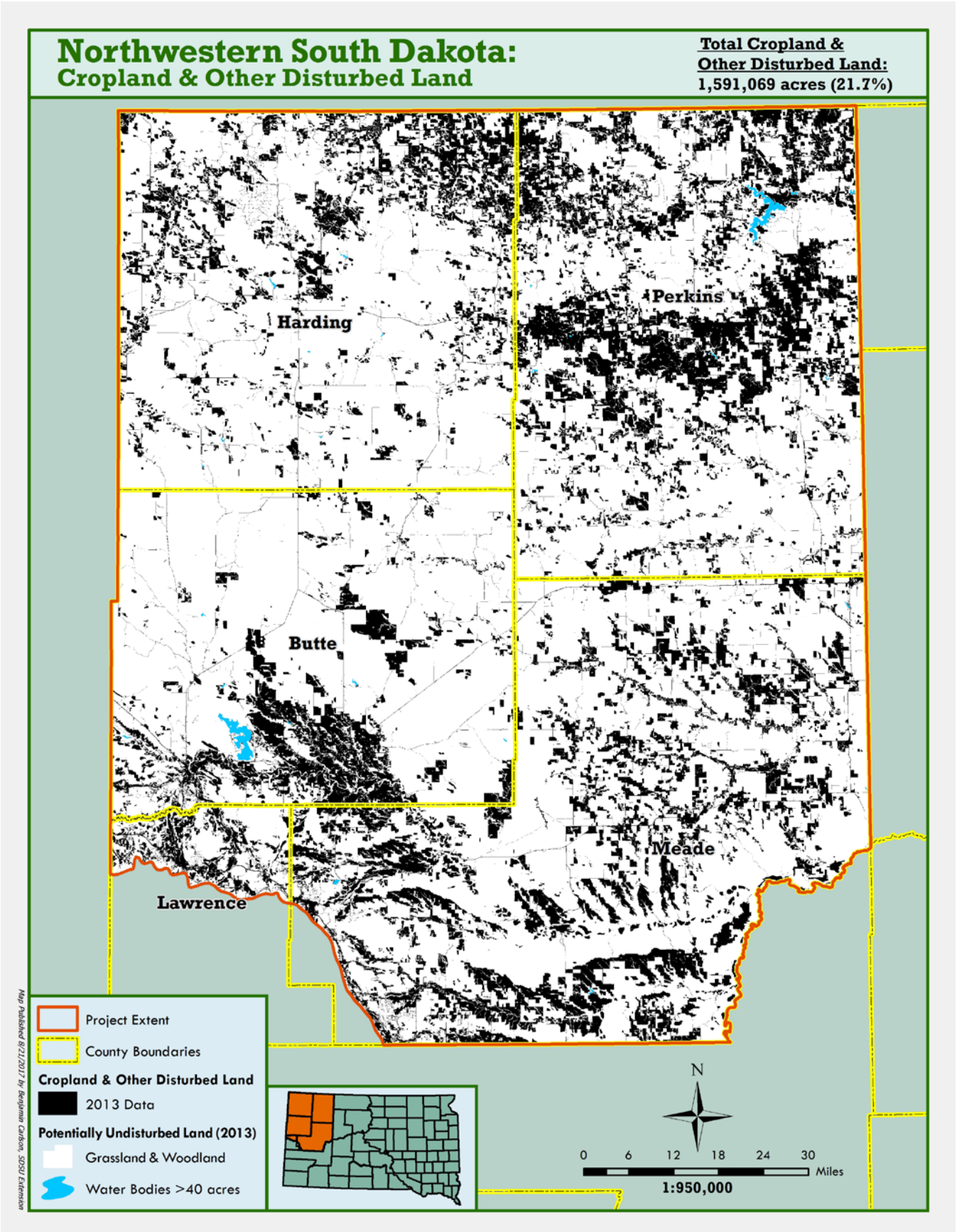

Figure 20: Northwestern South Dakota: Extent of all Cropland and other disturbed land as of 2013

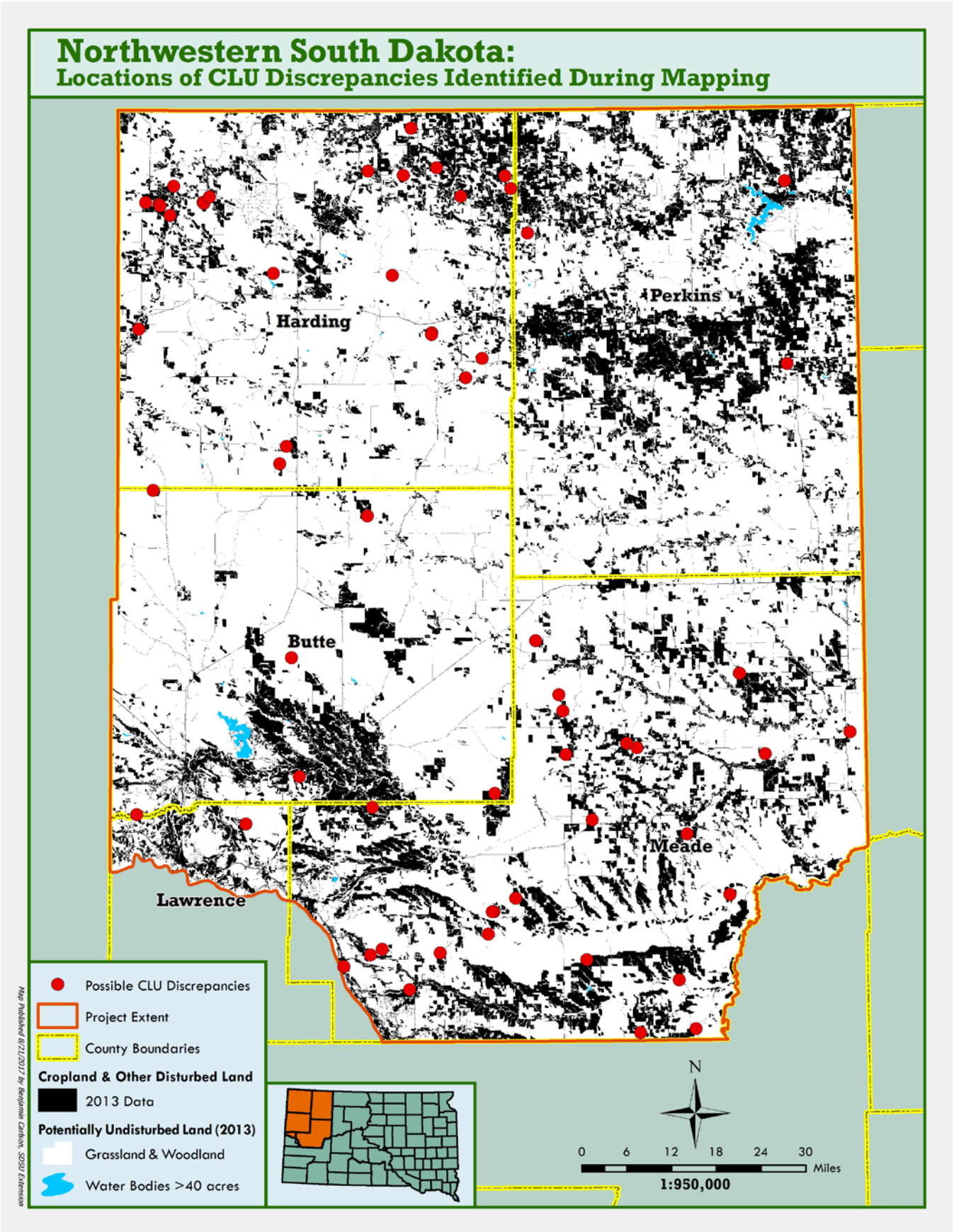

Figure 21: Northwestern South Dakota: Discrepancies in CLU data identified during mapping process

(Belle Fourche and Shadehill Reservoirs, respectively). Overall, there are very few large water bodies in this region, and the impact of removal of large water bodies from the undisturbed land layer only increased the undisturbed land statistic by 0.1%, from 78.2% to 78.3%.

Landscape Refinement Measure

If we relied solely on the FSA CLU cropland coded tracts as a means of estimating the amount of undisturbed land in northwestern South Dakota without considering large water bodies and other types of disturbance, the result would be an estimate of about 5,950,313 acres of undisturbed land remaining. In contrast, by removing large water bodies and evaluating all other disturbances to the land, we estimate the maximum area of undisturbed land remaining is about 5,743,137 acres, a difference of 207,176 acres.

We developed the Landscape Refinement Measure to evaluate the impact of our analysis on the general understanding of the eastern South Dakota landscape beyond what could simply be estimated by analysis based solely on the FSA CLU cropland designated acres. We compared our undisturbed acreage total after all large water bodies and disturbances were removed to the above estimated undisturbed area based only on the removal of FSA CLU cropland acres from the landscape. We applied this analysis to northwestern South Dakota as well. The overall result for northwestern South Dakota was a 3.5% 'refinement' in our understanding of the composition of acres not categorized as CLU cropland coded acres. In counties with few undisturbed acres compared to high non-crop disturbances such as cities, roads, and unrecorded crop acres, refinement factors are generally much higher. In northwestern South Dakota, Lawrence county had the highest landscape refinement factor at 12.2%, whereas Harding County had the lowest at 2.3%. These factors are likely to increase upon future evaluation of the go-back areas identified.

Results Tables

The following tables are arranged in a progressive manner with superscripts introduced as necessary. The reader should refer to a previous table for superscripts as necessary. Tables are arranged alphabetically by county and include formula descriptions and clarifying footnotes where needed. The tables are intended give full explanation to our findings and to assist government, non-government, tribal, and other agencies in refining their land management programs, including protection or conservation activities on private and public lands. All tables can be viewed as .xlsx files distributed with this report.

Interpreting Results based on Ecoregions

Our county-based analysis has proven valuable for understanding the land management history of northwestern South Dakota, and there is no limit to the number and types of boundaries that can be compared or overlaid on our GIS layers to better understand the land use history of this region.

As an example, we applied the US Environmental Protection Agency's ecoregional boundaries to illustrate the difference between ecological boundaries and sociopolitical boundaries (such as counties) (Table 10).

The EPA defines ecoregions as: "areas where ecosystems (and the type, quality, and quantity of environmental resources) are generally similar. They serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and their components. Ecoregions can help integrate these activities across agencies and programs that have different resource interests in the same geographic areas. Ecoregions are identified by analyzing patterns of biotic and abiotic phenomena, both terrestrial and aquatic. These phenomena include geology, landforms, soils, vegetation, climate, land use, wildlife, and hydrology."

The EPA provides various scales of ecoregional analysis from the coarse Level I containing only 12 ecoregions for the continental US to the most detailed Level IV which divides the continental US into 967 ecoregions. We applied the nine Level IV Ecoregional boundaries that overlap northwestern South Dakota in order to provide an alternative perspective on landscape analysis https://www.epa.gov/eco-research/ecoregion-download-files-state-region-8#pane-39.

While the overall distribution of undisturbed lands highlights actual areas of intact habitat, ecoregional analysis can help in determining how the availability of undisturbed lands might affect specific biotic or abiotic priorities or goals within an area. Ecoregion size and shape varies in northwestern South Dakota,

Table 4: County statistics for Northwestern South Dakota

County Area Analyzed: Northwestern SD - 2013					
A	B	C	D	E	F
County	Total County Area (mi^2)[1]	County Area Included in Northwest SD Analysis (mi^2)[1]	Total County Area (Acres)[1]	County Area Included in Northwest SD Analysis (Acres)[1]	Percent of County Area in Analysis Area
Butte	2,272	2,272	1,453,821	1,453,821	100%
Harding	2,684	2,684	1,717,464	1,717,464	100%
Lawrence*	803	235	513,625	150,251	29%
Meade*	3,487	3,397	2,231,786	2,174,353	97%
Perkins	2,894	2,894	1,851,923	1,851,923	100%
Total	**12,138**	**11,481**	**7,768,618**	**7,347,812**	**95%**

* Excluding Black Hills region

[1] Calculated using GIS from an intersection between US Census Bureau 2002 county boundary data published by the Natural resources Conservatoin Service (2009) and US EPA Level IV Ecoregion Boundaries (2012)

Table 5: Disturbed and Undisturbed Land Statistics for Northwestern South Dakota.

County Statistics for Undisturbed[5] Land in Northwestern SD - 2013

	General Statistics						FSA CLU Crop History			Other Disturbances			Combined Disturbance Statistics					'Undisturbed' Grasslands and Woodlands Statistics					County Undisturbed	
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Z
County	Total County Area (Acres)[1]	County Area Included in Northwest SD Analysis (Acres)[1]	Acres of Large Water Bodies (≥40 Acres) NOT Classifed as Cropland in County[2]	Percent of Large Water Bodies (≥40 Acres) NOT Classifed as Cropland in County[2]	Acres of Land (Includes Water Bodies ≤40 acres) in County[2]	Percent of Analysis Area Excluding Large Water Bodies (≥ 40 acres)[2]	FSA CLU Recorded Cropland Acres (2013) in County[3]	Percent of Analysis Area (Land and Water) Classified as FSA CLU Cropland[3]	Percent of Analysis Area (Land Only) Classified as FSA CLU Cropland[3]	Other Disturbed[4] Land Acres in County	Percent of Analysis Area (Land and Water) Classified as Other Disturbed[4]	Percent of Analysis Area (Land Only) Classified as Other Disturbed[4]	Total Disturbed[3,4] Land Acres in County	Percent of Disturbed[3,4] Land Classified as FSA CLU Cropland[3]	Percent of Disturbed[3,4] Land Classified as Other[4]	Percent of Analysis Area (Land and Water) with Disturbance History (Cropland and Other)[3,4]	Percent of Analysis Area (Land Only) with Disturbance History (Cropland and Other)[3,4]	Potentially Undisturbed[6] Grassland Acres in County	Potentially Undisturbed[6] Woodlands Acres in County	Total Potentially Undisturbed (Grasslands and Woodlands) Acres in County[6]	Percent of Potentially Undisturbed[6] Land Classified as Grasslands	Percent of Potentially Undisturbed[6] Land Classified as Woodlands	Percent of Analysis Area (Land and Water) Classified as Undisturbed[6] (Grasslands and Woodlands)	Landscape Refinement Measure (D+K)/(C-H)[6]
Butte	1,453,821	1,453,821	6,691	0.46%	1,447,130	99.54%	177,855	12.23%	12.29%	40,424	2.78%	2.79%	218,280	81.5%	18.5%	15.01%	15.08%	1,224,403	4,447	1,228,850	99.6%	0.4%	84.5%	3.7%
Harding	1,717,464	1,717,464	572	0.03%	1,716,892	99.97%	243,448	14.17%	14.18%	33,495	1.95%	1.95%	276,943	87.9%	12.1%	16.13%	16.13%	1,425,716	14,232	1,439,949	99.0%	1.0%	83.8%	2.3%
Lawrence	513,625	150,251	0	0.00%	150,251	100.00%	30,360	20.21%	20.21%	14,635	9.74%	9.74%	44,994	67.5%	32.5%	29.95%	29.95%	86,775	18,482	105,257	82.4%	17.6%	70.1%	12.2%
Meade	2,231,786	2,174,353	510	0.02%	2,173,843	99.98%	462,773	21.28%	21.29%	63,363	2.91%	2.91%	526,136	88.0%	12.0%	24.20%	24.20%	1,630,180	17,527	1,647,707	98.9%	1.1%	75.8%	3.7%
Perkins	1,851,923	1,851,923	5,832	0.31%	1,846,091	99.69%	483,064	26.08%	26.17%	41,652	2.25%	2.26%	524,716	92.1%	7.9%	28.33%	28.42%	1,319,721	1,654	1,321,374	99.9%	0.1%	71.4%	3.5%
Total	7,768,618	7,347,812	13,605	0.19%	7,334,206	99.81%	1,397,499	19.02%	19.05%	193,570	2.63%	2.64%	1,591,069	87.8%	12.2%	21.65%	21.69%	5,686,795	56,342	5,743,137	99.0%	1.0%	78.2%	3.5%

[1] Calculated using GIS from an intersection between US Census Bureau 2002 county boundary data published by the Natural resources Conservatoin Service (2009) and US EPA Level IV Ecoregion Boundaries (2012)
[2] SD Department of Game, Fish, and Parks Lakes layer (selected for water bodies > 40 acres), SD Department of Tranpsortation Missouri River layer, and Army Corps of Engineers Lake Oahe full basin layer.
[3] 2013 Farm Service Agency Common Land Unit data layer: cropland
[4] All non-CLU cropland and disturbed lands. This column represents the results of the SDSU analysis of disturbed acres.
[5] Includes all land tracts with no apparent disturbance as of 2012 (may include land tracts with historic disturbance that cannot be detected by SDSU analysis methodology. (Example: go-back grasslands)
[6] Column P reflects the additional 'disturbed' acres we removed to arrive at a final estimation of 'undisturbed' land as a percentage of all lands not removed by CLU cropland and large water bodies.

Table 6: Evaluation of Impacts of Land With Uncertain Disturbance History in Northwestern South Dakota.

Potentially Undisturbed[5] Lands with Uncertain Disturbance History (Go-Back[7] and/or Range Manipulation[7] Sites) in Northwestern South Dakota - 2013

A	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
County	Total County Area (Acres)[1]	County Area Included in Northwest SD Analysis (Acres)[1]	Percent of County Area in Analysis Area	Total Potentially Undisturbed[5] (Grasslands and Woodlands) Acres	Total Number of sections as per the *Public Land Survey (PLS, 2000)* in Analysis Area	Potentially Undisturbed[5] Acres with Uncertain Disturbance History (ie. Go-Back) Based on Polygons in Analysis Area[7]	Percent Potentially Undisturbed[5] Acres with Uncertain Disturbance History (ie. Go-Back)[7] Based on Polygons in Analysis Area (H/F)	Number of Possible Go-back Field[7] Polygons in Analysis Area	Average Acreage of Possible Go-back Field[7] Polygons in Analysis Area	Number of Possible Go-back Field[7] Points in Analysis Area	Approximate Acreage of Go-back Fields[7] Represented by Points in Analysis Area (26.06xL)	Total Approximate Acreage of Go-back Fields[7] Represented by Points *AND* Polygons in Analysis Area (H+M)	Percent Potentially Undisturbed[5] Acres that are Possible Go-Back Fields[7] Represented by Points *AND* Polygons in Analysis Area (P/F)	Number of PLS Sections with Possible Go-back Fields[7] Represented by Points *AND* Polygons in Analysis Area	*Percent* of PLS Sections with Possible Go-back Fields[7] Represented by Points *AND* Polygons in Analysis Area (P/G)	Number of PLS Sections with Possible Range Manipulation Points[7] in Analysis Area	Percent of PLS Sections with Possible Range Manipulation Points[7] in Analysis Area (R/G)
Butte	1,453,821	1,453,821	100%	1,228,850	2,284	7,836	0.6%	356	22.01	1,410	36,742	44,578	3.6%	848	37.1%	72	3.2%
Harding	1,717,464	1,717,464	100%	1,439,949	2,754	77,365	5.4%	3,388	22.83	7	182	77,547	5.4%	1,789	65.0%	39	1.4%
Lawrence	513,625	150,251	29%	105,257	232	1,757	1.7%	154	11.41	305	7,948	9,705	9.2%	155	66.8%	6	2.6%
Meade	2,231,786	2,174,353	97%	1,647,707	3,403	16,378	1.0%	562	29.14	5,810	151,397	167,775	10.2%	2,135	62.7%	150	4.4%
Perkins	1,851,923	1,851,923	100%	1,321,374	2,907	103,225	7.8%	3,467	29.77	1,804	47,009	150,234	11.4%	2,315	79.6%	49	1.7%
Total - Phase V	7,768,618	7,347,812	95%	5,743,137	11,580	206,562	3.6%	7,927	26.06	9,336	243,277	449,839	7.8%	7,242	62.5%	316	2.7%

[7] Uncertain Disturbance history includes tracts that show various degrees of indicators of historical tillage or manipulation but which lack tillage records or definitive indicators of field edges at this time; commonly referred to as "Go Back" land. Polygons were used to denote go-back areas primarily in Harding and northern Perkins Counties, and occasionally in other counties. Points were utilized to identify potential go-back fields in other portions of the analysis area.

Table 7: Protection Status of Land in Northwestern South Dakota

Protected[8] Potentially Undisturbed[5] Land - County Statistics for Northwestern SD - 2013

A	B	C	D	E	F	G	H	I	J
County	Total County Area (Acres)[1]	County Area Included in Northwest SD Analysis (Acres)[1]	Total Acres With Protected[8] Status in Analysis Area	Percent of Analyis Area With Protected[8] Status (D/C)	Total Potentially Undisturbed[5] (Grasslands and Woodlands) Acres in County	Potentially Undisturbed[5] Acres *With* Protected[8] Status in County	Percent of Protected[8] acres in County that are Undisturbed[5] (G/D)	Percent of Potentionally Undisturbed[5] Acres that are Protected[8] (G/F)	Percent Classified as Undisturbed[5] *And* Protected[8] Status in County (G/C)
Butte	1,453,821	1,453,821	6,158	0.4%	1,228,850	5,739	93.2%	0.5%	0.4%
Harding	1,717,464	1,717,464	13	0.0%	1,439,949	8	60.5%	0.0%	0.0%
Lawrence	513,625	150,251	405	0.3%	105,257	327	80.7%	0.3%	0.2%
Meade	2,231,786	2,174,353	1,901	0.1%	1,647,707	1,537	80.8%	0.1%	0.1%
Perkins	1,851,923	1,851,923	3,838	0.2%	1,321,374	3,225	84.0%	0.2%	0.2%
Total	7,768,618	7,347,812	12,315	0.2%	5,743,137	10,835	88.0%	0.2%	0.1%

[8] Protected lands include fee title property and/or permanent easements held by: US Fish and Wildlife Service, Natural Resources Conservation Service, and The Nature Conservancy. Not all protected acres are comprised of historically undisturbed land. Many protected acres are comprised of old fields.

Table 8: Status of State Owned Land in Northwestern South Dakota

County Statistics				SD School and Public Lands (SDSPL)				SDGFP[9] Game Production Areas (GPA)				SDGFP[9] Parks and Recreation Areas				Total SDGFP[9] Ownership				Total Combined SDSPL & SDGFP[9]			
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
County	Total County Area (Acres)[1]	County Area Included in Northwest SD Analysis (Acres)[1]	Total Potentially Undisturbed[5] (Grasslands and Woodlands) Acres in County	Total Acres Managed by SD School & Public Lands in County	Undisturbed[5] Acres Managed by SD School & Public Lands in County	Percent of School & Public Lands acres in County that are Undisturbed[5] (F/E)	Percent of Total Undisturbed[5] Acres in County Managed by School & Public Lands (F/D)	Total GPA Acres in County	Undisturbed[5] GPA Acres in County	Percent of GPA acres in County that are Undisturbed[6] (J/I)	Percent of Total Undisturbed[5] Acres Managed as GPA's in County (J/D)	Total SD Parks & Rec Acres in County	Undisturbed[5] SD Parks & Rec Acres in County	Percent of SD Parks & Rec acres in County that are Undisturbed[5] (N/M)	Percent of Total Undisturbed[5] Acres Managed as Parks & Rec Areas in County (N/D)	Total Acres Managed by GFP in County (includes all GPAs, Parks, and Rec Areas)	Total Undisturbed[5] Acres Managed by GFP in County (includes all GPAs, Parks, and Rec Areas)	Percent of Total GFP acres in County that are Undisturbed[5] (includes all GPAs, Parks, and Rec Areas) (R/Q)	Total Undisturbed[5] Acres Managed by GFP in County (includes all GPAs, Parks, and Rec Areas) (R/D)	Total Acres Managed by the State (SD School and Public Lands and SD GFP) in County	Total Undisturbed[5] Acres Managed by the State (SD School and Public Lands and SD GFP) in County	Total Acres Managed by the State (SD School and Public Lands *AND* SD GFP) that are Undisturbed[5] in County (V/U)	Total Undisturbed[5] Acres Managed in County by the State (SD School and Public Lands *AND* SD GFP) (V/D)
Butte	1,453,821	1,453,821	1,228,850	72,952	72,058	98.8%	5.9%	212	149	70.1%	0.0%	1,167	916	78.5%	0.07%	1,379	1,064	77.2%	0.1%	74,331	73,122	98.4%	6.0%
Harding	1,717,464	1,717,464	1,439,949	253,746	251,171	99.0%	17.4%	1,224	802	65.6%	0.1%	0	0	0.0%	0.00%	1,224	802	65.6%	0.1%	254,970	251,973	98.8%	17.5%
Lawrence	513,625	150,251	105,257	0	0	0.0%	0.0%	2,924	2,527	86.4%	2.4%	0	0	0.0%	0.00%	2,924	2,527	86.4%	2.4%	2,924	2,527	86.4%	2.4%
Meade	2,231,786	2,174,353	1,647,707	44,670	42,446	95.0%	2.6%	864	667	77.3%	0.0%	1,938	1,619	83.5%	0.10%	2,802	2,286	81.6%	0.1%	47,471	44,732	94.2%	2.7%
Perkins	1,851,923	1,851,923	1,321,374	72,531	68,809	94.9%	5.2%	7,091	5,150	72.6%	0.4%	1,607	922	57.4%	0.07%	8,698	6,073	69.8%	0.5%	81,228	74,882	92.2%	5.7%
Total	7,768,618	7,347,812	5,743,137	443,899	434,484	97.9%	7.6%	12,315	9,296	75.5%	0.2%	4,711	3,457	73.4%	0.06%	17,026	12,752	74.9%	0.2%	460,924	447,237	97.0%	7.8%

[9] South Dakota Department of Game, Fish, and Parks

Table 9: Status of Federally Owned Land in Northwestern South Dakota

Potentially Undisturbed[5] Land Managed as Multi-Use Lands by Federal Agencies - County Statistics for Northwestern SD - 2013

County Statistics				Bureau of Land Management				US Forest Service				US Bureau of Reclamation				Total Federal Multi-Use Lands			
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
County	Total County Area (Acres)[1]	County Area Analyzed for NWSD (Acres)[1]	Total Potentially Undisturbed[5] (Grasslands and Woodlands) Acres in County	Total Acres Managed by BLM in County	Undisturbed[5] Acres Managed by BLM in County	Percent of BLM Acres in County that are Undisturbed[5] (F/E)	Percent of Total Undisturbed[5] Acres Managed by BLM in County (F/D)	Total USFS Acres in County	Undisturbed[5] USFS Acres in County	Percent of USFS acres in County that are Undisturbed[5] (J/I)	Percent of Total Undisturbed[5] Acres Managed by USFS in County (J/D)	Total BoR Acres in County	Undisturbed[5] BoR Acres in County	Percent of BoR acres in County that are Undisturbed[5] (N/M)	Percent of Total Undisturbed[5] Acres Managed by USBoR in County (N/D)	Total Acres Managed by Federal Agencies in County	Total Undisturbed[5] Acres Managed by Federal Agencies in County	Total Acres Managed by Federal Agencies that are Undisturbed[5] in County (R/Q)	Total Undisturbed[5] Acres Managed in County by Federal Agencies (R/D)
Butte	1,453,821	1,453,821	1,228,850	145,741	143,218	98.3%	11.7%	0	0	0.0%	0.0%	13,963	7,386	52.9%	0.6%	159,704	150,604	94.3%	12.3%
Harding	1,717,464	1,717,464	1,439,949	29,718	29,178	98.2%	2.0%	74,000	73,086	98.8%	5.1%	0	0	0.0%	0.0%	103,718	102,264	98.6%	7.1%
Lawrence	513,625	150,251	105,257	99	97	97.4%	0.1%	1,009	988	97.9%	0.9%	0	0	0.0%	0.0%	1,109	1,085	97.8%	1.0%
Meade	2,231,786	2,174,353	1,647,707	39,797	39,355	98.9%	2.4%	169	166	98.3%	0.0%	0	0	0.0%	0.0%	39,966	39,521	98.9%	2.4%
Perkins	1,851,923	1,851,923	1,321,374	8,090	8,008	99.0%	0.6%	123,544	122,085	98.8%	9.2%	5,362	355	6.6%	0.0%	136,997	130,448	95.2%	9.9%
Total	7,768,618	7,347,812	5,743,137	223,446	219,856	98.4%	3.8%	198,723	196,325	98.8%	3.4%	19,325	7,740	40.1%	0.1%	441,494	423,921	96.0%	7.4%

Table 10: Ecoregion Statistics

Ecoregion[10] (Landscape) Statistics for Undisturbed Land in Northwestern SD - 2013														
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Map Key	Ecoregion	Total Ecoregion Acres in Analysis Area [1]	Potentially Undisturbed[5] Grassland Acres in Ecoregion[10]	Potentially Undisturbed[5] Woodlands Acres in Ecoregion[10]	Total Potentially Undisturbed[5] (Grasslands and Woodlands) Acres in Ecoregion[10]	Percent of Potentially Undisturbed[5] Land Classified as Grasslands (D/F)	Percent of Potentially Undisturbed[5] Land Classified as Woodlands (E/F)	Percent of Ecoregion[10] Classified as Undisturbed[5] (Grasslands and Woodlands) (F/C)	Undisturbed[5] Acres *With* Protected[8] Status in Ecoregion[10]	Percent of Total Undisturbed[5] Acres *With* Protected[8] Status in Ecoregion[10] (J/F)	Percent Classified as Undisturbed[5] *And* Protected[8] Status in Ecoregion[10] (J/C)	Undisturbed[5] Acres on State/Federal Lands *Without* Protected[8] Status in Ecoregion[10]	Total Undisturbed[5] Acres *Witout* Protected[8] Status on State/Federal Land in Ecoregion[10] (M/F)	Classified as Undisturbed[5] *And* Unprotected[8] State/Federal Land' Status in Ecoregion[10] (M/C)
1	Black Hills Foothills	224,243	131,081	28,660	159,740	82.06%	17.94%	71.2%	1,762	1.1%	0.8%	7,363	4.6%	3.3%
2	Missouri Plateau	2,205,341	1,509,367	1,753	1,511,121	99.88%	0.12%	68.5%	8	0.0%	0.0%	197,967	13.1%	9.0%
3	River Breaks	279,235	239,485	3,955	243,440	98.38%	1.62%	87.2%	0	0.0%	0.0%	28,775	11.8%	10.3%
4	Forested Buttes	147,605	127,989	13,067	141,056	90.74%	9.26%	95.6%	0	0.0%	0.0%	93,355	66.2%	63.2%
5	Sagebrush Steppe	870,868	744,198	689	744,887	99.91%	0.09%	85.5%	0	0.0%	0.0%	175,323	23.5%	20.1%
6	Subhumid Pierre Shale Plains	57,144	47,938	111	48,048	99.77%	0.23%	84.1%	0	0.0%	0.0%	1,243	2.6%	2.2%
7	Semiarid Pierre Shale Plains	1,097,464	710,637	6,446	717,083	99.10%	0.90%	65.3%	5,651	0.8%	0.5%	55,484	7.7%	5.1%
8	Moreau Prairie	1,582,222	1,366,026	1,636	1,367,661	99.88%	0.12%	86.4%	3,225	0.2%	0.2%	138,100	10.1%	8.7%
9	Dense Clay Prairie	883,663	810,075	25	810,100	100.00%	0.00%	91.7%	190	0.0%	0.0%	173,547	21.4%	19.6%
Total		7,347,785	5,686,795	56,342	5,743,137	99.0%	1.0%	78.2%	10,835	0.2%	0.1%	871,158	15.2%	11.9%

[10] US Environmental Protection Agency. https://www.epa.gov/eco-research/ecoregion-download-files-state-region-8#pane-39

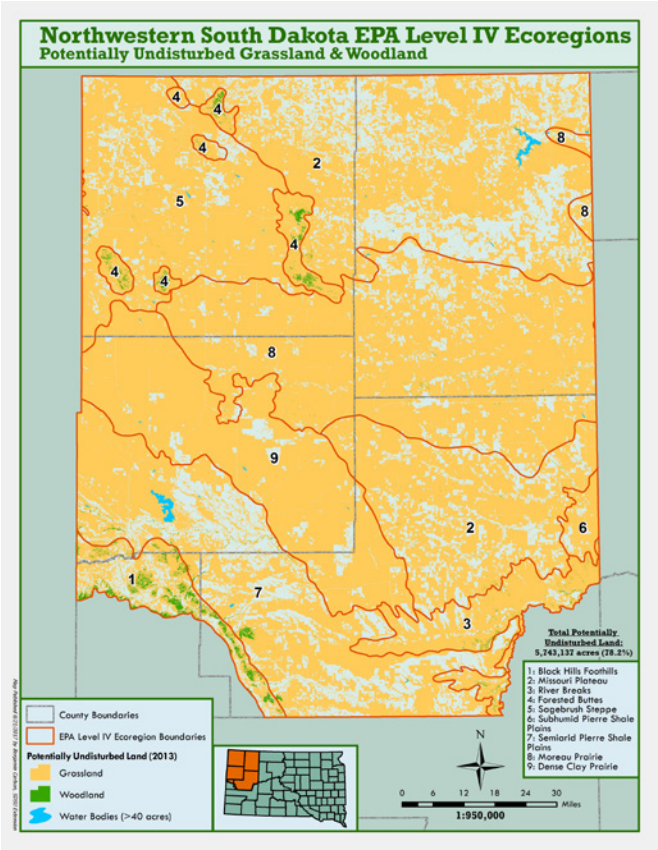

Figure 22: Northwestern South Dakota: Level IV US Environmetal Protection Agency Ecoregional Boundaries For Northwestern South Dakota in relation to potentially undisturbed land tracts.

and undisturbed grasslands and woodlands can be analyzed based on those boundaries (Figure 22).

The Missouri Plateau Ecoregion is the largest ecoregion represented in the analysis area and occupies over 2.2 million acres in large portions of Harding, Perkins, Butte, and Meade Counties. Next is the Moreau Prairie at nearly 1.6 million, the Semiarid Pierre Shale Plains at nearly 1.1 million, and the Dense Clay Prairie along with the Sagebrush Steppe, which are both nearly 900,000 acres. The undisturbed land in seven of the nine ecoregions is comprised of over 98% grassland, while the Black Hills Foothills and the Forested Buttes Ecoregions contain a higher percentage of undisturbed woodlands (17.9% and 9.3%, respectively).

Regarding the overall occurrence of undisturbed land, the Forested Buttes Ecoregion contains the most at 95.6%, while the Semiarid Pierre Shale Plains at 65.3%, the Missouri Plateau at 68.5%, and the Black Hills Foothills at 71.2% harbor the least remaining undisturbed (potentially native) lands. Overall, 78.2% of northwestern South Dakota was categorized as potentially undisturbed land. Six of the nine ecoregions ranking above the average have greater than 78.2% of their land base categorized as undisturbed.

We also overlaid the possible go-back areas within ecoregions to provide a visual assessment of density in relation to ecoregional boundaries. As per visual interpretation of this overlay, it appears the Moreau Prairie, Missouri Plateau, and Semiarid Pierre Shale Plains have the greatest density of go-back fields, which is consistent with our analysis of FSA CLU crop fields and other disturbances. (Figure 23).

Land protection status can also be evaluated at the ecoregional level, and ecoregions can be utilized to target protection efforts toward specific ecological objectives if desired. Through intersecting protected and undisturbed lands, we determined there are 10,835 acres in northwestern South Dakota that are both 'undisturbed' and 'protected' (0.2% of the total undisturbed land base). Because there are so few acres that met our criteria as protected land, and because of the vast size of the ecoregions in the analysis area, the impact of permanent land protection in this area is miniscule.

As previously discussed in the Results section of this report, lands owned by certain state and federal agencies are not considered protected due to a lack of law or policy, even if those lands have a low likelihood of conversion. Therefore, it is important to consider these lands when evaluating the impact of protection status on the future of undisturbed acres within ecoregions. In northwestern South Dakota, the total acreage is a fitting measure to evaluate the impact on public lands within ecoregions given that these lands are most often held open for public use. Of the nine ecoregions in the analysis area, four contain more than 130,000 acres of agency land, with the Missouri Plateau containing nearly 198,000 acres of federal and state land. However, the Forested Buttes Ecoregion offers the highest overall density of undisturbed state and federal land at 63.2% of the total area of the ecoregion (Figure 24).

Discussion

Overall, northwestern South Dakota is a relatively intact landscape with about 78% of the land within the five-county analysis area classified as undisturbed. We hypothesize based on our initial analysis, that it is

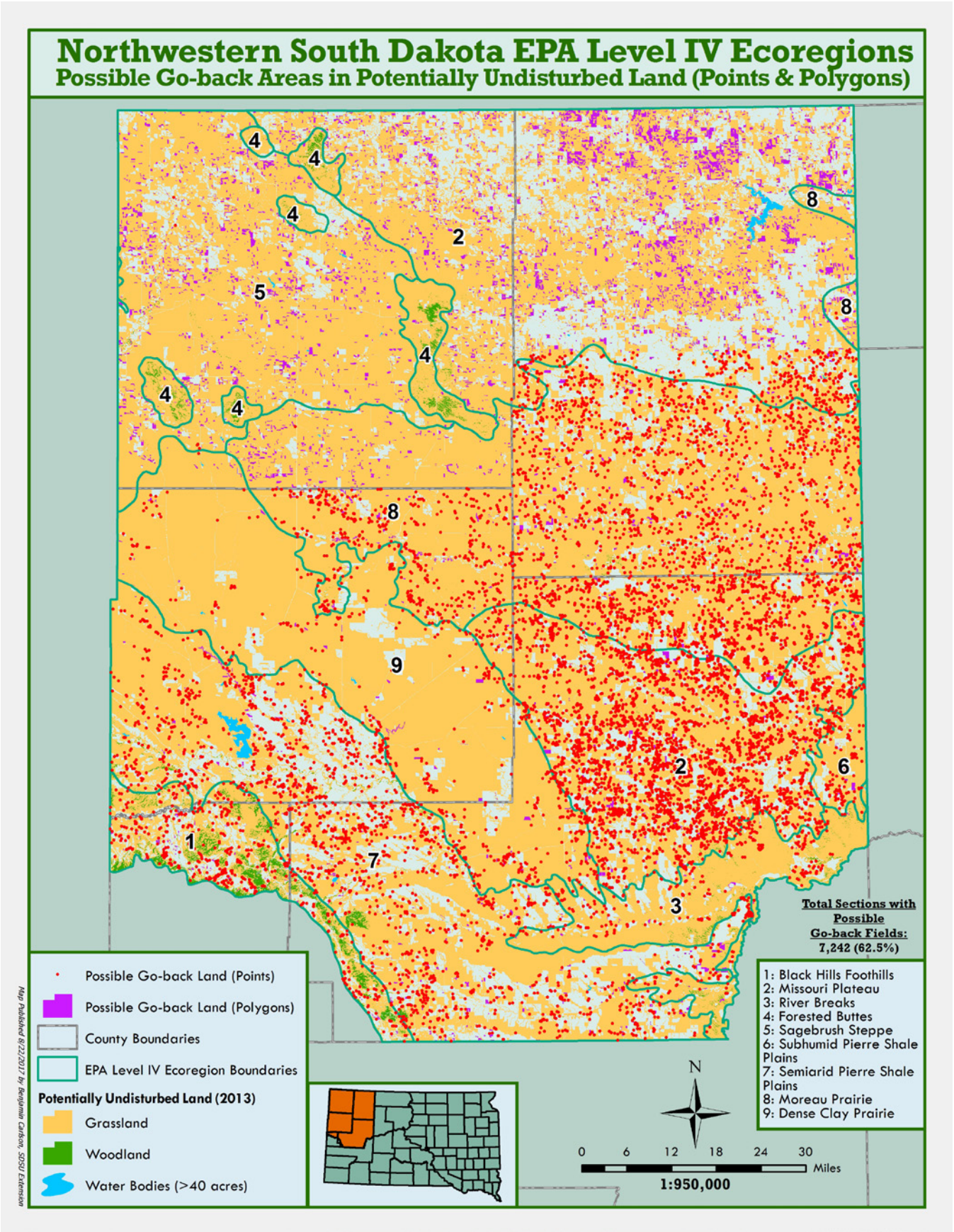

Figure 23: Northwestern South Dakota: Level IV US Environmetal Protection Agency Ecoregional Boundaries For Northwestern South Dakota in relation to possible go-back fields.

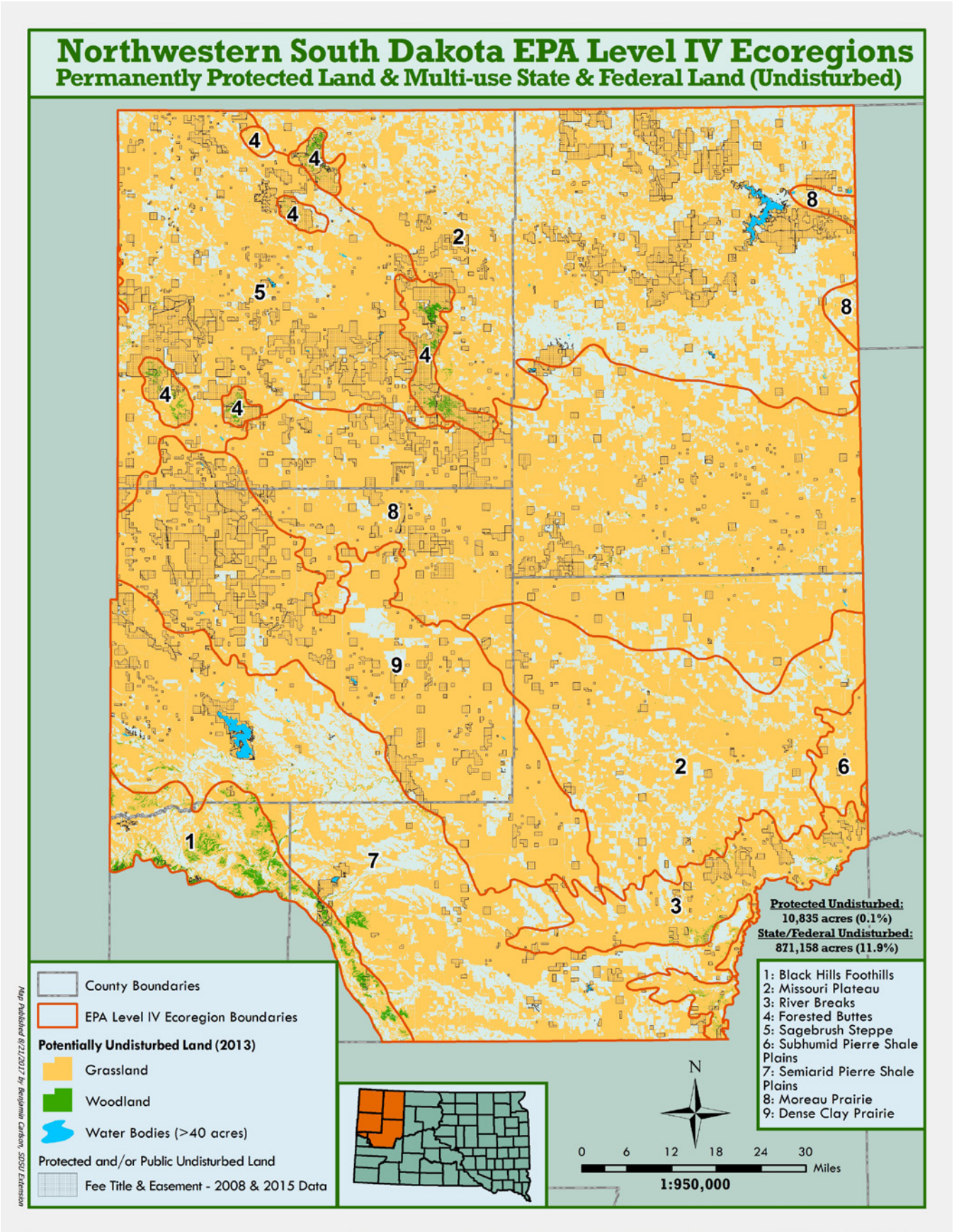

Figure 24: Northwestern South Dakota: Level IV US Environmetal Protection Agency Ecoregional Boundaries For Northwestern South Dakota in relation to potentially undisturbed AND protected land tracts.

likely additional disturbance areas might reduce the total undisturbed land by roughly 10%. Thus, we are confident as of 2013, northwest South Dakota was probably about 70% undisturbed (native) land. In comparison, the whole of eastern South Dakota was about 24% undisturbed.

Complicating our analysis of land use is the fact that portions of the landscapes we evaluated for this report were historically farmed for varying periods of time prior to public record keeping. These tracts, if identified, are usually referred to as 'go-back' fields or pastures, indicating they were allowed to 'go-back' or re-vegetate naturally (more or less). 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. This situation can also occur where range or pasture water retention projects, such as terracing or rangeland furrowing occurred (see Step 3 of the Deductive Analysis Procedures in the Methods section of this report). While nearly impossible to confidently categorize from aerial imagery, the land use history of many of these tracts can be determined through future on-the-ground evaluation of physical and ecological indicators such as tillage furrows, rock piles, and simplified plant communities infested with exotic species. However, classifying land use history solely based on plant community composition where physical indicators may be limited, and where native plant diversity is high, may be difficult.

Accurately assessing go-back fields and other disturbance areas from aerial imagery proved challenging in northwestern South Dakota. We expect this trend to continue as we finish the western portions of the state. We identified thousands of go back field polygons and points representing possible old crop fields, rangeland manipulation projects, and other disturbance areas that remain nested within the undisturbed layer for this region. When accurately identified through future analysis, these disturbances will reduce the actual percentage of undisturbed land in the analysis area.

The presence and distribution of go-back areas in northwestern South Dakota is important from both historical and ecological perspectives. Historically, these fields indicate past attempts at agricultural production where it was ultimately deemed infeasible, uneconomical, or perhaps was simply a decision to return old fields to grass or hay production due to other management concerns.

We did not seek to locate all abandoned homesteads in the region, but we speculate that the indicators of old homesteads coincide with the general distribution of go-back fields, reflecting a period when breaking of land for crops was encouraged (or required) without consideration for the long-term impacts of cropping poor soils. We tracked the occurrence of old house foundations and other indicators of historic homesteads when visibly apparent in the analysis area coincidental to assessing other landscape features and disturbances, and identified nearly 1,500 of these abandoned sites. While our homestead evaluation is neither comprehensive or complete, it does offer a reasonable glimpse into the impacts of initial settlement within this large region of the state (Figure 25).

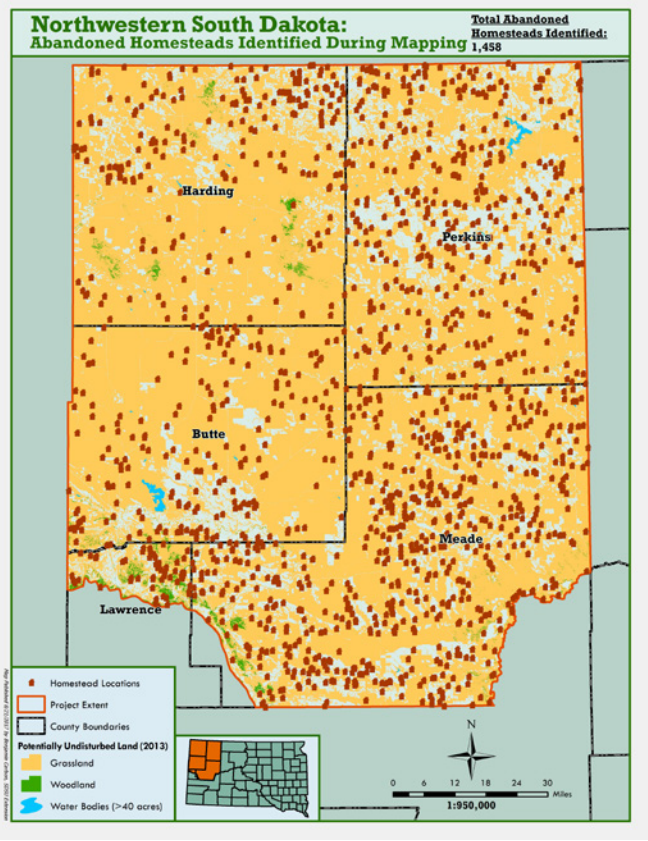

Figure 25: Northwestern South Dakota: Abandoned homesteads identified while performing the undisturbed land analysis for this region.

Management Implications

Future Data Refinement and Analysis of Conservation Lands

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 agency ownership 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 agency ownership 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 northwestern South Dakota. However, the accuracy and completeness of our dataset is limited by that of the source data used in analysis and by the natural geology and geography of this region, which can resemble historic tillage in certain situations. 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, unless efforts in addressing Common Land Unit discrepancies by the FSA resulted in significant changes in CLU geometry. Certain issues relating to the quality of the FSA Common Land Unit (CLU) layer and its cropland indicators are discussed at length above.

Ideally, information on FSA cropland to non-cropland reclassification history could serve to refine our analysis, however we are unaware of any practically accessible dataset that would contain this history. Such data does exist as archived CLU data (available to USDA cooperators from the Aerial Photography Field Office) or individual farm or tract data files within FSA county offices, but would require analysis for each individual CLU tract to properly assess cropping history from changes in CLU cropland indicators.

Some agencies and organizations have begun internal land cover classification projects for their fee title lands, but these data are generally 'in process' and their applicability to our analysis was variable. We urge agencies and organizations with significant land holdings to consider conducting on-the-ground surveys, along with historical research, to determine disturbance history on these properties.

Additionally, publicly accessible historic aerial photography exists for some states such as Minnesota dating to the late 1930's and early 1950's through the 1960's, but we could not locate such readily accessible public resources for South Dakota. In the future, acquiring and georectifying these historic photos should be considered, which could further inform undisturbed land classification data.

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. 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 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.

Recent Land Conversion in Northwestern SD

While it would be simple to assume current land use trends or rates of conversion for all South Dakota counties are similar, the geology, hydrology, and soil capability within any region of the state can be highly variable. Some areas lend themselves to an increased threat of conversion to farmland while other areas remain topographically challenging or have limited production potential, even with today's modern farm technology. This is true of the northwestern region. Additionally, while not formally protected, land owned by state or federal agencies in this region is likely not under immediate threat of conversion to cropland or other uses.

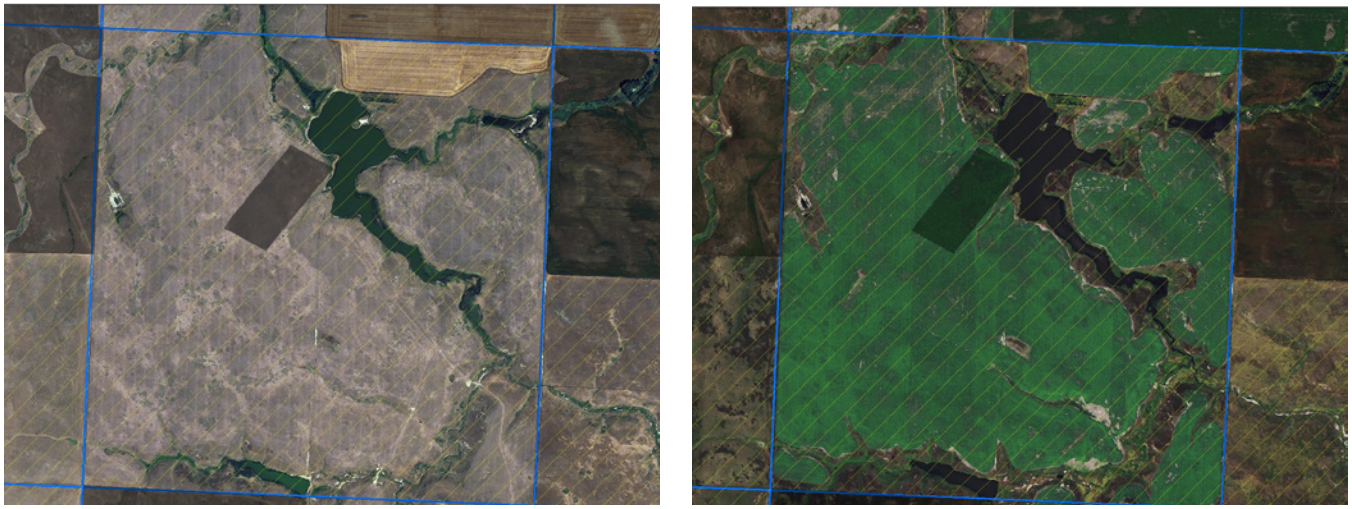

Figure 26: Conversion of a section of Perkins County land from primarily native grassland in 2012 (left) to primarily row crop or small grain production by 2014.

Throughout all phases of this analysis we have been able to detect land use changes happening in the present (since 2012 imagery). Simply due to the nature of data processing and acquisition, our assessments of land will always lag behind the actual changes. However, we are confident that the data we provide here can serve as a baseline that will allow future assessments to be completed more quickly.

Mapping technicians have incidentally witnessed a great deal of land conversion that has happened between 2012 and 2016 in some areas of the state. A revisit of our methodology in the near future will provide an opportunity to quantify loss of previously undisturbed (native) and/or possible go-back acres in the northwest region. Numerous examples of recent land conversion have been cataloged, and a few are provided here as examples of conversion that continues in this region. Figure 26 illustrates conversion of a section of Perkins County land between 2012 and 2014.

Pennington County, located just south of Meade County, was not included in this initial analysis. However, Figure 27 provides illustration of conversion on a very large scale. Here a 12-section area in Pennington and Meade Counties was nearly entirely converted to grain production over a short period. In 2006, the land was native grassland (left photo). By 2010, the conversion process had begun, possibly via chemical kill of the grassland (middle photo). By 2013, most of the land in the area had been converted to small grain production (right photo). In regions of northwestern South Dakota where soils are light or rocks are prevalent, chemical treatment followed by no-till planting of crops appears to be a very popular method of conversion of grasslands to cropland. This type of evidence of ongoing conversion clearly justifies the need to repeat our analysis in the future, as this tract and others like it will then be categorized as cropland and will serve as a true measure of loss of native grassland in the region.

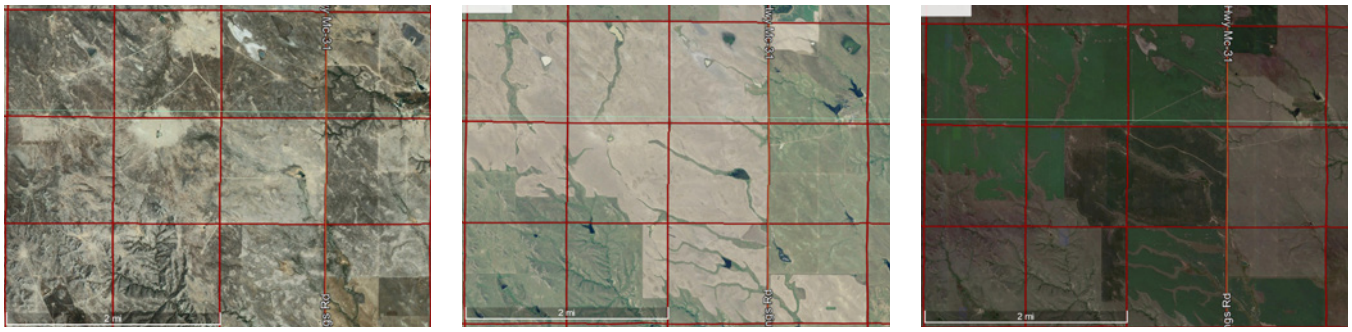

Figure 27: Conversion of 12 sections of Pennington and Meade County land. 2006 (left), 2010 (middle), and 2013 (right).

Threat of Future Land Conversion

There is no doubt that conversion of native land will continue to be a factor in northwestern South Dakota. A recent analysis by the World Wildlife Fund (WWF) depicts the overall conversion potential of the US portion of the Northern Great Plains based on several factors, including soil capability classifications based on the Natural Resources Conservation Service's (NRCS) Land Capability Classification (Figure 28).

World Wildlife Fund's protocol for categorizing soil crop suitability for northwestern South Dakota follows NRCS guidelines for the suitability of the eight primary soil classes to support crop production. Soil classes I -IV are considered arable land in that there are either slight limitations to agriculture (Class I) or moderate/severe limitations that can be mitigated by plant selection or conservation practices (Class IV). The upper four classes (V-VIII) are considered unsuitable for row crop agriculture due to non-mitigatable limitations (slope, big rocks, etc.) (Sarah Olimb, WWF, pers. comm.). As this map illustrates, the northwestern South Dakota region has a mixed conversion potential based on these factors as compared to other regions.

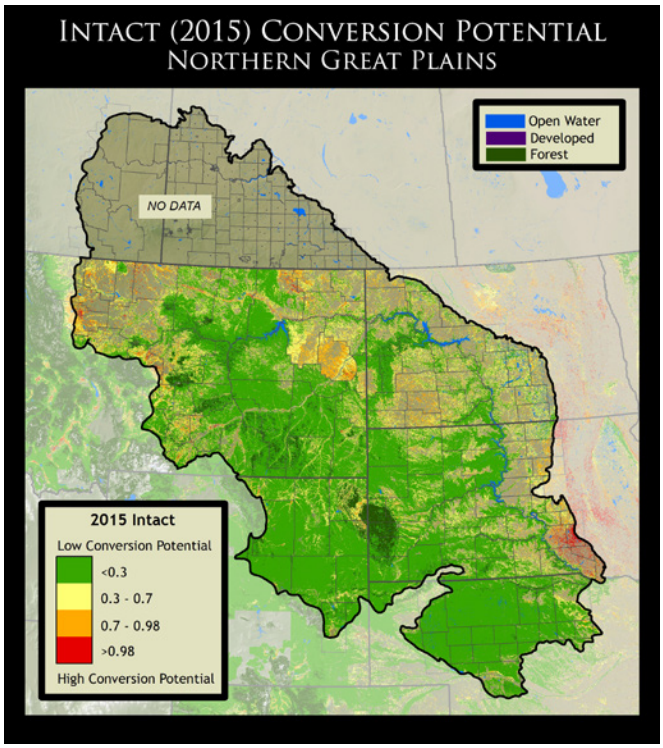

Figure 28: World Wildlife Fund analysis of conversion potential for the northern great plains.

We wanted to provide a more focused assessment of the potential for land conversion to crops for northwestern South Dakota using the same NRCS data provided by WWF for both high (classes I-IV) and low capability (classes V-VIII) soils. We overlaid the soil capability data on the undisturbed and disturbed land layers to determine which areas of northwestern South Dakota might be at most risk of future conversion. We also layered our go-back and range manipulation points and polygons to provide a true sense of land conversion history.

One might expect that regions with a high soil capability classification would be more prone to future threat of conversion since those areas have a soil rating conducive to raising crops. Figure 29 illustrates the occurrence of land deemed suitable for cropping in this region, some of which is currently categorized as FSA CLU cropland or has a proven disturbance history (shown in black on the image).

Some of these regions have dense CLU cropland occurrence already such as that on the northern portion of the border between Harding and Perkins Counties, central Perkins County, south-central Butte County, and southern Meade County. Other areas that appear capable of producing crops in southern and western Harding County and northeastern Butte County have large areas of intact grasslands remaining. The overlap of federal and state land would realistically limit the conversion threat in some areas.

Even with the larger footprint of publicly owned lands in this region as compared to other areas of the state, most of the land is privately owned. Roughly 86%, or about 1.9 million acres of the remaining undisturbed (native) sod classified as suitable for crops in this region is under private ownership, and whether additional grasslands are converted to row crops will be influenced by crop prices, technology, and federal programs. However, conversion does not always equate to successful production. Figure 30 represents flag points in suspected go-back fields within the crop suitable soil classification. One can only speculate on why these fields were returned to grass or grass-like cover, but it is likely that crop production in this semi-arid region proved difficult even on these crop suitable soils, and thus land

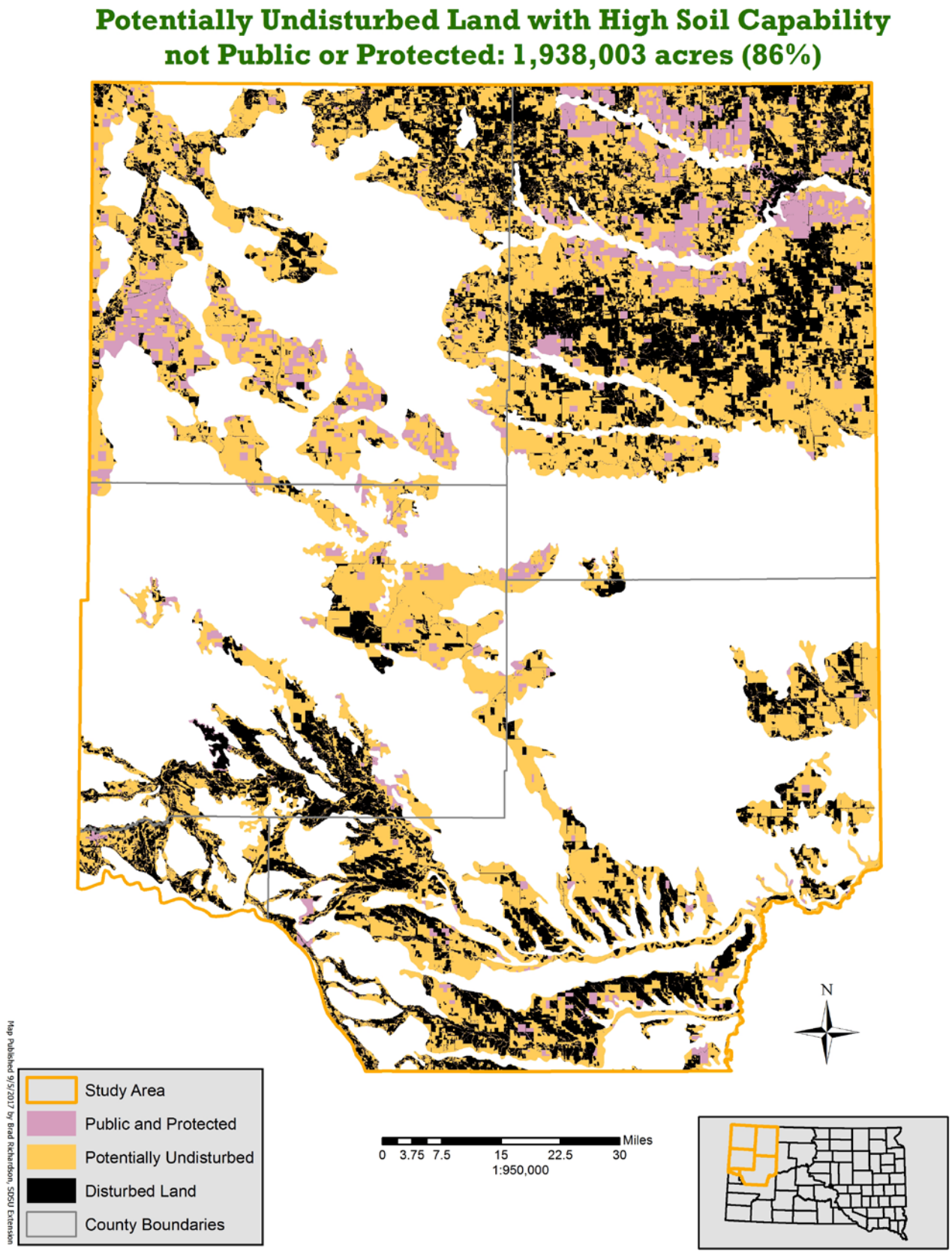

Figure 29: Northwestern South Dakota: Overlap of undisturbed land and areas with soils with a high capabilty class for crop production.

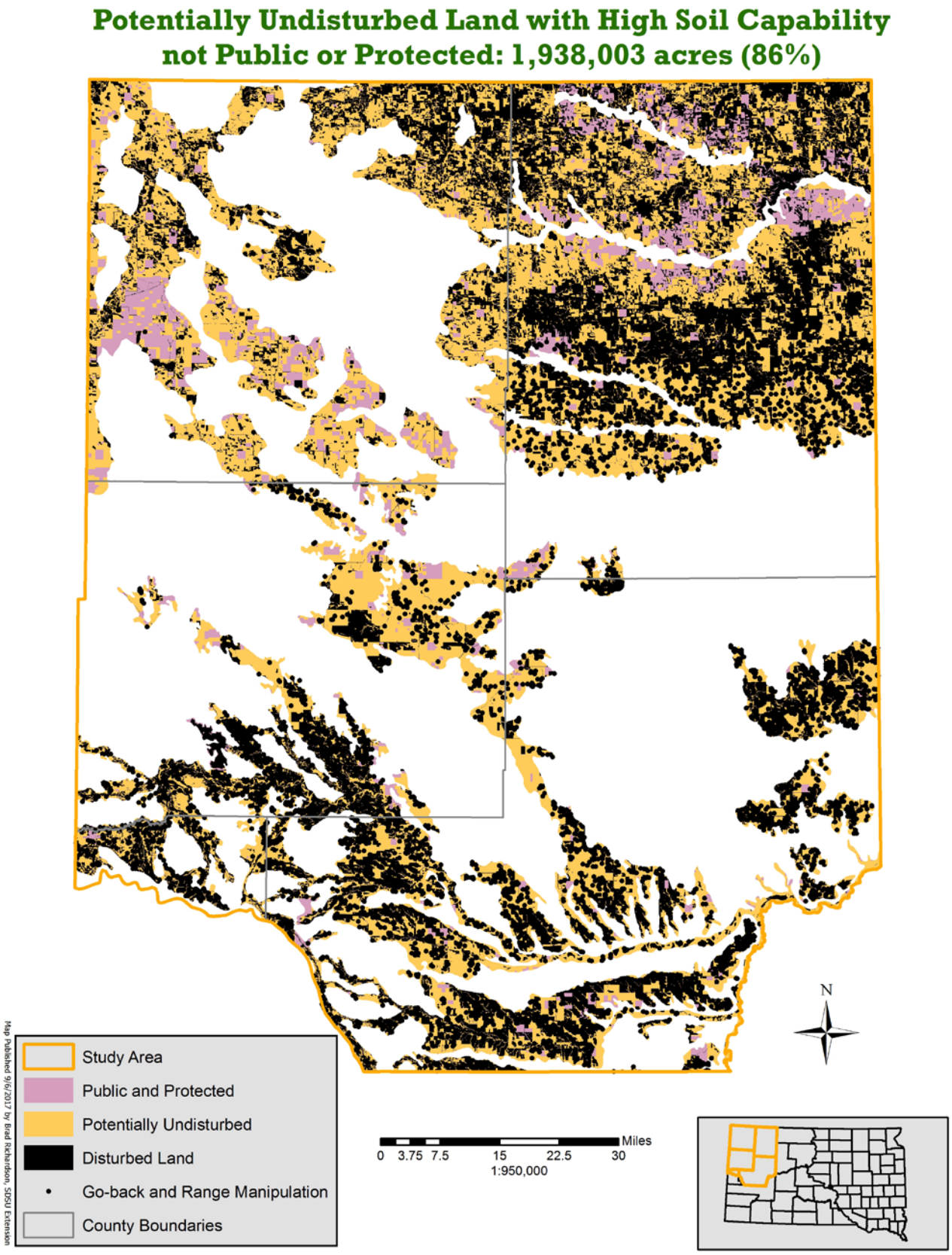

Figure 30: Northwestern South Dakota: Overlap of undisturbed land and areas with soils with a high capabilty class for crop production (Points are exagerated for visual identification and do not represent actual scale of go-back fields).

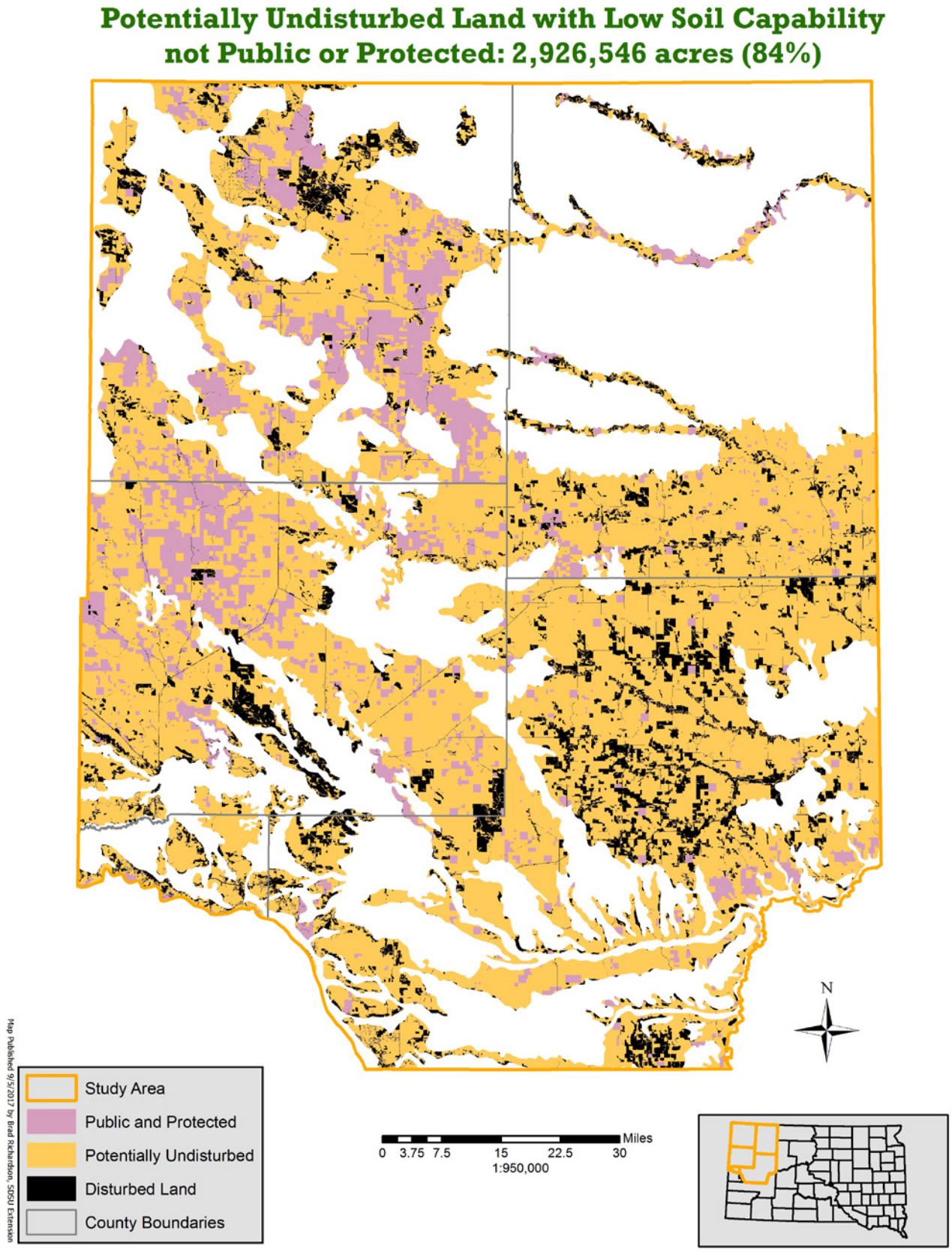

Figure 31: Northwestern South Dakota: Overlap of undisturbed land and areas with soils with a low capabilty class for crop production.

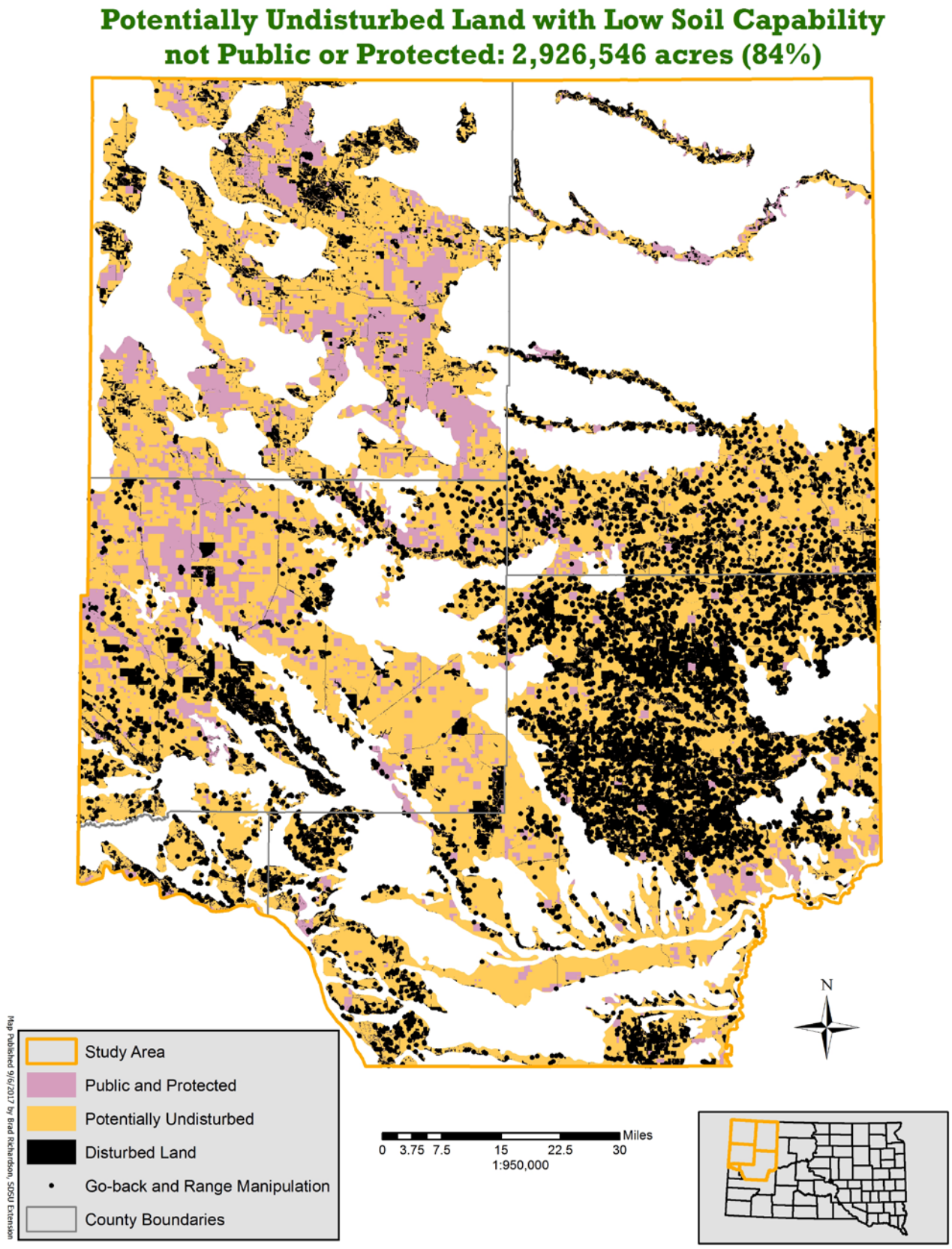

Figure 32: Northwestern South Dakota: Overlap of undisturbed land and areas with soils with a low capabilty class for crop production (Points are exagerated for visual identification and do not represent actual scale of go-back fields).

managers opted to passively or actively allow the land to revert to perennial grassy cover.

As one might expect, our evaluation of soils with the low crop capability rating yielded results that showed much less cropping history as compared to that of the high rating. Figure 31 illustrates the occurrence of land deemed unsuitable for cropping in this region, some of which is currently categorized as FSA CLU cropland or has a proven disturbance history (shown in black on the image). There are fewer pockets of dense CLU cropland occurrence in the low soil capability areas, but dense areas of conversion do occur in southcentral Butte, extreme southeastern Butte, and northcentral Harding counties. Again, the overlap of federal and state land would realistically limit the conversion threat in certain areas as well.

The low capability soil class occupies significantly more area in the northwestern SD region. Roughly 84%, or about 2.9 million acres of the remaining undisturbed (native) sod classified as unsuitable for crops in this region is under private ownership, and similar influences of crop prices, technology, and federal programs will influence future land use decisions. While one might assume the low capability soil would not be subject to as much future conversion, history indicates that previous land managers were at least willing to attempt crop production. Of course, these attempts may have been largely influence by misguided policies, such as breaking arid lands under the Homestead Act. At any rate, one cannot assume that low cropping suitability is a deterrent to attempting crop production. Figure 32 represents flag points in suspected go-back fields within the unsuitable soil classification.

Threat of Energy Production: Oil Wells and Other Features

Unlike eastern South Dakota, the northwestern region has not been influenced by the expansion of the wind industry. However, portions of this region do have a long history of mining and oil extraction which can create land disturbance and may influence the use of surrounding undisturbed land. We identified 298 oil wells, drill sites, and associated facilities (primarily in the Sagebrush Steppe Ecoregion of Harding County) (Figure 33). Of these sites, 262 (87.9%) were located adjacent to undisturbed areas. This represents oil features that were located within a 250-foot buffer of undisturbed grassland but were also not located (±100 feet) within crop fields. The use of these buffers in calculating this statistic was necessary because geometry for both CLU data layers and our undisturbed land layer were altered to account for disturbance from oil well pads and access roads. Ultimately, the influence of energy production on the conversion of land will be determined by market forces and decisions beyond the scope of this report.

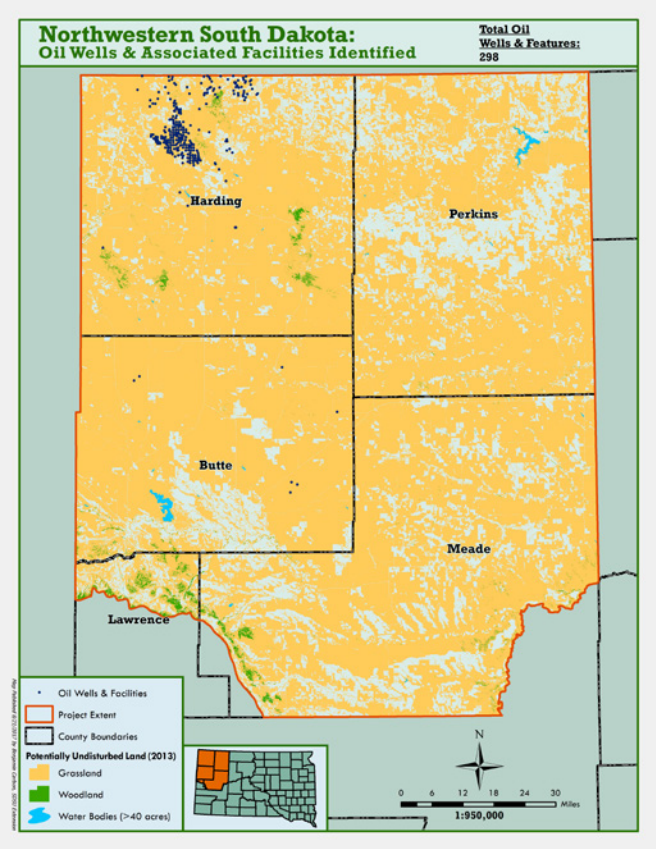

Figure 33: Northwestern South Dakota: Oil wells and other facilities

Understanding Land Conversion Issues

Our previous reports discussed recent published literature describing the impacts of land conversion in the region. We recommend reviewing recent literature. Some of the most notable papers providing background on the status of land conversion in the Northern Great Plains and the neighboring Prairie Pothole Region 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 that coincide with local observations of land conversion.

In addition to the papers mentioned above, many reports 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).

Conservation Prioritization in Northwestern SD

Ultimately, our data can be utilized to target conservation strategies, including prioritizing protection of undisturbed (native) habitats. Because of the incredible scale of this region, it is likely that strategies necessary to preserve the remaining undisturbed land must be of comparable scale and scope, and our results indicate that there is great potential for development of more aggressive conservation programs if the goal is to ensure future protection of undisturbed habitats. Keeping undisturbed land functioning as working ranches with a priority on native grassland preservation may be the top strategy for the perpetual protection of these areas.

Valuing Native Grasslands and Associated Species

Within all previous reports on land use trends, conversion of native grassland is included as an unquantified portion of total grassland loss. Native habitats cannot be re-created over time and space. Once the soil is physically disrupted, the full assemblage and complex interactions of the native biotic community with the abiotic elements are likely gone forever. Converted native grassland and woodland acres can eventually be re-established 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). Endangered species alone may serve as the necessary catalyst to re-think our approach to native habitat management.

Utilization of this Data for Future Assessments

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 or reported, while admitting that we must expand our methods to accurately evaluate our flagged go-back fields in the future. Nonetheless, our methodology provides a baseline dataset to evaluate potential areas of native sod within 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 eliminating native grassland conversion. 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.

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. We believe that significant change in the native woodland layer would be required to accurately detect change through short term analysis.

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. These areas cannot be completely quantified without some sort of improved evaluation through ground-truthing or LiDAR analysis.

Concluding Statement

Overall, our analysis team was challenged to think critically about the true amount of potentially undisturbed lands remaining as of 2013 in this region. On one hand, while it is encouraging to report over 5.7 million acres of potentially undisturbed land remaining in northwestern South Dakota representing an average of 78.2% of the land base, it is also important to note that these numbers represent the absolute maximum acreage of native habitat we will ever have. Any further conversion of native habitats will have a negative impact on species and communities that depend on these dwindling resources. How well these acres are managed for the perpetuation of biodiversity remains as perhaps the biggest unknown for the future of native species in northwestern South Dakota.

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Appendix A:
Northwestern SD County Maps
Undisturbed Land