



Global Yield
Gap Atlas

Technology Extrapolation Domains (TEDs)

Tool tutorial

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TED justifications

- Traditional agricultural research is mostly conducted at specific locations.
- It's a challenge to interpret results and upscale them to larger spatial scales
- TEDs classify sites based on key climate and soil factors that govern crop yield.
- Concept was developed in the context of the Global Yield Gap Atlas project.
- TEDs have been developed for the United States (US) and sub-Saharan Africa.

TED applications

- If you are a farmer:

View results of product trials to see if trials were conducted in regions with similar climate and soils to yours.

- If you conduct ag research:

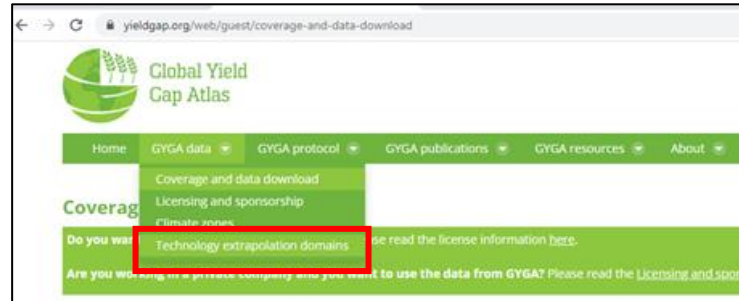
You might want to consider conducting research in a variety of TEDs to capture varying climate and soil conditions and represent well the main crop producing areas and/or those where your product is expected to deliver the largest impact.

TED interactive tool website

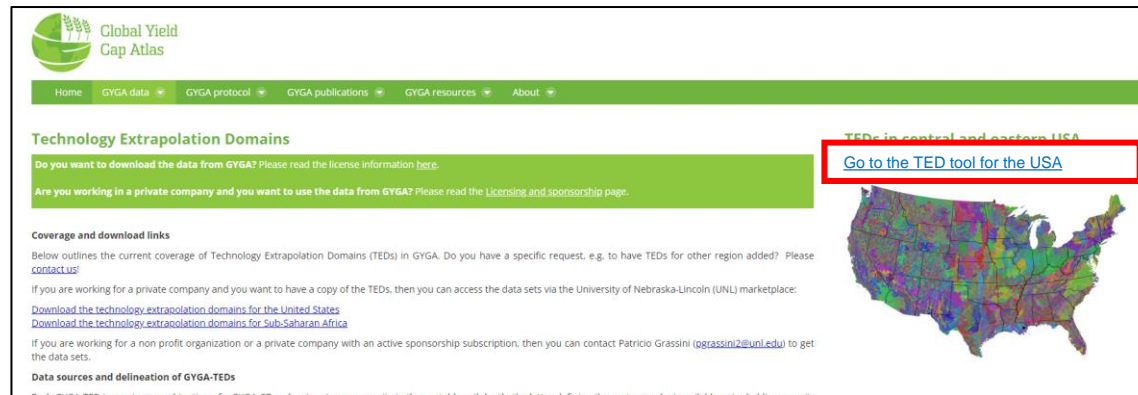
<https://www.tooled.org/>

Access TED interactive tool via GYGA

From GYGA Homepage, click on GYGA data -> Technology extrapolation domain



Click on the link that will direct to TED tool

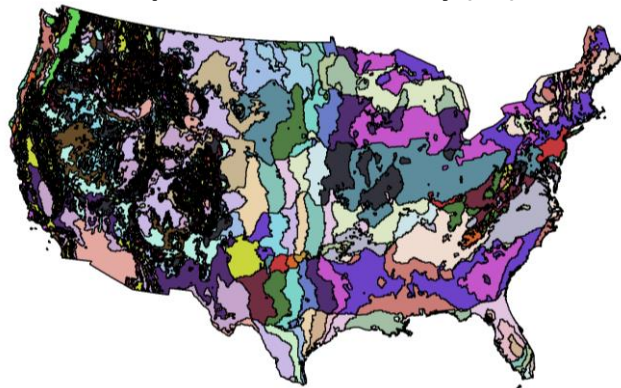


Components of TEDs

$$\text{Unique TED} = \text{CZ} + \text{RZWHC}$$

Climate Zones (CZ)

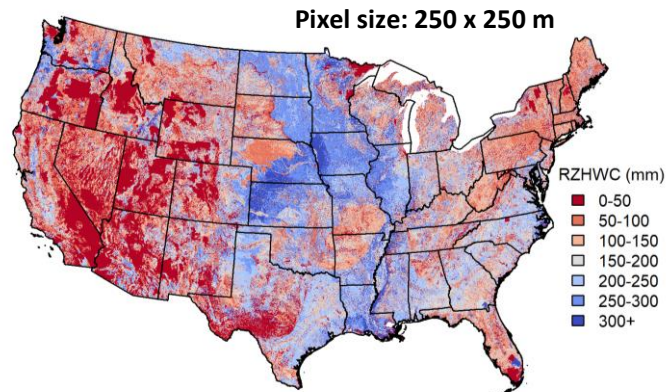
- Growing degree days (GDD)
- Aridity index (AI)
- Temperature seasonality (TS)



Source: van Wart et al.(2013)

Soil water storage capacity

- Root-zone water holding capacity (RZWHC)



Source: gSSURGO, USDA-NRCS

Values of TEDs based on components

$$\text{TED} = \text{CZ} + \text{RZWHC}$$

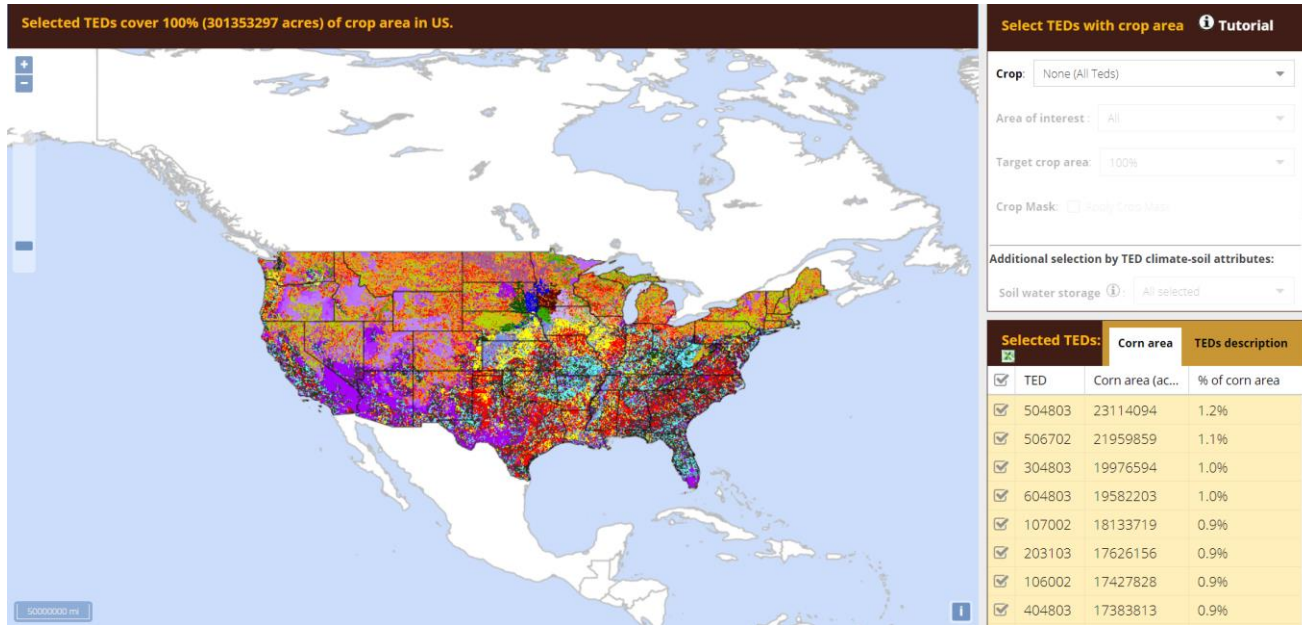
Each number is a code associated with a specific range of climatic and soil conditions.

Example TED value: 604803

Diagram illustrating the components of the TED value 604803:

- 6: RZWHC (blue arrow pointing up)
- 0: GDD (red arrow pointing down)
- 4: AI (green arrow pointing up)
- 8: TS (yellow arrow pointing down)
- 0: (unlabeled)
- 3: (unlabeled)

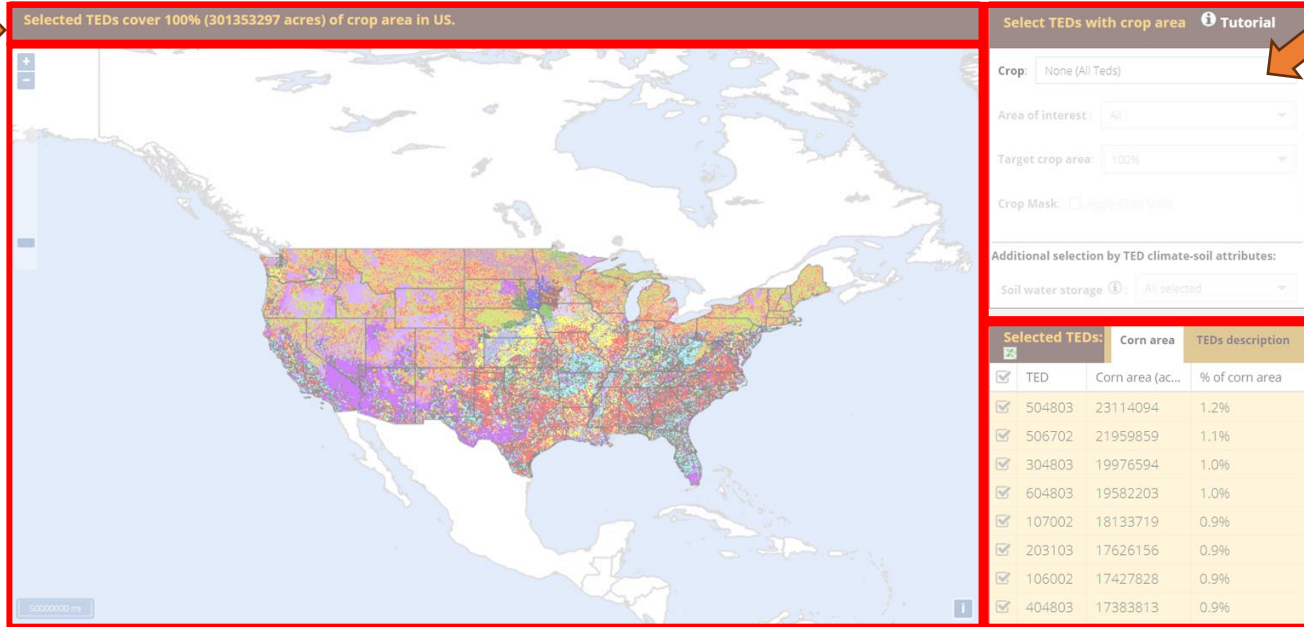
TED interactive tool



TED Tool layout

map
header

TED selection menu



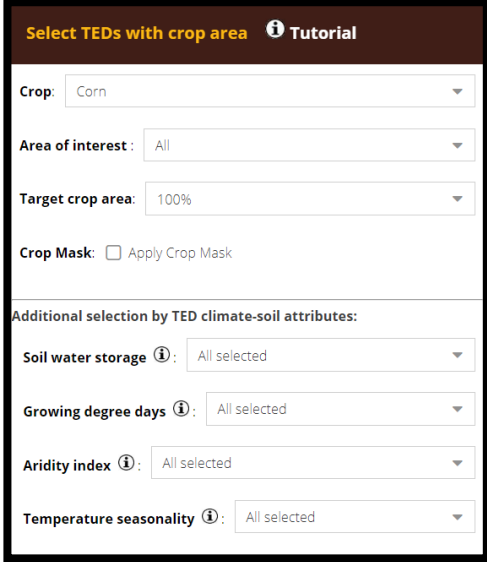
Selected
TEDs
table

interactive map

TED selection menu

For each crop, users can select areas to display based on:

1. Crop
2. Area of interest
3. Target crop area
4. Actual crop producing areas (crop mask)
5. TED climate-soil attributes
 - Soil water storage
 - Growing degree days
 - Aridity Index
 - Temperature seasonality

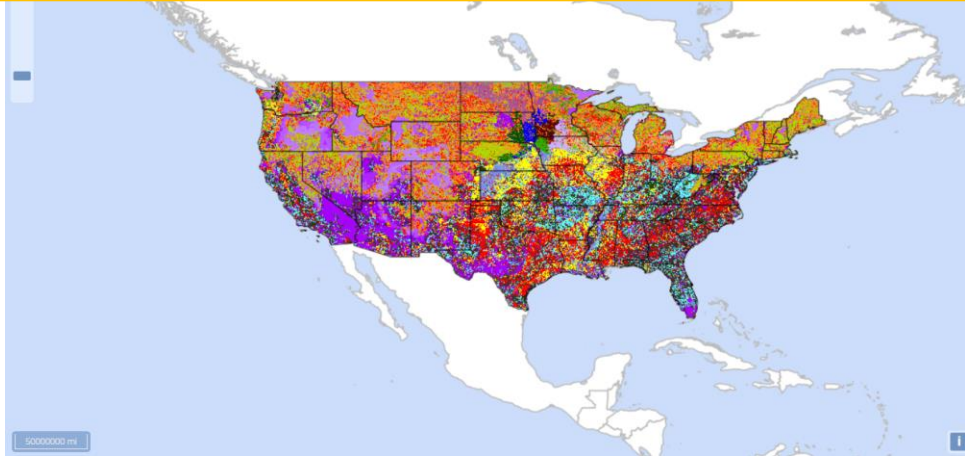


The screenshot shows a web interface titled "Select TEDs with crop area" with a "Tutorial" link. It contains several dropdown menus and a checkbox. The "Crop" dropdown is set to "Corn". The "Area of interest" dropdown is set to "All". The "Target crop area" dropdown is set to "100%". There is a "Crop Mask" section with a checkbox labeled "Apply Crop Mask" which is currently unchecked. Below this is a section titled "Additional selection by TED climate-soil attributes:" which contains four dropdown menus: "Soil water storage" (All selected), "Growing degree days" (All selected), "Aridity index" (All selected), and "Temperature seasonality" (All selected). Each dropdown menu has a small information icon (i) to its left.

1. Select Crop

The first step is crop selection. This enables the other selection options.

5 crops currently available: Corn, Rice, Sorghum, Soybean, and Wheat*



Select TEDs with crop area Tutorial

None (All Teds)

Corn

Rice

Sorghum

Soybean

Wheat

Additional selection by TED climate-soil attributes:

Soil water storage ? All selected

Selected TEDs:

	Corn area	TEDs description
<input checked="" type="checkbox"/> TED	Corn area (ac...)	% of corn area
<input checked="" type="checkbox"/> 504803	23114094	1.2%
<input checked="" type="checkbox"/> 506702	21959859	1.1%
<input checked="" type="checkbox"/> 304803	19976594	1.0%
<input checked="" type="checkbox"/> 604803	19582203	1.0%
<input checked="" type="checkbox"/> 107002	18133719	0.9%
<input checked="" type="checkbox"/> 203103	17626156	0.9%
<input checked="" type="checkbox"/> 106002	17427828	0.9%
<input checked="" type="checkbox"/> 404803	17383813	0.9%

* Wheat includes winter wheat, spring wheat, and durum wheat

2. Area of interest

Select TEDs with crop area ⓘ Tutorial

Crop:

Area of interest:

Target crop area:

Crop Mask: ☐ Apply Crop Mask

Additional selection by TED climate-soil attributes:

Soil water storage ⓘ:

Growing degree days ⓘ:

Aridity index ⓘ:

Temperature seasonality ⓘ:



All

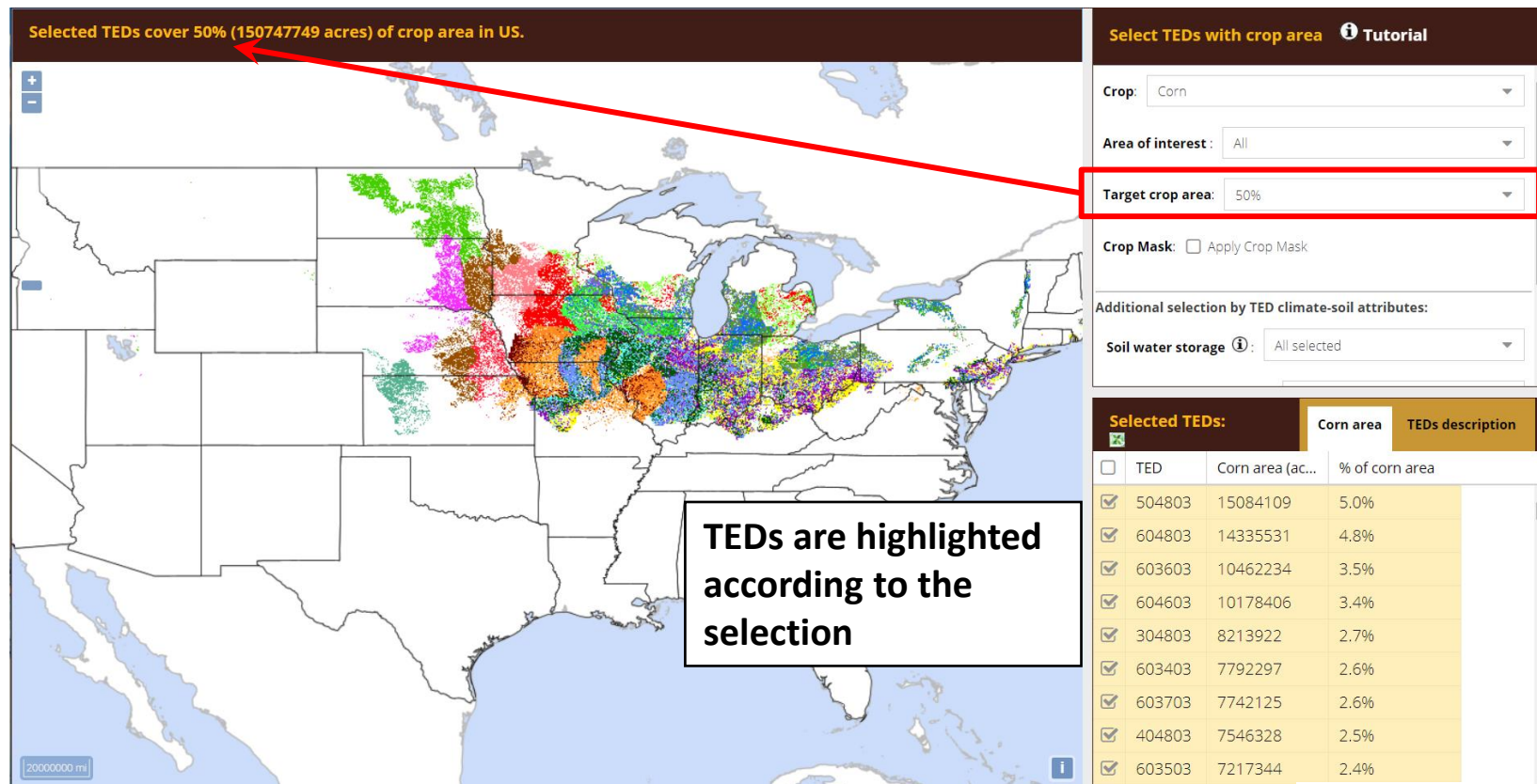
State (click on a state)

User-defined area (draw a rectangle)

Specific sites (enter GPS coordinates)

The default Area of Interest is the entire USA.
Other options are explained in subsequent slides.

3. Target crop area

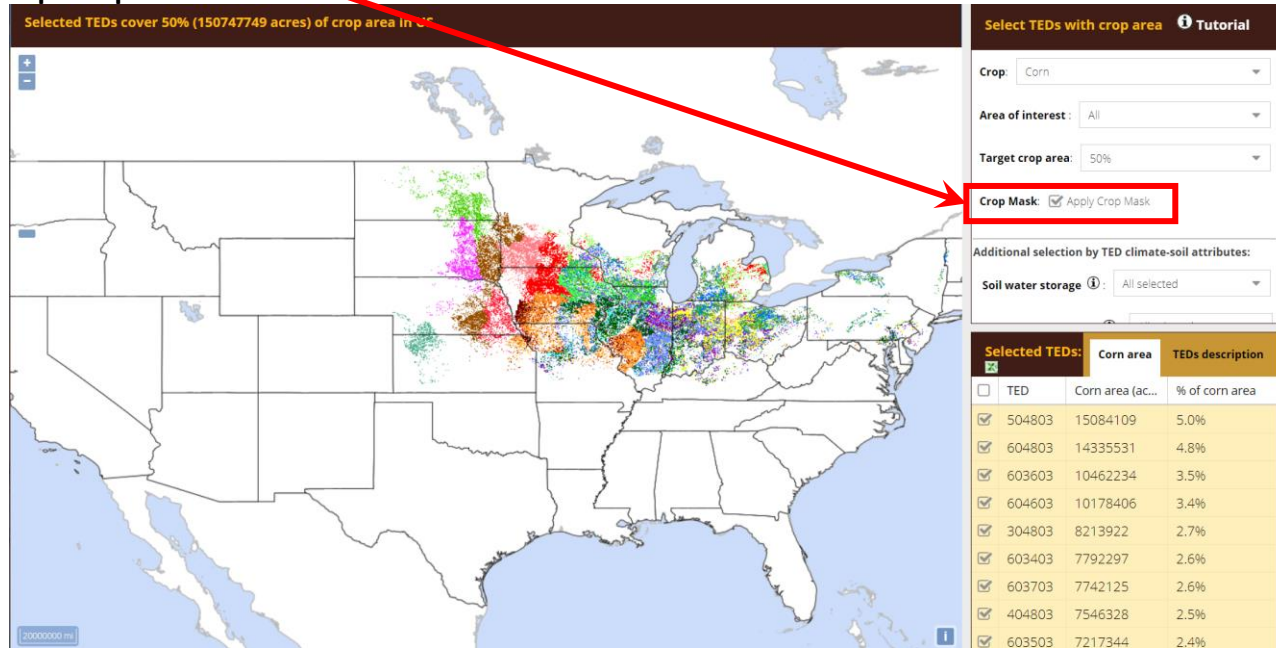


TED selection – Important notes

- When the tool first loads, it shows all TEDs in the US
- The user can choose to view any % of crop area up to 100% - but when many TEDs are selected (e.g., those that cover 70% of all corn area in the US), each TED cannot be represented by a unique color, and the selection includes many TEDs with very small crop area.
- To better visualize the extent of each TED when the area of interest is the entire USA, we recommend selecting a crop area of 50% or less

4. Actual crop production (corn mask)

Checking “apply crop mask” further filters areas where the selected crop is produced



Crop masks are based on 2008-2021 USDA-NASS cropland data layers.

4. TED climate-soil attributes

Selected TEDs cover 50% (150747749 acres) of crop area in US.

Click on the icon to show the definition of each attribute

Soil water storage

Soil water storage (in mm) represents the plant-available soil water in the root zone. There are 7 classes ranging from 0-50 mm (low soil water storage) to >300 mm (high soil water storage)

OK

Select TEDs with crop area **Tutorial**

Crop: Corn

Area of interest: All

Target crop area: 50%

Crop Mask: ☒ Apply Crop Mask

Additional selection by TED climate-soil attributes:

Soil water storage ⓘ: All selected

Growing degree days ⓘ: All selected

Aridity index ⓘ: All selected

Temperature seasonality ⓘ: All selected

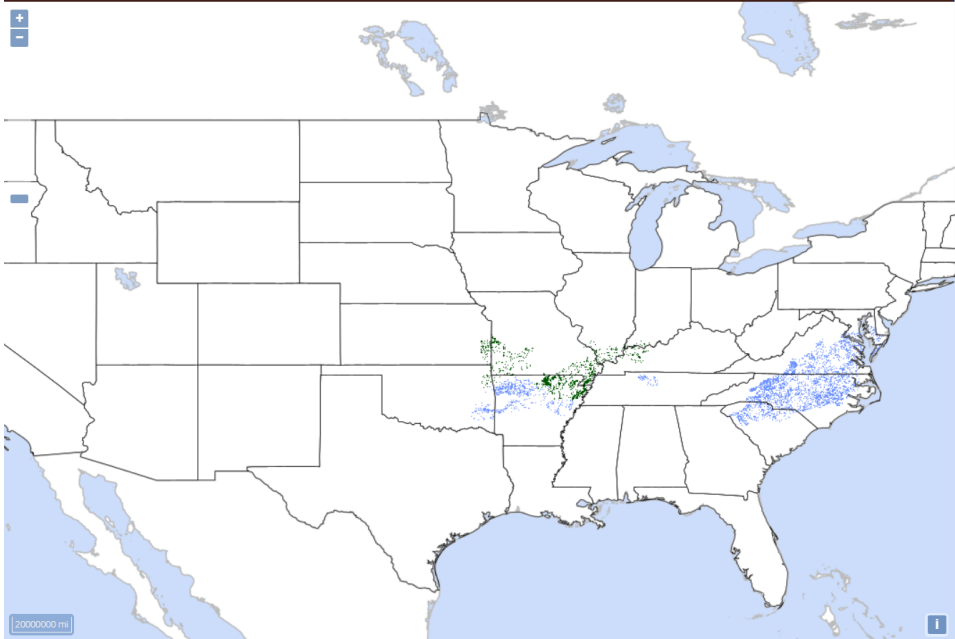
Selected TEDs: **Corn area** **TEDs description**

<input type="checkbox"/>	TED	Corn area (ac...)	% of corn area
<input checked="" type="checkbox"/>	504803	15084109	5.0%
<input checked="" type="checkbox"/>	604803	14335531	4.8%
<input checked="" type="checkbox"/>	603603	10462234	3.5%
<input checked="" type="checkbox"/>	604603	10178406	3.4%

4. TED climate-soil attributes

You can select by combination of the 4 attributes defining TEDs

Selected TEDs cover 1.1% (3449594 acres) of crop area in US.



Select TEDs with crop area [Tutorial](#)

Crop: Corn

Area of interest: All

Target crop area: 100%

Crop Mask: ☐ Apply Crop Mask

Additional selection by TED climate-soil attributes:

Soil water storage ⓘ: 150 - 200 mm

Growing degree days ⓘ: 4830 - 5949

Aridity index ⓘ: 8686 - 10181

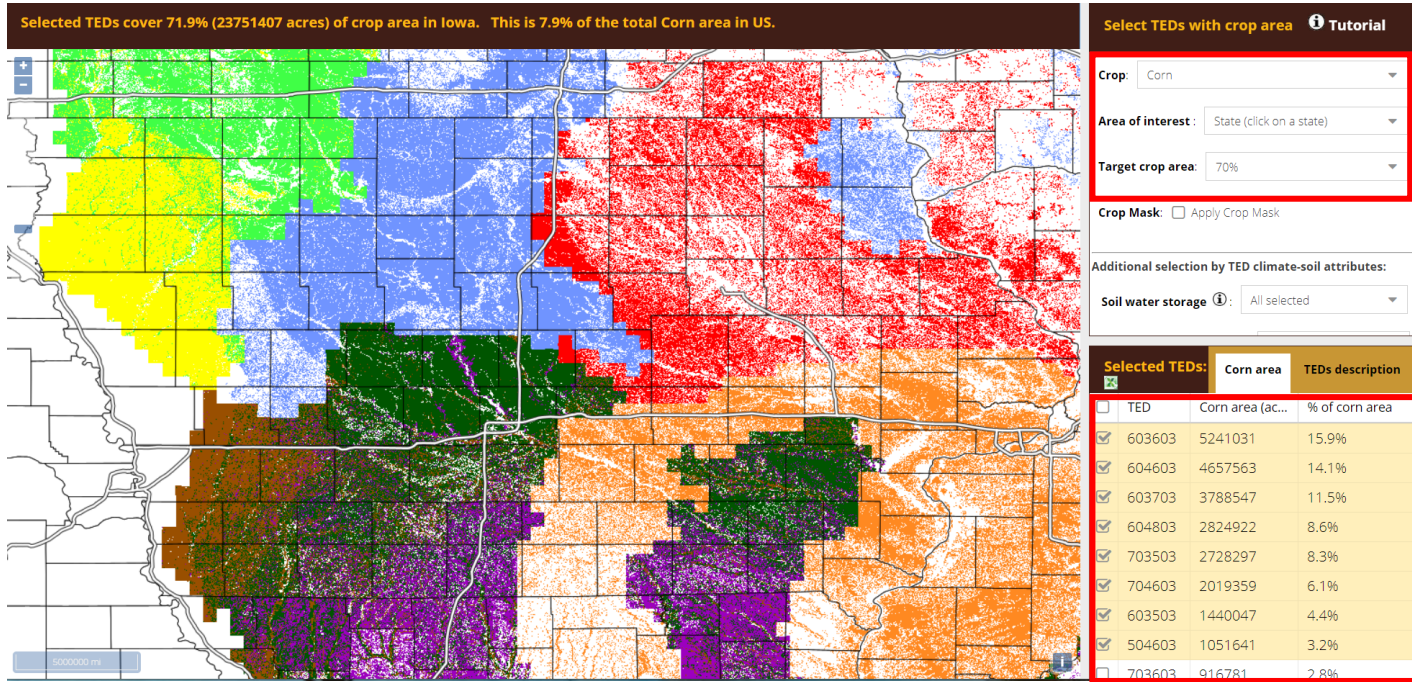
Temperature seasonality ⓘ: All selected

Selected TEDs:

	Corn area (ac...)	% of corn area
<input type="checkbox"/> TED		
<input type="checkbox"/> 703603	2795813	0.9%
<input type="checkbox"/> 503603	2680016	0.9%
<input checked="" type="checkbox"/> 405702	2590516	0.9%
<input type="checkbox"/> 505702	2568281	0.9%
<input type="checkbox"/> 302703	2311047	0.8%

Corn area **TEDs description**

2.b. Area of interest: Select by State

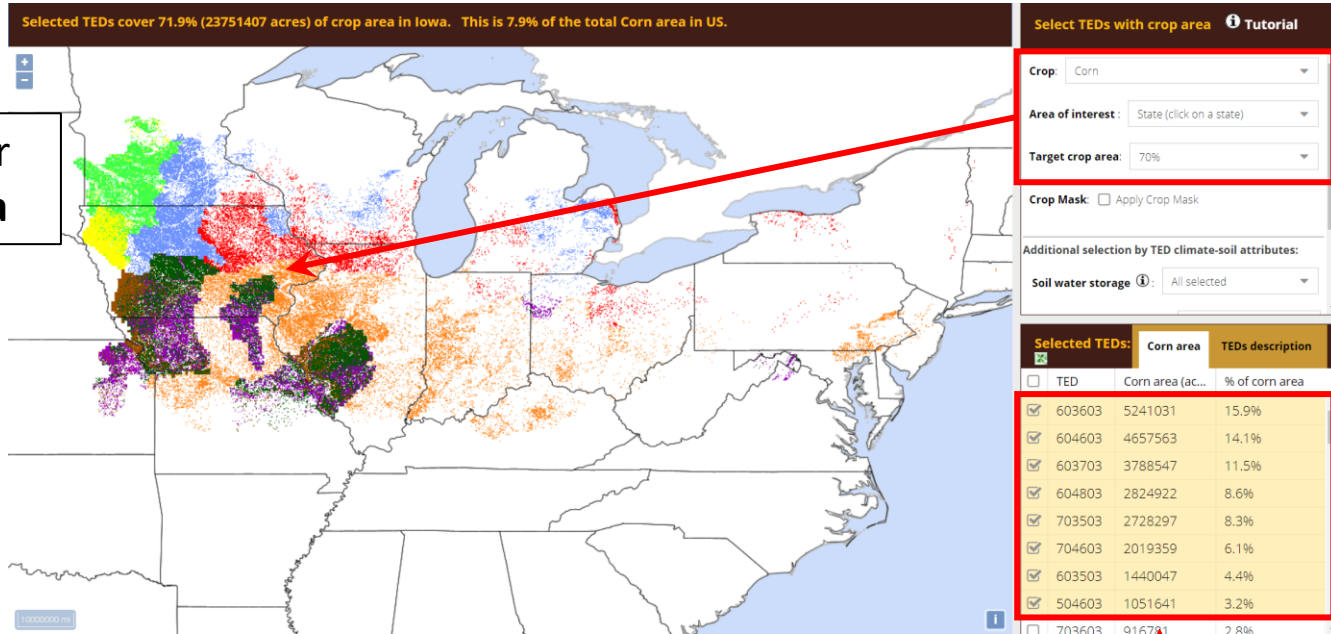


Example: user
selected **70%**
of corn in Iowa

Each color corresponds to one TED. In the case of Iowa, production areas were categorized into **eight TEDs**. Zooming out, the TED tool will show other areas where the same seven TEDs are found (*see next slide*).

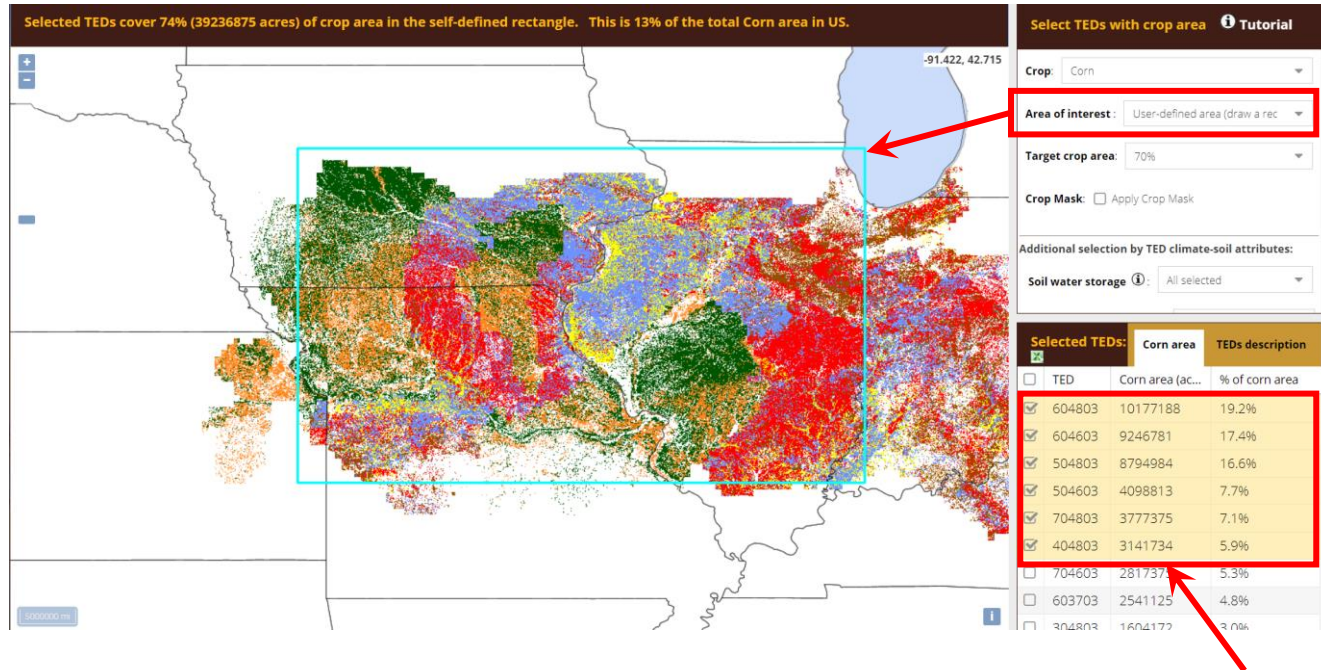
TEDs in Iowa extends to other states

Example: user selected **Iowa**



Each color corresponds to TED. In case of Iowa, production area were categorized into **eight** TEDs

2.c. Area of Interest: User-defined rectangle



User selected an area including 70% of TEDs within the rectangle that was represented by **six TEDs**

2.d. Area of interest: Specific sites (GPS coordinates)

Selected TEDs cover 99% (298335730 acres) of crop area in US.

Upload GPS coordinates of your sites

Enter your paired latitude, longitude coordinates (one pair per line) as shown below: (NB. The order lat,lon is new March 2019)
37.214, -85.523
37.992, -86.117
(Use a comma or a space to separate lat and long, providing, at least, 3 digits after the decimal point for better accuracy)

Area of interest: Specific sites (enter GPS coordinates)

Target crop area: 100%

Crop Mask: ☐ Apply Crop Mask

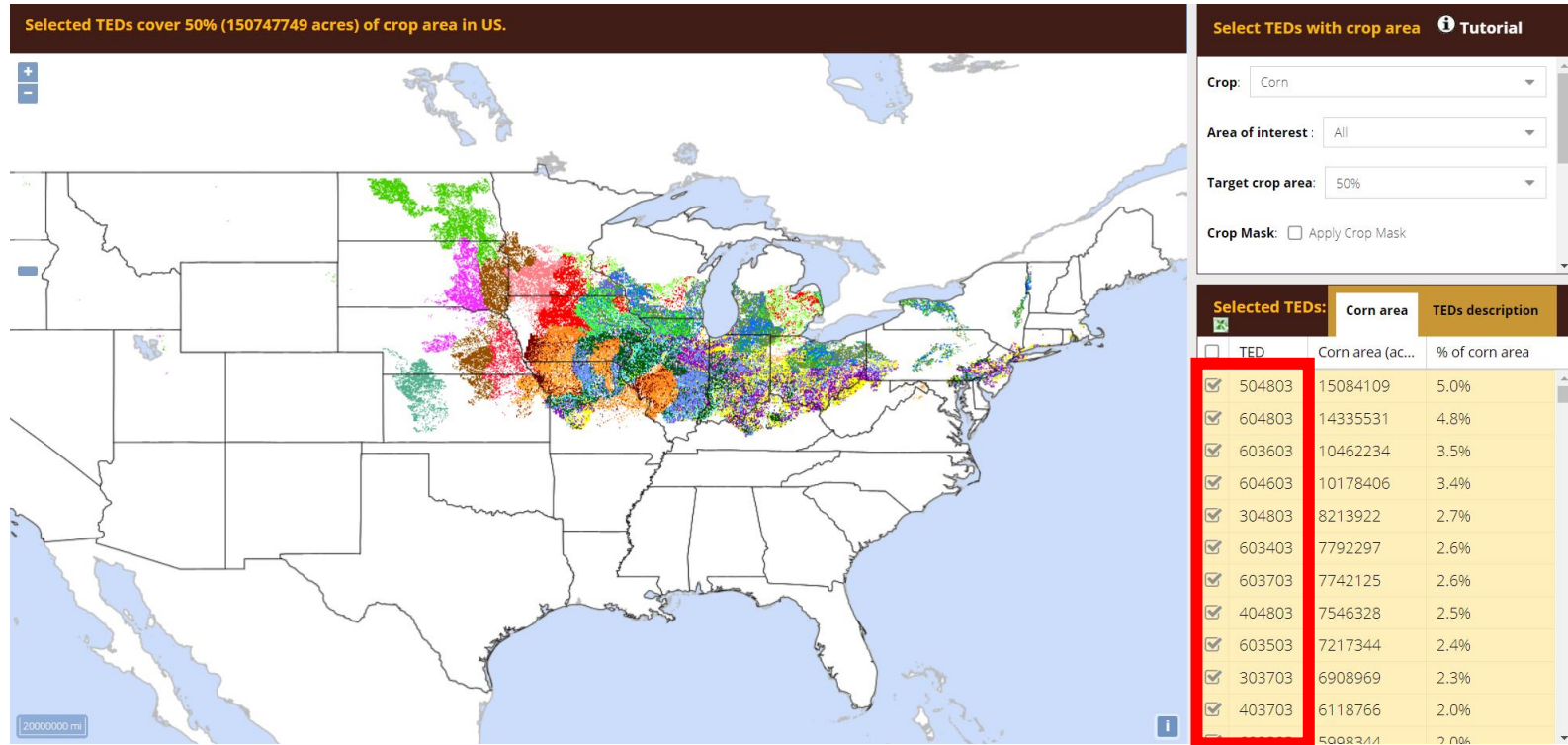
Additional selection by TED climate-soil attributes:
Soil water storage ⓘ: All selected

Selected TEDs:

TED	Corn area (ac...)	% of corn area
504803	15084109	5.0%
604803	14335531	4.8%
603603	10462234	3.5%
604603	10178406	3.4%
304803	8213922	2.7%
603403	7792297	2.6%
603703	7742125	2.6%
404803	7546328	2.5%
603503	7217344	2.4%

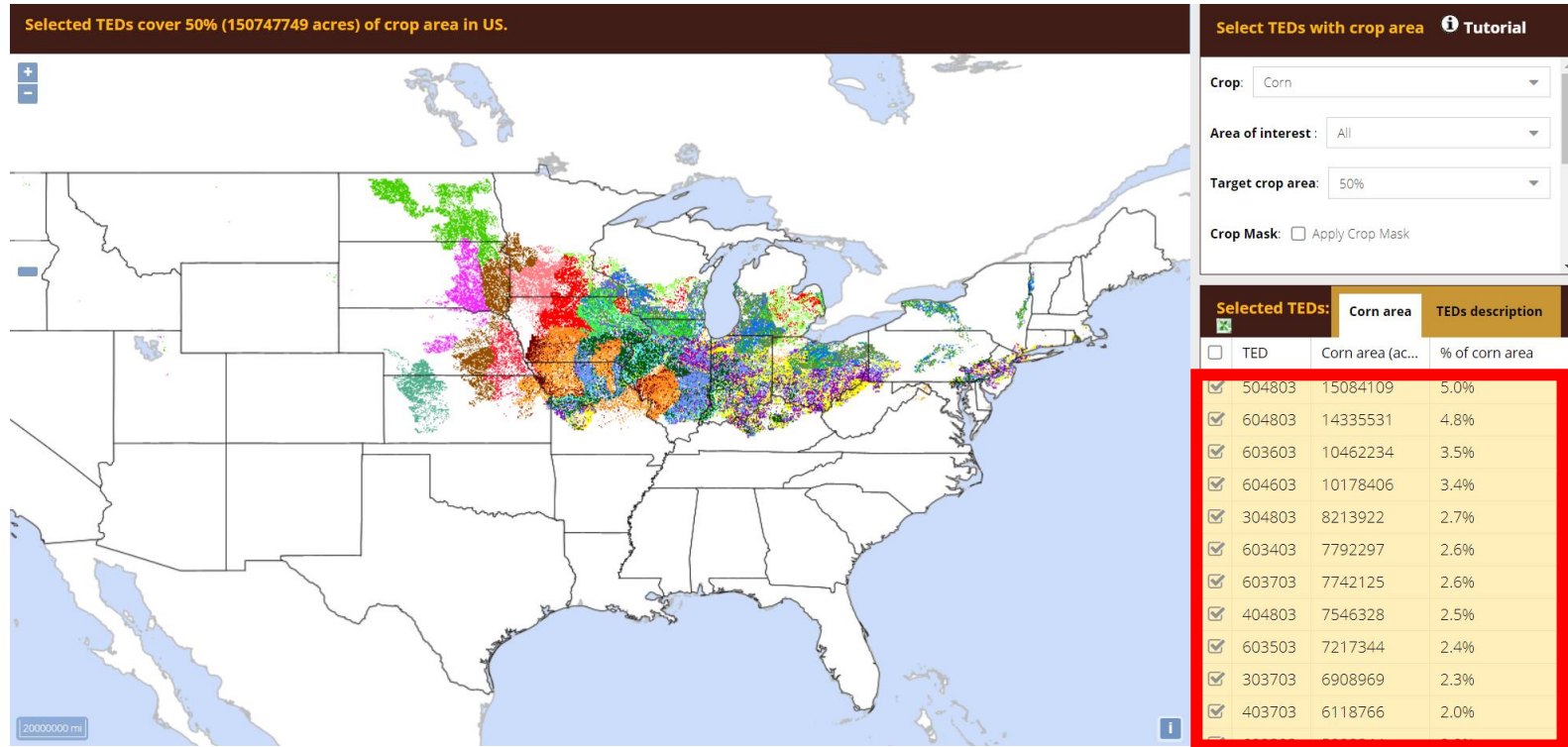
Users can upload any coordinates of specific area of interest and check the corresponding TEDs.
Note: the tool will list all TEDs within 1-mile buffer of the specified site and their associated area coverage.

List of selected TEDs



Scroll down in the lower right panel to see the full list

Associated crop area for each TED




Crop area (acres and % of US total) represented by each TED for the selected crop is shown

Further TED selection

Selected TEDs cover 5% (15084109 acres) of crop area in US.

Click on one TED to display it individually or click on any checkmark to add or remove a TED from the selection

Select TEDs with crop area 

Crop: Corn

Area of interest: All

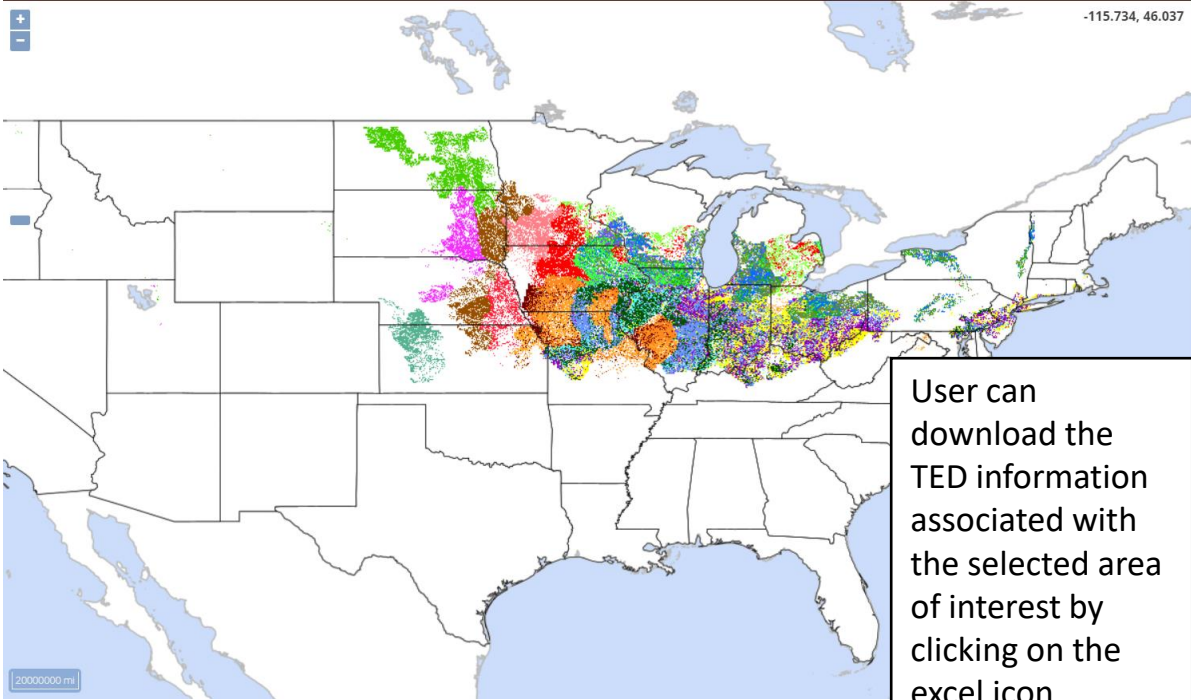
Target crop area: 50%


Crop Mask: ☐ Apply Crop Mask

Selected TEDs:		Corn area	TEDs description
<input type="checkbox"/>	TED	Corn area (ac...)	% of corn area
<input checked="" type="checkbox"/>	504803	15084109	5.0%
<input type="checkbox"/>	604803	8213922	4.8%
<input type="checkbox"/>	603403	7792297	3.5%
<input type="checkbox"/>	604603	8213922	3.4%
<input type="checkbox"/>	304803	8213922	2.7%
<input type="checkbox"/>	603403	7792297	2.6%
<input type="checkbox"/>	603703	7742125	2.6%
<input type="checkbox"/>	404803	7546328	2.5%
<input type="checkbox"/>	603503	7217344	2.4%
<input type="checkbox"/>	303703	6908969	2.3%
<input type="checkbox"/>	403703	6118766	2.0%
<input type="checkbox"/>	602303	5998344	2.0%

Export selected TED information

Selected TEDs cover 50% (150747749 acres) of crop area in US.



Select TEDs with crop area 

Crop:

Area of interest:

Target crop area:

Crop Mask: ☐ Apply Crop Mask

Selected TEDs:	Corn area	TEDs description
<input type="checkbox"/> TED	Corn area (ac...)	% of corn area
<input type="checkbox"/> 603603	15084109	5.0%
<input type="checkbox"/> 603603	14335531	4.8%
<input checked="" type="checkbox"/> 603603	10462234	3.5%
<input checked="" type="checkbox"/> 604603	10178406	3.4%
<input checked="" type="checkbox"/> 304803	8213922	2.7%
<input checked="" type="checkbox"/> 603403	7792297	2.6%
<input checked="" type="checkbox"/> 603703	7742125	2.6%
<input checked="" type="checkbox"/> 404803	7546328	2.5%
<input checked="" type="checkbox"/> 603503	7217344	2.4%
<input checked="" type="checkbox"/> 303703	6908969	2.3%
<input checked="" type="checkbox"/> 403703	6118766	2.0%
<input checked="" type="checkbox"/> 602303	5998344	

User can download the TED information associated with the selected area of interest by clicking on the excel icon.

Downloaded file with TEDs and attributes

TED download in csv-format

Thank you for your interest in GYGA TEDs. In case the download doesn't start please click [here](#).

	A	B	C	D	E	F	G
1	ted	corn area in acres	percentage of corn area in US	soil water storage	growing degree days	aridity index	temperature seasonality
2	504803	5340078	6.188	200 - 250 mm	3792 - 4829 Â°C.day	10182 - 12876	High
3	604803	5143672	5.96	250 - 300 mm	3792 - 4829 Â°C.day	10182 - 12876	High
4	603603	4212234	4.881	250 - 300 mm	3170 - 3791 Â°C.day	7786 - 8685	High
5	604603	3672984	4.256	250 - 300 mm	3792 - 4829 Â°C.day	7786 - 8685	High
6	603703	3076609	3.565	250 - 300 mm	3170 - 3791 Â°C.day	8686 - 10181	High
7	603503	2897719	3.358	250 - 300 mm	3170 - 3791 Â°C.day	6589 - 7785	High
8	603403	2743656	3.179	250 - 300 mm	3170 - 3791 Â°C.day	5690 - 6588	High
9	304803	2555125	2.961	100 - 150 mm	3792 - 4829 Â°C.day	10182 - 12876	High
10	404803	2542469	2.946	150 - 200 mm	3792 - 4829 Â°C.day	10182 - 12876	High
11	303703	1838078	2.13	100 - 150 mm	3170 - 3791 Â°C.day	8686 - 10181	High
12	403703	1813672	2.101	150 - 200 mm	3170 - 3791 Â°C.day	8686 - 10181	High
13	604403	1771844	2.053	250 - 300 mm	3792 - 4829 Â°C.day	5690 - 6588	High
14	704803	1734547	2.01	> 300 mm	3792 - 4829 Â°C.day	10182 - 12876	High
15	603303	1717641	1.99	250 - 300 mm	3170 - 3791 Â°C.day	4792 - 5689	High
16	704603	1556922	1.804	> 300 mm	3792 - 4829 Â°C.day	7786 - 8685	High

Note: the csv-file has a UTF-8 encoding. If the file is opened in Excel, a Â symbol will appear before the GDD units.

To avoid that, you can follow the instructions [on this link](#)

Access to TEDs

- TEDs can be accessed via :
 - <https://www.toolded.org>
 - <https://www.yieldgap.org/web/guest/technology-extrapolation-domains>
- The TEDs can be requested for free in the case of non-profit organizations.
- In the case of for-profit organizations, there are two ways to have access to the TEDs:
 1. By purchasing a GYGA sponsorship or commercial license, which provides access to all the data included in the GYGA website: <https://www.yieldgap.org/licensing-and-sponsorship>
 2. By purchasing a license ONLY for accessing the TEDs *via* NUtch ventures:
 - TEDs for the entire United States: <https://marketplace.unl.edu/nutechmarketplace/nutech-teds.html>
 - TEDs for Sub-Saharan Africa: <https://marketplace.unl.edu/nutechmarketplace/nutech-teds-ssa.html>
- If you want to discuss extensions and/or applications of TEDs for other geographic areas or uses, feel free to contact us at: pggrassini2@unl.edu (Professor Patricio Grassini, University of Nebraska-Lincoln).

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