American Farmland Trust

Farms Under Threat: The State of the States
Productivity, Versatility, and Resiliency (PVR) Analysis
June 3, 2020

This document is a companion piece to the ***Farms Under Threat: The State of the States*** *report, available [here](). More in-depth information on how the PVR analysis was conducted is available in the technical documentation, available at the same link*.

Summary

American Farmland Trust's *Farms Under Threat* PVR analysis was designed to identify the agricultural lands best suited for intensive cultivation, with a focus on production of human-edible food crops. It provides relevant information about the land's productivity, versatility, and resiliency (PVR). We developed a detailed spatial dataset representing soil productivity and capacity, land cover and use, food production for direct human consumption, production limitations, and length of growing season. The PVR model combined these datasets using weights elicited from a group of national agricultural experts. The higher the PVR value, the more productive, versatile, and resilient the land is for long-term cultivation. These values were then used to identify two important land classifications: **Nationally Significant agricultural land**, which is the land best-suited to long-term, intensive crop production within the contiguous United States; and **each state's "best land,"** which is approximately the better half of all agricultural land in each state.

Background

To assess the suitability of agricultural land for long-term cultivation and food production, *Farms Under Threat (FUT)* developed a method using three factors that provide relevant information about the land's productivity, versatility, and resiliency (PVR) in different ways.[1] Combining these factors uniquely recognizes that resiliency and versatility will be as important as productivity in the future, as more severe weather events and changes in growing season length disrupt existing production systems.

The three factors we used are: 1) soil suitability, 2) crop type and growing season length, and 3) land cover/use type. These factors are quantified and mapped using high-quality national spatial datasets. The analysis combines these maps using weights that reflect the relative importance of the three factors as determined by 33 national agricultural experts. The experts participated in a structured process based on decision analysis theory to identify the weight of each PVR factor and each component within each of the factors (Theobald et al. 2018; CSP 2020). This allowed us to combine the three PVR factors to assess agricultural land quality with a single, quantitative metric.

The higher the PVR value, the more likely the land will be suitable for long-term cultivation when treated and managed according to acceptable farming methods (Figure 1). Not surprisingly, cropland scores highest on the PVR value continuum. Most pastureland, rangeland, and woodland are not ideally suited

[1] **Productivity** is output per unit of input (often measured as crop yield per acre). The highest productivity occurs in coastal areas where climate, soil, location, and irrigated conditions favor the production of perishable crops (fruits and vegetables) and in the central U.S. where favorable soil and climate conditions support intensive grain production (Widbe and Gollehon 2006). **Versatility** is the ability of land to support production and management of a wide range of crops. It is mainly assessed in terms of soil and land physical characteristics (Bloomer 2011). **Resiliency** is the land's ability to provide ecosystem services consistently over time, despite climate variability. Resiliency depends on the same factors that determine potential productivity, especially soil properties and topography (UNEP 2016).

for long-term cultivation and score lower on the PVR continuum, even though they may be highly productive, versatile, and resilient for the other ecosystem service benefits they provide (e.g. wildlife and pollinator habitat, forage for grazing livestock, climate change mitigation, etc.; Havstad et al. 2007; Hardelin and Lankoski 2018).

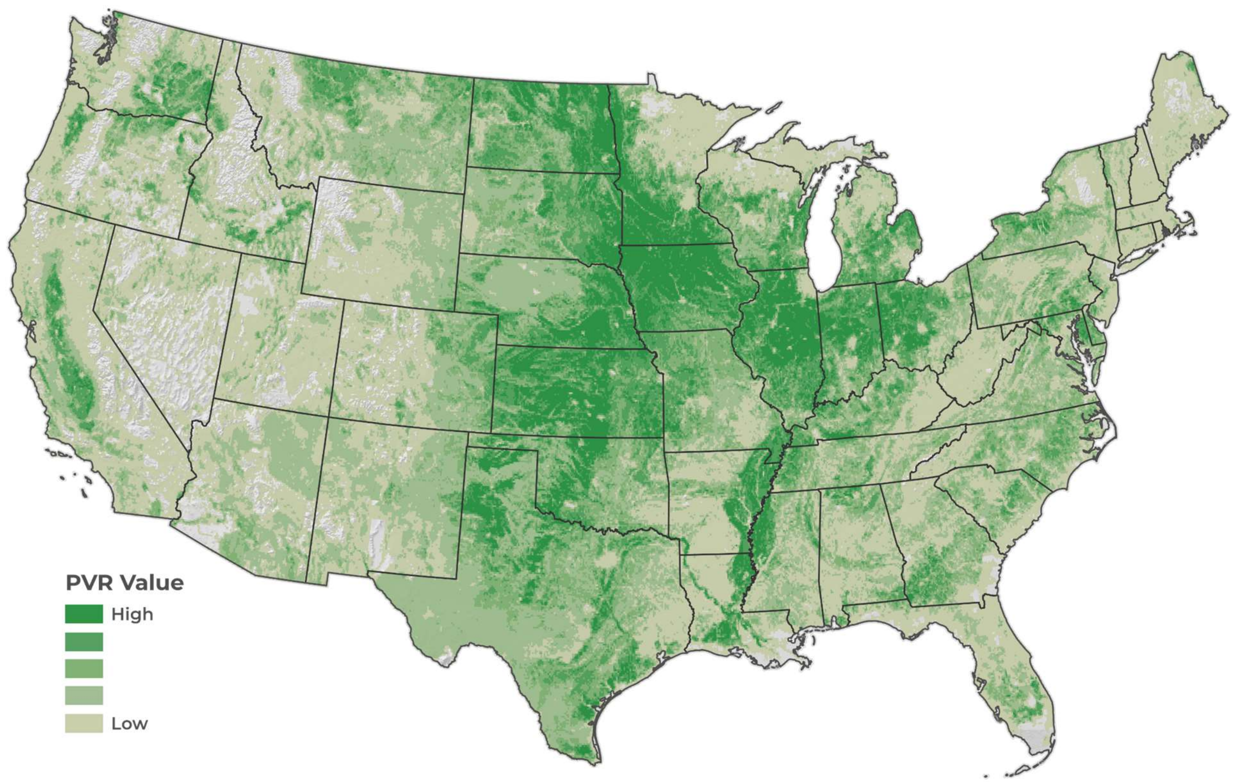

Figure 1. The range of PVR values across the contiguous United States in 2016. An interactive version of this map is available at www.farmland.org/farmsunderthreat.

The PVR analysis was unveiled in the first *FUT* analysis released in May 2018, *The State of America's Farmland* (*FUTv1)*. In *The State of the States (FUTv2)*, improvements in the datasets released in 2018 and 2019 enabled us to make important enhancements to the PVR analysis (CSP 2020). *FUTv1* calculated PVR values only for agricultural land types (cropland, pastureland, rangeland, and woodland associated with farms) at 30 m resolution and had a recommended mapping unit of 1,000 acres or more (Theobald et al. 2018). In contrast, *FUTv2* expanded the analysis to all land cover types, including forestland, federal lands, and some land that has already been converted to development. Therefore, it can indicate the potential for forested acres to be used for food production, which is under consideration in some states. The *FUTv2* analysis also enhanced the resolution to 10 m, which reduces the minimum mapping units to 100-200 acres. Therefore, the updated analysis can better support land-use decisions, including agricultural land protection and solar energy siting at a sub-county level.

Methodology

The *FUTv2* PVR analysis evaluates and combines the following factors:

1. ***Soil suitability***: *FUT* determines soil productivity and capacity by using important farmland designations (also called farmland classes) and land capability classes (LCC) from the NRCS Soil

Survey Geographic and State Soil Geographic datasets (SSURGO and STATSGO 2018). The important farmland designations identify land with the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops. These lands have the soil quality, growing season, and moisture supply (i.e. adequate and dependable water supply from precipitation or irrigation) needed to economically produce sustained high yields and/or high quality of crops when treated and managed, including water management, according to acceptable farming methods. Soil suitability weights as determined by the panel of experts were:

Prime	Unique	Prime with limitations	State Important	State Important with limitations
1.00	0.72	0.55	0.50	0.30

We then strengthened the analysis by including a secondary factor based on production limitations identified in the LCC (USDA SCS 1961). The LCC classes consider the land's limitations for field crops, the risk of damage if it is used for crops, and the way it responds to management. High erosion and runoff, shallow soils, hardpan layers, and climate are the main factors that can limit agricultural capability.

2. ***Food production***: *FUT* used the USDA National Agricultural Statistics Service Cropland Data Layer (CDL) to identify crop type, assigning higher values to crops used for direct human consumption. We grouped the crop types listed in the CDL into one of five classes: 1. fruit and nut trees; 2. fruits and vegetables grown as row crops; 3. staple food crops (e.g. wheat, rice, barley, oats, dry beans, potatoes); 4. feed grains, forages, and crops grown for livestock feed and processed foods (corn and soybean; hay and alfalfa; oilseeds and sugar beets and sugarcane); and 5. non-food crops (i.e., crops used for energy production excluding corn, fiber, tobacco, and nursery/greenhouse). The crop type weights were:

Fruits and nut trees	Fruits and vegetables	Staples	Grains for livestock feed	Non-food
1.00	0.959	0.635	0.325	0.093

To account for the interannual variability of crop types, we calculated the average crop type score from 2014-2018 for each pixel. We also factored in the length of the growing season (which limits the type of crop that can be grown), using information on the proportion of freeze-free days in a year from the USDA NRCS Major Land Resource Area classification (v4.2).

3. ***Land cover and use***: The *FUTv2* land cover/use data layer for both 2001 and 2016 was used in the PVR model. Current land use indicates an area's ability to support different types of agriculture. Our agricultural experts weighted each *FUT* land cover/use class (CSP 2020) and favored land in cultivation (cropland), followed by pastureland, rangeland, and woodland. *FUTv2* extended the weights for non-agricultural land cover/use classes and federal lands to map PVR seamlessly for the conterminous 48 states. *FUT* land cover/use weights are shown below:

Crop-land	Pasture-land	Range-land	Wood-land	Forest-land	Urban	Federal	Federal grazed	Other	Roads	Water
1.00	0.54	0.318	0.246	0.123	0.0	0.123	0.318	0.123	0.0	0.0

The final weights for combining the three factors were:

Soil Suitability	Food Production	Land Cover/Use
0.541	0.314	0.196

Identifying Nationally Significant Land

To identify the most important land for permanent protection, we mapped **Nationally Significant agricultural land**, which is the land best suited for long-term production of crops, especially human-edible crops. We identified the minimum conditions for inclusion in this category:

- soil suitability types: prime, unique, and prime with limitations (i.e. > 0.423);
- land cover/use types: cropland and pastureland (i.e. > 0.538); and
- and all food production types except the non-food type (i.e. > 0.299).

Then, we calculated the threshold value (0.43) by combining these three factors using the weights listed above (CSP 2020). All pixels with PVR values greater than 0.43 were considered Nationally Significant. In our validation against the NRI points, we found that this land includes prime farmland and land in USDA NRCS Land Capability Classes (LCC) I and II.

Identifying Each State's "Best Land"

The principal purpose of *FUTv2* was to provide information about each state's agricultural lands. Since some states have very little Nationally Significant land, we also identified the "best land" in each state by mapping the agricultural lands with PVR values above the state median. In other words, this category includes approximately the better half of a state's agricultural land as determined by PVR. In some states (like Illinois and Delaware), median PVR value is well above the Nationally Significant threshold of 0.43, indicating that much of the state's land is very high quality and primarily composed of cropland. In other states (like Nevada and Arizona), the median PVR value is below the Nationally Significant threshold, so the state's "best land" may include rangeland. Rangeland has many agricultural as well as public values and is especially critical to both livestock production and wildlife habitat in many areas (Havstad et al. 2007). In most cases, however, it is not suitable for cultivation. State median PVR values ranged from 0.12 to 0.56 (CSP 2020). Without rangeland included, the farmland median PVR values ranged from 0.19 to 0.62 (CSP 2020).

Comparing Mean PVR Values for Various Classes

In the validation process for *FUTv1*, PVR values for different *FUT* agricultural land classes were compared against other soil classification schemes (Table 1). PVR values generated for the NRI field observation data points were used to determine the mean PVR values for the eight land capability classes and prime farmland soils. The mean values showed that croplands had the highest PVR values, while pasturelands, woodlands, and rangelands had progressively lower PVR values since they were not ideally suited for food crop production. In other words, the PVR values were in line with what we expected to see. Similarly, the alignment between PVR and LCC values validated the usefulness of the PVR method.

Table 1. Comparing mean PVR values for various land classes.

	Cropland	Pastureland	Woodland	Rangeland
	39.0% of ag land	11.8% of ag land	5.9% of ag land	43.3% of ag land
PVR mean value, (min – max)	0.51 *(0.39 to 0.63)*	0.33 *(0.19 to 0.47)*	0.25 *(0.11 to 0.39)*	0.18 *(0.06 to 0.30)*
SSURGO prime	*0.45*			
LCC I	*0.53*			
LCC II	*0.49*			
LCC III	*0.40*	*0.40*		
LCC IV		*0.29*	*0.29*	*0.29*
LCC V		*0.29*	*0.29*	*0.29*
LCC VI			*0.20*	*0.20*
LCC VII			*0.15*	*0.15*
LCC VIII			*0.15*	*0.15*

ADDITIONAL TABLE 1 INFORMATION

Land Capability Classes LCC): This commonly used classification was first developed by USDA in 1961 to group soils primarily on the basis of their capability to produce commonly cultivated crops and pasture plants without deteriorating over a long period (USDA SCS, 1961). They take into account various management hazards (e.g. erosion, wetness, root zone limitations and climatic limitations). Class codes I to VIII indicate progressively greater limitations and narrower choices for agriculture and represent both irrigated and non-irrigated land capability. Soils in Class I have few limitations that restrict their use. Soils in Class II require careful soil management, including conservation practices, to prevent deterioration, but the practices are easy to apply. Soils in Class III have severe limitations that reduce the choice of plants or require special conservation practices. Soils in Class IV have very severe limitations that restrict the choice of plants, require very careful management or both. The land generally not suited to cultivation mostly falls into Classes V-VIII. Soils in Class V have little or no soil erosion hazard but have other limitations (wet, stony, etc.) that limit their use largely to pasture, range, woodland or wildlife food and cover. Soils in Class VI, Class VII and Class VIII have progressively more severe limitations. Suitable uses for Class VI include pasture, range, woodland or wildlife food and cover; for Class VII grazing, woodland or wildlife; and for Class VIII, recreation, wildlife, water supply or aesthetic purposes.

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