

# A FOSS Web Mapping Solution for Disparate Precision Agriculture Data

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FOSS4G, 2017 - Boston

August 18, 2017

## Objective of Project

- Address challenges of visualizing disparate data produced by precision agriculture operations
- Develop on-line mapping environment
  - Free and open source technologies

→ Support independent farmer in their decision-making and analysis process

- 1) Ingest diverse precision agriculture-related data
- 2) Visualize spatially the ingested data
- 3) Generate reports and visualizations



|         |                       |                 |                     |                 |                      |
|---------|-----------------------|-----------------|---------------------|-----------------|----------------------|
| Project | Precision Agriculture | Data Processing | Desktop Application | Web Application | Impact & Future Work |
|---------|-----------------------|-----------------|---------------------|-----------------|----------------------|

# Precision Agriculture

- Background
- Technology
  - Enabled by highly-accurate position information
- Auto-steering equipment
- Variable-rate technology (planting, treatments)
- Yield monitors
- Soil samples
- Benefits of precision agriculture



|         |                       |                 |                     |                 |                      |
|---------|-----------------------|-----------------|---------------------|-----------------|----------------------|
| Project | Precision Agriculture | Data Processing | Desktop Application | Web Application | Impact & Future Work |
|---------|-----------------------|-----------------|---------------------|-----------------|----------------------|

# Precision Agriculture Data Challenges

- Data inconsistencies and complexity
- Collected using different vendor machinery
- Data formats and access



|         |                       |                 |                     |                 |                      |
|---------|-----------------------|-----------------|---------------------|-----------------|----------------------|
| Project | Precision Agriculture | Data Processing | Desktop Application | Web Application | Impact & Future Work |
|---------|-----------------------|-----------------|---------------------|-----------------|----------------------|

# Precision Agriculture Data Challenges

- Vendor viewers, portals, static reports
- Challenges analyzing relationship between data

| Field         | Yield (bu/ac) | Moisture (%) | Area (ac)   | Weight (lb)       | Wt/Dry (lb)    | Created          |
|---------------|---------------|--------------|-------------|-------------------|----------------|------------------|
| Beggs Farm    | 236.6         | 19.51        | 124.7       | 1,776,946         | 51,763         | 9/12/2016        |
| Beggs Home NW | 245.2         | 18.47        | 105.8       | 1,576,582         | 21,499         | 9/12/2016        |
|               |               |              |             |                   | 25,950         | 9/12/2016        |
| HE            | 244.7         | 18.54        | 188.8       | 2,735,975         | 48,887         | 9/12/2016        |
|               |               |              |             |                   | 48,264         | 9/12/2016        |
| College West  | 2391          | 17.30        | 106.4       | 1,922,103         | 27,002         | 9/12/2016        |
|               |               |              |             |                   | 25,964         | 9/12/2016        |
| Davis         | 2017          | 18.57        | 73.07       | 865,049           | 16,447         | 9/12/2016        |
|               |               |              |             |                   | 16,276         | 9/12/2016        |
| East West     | 2318          | 21.06        | 142.2       | 1,998,300         | 35,485         | 9/12/2016        |
|               |               |              |             |                   | 32,728         | 9/12/2016        |
| Home Field    | 242.4         | 21.30        | 71.35       | 1,056,875         | 19,764         | 9/12/2016        |
|               |               |              |             |                   | 19,205         | 9/12/2016        |
| Wabler Farm   | 244.2         | 20.75        | 164.5       | 2,477,586         | 44,243         | 9/12/2016        |
|               |               |              |             |                   | 40,837         | 9/12/2016        |
| <b>Total</b>  | <b>2318</b>   | <b>19.38</b> | <b>1061</b> | <b>13,946,805</b> | <b>249,264</b> | <b>9/12/2016</b> |
|               |               |              |             |                   | <b>233,998</b> | <b>9/12/2016</b> |

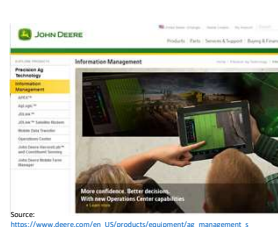
Source: Author & <https://www.agfiniti.com/>



Source: Author & <https://www.agfiniti.com/>



Source: Author & <https://fieldview.precisionplanting.com>



Source: [https://www.deere.com/en\\_US/products/equipment/ag\\_management\\_4/ubios/information\\_management/information\\_management.page](https://www.deere.com/en_US/products/equipment/ag_management_4/ubios/information_management/information_management.page)



Source: <http://www.agleader.com/products/sms-subpages/subpagesad>

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# Data Processing: Scripting & Database

- Original data: sources and formats
- Processing: consistent data fields, importing raw data

Populating empty tables with raw data

**Creating empty tables**

```

-- Creating scratch table from field data
CREATE TABLE _scratch_planting_agfiniti_01
(
  longitude numeric(12,8) NOT NULL,
  latitude numeric(12,8) NOT NULL,
  dataset varchar(255) NOT NULL,
  product varchar(255) NOT NULL,
  crop_year numeric(12,4) NOT NULL,
  track_deg double precision NULL,
  swath_width double precision NULL,
  distance_f double precision NULL,
  elevation double precision NULL,
  time varchar(255) NOT NULL,
  area_count numeric(12,4) NOT NULL,
  north_south numeric(12,4) NOT NULL,
  east_west numeric(12,4) NOT NULL,
  x_offset_f numeric(12,4) NOT NULL,
  y_offset_f numeric(12,4) NOT NULL,
  moisture numeric(12,4) NOT NULL,
  yield_maas_w numeric(12,4) NOT NULL,
  yield_maas_d double precision NULL,
  yield_maas_dr double precision NULL,
  active_flow boolean NULL,
  humidity numeric(12,4) NOT NULL,
  wind_speed numeric(12,4) NOT NULL,
  crop_flow_m numeric(12,4) NOT NULL,
  moist_maas numeric(12,4) NOT NULL,
  speed_mph numeric(12,4) NOT NULL,
  crop_flow_v numeric(12,4) NOT NULL,
  yield_maas_w double precision NULL,
  yield_maas_d double precision NULL,
  yield_maas_dr double precision NULL,
  active_flow boolean NULL,
  humidity numeric(12,4) NOT NULL,
  wind_speed numeric(12,4) NOT NULL,
  crop_flow_m numeric(12,4) NOT NULL,
  moist_maas numeric(12,4) NOT NULL,
  speed_mph numeric(12,4) NOT NULL,
  crop_flow_v numeric(12,4) NOT NULL
);
            
```

```

# Create cursor and connect to database
conn = psycopg2.connect(database='postgres', user='postgres', host='localhost', port='5432')
cur = conn.cursor()

# Create table
cur.execute('CREATE TABLE _scratch_planting_agfiniti_01')

# Populate table
for row in rows:
    cur.execute('INSERT INTO _scratch_planting_agfiniti_01 (%s) VALUES (%s);' % (','.join(row.keys()), ','.join(row.values())))

# Commit and close
cur.commit()
cur.close()
conn.close()
            
```

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# Data Processing: Database

- Schema
- Final tables

## Populate final tables

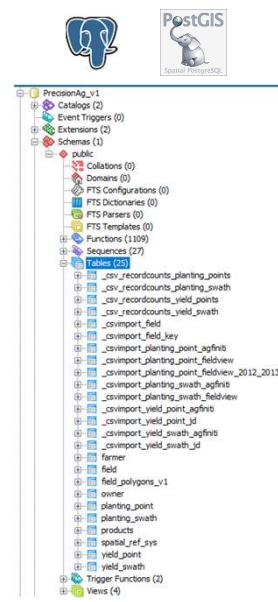
```

457 -----
458 # Copy/insert all yield and planting point records from raw CSV to final "yield" table
459
460 print("Copying/inserting all records from raw CSV yield point files (both John Deere and AgInits) to "yield_point" table.")
461 yield_point_finaltable_populate_cursorCommand = ("
462 INSERT INTO yield_point(longitude,latitude,field,dataset,product,obj_id,track_deg,width,distance_f,duration,s_elevation
463 SELECT longitude,latitude,field,dataset,product,obj_id,track_deg,width,distance_f,duration,s_elevation,area_count,df
464 FROM _csvimport_yield_point_id")
465
466
467 INSERT INTO yield_point(longitude,latitude,field,dataset,product,obj_id,track_deg,width,distance_f,duration,s_elevation
468 SELECT longitude,latitude,field,dataset,product,obj_id,track_deg,width,distance_f,duration,s_elevation,area_count,df
469 FROM _csvimport_yield_point_aginits")
470
471
472 For command in yield_point_finaltable_populate_cursorCommand:
473     cursor.execute(command)
474 print("Completed copying/moving all records from raw CSV yield point files (both John Deere and AgInits) to "yield_point"
475 connection.commit()
476 print("Current time: " + str(datetime.datetime.now()))
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## Spatially-enabled (points and swaths)

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|---------|-----------------------|-----------------|---------------------|-----------------|----------------------|
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# GeoServer



- Connection to PostGIS
- Utilize SQL Views

Stores

Manage the stores providing data to GeoServer

| Data Type                | Workspace      | Store Name  | Type    |
|--------------------------|----------------|-------------|---------|
| <input type="checkbox"/> | precisionag_v1 | precisionag | PostGIS |

Layers

Manage the layers being published by GeoServer

| Type                                | Title                                 | Name   | Store       | Enabled | Native SRS |
|-------------------------------------|---------------------------------------|--|-------------|---------|------------|
| <input type="checkbox"/>            | yield_point_2016_soybean_yieldvolume  | PrecisionAg_v1:yield_point_2016_soybean_yieldvolume  | precisionag | ✓       | EPSG:3857  |
| <input type="checkbox"/>            | yield_point_2016_soybean_yieldmass    | PrecisionAg_v1:yield_point_2016_soybean_yieldmass    | precisionag | ✓       | EPSG:3857  |
| <input type="checkbox"/>            | yield_point_2016_soybean_moisture     | PrecisionAg_v1:yield_point_2016_soybean_moisture     | precisionag | ✓       | EPSG:3857  |
| <input type="checkbox"/>            | yield_point_2016_com_yieldvolume      | PrecisionAg_v1:yield_point_2016_com_yieldvolume      | precisionag | ✓       | EPSG:3857  |
| <input type="checkbox"/>            | yield_point_2016_com_yieldmass        | PrecisionAg_v1:yield_point_2016_com_yieldmass        | precisionag | ✓       | EPSG:3857  |
| <input type="checkbox"/>            | yield_point_2016_com_moisture         | PrecisionAg_v1:yield_point_2016_com_moisture         | precisionag | ✓       | EPSG:3857  |
| <input type="checkbox"/>            | yield_point                           | PrecisionAg_v1:yield_point                           | precisionag | ✓       | EPSG:3857  |
| <input type="checkbox"/>            | planting_point_2016_soybean_seedspace | PrecisionAg_v1:planting_point_2016_soybean_seedspace | precisionag | ✓       | EPSG:3857  |
| <input type="checkbox"/>            | planting_point_2016_soybean_ratecount | PrecisionAg_v1:planting_point_2016_soybean_ratecount | precisionag | ✓       | EPSG:3857  |
| <input type="checkbox"/>            | planting_point_2016_com_seedspace     | PrecisionAg_v1:planting_point_2016_com_seedspace     | precisionag | ✓       | EPSG:3857  |
| <input type="checkbox"/>            | planting_point_2016_com_ratecount     | PrecisionAg_v1:planting_point_2016_com_ratecount     | precisionag | ✓       | EPSG:3857  |
| <input type="checkbox"/>            | planting_point                        | PrecisionAg_v1:planting_point                        | precisionag | ✓       | EPSG:3857  |
| <input checked="" type="checkbox"/> | field_polygons_v1                     | PrecisionAg_v1:field_polygons_v1                     | precisionag | ✓       | EPSG:3857  |

|         |                       |                 |                     |                 |                      |
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# Desktop Application

QGIS 2.14.2-Essen - Desktop\_App\_v1

Project | Edit | View | Layer | Settings | Plugins | Vector | Raster | Database | Web | MHQGIS | Processing | Help

Layers Panel

- Farm
  - Planting Data
    - 2016
      - Corn, Seed Space (m)
        - 0.00 - 5.64
        - 5.64 - 5.75
        - 5.75 - 5.81
        - 5.81 - 5.86
        - 5.86 - 5.93
        - 5.93 - 6.04
        - 6.04 +
      - Corn, Seed Space (m)
      - Corn, Rate Count (kods/ac)
      - Corn, Rate Count (kods/ac)
      - Soybean, Seed Space (m)
      - Soybean, Seed Space (m)
      - Soybean, Rate Count (kods/ac)
      - Soybean, Rate Count (kods/ac)
    - Harvest Data
      - 2016
        - Corn, Moisture (%)
        - Corn, Yield Volume (dry) (bu/ac)
        - Corn, Yield Hass (dry) (bu/ac)
        - Soybean, Moisture (%)
        - Soybean, Yield Volume (dry) (bu/ac)
        - Soybean, Yield Hass (dry) (bu/ac)
        - Soybean, Yield Hass (dry) (bu/ac)
    - Original/Raw Data
      - POINT DATA
      - Source Data
    - Fields
      - Base Reference Layers
        - IL\_ILMRY\_State\_Plane\_Zones\_Py
      - Imagery
        - NADIP Imagery Service (2015, Illinois)
        - Logan County, IL (MAIP, 2015)
        - DeWitt County, IL (MAIP, 2015)
        - NADIP Seamlines for 2015 Imagery

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# Desktop Application

QGIS 2.14.2-Essen - Desktop\_App\_v1

Project | Edit | View | Layer | Settings | Plugins | Vector | Raster | Database | Web | MHQGIS | Processing | Help

Layers Panel

- Farm
  - Planting Data
    - 2016
      - Corn, Seed Space (m)
      - Corn, Rate Count (kods/ac)
      - Corn, Rate Count (kods/ac)
      - Soybean, Seed Space (m)
      - Soybean, Seed Space (m)
      - Soybean, Rate Count (kods/ac)
      - Soybean, Rate Count (kods/ac)
    - Harvest Data
      - 2016
        - Corn, Moisture (%)
        - Corn, Yield Volume (dry) (bu/ac)
        - Corn, Yield Hass (dry) (bu/ac)
        - Soybean, Moisture (%)
        - Soybean, Yield Volume (dry) (bu/ac)
        - Soybean, Yield Hass (dry) (bu/ac)
        - Soybean, Yield Hass (dry) (bu/ac)
    - Original/Raw Data
      - POINT DATA
      - Source Data
    - Fields
      - Base Reference Layers
        - IL\_ILMRY\_State\_Plane\_Zones\_Py
      - Imagery
        - NADIP Imagery Service (2015, Illinois)
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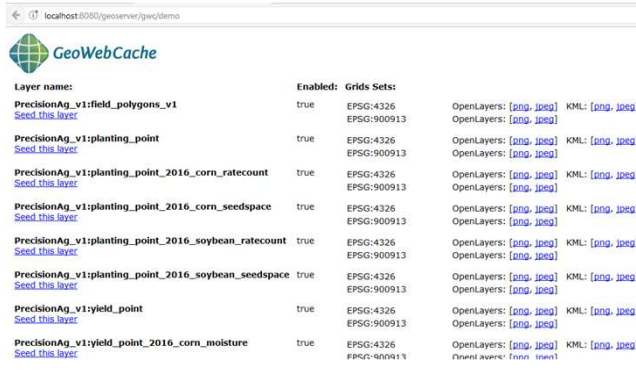


# Web Mapping Application - Preparation

- Styling of layers - YSLD
- Web services 
- Creation of tiles 

```

1 name: yield_point_2016_soybean_yieldvolume
2 title: 'yield_point_2016_soybean_yieldvolume'
3 feature: yield
4 name: Rule
5
6 filter: {yld_vol_dr >= 81.25}
7
8 symbolizers:
9 - point
10 - size: 4.50
11 - mark:
12 - shape: circle
13 - fill-color: '#19855d'
14
15 filter: {yld_vol_dr < 81.25 AND yld_vol_dr >= 75.79}
16
17 symbolizers:
18 - point
19 - size: 4.50
20 - mark:
21 - shape: circle
22 - fill-color: '#91cf60'
23
24 filter: {yld_vol_dr < 75.79 AND yld_vol_dr >= 71.78}
25
26 symbolizers:
27 - point
28 - size: 4.50
29 - mark:
30 - shape: circle
31 - fill-color: '#d9eaf7'
    
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GeoWebCache interface showing layer management. The interface includes a search bar, a list of layers with their names, status, and grid sets, and a 'Styles' section on the right for managing published styles.

|         |                       |                 |                     |                 |                      |
|---------|-----------------------|-----------------|---------------------|-----------------|----------------------|
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# Web Application

- OpenLayers3 
- jQuery UI 

### HTML sample

```

70 <label id="product">Soybean</label><br/>
71 <!-- 2016, Soybean, Planting -->
72 <label id="event">Planting</label>
73 <input type="checkbox" class="checkbox" id="plantingPoint2016SoybeanSeedSpace" /><label
74 for="plantingPoint2016SoybeanSeedSpace">Seed Space (in)</label>
75
76 <input type="checkbox" class="checkbox" id="plantingPoint2016SoybeanRateCount" /><label
77 for="plantingPoint2016SoybeanRateCount">Rate Count (kads/ac)</label>
78
79 <!-- 2016, Soybean, Harvest -->
80 <label id="event">Harvest</label>
81 <input type="checkbox" class="checkbox" id="yieldPoint2016SoybeanMoisture" /><label
82 for="yieldPoint2016SoybeanMoisture">Moisture (S)</label>
83
84 <input type="checkbox" class="checkbox" id="yieldPoint2016SoybeanYieldVolume" /><label
85 for="yieldPoint2016SoybeanYieldVolume">Volume - dry (bu/ac)</label>
86
87 <input type="checkbox" class="checkbox" id="yieldPoint2016SoybeanYieldMass" /><label
88 for="yieldPoint2016SoybeanYieldMass">Mass - dry (lb/ac)</label>
    
```

```

601 // Yield - Point - 2016 - Soybean - Yield, Mass (dry) (lb/ac) (variable 'yld_vol_dr')
602 var yield_point_2016_soybean_yieldmass = new ol.layer.Tile({
603   opacity: 1,
604   source: new ol.source.TileWMS({
605     url: 'http://localhost:8080/geoserver/wms',
606     params: {
607       'LAYERS': 'PrecisionAg_v1:yield_point_2016_soybean_yieldmass', 'TILED': true,
608       'serverType': 'geoserver'
609     }
610   });
611 });
612 yield_point_2016_soybean_yieldmass.set('name', 'Yield - Point - 2016 - Soybean - Mass (dry) (lb/ac)');
613
614 // Yield - Point - 2015 - Soybean - Yield, Mass (dry) (lb/ac) (variable 'yld_vol_dr')
615 var yield_point_2015_soybean_yieldmass = new ol.layer.Tile({
616   opacity: 1,
617   source: new ol.source.TileWMS({
618     url: 'http://localhost:8080/geoserver/wms',
619     params: {
620       'LAYERS': 'PrecisionAg_v1:yield_point_2015_soybean_yieldmass', 'TILED': true,
621       'serverType': 'geoserver'
622     }
623   });
624 });
625 yield_point_2015_soybean_yieldmass.set('name', 'Yield - Point - 2015 - Soybean - Mass (dry) (lb/ac)');
    
```

### JavaScript samples

```

894 // 2016 - 2015: Corn Seed
895 * $( ".checkbox" ).change(function(index) {
896   var targetId = $(this).attr("id");
897   switch(targetId) {
898     case "plantingPoint2016CornSeedSpace":
899     * {
900       if (plantingPoint2016CornSeedSpace.checked) {
901         map.addLayer(planting_point_2016_corn_seedspace);
902       } else {
903         map.removeLayer(planting_point_2016_corn_seedspace);
904       }
905     }
906     case "plantingPoint2016CornRateCount":
907     * {
908       if (plantingPoint2016CornRateCount.checked) {
909         map.addLayer(planting_point_2016_corn_ratecount);
910       } else {
911         map.removeLayer(planting_point_2016_corn_ratecount);
912       }
913     }
914     case "yieldPoint2016CornMoisture":
915     * {
916       if (yieldPoint2016CornMoisture.checked) {
917         map.addLayer(yield_point_2016_corn_moisture);
918       } else {
919         map.removeLayer(yield_point_2016_corn_moisture);
920       }
921     }
922   }
923 });
    
```

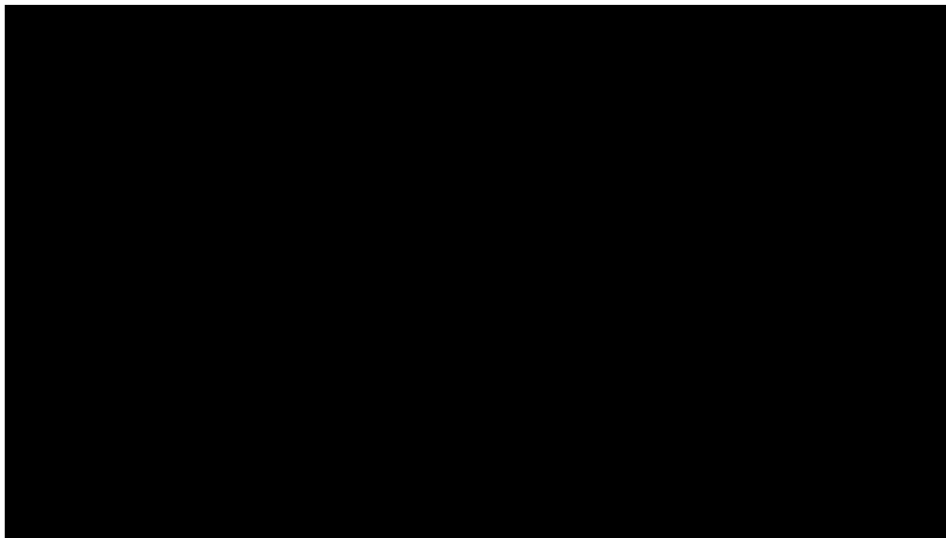


Mockup created using Balsamiq - [balsamiq.com](http://balsamiq.com)

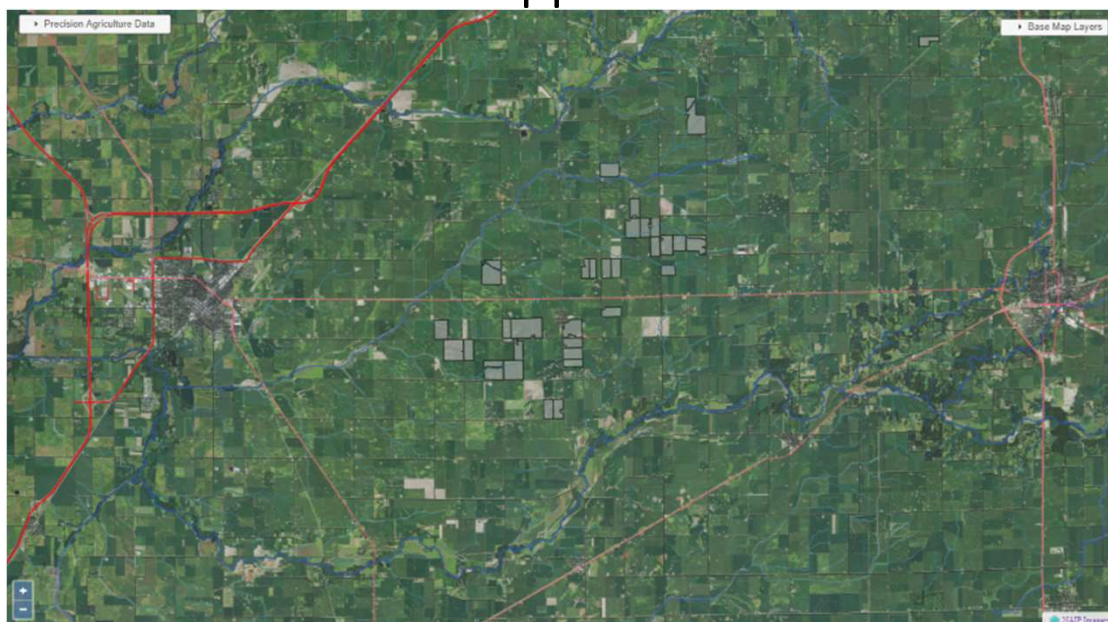
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|---------|-----------------------|-----------------|---------------------|-----------------|----------------------|
| Project | Precision Agriculture | Data Processing | Desktop Application | Web Application | Impact & Future Work |
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## Web Application – Video Demo

- <http://www.screencast.com/t/WYPxaF9d> (Flash required)

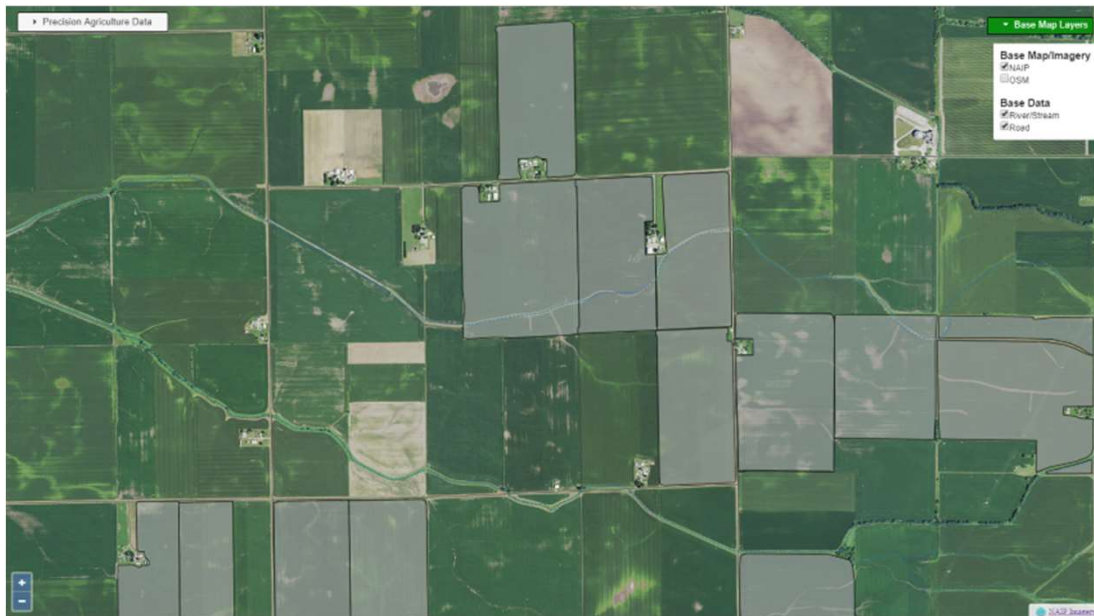


## Web Application



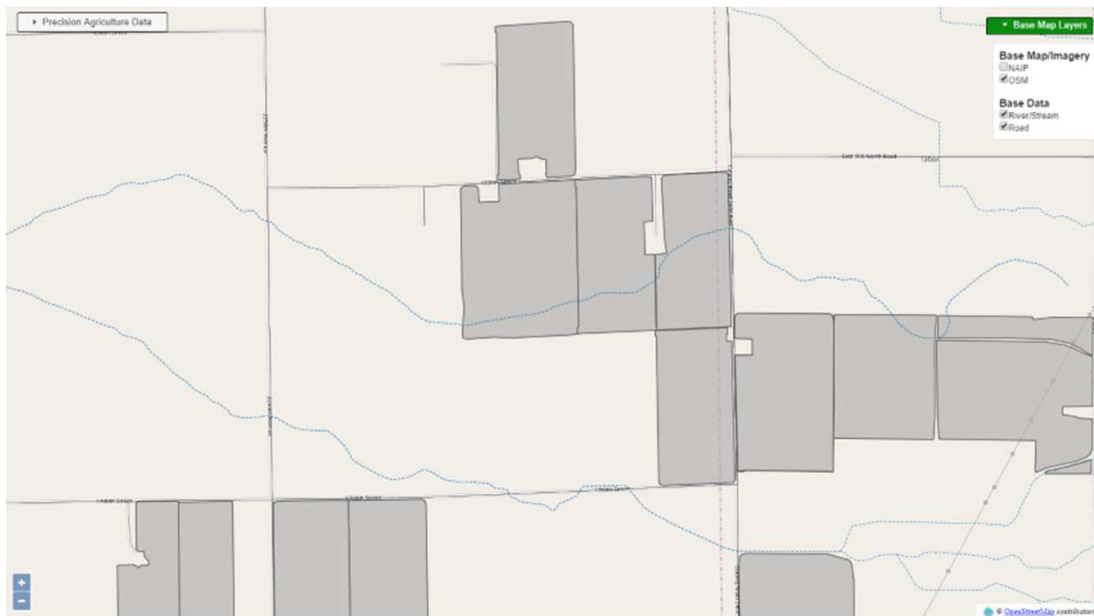
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# Web Application



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# Web Application



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# Web Application



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# Web Application



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# Web Application



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# Web Application



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# Web Application



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# Web Application



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## Project Impact

- Prototype application to visualize disparate data by farmer
  - Begin to visualize and understand relationships between variables
- Ability to connect producers, consultants, local dealers
- Open source-based web mapping and visualization application for disparate data
  - No software licensing concerns
- Database prepared for continued analysis

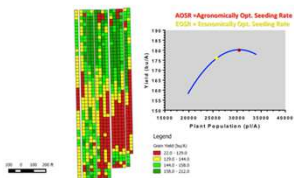
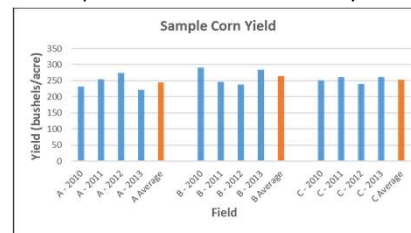
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| Project | Precision Agriculture | Data Processing | Desktop Application | Web Application | Impact & Future Work |
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## Future Work & Analysis

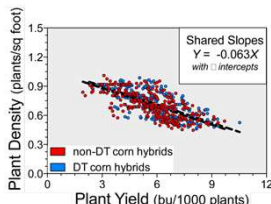
- Generate custom reports, tables, visualizations
- Analyze change in yields
- Analyze relationships
  - Soil – Seed – Yield



Sample Yield Table Generated by User



"Corn Seeding Rate Recommendations"  
 Source: [https://webapp.sprinc.bea.edu/cgi-bin/cgi-bin/article.pl?article\\_id=455](https://webapp.sprinc.bea.edu/cgi-bin/cgi-bin/article.pl?article_id=455)



- Different methods to serve data to web map

|         |                       |                 |                     |                 |                      |
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| Project | Precision Agriculture | Data Processing | Desktop Application | Web Application | Impact & Future Work |
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## Selected References



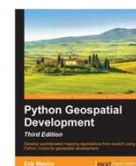
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Source: Author

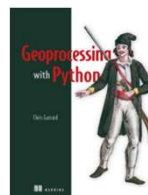
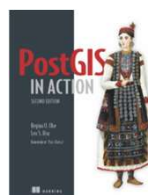
## Misc. Resources

- Packt Publishing  <https://www.packtpub.com/>



- Brackets text editor  <http://brackets.io/>

- Manning Publishing <https://www.manning.com/>



- Lucid Chart <https://www.lucidchart.com/>



# Questions



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Source: Author