Agricultural Land Assessment Implementation and Oversight Advisory Task Force: *Draft White Paper on Research Request*

Matthew Elliott, Ph.D.

South Dakota State University *Department of Economics*

Proposed Research Area:

This white paper defines the research question, scope, and provides a preliminary budget[1] proposal for the research requested of the SDSU Department of Economics by the Agriculture Land Assessment and Oversight Advisory Task Force. The initial request was limited in scope to study the research question: what would be the impact to property tax assessments if the current *productivity valuation system* was comprehensively adjusted to reflect *actual use* instead of *highest and best use.* Subsequent discussions with Department of Revenue, Carter Anderson USDA-NASS, and Dr. Burton Pflueger, identified additional issues (listed below) with the current *productivity valuation syste*m that may need to be addressed in the future if sufficient merit is determined by the task force. In addition, the discussions identified the limitations of studying only the impact of a comprehensive adjustment without addressing implementation, verification, and other issues. The most imperative other issue would be the determination of method for the formula value for county cash rental rates for grassland. The previously used county cash rental rates will not be available in 2014 from USDA-NASS, and is now mandated by current farm law to be only available every other year for the next five years[i]. Further, the county cash rental rate will only be a "factor" in the future for determining rental rates for appropriate USDA conservation programs, which was the historical purpose for the survey collection.

To that end, this white paper outlines a research agenda that can use public satellite data to fulfill the requested impact study to a comprehensive adjustment for actual use in the current productivity system; but the research agenda could also be expanded in scope to research development of a more accurate cropland, and grassland, map to assist in an implementation of an actual use adjustment. Moreover, the research will provide the ability to assess the consistency of the productivity valuation system of South Dakota Ag land, which uses soil tax tables based on the National Commodity Crop Productivity Index (NCCPI) and assessed with county revenue/cash rents as baseline values. The broader research scope would likely reduce the costs to implement a comprehensive *actual use adjustment.* The accuracy and the method of the more limited, accelerated research study of using the USDA-NASS CDL layer to determine impact of a comprehensive actual use adjustment may be problematic. The broader proposed research agenda would require additional resources to undertake than the more limited research scope of the initial request. Below lists an **estimated** cost proposal, and timeline from SDSU Department of Economics to pursue the more limited scope research, and a more extensive research scope.

[1] The estimated research budget has not been reviewed by the necessary parties at SDSU for approval, and may change after further review.

DRAFT

Limited Scope, Accelerated Research (maximum 1 Year research timeline, estimated $151.000 research budget)

A more limited research question **would measure the impact of a comprehensive adjustment** to *actual use* in the current *productivity valuation system*, or an *actual use productivity valuation system* (defined below) on an accelerated timeline (maximum 12 Months). The research of impact may conclude that the impact could be a relatively small effect to property tax distributional changes, and may not be justifiable to implement a comprehensive adjustment to tax assessments for *actual use* considering potential administrative and implementation costs. The alternative research conclusion could be that the impact would be relatively large, or the implementation/administrative costs relatively low, and a method could be devised that would enable the director(s) of equalizations the ability to implement a comprehensive adjustment based on *actual use* as stated in the existing law (see below). The latter case would likely require additional research resources to implement a comprehensive adjustment for *actual use* than a more limited research scope of only understanding the impact to a comprehensive adjustment to *actual use*.

The Department of Economics at SDSU would be the principal investigator and would, with other SDSU researchers, merge multiple years (e.g. 2011, 2012, and 2013) of USDA-NASS Cropland Data Layer (CDL), and then align the merged cropland data layer with the NRCS soil layer using *ArcGIS* and/or *Erdas Imagine* software (See Pierre PDF). The spatial software data will be combined with South Dakota Department of Revenue data on soil tables and values, and SDSU productivity formulas, to estimate property valuations by soil type. Property tax valuations will be mapped, using spatial analysis software, under the current *productivity system* for each section within a county and each county within the state. Property tax valuations will be mapped under a comprehensive *actual use system*. Areas that were cropped within a specified time period (yet to be defined) will be valued using the cropland valuation formula, and areas that have not been cropped during the specified time period will be valued using the grassland value formula. The value differences between the *current system* valuations and an *actual use productivity valuation system* will be mapped for each county within the state, and potentially each section within the county. A report will include the maps and summarize the findings of impact of a comprehensive adjustment to an *actual use system*. In addition, the report will describe in detail errors associated with the analysis. The errors of the analysis will provide a beginning basis for determining administrative costs, and additional research costs, to convert to an actual use system. The preceding presumption is that the errors are expected to be normally distributed. Thus our impact estimates are expected to be robust and to allow for a reasonable understanding of distributional changes and magnitude of impact from a tax assessment and tax revenue perspective. However, the errors of the research method may be to a significant degree that results in a prohibitively costly method to implement/administrate as a comprehensive adjustment tool, where normally distributed errors of overestimating cropland would likely result in property tax appeals, and underestimation of cropland will reduce county and state revenues. Both would require on-site inspections and verifications to determine accurate actual use acreage. As a result, this part of the research can be combined with a broader research scope to focus on implementation that would be on a separate timeline and require additional resources.

DRAFT

Broader Research Scope (2.0 Years research timeline, estimated $343,000 research budget)

As described above, additional issues have been identified that may warrant further research in the future. These additional issues may be addressed in pursuit of a comprehensive actual use adjustment tool to assist with implementation. The issues relate to the accuracy, consistency, and long-term stability of the formulas used in the *productivity valuation system* and include the following:

- Limited survey data in future years, including the availability of cash rental values from NASS in alternating years;
- Data limitations for determining productivity values using yields and soil tables;
- Determining a nondiscriminatory methodology for adjustments by directors of equalization that is consistent across counties;
- Lack of uniformity in valuations across county lines; and
- Changes in producer practices that can provide greater revenue potential on lower quality soil.

This broader research scope would **1) primarily be devoted to developing more accurate South Dakota grassland and cropland maps** used for implementation in a comprehensive adjustment to actual use, but then also **2) would assess the consistency of remote sensing satellite data with the NCCPI and county cash rental/ revenue values**. The NCCPI was designed to determine soil ratings for time invariant non-irrigated crop production, but not rangeland production systems. This data, however, is used by the Department of Revenue to determine soil ratings for both grassland and cropland soil ratings. This data was also developed to be county specific and loses consistency on larger scales. Further, the disparity between cash county rental rates and expected market value for land has been shown to be increasing, this may partly be due to additional factors to the transaction that are not apparent by the survey respondents' stated value.

The broader research would use normalized difference vegetation indexes (NDVI), or other vegetation indices, to develop data layers that assesses productivity variations for both cropland and grassland at a 30 square meter resolution during a multi-year period. The best method for determination of more accurate grassland and cropland maps using vegetation indices will be developed, refined, and verified during the research period. However, no method of using remote sensing satellite data to understand land use, and changes to land use, will be able to be generated without error. The error variances associated with varying methods and data sources will be assessed and reported.

The multiple year vegetation values will also be compared with the tax assessment values using the current assessment methodology. Large departures in assessed values compared to vegetation variations may suggest discrepancies in property tax assessments compared to actual productivity potential. The potential product of the research would be to develop an enhanced methodology for assessing grassland productivity in a manner that is consistent with cropland assessment.

DRAFT

Remote sensing satellite data is commonly used to monitor agriculture productivity and land used changes in South Dakota. The data that will be used for this project will be data from Landsat Satellites, such as the WELD project led by Professor David Roy of the Geospatial Sciences Center of Excellence (GSCE) at SDSU. WELD projects makes available for public research and use corrected Landsat 7 ETM+ and Landsat8 OLI/TIRS data. (see Clark County PDF attached).

Roy, D.P., Ju, J., Kline, K., Scaramuzza, P.L., Kovalskyy, V., Hansen, M.C., Loveland, T.R., Vermote, E.F., Zhang, C., 2010, Web-enabled Landsat Data (WELD): Landsat ETM+ Composited Mosaics of the Conterminous United States, *Remote Sensing of Environment*, 114: 35-49.

Definitions and Relevant Existing Law:

Productivity Valuation System (highest and best use)- (see link)

http://dor.sd.gov/Taxes/Property_Taxes/Productivity_Valuation_for_Agricultural_Land_Assessments.aspx

Actual use productivity valuation property tax system- determine property tax assessments based off the property's use (i.e. cropland or grassland) and productivity formulas (e.g. 8 year Olympic average county revenue) and current soil tax tables.

Relevant South Dakota Law:

10-6-33.31. Director of equalization to be provided agricultural income value for county--Adjustment of assessed value. Before July first each year, the secretary of revenue shall annually provide each director of equalization the agricultural income value for each county as computed pursuant to § 10-6-33.28. The director of equalization shall annually determine the assessed value of agricultural land.

The assessed value of agricultural land may be adjusted by the following factors affecting productivity:

(1) The capacity of the land to produce agricultural products as defined in § 10-6-33.2; and

(2) The location, size, soil survey statistics, terrain, and topographical condition of the land including the climate, accessibility, and surface obstructions.

Each adjustment shall be documented. The director of equalization may document an adjustment by using data from sources reasonably related to the adjustment being made. In addition, the director of

DRAFT

equalization may use data from comparable sales of agricultural land to document the adjustment concerning productivity for any of the factors listed in this section.

If the actual use of agricultural land varies from the land use category specified by soil classification standards, the property owner may request an examination of the land by the director of equalization. The director of equalization shall make a determination of whether to adjust the assessed value of the agricultural land pursuant to the factors listed in subdivision (2).

Relevant Changes to Agriculture Act:

(A) in subparagraph (A), by striking ''conduct an annual survey'' and inserting '', not less frequently thanonce every other year, conduct a survey'';

(B) in subparagraph (B), by striking ''annual''; and(C) by adding at the end the following: ''(C) USE.—The Secretary may use the estimates derived from the survey conducted under subparagraph (A) relating to dryland cash rental rates as a factor in determining rental rates under this section in a manner determined appropriate by the Secretary.''. (PUBLIC LAW 113–79—FEB. 7, 2014 128 STAT. 649)

Data available to research and/or implement an actual use or actual revenue system

1. Starting in the 2007 crop year, USDA-NASS began distributing for public use the USDA, NASS Cropland Data Layer (CDL), a raster, geo-referenced, crop-specific land cover data layer. The resolution is 30 square meters. The CDL is produced using satellite imagery from the Landsat 8 OLI/TIRS sensor, Landsat 7 ETM+ sensor, and the Disaster Monitoring Constellation (DMC) DEIMOS-1 and UK2 sensors collected during the growing season, and available annually around February of the year following the crop year. Accuracy is approximately 85-95% on identifying actual acres and crop type per year for major row crops in South Dakota.

http://nassgeodata.gmu.edu/CropScape/
http://www.nass.usda.gov/research/Cropland/metadata/metadata_sd13.htm

2. WELD and Landsat data from Landsat 7 ETM+ sensor and Landsat 8 data from the Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) are available through USGS. Landsat 8 since May of 2013. Resolution enhancements to OLI and TIRS sensor data may provide reasonably accurate vegetation mapping and modeling to 30 square meters and reduce atmospheric distortions.

http://weld.cr.usgs.gov/index.php
http://pubs.usgs.gov/fs/2013/3060/pdf/fs2013-3060.pdf
http://landsat.usgs.gov/landsat8.php

3. Enhanced Vegetation index (EVI) and normalized difference vegetation index (NDVI) are also available through USGS from the Modis satellite. The EVI and NDVI are available every two weeks throughout the year. The resolution for EVI is approximately 250 square meters.

https://lpdaac.usgs.gov/products/modis_products_table/mod13a2
http://e4ftl01.cr.usgs.gov/MOLT/

DRAFT

4. County and State Yields and average prices are available through USDA-NASS.

5. Soil Survey Data is available through NRCS.

http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

6. County Certified Crop Acres by crop are available through FSA since 2007. Final numbers are determined January 15th the year following the crop year.

http://www.fsa.usda.gov/FSA/webapp?area=newsroom&subject=landing&topic=foi-er-fri-cad

7. South Dakota crop basis values are available through SDSU.

DRAFT

8. South Dakota survey based multi-county land and cash rent market values are available from SDSU.

9. NCDC provides geo-reference weather data products

http://www.ncdc.noaa.gov/wct/data.php

Data analysis tools:
ArcGIS and *Erdas Imagine* software can be used to analyze large metadata using geo referenced coordinate systems. Research can be done to analyze land use changes, estimate productivity, and build models on productivity as a result of soil types, soil classification, crop selection, climate, etc.

http://www.esri.com/software/arcgis
http://www.hexagongeospatial.com/products/remote-sensing/erdas-imagine/overview

The *ArcGIS or Erdas Imagine software* aligns layers of metadata for statistical analysis such as the NRCS soil type, the USDA-NASS CDL layer, and EVI or NDVI.

SAS/SPSS are broad based statistical software that can be used to model commodity prices, volatility, etc.

http://www.sas.com/en_us/home.html http://www-01.ibm.com/software/analytics/spss/

Research Needs:

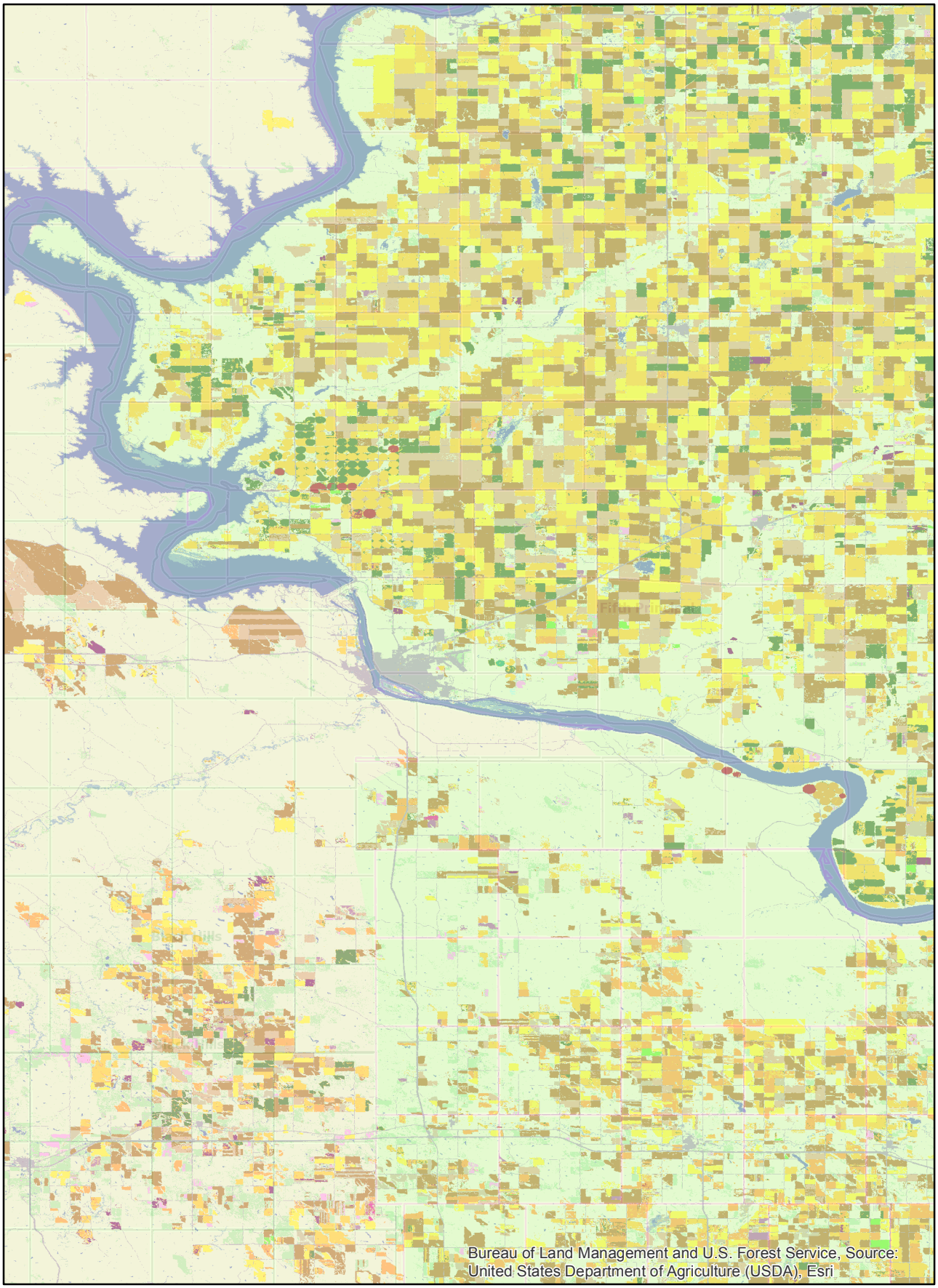
1. Compensation for SDSU Faculty and student(s) using full-time equivalent (FTE)
    a. Economics Faculty and Student(s)
    b. Geography/ or other Faculty and Student with *ArcGIS* proficiency
2. Department of Revenue Data and tax tables based on soil types
3. Licenses for *ArcGIS and Erdas Imagine* software with advanced spatial analysis capability and SAS/SPSS software

Deliverables:
Report(s) on impact of comprehensive adjustment to *actual use productivity system* and consistency assessment of productivity valuation system with remote sensing satellite data.

- Map changes to tax assessments from a comprehensive adjustment
- Develop accurate grassland, cropland maps for South Dakota for actual use implementation
- Assess consistency in productivity values using soil rating tables and county revenue/cash rental rates and productivity variations in remote sensing satellite data.

DRAFT

DRAFT


Bureau of Land Management and U.S. Forest Service, Source:
United States Department of Agriculture (USDA), Esri

Sum of Annual Max NDVI (2003-2012)

Clark County, SD includes both croplands on the Coteau and in the James River valley, making it a good test location.

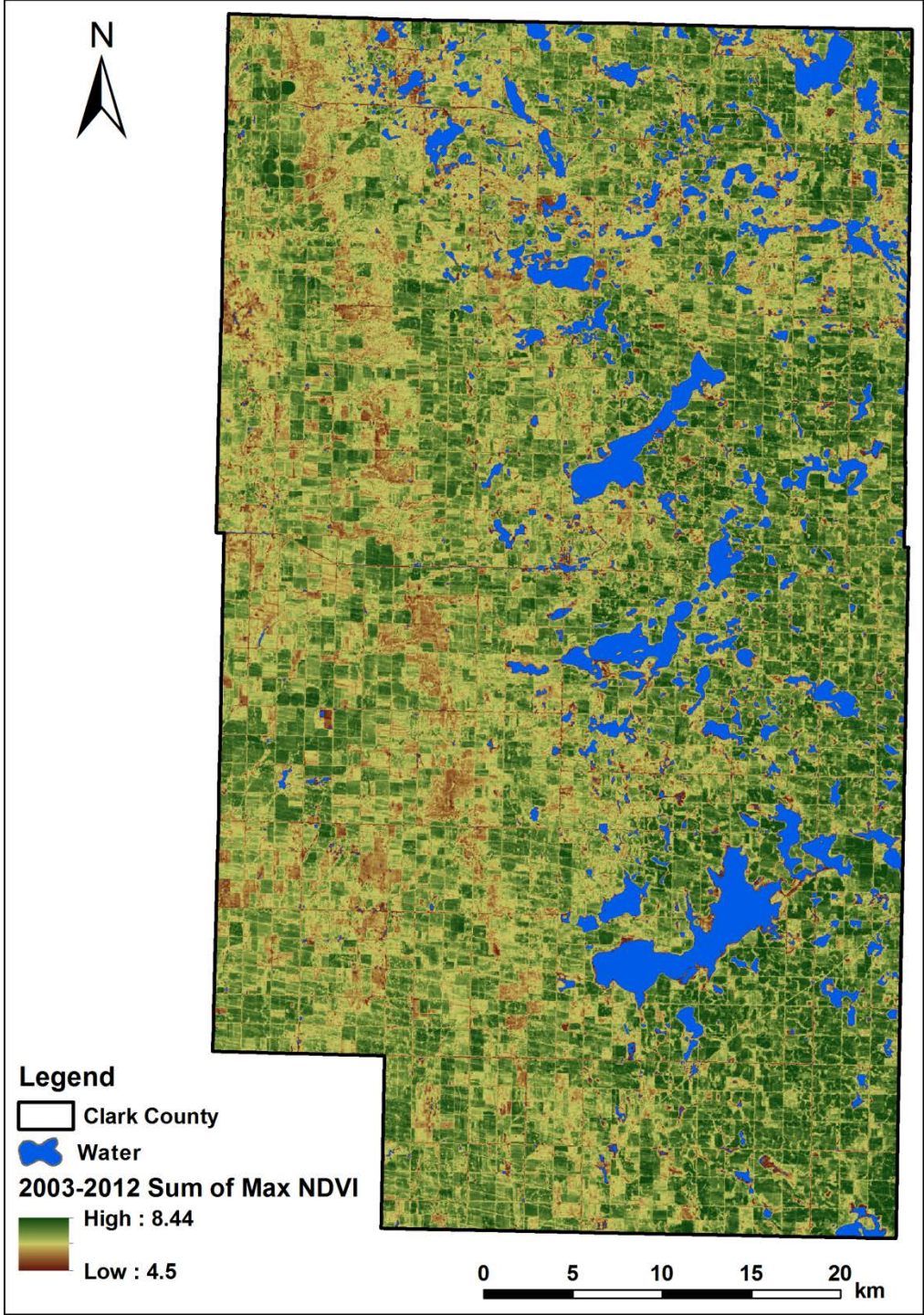
The image to the right is the sum-above-base of annual NDVI maxima images for the period 2003-2012. The underlying data are from the NASA funded WELD product generated at Prof. David Roy of the Geospatial Sciences Center of Excellence (GSCE) at SDSU.

The NDVI (Normalized Difference Vegetation Index) shows areas of higher vegetation cover. An annual NDVI maximum image reveals areas of higher and lower productivity.

WELD: Web Enabled Landsat Data

WELD: http://weld.cr.usgs.gov

GSCE: http://globalmonitoring.sdstate.edu



Sum of Annual Max NDVI (2003-2007)

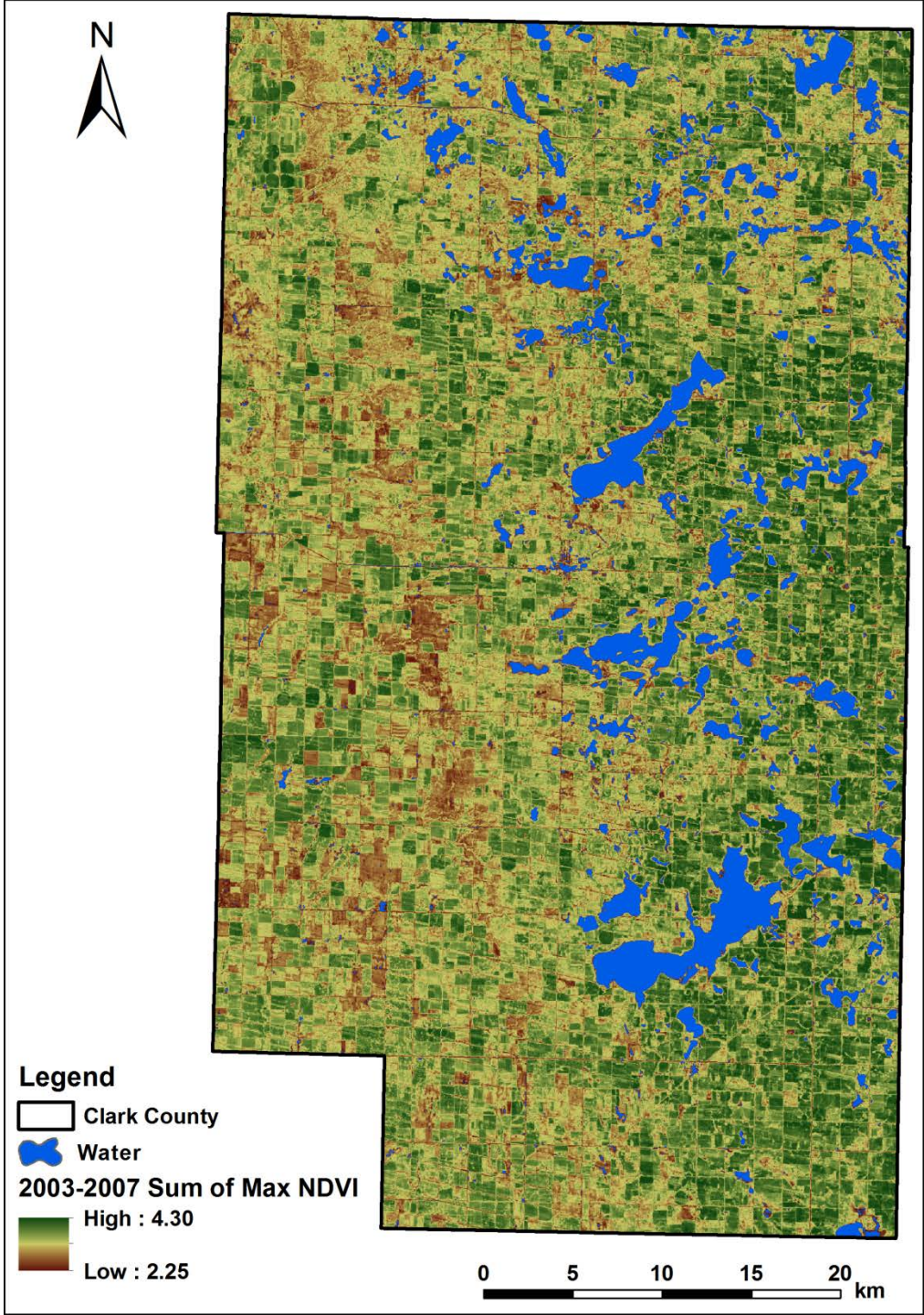
The image to the right is the sum-above-base of annual NDVI maxima images for the period 2003-2007, which corresponds to the period prior to the push toward increasing corn acreage. The underlying data are from the NASA funded WELD product generated at Prof. David Roy of the Geospatial Sciences Center of Excellence (GSCE) at SDSU.

The NDVI (Normalized Difference Vegetation Index) shows areas of higher vegetation cover. An annual NDVI maximum image reveals areas of higher and lower productivity.

WELD: Web Enabled Landsat Data

WELD: http://weld.cr.usgs.gov

GSCE: http://globalmonitoring.sdstate.edu



Sum of Annual Max NDVI (2008-2012)

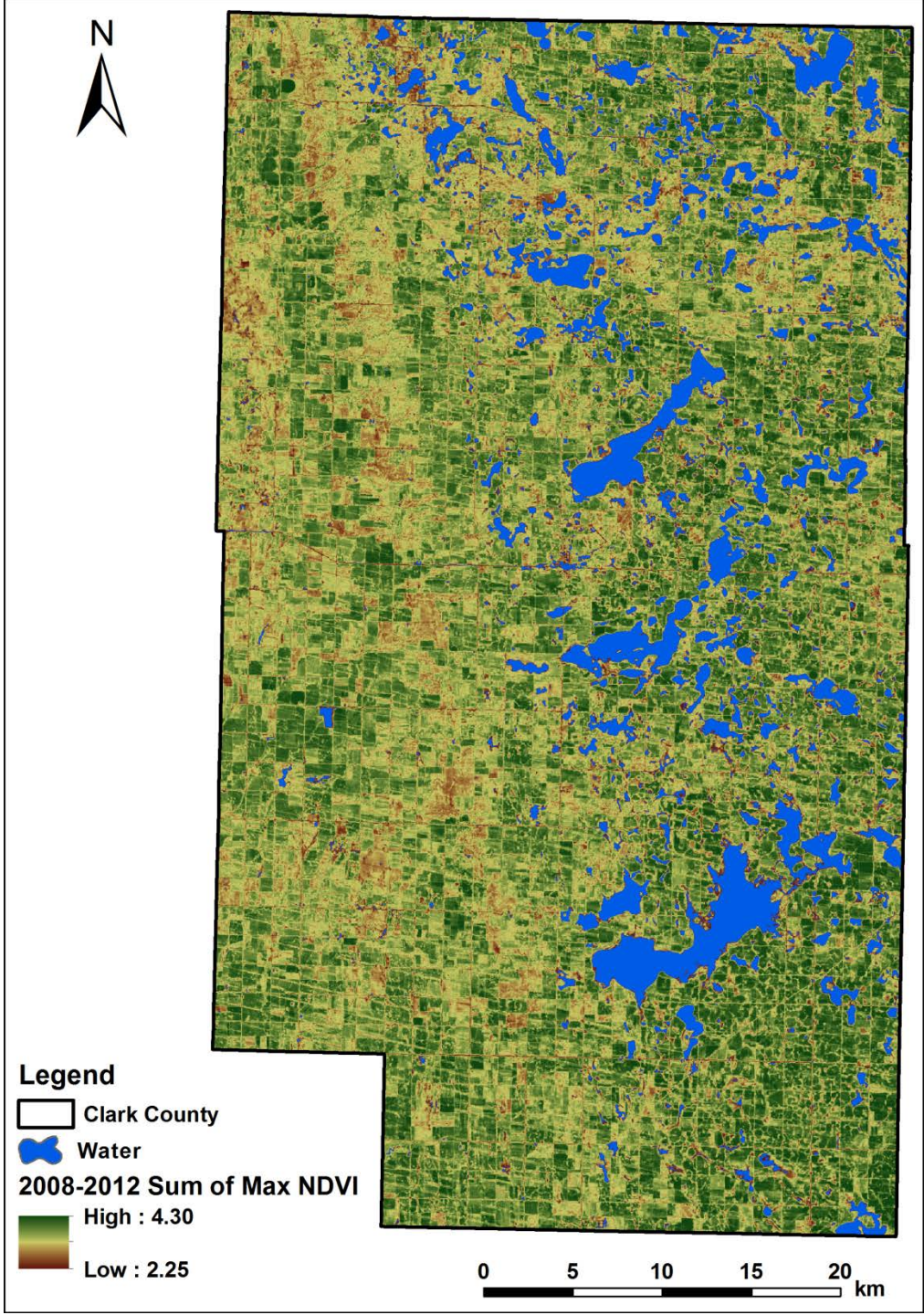
The image to the right is the sum-above-base of annual NDVI maxima images for the period 2008-2012, which corresponds to the period of increasing corn acreage. The underlying data are from the NASA funded WELD product generated at Prof. David Roy of the Geospatial Sciences Center of Excellence (GSCE) at SDSU.

The NDVI (Normalized Difference Vegetation Index) shows areas of higher vegetation cover. An annual NDVI maximum image reveals areas of higher and lower productivity.

WELD: Web Enabled Landsat Data

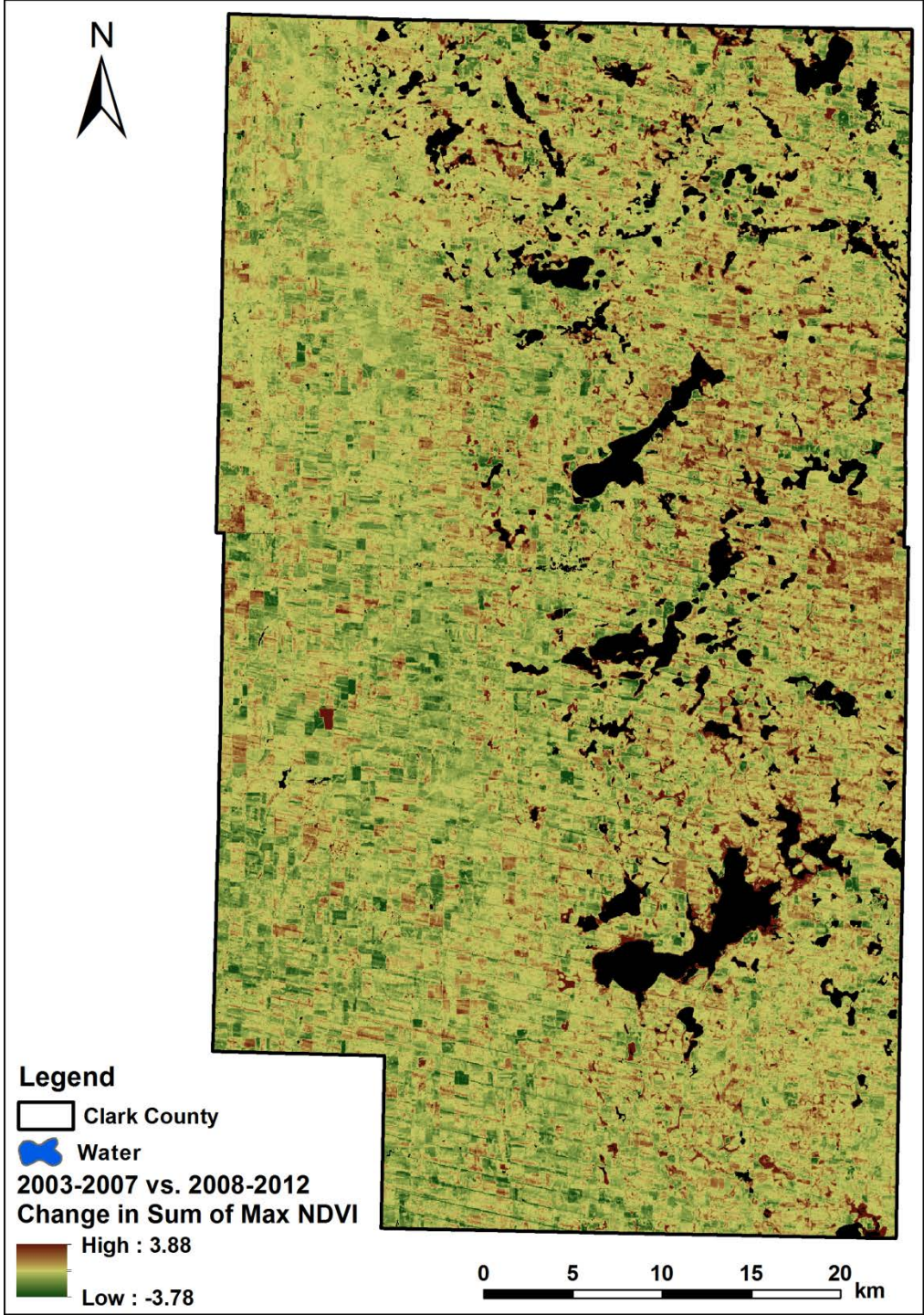
WELD: http://weld.cr.usgs.gov

GSCE: http://globalmonitoring.sdstate.edu



Change in Sum of Annual Max NDVI (2012-2003)

- This image is the simple difference from the previous two annual maxima: max(2008 to 2012) minus max(2002 to 2008).
- Positive changes are in shades of green, indicating higher productivity during the latter period than former; whereas, negative changes are in shades of brown, indicating higher productivity during the former period than the latter.
- Changes around lakes are mostly artifacts of zero values.
- Stripping evident results from underlying issues with the Landsat 7 ETM+ data. The newer Landsat 8 OLI data do not have these problems but the image record is much shorter.



MAX of Annual Max NDVI (2003-2012)

The image to the right comprises the maximal NDVI values at each pixel during the entire period 2003-2012.

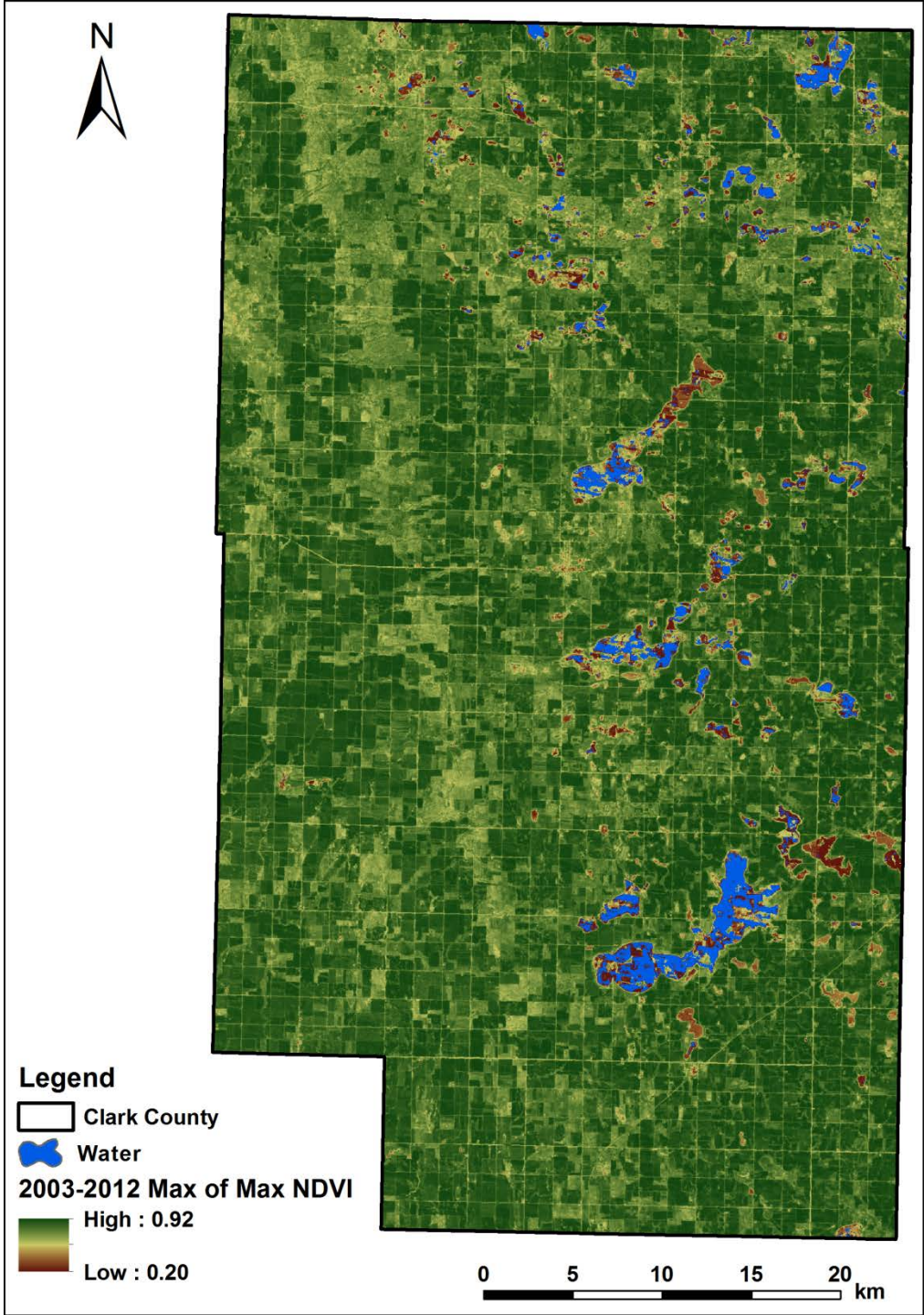
This image differs from the sum-above-base images because the latter include data from drier years (e.g., 2006, 2012) when productivity was lower; whereas, the maximum across years will select the higher productivity wetter years (e.g., 2010, 2011).

In this image the water masking is incomplete.

WELD: Web Enabled Landsat Data

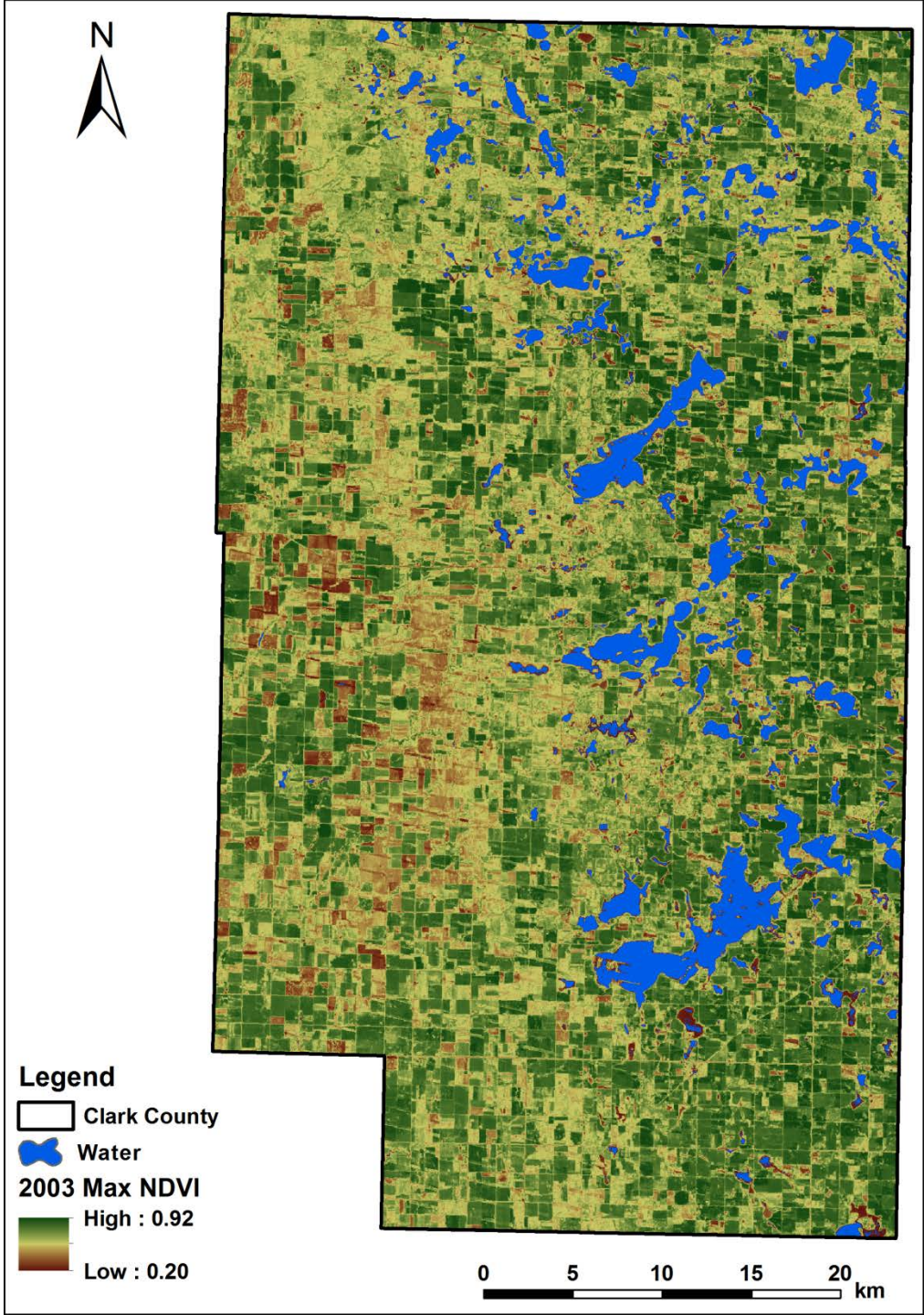
WELD: http://weld.cr.usgs.gov

GSCE: http://globalmonitoring.sdstate.edu



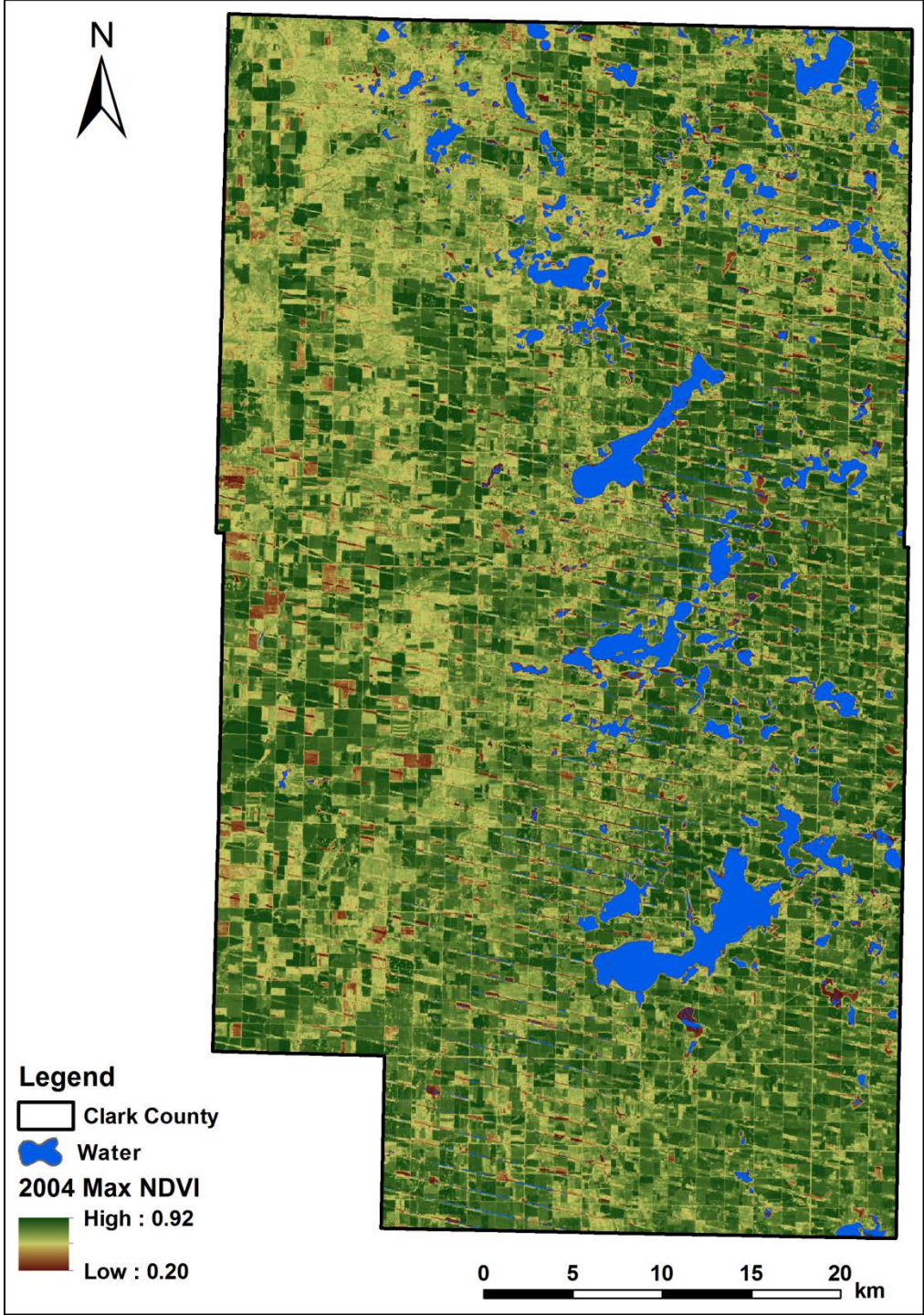
Annual Max NDVI 2003

- Stretched to Max of Max for the decade



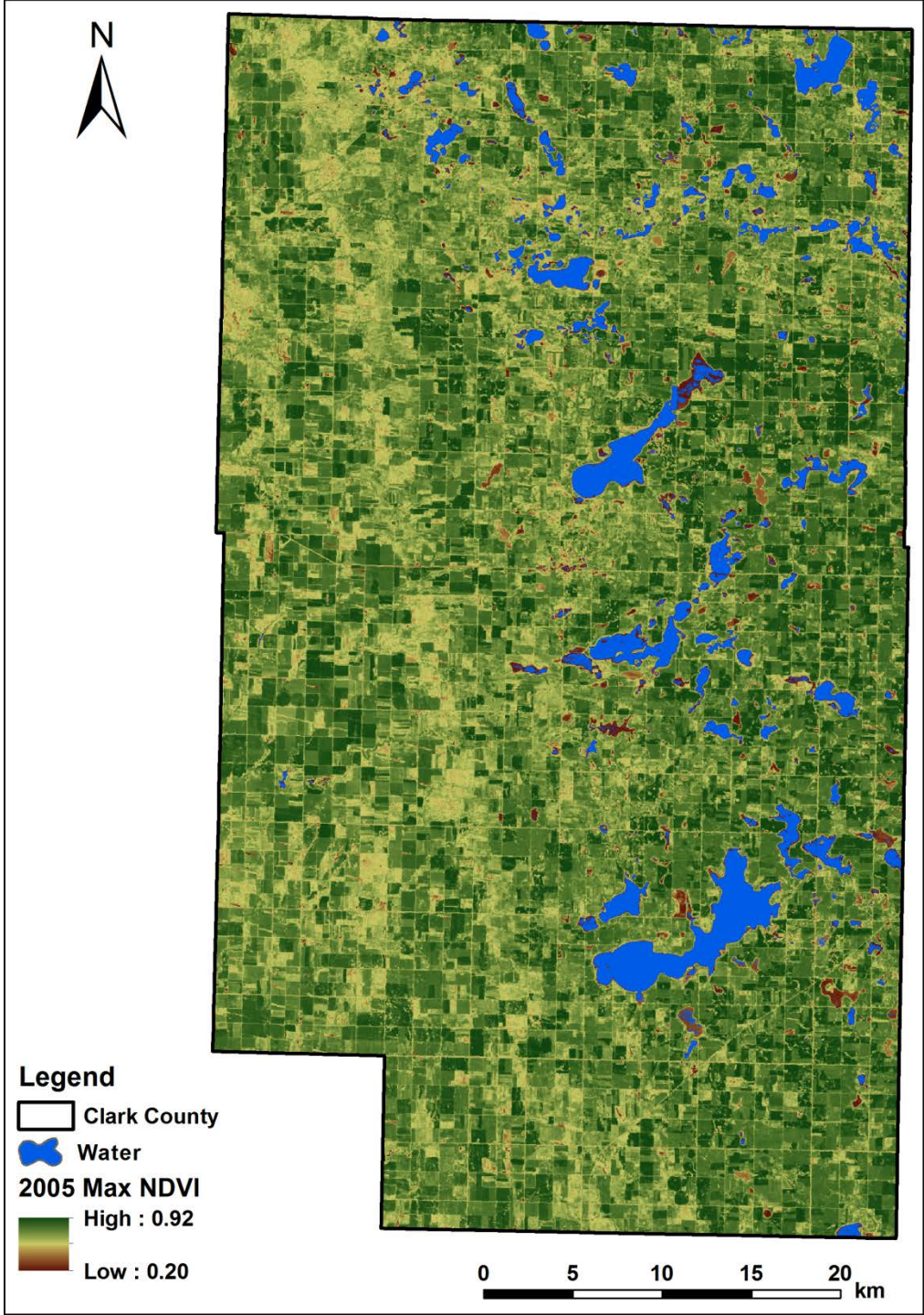
Annual Max NDVI 2004

- Stretched to Max of Max for the decade



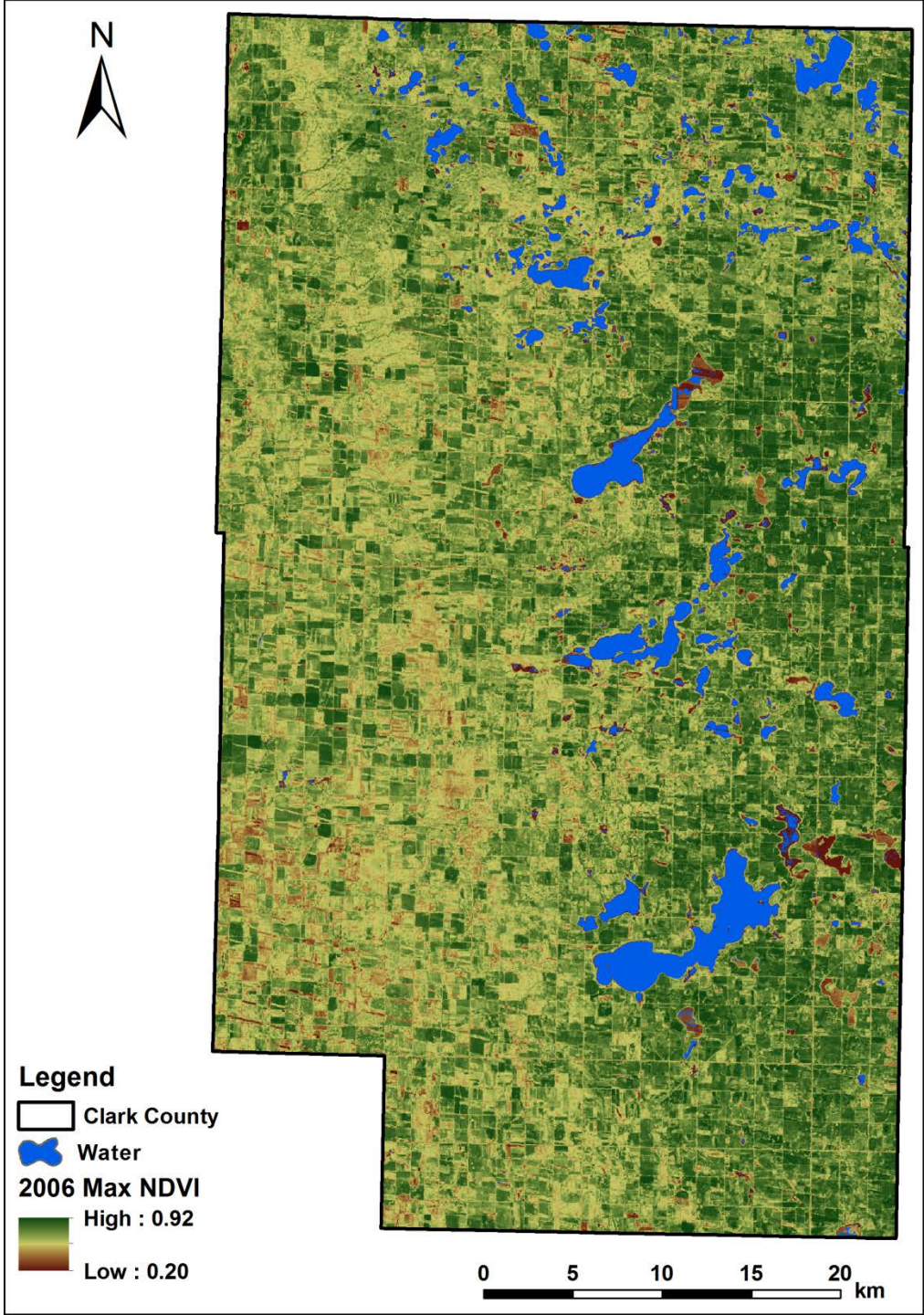
Annual Max NDVI 2005

- Stretched to Max of Max for the decade



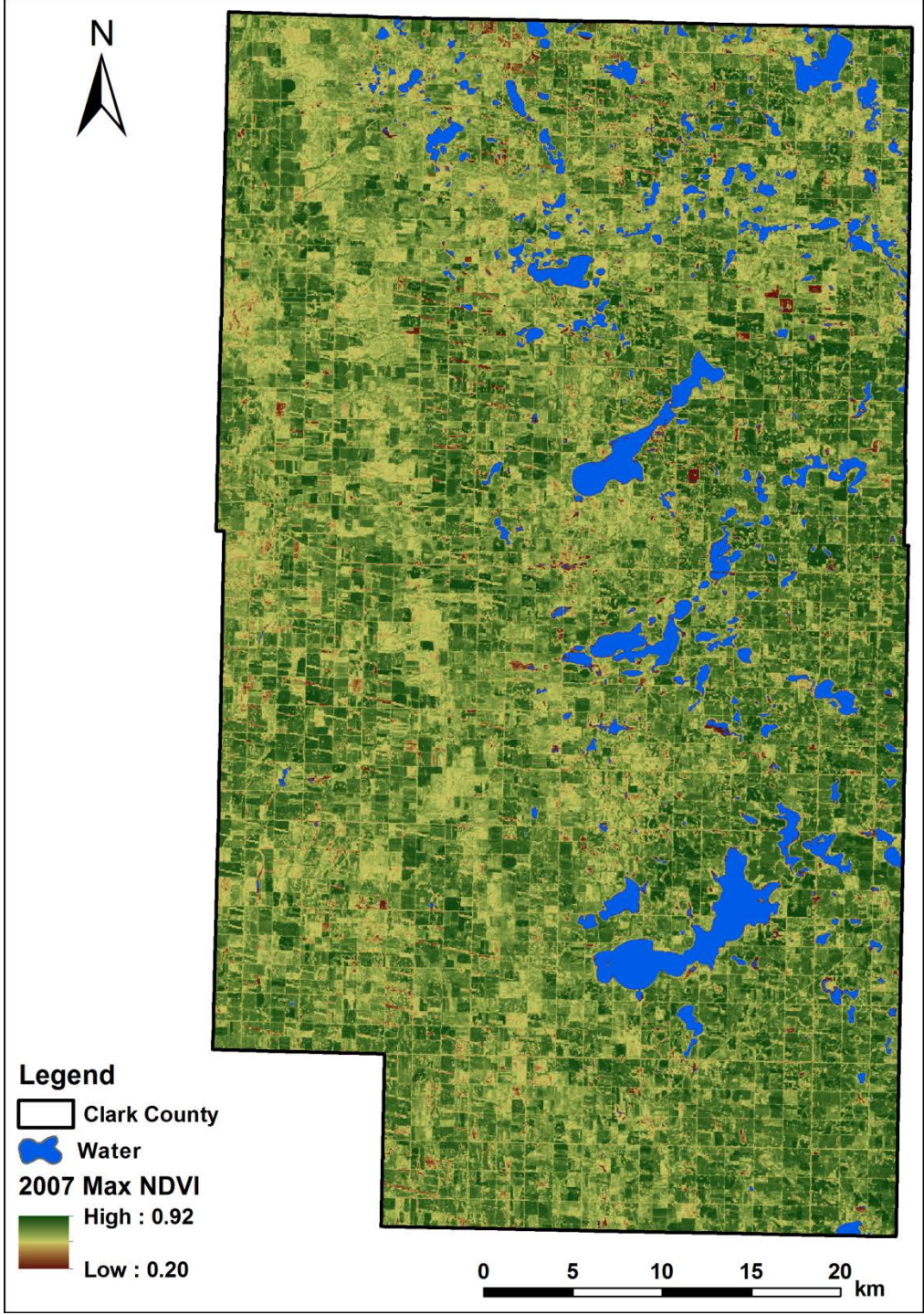
Annual Max NDVI 2006

- Stretched to Max of Max for the decade



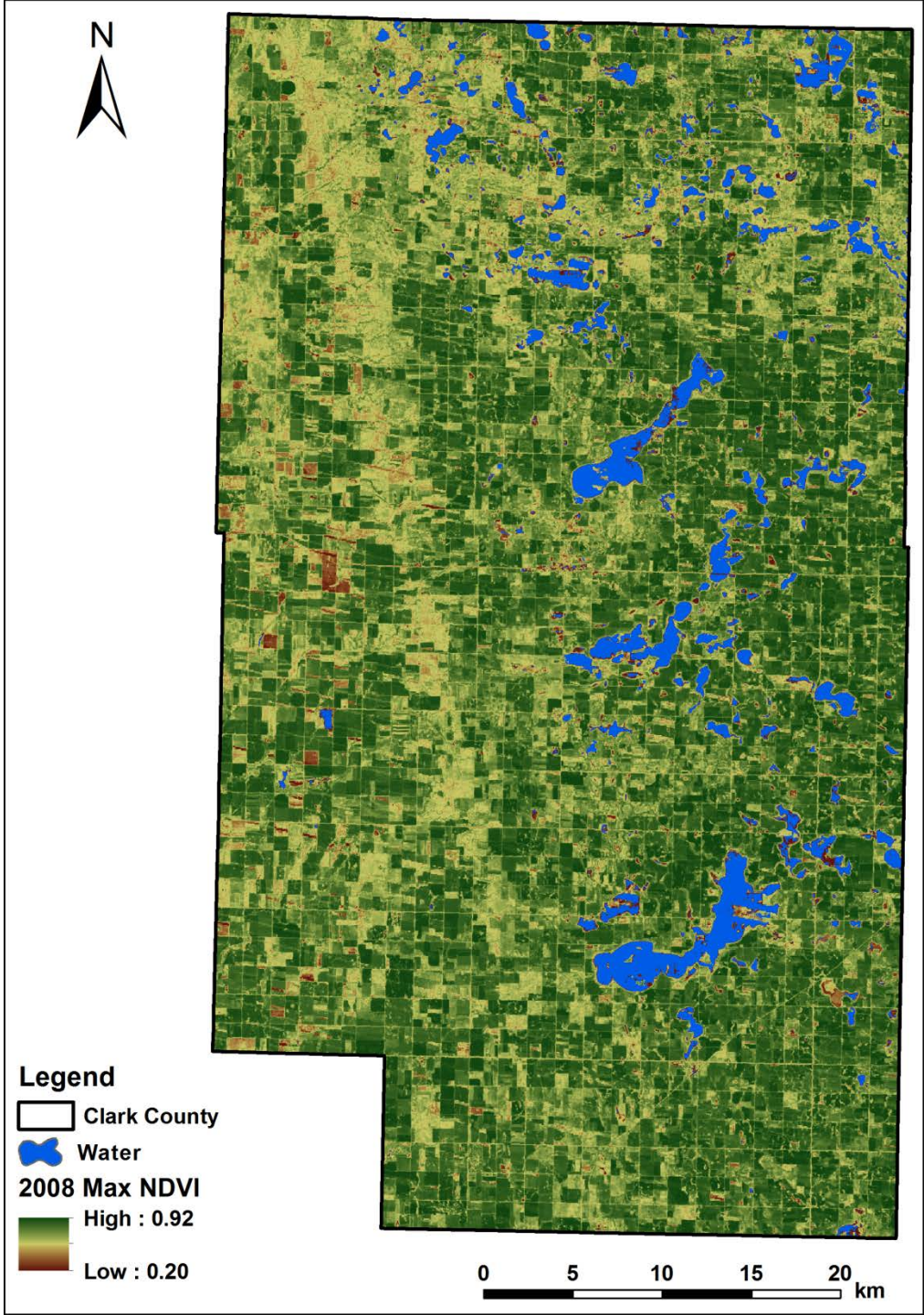
Annual Max NDVI 2007

- Stretched to Max of Max for the decade



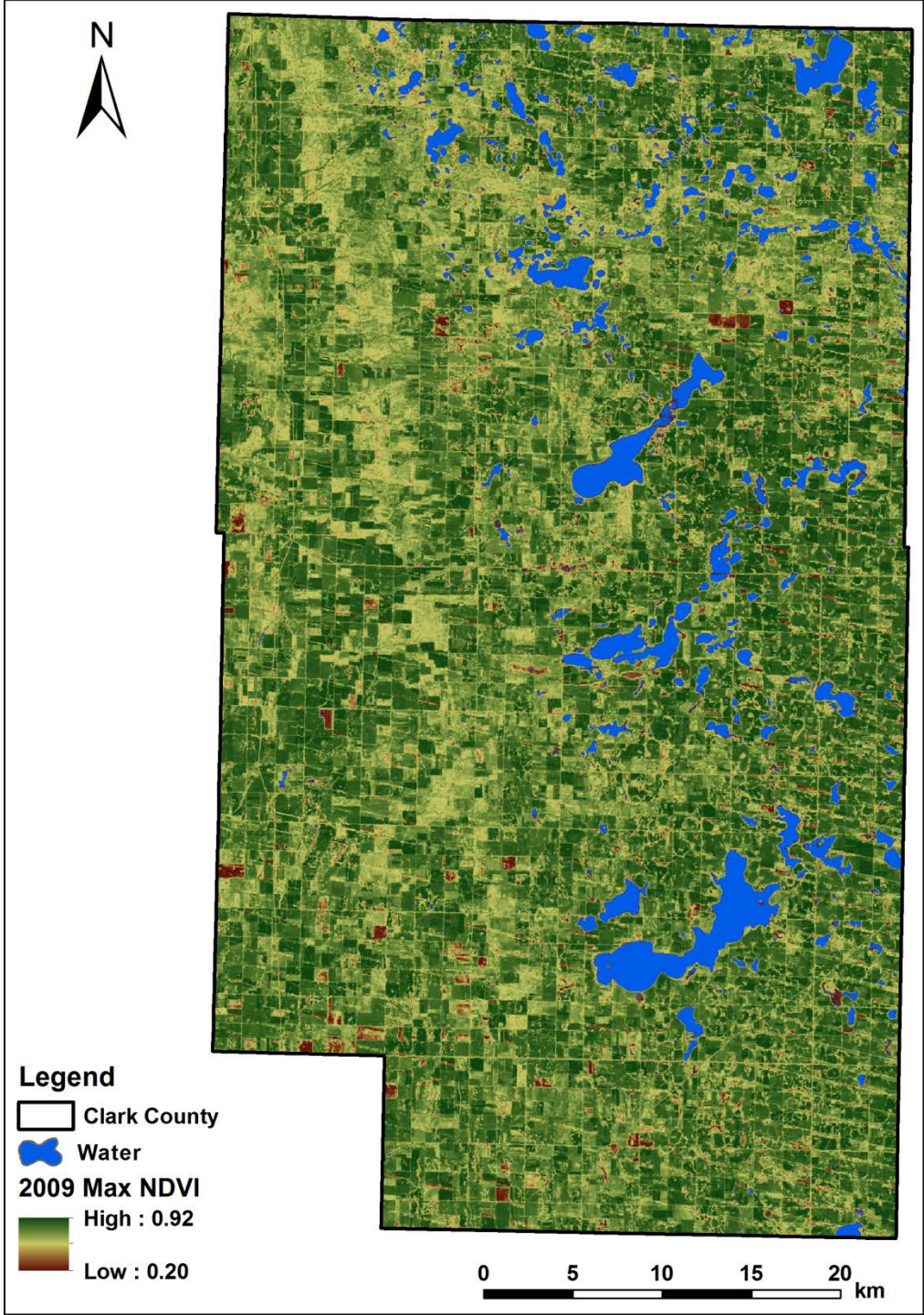
Annual Max NDVI 2008

- Stretched to Max of Max for the decade



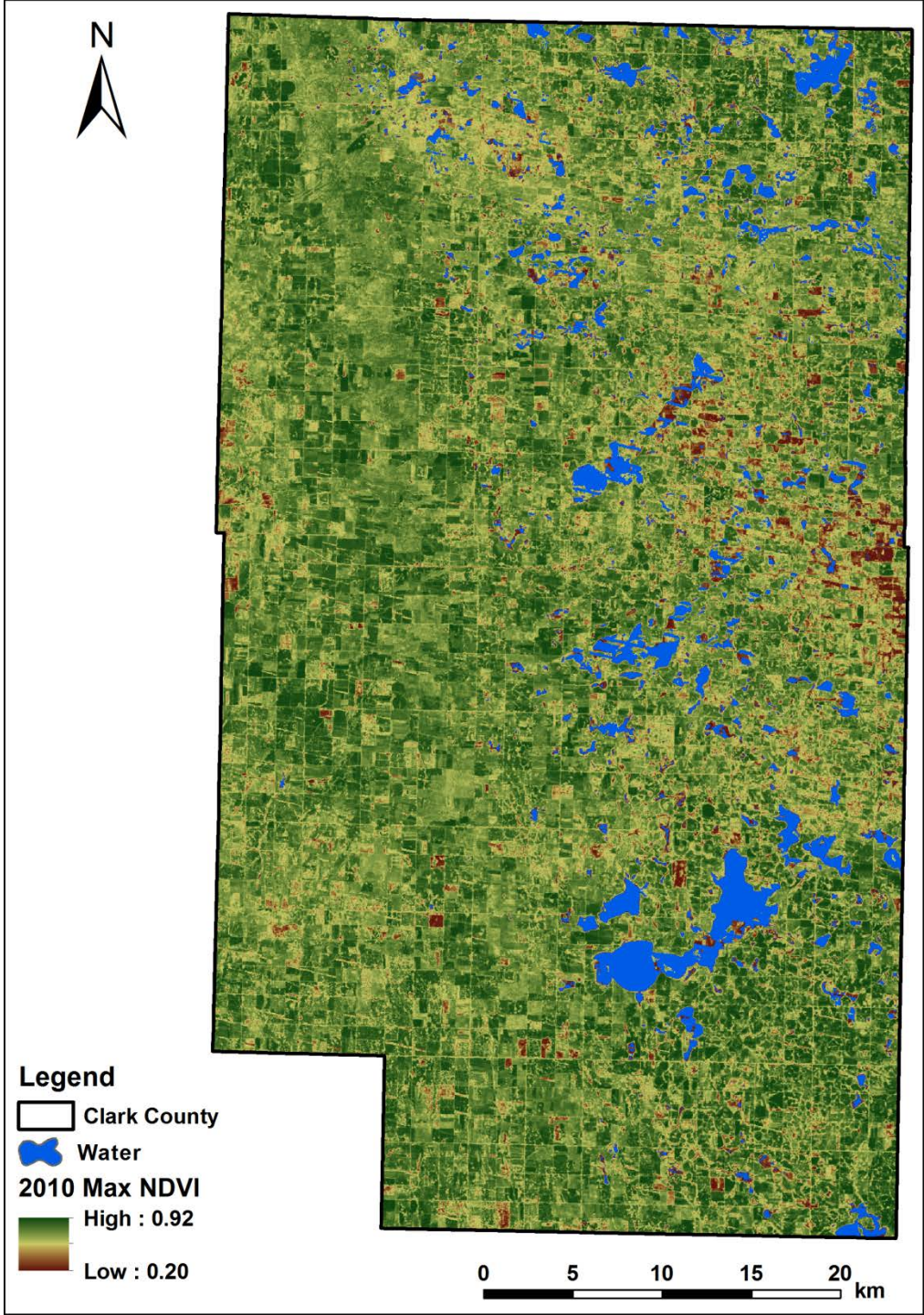
Annual Max NDVI 2009

- Stretched to Max of Max for the decade



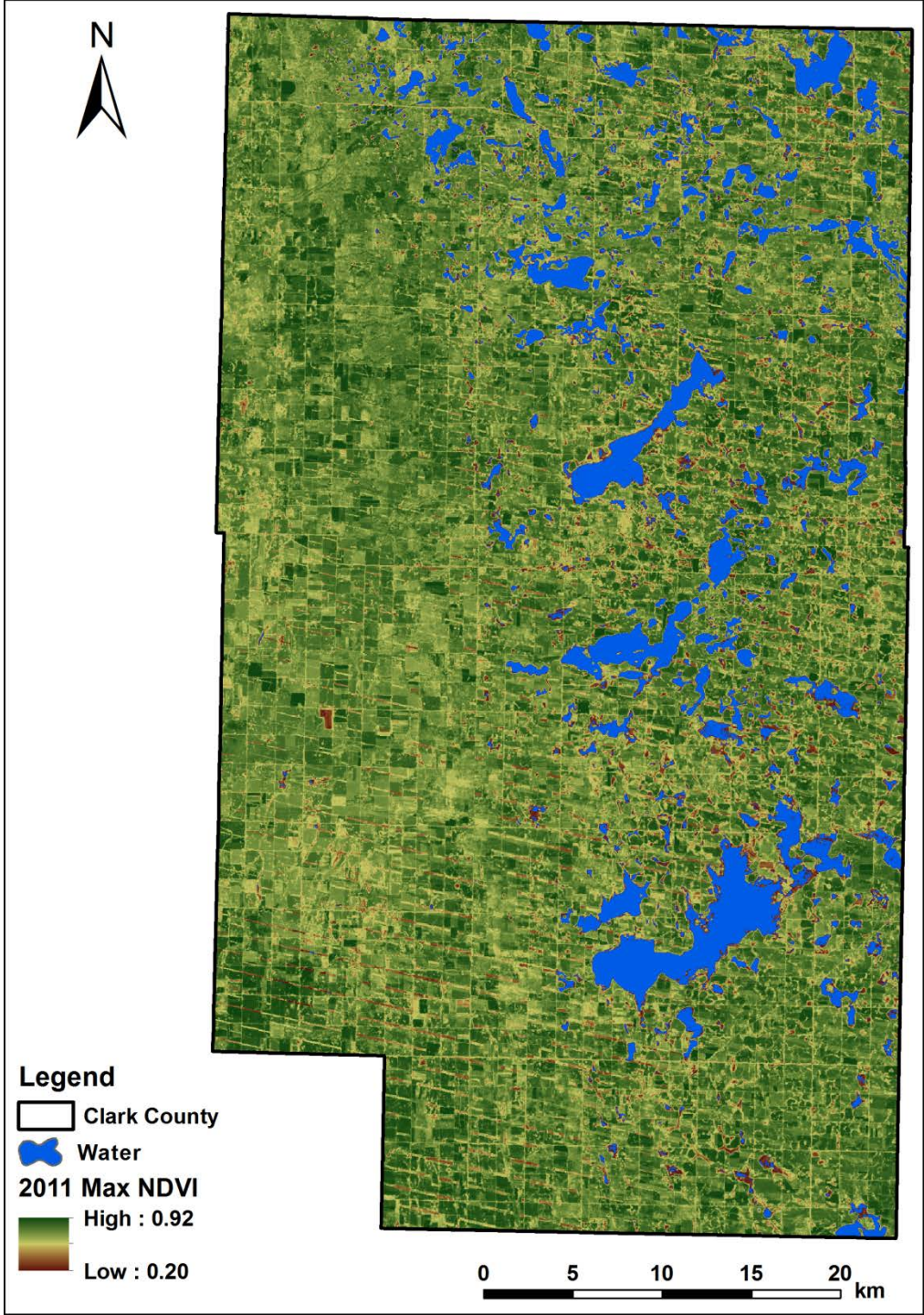
Annual Max NDVI 2010

- Stretched to Max of Max for the decade



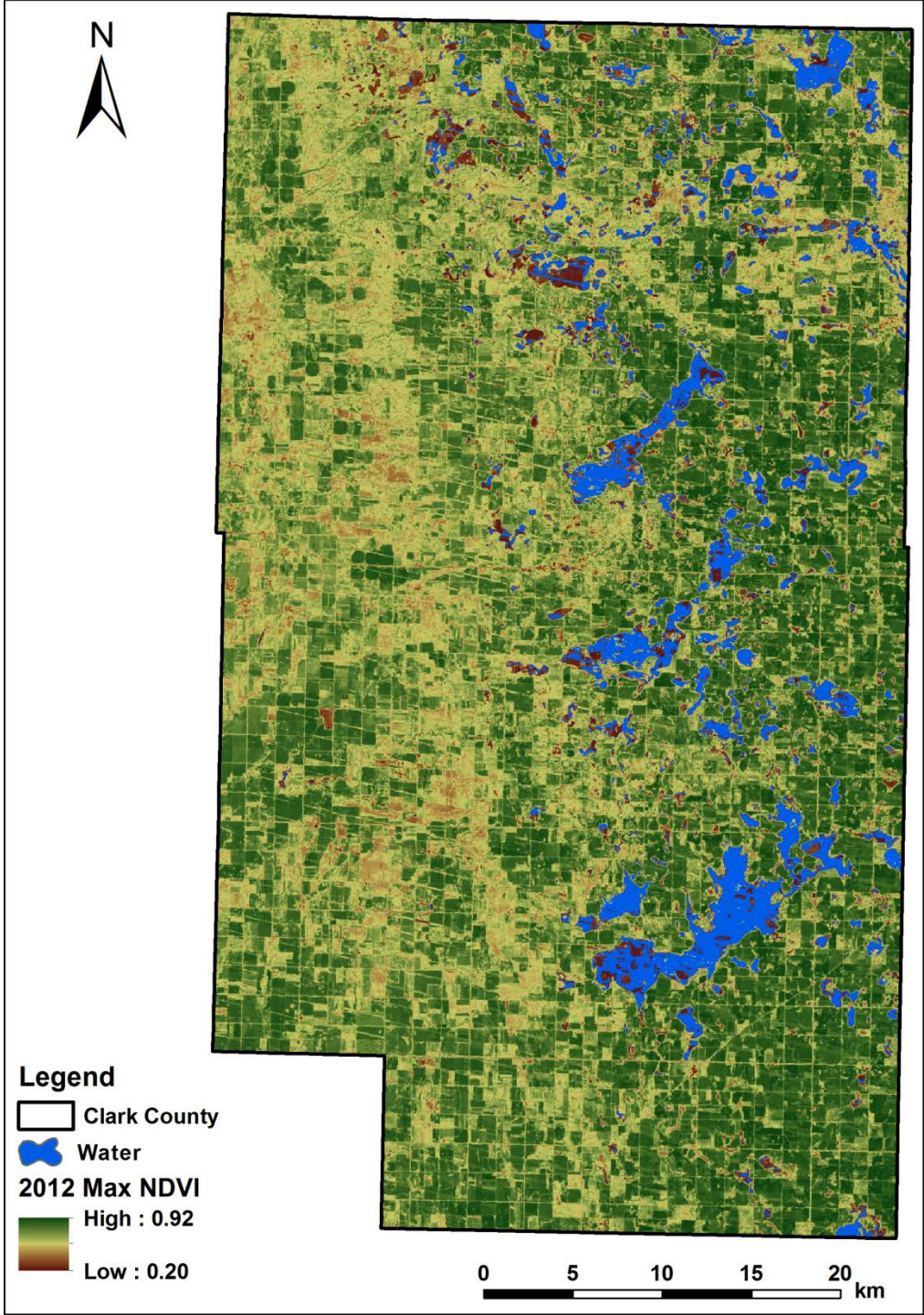
Annual Max NDVI 2011

- Stretched to Max of Max for the decade



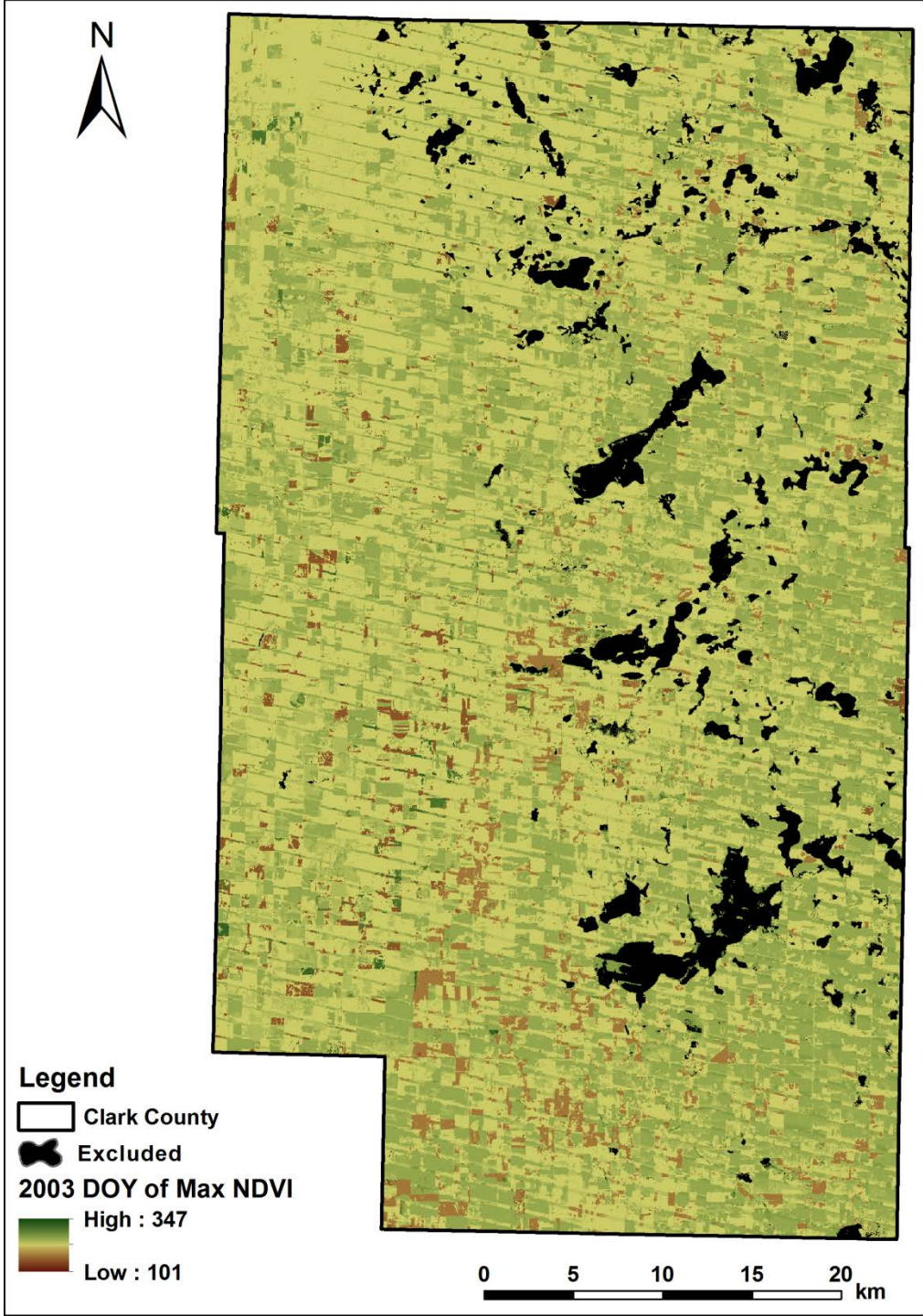
Annual Max NDVI 2012

- Stretched to Max of Max for the decade



Day of Year of Max NDVI observation for 2003

Each WELD pixel in the time series has a date associated with it. Thus, it is possible to identify what time of year the maximum NDVI value occurred in each year. The timing of the maximum is associated with vegetation growth and development and is useful for distinguishing land use – summer crops from pastures from alfalfa fields, for instance.

This image is for 2003 and one such image can be produced for each year, which should allow for land use changes to be identified.

Nevertheless, there are many uncertainties in how this approach would work when applied across SD. Calibration, validation, and verification steps are needed in the development of any decision support system that uses remote sensing data or products for decision-making.