HOW YOU CAN USE THE *FARMS UNDER THREAT* MAPPING AND DATA FOR YOUR COUNTY

American Farmland Trust: June 2023

This Users' Guide provides information about some of the mapping data available from American Farmland Trust's *Farms Under Threat* Initiative and how you might use it.

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Introduction

Converting farmlands to more developed uses can put food security and ecosystem connectivity at risk. To help identify threats to land conversion, American Farmland Trust (AFT) and its technical mapping teams developed high-resolution spatial data of national agricultural land quality and land use change due to development patterns for the lower 48 states between 2001 and 2016 (*Farms Under Threat: The State of the States;* see Freedgood et al., 2020). Using this analysis as a baseline, AFT then projected development and climate change to 2040 under different scenarios (*Farms Under Threat 2040: Choosing an Abundant Future;* see Hunter et al., 2022).

AFT's geospatial data from these analyses are widely available at 120 meter resolution (120 meter x 120 meter pixels, or about a third of an acre). Higher resolution data (30 meter x 30 meter) is also available for many layers upon request. The spatial data request form for *Farms Under Threat: State of the States* data can be accessed here and the spatial data request form for *Farms Under Threat 2040* data can be accessed here.

Farms Under Threat: State of the States Geospatial Layers

AFT's *Farms Under Threat: The State of the States* (*FUT: SoS*), developed in partnership with Conservation Science Partners (CSP), documented the changes in agricultural land cover between 2001 and 2016. The data further included a measure of agricultural land suitability for long-term cultivation and food production. AFT synthesized data from many sources, including the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) National Resources Inventory (NRI), the U.S. Geological Survey National Land Cover Database (NLCD), the USDA NRCS Soil Survey Geographic Database (SSURGO), and the USDA NRCS Digital General Soil Map of the United States (STATSGO) to generate these new agricultural data layers (CSP 2020).

The resulting analyses (1) harmonized NRI's ground-based estimates of agricultural land with NLCD remote sensing to improve the understanding of agricultural land conversion, (2) mapped agricultural land conversion in a nationally consistent way over time, and (3) mapped new land-use classes including low-density residential land use (LDR), woodlands associated with farms, and grazing on federal lands (CSP 2020).

The *Farms Under Threat: State of the States* web app allows you to select a state, see the key metrics for agricultural land conversion and download a state conversion summary. You can also download a state policy summary through the Reports and Data tab. You can request the *FUT: State of the States* data and download the technical report here or through the web app. Available geospatial datasets include:

- 2001 land cover/use
- 2016 land cover/use
- 2016 productivity, versatility, and resiliency PVR) continuum
- Conversion of agricultural land to developed uses (2001-2016)

Tabular data for the continental U.S. and the 48 states include:

- 2016 acres of land/cover use types
- 2016 acres of Nationally Significant agricultural land
- Acres of conversion of agricultural land to urban and highly developed land uses (2001-2016)
- Acres of conversion of agricultural land to low density residential land uses (2001-2016)

More information about these data layers appears below. The *FUT:SoS* datasets provided the baseline for the subsequent *Farms Under Threat 2040* mapping.

Agricultural land quality metric (PVR):

AFT and CSP developed the Productivity, Versatility and Resilience metric (PVR) as a measure of the suitability of agricultural land for long term cultivation and food production (CSP, 2020). Here, productivity is defined as output per unit of input (often measured as yield per acre), versatility is the ability of the land to support production and management of a wide range of crops, and resiliency is the land's ability to provide ecosystem services over time despite climate variability.

The PVR metric combines three factors that provide relevant information about the suitability of agricultural land: 1) the suitability of the soil to support cultivation (soil productivity) and production limitations, 2) current crop type and growing season length, and 3) land use and land cover (LULC) type. Combining these factors recognizes that versatility and resiliency are important in ways that are not widely acknowledged. They will increasingly compliment soil productivity in the future, as lands with greater versatility and resilience are better suited to withstand the severe weather events and other environmental changes during a growing season that often disrupt existing production systems.

To create the metric, AFT and CSP mapped soil suitability using the USDA's important farmland designations (i.e., prime, unique, prime with limitations, state important and state important with limitations) from the 2018 NRCS SSURGO and STATSGO datasets along with information on the soil's production limitations taken from its land capability class designation (LCC; USDA SCS, 1961).

To map food production, we used the USDA National Agricultural Statistics Service 2018 Cropland Data Layer (CDL) to identify five categories of crops: fruits & nut trees, fruits and vegetables grown as row crops, staple food crops (e.g., wheat, rice, barley, oats, dry beans, potatoes), grains for livestock feed and processed foods (e.g., corn and soybean, hay and alfalfa, oilseeds and sugar beets and sugarcane), and non-food crops (e.g., crops used for energy production excluding corn, fiber, tobacco and nursery/greenhouse). To reflect the disproportionate value of fruit, tree nuts, and vegetables to food production, we applied a squared transform to accentuate the weights assigned to fruits, nut trees, and vegetables and decrease the weights applied to staple food crops, grains for livestock feed, and non-food. Fruits, nuts, and vegetables occupy only a small percentage of total cropland acres and often depend on unique microclimates that limit their range. We also included information on the proportion of freeze-free days in a year using the 2006 USDA NRCS Major Land Resource Area (MLRA) classification.

LULC were derived from the *FUT* LULC data for both 2001 and 2016 which included cropland, pastureland, rangeland, woodland, forestland, urban, federal, federal grazed, other, roads, and water.

AFT and CSP then led a group of 33 national agricultural experts through a structured process to identify how important the components comprising each factor were in keeping the land productive, versatile, and resilient. Using their feedback, we assigned weights to each factor and combined the resulting values into a single, quantitative, and pixelated PVR metric. Data were ultimately normalized from zero to one, where higher values represented better suitability than low values.

We calculated the overall PVR value for each 30 meter pixel to align with spatial scale of other *FUT* products.

- Nationally Significant Agricultural Land: AFT calculated a significant PVR threshold value based on the following conditions: soils that are designated by USDA NRCS as prime, unique, or prime with limitations; areas that are mapped as cropland and pastureland; and recent history of producing food crops. AFT classified all agricultural land with PVR values above this threshold as Nationally Significant.

- State's Best Agricultural Land: Since PVR is nationally variable, we further identified each state's most suitable agricultural land by mapping the lands with PVR values greater than a state's median PVR value. You can view this layer on our web app.

More information on the PVR metric is available in the *FUT:SoS* PVR Analysis fact sheet. In-depth information on how the PVR analysis was conducted is available in the technical documentation (CSP, 2020), available at the same link.

Developed land use mapping layers:

- Urban and Highly Developed Land Use (UHD): This mapping layer used the urbanized land cover classifications in the NLCD (classes 21-24) to map urban and highly developed land uses (UHD; CSP, 2020). UHD consists of largely built-up areas where most of the land has been converted into commercial, industrial, or residential uses, though opportunities may exist for urban agriculture. UHD areas are commonly found in and around cities and towns but also may include distributed energy production (e.g., well pads or wind turbines). UHD areas are characterized by a high percentage (30% or greater) of constructed materials like asphalt, concrete, and buildings (NLCD classes 22-24) and a developed, open space classification (NLCD class 21) where impervious surfaces account for less than 20% of total cover. UHD can also include parks, golf courses, and some residential areas based on these classifications. Typically, residential areas with less than one housing unit per one to two acres are not included in the NLCD developed classes.

- Low density residential land use (LDR): In a novel analysis that maps low density residential areas, *FUT* started with the assumption that agricultural viability is threatened below a certain minimum farm size that varies by county based on local agricultural production. We then used housing density data to identify where the intrusion of large-lot subdivisions and homes and housing clusters spread out along rural roads could threaten agricultural viability. *FUT* used census block polygons and housing density data from the 2010 U.S. Census. We used a linear extrapolation method based on the change in housing density between the 2000 and 2010 Census to estimate housing density in 2016 (CSP, 2020). U.S. census blocks are statistical areas bounded by visible features such as roads, streams, and railroad tracks and by nonvisible boundaries such as property lines, city, township, school district, county limits and short line-of-site extensions of roads. Census blocks are generally small in area (e.g., a city block in urban areas, 100 acres in suburban areas, and 1,000 acres in rural areas).

  To distinguish between a house and a probable farmstead, *FUT* requested a special tabulation for county-level farm size data from USDA National Agricultural Statistics Service (NASS) and used the 10^{th} percentile in farm size in each county as its minimum farm size threshold. Based on feedback from researchers involved with the NRI, CDL, and NLCD, this approach best represented the point below which agricultural lands are likely too small/fragmented to support an agricultural operation. The 10^{th} percentile thresholds for farm viability reported for the various counties ranged from 1-335 acres (average was 16.7 acres). *FUT* converted these thresholds to units per km^2 and applied them to the census block housing density continuous values data. The census block was classified as LDR land use if the census block density was below the county's minimum farm size threshold. Although agricultural production may still occur in areas of LDR land use, increased housing density reduces the available land base, limits management options, and may also affect the economic viability of remaining farms.

Farms Under Threat 2040 Geospatial Layers:

AFT undertook the *FUT2040* development scenario analysis in partnership with CSP and the Center for Sustainability and the Global Environment at the University of Wisconsin-Madison. Collectively, *FUT2040* (1) projected three different development scenarios, (2) quantified the amount and type of agricultural land lost, (3) provided metrics on the quality of those lands lost based on the PVR metric, and (4) projected how additional protection could preserve critical supplies of farmland and ranchland by 2040 in 10 metropolitan areas. To project future development scenarios, AFT used the rates and patterns of conversion of agricultural land to development documented in *FUT: The State of the States* to create future development forecasts from 2016 to 2040 (Xie and Lark, 2022; Xie et al. 2023). The resulting forecast data visualized plausible transformation trends to farmland and ranchland in a county if development were to continue as usual (i.e., unaddressed). Lands lost to projected sea level rise were also included in the data layers. You can request the *FUT2040* data and download the technical report (Xie and Lark, 2022) here. Available spatial data layers include:

- Urban and Highly Developed (UHD) suitability layer: *FUT* estimated development suitability for each pixel within a county on a normalized scale of zero to one. Higher values represent lands that are more suitable for development. The potential for a location to be urbanized was defined by a set of spatial and socioeconomic determinants that favor development such as accessible terrain, relationships to existing urban areas, transportation networks, water resources, other land resources (e.g., protected natural resources), urban fraction within a pre-defined buffer, land value, and nighttime light intensity.

- Business as Usual Development (BAU) 2040: We projected recent land transformation patterns (2001-2016) into the future at the same rate of land conversion to serve as a baseline for threats to conversion. We then used the BAU estimation as the reference to estimate UHD and LDR demands for the remaining three scenarios.

- Runaway Sprawl (RS) 2040: To mimic *accelerated* conversion rates, we used the same level of demand for UHD as in the BAU scenario but increased the demand for LDR by 50%. This scenario simulated outcomes when development is even less efficient and low-density housing increases.

- Better Built Cities (BBC) 2040: To mimic *decelerated* conversion rates, we reduced the demand for UHD and LDR by 25% and 50%, respectively. This scenario simulated how compact development reduced sprawl and prevented farmland and ranchland from conversion to more developed land uses.

- Farmland Protection Scenarios: This focused scenario started with the BBC scenario and protected an additional 10% of agricultural land in 10 metropolitan areas by 2040 (Boise City-Nampa, ID; Pittsfield, MA; Fresno, CA; Washington-Arlington-Alexandria, DC-VA-MD-WV;

Madison to Milwaukee corridor; Austin-Round Rock, TX; Atlanta-Sandy Springs-Alpharetta, GA; Buffalo-Cheektowaga, NY; Chicago-Naperville-Elgin, IL-IN-WI; and Raleigh-Durham-Cary, NC.)

Using the *FUT2040* Web App

The *Farms Under Threat 2040* web app shows: 1) 2016 land cover, 2) the three development scenarios projected to 2040 (BAU, RS, and BBC), and 3) farmland protection scenarios for the 10 metropolitan areas. A YouTube video tutorial can be accessed to showcase how to navigate and use the web app by clicking *How to.*

To use the maps, select a county and zoom in to see where development is projected to occur. Multiple data layers included in *FUT2040* can be viewed at these higher spatial resolutions. When a county is selected, additional state and county summary statistics will appear below the maps that include: 1) loss of farmland in BAU, RS and BBC scenarios, 2) percent of conversion that will occur on what AFT characterizes as the state's best land based on the PVR metric, 3) statewide totals of agricultural land that may be converted to more developed land uses, and 4) the likelihood that agricultural land in the state currently under LDR land use may be converted to UHD by 2040. In this section, a report that summarizes statewide statistics can also be downloaded.

The web app can help support county planning visioning sessions. These maps are neither predictive nor prescriptive but rather illustrate three projected futures. At the local level, the results should be seen as broadly illustrative of development patterns and should not be evaluated against specific zoning ordinances in precise locations.

Using the *FUT2040* county data sheets

AFT offers tabular data at three spatial levels: 1) the continental U.S., 2) each of the lower 48 states, and 3) individual counties within each state. AFT's county development statistics include the following metrics (Request data):

Category	Statistics Available from the FUT2040 County Data Sheets
Land use and land cover	○ Total cropland, pastureland, rangeland, and woodland associated with farms under UHD* and LDR* in 2016. ○ Total areas associated with roads (transportation) and "other" land uses (includes barren areas and steeper slopes). ○ Total cropland, pastureland, rangeland, and woodland associated with farms under UHD and LDR in 2040 under different development scenarios.
Conversion by development	○ Area and type of agricultural land converted to developed lands by each scenario. ○ Area and percent of agricultural land converted to UHD* and LDR* under each scenario. ○ Summary of how much cropland, pastureland, rangeland, and woodland is converted to both UHD* and LDR* under each scenario.
Impact on Nationally Significant and a State's Best Land	○ Area and percentage of "Nationally Significant" land converted in each county under each scenario by 2040. ○ Area and percentage of the states' "best" agricultural lands converted in each county under each scenario by 2040.
Flooded land	○ Area projected to be impacted by flooding due to sea level rise by 2040.
Farmland Protection Scenarios	○ Summary statistics for the farmland protection scenarios.

* Urban and Highly Developed land uses and Low-Density Residential land uses

Estimating effects on economic indicators:

AFT calculated the effects of agricultural land conversion on key economic indicators for each county using county level data from the 2017 USDA Census of Agriculture. AFT multiplied the number of farms, number of farm jobs, and annual commodity total sales by the percentage of agricultural land in each county that was projected to be converted. The number of farm jobs was the sum of number of producers and number of hired workers provided in the census data.

Using AFT's Protected Agricultural Land Database (PALD):

AFT has also made available the Protected Agricultural Lands Database (PALD), which can be used to view and analyze permanently protected farmland at the county-level. The PALD is a novel national inventory of protected agricultural lands. It contains boundaries of easements that protect private farmland and ranchland in the U.S. as well as important information about each site such as date established, total acres, easement holder, and owner type. This database was compiled by AFT to complement survey data gathered by AFT's Farmland Information Center of state and local Purchase of Agricultural Conservation Easements (PACE) programs and land trusts that protect land for agriculture.

A summary of protected agricultural areas can be viewed with the PALD web map. For example, zoom into a county and view the protected agricultural land parcels. While AFT strives to make the PALD as complete and comprehensive as possible, there are known gaps in the PALD both in terms of actual easements and the attributes assigned to them. Because the PALD is a compilation of data collected from hundreds of sources, data quality differs throughout the database despite AFT's ongoing efforts to standardize data incorporated into the PALD. Additionally, AFT receives some protected lands data with the caveat that the spatial boundaries are not shared with the public. The public version of the PALD that is available for sharing via the web map contains approximately two thirds of the total easements in the full PALD. For complete summary statistics of the PALD in an area, reach out to maps@farmland.org.

Requests for custom analyses:

AFT accepts requests for custom analyses. For example, AFT can create custom maps, calculate spatial statistics for a specified area, or do more in-depth work that brings *FUT* data together with other datasets for an area of interest. If you are interested in a custom analysis, please describe what you need in the data request form or reach out to maps@farmland.org. AFT will follow up to determine the projected cost and a time estimate for completion.

Data use and limitations:

This data provides some of the best available spatial assessments of agricultural LULC and agricultural land conversion as a nationally consistent data product. However, as with any spatial analysis and mapping of this complexity, detail, and extent, there are some limitations to keep in mind.

First, making a direct comparison of *FUT* and USDA NRCS NRI agricultural land conversion estimates is challenging due to methodological and LULC classification differences between the approaches. Although AFT calibrated its land cover model to NRI acreage estimates, limitations in mapping and statistical precision, as well as uncertainty around NRI estimates, prevented AFT's model outputs from fully converging with NRI estimates. Specifically, the estimates of UHD land cover are often lower than NRI because the classification of urban land (derived from NLCD) is less expansive than the NRI definition of developed land and *FUT* does not include roads as UHD land cover.

Second, the NLCD dataset is fundamental to the *FUT* product, and thus, the accuracy of NLCD is directly tied to how well the land cover is mapped in *FUT*. The Level II and I accuracy of the 2016 NLCD is 86.4% and 90.6%, respectively (Wickham et al. 2021).

Third, AFT's mapping of low-density residential (LDR) land use is an explicit attempt to identify areas that are not high enough in housing and impervious surface density to be mapped as urban areas but where agricultural production may face increasing limitations due to adjacent residential land use. However, AFT's method inevitably captures some viable agricultural areas within LDR areas.

While the *FUT* datasets can be visualized at their native resolution, AFT cautions against the use of these data below this recommended minimum mapping unit, for example, in calculating summary statistics such as land cover acreage. We consider a reasonable minimum mapping unit to be between 100 and 200 acres (CSP 2020). AFT recognizes there will be utility in applying the data at a relatively fine scale but urges caution when interpreting or comparing analytical results, particularly when applying the data to site-specific planning activities. Calculating landscape change is particularly challenging. Analytical results will be most robust at the national and state scales; county and sub-county analyses should proceed under the advisement of the data developers on a case-by-case basis. The exception is the PVR data which AFT believes may be useful at a higher level of detail (i.e., 30 m).

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