# cmdty CropPlus+ Index Family Methodology

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# Contents

# 1 Introduction

## 1.1 cmdty CropPlus+ Index Family

The cmdty CropPlus+ Index Family (”CropPlus+ Indexes”) is composed of yield projections available on a nominal and adjusted (chained/constant for advancements in technology and agronomy) basis; and index values that represent point-in-time estimates of cumulative growing conditions for a given area, crop, and season normalized against the applicable national-level benchmark. The index family uses observed micro-climate specific accumulated weather conditions as inputs into both yield estimates and normalized index values.

The purpose of the cmdty CropPlus+ Index Family is to present producers, merchandisers, and agribusinesses with simple-to-understand actionable measures that improve decisions around agronomy practices and grain trading.

CropPlus+ Indexes are calculated weekly and distributed in three data series: the cmdty CropPlus+ Yield Index, the cmdty CropPlus+ Yield Adjusted Index, and the cmdty CropPlus+ Conditions Index. Each series is available for four area types: County, District, State, and National. A bottoms-up calculation method is used to calculate the applicable county indexes and then aggregate these forecast results through to each area-type that resides above the County level.

## 1.2 Naming Convention

The cmdty CropPlus+ Index Family adheres to the following naming conventions specific to each index series.

Long version - cmdty CropPlus+ [area] [crop] [indexType]

- County - cmdty CropPlus+ Boone County, IA Corn Yield Index
- District - cmdty CropPlus+ IA CRD10 Corn Yield Index Adj
- State - cmdty CropPlus+ IA Corn Conditions Index
- National - cmdty CropPlus+ National Corn Yield Index

Short Version - cmdty [area] [crop] [indexType]

- County - cmdty IABO Corn Yield Idx
- District - cmdty IA10 Corn Yield Idx Adj
- State - cmdty IA Corn Cond Idx
- National - cmdty Nat Corn Yield Idx

## 1.3 Data Sourcing and Integrity

cmdty collects data from multiple sources to ensure the accuracy and quality of our measurements.

Remote sensor variables are derived from the Terra/Aqua satellite's Moderate Resolution Imaging Soectroradiometer (MODIS) and from the NASA Soil Moisture Active Passive.

1. NDVI - Calculated from Terra Surface Reflectance 8-Day L3 Global 250 m SIN Grid (DOI: 10.5067/MODIS/MOD09Q1.006)
2. NDWI - Calculated from Aqua Surface Reflectance Daily L2G Global 1 km and 500 m SIN Grid (DOI: 10.5067/MODIS/MYD09GA.006)
3. Daytime LST - Produced from Aqua Land Surface Temperature/Emissivity 8-Day L3 Global 1 km SIN Grid (DOI: 10.5067/MODIS/MYD11A2.006)
4. Soil Moisture - Produced from NASA-USDA SMAP Level 3 soil moisture

Ground based sensor variables

1. Precipitation - Derived from the NOAA/NWS Nexrad ground based system
2. Precipitation Anomaly - Produced from the NOAA Climate Data Online web service
3. Solar Radiation - Produced from the NOAA Climate Data Online web service
4. Relative Humidity - Produced from the NOAA Climate Data Online web service

# 2 cmdty County CropPlus+ Indexes

## 2.1 Indicator Definitions

### 2.1.1 NDVI

Normalized Difference Vegetation Index (NDVI) is a graphical indicator to identify vegetated areas and their conditions. NDVI is calculated as follows:

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

where,

$NIR$ stands for the spectral reflectance measurements acquired in near-infrared regions

$RED$ stands for the spectral reflectance measurements acquired in the red (visible)

### 2.1.2 NDWI

Normalized Difference Water Index (NDWI) is a remote sensing-derived indexes to monitor changes in water content of leaves. NDWI is calculated as follows:

$$NDWI = \frac{NIR - SWIR}{NIR + SWIR}$$

where,

NIR stands for the spectral reflectance measurements acquired in near-infrared regions

SWIR stands for the spectral reflectance measurements acquired in short-wave infrared wavelengths

### 2.1.3 LST

Land Surface Temperature (LST) describes the temperature of the land surface in Kelvin.

### 2.1.4 Soil Moisture

Surface soil moisture levels are useful for monitoring the planting and harvesting activities for most crops. The surface soil moisture is assumed to hold a maximum of one inch (or 25-mm) of available water, which means the top-layer soil depth is dependent on the soil texture. Surface soil moisture levels from:

- 20-25-mm are best for germinating and emerging a new crop, but can halt fieldwork and could damage newly-seeded crops that remain in the wet environment for an extended period of time.
- 15-20-mm of water are normally best for vigorous field activity.
- 10-mm or less will not support seed germination or early growth potentials for a recently emerged crop

### 2.1.5 Precipitation - TBD

### 2.1.6 Precipitation Anomaly - TBD

### 2.1.7 Solar Radiation - TBD

### 2.1.8 Relative Humidity - TBD

## 2.2 Index Calculation

### 2.2.1 County Index Calculation Guide

$$
\begin{aligned}
Y_t &= \overline{Y}^{5y} + \int_{t_0}^{t} W_t(I_t - \overline{I}_t^{5y})dt + 2.5r \\
Y_t^{adj} &= Y_t - \Delta t * r \\
V_t &= \frac{Y_t^{adj}}{Y_0}
\end{aligned}
$$

Where,
$t$ is the timestamp that county index is calculated.

$t_0$ is the timestamp that crop growing season starts for the given crop type at the given county.

$Y_t$ is the forecast yield at time $t$ for the given county and crop type .

$\overline{Y}^{5y}$ is the average historical yield for the given county and crop type for the preceding 5 years.

$W_t$ is a row vectors of weightings for weather indicators observed at time $t$ - $(W_0^t, W_1^t, \ldots, W_n^t)$ - $W_t$ is extracted from a multiple variables linear regression model. The model is trained by the preceding 5 years weather indicators and yield for all counties within same climate zone.

$I_t$ is a column vector of weather indicators observed at time $t$ - $(I_0^t, I_1^t, \ldots, I_n^t)^\intercal$ - representing residuals, NDVI, NDWI, LST, Soil Moisture,..., etc, respectively.

$\overline{I}_t^{5y}$ is a column vector of mean weather indicators at point of time $t$ in preceding 5 years - $(\overline{I}_0^t, \overline{I}_1^t, \ldots, \overline{I}_n^t)^\intercal$ - representing mean residuals, mean NDVI, mean NDWI, mean LST, mean Soil Moisture,..., etc, respectively.

$r$ is the average national annual yield growth for the given crop for past 40 years. $r$ for soybeans is 0.41194 bushel per acre per year, and for corn is 1.945181 bushel per acre per year. We assume the historical yield growth is driven by technology growth, and assume this trend will hold constantly in our model.

$Y_t^{adj}$ is the weather-impact-only forecast yield at time $t$ for the given county and crop type, excluding impact of technical improvement since benchmark year.

$\Delta t$ is the year difference between time $t$ and benchmark year.

$Y_0$ is the average yield for the given crop in U.S at benchmark year.

$V_t$ is the index value at time $t$ for the given crop type and county, representing the relative strength of weather condition for grain growing comparing to that for national level in benchmark year.

### 2.2.2 District Index Calculation Guide

$$W_i = \frac{\overline{A}_i^{5y}}{\sum_{i=1}^{N} \overline{A}_i^{5y}}$$

$$Y_t = \sum_{i=1}^{N} W_i Y_{it}$$

$$Y_t^{adj} = Y_t - \Delta t * r$$

$$V_t = \frac{Y_t^{adj}}{Y_0}$$

Where,

$i$ is any county that grows the given crop within the given crop reporting district in the preceding 5 years.

$N$ is the amount of counties that grow the given crop within the given crop reporting district the preceding 5 years.

$\overline{A}_i^{5y}$ is the average harvested areas for county $i$ for the given crop in preceding 5 years.

$W_i$ is the weight for county $i$ that used to calculate forecast yield for the given district.

$t$ is the timestamp that district index is calculated.

$Y_{it}$ is the forecast yield at time $t$ for county $i$. It is calculated in Section 2.2.1

$Y_t$ is the forecast yield at time $t$ for the given district and crop type .

$\overline{Y}^{5y}$ is the average historical yield for the given district and crop type for the preceding 5 years.

$r$ is the historical average national annual yield growth for the given crop. $r$ for soybeans is 0.41194 bushel per acre per year, and for corn is 1.945181 bushel per acre per year.

$Y_t^{adj}$ is the weather-impact-only forecast yield at time $t$ for the given district and crop type, excluding impact of technical improvement since benchmark year.

$\Delta t$ is the year difference between time $t$ and benchmark year.

$Y_0$ is the average yield for the given crop in U.S at benchmark year.

$V_t$ is the index value at time $t$ for the given crop type and district, representing the relative strength of weather condition for grain growing comparing to that for national level in benchmark year.

### 2.2.3 State Index Calculation Guide

$$W_j = \frac{\overline{A}_j^{5y}}{\sum_{j=1}^{M} \overline{A}_j^{5y}}$$

$$Y_t = \sum_{j=1}^{M} W_j Y_{jt}$$

$$Y_t^{adj} = Y_t - \Delta t * r$$

$$V_t = \frac{Y_t^{adj}}{Y_0}$$

Where,

$j$ is any district that grows the given crop within the given state in the preceding 5 years.

$M$ is the amount of districts that grow the given crop within the given state in the preceding 5 years.

$\overline{A}_j^{5y}$ is the average harvested areas for district $j$ for the given crop in preceding 5 years.

$W_j$ is the weight for district $j$ that used to calculate forecast yield for the given state.

$t$ is the timestamp that state index is calculated.

$Y_{jt}$ is the forecast yield at time $t$ for district $j$. It is calculated in Section 2.2.2

$Y_t$ is the forecast yield at time $t$ for the given state and crop type .

$\overline{Y}^{5y}$ is the average historical yield for the given state and crop type for the preceding 5 years.

$r$ is the historical average national annual yield growth for the given crop. $r$ for soybeans is 0.41194 bushel per acre per year, and for corn is 1.945181 bushel per acre per year.

$Y_t^{adj}$ is the weather-impact-only forecast yield at time $t$ for the given state and crop type, excluding impact of technical improvement since benchmark year.

$\Delta t$ is the year difference between time $t$ and benchmark year.

$Y_0$ is the average yield for the given crop in U.S at benchmark year.

$V_t$ is the index value at time $t$ for the given crop type and state, representing the relative strength of weather condition for grain growing comparing to that for national level in benchmark year.

### 2.2.4 National Index Calculation Guide

$$W_k = \frac{\overline{A}_k^{5y}}{\sum_{k=1}^{K} \overline{A}_k^{5y}}$$

$$Y_t = \sum_{k=1}^{K} W_k Y_{kt}$$

$$Y_t^{adj} = Y_t - \Delta t * r$$

$$V_t = \frac{Y_t^{adj}}{Y_0}$$

Where,

$k$ is any state that grows the given crop within the U.S. in the preceding 5 years.

$K$ is the amount of districts that grow the given crop within the given state in the preceding 5 years.

$\overline{A}_k^{5y}$ is the average harvested areas for state $k$ for the given crop in preceding 5 years.

$W_k$ is the weight for state $k$ that used to calculate forecast yield for the nation.

$t$ is the timestamp that national index is calculated.

$Y_{kt}$ is the forecast yield at time $t$ for state $k$. It is calculated in Section 2.2.3

$Y_t$ is the forecast yield at time $t$ for the nation and crop type .

$\overline{Y}^{5y}$ is the average historical yield for the nation and crop type for the preceding 5 years.

$r$ is the historical average national annual yield growth for the given crop. $r$ for soybeans is 0.41194 bushel per acre per year, and for corn is 1.945181 bushel per acre per year.

$Y_t^{adj}$ is the weather-impact-only forecast yield at time $t$ for the nation and crop type, excluding impact of technical improvement since benchmark year.

$\Delta t$ is the year difference between time $t$ and benchmark year.

$Y_0$ is the average yield for the given crop in U.S at benchmark year.

$V_t$ is the index value at time $t$ for the given crop type and nation, representing the relative strength of weather condition for grain growing comparing to that for national level in benchmark year.

## 2.3 Index Maintenance

cmdty performs an annual review of the entire cmdty CropPlus+ Index Family on March 1st. We will collect crop yield data, crop harvested area data, and weather indicators for the last 5 years from all sources. The updated yield data, and weather indicators will be used to re-train the regression models. The updated harvest areas data will be used to revise the weighting matrix for all indexing areas.

## 2.4 Index Dissemination

CropPlus+ Indexes are calculated weekly starting at May, and ending at October each year. Historical CropPlus+ Indexes are available from 2010.

## About cmdty by Barchart

Barchart, through the cmdty by Barchart product line, delivers the data, solutions, and insights that commodity professionals need to drive their business. Our offerings are built for the most demanding of users - and are designed to be smart, transparent, and easily integrated into any client solution.

## Contact Information

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## Disclaimer