Conservation Technology Information Center

Viridis View Methods Overview

This document provides a summary of remote sensing methods generally, methodological reasons estimates can differ between providers, and notes on Census of Agriculture data in the tool. Links are included to detailed methods documentation from each data provider.

How remote sensing data are used to generate estimates of observed cover crops and tillage intensity

Earth observation satellites use sensors that detect absorbance and reflectance across specific bands of the electromagnetic spectrum including infrared, visible light, and ultraviolet wavelengths. Different land cover types on the Earth's surface reflect and absorb energy differently, enabling scientists to convert the spectral signals of satellite image pixels into a prediction of what is on Earth's surface. Scientists rely on ground level observations, "ground truth", of cover crops and different tillage types to calibrate computer algorithms to the different ways cover crops and tillage can appear in satellite imagery. Satellites are observing the Earth year-round, so these estimates are usually drawn from a series of cloud-free observations between cash crops. Cover crop mapping generally relies on time series vegetation index values measured during the winter period, most often using publicly available Landsat and Sentinel satellite imagery. Greater cover crop biomass in both the fall and spring increases the likelihood that a pixel and field will be classified as cover crops present. A similar time series of tillage-related satellite indices can be used to map tillage intensity. Tillage classes are identified based on the percent of crop residue covering the soil surface: high % residue cover indicates low intensity tillage or no-till, low residue cover is associated with more intensive tillage, and specific thresholds can be used to identify various tillage classes

All data providers' tillage class and cover crop estimates are provided by crop year, with tillage and cover crops reported for the following spring. For example, a cover crop planted in the fall of 2025 and terminated in the spring of 2026 is reported as 2026 in the cover crop datasets.

Methodological reasons estimates can differ between providers

There are many ways to peel an orange. Similarly, there are many ways to convert satellite spectral signals into cover crop presence/absence and tillage intensity estimates. Each data provider in Viridis View has developed their own methods to suit their different needs. Some of the key differences include:

- Cash crop **lands included**: some focus on corn and soybean acres only, others include additional crop types

- The **time period** they look for tillage events: some look only in the spring, others in the spring and fall
- The algorithm, machine learning model, or other **modeling used to classify** spectral signals
- Some classify **tillage classes** differently depending on the fragility of the previous cash crop, i.e., soybean residue decomposes much more quickly than corn residue. Others are agnostic to crop residue type.
- Some include **winter commodity crops** like winter wheat acres in their analysis for cover crops (and change the detection period for those crops) while others exclude winter commodity acres from their analysis.
- Some methods can **detect winter kill cover crops** while others require greenness in both fall and spring to count as a cover crop.
- Each provider has their own **ground truth datasets** to calibrate and validate their estimates.
- Additionally, the methods use different approaches to tune the models to variation in landscape and time (some years and areas are more productive for cover crops, requiring different thresholds for cover crop identification).

Brief overview of methodologies by data provider. See each data provider's detailed methods document for more information (names in table header are links). "NT" is no-till, "RT" is reduced tillage, and "CT" is conventional tillage.

	DTN	Iowa State U.	Regrow	Terion AI	TerraDiagnostics
Organization type	For-profit company	University	For-profit company	For-profit company	For-profit company
Year started using remote sensing	2024	2014 for tillage, 2026 for cover crops	2017	2019	2024
Satellite(s)	Harmonized Landsat and Sentinel-2	Sentinel-2	Landsat 7,8,9; Sentinel-2	Harmonized Landsat and Sentinel-2	Sentinel-2
What is the satellite re-visit time?	Approximately every 2-3 days	Approximately every 2-3 days	Approximately every 2-3 days	Approximately every 2-3 days	Approximately every 5 days.
Cash crop lands included in estimates	All crops in the Cropland Data Layer (CDL) - including Corn (maize), Soybeans, Cotton, Wheat, and many others.	Corn (maize), Soybeans	Corn (maize), Soybeans, Cotton, Wheat, Winter Wheat, Spring Wheat, Alfalfa, Sorghum, Sugarcane – *see detailed methods for full list*	Corn (maize), Soybeans, Cotton, Wheat, Sorghum	Corn (maize), Soybeans, Cotton, Sorghum
What time period is imagery analyzed for tillage?	Fall and spring, classified separately. The reported class is the more intense of the two.	Spring only (April 15-May 30)	Field-specific observation windows during 8-12 week post-harvest and pre-plant periods, set dynamically for each field. The reported class is the most intense of the pre-plant	Field-specific windows after cash crop senescence and before cash crop emergence. The reported class is the most intense observed during the window.	Fall postharvest through spring pre-planting. The model integrates spectral evidence across these periods rather than explicitly identifying the most intensive tillage event.

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			and post-harvest observations.		
Tillage classes	CT (Conventional Tillage), RT, NT	CT, RT, NT	CT, RT, NT	Tilled and NT	Tilled and NT
Crop residue % thresholds for tillage classification (NDTI = normalized difference tillage index)	No fixed % residue cutoffs. NDTI is converted to residue using per-state formulas, and tillage classes are assigned by national share of cropland acres: lowest 31.4% of the residue distribution is CT, middle 28.5% is RT, highest 40.1% = NT.	% residue cover binned uniformly across all crop types: 0–15% = CT, 15.1–30% = RT, >30% = NT	Thresholds are specific to crop fragility: Fragile (soybean, wheat, etc.): CT = 0–15%, RT = 16–30%, NT >30% residue. Non-fragile (corn, sorghum, etc.): CT =0–30%, RT= 31–60%, NT >60%	Method does not estimate % residue cover	Method does not estimate % residue cover
What time period is used for cover crop analysis?	Fall through the following spring (approximately Sep 1 to May 1)	Fall (Nov 15–Jan 15) and spring (Apr 15–May 30) production windows; presence requires detection in both.	postharvest to pre-plant	postharvest to pre-plant	Fall postharvest through spring planting
How are commodities like winter wheat accounted for in cover crop analysis? (CDL = USDA NASS Cropland Data Layer)	The ensemble of models are theoretically able to distinguish this by looking for a terminating event in an appropriate timeframe in the spring to distinguish between winter wheat and cover crop.	CDL filters used to target commodity crops and filter out winter commodities listed above	In-house CropID ML model classifies crop types, including winter commodities (i.e. winter wheat). Winter commodity crops with a minimum 2 month gap with the prior crop harvest are excluded from winter cover crop acreage.	CDL is used to adjust the search window time period for cover crops, so that cover crops can still be detected in crop rotations that include winter commodity crops	CDL filters to target commodity crops listed above
How are winter kill cover crops accounted for?	Driven by the observational data included in model training. To the extent that winter-killed cover crops were included, the machine learning models will pick this up.	Winter kill cover crops or cover crops with a signal that only emerges in the springtime are not counted in ISU cover crop acres - the cover crop must be detected in both the fall and spring.	Any period of vegetation growth between cash crop harvest and planting is considered, even if that growth only occurs in the fall	Any period of vegetation growth between cash crop harvest and planting is considered, even if that growth only occurs in the fall	Winter-killed cover crops may be detected when sufficient seasonal vegetation evidence is available.
Accuracy assessments	Pixel- and field-level ground truth data are split into separate pools for training and for evaluating accuracy. County-level estimates are	No external accuracy validation with ground truthing yet - planned next step. Current check: for each pixel we compare	Validates practice estimates against independent ground-truth and reference datasets, using standard	For both the cover crop and tillage algorithms, we quantify accuracy using 10-fold cross-validation performed independently	Models evaluated using field-level ground truth, randomized cross-validation, and geographically separated smaller and larger spatial

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	calibrated against the Census of Ag.	the observed spectrum with the predicted spectrum and work to minimize this error.	classification metrics.	within each CMZ. For each fold, we calculate a range of validation statistics.	validation blocks to assess geographic transferability.

Census of Agriculture data in Viridis View

The USDA NASS Census of Agriculture is conducted every five years and, since 2012, has collected information from farmers about the tillage type they use and whether or not they planted a cover crop. These 2012, 2017, and 2022 data at the county level are useful to compare to the remote sensing data in Viridis View. In order to compare the acres reported in the Census at the county level to the percentage observed in Viridis View, we had to calculate the total amount of land in a county for the denominator in the percentage calculation. For cover crops, we followed the calculation used in LaRose and Myers 2019:

> **Cropland available for cover crops** = Total cropland reported in the Census – (pastured cropland + hay land and haylage acres + CRP and WRP acres + winter wheat acres)

And % cover crop was calculated as:

> **% cover crop** = (cover crop acres reported in Census / cropland available) * 100

As a check on cropland available, we then calculated:

> **Acres with no cover crops** = cropland available – cover crop acres reported in the Census

In 59 county-years (out of 9,197 total county-years) no cover crops was negative. In those cases we used the total cropland reported in the Census as the denominator for % cover crop.

For tillage, we used the sum of tillage types as the denominator:

> **% no-till** = (no-till acres / (no-till + reduced till + conventional tillage)) *100

and so on for the other tillage classes. In some county-years one or more of those tillage classes were not available in the Census. If no-till was not available, it was converted to zero in the calculation of % reduced till and % conventional till. Similarly, if reduced tillage was not available, it was converted to zero in the calculation of % no-till and % conventional tillage. It should be noted that the 2022 Census defines the categories as: (no % residue coverage definition given for no-till); “conservation or reduced tillage” as >15%, and conventional tillage as 0-15%.

Why might Census of Agriculture data differ from earth observation estimates?

Timing - The Census data are gathered based on the prior calendar year, whereas the earth observation data in Viridis View are based on the crop year (post-crop-harvest, prior to planting

the subsequent year's cash crop). In other words, cover crop acreage reported in the 2022 Census refers to cover crops planted in fall 2022 and would be reported in the crop year 2023 in Viridis View. The tillage acres reported in 2022 Census may refer to tillage occurring in spring 2022 (and shown in 2022 Viridis View data) or fall 2022 (and shown in 2023 Viridis View data).

Practice definitions. For cover crops, the Census asks if cover crops *were planted*, so this can lead to a higher percent of acres reported with cover crops compared to what is *observed* given that not all planted acres will emerge and grow sufficient biomass to be visible from space.

For tillage, the assumed definitions for each class may differ from farmer to farmer. The Census question may not be clear about which tillage events to describe (fall and/or spring events).

Croplands assessed. Another major point of discrepancy can be that the Census gathers data on *all cropland*, whereas the Viridis View data providers gather data on certain cash crop lands (see table above). In a state where most croplands are corn and soybeans, this would not cause much of a discrepancy. In states where croplands are more diverse, the cropland type can contribute to a greater discrepancy between the Census and a data provider.

Response rate. Not everyone responds to the Census, e.g., response rates were 72% in 2017 and 61% in 2022. To meet state coverage targets, NASS uses weighted adjustments for undercoverage, nonresponse, and misclassifications to calibrate the data. Just as there is error in Earth observation data, there is error embedded in Census data.

Authors: Bonnie McGill and W. Dean Hively.

Conservation Technology Information Center

ctic@ctic.org | CTIC.org

P.O. Box 85 Lafayette, IN 47902 | (319)768-8348