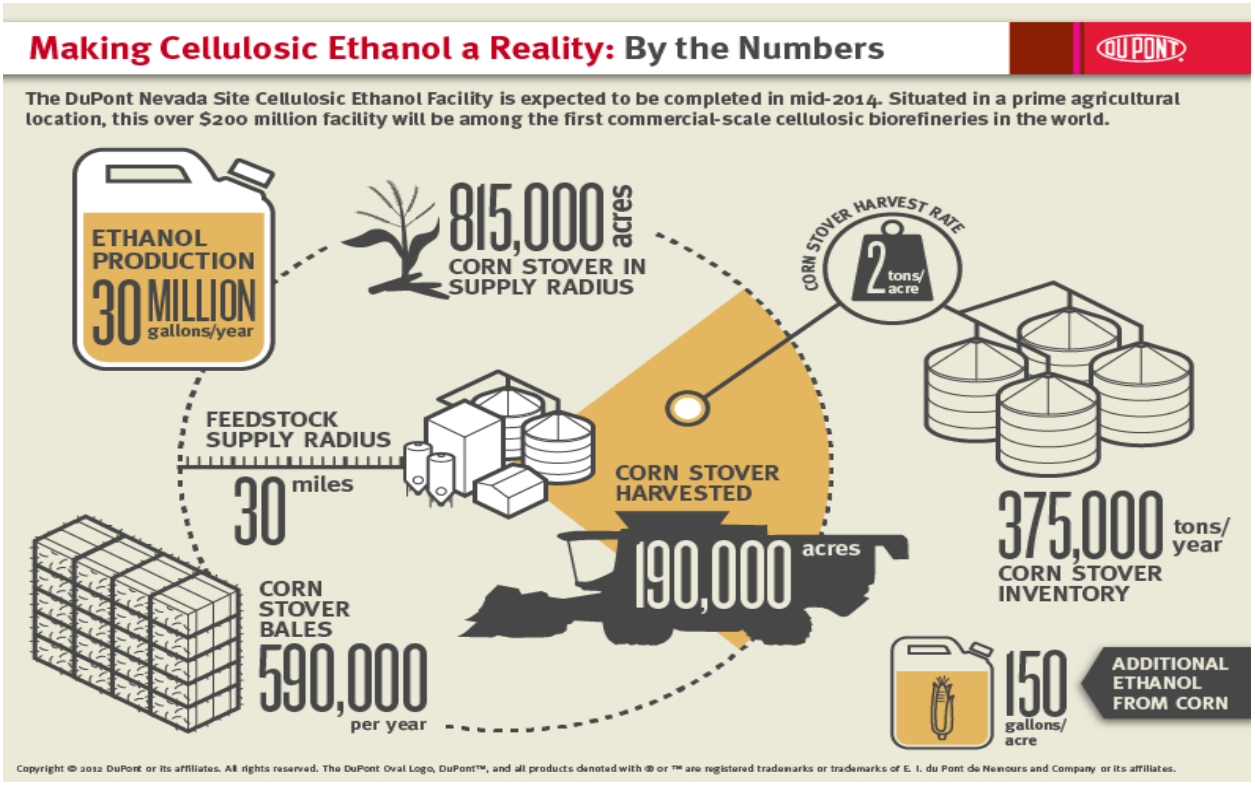
Ryan Soutter

GIS Final Project

Cellulosic Ethanol Feasibility for Existing Ethanol Plants in Iowa

## Problem Formulation

The question this project answers is which dry mill ethanol plants in Iowa are most feasible to add a cellulosic attachment to their refinery based on the DuPont equation in the following graphic without competing for resources? In other words, which plants are surrounded by at least 815,000 acres of corn in a 30 mile radius that only they can use? Plants with more corn surrounding them make better candidates for cellulosic ethanol expansion. Note that current plants only use the starch from the corn grain to produce ethanol as of this time and not the corn stover which is the left over plant matter.

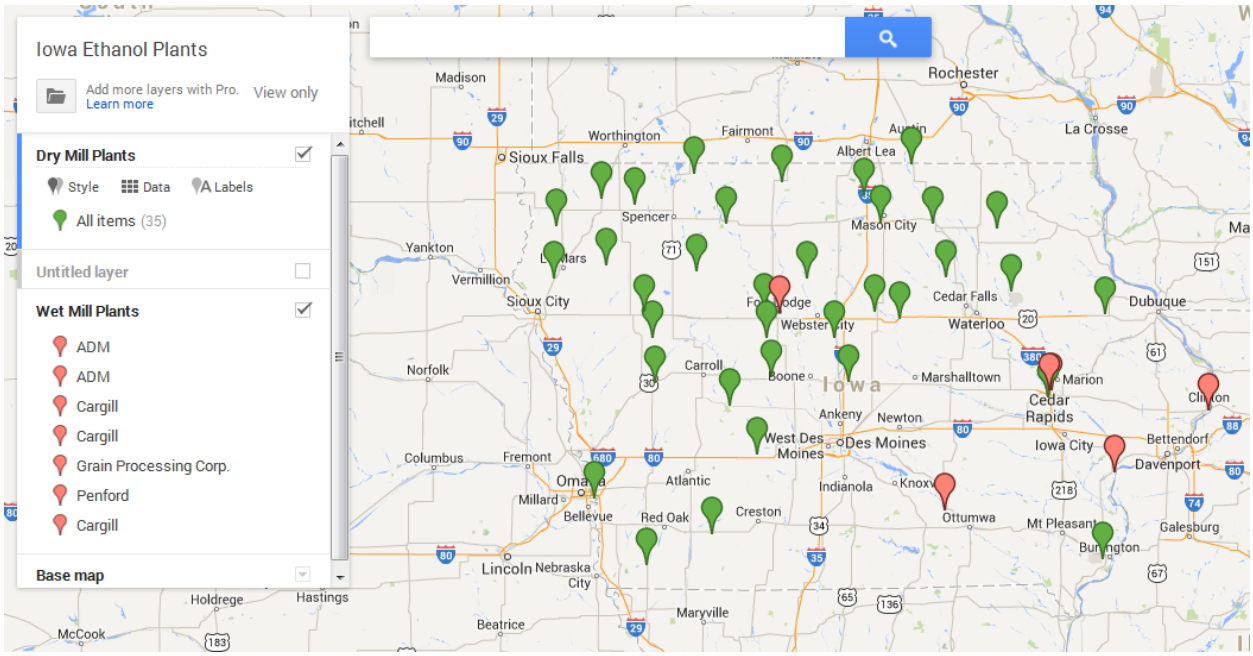



Source: http://biofuels.dupont.com/cellulosic-ethanol/nevada-site-ce-facility/

To do this I will locate the Iowa dry mill ethanol plants and create a point file. I will then add a raster comprised of corn crop cover for Iowa. I must reclassify the raster so that all values are 0 except for corn. I then make a 30 mile dissolved buffer for each plant and a Thiessen polygon for each plant and I will intersect the two to create boundaries that do not overlap and are equidistant from each point. With these buffers and the corn raster layer I then use Zonal Statistics as Table to acquire the amount of pixels in each zone. Using some simple arithmetic in field calculator I convert the $30m^2$ pixels into acres and evaluate. Then I clip with an Iowa state boundary layer.

Data Collection/Preprocessing

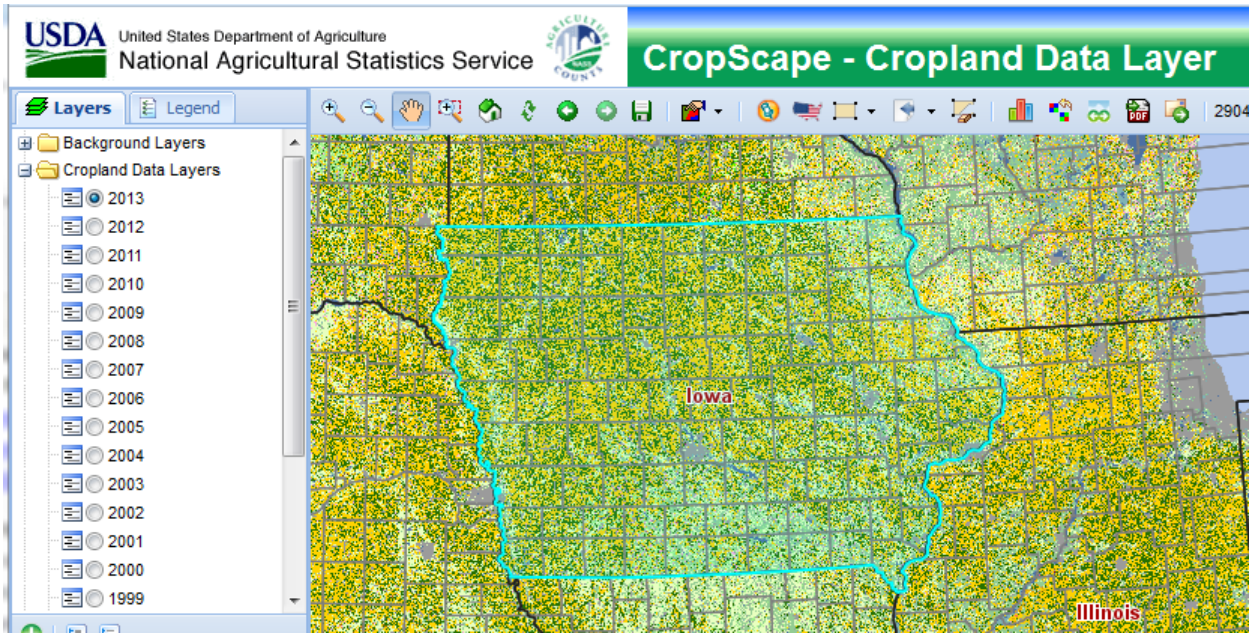
The first thing I did was to locate the ethanol plants in Iowa. I did so with Mapsengine (https://mapsengine.google.com/map/u/0/edit?hl=en&mid=zj0Os5WZ9AYI.kzpoJ-jelJ0o ).




This gave me the name and general location of each plant. I then needed to find out their exact locations. I then found latitude and longitude coordinates in decimal degrees in Iowa state files at http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=7&ved=0CEYQFjAG&url=http%3A%2F%2Fwww.iowadnr.gov%2FPortals%2Fidnr%2Fuploads%2Fwater%2Fnpdes%2FWebsite_file.xls&ei=BAJcU4f-COGsyAGCwoC4CQ&usg=AFQjCNFCOCaZU-JVh-UpTt_FnQvFVgtOlA&bvm=bv.65397613,d.aWc

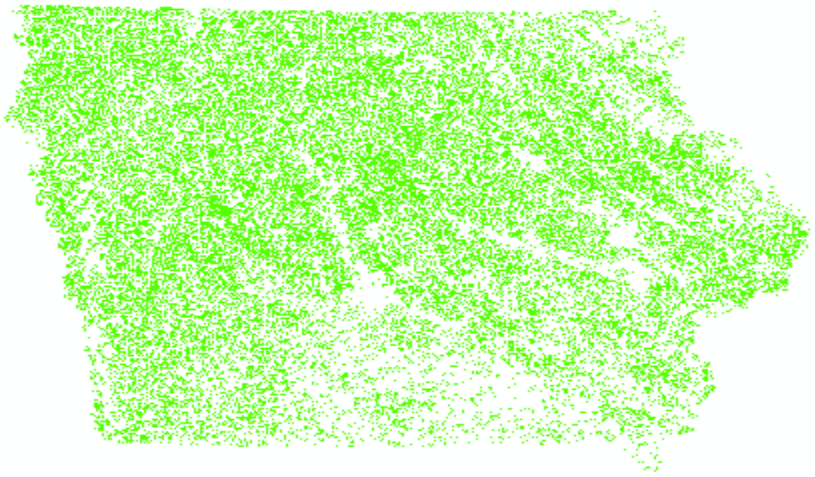
I am working in a NAD83 UTM 15N projection because I will need to calculate length later so I found an online conversion calculator and turned my decimal degrees into x, y coordinates for NAD83, UTM 15N. I uploaded this information, along with the ethanol plant name, city, and county, into an excel spreadsheet. I then added data>Add XY Data and input the points into ArcMap.

Next I located and downloaded an online raster of crop data for Iowa at http://nassgeodata.gmu.edu/CropScape/




With the metadata at http://www.nass.usda.gov/research/Cropland/metadata/metadata_ia13.htm

I used the Reclassify tool to eliminate the large list of crops into corn and null values.



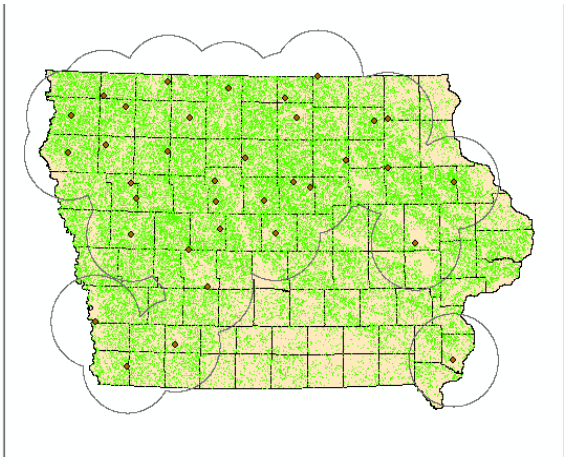
I also obtained a county outline shape file for Iowa at http://www.igsb.uiowa.edu/nrgislibx/

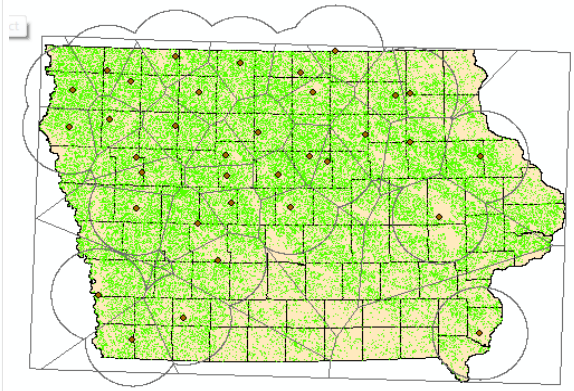
With metadata at: ftp://ftp.igsb.uiowa.edu/gis_library/IA_state/Admin_Political_Boundary/County.htm

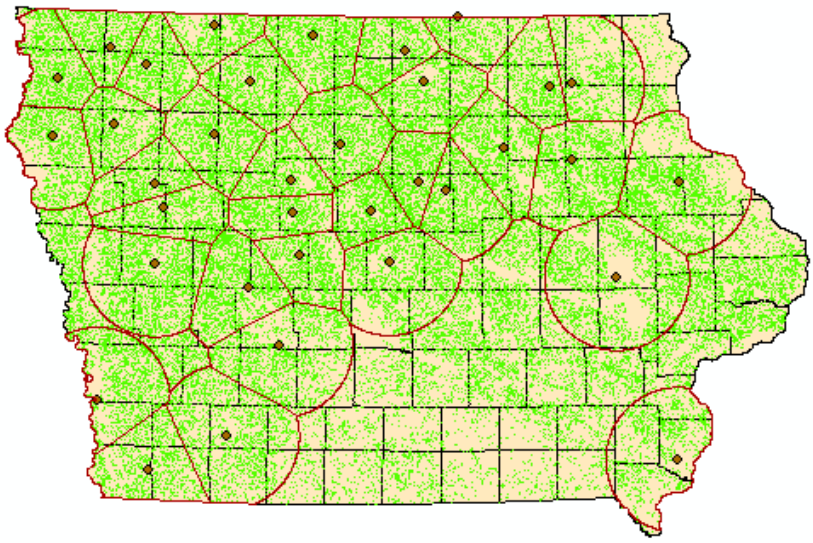
Now I have all the data I need to perform my analysis! Luckily, NAD83 UTM 15N is very common for Iowa, and I don't have to convert my imported data.

ArcGIS Processing

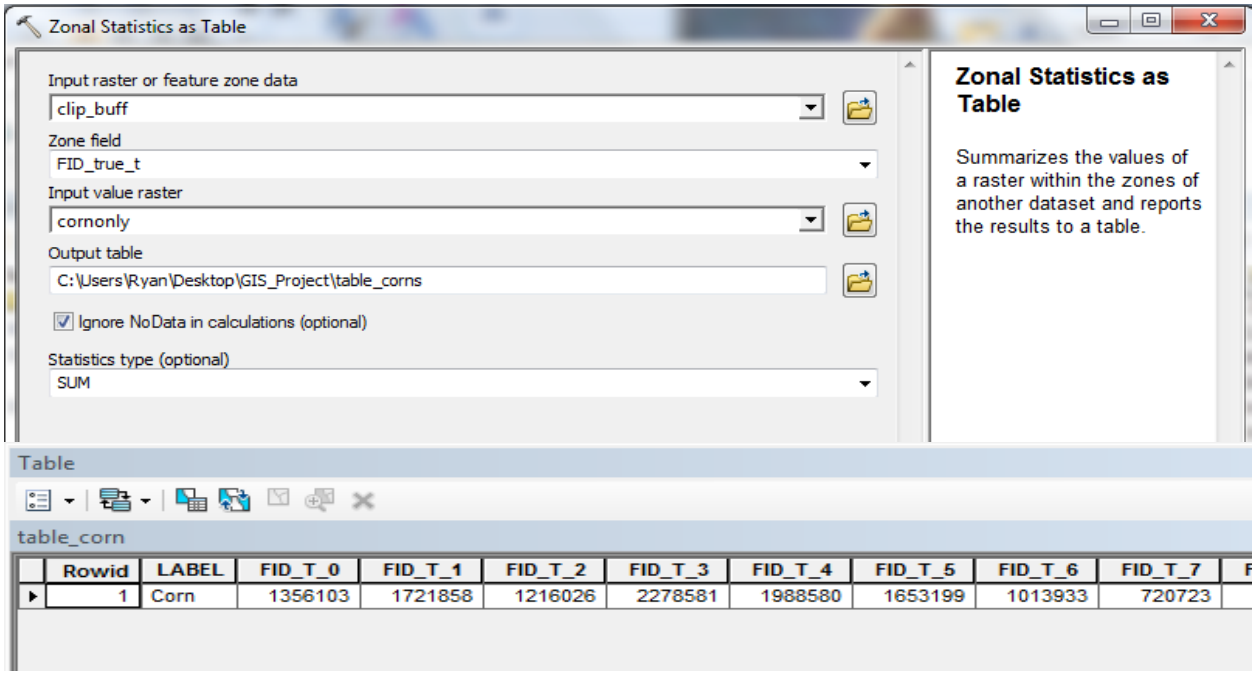
Now that I have my county outline shape file, my separated corn raster data, and my plant location point file uploaded I can begin processing my data. First I start by buffering the ethanol plants by 30 miles (48280 meters) with a dissolve so that they create one polygon if they do overlap. This is step is needed because you would segment your analysis in a way that is not conducive to easily getting data if you didn't dissolve. Then I apply a Thiessen polygon to the plant locations taking care in the Environments section to fit the polygons to my corn raster. Finally I use the Intersect tool on the Thiessen polygons and the 30 mile dissolved boundary buffers and I clip it to the state border. It looks like this:



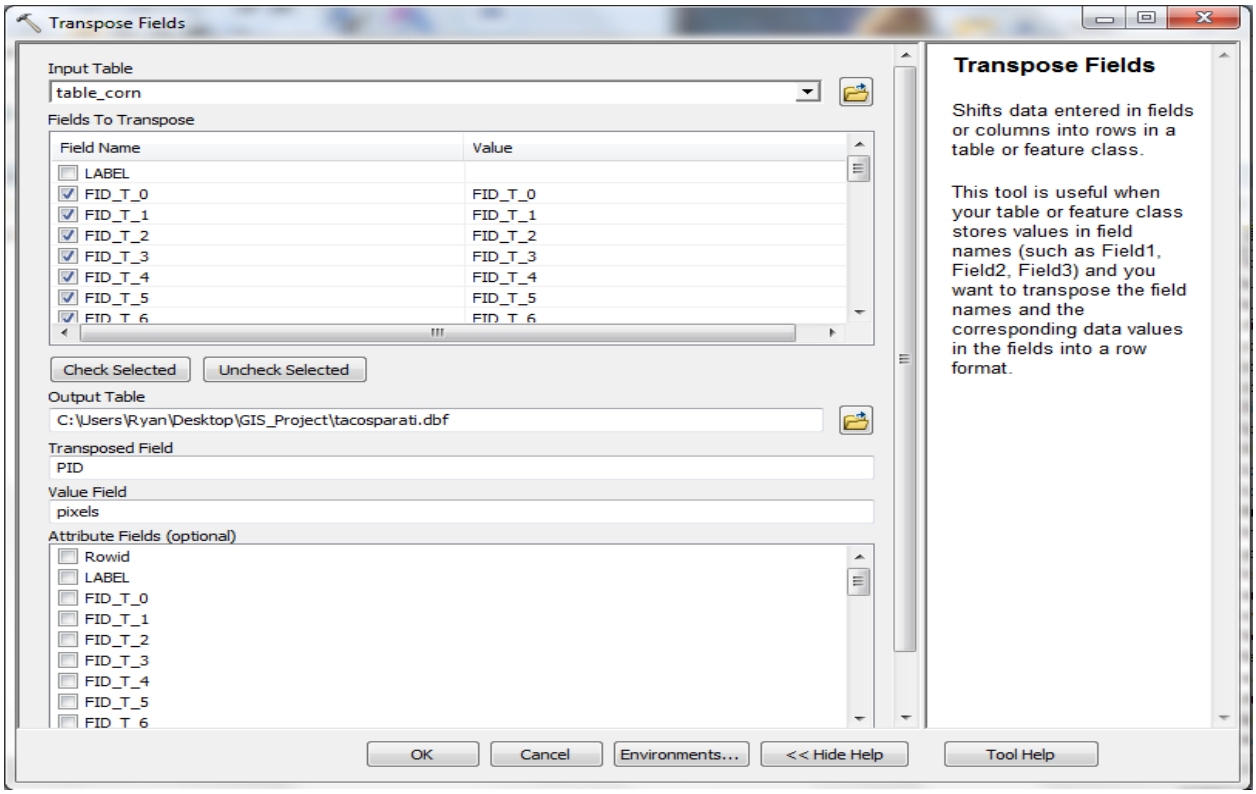


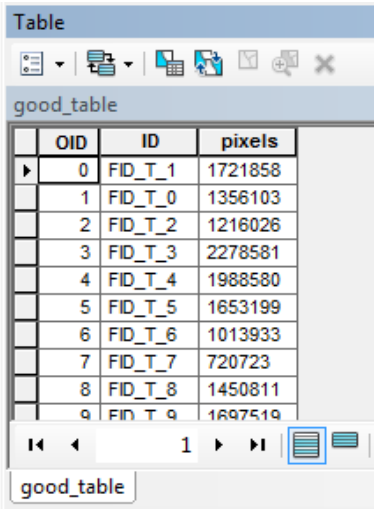


Now I have my areas all partitioned out and my corn data ready for processing. I use Zonal Statistics as Table to create values for the amount of pixels but my data came out sideways (literally).



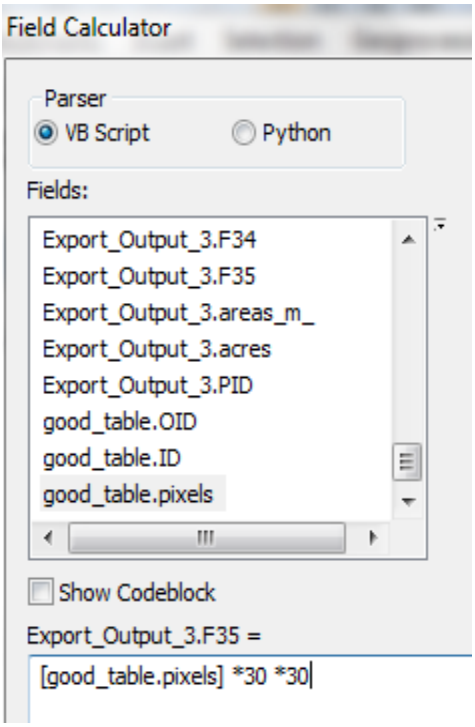

I can't add fields or manipulate my data in this format very easily so I reached for my Transpose Fields tool, selected my pixel values, and presto!

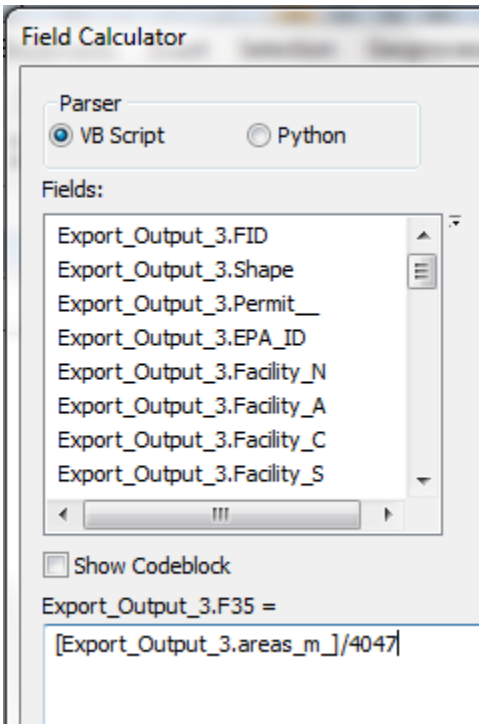





| pixels | Facility_N |
|---|---|
| 1721858 | SOUTHWEST IOWA RENEWABLE ENERGY |
| 1356103 | GREEN PLAINS SHENANDOAH, LLC |
| 1216026 | POET BIOREFINING - CORNING |
| 2278581 | BIG RIVER RESOURCES WEST BURLINGTO |
| 1988580 | FLINT HILLS RESOURCES MENLO, LLC |
| 1653199 | POET BIOREFINING - COON RAPIDS |
| 1013933 | LOUIS DREYFUS COMMODITIES, GRAND JU |
| 720723 | POET BIOREFINING - GOWRIE |
| 1450811 | VALERO RENEWABLE FUELS COMPANY, L |
| 1697519 | CORN, LP |
| 1939681 | LINCOLNWAY ENERGY, LLC |
| 1174023 | POET BIOREFINING - JEWELL |
| 1161783 | FLINT HILLS RESOURCES IOWA FALLS, LL |

Now I take these values and join them to my ethanol plant point layer so that I can have my pixel value associated with the name and location of the plants. Pixels don't mean much to me so I need to put them into useable values. First I make a new field and call it area_m_. I know my pixels are $30m^2$ so I multiply the total count by $30^2$ in the field calculator in the attribute table. This gives me my area in meters, but what I really want to know is what the area is in acres. So I take the area_m_ and divide it by 4,047 in the attribute table field calculator because there are 4,047 square meters in one acre. Now I know my cover of corn for each segment in acres!



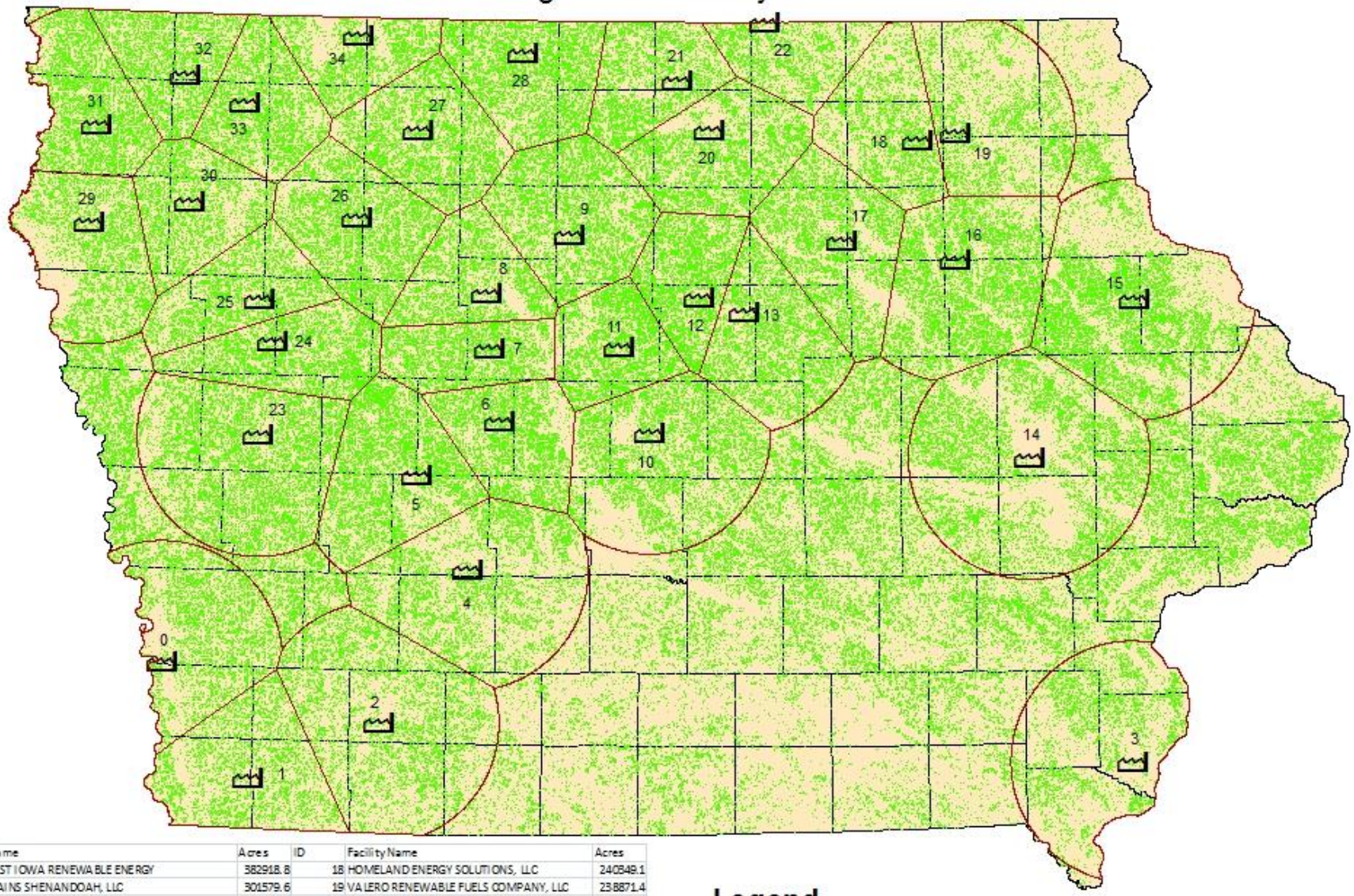
Unfortunately, none of the areas meet the requirements for DuPont's assessment…

| Facility Name | acres |
|---|---|
| BIG RIVER UNITED ENERGY, LLC | 541997.3 |
| SIOUXLAND ENERGY & LIVESTOCK COOP | 522150.6 |
| BIG RIVER RESOURCES WEST BURLINGTON, LLC | 506726.7 |
| FLINT HILLS RESOURCES MENLO, LLC | 442234.2 |
| LINCOLNWAY ENERGY, LLC | 431359.7 |
| GOLDEN GRAIN ENERGY, LLC | 427208 |
| SOUTHWEST IOWA RENEWABLE ENERGY | 382918.8 |
| CORN, LP | 377506.1 |
| POET BIOREFINING - COON RAPIDS | 367649.9 |
| PLYMOUTH ENERGY, LLC | 341642.8 |
| VALERO RENEWABLE FUELS COMPANY, LLC | 322641.4 |
| ADM CORN PROCESSING | 318312.9 |
| FLINT HILLS RESOURCES SHELL ROCK, LLC | 317859 |
| GREEN PLAINS LAKOTA, LLC | 305314.8 |
| GREEN PLAINS SHENANDOAH, LLC | 301579.6 |
| FLINT HILLS RESOURCES FAIRBANK, LLC | 293677.3 |
| QUAD COUNTY CORN PROCESSORS | 289015.2 |
| POET BIOREFINING - EMMETSBURG | 270898.7 |
| POET BIOREFINING - CORNING | 270428.3 |
| LITTLE SIOUX CORN PROCESSORS, LLLP | 266411.8 |
| POET BIOREFINING - JEWELL | 261087.4 |
| FLINT HILLS RESOURCES IOWA FALLS, LLC | 258365.4 |
| THE ANDERSONS DENISON ETHANOL, LLC | 252929.4 |
| FLINT HILLS RESOURCES ARTHUR, LLC | 250909.4 |
| HOMELAND ENERGY SOLUTIONS, LLC | 240349.1 |
| VALERO RENEWABLE FUELS COMPANY, LLC | 238871.4 |
| VALERO RENEWABLE FUELS COMPANY, LLC | 232445.7 |
| POET BIOREFINING - ASHTON | 232021.4 |
| LOUIS DREYFUS COMMODITIES, GRAND JUNCTION, LLC | 225485.5 |
| PINE LAKE CORN PROCESSORS, L.P. | 222865.1 |
| POET BIOREFINING - HANLONTOWN | 218867.9 |
| GREEN PLAINS SUPERIOR, LLC | 214851.4 |
| ABSOLUTE ENERGY | 209702 |
| POET BIOREFINING - GOWRIE | 160279.4 |
| VALERO RENEWABLE FUELS COMPANY, LLC | 150281.8 |

However, it's good news for the switch grass industry because they can come in and use idle/fallow land to supplement corn stover production and make some of these sites viable for cellulosic ethanol production. Now they know where their best bet for that is based on already available cellulosic corn

stover. This study was bound by Iowa State so there could be more competition just across the border that could affect these results. Another factor for people interested in revisiting this is the inclusion of corn crops in the surrounding states. It could increase the numbers for some of these peripheral plants. Also, if these ethanol plants were to collaborate, they could allow one plant the lion's share of an area for a certain fee and meet DuPont's criteria, but the plant that builds the cellulosic annex would most likely come out on top financially. That is why there is competition for the corn acreage.

# Available Corn Acreage for Iowa Dry Mill Ethanol Plants




| ID | Facility Name | Acres | ID | Facility Name | Acres |
|---|---|---|---|---|---|
| 0 | SOUTHWEST IOWA RENEWABLE ENERGY | 382918.8 | 18 | HOMELAND ENERGY SOLUTIONS, LLC | 240849.1 |
| 1 | GREEN PLAINS SHENANDOAH, LLC | 301579.6 | 19 | VALERO RENEWABLE FUELS COMPANY, LLC | 238871.4 |
| 2 | POET BIOREFINING - CORNING | 270428.3 | 20 | GOLDEN GRAIN ENERGY, LLC | 427208 |
| 3 | BIG RIVER RESOURCES WEST BURLINGTON, LLC | 506726.7 | 21 | POET BIOREFINING - HANLONTOWN | 218867.9 |
| 4 | FLINT HILLS RESOURCES MENLO, LLC | 442234.2 | 22 | ABSOLUTE ENERGY | 209702 |
| 5 | POET BIOREFINING - COON RAPIDS | 367649.9 | 23 | THE ANDERSONS DENISON ETHANOL, LLC | 252929.4 |
| 6 | LOUIS DREYFUS COMMODITIES, GRAND JUNCTION, LLC | 225485.5 | 24 | FLINT HILLS RESOURCES ARTHUR, LLC | 250909.4 |
| 7 | POET BIOREFINING - GOWRIE | 160279.4 | 25 | QUAD COUNTY CORN PROCESSORS | 289015.2 |
| 8 | VALERO RENEWABLE FUELS COMPANY, LLC | 322641.4 | 26 | VALERO RENEWABLE FUELS COMPANY, LLC | 232445.7 |
| 9 | CORN, LP | 377506.1 | 27 | POET BIOREFINING - EMMETSBURG | 270898.7 |
| 10 | LINCOLNWAY ENERGY, LLC | 431359.7 | 28 | GREEN PLAINS LAKOTA, LLC | 305314.8 |
| 11 | POET BIOREFINING - JEWELL | 261087.4 | 29 | PLYMOUTH ENERGY, LLC | 341642.8 |
| 12 | FLINT HILLS RESOURCES IOWA FALLS, LLC | 258365.4 | 30 | LITTLE SIOUX CORN PROCESSORS, LLLP | 266411.8 |
| 13 | PINE LAKE CORN PROCESSORS, L.P. | 222865.1 | 31 | SIOUXLAND ENERGY & LIVESTOCK COOP | 522150.6 |
| 14 | ADM CORN PROCESSING | 318312.9 | 32 | POET BIOREFINING - ASHTON | 232021.4 |
| 15 | BIG RIVER UNITED ENERGY, LLC | 541997.3 | 33 | VALERO RENEWABLE FUELS COMPANY, LLC | 150281.8 |
| 16 | FLINT HILLS RESOURCES FAIRBANK, LLC | 295677.3 | 34 | GREEN PLAINS SUPERIOR, LLC | 214851.4 |
| 17 | FLINT HILLS RESOURCES SHELL ROCK, LLC | 317859 | | | |

**Legend**

- Plant Boundary
- Corn
- Counties

N

0 25 50 100 150 200 Kilometers

Ryan Soutter 4/29/14