Tracking Conservation Tools
November 2020

Remote sensing technologies, including satellite imagery and aerial photography, are increasingly being used to characterize and track crop areas, cover crops, riparian vegetation, and pasture-based practices for overall conservation system assessment and tracking. There are several available technologies (free and publicly available, commercial, and state specific) that can be used to track agricultural practices in the United States. The remote sensing technologies summarized in this document are a compilation of all the different technologies known to the Hypoxia Task Force (HTF). If a reader would like to suggest additional tools for inclusion, please contact OW-Hypoxia@epa.gov. This is a living document, and additional technologies can be added.

In addition to imagery-based tools, there are several additional tools available. These tools are a mix of spatial conservation practice effectiveness tools, other data sources to track conservation practice implementation, information to help target areas suitable for conservation practice implementation, or tools to evaluate potential impact. Combining suites of tools can provide tangential or parallel lines of evidence for tracking efforts across the HTF states.

This document is intended as a resource for the HTF Nonpoint Source Workgroup and other workgroups. The first section provides a brief introduction and the second section summarizes all the technologies in a simple table format. The last section of the document provides a one-page summary per technology, including who developed the technology, a brief summary of the technology, what data are available, spatial resolution, scale, how to access the data, benefits of the technology, a brief success story, and resources. The final section lists references used in preparing this document. Finally, Appendix A provides a summary of available technology by HTF state and level of coverage (full/partial).

Introduction

Free, Publicly Available Imagery Technologies

- Cropland Data Layers (CDL)
  - A geospatial crop-specific land cover classification product published on the U.S. Department of Agriculture's (USDA's) CropScape web application.
- Google Earth Engine
  - A free, publicly available tool for analyzing and visualizing geospatial data sets that hosts a large amount of publicly stored data that includes satellite images going back more than 40 years. The engine allows for analysis of forest and water coverage, land-use change, assessing agricultural field health, and many other analyses.
- Landsat Satellite Imagery Program
  - The longest continuous archive of satellite imagery currently available. Since 2008, the entire Landsat imagery archive has been available online at no cost to the public.
- USGS 3D Elevation Program (3DEP) (Using LIDAR)
  - A remote sensing tool that generates high-resolution three-dimensional (3D) images of terrain that can be used for many applications. 3DEP is managed by the U.S. Geological Survey (USGS) with the goal of acquiring nationwide light detection and ranging (LIDAR) data by 2023 that meet specific quality standards.
- National Agricultural Imagery Program (NAIP)
  - NAIP acquires aerial imagery during the agricultural growing seasons that can be used for several purposes in the commercial sector as well as by federal, state, and local agencies.
- NOAA Coastal Change Analysis Program (C-CAP)
  - NOAA's C-CAP produces national and standardized land cover and change products that include over 25 categories of land cover (e.g., cropland, pasture, grassland, and various stages of developed land).
- Operational Tillage Information System (OpTIS)
  - Automated system designed to monitor the yearly usage trends of soil health practices over large agricultural areas.

Commercial Technology Products

- AgTrends
  - A commercial product that uses satellite data and machine learning models to enable users to track agricultural management practices on the ground with efficient data collection and insights on practices and impacts at both the field and watershed scale.
- CubeSats–Nanosatellites
  - Miniaturized satellites that are increasingly being used for near real-time monitoring for various uses such as weather monitoring and agricultural monitoring and management.

State-Specific Programs

Indiana

Cover Crop and Tillage Transect Survey

A visual on-the-ground survey of cropland that has been conducted in Indiana every year since 1990. The survey identifies the types of tillage and cover crop systems farmers are using and long-term trends of these conservation adoption practices by using global positioning system technology and a model for estimating farm management and related annual trends.

Iowa

Iowa BMP Mapping Project

A free, publicly available database that provides a comprehensive inventory of conservation practices in the state at the watershed scale (HUC-8 and HUC-12). The project established protocols and determined the presence of six existing BMPs on the landscape including: terraces, water and sediment control basins (WASCOB), grassed waterways, pond dams, contour strip cropping and contour buffer strips. This tool can be used to show areas with differing levels of conservation practice investment and to show potential areas that could be implemented with BMPs based on landscape features and cropping systems.

Kentucky

KyFromAbove Initiative

A program developed to build and maintain a geographic information system (GIS) basemap from LIDAR and aerial photography for Kentucky. The basemap was developed to be a versatile tool to use in many ways, including modeling 3D terrain with vegetation cover mapping, tracking farmland use, and modeling urban growth of agricultural districts.

Minnesota

Minnesota–Tillage and Erosion Survey Program

Created as a long-term program to systematically collect tillage data showing trends, cover crop adoption data, land cover data, and soil loss by water and wind in agricultural county areas in Minnesota through funding from the state's Clean Water Fund.

Healthier Watersheds: Tracking the Actions Taken Website

A website that aggregates data used for the tracking of the status of impaired lakes and streams with approved TMDLs, tracking reductions at wastewater treatment facilities, tracking best management practices (BMPs) implemented by watershed, and learning about state, local, and federal spending for implementation of clean water projects.

Wisconsin

Erosion Vulnerability Assessment for Agricultural Lands (EVAAL)

A GIS-based tool that was developed to assist watershed managers in assessing agricultural lands and lands that might be vulnerable to water erosion and could contribute to surface water quality problems.

Technology Summary Table

Technology	MARB States[a]	Time Period of Data	Free/Publicly Available?	Data Updated Regularly?	Scale	Spatial Resolution	Agricultural Data Monitoring Uses	Software Needed
Free, Publicly Available Technologies								
CDL	All states AR, IL, MS, IN, IA	2008–2019 2000–2019	Yes	Yes. New information compiled annually and released to public a few months after end of growing season.	Field level	30–56-m resolution (depending on state/year)	Crop planting frequency/intensity; cultivated land mapping; crop yield modeling	Use https://nassgeodata.gmu.edu/CropScape/ to explore data
Google Earth Engine	All states	1980s–-present	Yes	Yes. Updated automatically from several data sources (4,000 new images uploaded every day).	Varies	Varies	Many: analyses like normalized difference tillage index and normalized difference vegetation index; cropland mapping; crop classification; crop status monitoring	Use signup.earthengine.google.com to sign up for access to the engine; use https://developers.google.com/earth-engine/datasets/ to search and download data
Landsat	All states	1999–present	Yes	Yes. New images every 16 days.	Field level	30-m resolution	Crop production estimation; water use monitoring; cropland data layers development; tillage monitoring	Use https://earthexplorer.usgs.gov/ to explore data
LIDAR–3DEP	All states; some data collection in progress	2016–present	Yes	Yes. New data are added regularly and will be through 2023.	Field level	1-m resolution	Flood maps; tile and surface drainage; topographic layer for precision agriculture	Download/view LIDAR data at https://viewer.nationalmap.gov/basic/ or https://prd-tnm.s3.amazonaws.com/LidarExplorer/index.html#/
NAIP	All states	2006–2019 Growing season (June–August)	Yes; can purchase ½-m resolution maps (full state only)	No. Currently NAIP is refreshed on a 3-year cycle due to funding but the goal is every year.	Field level	1–2-m resolution	Many: acreage use monitoring; land classification; agriculture certification; farm modeling; livestock containment site monitoring; land-use changes; crop yield maps	Use http://www.arcgis.com or https://earthexplorer.usgs.gov to explore data

Technology	MARB States[a]	Time Period of Data	Free/Publicly Available?	Data Updated Regularly?	Scale	Spatial Resolution	Agricultural Data Monitoring Uses	Software Needed
NOAA C-CAP	Coastal counties of OH, IL, WI, MN, and LA	2006/2015–high res data for OH; 1985–2010 for 30-m res for all states	Yes	1-4-m resolution is not; 30-m resolution is updated every 5 years.	Field level	1–4-m resolution; 30-m resolution	Land cover change monitoring for coastal counties; cultivated land mapping; pasture/hay land mapping	Use https://coast.noaa.gov/ccapatlas/ to explore data; use https://coast.noaa.gov/ccapftp/#/ to download data
OpTIS	All of IL, IN, IA; parts of MN, MO, OH, and WI	2005–2018	Yes	No. State data are added irregularly once data are compiled.	County level; watershed (8-digit HUC) level	30-m resolution	Tillage; crop residue cover; winter cover; soil health practices maps	None; online at https://www.ctic.org/OpTIS
Commercial Technology Products								
AgTrends	All states	Year-to-year data and real-time data	No	Yes. Updated automatically from several satellites.	Watershed level to field level	0.5-m resolution	Cover cropping; riparian buffers; tillage; crop residue; perennial vegetation; irrigation intensity; crop type; carbon metrics; water quality trends	Need to purchase subscription at https://upstream.tech/agriculture/
CubeSats–nanosatellites	All states	Real-time data	No	Yes. Updated daily.	Field level to individual plant level	27-cm, 3–5-m resolution	Vegetation/crop monitoring; agricultural monitoring and management	Need to purchase subscription at https://www.planet.com/products/planet-imagery/
State-Specific Programs								
Cover Crop and Tillage Transect Survey	IN	1990–present	Yes	Yes. Updated annually.	County level	N/A	Cover cropping; tillage; crop residue trends	Data and data reports are available at https://www.in.gov/isda/2383.htm
Iowa BMP Mapping Project	IA	1980s; 2007–2010; 2016–2018	Yes	No. Data are added irregularly once data are compiled and reviewed.	Watershed level (HUC-8;HUC-12)	N/A	Conservation BMP inventory mapping for terraces, water and sediment Control basins (WASCOB), grassed waterways, pond dams, contour strip cropping and contour buffer strips	Download/view current data at https://benson.gis.iastate.edu/ISU/BMP/BMP.html

Technology	MARB States[a]	Time Period of Data	Free/Publicly Available?	Data Updated Regularly?	Scale	Spatial Resolution	Agricultural Data Monitoring Uses	Software Needed
KyFromAbove	KY	2010–present: LIDAR 2012–present: imagery	Yes	Yes. Current data are being collected/ accepted.	Field level	6 in. to 1-m resolution	Vegetation cover mapping; tracking farmland use; modeling urban growth of agricultural districts	Download/view current data at https://kygeonet.maps.arcgis.com/home/index.html
Tillage and Erosion Survey Program	MN (along with parts of IA and WI)	2016–present	Under development	Under development.	County level; HUC-8 watershed level	N/A	Tillage trends; cover crop adoption; land cover monitoring; annual/daily soil loss trends	Under development for remote sensing data; daily erosion project information available at: https://www.dailyerosion.org/
Healthier Watersheds: Tracking the Actions Taken Website	MN	2004–present	Yes	Yes. Updated annually.	Statewide, major drainage basin, HUC-8 and HUC-12 watershed levels	N/A	Nonpoint source BMP adoption: tillage , cover crops, nutrient management, erosion control, drainage water treatment, perennials, & more	Data available at https://www.pca.state.mn.us/water/healthier-watersheds or the Minnesota Nutrient Reduction Strategy BMP Summary Website.
EVAAL	WI	2008–2019	Yes	Yes, updates concurrently with Cropland Data Layer	Field level; county level; watershed level	3-m resolution	Erosion vulnerability index maps; soil loss; stream power index; internally drained area mapping	Access the toolbox and data at https://dnr.wi.gov/topic/nonpoint/evaal.html

Notes: HUC = hydrological unit code; m = meter.

[a] Focused on MARB states: Arkansas, Illinois, Indiana, Iowa, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, Ohio, Tennessee, Wisconsin.

Individual Technology Summaries

Free, Publicly Available Technologies

Cropland Data Layer (CDL)

Fact Sheet: https://www.nass.usda.gov/Research_and_Science/Cropland/docs/ISI%20WSC%20Paper%20-%20Sandborn.pdf

Developed by: U.S. Department of Agriculture's (USDA's) National Agricultural Statistics Service (NASS)

What is it? A geospatial crop-specific land cover classification product that has data from more than 100 crop categories grown in the United States. CDLs are produced annually using satellite data, with the first CDL being produced in 1997. CDLs are developed using a supervised land cover classification of satellite imagery. CDLs use remote sensing techniques to provide operational in-season acreage estimates to the NASS Agricultural Statistics Board and Regional Field Offices. CDLs are published on the NASS CropScape web application, designed to provide the public with open access to serve the CDL with interactive visualizations, data dissemination, geospatial queries, and online analytics.

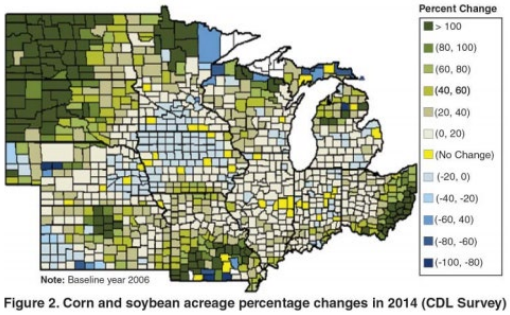


Figure 2. Corn and soybean acreage percentage changes in 2014 (CDL Survey)

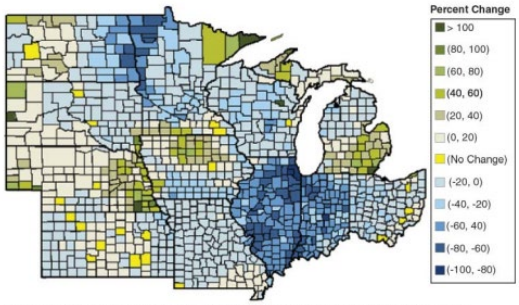


Figure 3. Grass-like acreage percentage changes in 2014 (CDL Survey)

(Gonzalez-Ramirez and Ji 2015)

What data are available? 2008–2019 data are available for all states in the contiguous United States. 2000–2019 data are available for Arkansas, Illinois, Indiana, Iowa, and Mississippi.

Spatial Resolution: 30-meter resolution

Scale: Field level

How to access data: https://nassgeodata.gmu.edu/CropScape/.

What are the benefits of CDL?

- CDL data are free and available to the public at https://nassgeodata.gmu.edu/CropScape/
- A new CDL is compiled annually and released to the public a few months after the end of the growing season
- High-resolution, field-level data with crop classification accuracies usually more than 90 percent
- Powerful tool for understanding/studying agricultural landscapes at fine detail
- Open-access application

Success Story: Tracking Crop Acreage Use in the Mississippi River Basin
Converting grass-like land to row crops (corn, soybean) can affect water quality by increasing nutrient runoff into the Mississippi River Basin. Iowa State University researchers studied agricultural land-use change in the Corn Belt by using Cropland Data Layer (CDL) to obtain data on the amount of change in corn and soybean acreage. Figures created from using CDL data show the amount of acreage changes, between grass-like acreage and crop acreage, in counties of states studied (Gonzalez-Ramirez and Ji 2015).

Google Earth Engine

Fact Sheet: https://earthengine.google.com/faq/

Developed by: Google

What is it? Google Earth Engine is a free, publicly available tool for analyzing and visualizing geospatial data sets. The engine hosts a large amount of publicly stored data that includes satellite images going back more than 40 years. The engine allows for analysis of forest and water coverage, land-use change, assessing agricultural field health, and many other types of analyses.

What data are available? Google Earth Engine has a searchable data catalog that includes ready-to-use data sets covering the entire world, including the entire EROS (USGS/NASA) Landsat catalog, numerous MODIS data sets, Sentinel-1 data, NAIP data, precipitation data, sea surface temperature data, CHIRPS climate data, and elevation data.

Spatial Resolution: Varies

Scale: Varies

How to access data: Users first must fill out the form at signup.earthengine.google.com to access Google Earth Engine and will receive a welcome email with instructions on accessing the engine. Data sets can be downloaded through the Google Earth Engine Data Catalog at https://developers.google.com/earth-engine/datasets/.

(Google 2020)

What are the benefits of Google Earth Engine?

- It is free and publicly available upon signing up to access
- It has a large searchable data catalog that includes multiple satellite and remote sensing data sets for analysis
- The engine is a cloud-based tool, which saves a lot of hard drive space while allowing for analysis of large spatial and temporal scales
- Google Earth Engine Application Programming Interface is available in Python and JavaScript, which allows for easy and efficient geospatial analysis

Success Story: Long-Term Mapping for Management of Irrigated Agricultural Areas
The Ogallala Aquifer, which spans eight states from Texas to South Dakota and supports a $20 billion agricultural economy with irrigation, is one of the largest and most stressed aquifer systems in the world. Michigan State University researchers, with the aid of Google Earth Engine and other free high-quality satellite imagery, were able to use machine learning to create an annual, high resolution irrigation map time series from 1984 to 2017 over the entire aquifer region. The team was able to use the irrigation map time series to help identify regions in the aquifer system that were declining, expanding, or were stable irrigated areas. Researchers are currently working with other universities across the region to investigate areas within the aquifer that might transition in the future, whether declining or expanding, and how to inform policies and management decisions to deal with these transitions (MSU 2020).

Landsat Satellite Imagery Program

Fact Sheet: https://pubs.usgs.gov/fs/2015/3081/fs20153081.pdf

Developed by: U.S. Geological Survey (USGS) and the National Aeronautics and Space Administration (NASA)

What is it? The Landsat program, created in 1972, is one of the longest standing agricultural monitoring systems in the world and has resulted in the longest continuous archive of satellite imagery currently available. Since 2008, the entire Landsat imagery archive has been available free online to the public. Landsat satellites take images of the same place on Earth every 16 days, and views individual farms and fields. The sensors on the satellites can analyze crops when stressed using infrared light. Farmers can download free Landsat data to monitor crop health and look at signs of crop stress. The U.S. Department of Agriculture also uses Landsat data to issue several reports during the growing season to forecast end-of-the-year crop production for certain crops.

What data are available? 1999–present data available for all states in the contiguous United States.

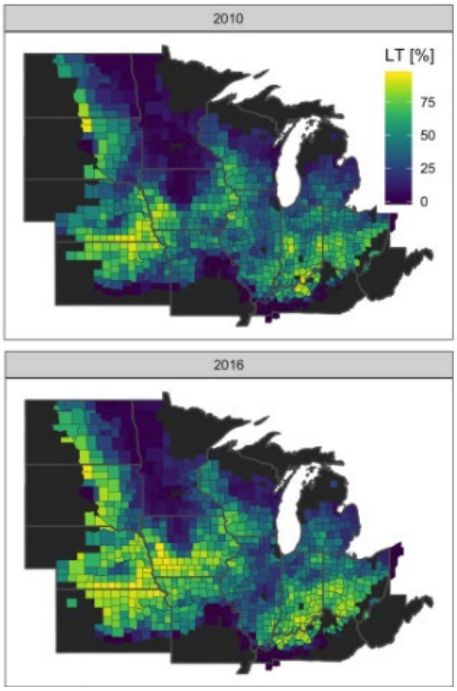
Spatial Resolution: 30-meter resolution

Scale: Field level

How to access data: https://earthexplorer.usgs.gov/.

What are the benefits of Landsat?

- Landsat data are free and publicly available at https://www.usgs.gov/land-resources/nli/landsat/landsat-data-access?qt-science_support_page_related_con=0#qt-science_support_page_related_con
- Large amounts of temporal data compared to other technologies (since 1999)
- Large amounts of spatial data compared to other technologies (across the United States)
- Little effect from cloud cover



(Azzari et al. 2019)

Success Story: Monitoring Low-Intensity Tillage Areas 2007–2016 in the United States

Low-intensity tillage has become more popular in the United States among farmers; however, there is little data on when and where low-tillage methods are being used across the country. Researchers were able to use Landsat satellite imagery across the United States to train a random forest classifier, a method of machine learning that is trained to classify relationships and make predictions, to generate annual large-scale maps of tillage intensity from 2005 to 2016. Researchers were then able to use these maps to track changes of low-intensity tillage use across states (Azzari et al. 2019).

USGS 3D Elevation Program (3DEP) Using LIDAR

Fact Sheet: https://pubs.usgs.gov/fs/2016/3088/fs20163088.pdf

Developed by: U.S. Geological Survey (USGS)

What is it? LIDAR is a remote sensing tool that generates high-resolution three-dimensional (3D) images of the terrain that can be used for many applications. It is a radar-like technology that uses short pulses of laser light to detect and differentiate airborne particles, gas, or molecules. It provides high-resolution, 3D, and spatial information about the land that can generate digital elevation models, vegetation models, and erosion control models. 3DEP is managed by USGS with the goal of acquiring nationwide LIDAR data by 2023. 3DEP provides millions of dollars annually to government agencies, private corporations, and citizens to collect LIDAR data and submit them with set standards the data must meet. LIDAR data can be used in many ways in agriculture, including farm design, farmland program management, farmland suitability analysis, drainage analysis, and conservation planning.

What data are available? Data are available or in progress for all MARB states.

Spatial Resolution: 1-meter resolution

Scale: Field level

How to access data: https://viewer.nationalmap.gov/basic/ or https://prd-tnm.s3.amazonaws.com/LidarExplorer/index.html#/.

(Sugarbaker and Carswell 2016)

What are the benefits of LIDAR?

- LIDAR instruments can rapidly measure the Earth's surface at sampling rates greater than 150 kilohertz
- Data must meet certain quality standards: low vertical error of no more than 10 centimeters
- Can view state fact sheets of available data at https://www.usgs.gov/core-science-systems/ngp/3dep/state-factsheets

Success Story: Using LIDAR to Examine Tillage Effects on Soil Erosion

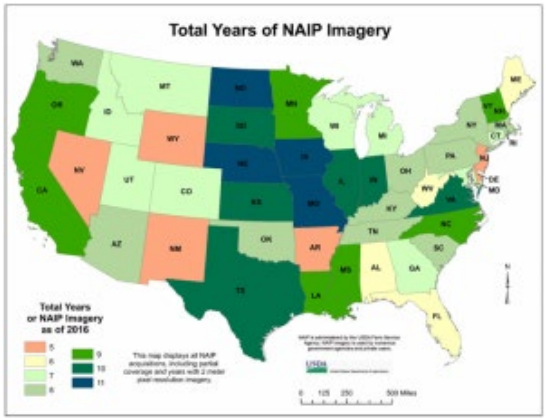
Researchers used LIDAR to examine long-term tillage practices and their effect on soil erosion at a North Carolina research site. They found that LIDAR can accurately characterize landscape change resulting from erosion, as it can estimate soil elevation changes and thus soil loss due to tillage practices. They also found that in general soil loss increased when tillage intensity increased. Researchers suggest that U.S. farmers and states can use LIDAR to monitor tillage practices and to know where to adopt conservation tillage practices to reduce soil erosion (Meijer 2013).

National Agriculture Imagery Program (NAIP)

Fact Sheet: https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/APFO/naip_info_sheet_2015.pdf

Developed by: U.S. Department of Agriculture's (USDA's) Farm Service Agency (FSA)

What is it? NAIP is a program that was established to acquire aerial imagery during the peak agricultural growing seasons (June–August) and deliver this imagery to USDA County Service Centers and as a public domain data set. The primary goal is to make digital ortho photography with 1-m resolution available to government agencies and the public within a year of acquisition. Due to funding shortfalls, the program is currently on a 3-year refresh cycle. NAIP imagery is used in a range of applications, but primarily is used in agricultural, natural resources management, and state and local planning. Some uses include acreage reporting and map changes, supporting federal farm programs, conservation practices, irrigation determinations, agricultural certification, and land classification.



(GeoPlatform 2019)

What data are available? Data are available from 2006 to 2019 for all states in the contiguous United States.

Spatial Resolution: 1- to 2-meter resolution

Scale: Field level

How to access data: http://www.arcgis.com or https://earthexplorer.usgs.gov/.

What are the benefits of NAIP?

- NAIP data are free and available to the public to download at https://datagateway.nrcs.usda.gov/GDGHome_DirectDownLoad.aspx
- Often used in combination with other data sets and software for a variety of purposes
- Ability to download compressed images, which reduces the number of files delivered to the user

Success Story: Measuring NAIP Imagery Precision for Agriculture Application in Small Scale Farming
A study performed by researchers as the University of Southern California compared NAIP imagery with Landsat7 ETM+ imagery to evaluate use in precision agriculture applications for small-scale farming. Their study included a case study in the South Eastern part of Pittsylvania County, VA, and compared 14 different agricultural fields of varying shapes and sizes. Their analysis consisted of computation and analysis to evaluate the effect of the different imagery resolutions on locating and visualizing vegetation and non-vegetation features. Results from the study showed that NAIP imagery was able to provide more precision in identification and monitoring of vegetation and non-vegetation compared to Landsat and could be used with high precision in monitoring small-scale farming practices (Bohon 2014).

NOAA Coastal Change Analysis Program (C-CAP)

Fact Sheet: https://coast.noaa.gov/data/digitalcoast/pdf/ccap-product-page.pdf

Developed by: National Oceanic and Atmospheric Administration (NOAA)

What is it? NOAA's C-CAP was created to better understand the impacts of land use on the coastal portion of the National Land Cover Database. It produces national and standardized land cover and change products that include over 25 categories of land cover, including cropland, pasture, grassland, and various stages of developed land. These image products can be used to track changes in landscape over time and the impacts due to these changes to help coastal resource managers make more informed regional decisions.

What data are available? 30-meter resolution data are available for coastal counties of Illinois, Ohio, Louisiana, Minnesota, and Wisconsin from 1985 to 2010. High-resolution data (1–4-meter resolution) is available only for Ohio from 2006 and 2015.

Spatial Resolution: 1–4-meter resolution for specific project areas; 30-meter resolution for all coastal areas

Scale: Field level

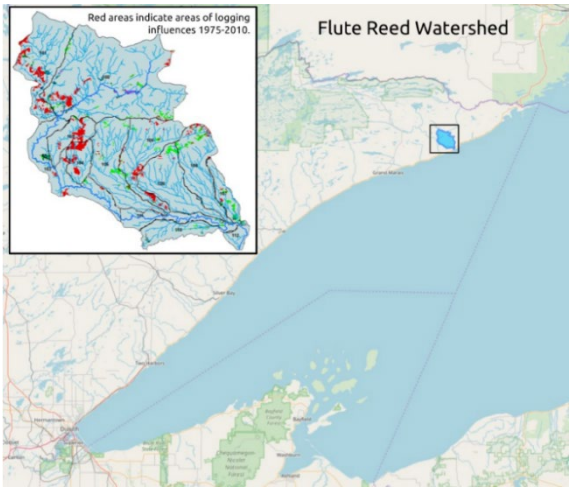
How to access data: https://coast.noaa.gov/digitalcoast/tools/lca.html.

What are the benefits of C-CAP?

- C-CAP data are free and available to the public to be viewed at https://coast.noaa.gov/digitalcoast/tools/lca.html
- Two file types are available: maps from one date and maps that compare changes from one date to another
- Uses standardized data and procedures to maintain consistency through time and across all geographic areas covered

Success Story: Identifying Watershed Stressors along Minnesota's North Shore

A project that is part of the Watershed Restoration and Protection Strategy process, developed by the Minnesota Pollution Control Agency in partnership with other agencies, used NOAA's land cover data to identify stressors within the Flute Reed Watershed that affect water quality. Through the land cover data, they were able to identify that total suspended sediments and turbidity are the largest stressors to the watershed. They were also able to identify areas of the watershed that are influenced by logging practices that increased stressors to the watershed (NOAA 2020).



(NOAA 2020)

OpTIS–Operational Tillage Information System

Fact Sheet:
https://www.nature.org/content/dam/tnc/nature/en/documents/OpTIS_Factsheet_092519_FINAL.pdf

Developed by: Applied GeoSolutions (AGS)

In collaboration with: Conservation Technology Information Center (CTIC); The Nature Conservancy

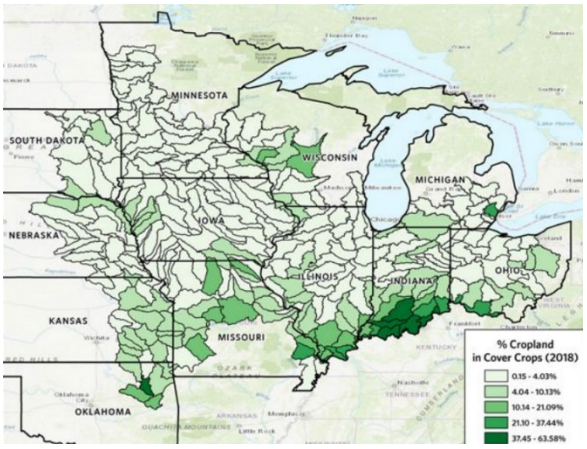
What is it? OpTIS is an automated system designed to monitor the yearly usage trends of soil health practices, including tillage and cover crop practices, over large agricultural areas. It produces accurate, timely, and spatially comprehensive maps of crop emergence, crop residue cover, and winter cover crops using information from multiple Earth-observing satellites (CTIC 2018).

What data are available? 2005–2018 data are available for all of Illinois, Indiana, and Iowa. Also available for parts of Minnesota, Missouri, Ohio, and Wisconsin and non-MARB states Kansas, Michigan, Nebraska, Oklahoma, and South Dakota. As of June 2020, there are plans to expand to many other parts of the contiguous United States within the next 12–18 months as well as to provide annual updates for 2019 and years beyond.

Spatial Resolution: 30-meter resolution

Scale: County level; watershed (8-digit HUC) scale

How to access data: https://www.ctic.org/OpTIS.



(CTIC 2019)

What are the benefits of OpTIS?

- OpTIS data are free and available to the public at https://www.ctic.org/OpTIS
- Can customize data queries by timeframe, units, crops, and geographic area
- OpTIS data are "longitudinal" making multi-year products possible (e.g., include crop rotation overlays)
- OpTIS calculations are performed and validated at the farm-field scale level
- Privacy of individuals is fully protected by only spatially aggregated results at large scales being reported instead of farm-field scale level
- OpTIS data can be used as input in biogeochemical models to estimate greenhouse gas emissions, nitrate losses, and changes in soil moisture holding capacity

Success Story: Monitoring Conservation Tillage and Cover Crops in Three States with OpTIS
With OpTIS data collected for Illinois, Indiana, and Iowa, CTIC and The Nature Conservancy were able to track and monitor the use of conservation tillage and cover crops in the three states between 2006 and 2018. They found the use of winter cover crops increased from 0.8 percent to 4.1 percent in the three states, and also found that conservation tillage practices, those that leave at least 30 percent of residue on the surface before planting, remained relatively the same over the years at a 45 percent average across the three states. These data will give conservation agencies the ability to measure the adoption of conservation practices in a cost-effective, large-scale way (No-Till Farmer 2019).

Commercial Technology Products

AgTrends

Fact Sheet: https://upstream.tech/agriculture/

Developed by: Upstream Tech

What is it? AgTrends is a commercial product created by Upstream Tech that uses satellite data and machine learning models to allow users to track agricultural management practices on the ground with efficient data collection and insights on practices and impacts at both the field and watershed scale. AgTrends can detect agricultural management practices such as cover cropping, riparian buffers, tillage, crop residue, perennial vegetation, irrigation intensity, and crop type. AgTrends can also track outcomes from established management practices through U.S. Department of Agriculture- (USDA-) supported models, such as carbon metrics using COMET-Farm and runoff metrics using the APEX Nutrient Tracking Tool.

What data are available? Year-to-year progress data as well as current conditions and trends over recent years.

Spatial Resolution: Up to 0.5-m resolution

Scale: Watershed level to field level

How to access data: Information is accessible through a web-based platform created by Upstream Tech.

(Upstream Tech 2020)

What are the benefits of AgTrends?

- Allows data processing and visualizations for up-to-date program insights
- Translates practices into outcomes across a program at the watershed level and at field level, including water quality and carbon metrics
- Enables automated monitoring to track practice changes and resulting outcomes
- Able to generate year-to-year progress reports

Success Story: Baseline Iowa Practice Adoption

The Iowa Soybean Association and 11 other partnering organizations, through a Regional Conservation Partnership Program (RCPP) awarded by the USDA-Natural Resources Conservation Service, are helping establish more conservation practices on more acres through a 5-year program in the North Raccoon River Watershed. Funding from the RCPP will support establishment of conservation practices such as cover crops, reduced or no-till management, construction of bioreactors and saturated buffers, and restoration of wetlands for wildlife habitat and water quality improvement (ISA 2020). Upstream Tech will be supporting this program with outcomes monitoring through AgTrends, using satellite data and machine learning to help in assessing past and present agricultural management practices in Iowa watersheds by tracking adoption of conservation practices year over year and determining program success (Smith 2020).

CubeSats–Nanosatellites

Fact Sheet: https://www.nasa.gov/content/about-cubesat-launch-initiative

Developed by: Many companies, like Planet Labs. NASA's CubeSat Launch initiative provides opportunities for nanosatellites built by universities, high schools, and nonprofit organizations to go into space on upcoming launches, providing a low-cost program to help conduct scientific investigations.

What is it? CubeSats, a class of research spacecraft called "nanosatellites," are miniaturized satellites that have been rapidly increasing in the global market due to reduced costs and standardization of satellite parts, allowing lots of organizations, companies, and agencies to create and launch them more easily. These satellites are increasingly being used for near real-time monitoring for various uses such as weather monitoring and agricultural monitoring and management. Planet Labs offers a near real-time monitoring service for viewing CubeSat data globally.

What data are available? Near real-time remote sensing data are available from Planet Labs for all states.

Spatial Resolution: 27-cm, 3–5-m resolution

Scale: Field level

How to access data: https://www.planet.com/products/planet-imagery/.

(NASA 2018)

What are the benefits of CubeSats?

- CubeSats are low-cost satellites that allow companies to launch many of them
- CubeSats provide near real-time data by updating imagery daily
- Many companies and agencies are investing in CubeSats, which will lead to more data availability

Success Story: Nanosatellites Improve Detection of Early-Season Corn Nitrogen Stress
Researchers from the University of Illinois and collaborators used nanosatellites to monitor and detect changes in corn crop nutrient status and discovered it was a better tool than using drones to monitor fertilizer use on corn. The nanosatellites can monitor changes in corn crop chlorophyll production, which can be used as a proxy to monitor crop stress. Researchers showed that these nanosatellites can detect nitrogen stress in crops early in the season, which would allow farmers to plan for fertilizer applications later in the growing season to alleviate nutrient stress for crops (Cai et al. 2019).

Indiana–Cover Crop and Tillage Transect Survey

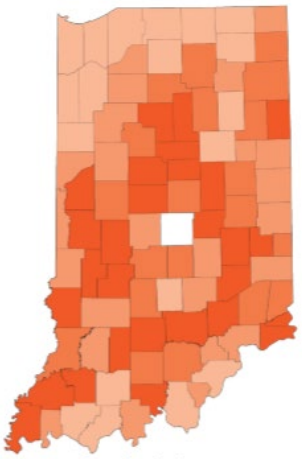
Fact Sheet: https://www.in.gov/isda/2383.htm

Developed by: Indiana Conservation Partnership

In collaboration with: U.S. Department of Agriculture's Natural Resources Conservation Service, Indiana State Department of Agriculture, Indiana's Soil and Water Conservation Districts, and Purdue Extension

What is it? Indiana's Cover Crop and Tillage Transect Survey is a visual on-the-ground survey of cropland in the state that has been conducted every spring since 1990 and every fall since 2014. The survey identifies the types of tillage and cover crop systems farmers are using and long-term trends of these conservation adoption practices by using global positioning system technology and a model for estimating farm management and related annual trends. The survey measures cover crop and tillage practice usage over the state of Indiana as well as trends related to crop residue (Indiana State Department of Agriculture 2020).

What data are available? All data, including tillage trends from 1990 to 2020 and cover crop trends from 2011 to 2020 for the state of Indiana, are publicly available on the Indiana State Department of Agriculture's website.



*Note: Darker colors had a greater percent increase in total conservation tillage acres (corn and soybeans) from 1990-2019

(Indiana State Department of Agriculture 2019)

Spatial Resolution: N/A

Scale: County scale

How to access data: https://www.in.gov/isda/2383.htm or https://ingov.maps.arcgis.com/apps/MapSeries/index.html?appid=d0833739be874312b86688ed07ee744c to view the data.

What are the benefits of the Cover Crop and Tillage Transect Survey?

- Data are free and available to the public at https://www.in.gov/isda/2383.htm
- The survey is conducted in the fall and spring every year, so data are updated regularly
- The survey shows a visual representation of the state's conservation efforts

Success Story: Spring Tillage Transect Survey Shows Indiana's Farmers Using Conservation Practices
The 2015 Spring Cover Crop and Tillage Transect Survey data showed that Indiana farmers are continuing to increase usage of conservation practices, including cover crops and no-till practices. The 2015 spring survey report showed that Indiana farmers saved over 32 million tons of soil by using reduced tillage methods and that farmers who used those reduced tillage systems saved over 14 million gallons of diesel by using less fuel. This survey allows for the visualization of progress with conservation efforts in Indiana and how those efforts are affecting farmers (USDA 2015).

Iowa–BMP Mapping Project

Fact Sheet: https://www.iowaview.org/wp-content/uploads/2018/03/Iowa-Best-Management-Practices-Mapping-Handbook.pdf

Developed by: Iowa State University

In collaboration with: Iowa Department of Natural Resources, Iowa Department of Agriculture and Land Stewardship, Iowa Nutrient Research Center at ISU, National Laboratory for Agriculture and the Environment, the Iowa Nutrient Research and Education Council, and AmericaView

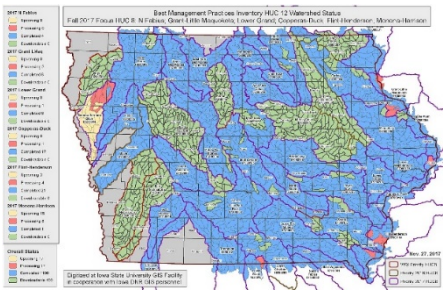
What is it? The Iowa BMP Mapping Project is a free, publicly available database that provides a comprehensive inventory of conservation practices in the state at the watershed scale (HUC-8 and HUC-12). The project established protocols and determined the presence of six existing BMPs on the landscape including: terraces, water and sediment control basins (WASCOB), grassed waterways, pond dams, contour strip cropping and contour buffer strips. This tool can be used to show areas with differing levels of conservation practice investment and to show potential areas that could be implemented with BMPs based on landscape features and cropping systems.

What data are available? 2007–2018 baseline data for six BMP types are available for the entire state by watershed (HUC-8 and HUC-12). Historic presence of BMPs (1980s) and current BMPs status (2016–2018) data was collected from 20% of randomly sampled HUC-12 watersheds from the entire state of Iowa. Available watersheds with historic and current BMPs can be found at https://www.gis.iastate.edu/gisf/projects/conservation-practices.

Spatial Resolution: N/A

Scale: Watershed scale (HUC-8 and HUC-12)

How to access data: Data can be downloaded and viewed at https://benson.gis.iastate.edu/ISU/BMP/BMP.html.



(McNeely et al. 2017)

What are the benefits of the BMP Mapping Project?

- Data are free and available to the public at https://benson.gis.iastate.edu/ISU/BMP/BMP.html
- The tool is a comprehensive database of detected conservation practices for the entire state during the time periods described

Success Story: A Comprehensive Database of Conservation Practices for the State of Iowa
A statewide effort to identify and map conservation practices has been completed and provides a comprehensive inventory of conservation practices in the state by watershed. While individual organizations and programs often keep track of the conservation practices that they implement, Iowa has lacked a comprehensive database of practices in each watershed until this tool was created. The initial number of practices identified by the mapping project include the following: 114,400 pond dams, 327,900 acres of grassed waterways, 506,100 terraces stretching 88,874 miles, 246,100 water and sediment control basins stretching 12,555 miles, 557,700 acres of contour buffer strips, and 109,800 acres of strip cropping. While the practices identified are focused on reducing soil erosion and phosphorus loss, this tool shows that with long-term focus and investment, proven conservation practices targeted at reducing nitrogen loss can be implemented (McNeely et al. 2017).

Kentucky–KyFromAbove Initiative

Fact Sheet: http://kyfromabove.ky.gov/

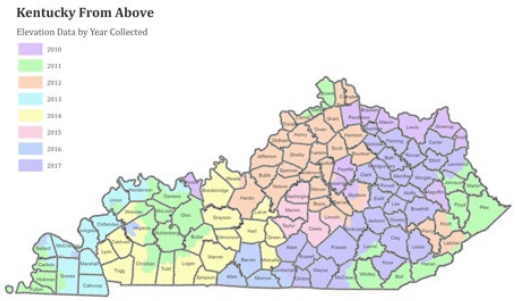
Developed by: Kentucky

In collaboration with: Federal Emergency Management Agency, Department of Interior, U.S. Geological Survey, U.S. Department of Agriculture's Farm Service Agency and Natural Resources Conservation Service

Current Status: In progress collecting and accepting current imagery data

What is it? The KyFromAbove initiative is a program that was developed to build and maintain a basemap for the state of Kentucky that can be used by all users: federal, state, local, and regional. The basemap is being created through elevation data (LIDAR) and aerial photography sent in from volunteers that must be reviewed and accepted. Imagery and elevation maps created will be available on Kentucky's ArcGIS server free to the public to use and download. The combined use of LIDAR and aerial photography allows for many uses, including modeling 3D terrain with vegetation cover mapping, tracking farmland use, modeling urban growth of agricultural districts, and so forth.

What data are available? Elevation data (LIDAR) is available for all Kentucky counties (see https://kygeonet.ky.gov/kyfromabove/pdfs/Inventory-by-agency-year.pdf for specifics). More data are being collected. Imagery data are available for some Kentucky counties (see https://kygeonet.ky.gov/kyfromabove/pdfs/KYAPED-Aerial-Status.pdf for specifics). More data are being collected.



KyFromAbove LiDAR Inventory by Year

(KyFromAbove 2020)

Spatial Resolution: 6-inch to 1-meter resolution

Scale: Field level

How to access data:
https://kygeonet.maps.arcgis.com/home/index.html.

What are the benefits of the KyFromAbove Initiative?

- Images and elevation data are free and available to the public at https://kygeonet.maps.arcgis.com/home/index.html
- No statewide color aerial photography has ever been acquired for the entire state until now
- Combined use of LIDAR and aerial photography allows for many uses by many agencies

Success Story: LIDAR for Interagency Collaboration & Water Supply
The Kentucky Division of Water (DOW) relies on LIDAR and aerial photography from the KyFromAbove initiative for a variety of daily applications. For example, DOW collaborates with the Governor's Office of Agriculture Policy to support agriculture water conservation through the On Farm Water Management Program. In its capacity as a technical advisor, DOW relies on KyFromAbove LIDAR tools and data from the USDA Soil Survey to assess soils, slopes, and elevations for water lines, pump locations, catchments, potential spring sites, pond sizing, and pond siting. LIDAR also helps DOW identify dam elevations and reference points on lakes, the presence of instream low head dams, and pool volumes in dammed streams when assessing water availability.

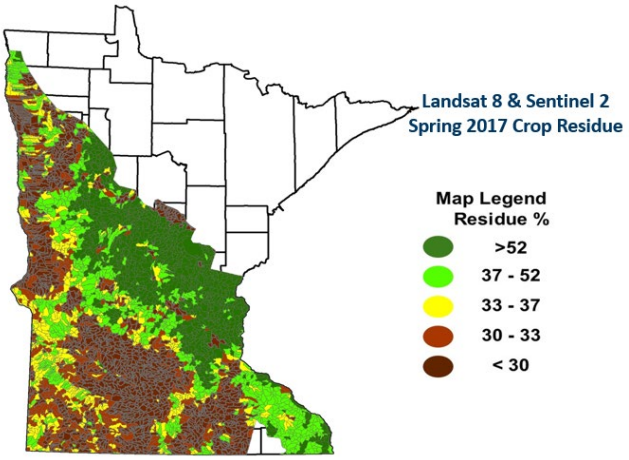
Minnesota–Tillage and Erosion Survey Program

Fact Sheet: https://bwsr.state.mn.us/sites/default/files/2018-12/tillage_and_erosion_survey_project_factsheet.pdf

Currently Being Developed by: Minnesota Board of Water and Soil Resources

What is it? The Tillage and Erosion Survey Program was created as a long-term program to systematically collect tillage data showing trends, cover crop adoption data, and land cover data in 67 county areas in Minnesota through funding from the Clean Water Fund supported by the Land, Water, and Legacy constitutional amendment. The program in development will use remote sensing technologies to assess crop residue cover using Landsat satellite imagery, while also collecting data across jurisdictions to calibrate and measure accuracy of the remote sensing algorithms. The program partners with University of Minnesota and Iowa State University, who are collecting ground and field validation data for crop residue and cover crop data.

What data are available? Daily/yearly erosion data for Minnesota, as well as parts of Iowa, Kansas, Nebraska, Wisconsin, are available on the Daily Erosion Project interactive map at https://www.dailyerosion.org. The program is developing more products to track residue cover, cover crop, and erosion trends that will be available to the public in the near future.



(Mulla et al. 2019)

Spatial Resolution: 3-meter resolution

Scale: Watershed (12-digit HUC) scale

How to access data: https://www.dailyerosion.org/map/#20200630//qc_precip/-93.22/44.33/6//0/.

What are the benefits of the Tillage and Erosion Survey Program?

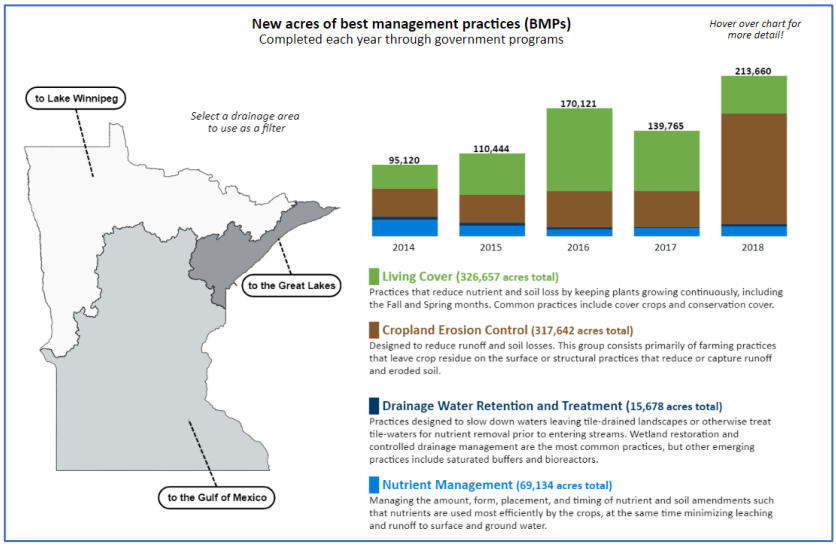
- Free, public online portal in development for data access and visualization of erosion estimates
- Remote sensing methodology is efficient and cost-effective for long-term data collection
- Able to measure voluntary conservation implemented by farmers
- Able to measure land cover changes (e.g., losses/gains and perennial cover, hay land, and pasture)
- Data are not collected anywhere else in Minnesota
- Data supports targeted best management practice recommendations with models and toolkits

Success Story: This project has been a collaborative effort between the Minnesota Board of Water and Soil Resources (BWSR), University of Minnesota Soil (U of M), Water and Climate Department and the Iowa State Biosystems and Bioengineering Department (ISU) to better track land cover and soil erosion trends in Minnesota's agricultural landscapes. Preliminary data for the project have helped to provide awareness to Minnesota's conservation community about the level of adoption of conversation practices and helped to provide a clearer picture of what is happening on the landscape. Project data will help inform other watershed models such as Hydrologic Simulation Program Fortran (HSPF) and have been used in watershed strategy and planning efforts within Minnesota. Over the next year, BWSR and the U of M will begin an outreach campaign to converse with partners and the general public about the use of these data.

Minnesota–Healthier Watersheds: Tracking the Actions Taken

Developed by: Minnesota Pollution Control Agency

What is it? Minnesota's "Healthier Watersheds: Tracking the Actions Taken" webpage on the Minnesota Pollution Control Agency website allows for the tracking of the status of impaired lakes and streams with approved TMDLs, tracking reductions at wastewater treatment facilities, tracking best management practices (BMPs) implemented by watershed, and learning about state, local, and federal spending for implementation of clean water projects.



(MPCA 2020)

What data are available? Current water quality protection and restoration nonpoint BMP adoption levels implemented through government programs, current impaired waters and TMDL approval status data, wastewater treatment plant progress (increase, decrease, or no change) data for several pollutants (phosphorus, total suspended solids, and oxygen demand) from 2000-2019, and current funding for watershed implementation projects data per watershed or county can be found at https://www.pca.state.mn.us/water/healthier-watersheds. The BMP information is also aggregated and graphed for major river basins and statewide so it can be used to evaluate progress toward Minnesota's Nutrient Reduction Strategy goals. Data from statewide and major basins for any period between 2004 and 2019 can be found at the Minnesota Nutrient Reduction Strategy BMP Summary Website.

Spatial Resolution: N/A

Scale: HUC-8/HUC-12 watershed-scales; BMP adoption shown at statewide and major drainage basin scales

How to access data: https://www.pca.state.mn.us/water/healthier-watersheds; BMP data for the entire state and major river drainage basins at Minnesota Nutrient Reduction Strategy BMP Summary Website.

What are the benefits of the tools on the Healthier Watersheds: Tracking the Actions Taken webpage?

- Data are free and available to the public
- Data are updated annually every July based on data from the previous year
- Webpage is user-friendly and data are easily accessible at different scales
- Ability to track nonpoint BMP adoption between years and observe trends
- Can be used in models to estimate load reductions expected in waters from the government-supported practice adoptions

Success Story: The webpage shows how successful collaboration of multiple state and federal agencies can produce a tracking system that comprehensively shows government supported BMP adoption from all major state and federal programs. The tracking system has been successfully used by local watersheds to understand BMP adoption in their local jurisdiction as well as state-level assessment of progress toward Minnesota's Nutrient Reduction Strategy. The tableau graphics have been used to show new BMP adoption at multiple scales and for multiple time periods.

Wisconsin–Erosion Vulnerability Assessment for Agricultural Lands (EVAAL)

Fact Sheet: https://dnr.wi.gov/topic/Nonpoint/documents/EVAAL/EVAAL_Fact_Sheet_v1_0.pdf

Developed by: Wisconsin Department of Natural Resources Bureau of Water Quality

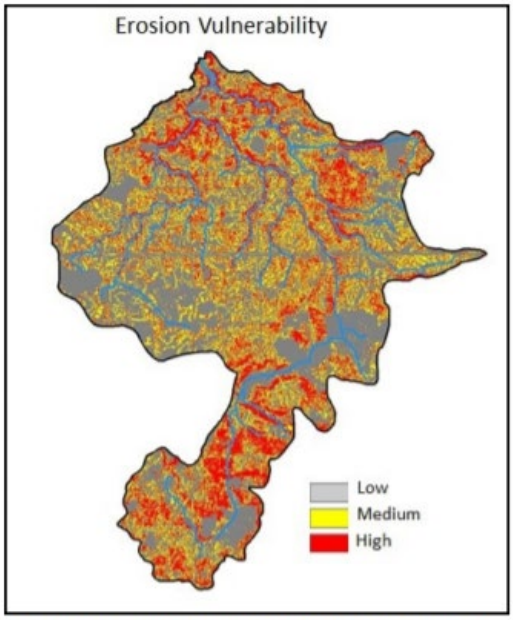
What is it? EVAAL is a GIS-based tool that was developed to assist watershed managers in assessing agricultural lands that might be vulnerable to water erosion and contribute to surface water quality problems. It uses readily available data that include topographic, soils, and land-use information to assess and identify those lands (WDNR n.d.).

What data are available? Tools for creating erosion vulnerability index maps and components of the index (soil loss, stream power index, internally drained areas) for the state of Wisconsin are available for free from the Wisconsin Department of Natural Resources website (WDNR 2014a).

Spatial Resolution: 3-meter resolution

Scale: Field level; county level; watershed level

How to access data: The EVAAL Toolbox (Version 1.0), Methods Documentation, Tutorial, and Tutorial Data sets can be downloaded from the Wisconsin Department of Natural Resources website for free (https://dnr.wi.gov/topic/nonpoint/evaal.html).



AN EXAMPLE OF A EROSION VULNERABILITY MAP PRODUCED BY EVAAL.

(WDNR 2014b)

What are the benefits of EVAAL?

- Data are free and available to the public at https://dnr.wi.gov/topic/nonpoint/evaal.html
- Uses readily available data so it is updated regularly
- It was designed to quickly identify areas vulnerable to erosion and thus more likely to export nutrients (phosphorus, nitrogen, etc.)
- Has a user-friendly interface

Success Story: EVAAL Used in Aiding in Development of Pollutant Reduction Plans

Outagamie County conservationists in Wisconsin used an early version of the EVAAL software in 2014 for several months in their efforts to develop a plan that addressed nonpoint source pollution issues occurring in the county. The conservationist team was focusing on phosphorus reduction, as it has been recognized as the controlling factor of plant and algae growth in Wisconsin lakes and streams. The maps and data produced by EVAAL allowed the team to efficiently work on developing pollutant reduction plans as it helped assist landowners with limited staffing resources (WDNR 2014b).

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Appendix A: Summary of Available Technology by HTF State and Level of Coverage (Full/Partial)

Technology	HTF State*											
	AR	IL	IN	IA	KY	LA	MN	MS	MO	OH	TN	WI
CDL	X	X	X	X	X	X	X	X	X	X	X	X
Google Earth Engine	X	X	X	X	X	X	X	X	X	X	X	X
Landsat	X	X	X	X	X	X	X	X	X	X	X	X
LIDAR-3DEP	X	X	X	X	X	X	X	X	X	X	X	X
NAIP	X	X	X	X	X	X	X	X	X	X	X	X
NOAA C-CAP		P				P	P		P	P		P
OpTIS		X	X	X			P		P	P		P
AgTrends	X	X	X	X	X	X	X	X	X	X	X	X
Cubesats	X	X	X	X	X	X	X	X	X	X	X	X
Cover Crop and Tillage Transect Survey			X									
Iowa BMP Mapping Project				X								
KyFromAbove					X							
Tillage and Erosion Survey Program				P			X					P
Healthier Watersheds: Tracking the Actions Taken Website							X					
EVAAL												X

X = Full Coverage of State; P = Partial Coverage of State

* https://www.epa.gov/ms-htf/hypoxia-task-force-members

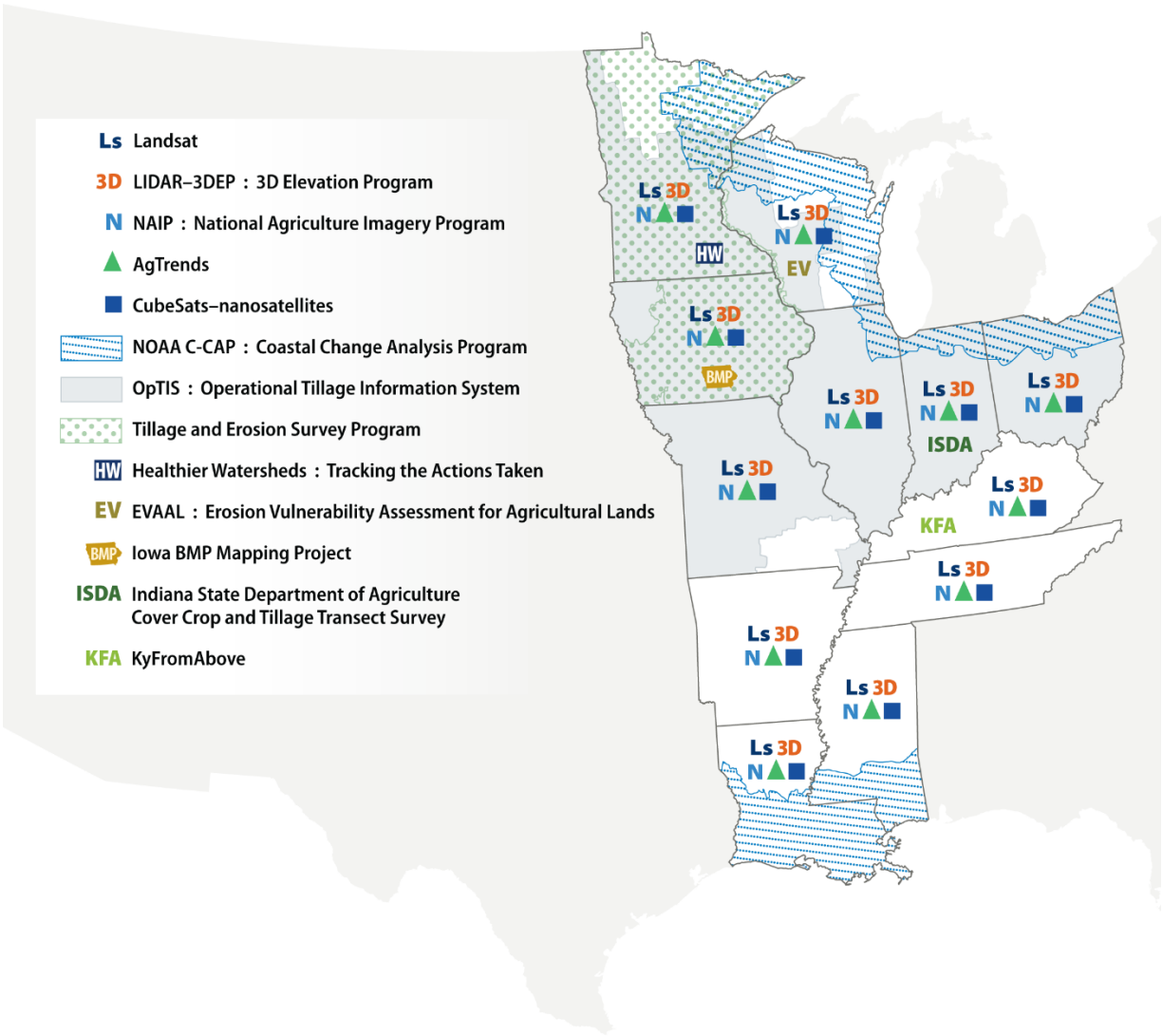

Figure 1. Map Showing Available Technology That Tracks Tillage Practices and Ground Cover by HTF State and Level of Coverage (Full/Partial)