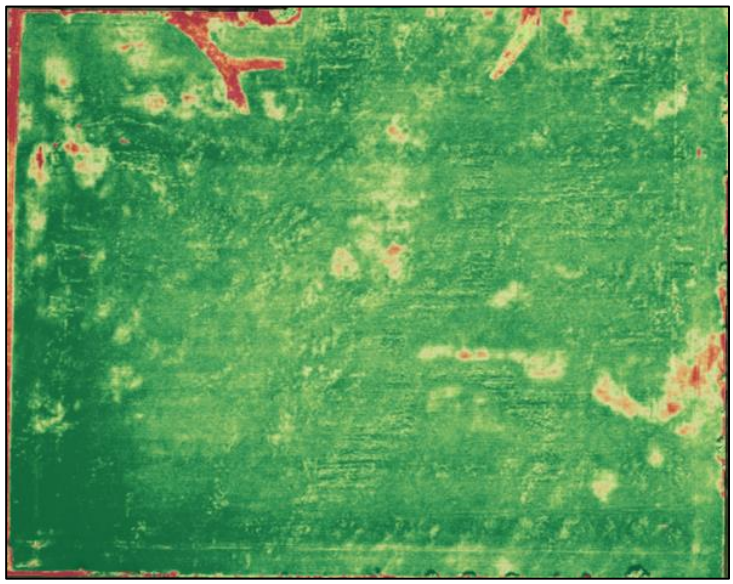
PURDUE UNIVERSITY | Extension

# UAV Initiative Compendium



## 2017-2021

**Purdue University Cooperative Extension Service UAV Initiative:**

- The Purdue University Cooperative Extension Service UAV Initiative started in 2017 with Specialists conducting field-level research and expanded in 2018 with funding support from Dr. Jason Henderson to acquire UAVs for Educators across the state. The initial group was comprised of 17 Educators and has since grown to over twenty Educators and several Specialists.

- This report covers UAV related work conducted throughout the state of Indiana. Much of our early work was related directly to corn and soybean production, with more recent strides into public safety, animal agriculture, natural resources, conservation, and new UAV technology application and evaluation.

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**Purdue University Extension Unmanned Aerial Vehicles Website:**

**https://extension.purdue.edu/uav/**

- A website dedicated to practical uses of UAVs (drones) focusing on Animal Agriculture, Row Crops, Diversified Crops, In-field Conservation, Marketing, Natural Resources, Public Safety, Structural, and Turf.

**Thank you to all Extension stakeholders who participated in these projects throughout Indiana by allowing us to engage with them and their businesses and communities to gather this information to share with others.**

**Acknowledgements**

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**Tipton County Agriculture and Natural Resource Educator:** Austin Pearson

**Wells County Agriculture and Natural Resource Educator:** Bill Horan

**White County Agriculture and Natural Resource Educator:** Andrew Westfall

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# ***UAV Initiative***

# ***Community Activities***

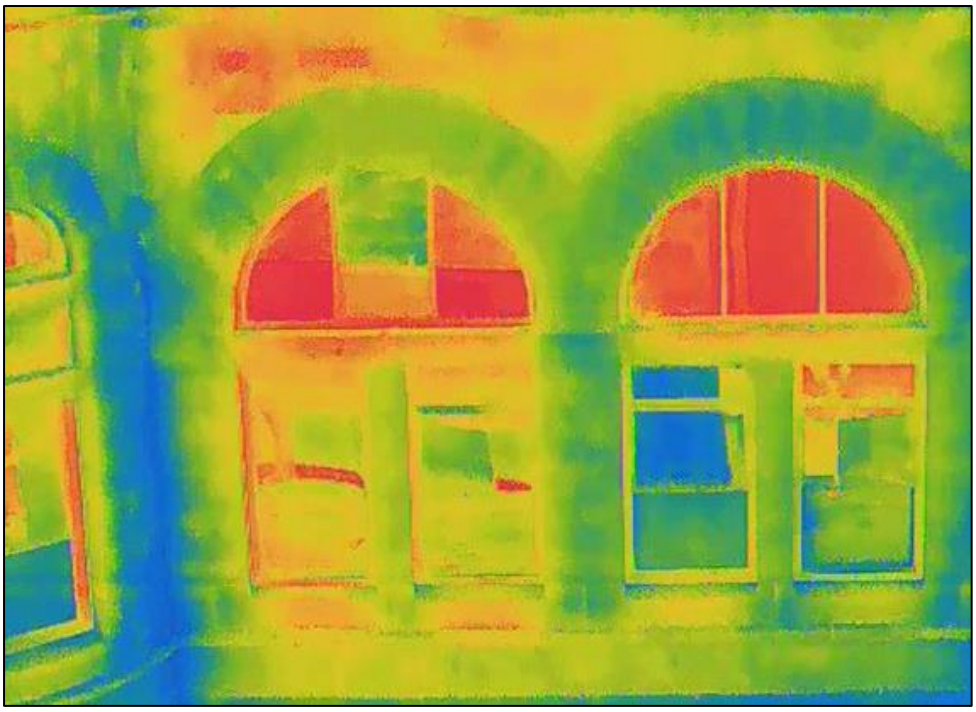
Building stronger communities by leveraging UAV technology in innovative ways.

# Courthouse Window Inspection using a Thermal Camera

***Mark Carter - Agriculture and Natural Resources Educator, Blackford County – Precision Agriculture Coordinator***

**Objective:**
The custodian for the Blackford County Courthouse recently contacted me to discuss doing an inspection on the courthouse with a drone. I told her that would be no trouble as she wanted to see if there was hail damage on the roof and any other issues. I scheduled the flight for a day late in August 2021 with assistance from Austin Pearson, ANR Tipton County and Grace Marshall, ANR Intern Blackford County. The flight took about 1.5 hours using RGB and IR-thermal cameras.

**Observations:**
The images showed many places on the roof that had significant hail damage, chimneys that did not have wire mesh over them to keep birds out, and a few windows that have lost seal (middle window in the left arch pictured).



**Why is this important?**
The county is currently in negotiations with their insurance company to get the roof replaced. They are planning on getting wire mesh installed on the chimneys. Further inspection of the windows from the inside revealed that all the windows found were installed improperly several years before being held in by one screw each. The windows are scheduled to be replaced and sealed properly.

# Leaking Window Investigation at the Courthouse

*Bryan Overstreet, Agriculture & Natural Resources Educator, Purdue Extension - Jasper County*

**Objective:**
The local commissioners asked for a flight to be conducted at the local courthouse to try and determine the cause of a leaky window into an office when it rained.

**Observations:**
We were able to locate leaky windows on the second floor of this courthouse using a UAV. We found that a clogged gutter was the culprit. It is possible to see the issue in the zoomed in image. In this instance it is a digital zoom (as opposed to an optical zoom) of the larger image. One positive of the stock drones is their cameras are high enough resolution that digital zooms can still be very useful for identifying issues and they are not as pixelated as inferior cameras while still being reasonably inexpensive (especially when considering costs of this resolution even a few years ago).

The digital zoom showing the plugged downspout and leaking gutter (the smoking gun).

**Why is this important?**

A UAV was a faster, safer, and more cost-effective alternative to human climbing in identifying this problem. This was completed by using the standard drone right out of the box. It required no additional software or hardware, meaning no additional cost to the original drone cost except time.

# Solar Farm Installation – Old Fence Removal

*Adam Shanks - Agriculture and Natural Resources Educator, Clinton County*

**Objective:**

The Clinton County Area Plan Commission reached out needing some help in deciding on a 1700 acre solar farm proposed in Clinton County. The application for permits noted the removal of several fence rows within the project area to streamline installation and maintenance. The APC was concerned about just allowing these fence lines to be removed in case they influenced wildlife traffic patterns or opened up areas for surface water to move where it had not previously. I utilized the drone to quickly look at aerial views of the fence lines, and provided those to the APC.

**Observations:**

Upon review of the images, we were able to look extensively at each fence row proposed for removal. We were looking for wildlife habitat and traffic areas. We also were looking for "old-growth" trees and native species that could be detrimental to remove. There was also a potential to change surface water movement in areas where fence rows are removed.

**Why is this important?**

In summary, the review showed no real detriment to wildlife or plant species if the fence rows are removed. Most were classified as "scrub brush" and I personally feel will enhance the value of the farm by having them removed. After review, it was agreed by APC to allow the fence rows to be removed during construction of the solar farm.

# Henry County Expo Center

***Justin Curley - Agriculture and Natural Resources Educator, Jay County***

**Objective:**

The Henry County Commissioners and Council made an initial donation of 1 million dollars toward the construction of a new County Fairgrounds. This was the birth of the Henry County Expo Center. I was approached by members of the Henry County Expo Board and a representative of the County Commissioners about utilizing the UAV for recording footage of the Expo project so as to help showcase it to the community.

**Observations:**

I recorded videos and pictures of the Henry County Expo Center posted them to their social media pages.

A still portion of a video shot during the initial construction of the Expo Center.

**Why is this important?**

These aerial videos helped to breathe life into the project and spur fundraising efforts toward the construction of the Henry County Expo Center.

# Henry County Stellar Communities Grant application

***Justin Curley - Agriculture and Natural Resources Educator, Jay County***

**Objective:**

In 2019 the Henry County Council and Commissioners approached me about using a UAV to record images of county that they could use in their Stellar Communities grant application video. The Stellar Communities Grant was a joint effort between the City of New Castle and Henry County.

**Observations:**

Mark Carter of Delaware County and I recorded a series of videos highlighting the treasures of Henry County, such as Westwood Park, Broad Street, Memorial Park, and the Indiana Basketball Hall of Fame. UAV technology enabled us to show a perspective that would have been otherwise unattainable. With the grant application being submitted in video form out recorded videos served as an excellent backdrop to the story being told by community stakeholders. This served as an excellent opportunity for Purdue Extension to showcase our capabilities within the community as well as it being an excellent networking opportunity.

The Indiana Basketball Hall of Fame. A Henry County treasure.

**Why is this important?**

The county government expressed their deep gratitude at our involvement and it led to building stronger relationships with officials that benefitted the whole of Purdue Extension Henry County. Henry County did not win the top prize grant we were pursuing but finished 3rd out of all applicants. The process while not ultimately successful helped the county to shape a vision and a path for economic development that has benefitted the community greatly since.

# Hancock County Master Gardener Association

***Lais McCartney - Agriculture and Natural Resources Educator, Hancock County***

**Objective:**
A series of flights have been used by the Hancock County Master Gardener Association to map various areas of their demonstration gardens at the Extension office at 802 Apple St. Greenfield, IN 46140.

**Observations:**
The image shows an overhead view of a garden. This is just one example of the eight gardens that were imaged. It is possible to see different plants in the garden and even becomes simpler to identify weedy areas that may require attention. When the flowers are in bloom it is very aesthetically pleasing to see all the colors from the air.

**Why is this important?**
This helped the Master Gardeners to publicize their plants for their annual plant sale used to raise funds for college scholarships and get excited about their nine different gardens which serve as an outreach for the local community. They were also able to utilize a stitched overview mapped to place into their new educational kiosk for people who come to the gardens to learn more about the plants in the gardens.

# ***UAV Initiative***

# ***Conservation Activities***

Protecting our environment using UAVs as a management tool in a conservation minded industry

# Allen County River Survey Documentation

***Bill Horan - Agriculture and Natural Resources Educator, Wells County***

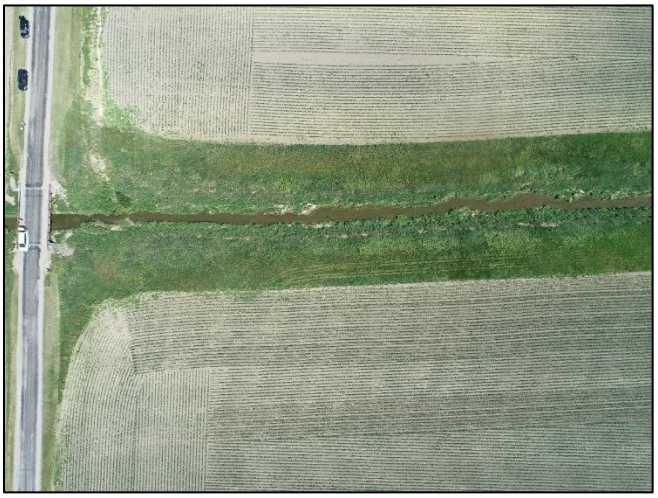
**Objective:**

The Allen County Soil and Water Conservation Service (SWCD) received a grant to survey several streams to monitor water quality. As a part of this grant, they were asked to provide aerial photos of the streams being sampled as a part of the sampling documentation. As the nearest Purdue Quad Squad member, I was asked to assist with this project.

**Observations:**

I met with the SWCD staff and we visited 5 streams where sampling was being performed, and used our UAV to get photos of the sampling site and 500 feet of the stream in each direction from the bridge / site.

Allen County SWCD river sampling.



Allen County river, being sampled as part of water quality grant.

Allen County stream and field, which were part of photo documentation for grant.

**Why is this important?**

This assistance to our fellow agriculture agency helped them to meet the requirements of their stream sampling grant, and saved them from the need to hire a professional photographer to accomplish this task.

# Rainscaping Signature Program Demonstration Garden

**Lais McCartney** - ***Agriculture and Natural Resources Educator, Hancock County***

**Objective:**

A flight to demonstrate the placement of the raingarden that was created during a rainscaping two-day workshop was useful to share with local commissioners to get permission to work on the county property. This flight also showed the low spots and justified the placement of the raingarden to participants of the class.

**Observations:**

This flight also showed the low spots and justified the placement of the raingarden to participants of the class. The image below was used to determine the raingarden placement by observing drainage patterns and also get a rough estimate of the area to use when ordering materials and plants.

**Why is this important?**

The raingarden class was a success, and the runoff has been slowed with native plants being useful to the local insect and pollinator population.

# Mapping Grassed Waterways

**Jon Charlesworth** - ***Agriculture and Natural Resources Educator, Benton/Warren Counties***

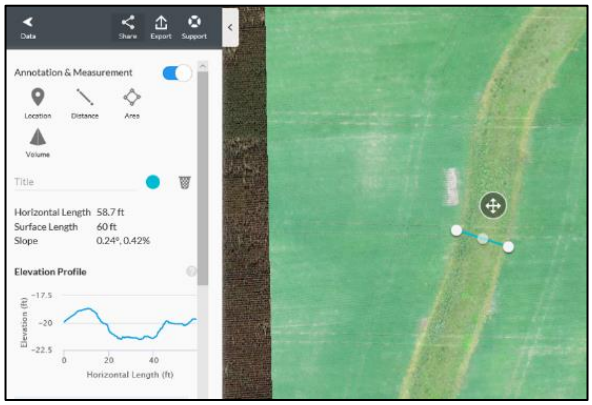
**Objective:**

Monitoring grassed waterways is currently conducted by physically walking (or in some instances driving) along the waterway to look it over. Professionals are looking to see if the waterway follows the agreement regulations, such as not being used to raise a crop and is in good working order. This task can take several hours and if several waterways need inspected several days to weeks. This work was conducted to test how well a UAV could perform some inspection tasks and if it would be more efficient.

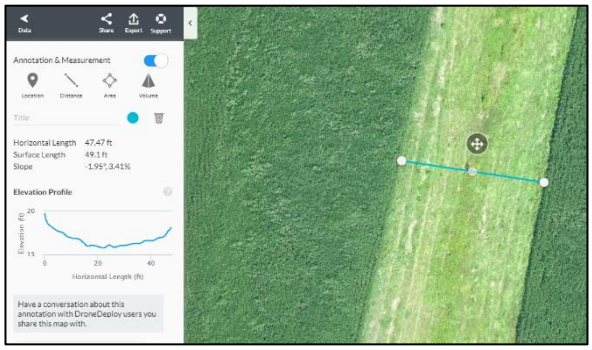
**Observations:**

A square section of the field was flown that collected images of the entire waterway and a map was created in DroneDeploy. This was then analyzed using tools in the software to measure the distance from edge to edge of the waterway resulting in the width. An unexpected result was the appearance of the elevation profile and surface length measurement. The elevation profile showed how the surface of the ground changed across the width of the waterway. The surface length showed the width relative to the change in the surface profile. Using these tools, we could determine the situation on the ground.

In the original flight there was a hump in the elevation profile that turned out to be a patch of giant ragweed.




In a later image of a different waterway that had been mowed it is possible to see how the actual waterway is shaped.




**Why is this important?**

This test showed that the UAV could be used to map a waterway and using some basic analysis tools determine the depth of the waterway to check if it was compliant. The biggest limitation to this currently is that the software creates a digital surface model (DSM) so any vegetation will appear as a rise. Since this work was conducted the software technology has improved to allow spline flights, meaning that a programmed flight can be created to only fly the waterway and will follow the waterway movements. This has even greater potential for this technology to be used in assessing this conservation structure.

## Assessing Newly Constructed Grassed Waterways

***John Scott – Purdue Extension Digital Agriculture Coordinator***

**Objective:**

In collaboration with the Natural Resource Conservation Service (NRCS) Tippecanoe office, we flew several sites to examine conservation structures, erosion, and weed pressure in wetlands. This flight was over a newly installed grassed waterway to examine the waterway and see what a manual flight could achieve.

**Observations:**

Water standing in this newly installed grassed waterway (below) indicates a problem. While several issues could be at fault, an exact determination requires someone to closely examine the tile. However, the UAV is a good tool to offer a snapshot of performance to conservationists. This waterway was not mapped like the earlier waterway since the purpose of the flight was to manually observe it only for the conservationists to look at the quality of the installation.

Surface water was present on both the lower and upper sections of the waterway. Since this was a new installation and only minimal rain had fallen the conservationist was concerned.

**Why is this important?**

Using this imagery, the conservationists examined the subsurface drainage tile more closely after harvest and determined that it was off-grade and in the incorrect location to properly drain. They contacted the installer and had the work redone at the proper location and grade so the waterway could function properly for the producer.

# Mapping Newly Constructed Water and Sediment Containment Basins (WASCOB)

***John Scott – Purdue Extension Digital Agriculture Coordinator***

**Objective:**

In collaboration with the Natural Resource Conservation Service (NRCS) Tippecanoe office, we flew several sites to examine conservation structures, erosion, and weed pressure in wetlands. This flight was over a newly installed WASCOB system conducted while the cash crop was in the field (making the WASCOB difficult to reach on the ground). Our purpose was to look for any issues with the system, check on the planted vegetation, and examine the berms built to create the basins and split up the slope.

**Observations:**

Here are views of three water and sediment control basin (WASCOB) structures, each containing two to three basins. A WASCOB is designed to control water runoff after a rain. Each structure has a subsurface drainage system at the lowest point of the basin where the water pools. Once the water reaches the top of the drainage system, it is discharged through the main tile system. Any sediment in the water settles to the bottom of the basin, which prevents permanent erosion and reduces pollution in other water bodies.

The elevation profile on the left of the image above makes it possible to see overall hillslope as well as each individual berm.


Visual confirmation of a riser that became unattached to the subsurface drain below.

**Why is this important?**

It was revealed to the conservationists that the WASCOB was functioning properly. The berms were in place and at a proper height. It was noted that several risers installed at the bottom of the basin had fallen over and needed repaired. This information led to the conservationists planning to return and maintain the structure after the cash crop was harvested.

# Locating and Assessing Erosion

***John Scott – Purdue Extension Digital Agriculture Coordinator***

**Objective:**

In collaboration with the Natural Resource Conservation Service (NRCS) Tippecanoe office, we flew several sites to examine conservation structures, erosion, and weed pressure in wetlands. This flight was over fields with erosion concerns by the conservationists. Our purpose was to look for any erosion and attempt to gauge its severity across the landscape.

**Observations:**

This flight was conducted over a series of about four or five fields to manually look for signs of soil erosion by water. Due to the nature of the flight the fields were not mapped, the conservationists wanted to follow the erosion paths from the areas first noted to their sources. Most of these flights were video recorded so they could be replayed later.

**Why is this important?**

Using this imagery, the conservationists had conversations with the landowners and/or producers to consider erosion mitigation practices. As a direct result of this work some of the fields had grassed waterways installed or different tillage practices were implemented to reduce the erosion.

# Aerial Native Wildlife Habitat Seeding

***Jarred Brooke – Purdue Extension Wildlife Specialist***
***John Scott – Purdue Extension Digital Agriculture Coordinator***

**Objective:**
In collaboration with Ivy Tech Lafayette, the Natural Resource Conservation Service (NRCS) Tippecanoe office, Tippecanoe SWCD, Wabash River Enhancement Corporation (WREC), and Purdue University Extension Wildlife Specialist, Jarred Brooke; we flew a DJI Agras MG-1P to frost seed a native mix of grasses and forbes to a four-acre mound at the Ivy Tech Farm Plot. The mound was made using soil from digging a nearby retention pond and until this application had been left alone. The purpose of this activity is to create a native plant wildlife habitat.

**Observations:**
This flight was conducted in late January during a snow squall but the UAV handled the elements well and the fresh snowfall allowed us to monitor the spread pattern on the ground. Due to UAV malfunctions and the seed quality issues, spreading the four acres took about seven hours. Regarding the malfunctions an electronic part failed that needed replaced. Since we didn't have one on hand we overrode the error and were able to conduct the flight. This only worked since we had a static hopper gate opening. If we would have needed to adjust the hopper gate opening we would have had to wait for the parts. Regarding the seed quality, due to a high amount of foreign matter in the seed it didn't flow well through the hopper (even with a 4:1 mixture of pelletized lime as a carrier). This caused errors where the UAV sensors showed it as empty while it was still half full or better (bridging was the issue here as the sensor is toward the bottom of the hopper and the seed remained at the top).

The drone in action spreading seed on the hillside of the mound.

Visual confirmation of the spread pattern. Even with some complications the spreading was a success. *Photo credit: Jarred Brooke*

**Why is this important?**
The application had some complications but was ultimately a success. This was the initial step and will be followed up over the next few growing seasons to monitor plant performance as the habitat grows and takes hold. Our work does show that drones can be used to apply native plant seeds to small areas under less than ideal conditions successfully. This work also allows seeding over areas that a traditional ground rig might not reach safely as the terrain is no longer a constraint.

# Aerial Cover Crop Seeding

*Mark Carter - ANR Educator, Blackford County – Precision Agriculture Coordinator*
*Jeff Boyer – Superintendent, Davis Purdue Agriculture Center*
*John Scott – Purdue Extension Digital Agriculture Coordinator*

**Objective:**
Aerial application of cover crops is a practical method to apply cover crops in their seeding window (early fall) where ground-based equipment might not be viable. This results in cover crops often being flown on by airplanes but they still have limitations especially along end rows, tree lines, and waterways. We engaged in several demonstrations to test if a UAV could be a viable option for applying cover crops, including several side-by-side comparisons.

- Project 1: Purdue Extension Blackford County and Davis Purdue Ag Center teamed up to try applications of cereal rye following corn and an oats/radish following soybeans.
- Project 2: Purdue Extension and Boone County SWCD collaborated using several different mixes comparing drilled (post-harvest) and aerial (pre-harvest).
- Project 3: Purdue Extension WHIN and Ivy Tech Lafayette collaborated using cereal rye and hairy vetch following corn and soybeans.

**Observations:**

- Project 1: The DJI Agras MG-1Pspreader drone applied 50 lbs./acre of cereal rye and oats/radish to both commodity crops. The applications were done with the drone's 20 lb. hopper capacity which would spread a little less than half an acre per flight. Five acres of each crop was flown on over several flights. Cover crop establishment was successful by visual observation of growing vegetation after crop harvest occurred. No biomass samples were collected. More field research is being developed beginning 2022.

- Project 2: This demonstration plot is a 10-acre long-term no-till, cover crop plot located at the Boone County, IN Fairgrounds. In August 2021 the UAV was used to seed four seed mixtures determined by the Soil and Water Conservation District partners into standing soybeans. These mixtures were oats/rape/hairy vetch, annual ryegrass/crimson clover, oats/oilseed radish, and

cereal rye. Rates used were the same that were later used for drilling (so a little low for aerial application) due to seed constraints. The UAV applied each mix in a strip flying down and back. After harvest the strips adjacent to the UAV applied cover crop were drilled with the same cover crops at the same rate. The center of the field was left without any cover crop to serve as a control area. Pre-frost observations showed the drilled cover coming along well, while the aerial applied cover was struggling to non-existent.

- Project 3: Collaborating with Ivy Tech as part of the Wabash Heartland Innovation Network (WHIN), Purdue Extension has participated in an NRCS funded project looking at interseeding cover crops, aerial cover crop application with a drone, and post-harvest drilling cover crops. Cover crops used were a cereal rye/hairy vetch and cereal rye/crimson clover mix applied at 70 lbs. product/acre aerially. The rates were usually 40-50 pounds/acre for the interseeding and drilling. A section was left that had no cover crops planted as well to monitor any difference. The entire field is long-term no-till.

  This was followed through the next spring (sp 2021) where the aerial applied cover crop performed better than the post-harvest drilled, but never caught up to the interseeded cover crop. Due to the success of the seeding it was repeated in fall 2021 and expanded from 4 acres to 8 acres.

**Why is this important?**

It is possible to use a UAV to seed cover crops but not likely practical yet, especially for larger acreages. Most of our demonstrations are conducted on a smaller scale (4, 8, or 10 acres) and it takes a day or more (8-10 hours) to complete. This may be an option for smaller areas that get flooded to prevent weed pressure however. We also have used a lot of cereal rye which has a high application rate. Using more legumes with a lower application rate would greatly increase our efficiency. Moisture also appears to be critical for the success or failure of aerial application when comparing to drilled. When broadcasting the seed is on the soil surface and exposed, without moisture the viability seems to degrade quickly.

# ***UAV Initiative***

# ***Cropping Systems***

UAVs for Scouting, Mapping, Spraying, and Improving Safe and Efficient Management on the Farm.

# New Field Evaluation

***Ashley Adair – Purdue Extension Organic Agriculture Specialist (Former Agriculture and Natural Resources Educator, Montgomery County)***

**Objective:**
These flights were intended to assist in helping the farmer crop scout two newly rented fields. These fields are county-owned land, within the city limits of Crawfordsville, IN, and the county commissioners had also expressed interest in better understanding the challenges that faced the property. Flights were conducted very 2-4 weeks depending on weather conditions and need.

**Observations:**
One field ("west field") was infested with groundhogs. This is likely due to the field's proximity to Sugar Creek and a forest strip between the field and the creek. Damage to soybeans was more prevalent early in the season. The other field ("south field") was infested with Canada thistle due to previous management (or lack thereof) as an alfalfa hay field.

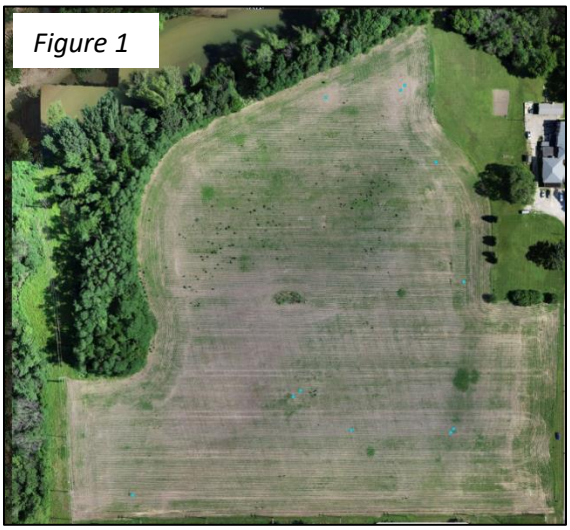



*Figure 1: West field showing groundhog burrows marked with blue dots, 6-14-19. Eleven burrows are marked and were ground-truthed once during the season.*

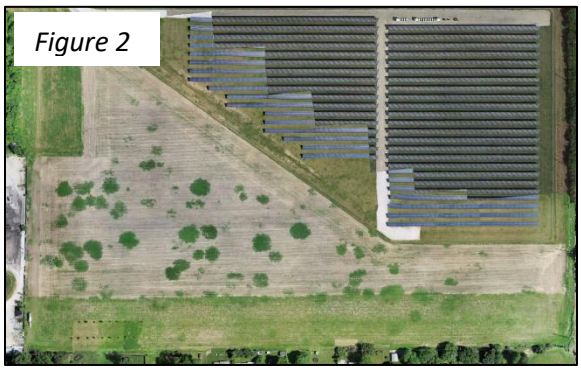



*Figure 2: South field showing Canada thistle infestation areas, 6-14-19. Image shows roughly circular growth habit of each individual Canada thistle colony. Thistle patches overlap the south strip of the field, which was still managed for alfalfa hay in 2019. Alfalfa hay area is harboring a population which is propagating itself by seed into other areas.*

**Why is this important?**
Conditions in the fields identified through UAV scouting informed management decisions for future years in these fields. While groundhog control could not be implemented in the west field due to its location within city limits (no firearms can be used for control based on city ordinance), yield reduction and input choices/rates were adjusted to reflect an economic optimum in the field. Canada thistle control was prioritized for as early in the season as possible in the south field, with an understanding that the level of infestation will require a patient multi-year mitigation effort.

# Southern Indiana Wind Damage in Corn

*Hans Schmitz –Agriculture and Natural Resources Educator, Posey County*

**Objective:**
I was contacted by a farmer to fly a field with suspected wind damage and lodging in corn just prior to tasseling. A recent storm event had affected a known area of the field, but the extent of local damage remained unknown.

**Observations:**
I was able to fly approximately 200 acres, observing that minor, recoverable wind damage existed in small areas of most fields, but one particular hybrid was nearly completely lodged, with greensnap just above the ear leaf node. Crop insurance was then contacted for relief. With the farmer's permission, we flew the field two additional times during the growing season, with one flight being observed by the local cooperative's interns as a part of their training for the summer.

**Why is this important?**
As a result of these flights, a farmer was able to recuperate some income through crop insurance, training was conducted of local cooperative interns, and identification of one local variety as particularly susceptible to lodging was completed.

# Northern Indiana Wind Damage in Corn

***Andrew Westfall - Agriculture and Natural Resources Educator, White County***

**Objective:**

On July 11th, 2020 a severe storm passed through White County, Indiana causing widespread damage, including crop damage attributed to wind and hail. Shortly after, a farmer contacted me about conducting some UAV flights over a field that was severely damaged. He was interested in seeing what the field looked like from the air, and to compare images collected to what the crop insurance adjuster determined about crop loss.

**Observations:**

Still and stitched imagery of the field were collected on 7/28, 8/13 and 9/8. Note from the picture below that the farmer switched varieties approximately half way through the field. The variety more susceptible to wind damage was also used for the border rows throughout the field. Also note the portion of the field that was protected by a windbreak of trees and buildings in the northern panhandle part of the field.

Field from the Southwest, 7/28/2020

In the foreground it is possible to see the damaged corn. In the background to the right it is possible to see standing corn. These are two separate hybrids.


This orthomosaic map was created by flying the field with an autonomous flight program. The images were taken and stitched together to show the complete status of the field. The lighter brownish areas within the field boundary are the areas were wind impacted the crop.


Plant health stitched imagery from 8/13/2020

Using the "Plant Health" map feature on Drone Deploy, it was determined that approximately 10 acres (+/- 2 acres) was severely damaged by wind.

The plant health feature uses an index called Visible Atmospherically Resistant Index (VARI) to apply a color palate to the map. In this case the red areas are the damaged areas and the green/yellow areas are healthy.

**Why is this important?**

Accurate crop damage assessments can be determined with a UAV. Among the 3 flights, mid-August seemed to be the "sweet spot" for an accurate assessment in this particular case, as July and September images were thrown off by the crop canopy still closing and leaves beginning to drop naturally, respectively. It should also be noted that hybrid selection played a huge role in withstanding high winds. Lastly, this case highlights a continued demand to train the agronomic industry in using UAV's, as the farmer noted that the insurance adjuster determined crop loss by physically walking the field.

# Acreage Determination for Planter Skips

***Austin Pearson - Agriculture and Natural Resources Educator, Tipton County***

**Objective:**

The Purdue Extension-Tipton County Office was contacted by a row crop producer inquiring about unmanned aerial vehicle flights for their corn fields as they had widespread spring 2021 planter issues. Purdue Extension-Tipton County flew 431 acres (17 total fields) using DroneDeploy to map fields post-harvest to estimate acreage impacted by the equipment malfunction so that the producer could approach the equipment dealer about potential compensation.

**Observations:**

After an initial test flight, it was determined that aerial imagery and post-processing with DroneDeploy could detect the planter skips as well as estimate the total acreage impacted by planter skips. Planter skips were easily identifiable as bare soil could be observed due to the lack of corn residue. A flight report for all 17 fields was generated with orthomosaic imagery from the flights (*Figure 1*), annotated imagery with polygons (*Figure 2*), and Microsoft Excel was utilized to calculate total acreage impacted within the fields.

*Figure 1: Orthomosaic Imagery*

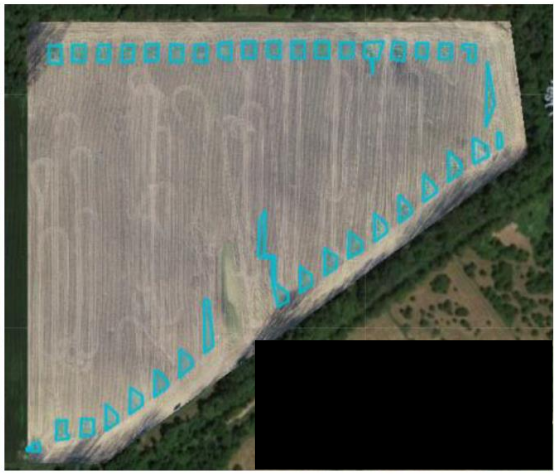


*Figure 2: Orthomosaic Imagery with Polygons*

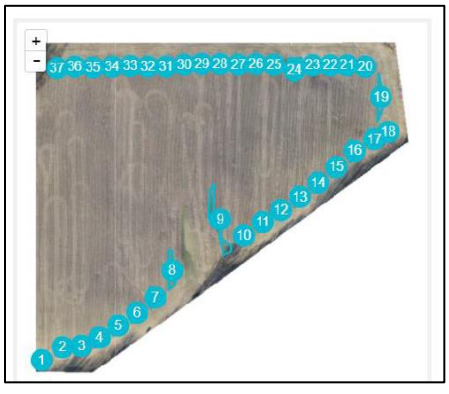



*Figure 3: Numbered Polygons*

Each polygon was assigned a numerical value (*Figure 3*) and was used to document the area within Microsoft Excel. Total acreage was then calculated accounting for each polygon. In this example, there were a total of 37 planter skips within this 38-acre field, most occurring near the end rows. It was determined that this field had a total of 2.03 acres of planter skips, which impacted 5.34% of the field. Assuming normal yields of 200 bushels per acre and a corn market price of $6.00 per bushel, that would equate to a potential yield loss of $2,436 from this field alone.

*Figure 4: Long Planter Skip*

When observing another field, it was noticed that the skipping issue was not subject to the end of the field. In this field, a planter skip nearly encompassed the entire length of the field (*Figure 4*). This particular skip accounted for 0.6 acres in the 16-acre field. Similar features were seen in 10 of the 17 fields.

All of the fields had skips near the end rows, which would suggest a planter stop/start issue. The producer noted that at times the planter monitor would indicate that the planter was planting backwards. Technicians visited the farm to attempt to work out the bugs, but could not fix the issue onsite. The producer had no choice but to continue planting the remainder of their corn crop.

All data from each of the fields are reported in *Figure 5*. Five of the fields had planter skips in excess of one acre. Planter skips ranged from 0.01-2.58 acres. Planter skips were estimated to be 14.8 acres out of 431 total acres, which is 3.43% of total acres intended to be planted.

This is may seem insignificant, but this directly impacts the producer economically. Similar to the previous example, assuming yields of 200 bushels per acre and a grain price of $6.00 per bushel the potential yield loss for all 17 fields was estimated to be $17,760. It is important to note that this estimate was not shared with the producer, but used for potential Extension impact.

| Field | Total Acres | Planter Skip (Acres) | % of field impacted |
|---|---|---|---|
| 1 | 10 | 0.44 | 4.40 |
| 2 | 16 | 0.76 | 4.75 |
| 3 | 11 | 0.85 | 7.73 |
| 4 | 20 | 0.01 | 0.05 |
| 5 | 60 | 1.41 | 2.35 |
| 6 | 11 | 0.75 | 6.82 |
| 7 | 16 | 0.61 | 3.81 |
| 8 | 7 | 0.11 | 1.57 |
| 9 | 50 | 2.01 | 4.02 |
| 10 | 25 | 0.12 | 0.48 |
| 11 | 41 | 1.11 | 2.71 |
| 12 | 18 | 0.28 | 1.56 |
| 13 | 11 | 0.61 | 5.55 |
| 14 | 24 | 0.98 | 4.08 |
| 15 | 67 | 2.58 | 3.85 |
| 16 | 6 | 0.14 | 2.33 |
| 17 | 38 | 2.03 | 5.34 |
| **Grand Total** | **431** | **14.8** | **3.43** |
| **Average/field** | **25.35294118** | **0.870588235** | **3.611601676** |

*Figure 5: Planter Skip Results*

**Why is this important?**

In summary, the use of unmanned aerial vehicles to quickly determine acreage impacted by planter skips was successful. Not only did it save time from manually measuring all skips, but it also helped guide the producer to estimate potential economic losses from the issue. Our internal estimates of economic loss of $17,760 using assumptions of 200 bushel per acre yield and $6.00 grain price. The producer was grateful for Extension's effort on this project and intends to approach the equipment dealer about potentially resolving the issue.

# Cornfield streaks

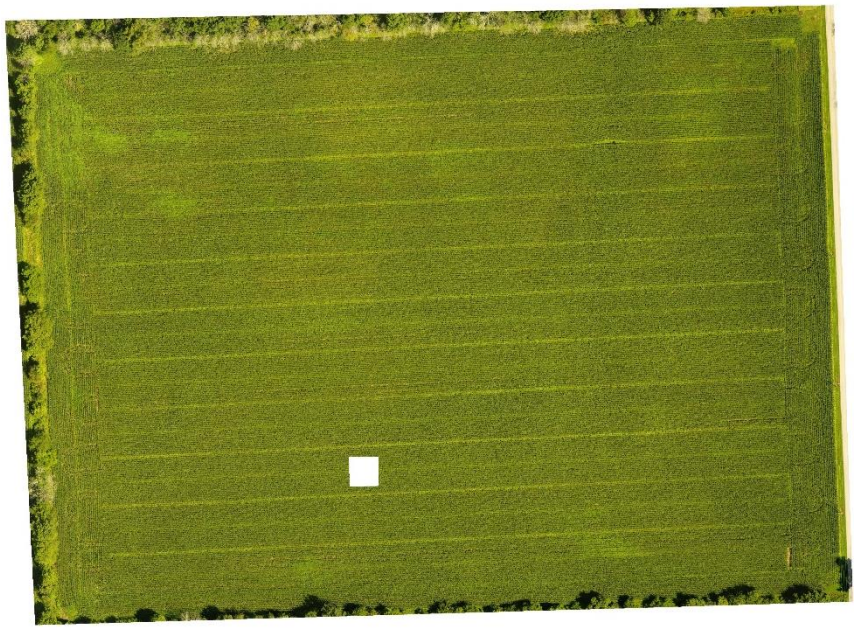
***Mark Carter - Agriculture and Natural Resources Educator, Blackford County – Precision Agriculture Coordinator***

**Objective:**

This cornfield was flown in summer of 2018 as part of the Infield Advantage program. The grower signed up a 30-acre field which was continuous to another 400 acres of corn. The corn was 9 feet tall and tasseled.

**Observations:**

After showing the producer the flight, we noticed that there were horizontal lines equal distant apart. We deduced that the lines were a plugged knife on his 28% applicator. All 400 acres were the same as the outside round on one side was lacking nitrogen due to that plugged knife.



**Why is this important?**

There was nothing that could be done to fix the situation in that growing season, but the producer learned that he needed to clear all the lines on the 28% applicator in between fields.

## Farm field survey demonstration

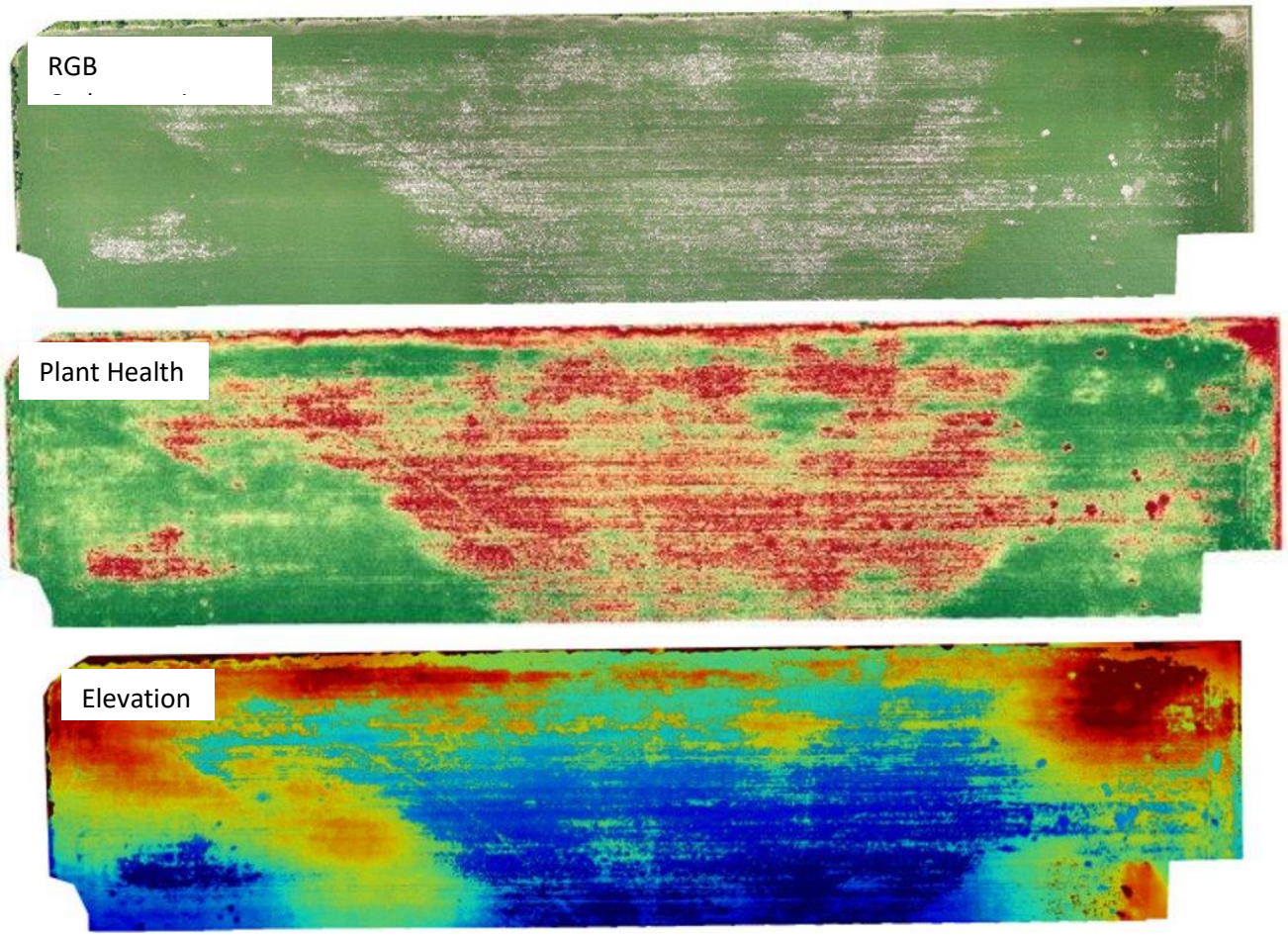
*Lais McCartney - Agriculture and Natural Resources Educator, Hancock County*

**Objective:**

A flight to demonstrate the drone to a local farmer to learn the capabilities and mapping aspects included in the software.

**Observations:**

Three maps were generated; an RGB Orthomosaic, a plant health (VARI), and an elevation map. It is possible to see that in the lower areas (blue in the bottom map) the crop stand or canopy was weak (brown in the RGB or red in the plant health).




**Why is this important?**

The producer was able to confirm a weed issue in some low-lying areas and also liked seeing the elevations. He may be interested in a UAV class in the future.

**INField Advantage flight – Greene Co.**

***Bob Bruner - Agriculture and Natural Resources Educator, Clay/Owen Counties***

**Objective:**

The purpose of this flight was to assist the farmer in determine the quality of his developing crop in a problem field (Fig. 1). Several flights were performed between June and July of that year, with the most obvious issues visible in mid-July. As the images demonstrates, a clear pattern of differing plant health correlated closely with different topographical features (Fig. 2) in the landscape.

**Observations:**

As the landscape elevation lowers on a north-to-south trajectory, ridges become more prominent features as the land shifts towards a nearby body of water. The plant health analysis (Fig. 3) shows that, as the topography varied along those ridges, crop development experienced a significant impact. This means that growers can use information gathered through UAV technology to plan for problems in field quality more efficiently.

*Figure 1. Orthomosaic image of corn field in Greene County.*

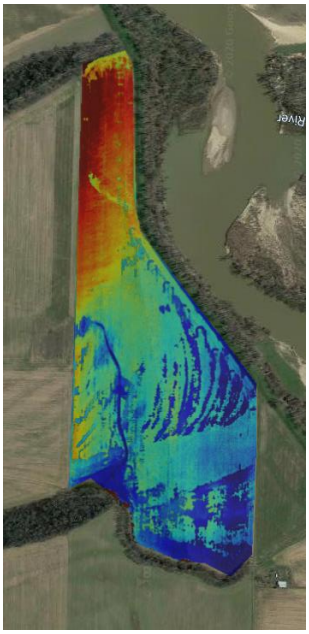


*Figure 2. Topographic map of corn field.*

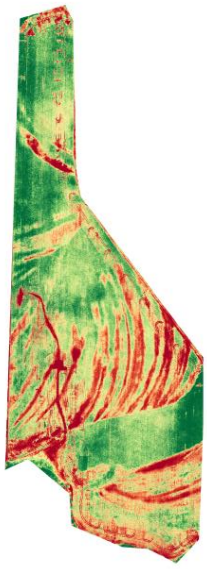


*Figure 3. Plant health analysis of field.*

**Why is this important?**

By examining details such as elevation shifts and changes in the land structure, both natural and man-made, drones can serve a purpose in planning not only during the growing season, but also before planting by looking at the interaction of water movement, land structure, and crop development.

## Corn Flame Weeding on Organic Grain Farm

***Ashley Adair – Purdue Extension Organic Agriculture Specialist (Former Agriculture and Natural Resources Educator, Montgomery County)***

**Objective:**

*Purpose of flights*: One 15-acre portion of an organic corn field was flown for a grower who acquired a new 16-row flame weeder. The goal of the flights was to show corn stress response, based on leaf color change, before and after the passage of the flame weeder. Flame weeders are fueled by propane and produce anywhere from 500,000 to 1 million BTUs for a very short period of time to weeds as the equipment travels through the field at 3-5 mph.

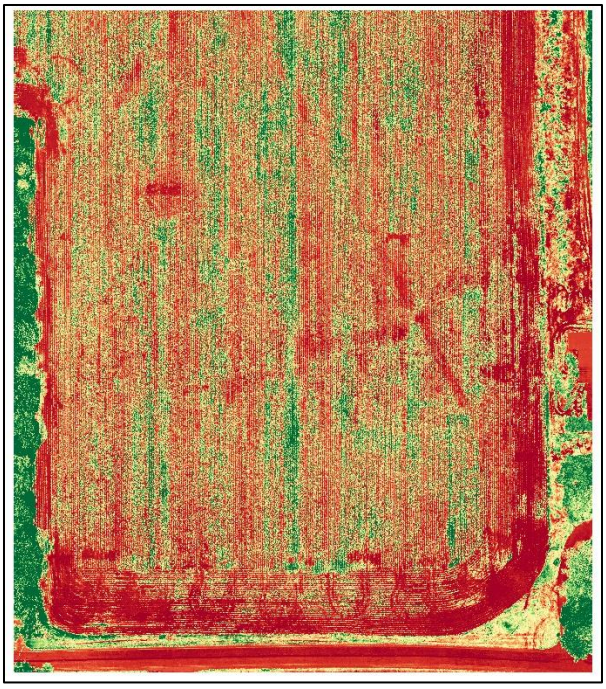
**Observations:**

Flights were conducted during a time period of learning for the farmer involved, so strips of the field were flamed over the course of a few days during the flights and at different thermal output. Corn was approximately V6 at this time. A Double 4K sensor was used to generate plant stress data using the NDVI algorithm. Because of the piecemeal nature of flaming the field, some strips of corn in the field show damage from the flame weeder while others don't. A time lapse camera was used in conjunction with drone flights to show the recovery of corn plants over time.

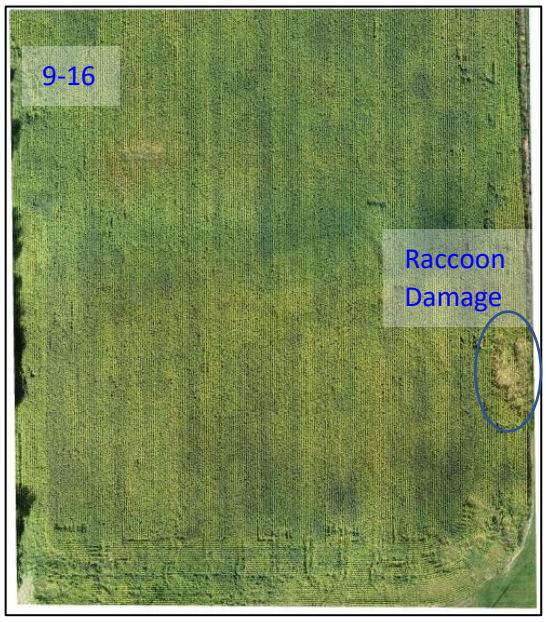
An image of the flame weeder. It uses a 500 gal propane tank to fuel the flame on a modified toolbar. Temperatures are in the thousands (F) and icing of the fittings can be problematic on humid days.

Corn plants showing damage on lower leaves from one pass of a flame weeder.

Aerial image using Double 4K sensor and NDVI algorithm to show areas of the field experiencing recent stress from flame weeding (red striping) versus areas of the field that had not been weeded yet (green striping). The diagonal line right of center is indicative of a traffic path used by equipment the previous year for clearing trees and shrubs in another corner of the field.



9-16: Corn has black-layered. The map shows some wheel tracks from various field operations through the season and the area at the top of the image shows raccoon damage. Overall corn appears healthy and weed pressure is low.




**Why is this important?**

This imagery was collected to show folks with limited flame weeding experience how a field might look half dead after treatment with a flame weeder, but how corn plants recover quickly over the course of the following 48 hours. Imagery and time lapse photography showed the farmer how quickly recovery takes place and whether the flame weeding operation was successful.

## Fresh Cut Flowers – Diversifying the Farm

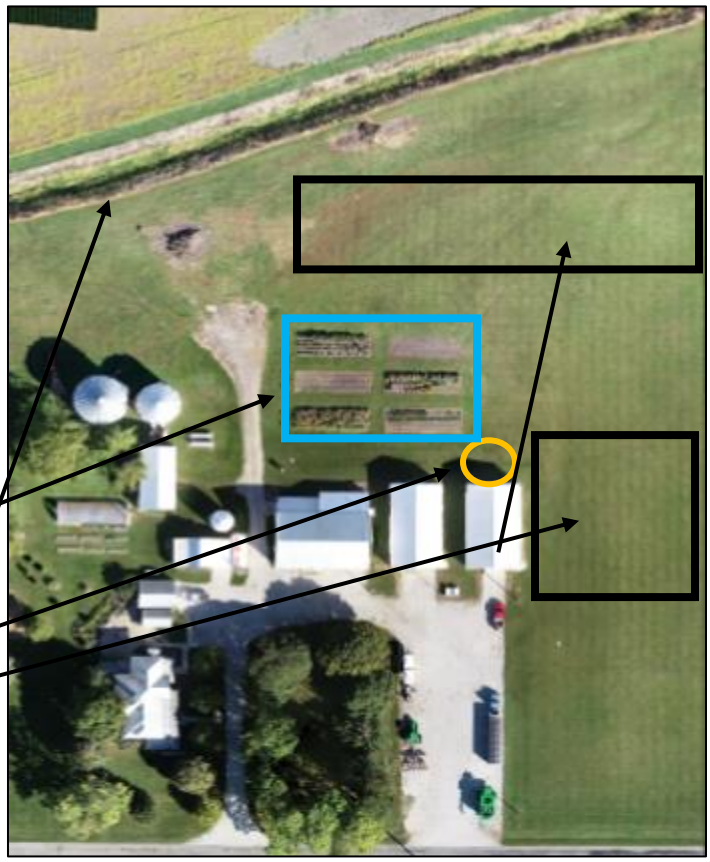
***Adam Shanks - Agriculture and Natural Resources Educator, Clinton County***

**Objective:**

A local farmer is diversifying the family farm to include a "fresh cut" flower farm. The family is wanting this to become a destination for pictures, gatherings, and sell some flowers along the way. The farmer wanted to see what his property looks like with the current flower beds and where they could place further flower beds, along with aesthetic items to enhance customers experiences while at the farm.

**Observations:**

Upon completion of the flight, we processed the imagery through Drone Deploy and created an interactive map for the farmer to investigate. There appeared to be room to expand the flower beds and add new ones. There was also room for a gazebo and some other items for experience enhancement.




**Why is this important?**

This farmer did expand the flower business in 2021. Due to COVID, the business did not see the number of customers that it had originally anticipated, so the growth was not as large as originally intended, but is still the goal as business increases.

# Irrigated Corn Case Study

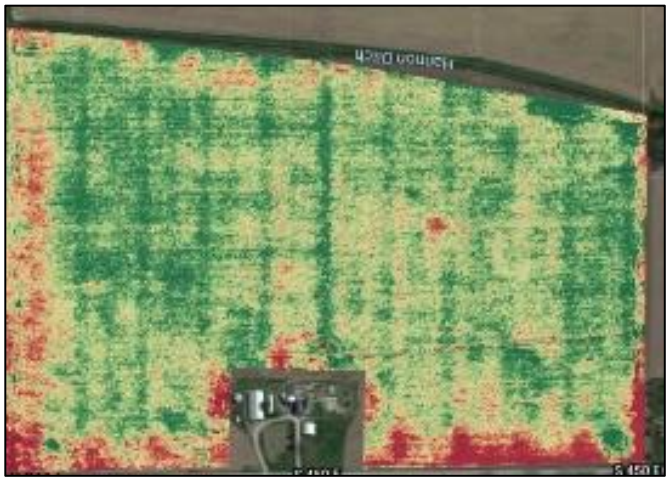
*Nikky Witkowski - Agriculture and Natural Resources Educator, Porter County*

**Objective:**

A corn grower was interested in flights of several fields, but specifically an irrigated corn field. We were both curious how the non-irrigated ground would look compared to the irrigated over time. I also flew a thermal imaging drone over sections of the field that were irrigated to see the heat differences in the field.

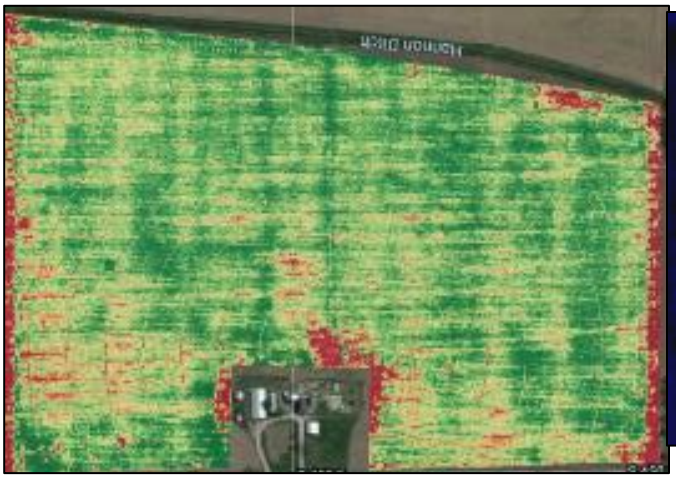
**Observations:**

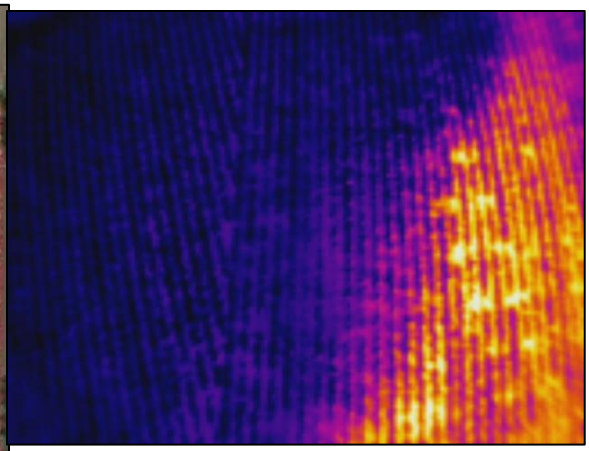
I flew the fields on a monthly basis for the plant health imagery. You can see from the following images how the field change over the year. You can see the May photo that the edges are suffering, but the field was not far along at that time.



The June plant health map shows that some of the edges appear to not be getting enough water as indicated by the red areas. The right edge has the irrigator end jet shut off to not hit the property that is adjacent. You can also see the lower right side has some more yellow/red as the irrigator does not go there due to the farmstead that prevents a full circle.

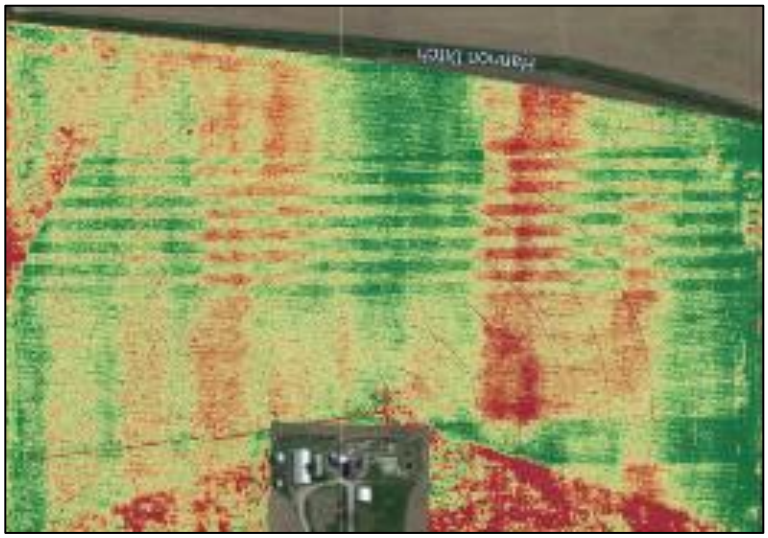
I collected thermal images as well when this was mapped and included one that shows the edge of irrigator path. You can clearly see the line of where the irrigator is watering or cooling off the plants versus missing them.





The last time I flew was in August after a droughty summer. Flying was more challenging later in the summer since I didn't want to fly when the irrigator was running. You can clearly see differences here with the non-irrigated areas generally redder than the overall field. The right edge of the photo is only green because the clouds appeared after 3 passes with the drone skewing the map.

You can also see striping in the field on the upper edge. This surprised myself and the grower. It turns out he was given a seed variety to try and the difference in genetics is showing.



**Why is this important?**

At time of writing this, yields were not available to determine if the irrigated areas were truly economically better/healthier or just "greener". The grower was interested in seeing the imagery and how crucial irrigation could be to the overall operation. It was also interesting to discuss the hybrid variation noted. In areas without irrigation it may be worth considering lower cost or fewer inputs in the future especially in droughty years.

## Varying Corn Populations Field Demonstration

**Austin Pearson** - ***Agriculture and Natural Resources Educator, Tipton County***

**Objective:**

A Tipton County producer wanted to evaluate corn plant populations using their average rate plus/minus approximately 5% (variable rate technology average = 38,500 seeds per acre, high rate = 40,000 seeds per acre, and low rate = 36,500 seeds per acre). Unmanned aerial vehicle flights were conducted to check the status of the crop throughout the growing season.

**Observations:**

Details from the demonstration are observed in Figure 1.

| | Population 1 | Population 2 | Average Population Rx |
|---|---|---|---|
| Previous Crop | | Soybeans | |
| Tillage | | Conventional | |
| Planting Date | | 5/6/2021 | |
| Row Spacing | | 30" | |
| Planting Equipment | | Planter | |
| Relative Maturity | | 108 | |
| Harvest Date | | 9/30/2021 | |
| Starter | | 10-34-0 blend | |
| Planting Population | 40,000 seeds/ac | 36,500 seeds/ac | 38,500 seeds/ac |
| Average Yield (bu/ac)* | 290.9 | 290.4 | 292.7 |
| Flight Dates: June 16, July 6 and 28 | | | |

*Producer Reported

*Figure 1: Demonstration Details*

The high seeding rate, 40,000 seeds per acre (green strip) and low rate, 36,500 seeds per acre (red strip), can be seen in *Figure 2*. All other areas received the variable prescription rate. Throughout the growing season, precipitation varied tremendously (dry and wet periods). Overall, much of the growing season ended up recording above normal precipitation.

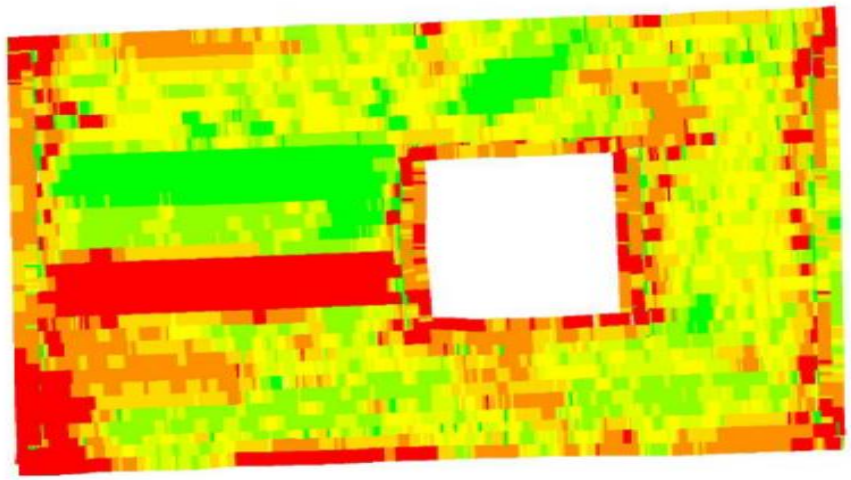


*Figure 2: Seeding Rates*

Three flights were conducted through June and July. From the beginning of the season, physical differences from the air could be seen on the northern side of the map (possible planting date difference). The vegetation appears to be physiologically more mature compared to the rest of the field (indicated by the red box in *Figure 3*). Planter skips can be seen at the end rows and where they planter may have stopped and started. Striping across the field can be seen, but seeding rate differences were difficult to tease out.

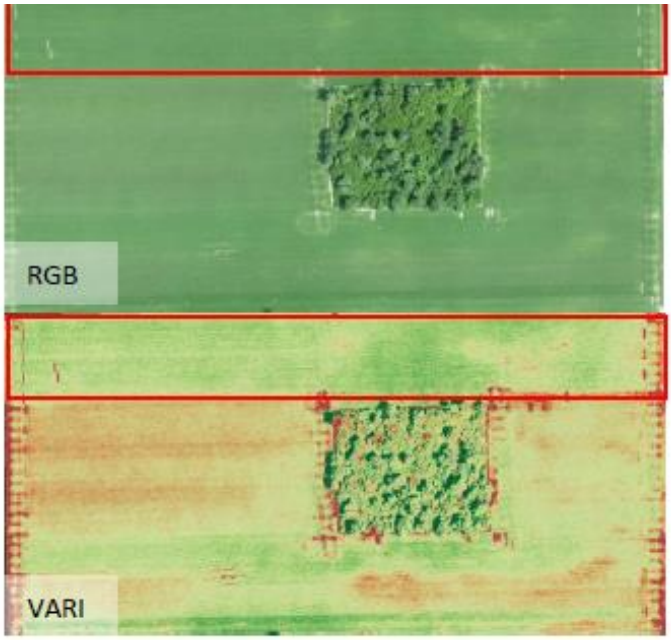


*Figure 3: UAV Imagery*

The producer generously provided a yield map (*Figure 4*). Yields appear to be very uniform across the field, especially on the west side where the seeding rates were altered. Producer identified data indicate that the prescription rate averaged 292.7 bushels per acre, which was nearly 2 bushels per acre higher compared to the high and low prescription rates.

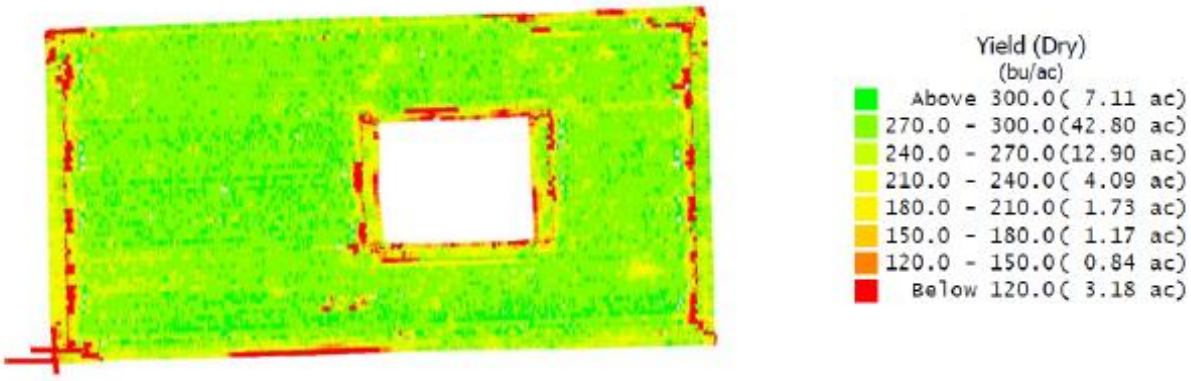


*Figure 4: Yield Map*

**Why is this important?**

Multiple flights struggled to pick up treatment differences in the field, but a possible difference in planting date could be seen on the north part of the field. Based on producer identified yield data, prescription rate yields (their standard practice) were nearly 2 bushels per acre higher compared to the high and low seeding rates. Based on two additional trials, there was no advantage to deviating from the prescription plan.

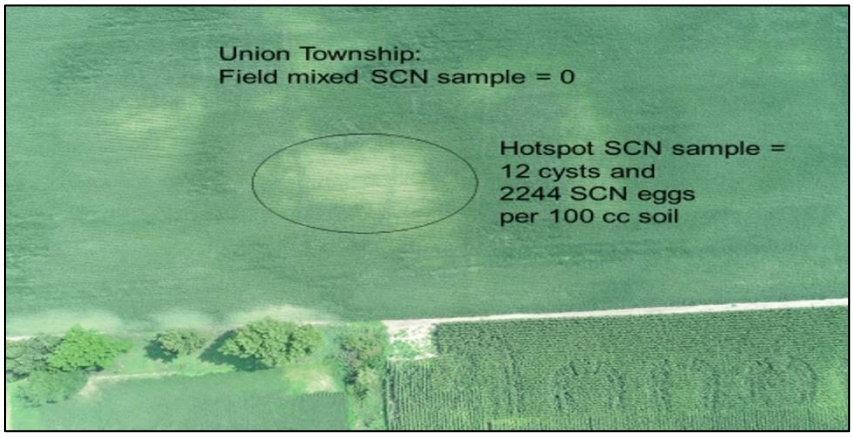
# Wells County Soybean Cyst Nematode (SCN) Survey

**Bill Horan** - ***Agriculture and Natural Resources Educator, Wells County***

**Objective:**
Two fields in each of Wells County's nine townships were flown and mapped with a UAV to determine if a UAV could be used to effectively locate SCN infestations, and to determine how widespread and serious the levels of SCN were in our fields.

**Observations:**
Once the fields were flown and mapped with the UAV, they were then sampled for SCN. A random sampling (five locations) was taken in each field to get a whole field average SCN infestation level, and then the aerial maps were used to pick out "hotspots" that exhibited thin, discolored, or stunted plants. These areas were sampled separately to determine if SCN populations were higher in that area and possibly a factor in that area's stress.

The SCN field survey kit, including DJI Phantom 4 Pro UAV, and soil sampling tools.




Wells County soybean field, showing "hotspot" area that tested high for soybean cyst nematodes.

**Why is this important?**
It was determined that the UAV was an effective tool to scout and survey for pests such as SCN. We also found that the levels of SCN in our county were very low, and for most producers, not a concern that warranted treatment other than crop rotation. These results were documented in a PowerPoint slide presentation, and delivered to farmers during three Pesticide Applicator Training sessions the following winter.

# Nitrogen Deficient Soybeans

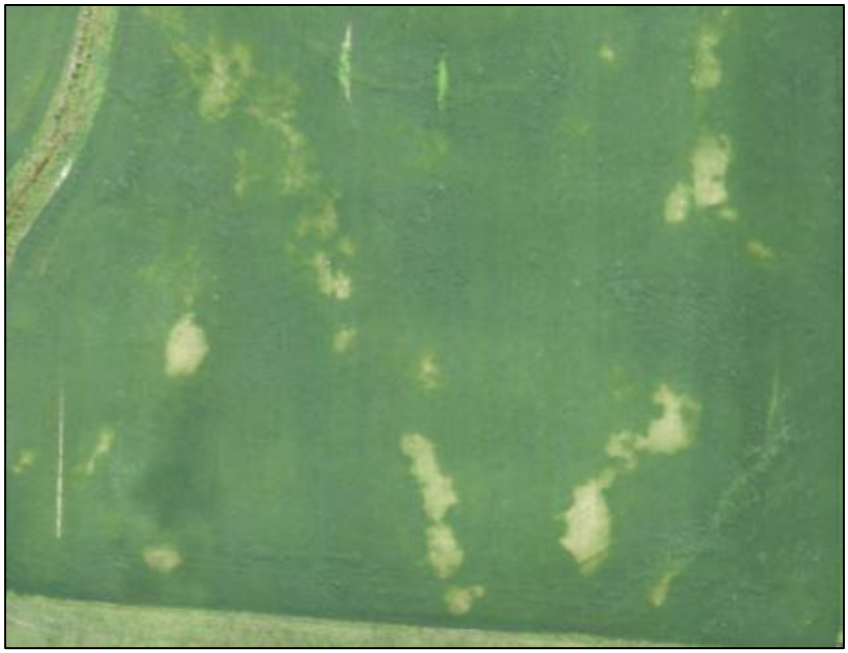
**Jon Charlesworth** - ***Agriculture and Natural Resources Educator, Warren County***

**Objective:**
The land owner and operator were seeing patches of light green (a.k.a. highlighter green) soybeans in several otherwise healthy appearing soybeans fields. UAV flights were conducted to get a better approximation of what proportion of the fields were affected.

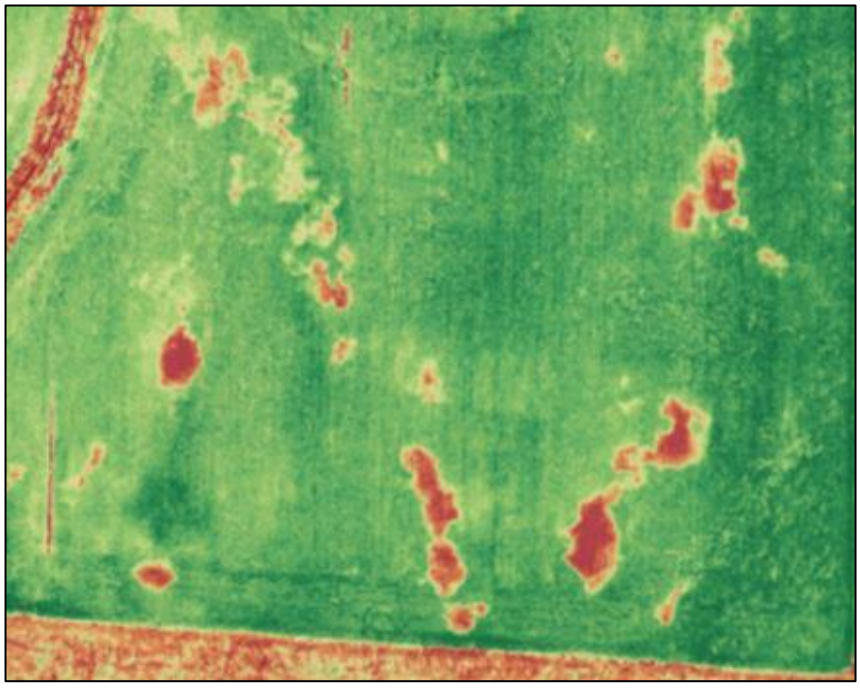
**Observations:**
Crop health maps and oblique angle aerial photos were useful in determining the extent of the crop injury. The pattern of discolored soybeans followed the same pattern as was seen in many fields during the summer of 2018. The light green soybeans were usually located on side slopes whereas the soybeans on the hill tops, swales and flat ground were a darker, healthy green. Representative plants of both the dark green and light green colors, were dug up, washed, and the roots photographed. The healthy dark green soybeans had much more extensive root systems and many more nodules on average. In addition, the nodule interiors on the healthy plants were a healthier pinkish-red color than the nodule interiors of the light green soybeans.

Oblique angle photo from altitude of 100’ showing extent of highlighter green soybeans in an otherwise healthy field of soybeans.

The stitched orthomosaic map showing in more detail the areas of stressed plants.



This is the plant health map (VARI) where the red spots are the stressed plants. This could be quantified for the producer to know exactly how many acres were under stress.



**Why is this important?**

It was determined that the discolored soybeans were a result of extended periods of wet soil in June and July and the shallow depth to limiting layer on these side slopes which resulted in delayed nodulation and reduced nodule health and activity. These photos were taken in 2018. At that time, it was assumed that this was a result of near record setting rainfall in June and July and that was an anomaly that would not likely be repeated. In 2021, we had very similar conditions leading to the same conditions but this time not on the hillsides, but rather in the low ground.

# 2018 Soybean Sulfur Demonstration

**Austin Pearson** - ***Agriculture and Natural Resources Educator, Tipton County***

**Objective:**

A Tipton County producer wanted to participate in the statewide sulfur study initiated by Dr. Shaun Casteel. The study involved applying a rate of 100 pounds ammonium sulfate per acre (20 pounds sulfur per acre) broadcast over V1-V2 soybeans. Unmanned aerial vehicle flights were conducted throughout the growing season, yield estimates, and plant tissue sampling. The purpose was to identify if addition of sulfur to soybeans would provide any yield benefits.

**Observations:**

The soybeans were planted on May 2, preceding a cereal rye cover crop that had grown over 3 feet tall and was terminated with herbicide on April 30. Once soybeans reached V1-V2, AMS was broadcast in strips across the field on May 13. The as-applied map is included in *Figure 1*.

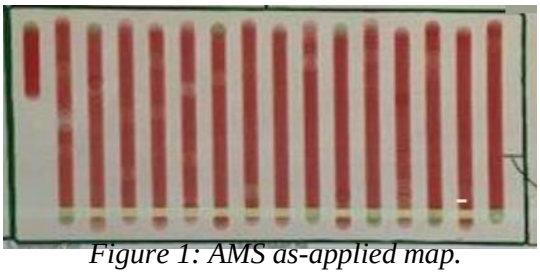


*Figure 1: AMS as-applied map.*

Throughout the growing season, localized damage was noted in the soybeans starting on June 1 and continued to be noted throughout the growing season. Images were collected both aerially and, on the ground, (*Figure 2*). Damage was even observable from the aerial imagery taken at 400 feet. This is likely due to a vertebrate pest of some sort, such as a vole, ground squirrel, or field mice and is not uncommon in fields planted to soybean after cereal rye cover crops.


*Figure 2: AMS as-applied map.*

Initial UAV flights were conducted on July 6 where AMS treated strips appeared dark green compared to the light green non-treated strips. Both could be picked up in the red, green, blue (RGB) and the plant health (VARI) images (*Figure 3*).

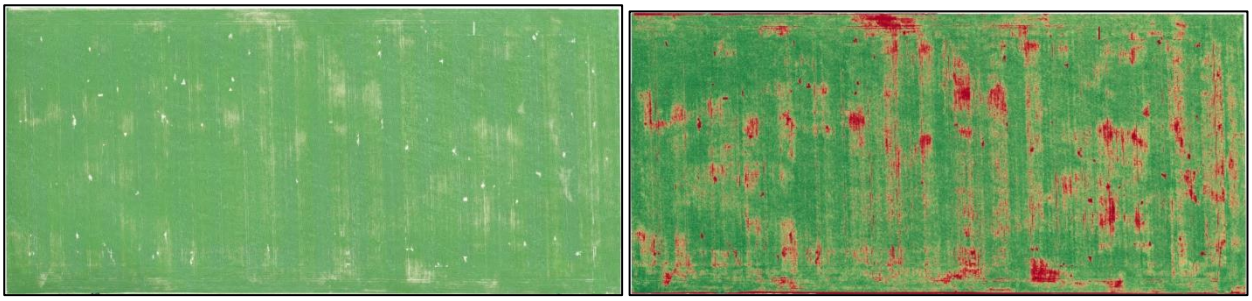


*Figure 3: July 6 Aerial Imagery RGB (left), VARI (right)*

Throughout the growing season, the non-AMS appeared lighter in color but also was shorter and had smaller pods. It was estimated that the non-AMS soybeans were roughly 1 growth stage behind the AMS applied soybeans. The AMS applied soybeans likely had an increased seed fill window and potentially larger seeds (*Figure 4*).

*Figure 4: AMS = treatment,*

Both tissue and soil samples were collected on July 11. Fertility levels in both the tissue and soils were adequate. The most interesting about the tissue results was the tipping point for the nitrogen to sulfur ratio (N:S). All of the treated plots had N:S ratio of 16.25:1 or less (resulting in an average yield of 85 bushels per acre), while the current Purdue critical number is 18:1. The general trend in this trial is that a lower N:S ratio results in a higher yield. It is also important to note that all treated plots had a sulfur concentration ranging from 0.38-0.41, while the generally accepted sufficiency range is 0.2-0.3. On average treated was higher overall in both nitrogen and manganese concentration which further drives biological nitrogen fixation and protein development further increasing seed size and scale. Most soil test variables were within the acceptable ranges. Phosphorus (P) and Potassium (K) levels trended higher in the AMS-applied zones compared to the no-AMS applied zones. Sulfur levels were elevated on average three times for the AMS applied compared to the no-AMS applied zones.

In both of the August 13 RGB and VARI images, treated strips were clearly visible driving down the road. Aerial imagery showed the same patterns as the July flight; however, the contrast between the plots with and without AMS is even greater as the plants mature (*Figure 5*).

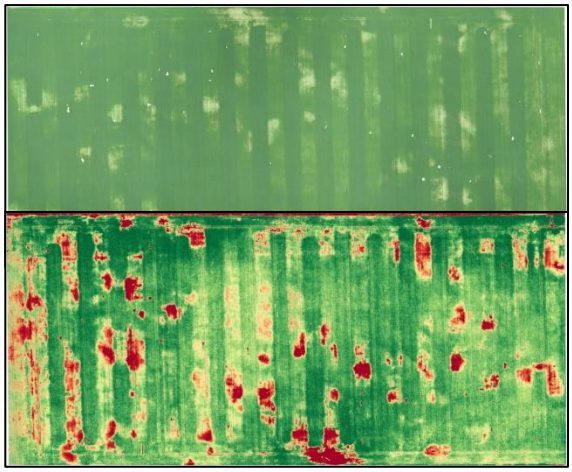


*Figure 5: August 13 Aerial Imagery RGB (top), VARI (bottom)*

Overall, the yield advantage in this trial was 11 bushels per acre for the AMS-applied soybeans compared to the control (84.9-73.9 bushels per acre). As indicated by the in-season flights, scouting, tissue, and soil samples this was likely due to an increase in available nitrogen and sulfur to the soybean plant throughout its growth and development.

**Why is this important?**

UAV flights accompanied with in-field scouting techniques allowed for the determination that in this particular case, AMS increased soybean physiological function allowing it to develop more quickly than the untreated. This increased photosynthetic capacity more rapidly and stretching the seed fill window over a longer period of time. The 11 bushel per acre observed difference has economic impact and the producer should repeat the trial to see if similar results are obtained.

# Sunflower Field Establishment

**Austin Pearson -** ***Agriculture and Natural Resources Educator, Tipton County***

**Objective:**

In fall 2020, Purdue Extension – Tipton County was approached by local producer wanting aerial imagery of their sunflower field. The producer was concerned about the bare spots in their field, given they were working with a local company to harvest for sunflower oil. This was their first-time planting sunflowers and had a planter setting issue, which led to poor establishment. Despite the poor establishment, the producer was highly successful with family photos.

**Observations:**

Both manual and autonomous flights were flown to assess the 2.4-acre sunflower field. Manual photos can be seen in *Figure 1* and *Figure 2*.

*Figure 1: Side shot of sunflower field.*

*Figure 2: Overhead shot of sunflower field.*

An autonomous flight was flown at 150 feet using DroneDeploy. The orthomosaic image (*Figure 3*) and plant health image (*Figure 4*) easily identify the bare spots due to the strong contrast between bare soil and healthy plant tissue. Surprisingly these widespread locations were not overrun with weed as the producers recently hired a crew to cultivate the weeds. The bare spots show up as red in the plant health image. By using DroneDeploy, it was determined that 0.4 acres had sunflower establishment issues (17% of the field).

*Figure 3: Orthomosaic*

*Figure 4: Plant Health*

**Why is this important?**

Unmanned aerial vehicle technology was quickly able to determine the total acreage impacted by establishment issues. The producer utilized the information to better control planting strategy for the 2021 growing season.

# Rodent Damage in Soybean

**Jon Charlesworth** - ***Agriculture and Natural Resources Educator, Benton County***

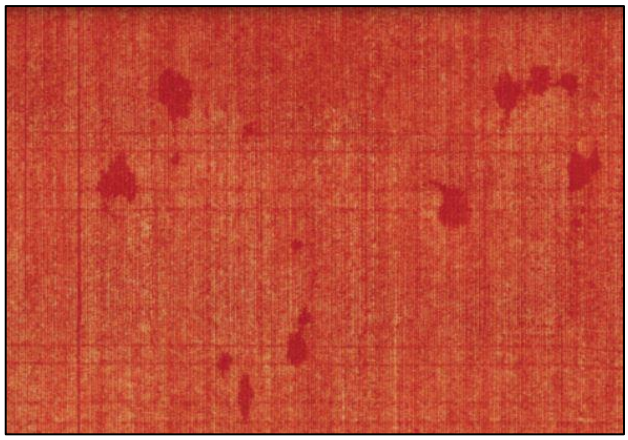
**Objective:**

The land owner and operator wanted to know if it would be possible to estimate percent crop loss due to vole damage in a soybean field. Flight was conducted on June 17th, 2020 and the soybean crop was at V4 growth stage.

**Observations:**

The resulting crop health maps were useful in determining an approximate percentage of crop that had been destroyed by the voles. The NDVI image was especially useful and seemed to be the most accurate predictor of what we could see when walking the field on foot. It was determined that the south half of the field was not heavily impacted. Using the NDVI image, I estimated that approximately 1%-2% of the soybean plants had been destroyed by voles and most of the patches were small enough in dimeter that the soybeans around the perimeter of these patches could be expected to subsequently fill in a significant portion of the missing canopy.

Stitched map of a portion of the infested part of the field. The irregular patches show the vole damage (an example is circled).



NDVI map of the infested area. The deeper red show the damaged areas clearly more clearly than the natural image.

**Why is this important?**

Using the aerial images combined with ground truthing by walking the field, the decision was made that it would not be worthwhile to attempt to do any sort of replant or interplant of the affected areas. I forward extension publications from Purdue as well as the U. of Missouri to the producer as he was interested in what management options he could consider pursuing after soybean harvest in preparation for the next season's corn planting on this parcel. After weighing options, this producer decided not to till this parcel but did opt not to plant any cover crop post-harvest. This field is also being scouted more thoroughly for vole damage because of the past infestation.

# Waterhemp Weed Escape Evaluation

**Phil Woolery** - ***Agriculture and Natural Resources Educator, Pulaski/Starke County***

**Objective:**

A producer contacted me to use my drone to scout a soybean field for weeds. They had noticed that there were some water hemp escapes, and they wanted to know if the weeds were just in one location or distributed throughout the field.

**Observations:**

To determine this, I performed a manual flight. I used a spot of water hemp to calibrate the height to fly. This was about 75 feet above ground where I could still identify the water hemp. This allowed me to scan the largest area while flying. I was able to scout the field in about 30 minutes. I found out that the water hemp escapes were in the southern and western part of the field.

Close up of a waterhemp plant. It is a slightly lighter green and is taller than the surrounding soybeans.

Overhead still shot of the field with some waterhemp visible. This was ~75 feet off the ground and the greatest height that waterhemp could be visually separated from the surrounding crop. (An example of waterhemp plants is circled)

**Why is this important?**

The producer was able to respray a portion of the field. They only sprayed less than 10 acres of the 160 acre field. This saved the producer time and money while controlling the weed escapes.

# Wheatfield streaking

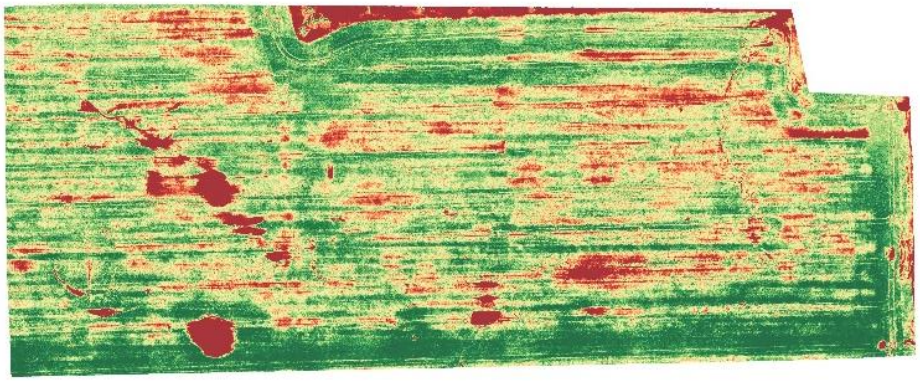
***Mark Carter - Agriculture and Natural Resources Educator, Blackford County – Precision Agriculture Coordinator***

**Objective:**

I had a producer contact me in May 2018 about flying a wheat field in southeast Delaware County that he was concerned about. He did not give me any indication of what the problem might be.

**Observations:**

I went out to fly the field late morning, it was a 230-acre wheat field that was about 6-8" tall. The seed heads were not coming on yet. After processing the imagery from the field, I met with the producer to show him the imagery. We looked at the imagery for about 15 seconds when he excused himself and called his crop consultant and insisted he come to the field at that minute. The consultant showed after about 20 minutes and looked at the imagery. They proceeded to walk the field after looking at the imagery and determined that there was a serious nutrient deficiency in much of the field in streaks. Upon inspection of the fertilizer spreader wagon used to apply the producer's fertilizer, it was found that it did not function properly.



The VARI maps shows the streaking clearly across the field. The red lines are the areas where urea was underapplied.

**Why is this important?**

Due to the failure on the spreader cart, the fertilizer company did another application of urea (nitrogen) to the producer's wheat. The producer and crop consultant figured that the field received a 5-10-bushel yield bump from the second application. Crop price at harvest was $5.30 for 230 acres and 10 bushels per acre yield bump is $12,190 more revenue the producer potentially received.

## UAV Imagery Assists Farmers in Estimating Construction Damage

***Andrew Westfall - Agriculture and Natural Resources Educator, White County***

**Objective:**

For the last several years, White County has had numerous energy related construction projects interrupt farming activities throughout the county, including transmission tower installation and windmill construction. Despite farmers urgings, oftentimes these projects are constructed in fields in less than ideal conditions, leading to long and short term damage to the farm ground caused by compaction and damage to tile. Throughout the past few years, I have flown over a few of these construction projects that farmers have inquired about in attempt to measure damage and monitor soil recovery.

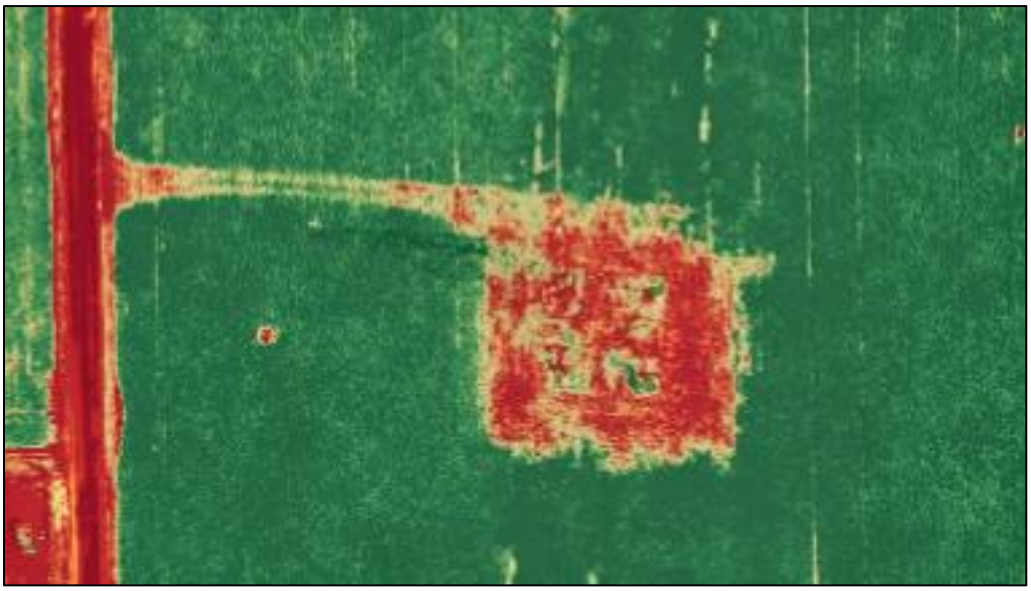
**Observations:**

The first example, is from a farmer who suffered tile damage in one of his fields during the construction of a transmission tower. As a result, several acres of his field drowned out that year, leaving a much bigger imprint of damages than what the company initially planned on. Using stitched imagery, we were able to determine the exact amount of acreage that was damaged or taken out of production, totaling almost 5 acres. This information assisted the farmer in computing an appropriate amount of damages to seek from the company.

In the second example, the farmer was interested in long term impacts from transmission tower installation in agricultural fields. After 2 years of production, it appeared that plant health was back to normal, however from the air it was clear that the imprint of these projects expanded beyond the imprint of the tower:

Picture from the East, June 9 2018

We then conducted a programmed flight on July 14th to gather plant health imagery and found an interesting pattern: the path that the company used to access the tower was still quite visible 2 years after use.



**Why is this important?**

These flights led to conversations between farmers regarding fair compensation for construction projects and interest in Purdue soil science researchers to assess the length of time that soils recover from compaction from projects such as these.

# Hemp Seeding Rate and Nitrogen Research

***Valerie Clingerman - Agriculture and Natural Resources Educator, Knox County***

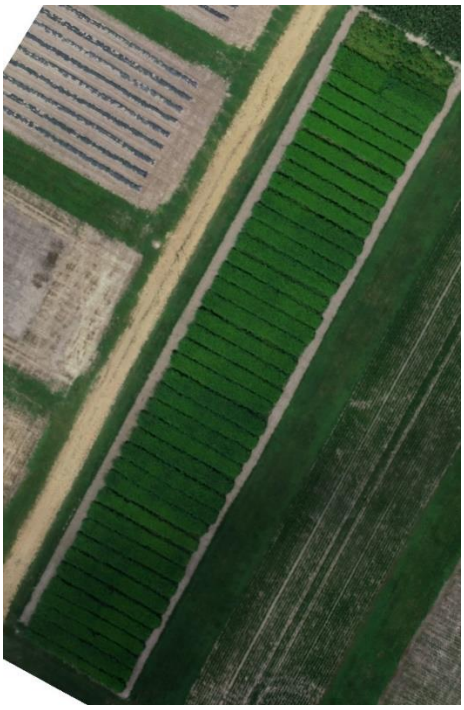
**Objective:**

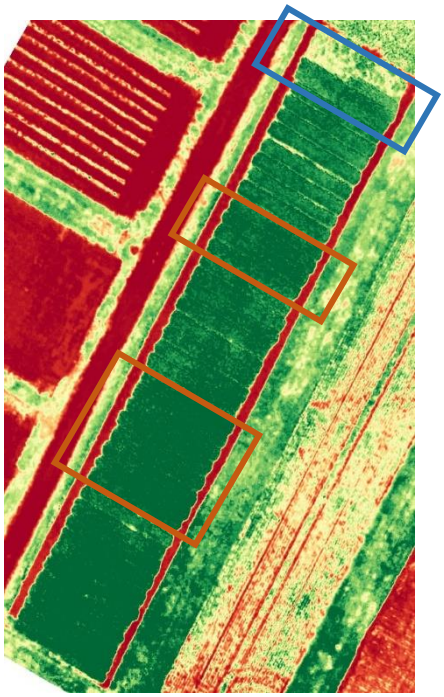
This trial had four fiber hemp seeding rates and three Nitrogen rates (50, 100, 200 lb./a) replicated three times and was drilled 5/16/2019. On July 10th plots were flown with a Phantom 4 Pro.

**Observations:**

Not able to see many differences between seeding rate/N rate in the plant health map. You can see a slightly darker area and less space between the planting passes in the plots that received the highest N rate (orange boxes).

On the top right of the images there was also a variety trial planted with 10 hemp varieties that originated from Canada and Italy (blue box). In the plant health map, you can see that the Italian lines are still reflecting greener than the Canadian lines.





**Why is this important?**

The plots with the highest N rate (200lb/a) statistically yielded more with 6.1 T whereas the 100 lb. rate and 50 lb. rates were statistically similar yielding 4.9 T and 4.6 T. Higher nitrogen rates also yielded taller plants, more lodging, and slightly larger stem diameter (Fig. 1).

When the temperatures warmed up, the Canadian plants started to shut down.

Effect of Nitrogen rate

| N Rate | Yield, T | | 7/10/2019 HT 1, in | | 8/15/2019 HT 2, in | | Lodging, % | | Stem dia, mm | |
|---|---|---|---|---|---|---|---|---|---|---|
| 200 | 6.1 | a | 68 | a | 106 | a | 19.8 | a | 7.2 | a |
| 100 | 4.9 | b | 63 | b | 96 | b | 10.6 | b | 6.3 | b |
| 50 | 4.6 | b | 62 | b | 91 | c | 6.3 | b | 6.3 | b |
| LSD | 0.939 | | 2.5 | | 4.0 | | 4.65 | | 0.38 | |
| C.V. | 11.58 | | 4.51 | | 4.83 | | 45.04 | | 6.92 | |
| MEAN | 5.2 | | 64.5 | | 97.9 | | 12.2 | | 6.6 | |

Figure 1: Nitrogen rate effect, provided by Chuck Mansfield and Marguerite Bolt

# Hemp growth and production for new growers

***Scott Gabbard – Agriculture and Natural Resources Educator, Shelby County***

**Objective:**

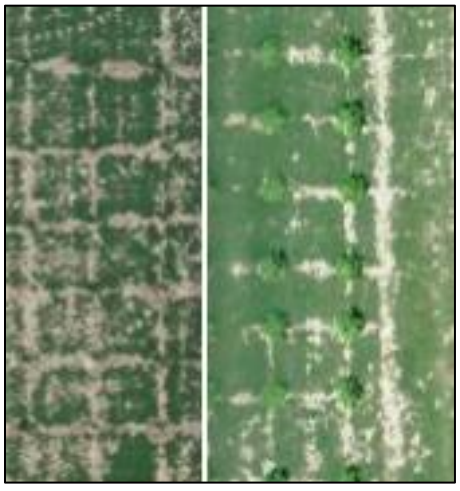
Growing Hemp is a relatively new cash crop that can be legally grown in Indiana. Cooperating with the grower, it was agreed that it would be interesting to watch the growth and development of the crop on the site throughout the year through periodic flights paired with ground operations.

**Observations:**

Four scheduled flights were made and correlated with ground observations to show growth and development from shortly after planting to the day of harvest.

*June 26th*

*July 24th*



Side by side comparison of the orthomosaic depicts the size differences of the plants and relatively growth one month later.

September 10th

Sept 22: Harvest

By September 10th, harvest is just over a week away. Plants missing due to root problems can be clearly seen (arrows). On September 22nd, over half of the 2-day hand harvest is complete (notice the tractor wagon and workers).

On August 12th, flights were made to help to determine the cause of healthy plants suddenly dying. Campus specialists and PPDL staff were live-streamed the drone's aerial view to see the layout and plant placement real-time while being able to converse with the grower and extension educator over 100 miles away in real-time. Using the drone to aid in picking plants to dig, package and send off for sampling; it was determined that the plants had become root-bound as seedlings before they were planted in the field (August 12 photos below, last photo clearly shows where three samples were taken for processing).

**Why is this important?**

Using the drone gave the grower and educator a unique view of the hemp growth process to compare to future seasons. It also served as a useful tool to aid specialists and pathologist in "seeing" the sight real-time to work with field staff and producers in making more informed decisions in field sampling to aid in more accurate results.

# Hemp Cultivar and Row Spacing Evaluation

***Bob Yoder – Agriculture and Natural Resources Educator, Marshall County***

**Objective:**

A local producer was curious about using drones to evaluate different hemp cultivars and also worked with Extension to see if row spacing impacted hemp production.

**Observations:**

The field was planted late July due to challenges in growing transplants, so size of hemp plants was impacted. The five varieties being evaluated were Unos, Sweets, Wifes, Cherry wine along with five cultivars under research at Sunrise genetics. Transplants were planted in 16 inch, 36 inch, and 72 inch row spacing.

Stitched image of variety plots and spacing within row study, note where plants looked tight was 16 inch spacing. Darker green large plants were the Sweets and large lighter cooler plants Cherry wine due to disease.

**Why is this important?**

Of the named cultivars, Unos performed poorly in part due to late planting so were small in size. Sweets and the five Sunrise research cultivars performed the best in terms of size, health, and production of CBD. Cherry wine had disease issues so appear yellowish in photos. It was noted that 36 inch spacing worked best in the shortened season.

# Hemp Cultivar and Planting Date Evaluation

***Bob Yoder – Agriculture and Natural Resources Educator, Marshall County***

**Objective:**

A local producer was curious about using drones to evaluate different hemp cultivars; as well as; looking at the effects of planting date on production.

**Observations:**

The cultivars were not taken through harvest due to lack of market so little work was done after the initial flight. The area with cultivar testing was mapped, photographed, and video recorded for the producer to review later. The planting date project was taken to harvest. It is possible to see in the imagery that the May planted hemp struggled more with disease and resulted in taller plants. The June planted was a more manageable plant size and healthier, resulting in a higher quality and more marketable product.

The map of the cultivars. It is possible to see variety in growth habits and disease pressure.

An image showing the two planting times side by side. The June planed is in the foreground being greener and the May planted in the background with yellowing leaves.

**Why is this important?**

The cultivar portion was terminated due to not finding a market for CBD oil extraction, so was not harvested. When looking at planting dates it was noted that the May planting date resulted in larger hemp plants with poor quality due to disease; while the June planting date produced a more manageable plant with superior health, quality, and marketability for the producer. This was critical since the only market the producer was able to secure was for smokable hemp in Michigan.

# Southern Indiana Hay Field Diagnoses

*Miranda Edge - Agriculture and Natural Resources Educator, Harrison County*

**Objective:**

Flights were requested by individual producers who felt there were changes in yields of their hay fields. There were 5 flights made in 2019 and 2020 for 3 hay fields to determine if there were visual changes in the field. One field was a mixture of clover and fescue.

**Observations:**

The first flight in 2019 showed striping patterns, delineating a nutrient deficiency. Soil analyses were then taken to determine recommended fertilizer applications. When the field was flown after the application and prior to the final cutting made that year, the striping pattern had almost completely been corrected. In a mixed grass hay field flown in 2020, aerial views showed no definite pattern leading to the producer and educator to conduct further tests and determine a compaction issue creating low yields in parts of the field.

**Why is this important?**

Mitigation included adding deeper rooting grasses and cover crops during the winter to break up the compaction and improve yields over several years. A new flight will be conducted along with other tests (compaction and nutrient analysis) in 2022 to determine any changes in the field. A third field was flown to determine the location of noxious weeds outgrowing the intended hay crop. Once identified, the producer was able to quickly manage the weeds and reduce time needed to improve yields in the hay field.

# UAV Derived Stand Counts

***John Scott – Purdue Extension Digital Agriculture Coordinator***

**Objective:**

Using a UAV for to conduct a stand count is nothing new. What is improving vastly is the various algorithms abilities to identify plants and generate an accurate stand count. Drones were tested on performance in taking stand counts to evaluate seed spacing and uniform stand in rows of popcorn and field corn.

**Observations:**

*Popcorn -*

Flights were conducted around the V2 growth stage or when two leaves are fully emerged to avoid too much canopy coverage. Four flights were conducted at 30, 50, 70 and 400 feet above ground level to compare resolution. Counts were conducted using Drone Deploy as well as Purdue startup Progeny, then compared with data from field crews. This was conducted in 2019, using what is now more rudimentary algorithms.

Popcorn breeding plot that was isolated for stand counts.

The same plot as above with the analytics conducted. Each red line indicates a computer recognized plant within the blue plot border.

*Field Corn -*

This example in corn was flown at 50 feet and covered about 7 acres with about 0.1 acres per point. While the algorithm was unable to collect enough data to evaluate all points (black dots are points without data), it did return a decent idea of what the field stand is. After the flight a manual count was conducted in 4 spots of the field.


An overall 'production' scale stand count conducted at field edge. The black dots represent areas the algorithm was unable to get an accurate count but overall the count was within expected tolerance compared to a manual count. There is room for the algorithms to improve as more data is incorporated into the model.

**Why is this important?**

*Popcorn -*

Both counts fell within an acceptable margin of error for the popcorn company.

*Field Corn -*

The software average stand was 32.9 for the counts collected and the counts in the 4 spots ranged from 32-33,000. This being the case it took about twice as long to manually get the stand counts by physically walking.

*Soybean -*

Attempts at soybean stand counts resulted in less than satisfactory counts, but again the technology can only improve.

# Agras MG-1P Aerial Applicator Summary

***Alex Helms – Technology Coordinator, Southeast Purdue Agricultural Center***

**Objective:**

Agricultural operations, such as spraying, can be difficult given the short window of time required to make applications, and is complicated by weather patterns that are difficult for meteorologists to predict. Warm temperatures several days after a significant rainfall event may provide optimum weather conditions for applications, but saturated soils can prevent tractors and larger agricultural equipment traveling through the field. Although manned aerial applications can continue with saturated soil conditions, producers must provide a number of acres for business that will allow an airplane or helicopter the economies of scale to make a profit, which can be difficult for small farmers and researchers. Small unmanned aerial systems (sUAS) can be a practical alternative to heavy ground equipment and larger more expensive manned aircraft across a small number of acres.

**Observations:**

The Southeast Purdue Agricultural Center (SEPAC) staff has deployed a DJI Agras MG-1P sUAS across a number of acres when ground conditions did not allow equipment to travel across the field and when the number of acres to be applied were too small to contract a custom manned aircraft. For example, in April of 2020 frequent rainfall events causing saturated soil conditions were making burndown herbicide applications difficult, but warm and sunny days following rain events caused cover crops to grow rapidly and would have otherwise been ideal conditions for herbicide applications. SEPAC staff was not able to spray a six-acre field prior to soil conditions becoming saturated with more rain in the forecast, so the Agras MG-1P was deployed to complete the application. The field was too small for a manned aircraft and too wet for ground equipment, but easily completed with the Agras. Figure 1 shows the success of the burndown application, without major compaction and damage that would have been created with a ground sprayer. The aerial burndown application allowed the cover crop to begin decaying earlier and planting to occur more timely compared to waiting for proper soil conditions with a ground sprayer.


*Figure 1-Burndown herbicide application applied by Agras MG-1P at 3 gal/acre. The brown area represents the field that was sprayed and shows the desiccated cover crop.*

In addition to spraying herbicides, fungicide applications can be important to protect corn and soybean plants from leaf diseases. Many of the fields at SEPAC are small and near trees that make manned applications difficult and dangerous. A military training center near SEPAC also complicates manned

aircraft applications. During the 2021 growing season, SEPAC staff applied fungicides on nearly 45 acres of corn with the Agras that was unable to be contracted by larger manned aircraft. Determining if a fungicide application is an economically sound practice is important and control areas or plots are required to observe the fungicide's impact, or lack of impact, and can be difficult or impractical with larger manned aircraft due to the small number of acres and trial design. During the growing season of 2020, SEPAC staff designed a small corn fungicide trial with plots being sprayed with a fungicide and some plots not being sprayed as a control group. The entire trial area consisted of only eight acres with individual plots being nearly one acre or less in size. In this one instance, the corn plots sprayed with fungicide yielded higher compared to the control plots except for the plot nearest to the tree line which is typically impacted by excess soil moisture and shade from the trees (Figure 2). Although fungicide trials should be conducted for several years across many environments and conditions, the trial provided some insight on the financial and yield impact of a fungicide for the 2020 growing season. The sUAS capabilities allowed the trial to be large enough to be harvested with a commercial combine and yield monitor while being confined to a relatively small number of acres.

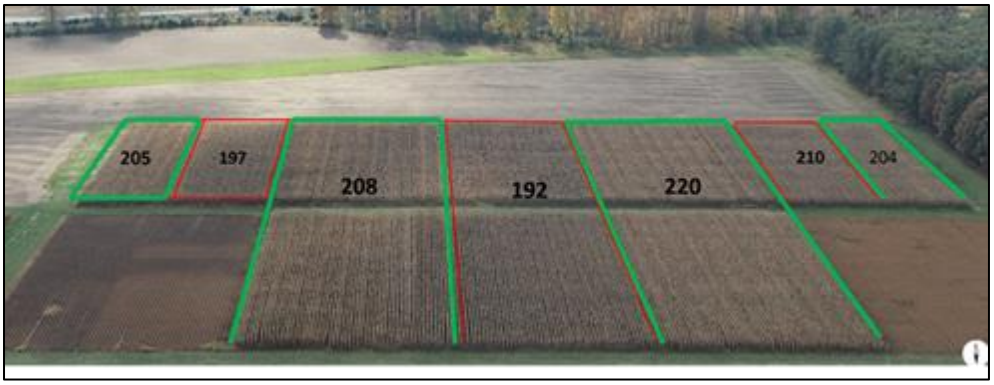



*Figure 2-Aerial image captured in September of 2020 of the corn fungicide trial. Yield in bushel per acre are overlaid on each plot area with the green areas representing plots with a fungicide application and red areas representing control plots.*

**Summary**

Traditional agricultural equipment will not be replaced completed by sUAS spray equipment in the foreseeable future, but may provide producers and researchers a solution for less conventional spray applications. The relatively low expense, increasing accessibility, and proven ability is providing a niche for some applicators and producers to exploit. As sUAS technologies improve, so will the practical implications of systems similar to the Agras MG-1P and adoption across the agricultural industry will grow. These examples provide evidence that sUAS can be an effective alternative in certain spray situations that are impractical or not advised for ground equipment and manned aircraft.

# ***UAV Initiative***

# ***Education Activities***

Specializing training with UAVs in an increasingly digital world for work and play.

# 2021 White County Ag Day gets 4th Graders Excited about UAV's

***Andrew Westfall – Agriculture and Natural Resources, White County***

**Objective:**

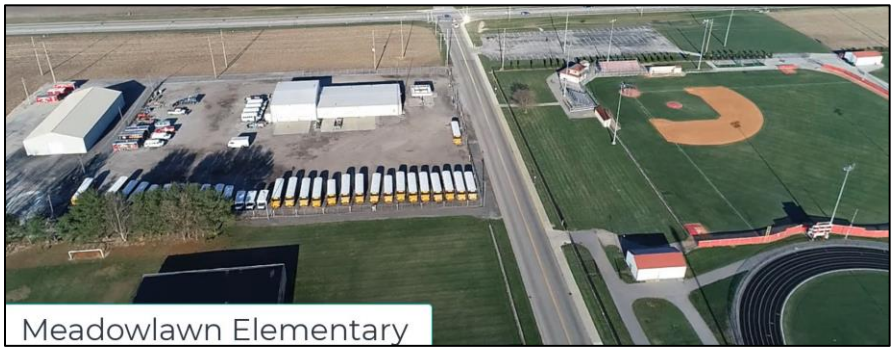
Each spring, the Purdue Extension Service of White County hosts Ag Day at the White County Fairgrounds. During the event, 4th graders from around the county spend the day at the fairgrounds learning about different aspects of agriculture including: livestock, crop production, farm safety, ag history, and ag technology. For 2021, the event went virtual with the Purdue Extension team creating an interactive website that students and teachers could interact with and learn from at their own pace.

For the ag technology portion, I put together a video for students where I talked about how technology is used in agriculture, including how UAVs are impacting agriculture and how I use one to help farmers and businesses in White County. Along with the presentation, I also recorded a flight at each elementary school so that kids could see a drone take off from a familiar site and get an aerial view of their school and town. This also relayed to kids how easy flying a drone can be and how quickly aerial views and imagery can be obtained.

**Why is this important?**

227 4th grade students in the county viewed this presentation. A pre and post-test was offered to participants to gauge their agricultural knowledge, with students showing a 23% improvement between the tests. One teacher noted that, "This REALLY was amazing!!! For this particular group of students, it worked out best for them to watch just a few lessons and have good discussions each time. Thanks to you and all of the volunteers who put this together! Andrew's drone presentation was awesome, too! I'd love to have him come share sometime--showing each elementary building was a GREAT idea!"

The 2021 White County Ag Day Website can be found here: https://bit.ly/2021WhiteCoAgDay




# Railroad Safety Demo

***Ashley Adair – Purdue Extension Organic Agriculture Specialist (Former Agriculture and Natural Resources Educator, Montgomery County)***

**Objective:**

This flight was conducted at the intersection of the Kankakee, Beaverville and Southern (KBS) Railroad and Lindberg Rd in West Lafayette, IN on July 2, 2020. This flight was requested by Fred Whitford, who was authoring a publication (now PPP-135) and gathering material for safety presentations across the state for winter meeting season that year.

**Observations:**

The KBS intersection with Lindberg was identified as a hazardous intersection due to its high volume of traffic and relative lack of safety equipment. This intersection was a stop sign only intersection at the time, with no automatic crossing arms. Safe crossing at the intersection was entirely up to motorists paying attention to the train whistle in the event of a train crossing.

The KBS Railroad intersects with Lindberg Rd. Image illustrates a common condition for RR crossings across the state of Indiana. The only safety features at this crossing are stop signs and RR crossing signs. This image was featured in PPP-135.

**Why is this important?**

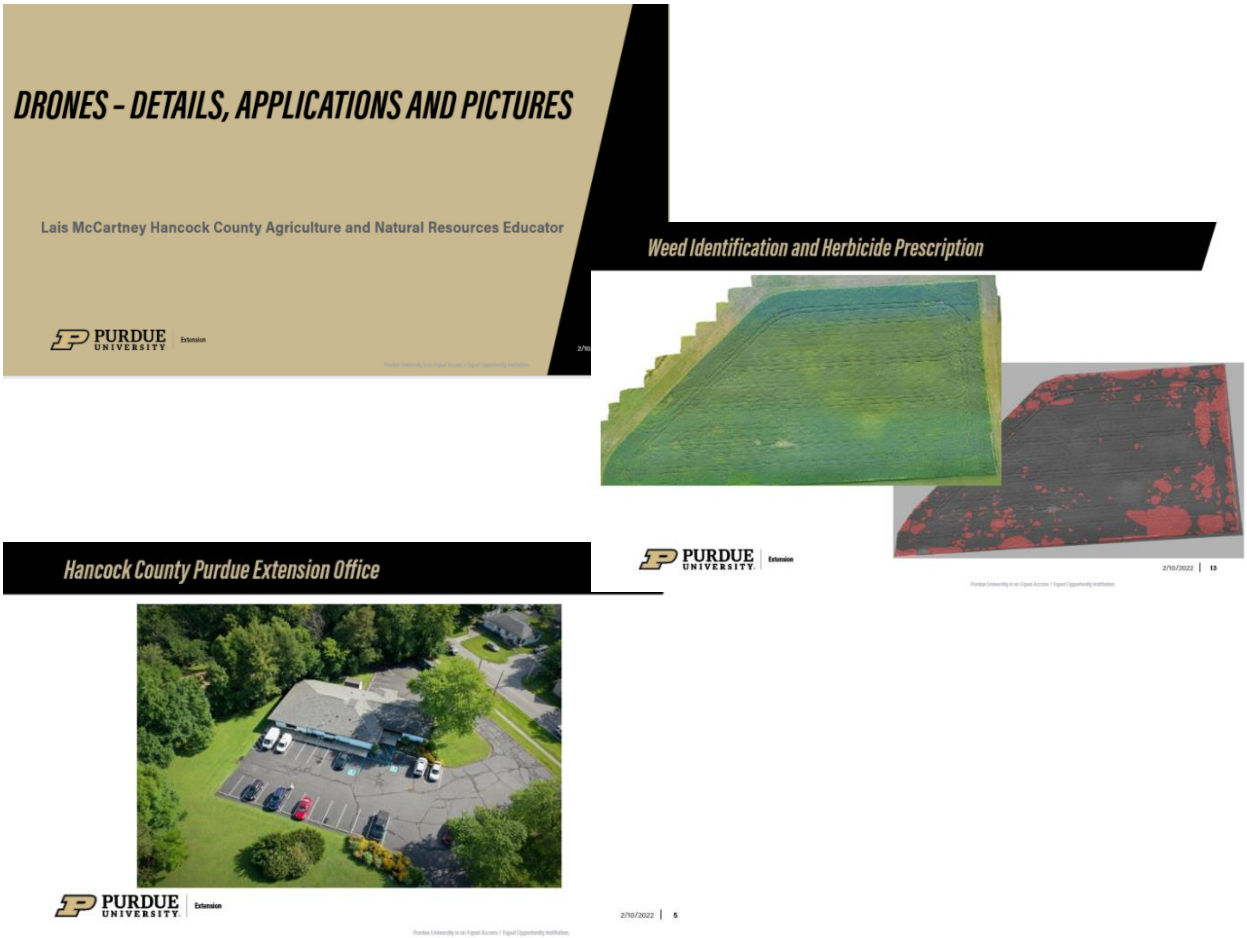
Photos from the site demonstrated the hazards of crossing this intersection. Video from the site demonstrated the speed of an approaching train (about 30mph) and the relative distance of the whistle signal from the intersection (i.e. how long a motorist might have to anticipate the train's crossing). A photo from this flight is featured on page 15 of PPP-135 and video from this flight was featured during Dr. Whitford's presentations on railroad safety during the 2020-21 winter meeting season.

## 4-H Junior Master Gardeners

***Lais McCartney - Agriculture and Natural Resources Educator, Hancock County***

**Objective:**
Showed the 4-H Junior Master Gardeners club how drones can be used in various aspects of horticulture and farming.

**Observations:**
The students enjoyed seeing the drone demonstration and one student was very excited to learn more even after the class was over. His mom said that he doesn't like many things and she was glad he took interest in this technology. I shared a presentation to highlight the technology and some practical uses. (excerpts below)




**Why is this important?**
The Junior Master Gardeners learned that careers are available in UAV technology and contracting.

# UAV Technology Signature Program

***Statewide Extension UAV Team***

**Objective:**

The purpose of this program is to serve as a higher-level program that any member of the Purdue Extension UAV team can deliver to local stakeholders. This program focuses on UAV technology including Federal Aviation Administration (FAA) commercial operation requirements, legal operation requirements, hands-on flight, and practical application of the technology in various industries (but focused primarily in agriculture and public safety).

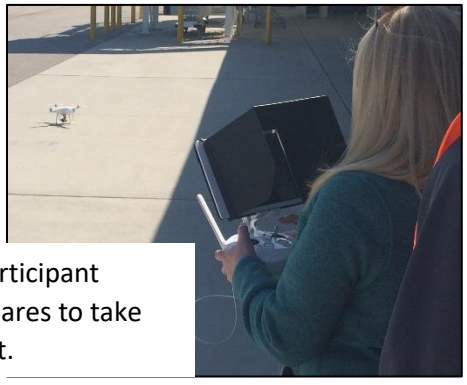
**Observations:**

Overall feedback to the program has been positive by our participants. Several enjoyed having in-person instruction to cover the material over other web-based providers. Our participants are electing to attend and are engaged in learning the material as they often view it as a way to increase their business prospects.

Giving our participants an opportunity to operate the UAVs before they are required to operate their own has also given many, who were otherwise intimidated by their own UAV, the confidence needed to actually operate it for themselves. This confidence coupled with our training for taking the FAA Commercial UAV Operator exam has helped this program become successful.

Educator Andrew Westfall shows how to create planned flights.

Participants study sectional charts to prepare for the exam.



A participant prepares to take flight.

**Why is this important?**

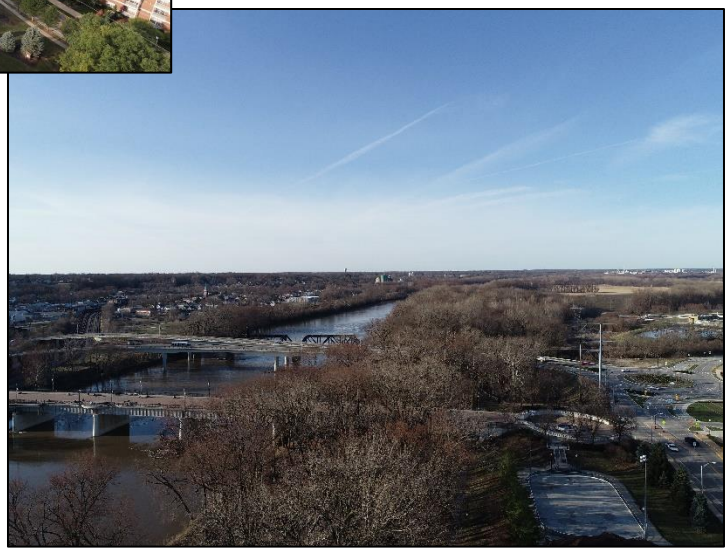
Hundreds of individuals have taken and completed the program with around a 95% passing the exam to become commercially certificated. This program has also evolved into a for credit Purdue College of Agriculture course for degree seeking students, it has been modified for high school as part of an Agriculture Technology/Precision Agriculture Curriculum, and it is currently being further modified as a 4-H project as part of a digital agriculture 4-H project.

# Creating Virtual Agronomy Courses in Response to the Pandemic

***John Scott – Purdue Extension Digital Agriculture Coordinator***
***Ashley Adair – Purdue Extension Organic Agriculture Specialist (Former Agriculture and Natural Resources Educator, Montgomery County)***
***Adam Shanks - Agriculture and Natural Resources Educator, Clinton County***

**Objective:**
Due to the pandemic, most of student life revolved around virtual classes and training. In order to allow the students to experience the unique landscape formations around Purdue two image collection events were scheduled for three locations, Tapawingo Park (to see floodplain features), Happy Hollow Park (to see erosion and discuss erosion mitigation in a natural environment), and Celery Bog Nature Area (to map the wetland, prairie restorations, and observe the surrounding environment). The initial set of flights was conducted in September 2020 and a second set of flights (along with ground-based imagery) was collected in March 2021.

**Observations:**
Flights were conducted in September since the classes were needing a virtual option for the field trips so the students could still get a visual understanding of the topics being covered. During the September flights it was decided to return in the winter/early spring and fly the locations again without any leaves of the trees. The leaves proved a challenge when trying to see the soils, but the landscapes shown through well. All locations were covered and Tapawingo and Celery Bog were selected to move forward as full virtual field trips.



Tapawingo Park in the fall (above) and early spring (right).

Happy Hollow Park in the Spring. It is possible to see the sloping hills that make up the park. In the distance it is also possible to see the landscape change as the valley turns into the broader plain.

This image from Celery Bog Nature Area shows what is believed to be the remnants of an old dyke from when this area was drained and farmed.

**Why is this important?**

Ninety-two percent had not had a virtual field trip before, so this was a novel experience for the majority of the class. One student commented, “I loved these narrtives [sic]. There [sic]were so well done. The 3D drone pictures, the history lesson, the explanation of soil science all came together to make a really good experience. I also liked that it allowed me to take in information at my own pace. Sometimes it is easy to fall behind or get distracted during a field trip, so that was really nice”. Eight-eight percent also agreed or strongly agreed that the virtual field trip format was appropriate given COVID-19; however, only 42% agreed or strongly agreed that they preferred the virtual format over an in-person field trip. (Schulze, DG, Rahmani, SR, Minai, JO, et al., 2021).

The field trips are publicly available here: https://ag.purdue.edu/agry/pages/virtualfieldtrips.aspx

Citation:

Schulze, DG, Rahmani, SR, Minai, JO, et al. Virtualizing soil science field trips. *Nat Sci Educ*. 2021; 50:e20046. https://doi.org/10.1002/nse2.20046

## Recording Video of a Grain Entrapment Rescue Demo for Future Trainings

***John Scott – Purdue Extension Digital Agriculture Coordinator***

**Objective:**
At the Central Indiana Field Day, a grain entrapment simulator was brought in and demonstrated by Co-Alliance LLC. The UAV was used to film this training from afar for future use in training on grain entrapment scenarios.

**Observations:**
The training started with an overview of the tools used and conversation about preventing the situation; as well as, the importance of training in a practical setting. A volunteer (in this case Dr. Fred Whitford) entered the grain tank and was purposefully submerged. After burying the rescue tube was inserted and the grain around the volunteer was augered out with a hand-held auger. With the grain removed Dr. Whitford was able to be helped out of the bin.

**Why is this important?**
This training was very informative to those in the audience, several of whom were first responders/public safety personnel. The video that was collected was shared with PPDL for the intention that a training video can be created to help others be aware of grain bin entrapment and methods of removing people from those situations.

# ***UAV Initiative***

# ***Animal Science***

UAV as a livestock management tool to help teach, manage, and monitor livestock operations.

## Indiana Beef Cattle Association – Beef-Forage Management Tour, July 2019

***Ashley Adair – Purdue Extension Organic Agriculture Specialist (Former Agriculture and Natural Resources Educator, Montgomery County)***

**Objective:**

Flights were conducted across Montgomery and Putnam Counties to provide educational content for the IBCA Beef-Forage Management Tour, an event that partnered with Purdue Extension. This was one of my first forays into content development for virtual delivery. The goal of the flights was to provide an educational overview of three unique beef operations, one in Montgomery County (Hodgen's Farms) and two in Putnam County (J&K Birt Farms and Willer Timber Ridge).

**Observations:**

Aerial stills and video were captured on each farm to highlight the beef management techniques at each operation. Hodgen's Farms showcased a pastured cow-calf operation managed alongside grain crops. J&K Birt Farms, also a cow-calf operation, featured a monoslope barn with capacity for 220 head. Willer Timber Ridge, a beef seedstock operation, demonstrated unique forage species used on-site to supplement pasture.

Cattle clustered together in pasture-Roachdale, IN.

Monoslope barn- Greencastle, IN.

Pasture and forage crop areas at near South Putnam High School-Greencastle, IN.

**Why is this important?**

Drone flights provided a unique view of each farm and allowed participants in the program to see each farm if they 1) were not able to participate in the field trip option or 2) if the farm was not available for hosting field trips. Overall, the drone imagery enriched the program for participants.

# Drone Monitored Tilapia Weed Control 2018-2022

***Dave Osborne - Agriculture and Natural Resources Educator, Ripley County***

**Objective:**

I Flew 14 ponds over a 4 year period to monitor weed growth. Using aerial images was much more affective in monitoring ponds.

**Observations:**

I have shared 2 paired pond flights for beginning, middle, and end of season images. Top ponds in these pictures were stocked with 100 fish per acre at a size of 20 fish per pound the first of June. Fish grew to 1.5 lbs. and had at least 2 generations of young.

Beginning

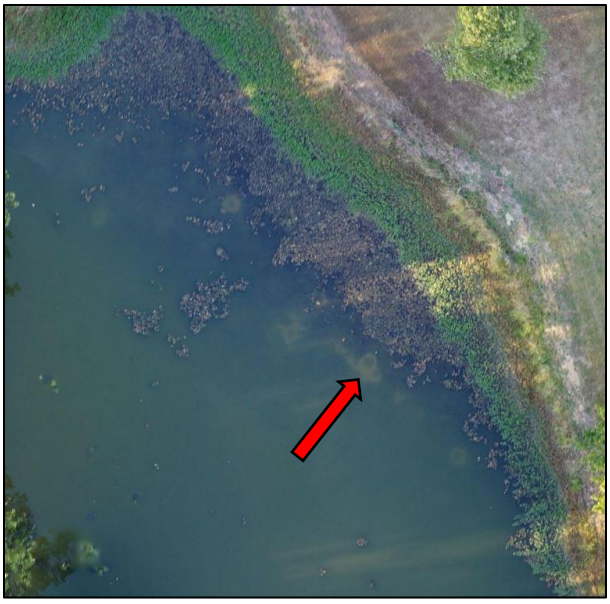
Middle

End

Beginning

Middle

End



Tilapia nesting are the light-colored circles on the bottom of the ponds in each image. (the arrow is pointing to an example)

Using the slider feature in Drone Deploy to compare July and August Flights.

**Why is this important?**

This technology helped track ponds as a whole that we could only see parts of from the ground. I also could see nesting sites from the air that were not able to be seen on the ground. Flying water made for some challenges as on sunny days the ponds were like mirrors and the images were useless. I had to fly on cloudy days or early in the morning in calm conditions. Wind caused image issues as well. The light rings around the ponds in the late season were where the fish cleaned up the bottoms. These observations were only possible with aerial images.

# Sorghum Grazing

***John Scott – Purdue Extension Digital Agriculture Coordinator***

***This work was done with Dr. Shelby Gruss as part of her Ph.D. research, Dr. Keith Johnson (Purdue Extension Forage Specialist), Dr. Ron Lemenager (Purdue Extension Beef Specialist) and Dr. Mitch Tuinstra (Purdue Agronomy)***

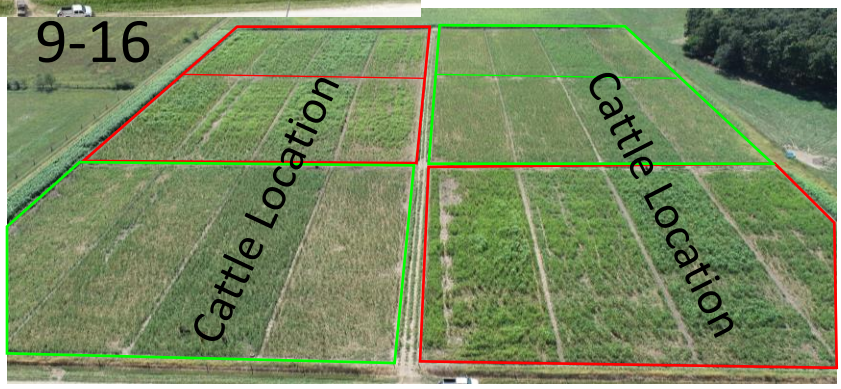
**Objective:**

A new forage sorghum was bred at Purdue that contains no prussic acid in times of stress. Prussic acid can become cyanide in cattle and can lead to poor performance or death. Though current commercial forage sorghum can be a valuable forage especially in more semi-arid environments it must be managed closely with the prussic acid risk. The new hybrid is not able to create prussic acid so this management constraint is alleviated; however, since it is a new hybrid questions about its suitability for grazing were raised and tested. In addition to ground-based management, UAV imagery was collected to help monitor the overall grazing progress.

**Observations:**

In the imagery the plots circled in red are the commercial hybrids and the plots circled in lime green are experimental. The current cattle grazing location is also indicated for each flight. It is possible to see that the cattle grazed the experimental more heavily over the course of the images.


The image from 8-6 shows the initial round of grazing taking place. When the image was taken the cattle had grazed 3 of the 4 paddocks.




By 9-16 the paddocks had been grazed over a few times and selection pressure in the experimental hybrid was evident.

**Why is this important?**

Seeing the pattern in the field were the cattle preferred the experimental variety it was not surprising that this also carried through into rate of gain where the cattle on the experimental hybrid gained weight faster than those on the commercial lines. This hybrid is currently being ramped up for larger scale production and has the potential to greatly improve feed value of sorghum, especially in droughty regions where it is primarily grown for forage.

# Locating Cattle

***John Scott – Purdue Extension Digital Agriculture Coordinator***

**Objective:**

Cattle can graze in forages that are much taller than they are, either in the case of a tall type forage grass pasture, a cover crop that is being grazed, or in a corn field if the animal gets out of the pasture. In this example, there had been some issues with the heifers jumping the fence (not due to the drone) and checking on them was done intensively for a time. This involved walking the paddocks to physically locate the heifers, so we decided to try finding them with the drone.

**Observations:**

We used the thermal camera to identify the groups from afar. We were able to zoom into the location of the heifers and get an accurate count, matching the number that should have been there. The image shows the thermal image and the 4 yellow/orange dots are heifers.

**Why is this important?**

By using the drone, no person necessarily needed to enter the paddock and the drone could operate outside of the study area to prevent any spooking. This allowed the cattle to remain calmer and kept the people safe. This could also be used to locate cattle in a corn field. The biggest limitation is heat from the sun but a night flight would likely reveal the heifers even better.

# Using a Telescopic Zoom to read Ear tag Numbers

***John Scott – Purdue Extension Digital Agriculture Coordinator***

**Objective:**

Keeping good records starts with animal identification and many are marked with ear tags. Unfortunately reading ear tags in the pasture can be difficult if not impossible. This makes identifying an individual animal problematic especially if the animal is sick or needed for a routine check. We tested if using the telescopic zoom on a Parrott Anafi USA would be sufficient for reading an ear tag on a heifer.

**Observations:**

We kept the drone about 50-75 feet away from the group so as to not disturb the heifers from grazing. In the first image it is possible to see the 4 heifers in the paddock all grouped up and grazing as a herd. The bottom image is a zoomed in look at a particular heifer from the same location (vertical and horizontal position from the herd). Here it is possible to make out her ear tag number.

The group of 4 heifers. The one zoomed in on is here.

This is the zoomed in image showing the ear tag number is H227 for this particular individual.

**Why is this important?**

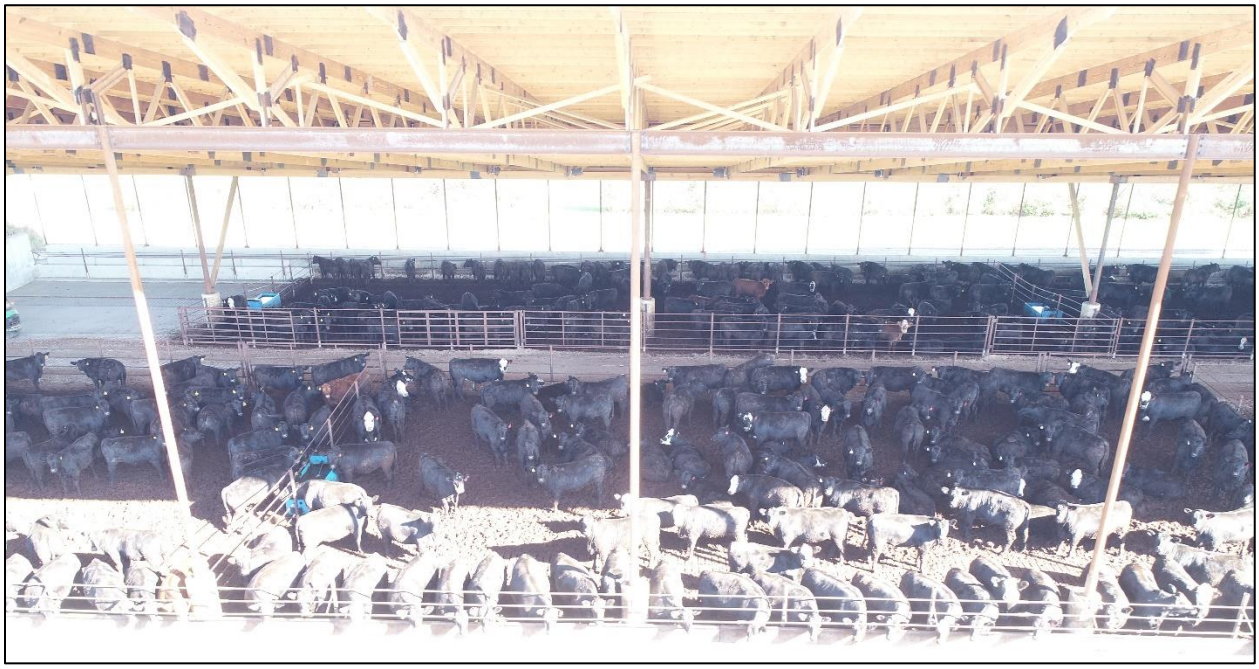
Using a drone with a zoom function is a quick and easy way to read ear tag numbers from far enough away that the animals remain calm and no people are in harm's way.

# Cattle Head Count

***John Scott – Purdue Extension Digital Agriculture Coordinator***
***Andrew Westfall – Agriculture and Natural Resources Educator, White County***

**Objective:**
A producer was curious about using a drone to monitor and count cattle in their feedlot operation. We used a Phantom 4 Pro to fly four buildings and acquire video/pictures of the cattle for counting.

**Observations:**
Flying indoors was attempted first but this quickly become difficult due to internal structural components of the building. The sound of the UAV did not appear to frighten the cattle in any way, but these cattle were used to being around large equipment all day. Once we realized that we could not get the images required from inside we went outside. This was better for collecting the actual data needed for the head count but we had more image quality issues due to the extreme change in light in areas shaded by the roof verse areas in the sun.



**Why is this important?**
The UAV was able to collect the necessary imagery for the producer to conduct a head count; however, this was still done manually using the images. While the UAV was able to capture this imagery, it had several limitations. We were generally unable to operate safely inside the structures due to the support beams, the cattle tended to move around, and the difference between the shaded areas of the barn and the sunny areas from the outside hurt the quality of our images. Ultimately it was recommended that the producer investigate stationary cameras that could be installed permanently on the structure for head counts.

# Pasture Infrastructure Inspection

***John Scott – Purdue Extension Digital Agriculture Coordinator***

**Objective:**
The UAV was used to investigate the pasture infrastructure to see how well (and quickly) it could conduct a fairly routine pasture check. This included checking automatic waterers, fencing, finding the herd, and corral/barn inspection.

**Observations:**
The first check was the automatic waterers, there were three total and all were functioning properly. Examining the fencing was next and although we did this quickly for the demonstration did not see any issues. An actual inspection would involve moving slower and looking more closely at individual posts. We were able to find the herd in a small grove of trees, taking advantage of the shade. We also got a few pictures of the corral and barn.

**Why is this important?**
The UAV was able to conduct all necessary tasks for the inspection. This was completed in about 10-15 minutes while talking to the manager it would take around 30-45 minutes in the traditional method (with a UTV) and they wouldn't have overhead shots of the facility.

# ***UAV Initiative***

# ***Natural Resources***

Using UAVs to lead the way in preserving our natural resources and removing invasive species.

# Certified Forest Collaboration

*Adam Shanks - Agriculture and Natural Resources Educator, Clinton County*

**Objective:**

An owner of a certified forest in Clinton County was interested in looking at aerial imagery of his certified forest. He wanted to have a direction for invasive species, and dead tree removal. This is a rather large and dense forest on each side of the county road.

**Observations:**

Reviewing the stitched maps from Drone Deploy provided visual confirmation of the need to remove dead and invasive species. Working with our District Conservationist, we were able to get an idea of invasive species locations to further ID issues. Plans were also made to eradicate the dead trees in orders to provide further growth within the forest.

**Why is this important?**

The imagery was shared with the forest owner and the county NRCS specialist. The collaboration resulted in a plan to mitigate dead and undesirable material to enhance the growth of the desired species within the forest.

# Forest Disease and Stress Pressure

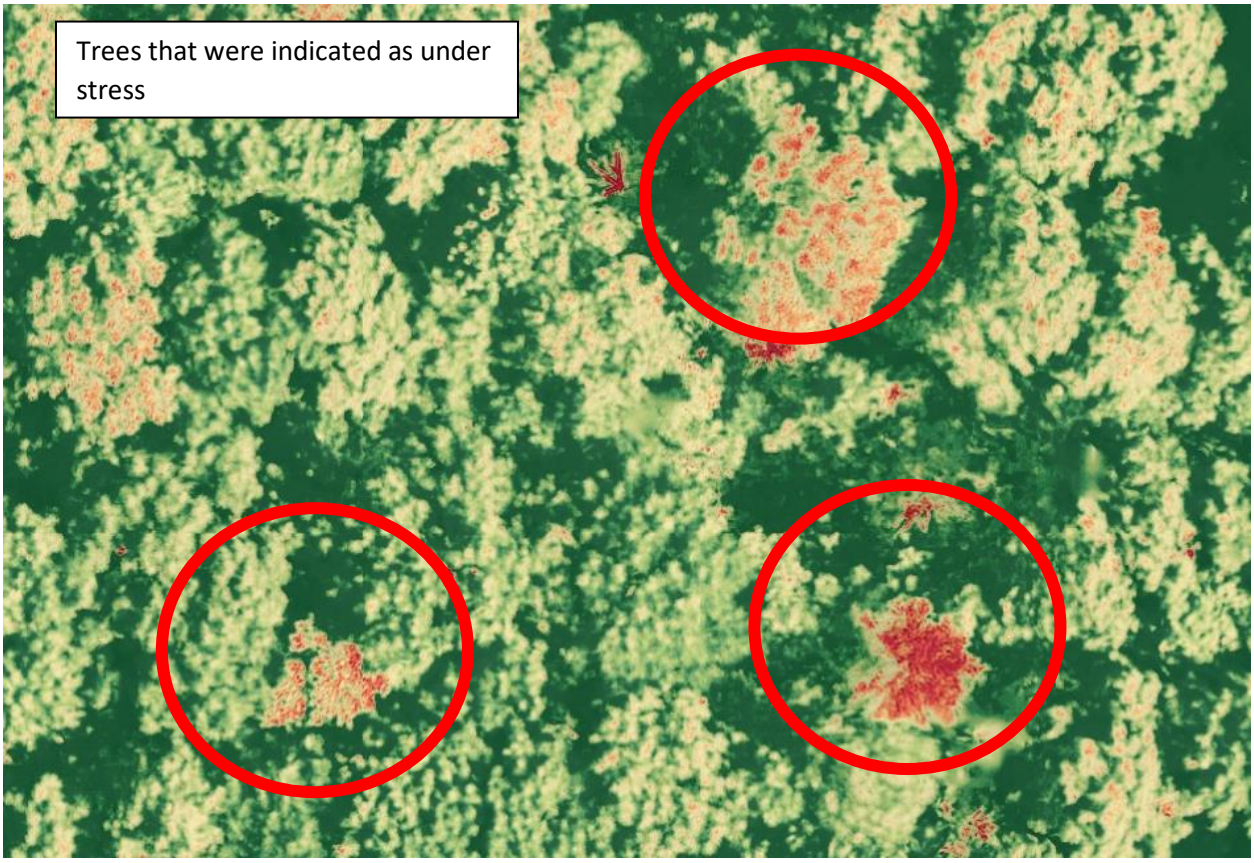
**Phil Woolery** - ***Agriculture and Natural Resources Educator, Pulaski/Starke County***

**Objective:**

In 2019 I used my drone to fly planned missions over the Starke County Forest. The Starke County Forest is a mix of native forest and mixed species plantations of different ages. It is managed for timber and recreation. I did planned flights with an RGB camera and infrared camera to look for plant stress in the forest.

**Observations:**

Looking at the data from the flight there were some differences in the data from NDVI (infrared) and VARI (RGB). There were some clear dead trees that could be seen in the plant health analysis and the RGB photos. We went out to the forest to check on individual trees. One of the trees that we checked was black walnut. At the time that we checked it, the leaves had all fallen off. This was in September, so this was not unusual for black walnut to lose their leaves at this point. The tree seemed healthy and had a healthy growth rate. It is likely that the tree had walnut anthracnose at the time of the flight. This common disease is usually not a problem. The other trees that we inspected were eastern white pine. We could see that these were not healthy. Based on the location, the site was too wet and allopathic compounds from black walnut trees were causing the decline in the tree health.




The eastern white pine in this photo showed signs of stress in the NDVI. It's likely suffering from allelopathy from the black walnut.

**Why is this important?**

The problems that we observed did not rise to an economic level that required any action. Drone technology gives the ability to quickly scout for stress and disease in forests.

# Scouting for Phragmites (Common Reed) in Wetlands

***Bryan Overstreet – Agriculture and Natural Resources Educator, Jasper County***

**Objective:**

Common reed (*Phragmites australis)* is an Indiana native, but invasive, weed. It's especially problematic in natural areas and wetlands where it spreads rapidly, pushing out other native plants. Here we map a wetland to identify and eradicate areas of common reed.

**Observations:**

The wetlands were mapped and the phragmites areas identified in 2019. The maps were given to NRCS specialists who worked with an applicator to spray the patches. This was followed up the following year to identify any Phragmites still present.

*Before Pictures*

Lighter colored vegetation = ***Phragmites australis***

Here is the original map prior to annotation to determine the areas with significant Phragmites growth.

With phragmites mapped out, 44 acres needed treated.

*After Pictures*



The wetland was reflown a year later in July and again in September. Both maps showed greatly reduced populations.

**Why is this important?**

All most all of the Phagamites were cleaned up in the wet lands after the application. The map generated using the UAV allowed conservationists to target the weed, quantify areas of most concern and effectively remove the species. This was done both faster and cheaper than the common method of scouting on foot, and was equally as capable of determining quality control a year later.

# Oak Wilt flights and discovery prior to Forestry Field Day

***Dave Osborne – Agriculture and Natural Resources Educator, Ripley County***

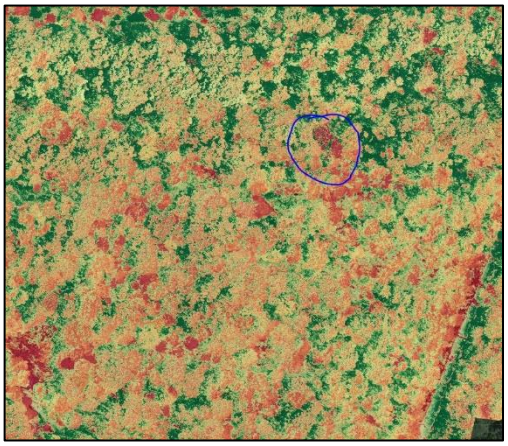
**Objective:**

We used drones at Southeast Purdue Ag Center (SEPAC) to get aerial images of known oak wilt out breaks in several woodlots so that we could share the images at a field day focusing on oak wilt control measures. The drone allowed us to cover many more acres than boots on the ground.

**Observations:**

While looking at the images, we found several other trees that looked suspect for oak wilt. On the ground inspection confirmed that there was much more oak wilt in the stand and a rescue and eradication harvest was planned to try to stop the disease in its tracks. Oak wilt can be detected by observations of wilting leaves in the July time frame. It is almost impossible to find 1$^{st}$ year infections from the ground because it is hidden in the canopy. We have about a month window to make flights to map the disease in the woods. Using the plant heath feature in Drone Deploy make the infected trees stand out even better. With these photos, many forester hours can be saved on the ground as we can cover 50 acres in a 15-minute flight. We can locate areas that need more attention and treatment from the air that we would never see from the ground.

Orthomosaic map with oak wilt suspected circled in blue.



Plant health map with oak wilt suspected circled in blue. The disease issue 'pops' more in the plant health map.

**Why is this important?**

We were able to track Trees at SEPAC and mark areas where more treatment and harvest was needed with a single flight. To cover this same area from the ground would take a forester many days and early infection symptoms are almost impossible to see from the ground. The time savings along make this a great technology to save time and improve results and treatments in forestry that we have not had in the past. Ground truthing a couple spots help us know what is going on in the whole woodlot. This can also be used as a scouting tool to locate outbreaks so that control measures can take place very early. Early eradication is important for the best success in controlling diseases in forests. This find getting ready for a field day saved the value of many trees that might have been lost without the drone images.

# Invasive Plant ID at Southeast Purdue Ag Center

***Dave Osborne – Agriculture and Natural Resources Educator, Ripley County***

**Objective:**

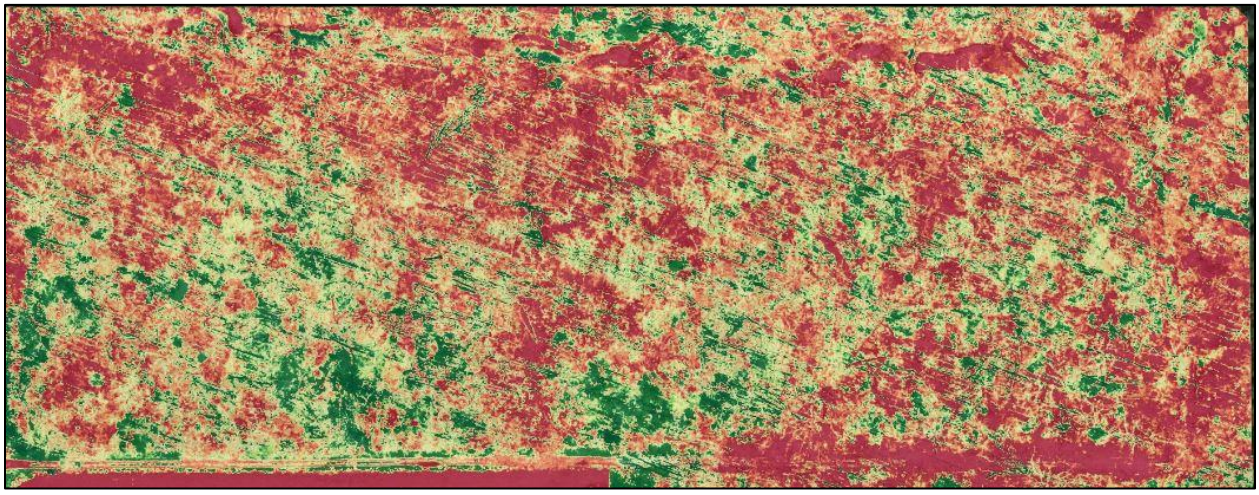
We used drones at Southeast Purdue Ag Center (SEPAC) to inventory invasive coverage in several woodlots so that we could monitor the success level of control measures. The drone allows us to cover many more acres than boots on the ground.

**Observations:**

Invasive species like rose and bush honeysuckle leaf out about two weeks before hardwood trees, this gives us a small window to make flights to map them in the woods. Using the plant heath feature in Drone Deploy make the invasive plants stand out even better. With these photos, many forester hours can be saved on the ground as we can cover 50 acres in a 15-minute flight. We can locate areas that need more attention and treatment at the beginning of a season.

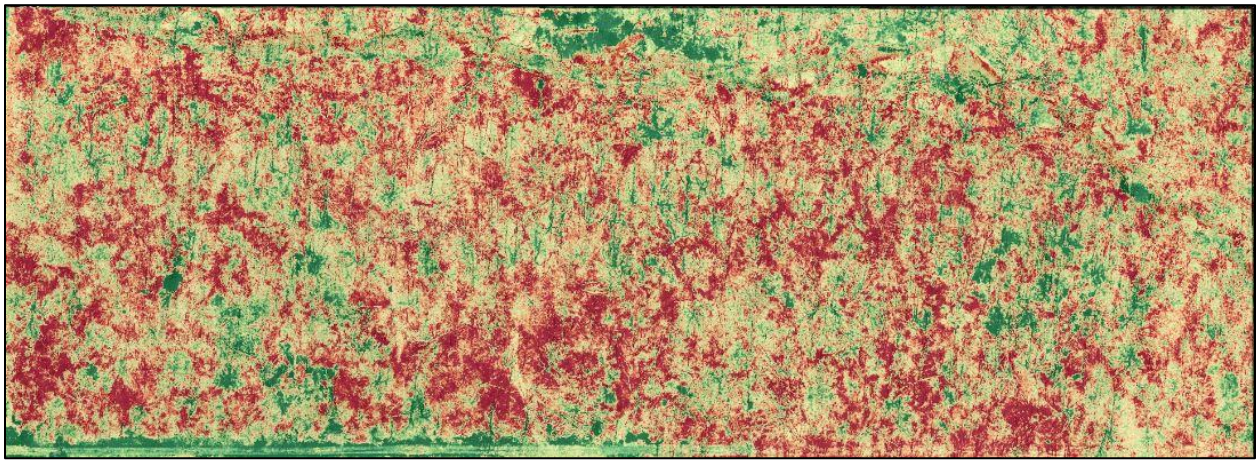
## Woods R 2018 before invasive control

## Woods R 2018 before invasive control (Green is invasive plant growth)



## Woods R 2019 after invasive control

## Woods R 2019 after invasive control (Green is invasive plant growth)



**Why is this important?**

We were able to track invasive populations at SEPAC and mark areas where more treatment was needed with a single flight. To cover this same area from the ground would take a forester days. The time savings along make this a great technology to save time and improve results and treatments in forestry that we have not had in the past. Ground truthing a couple spots help us know what is going on in the whole woodlot. This can also be used as a scouting tool to locate outbreaks so that control measures can take place very early. Early eradication is important for the best success in controlling invasive plants.

# Norwell High School Woodlot Invasive Mapping Project

***Bill Horan - Agriculture and Natural Resources Educator, Wells County***

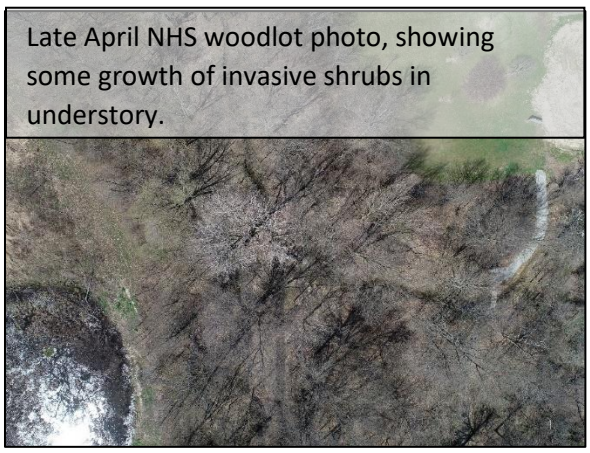
**Objective:**

Norwell High School (NHS) has an ongoing battle with invasive shrubs in their outdoor lab / woodlot. In order to assist them with mapping the location and extent of the invasive plants, a time-lapse aerial flight was planned in the spring as plants began to leaf out. Many invasive shrub species leaf out earlier in the spring than native trees and shrubs, so aerial photos of a woodlot at the correct time in the spring can capture the location of the patches of invasive shrubs and can help with plans for eradication.

**Observations:**

The NHS woodlot was flown and photographed at about a ten-day interval during the spring, beginning with no leafing out or growth, to the point where trees were leafed out to the extent they blocked out the view of the forest floor and the underlying shrub growth. These photos were then made available to document the location of the invasive plants.

Early April photo of NHS woodlot, showing little or no leaf growth.



Late April NHS woodlot photo, showing some growth of invasive shrubs in understory.

**Why is this important?**

This project was successful in locating the largest invasive shrub patches in the NHS woodlot, and has helped in the plans for eradication. Another similar UAV flight project is in the works to measure progress in the eradication plan.

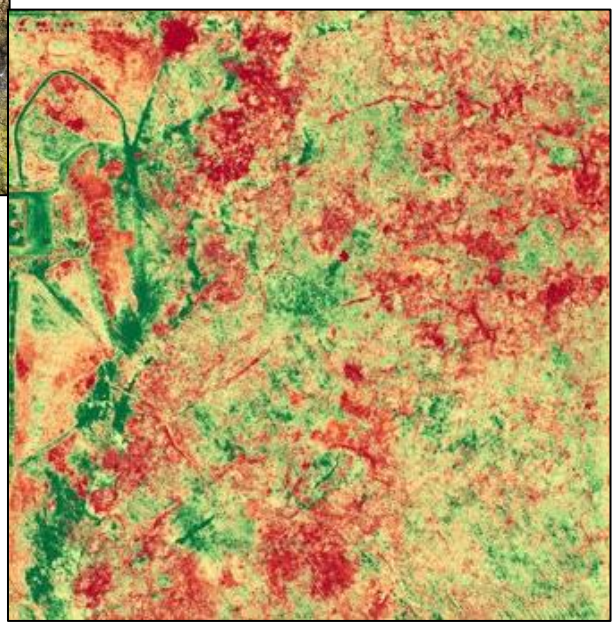
Early May photo of NHS woodlot, showing tree / upper canopy growth which hides invasive shrubs.

# Thornwood Preserve Invasive Species Eradication Planning

*Lais McCartney - Agriculture and Natural Resources Educator, Hancock County*

**Objective:**
A series of flights this past year have been used by the Greenfield Parks and Recreation Department to map their invasive species in Thornwood Nature Preserve.

**Observations:**
I was able to do a complete drone survey of the Thornwood preserve in Greenfield, Indiana. I chose to do these flights late in the fall because invasive species stay green longer than our native species typically. This makes it ideal to map the prevalent invasive plants to make a strategy to eradicate them.



The invasive plants are green in both the photograph and the plant health map.

**Why is this important?**
Working with the Parks Supervisor and the Hancock County CISMA group, a plan of mitigation was decided using the map to follow along the timeline. We organized the community in various Weed Wrangles to address these invasive plants. The community appreciated being a help to the parks that they enjoy and got exercise and educated on the invasive plants and how they hurt wildlife.

# Invasive Plant Survey – McCormick's Creek State Park

***Bob Bruner - Agriculture and Natural Resources Educator, Clay/Owen Counties***

**Objective:**

In the spring of 2021, McCormick's Creek state park reached out to the Purdue Extension in Owen County, asking if Extension educators could provide tools and technical expertise to help map out the spread of invasive multiflora rose through the park. After surveying the area in question, we determined that a short drone flight over the area would go a long way towards mapping out the invasive species present during that time of year.

**Observations:**

This survey provided a unique challenge to fly over. First, the area in question is adjacent to the Wolf Cave nature preserve, meaning the flight area was restricted from crossing that border due to aviation guidelines. The other challenge was determining how meaningful information would be obtained. As the below image demonstrates (Fig. 1), many trees had already started to develop a canopy. However, due to the time of year, any greenery developing in the understory could only be multiflora rose. Since the canopy was only starting to green out, we could plan a flight that studied the undergrowth with minimal interference from the developing tree leaves.

Figure 1. Developing tree canopy near Wolf Cave nature preserve.

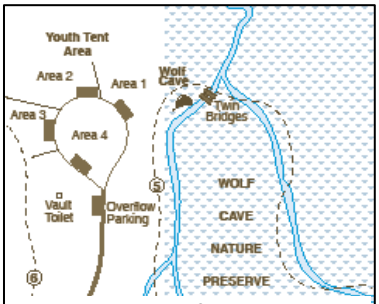



Figure 2. Map of area surrounding nature preserve.

**Why is this important?**

Since the goal of the flight was not to determine plant health, but rather, to map the edge of a spreading area of an invasive plant, we were able to remain effective while still respecting the nearby border of the nature preserve. As Fig. 3 shows, we were able to see the areas of multiflora rose through the developing canopy, allowing us to provide usable information to the park naturalists. This means that the use of UAV technology in invasive species mapping can be an impactful decision-making tool for landowners and conservationists wanting to keep their areas free of encroachment by unwanted plants.

Figure 3. Multiflora rose seen through canopy.

# Natural Resource Management in Practice

*Valerie Clingerman - Agriculture and Natural Resources Educator, Knox County*
*Addie Thornley – Former Agriculture and Natural Resources Educator, Gibson County*

**Objective:**
We were contacted by Department of Natural Resources (DNR) at Glendale Fish and Wildlife Area in Daviess County to fly some upland fields they planned to do some management on. I partnered with the ANR in Gibson Co. at the time and we flew the areas.

**Observations:**
The images show key areas that the DNR wanted to manage. These areas included dead and dying trees that were selected for removal, assistance with identifying location and severity of invasive species for management, and images for property managers to see before and after the practices were implemented.

**Why is this important?**
DNR used these images to highlight areas that they wanted to manage with the loggers and others doing the work. They also shared images with property managers. As of January 31, 2022, the loggers were able to harvest trees in the project areas and the DNR was able to work on the areas with their track loader and brush mower.

# Log Jam Locating and Mapping

***Bob Yoder - Agriculture and Natural Resources Educator, Marshall County***

**Objective:**

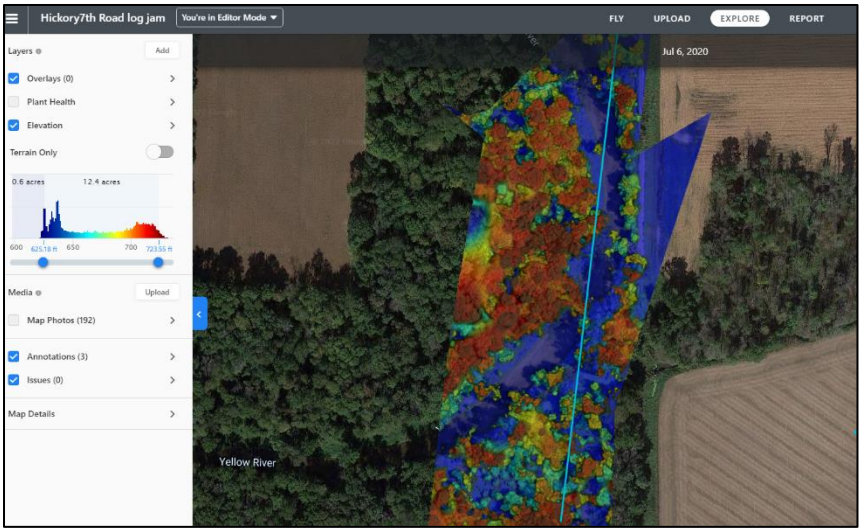
Craig Cultice (Marshall County Surveyor) requested Extension assistance to document a log jam on the Yellow River. Craig wanted to utilize the images collected to see the impact of the log jam and document the value of a sUAS as he was exploring the purchase of one.

**Observations:**

The site was flown and both individual images and a stitched map were generated to provide the value of aerial photos to document drainage issues such as log jams that need to be corrected. It is possible to see the impact of the log jam and the water movement as the jam was removed by the excavator.

A still of the log jam were the excavator is removing the jam to allow the water to flow.

An elevation map of the area where the log jam occurred.




**Why is this important?**

Photos were the highlight of a presentation used to demonstrate value of sUAS with and without additional software, including elevation maps to demonstrate the value of having software like Drone Deploy. Craig successfully received funding to purchase a sUAS by documenting its value. Craig has continued the relationship with Extension with questions pertaining to purchasing a sUAS, need for a commercial sUAS license, and how to gain instruction on flying the unit purchased.

# Confirming Glyphosate Injury on Trees

***Scott Gabbard – Agriculture & Natural Resources Educator, Shelby County***

**Objective:**

Assessing injury and determining the cause has always involved thorough site descriptions, documentation and specimen sampling. The introduction of UAV's has added an additional perspective of observation. In this case study, the drone was used to help document the entire site for arborists and pathologists to see if it helped them in determining the cause of tree damage.

**Observations:**

Ground assessment-

On May 26th, ground photos show at surface roots and girdling roots with grass stunted or killed back (picture 773) and various levels of dieback (image 769) with most, if not all of the damage being on the south side of the entry to the property with a few exceptions along the main road which left us with inconclusive results.

*picture 773*

*picture 769*

Drone assessment-

Aerial photography was provided on August 21st after two inconclusive ground trips. Aerial footage filled in the knowledge gaps by allowing a holistic view of the site in question.

*aerial photo 15*

In addition, 4k video was employed to also give diagnosticians aerial fly-bys at varying altitudes and perspectives. While two of the trees were confirmed to have verticillium, flights north of the drive were able to confirm glyphosate injury by showing dieback and stunting on the tree on the north end of the

drive (bottom of the picture) while more dramatic damage is observed on the trees on the south side of the drive (movie clip screenshot 1, 2 & 3).


Movie screenshots 1,2 & 3

**Why is this important?**

Employing the drone gave diagnosticians, the educator in the field and the homeowner a better, more conclusive view of the site, confirming injury that wasn't as obvious from the ground. It also provided the necessary "proof" to the homeowner that corrective actions would need to be taken to prevent further injury to the damaged and even the seemingly healthy looking trees at their site.

# ***UAV Initiative***

# ***Turf***

Not just cutting the grass, UAVs help monitor heavy use turf in high management systems and low input lawns.

# Seeing issues on the football field from the UAV.

***Bryan Overstreet – Agriculture and Natural Resources Educator, Jasper County***

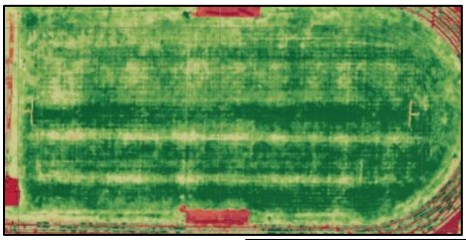
**Objective:**

The initial flight was a demonstration for one of the Rensselaer Agriculture classes. Once we saw the wear patterns in the field we started working with the athletic department on scheduling regular flights. I have flown the field prior to the season and throughout the season the past 3 years.

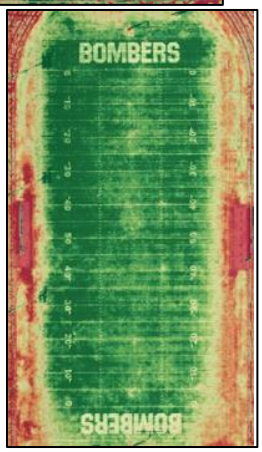
**Observations:**

To start with the coach was excited about seeing where he was going to need to over seed the next spring but once we started flying throughout the season we found other issues. The first few flights I flew at 250 feet but after doing some experimenting, flew most of the flights at 80 ft for better quality.

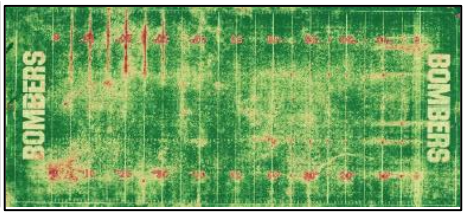
Prior to the season we saw a miss application of fertilizer that left stripes down the field.



In season, during an extended dry period we could see that they needed to change the location of their sprinklers to get to the edges of the field better. After they saw this they moved the sprinklers out toward the sidelines 5 yards to get the corners better.


They played one game the day after a 4-inch rain. From images taken two days later it was clear that most damage was where the linemen warmed up, even some cleat marks were observed. With this discovery, after they got a 3 inch rain they had the linemen warm up off the playing surface of the field.


**Why is this important?**

This imagery has been used by the high school athletic department to better maintain their football field. It has also directly led to increased collaboration between the county extension and the local high school in other areas. Curtis Craig Superintendent of, Rensselaer Central Schools stated “The drone pictures have been helpful in evaluating the condition of our facilities and athletic areas. Using before and after pictures from the drone allows us to visually document how community money has been spent. We have documented improvements to roofs, roads and a parking lot. This summer we will be able to document the substantial investment RCSC is making in new tennis courts.”

# UAV mapping at Ross-Ade Stadium

***John Scott – Purdue Extension Digital Agriculture Coordinator***

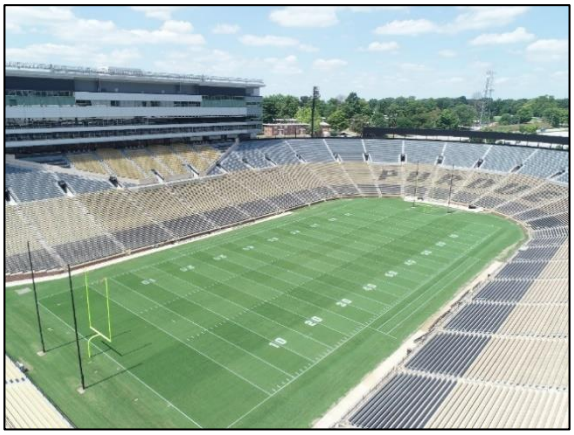
**Objective:**

Purdue Athletics teamed up with Purdue Extension to fly Ross-Ade Stadium weekly from August 9 through the end of the 2019 football season. The goal was to use imagery to help identify any turf issues for the grounds crew to more efficiently maintain the turf.

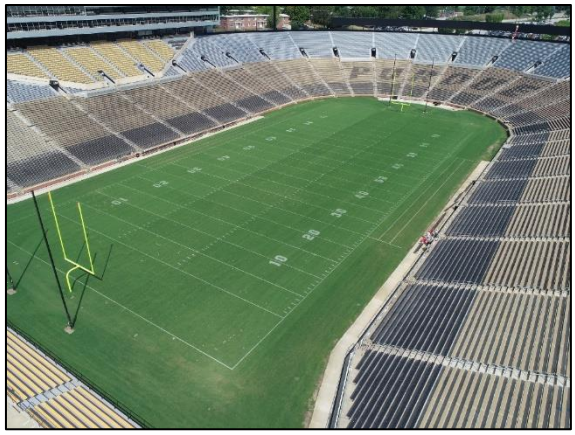
**Observations:**

The images below correspond with the weeks prior to the football season starting. These pre-season flights occurred before any football activity on the field (8-9), after a practice on the field (8-12), and after a scrimmage match on the field (8-19). Because of environmental conditions and time constraints, not all imagery was collected the same day or time of each week. However, all flight patterns are identical.

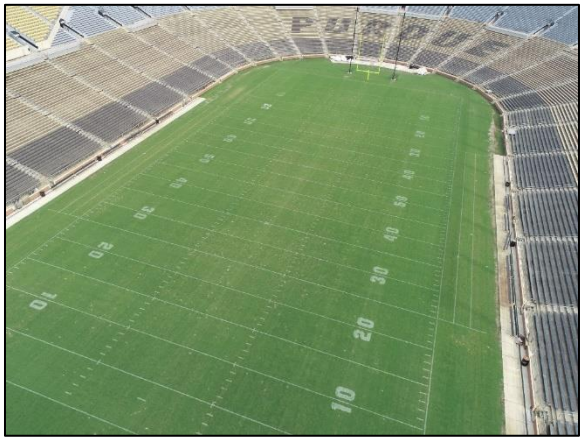
8-09



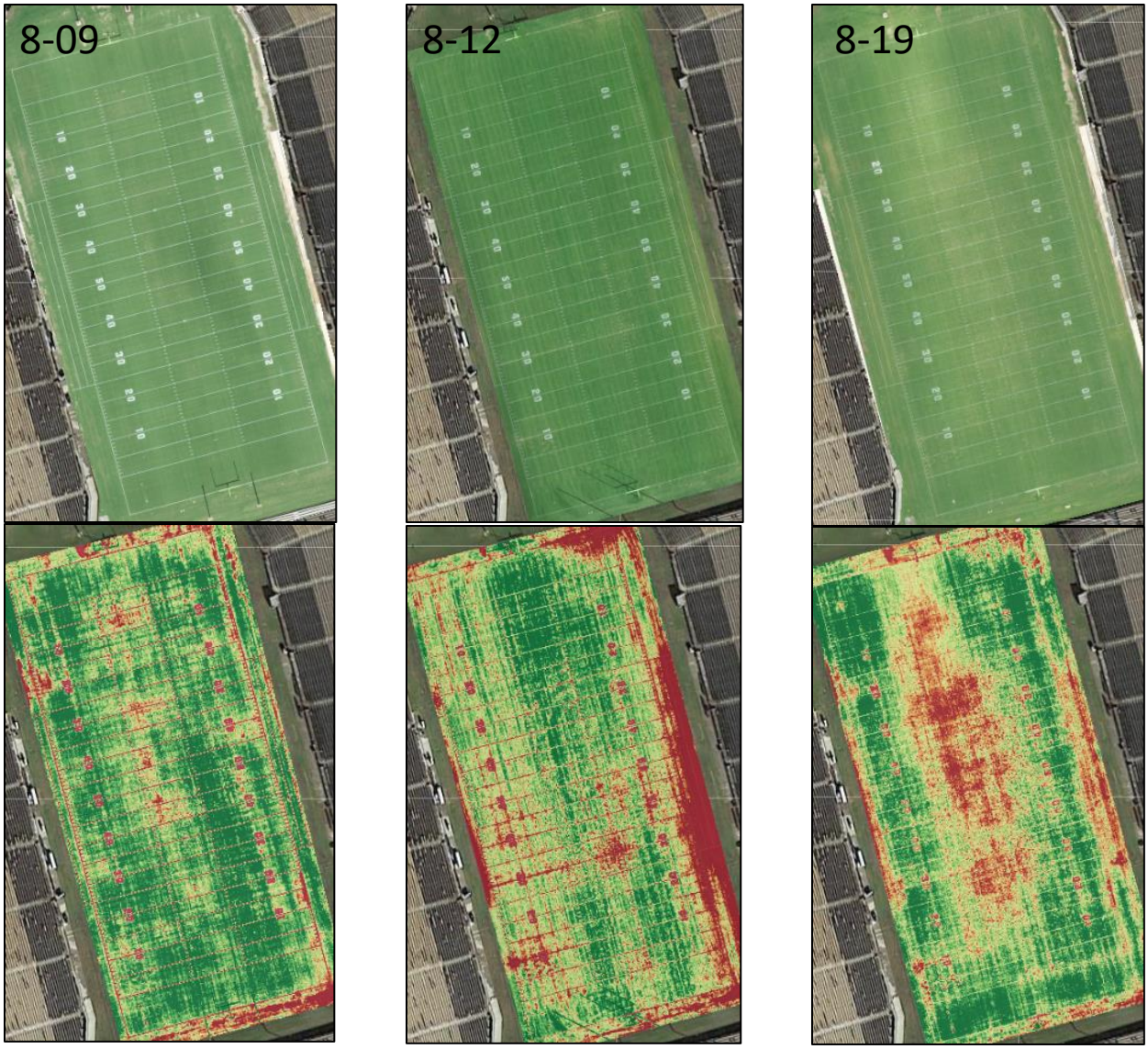
8-12



8-19



Still photographs of Ross-Ade Stadium pre-season. In the image from 8-9, the field is pristine, by 8-19 it is showing some wear and tear after workouts on it. However, the grounds team had the field back in order by the first game three weeks later.




Stitched maps from DroneDeploy showing the RGB orthomosaic (top) and plant health VARI (bottom). The wear patterns become more noticeable in these maps showing the high traffic areas/damaged areas.

**Why is this important?**

Flights were conducted throughout the football season and all imagery was shared with the Athletic Department. They were able to use the imagery to help determine if and when certain maintenance was required or to determine if maintenance that had been conducted was functioning as desired.

# Mapping a High School Soccer Field

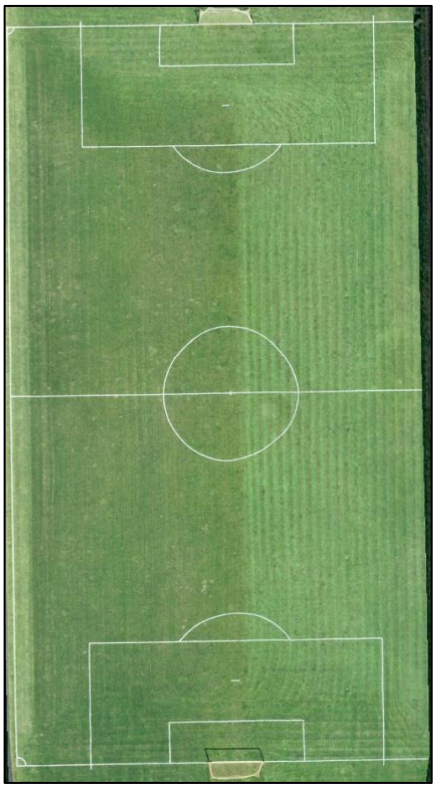
***John Scott – Purdue Extension Digital Agriculture Coordinator***

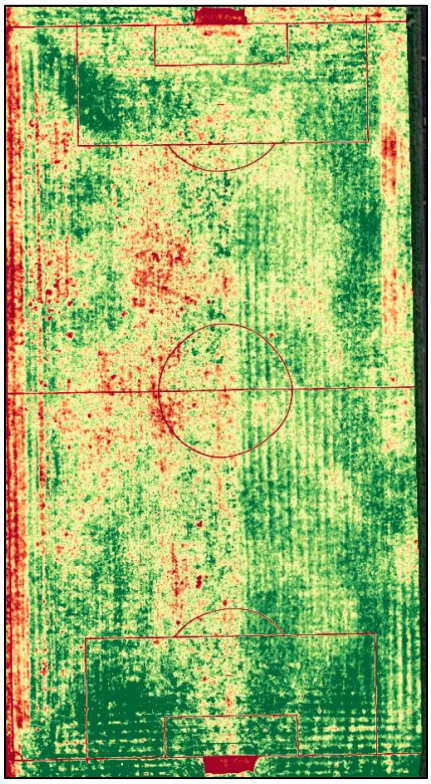
**Objective:**

Orthomosaic and plant health maps from Drone Deploy showing machine and human wear patterns on the soccer field at Rossville High School. Data collected during, and used for, programming between Extension and Rossville High School FFA.

**Observations:**

A stitched orthomosaic image (left) and a plant health image (right) show machine- and human-wear patterns on the field. Wear patterns identify areas in need of management. After the first flight, it appeared the top half of the field was heavily worn, an atypical finding that could have resulted from a camera error. The field was flown multiple times with several settings, and the same patterns emerged each time. We presented this to a group of students on the soccer team, and given their practice tendencies, corroborated this trend.





**Why is this important?**

Using the imagery, the coaches and grounds crew for the high school were able to make changes to both turf management and player positioning during practice to help with the wear and tear. The FFA group was able see how a UAV is used to create a map and how the imagery can be interpreted to make decisions.

# Mapping a Golf Course

***Mark Carter - Agriculture & Natural Resources Educator, Purdue Extension, Blackford County & Precision Agriculture Coordinator***

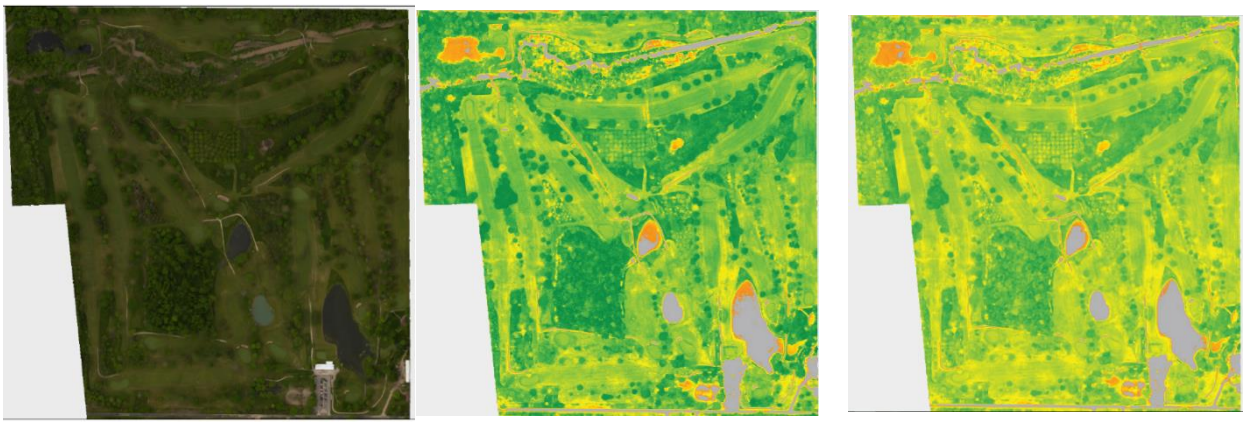
**Objective:**

In 2019, flights were conducted on Walnut Creek Golf Course in Marion, IN. The map series was generated using the Quantix fixed-wing UAV from AeroVironment. It excels in covering large tracts of land quickly and delivers actionable maps for near real-time decision making.

**Observations:**

Many improvement opportunities were identified for overall turf health, such as:

- Fertilizer treatments
- Tree root competition
- Shade
- Irrigation and drainage
- Compaction and traffic



**Why is this important?**

This knowledge was shared with golf course maintenance to make effective and efficient use of limited resources in improving ground conditions.

# Turf Evaluation with a Thermal Camera

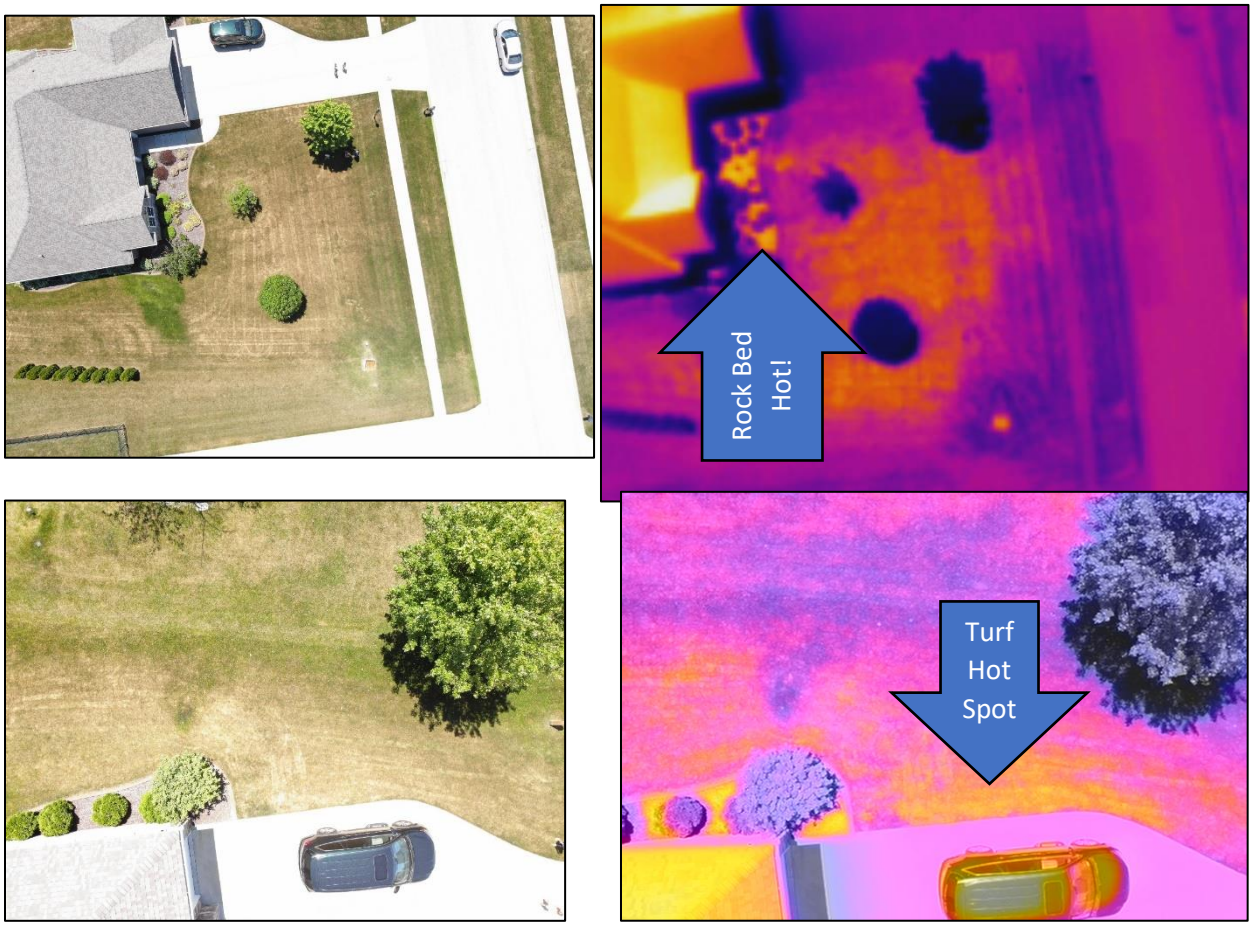
***Nikky Witkowski – Agriculture and Natural Resources Educator, Porter County***

**Objective:**

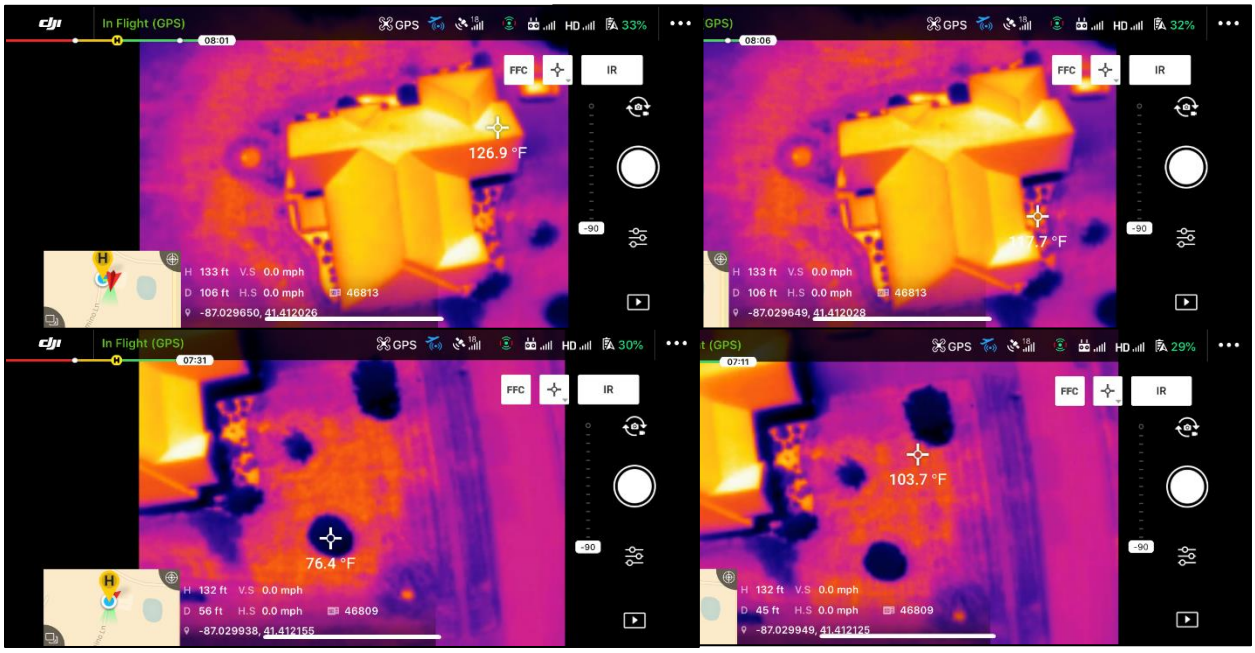
A homeowner was not pleased with the lawn quality and the applicator insisted there were other environmental factors involved that could not be avoided. A flight was conducted to observe the lawn from above using a thermal camera to attempt to identify areas of greater or lesser stress.

**Observations:**

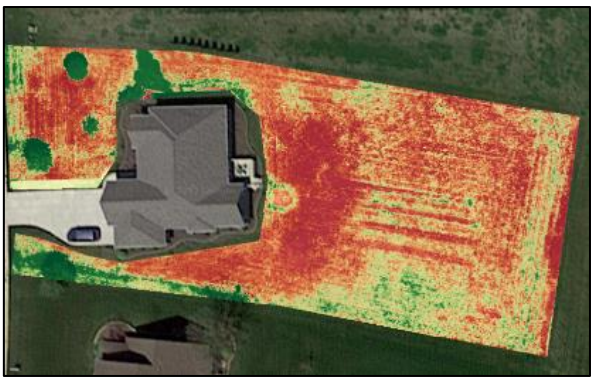
It was quickly shown to the homeowner that there were hot spots around the property. I was able to compare heat near sidewalks, rock beds, trees, and larger areas of turf. From those, you could clearly see that there were highly different temperatures in the areas. Anything near the rock or sidewalk was red (hot) compared to turf areas that were open more (purple).



It was especially awesome to show him the temperatures that were able to be used as a comparison to his house, rock, lawn, and tree. Those really showed that even if my temperature readings are off (meaning they are not actually 100 degrees), there is a large difference in temperature in the areas that can cause stress. Some of the open areas of turf were in the 90's.




The lawn was also mapped to further evaluate the turf conditions. It is possible to clearly see the trees and other vegetation along with what is likely the septic finger system in the back yard. Coupling this imagery with the thermal imagery helped determine that environmental factors were likely at play.



**Why is this important?**

From the images collected it could be seen that there were several 'hot' spots around the property that were showing stress. This is likely due to soil conditions given that the house was a recent build (2013) and the pattern of stress around the house. This lawn may be a good candidate for soil sampling and further mitigation measures.

# Evaluating a Lawn Before and After Mowing

***John Scott – Purdue Extension Digital Agriculture Coordinator***

**Objective:**

This stitched map was taken to observe turf and tree health for a homeowner before and after a mowing. They were curious if mowing changed any features that could be observed with the UAV.

**Observations:**

It was possible to see turf around trees that are struggling. This could have been due to competition for sunlight or water. It is also possible to locate the septic finger system, tile lines, and "**fairy rings**[†]." The first image shows the lawn prior to mowing and the second image after mowing. Light intensity of each photo is also different, probably due to the time of day for flight.

Lawn before mowing.

Lawn after mowing.

Still of the lawn before mowing. It is possible to see most of the same features as the mapped image.

A close up of the 'fairy rings'

**Why is this important?**

We could still identify the septic and tile lines after mowing; however, mowing eliminated some of the fine details, such as the fairy rings. This set of imagery was used to help guide fertilization and watering around the trees and since the fairy rings disappeared after mowing, no treatment was pursued.

[†] More information on fairy rings: https://www.extension.purdue.edu/extmedia/bp/bp-113-w.pdf