# Unmanned Aerial Vehicles (Drones) in Multi-Disciplinary Agricultural Research and Outreach
# Fruita, CO (Mesa County, Western Colorado)

**Ally Claar**, [2]Perry Cabot, Research Specialist, Research and Extension Leader; [4]Eric McPhail, Director, SW Region Co-Director; [3]Doug Dean, Director; [1]Elias Quiñonez, Manager of Student Life and Diversity

[1]College of Agricultural Sciences, [2]Western Colorado Research Center- Grand Valley, [3]CSU Tri-Rivers Extension, [4]Gunnison County Extension

## Research Questions & Goals

**Research Questions:**

- How can drones help farmers in making decisions in our changing climate?
- What are the current obstacles to adoption of this technology?
- What are the better data representations farmers could use to benefit their farms?

**Goals:**

- Compare traditional methods (observation, soil sampling, SPAD chlorophyll readings) against drone-based data using processing software (Pix4D).
- Practice agricultural research methods.
- Create a hypothesis for causes of outputs (e.g. index values, maps).
- Converse with locals to determine if drone technology is worth the investment.
- Identify diverse perspectives that are connected to water-related problems and water shortages in agriculture.

## Introduction to the Drone

The team selected a DJI Phantom 4 (P4) Multispectral* drone for our field evaluations. It is the only drone with a built-in multispectral camera, which captures regular color photos and reflected energy that we cannot see. Drones save producers time in the field, labor costs, and uncertainty. Flight time is 27 minutes on one battery, slightly less than others, but is equipped with higher resolution sensors.

Alternatives to drones are field scouting (gathering soil and forage, using chlorophyll meters, visual cues), flying planes for one photo, and getting data from satellites.

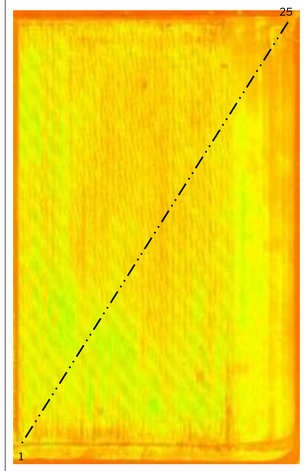
With the Colorado River's flow rate decreasing, it has become more imperative to manage water and nitrogen levels efficiently and conserve resources. Drones can mitigate this future of agricultural expenses.

* DJI, https://www.dji.com/company?site=brandsite&from=footer

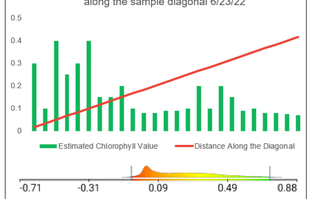
## What We Did

- Conducted flights in Mesa and Gunnison counties.
- Learned about agricultural practices and irrigation systems on the field.
- Stitched the processed image data into maps.
- Compared drone data and field samples within the same special array.

Application 1. RGB NDVI map of 10 acres corn, WRCR 6/21/22

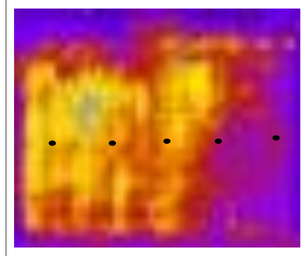



Corn Field SPAD Values are variable but decreasing along the sample diagonal 6/23/22

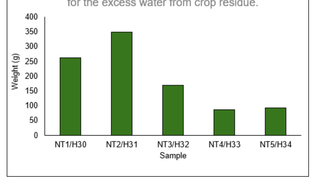



**NDVI value range (from -1 to 1)**
Normalized Difference Vegetation Index (NDVI). The amount of visible "light" that is reflected. Healthier plants have higher reflectivity.

Application 2. Thermal NDVI map of 0.5 acres triticale (wheat/rye hybrid), WCRC 6/21/22




Triticale Yield weights (g) 6/28/22
Yield decreases as temperatures and dryness increase. The five varieties may be fit for this environment but not for the excess water from crop residue.




From Application 1, we see that chlorophyll values correspond to the variability in the NDVI. As seen with Application 2, triticale is drying out and yielding less where NDVI values are lower. The right two samples show lower vigor, less density, and greater soil exposure. They may be overwatered.

### Limitations

We sampled one plant for each area: 10 corn soil samples, 25 corn chlorophyll samples, and 5 triticale quadrats. We used one operator's drone and another's computer and program. The drone and software customer service were critical.

## Discussion

NDVI maps can save time by highlighting areas of stress, but they do not directly diagnose. Drones are new and expensive upfront, so the decision depends on the farmer. Many farmers say that they pay for themselves often within a year, but it depends on the size and complexity of the operation. We would upscale this actionable information for larger farms. The drone can help to save fertilizers, land health, expense, and water in agriculture. The decision to purchase drones depends on certain factors:

- The enjoyment and comfort with traditional methods versus new technology.
- The farm type, cropping system, irrigation issues.
- The initial cost relative to other farm equipment and the farm budget, plus the land area.
- Whether the farmer would fly or hire a pilot.
- The user inclusivity of broad perspectives.

DJI Phantom 4 Multispectral drone. Below the body is the multispectral camera, capturing red edge, near infrared, visible, red, blue, and green lights. There are live NDVI and RBG (what we see) feeds. Atop the body is an RTK (real time kinematic) receiver for accuracy. It coordinates with GPS. Our drone is registered with the FAA (Federal Aviation Administration).

## Diversity and Inclusion as Priority

Every field of work has inequities and areas of exclusion. Particularly in agriculture and with drone work, we see white males dominantly represented. The people I worked with were relaxed, friendly, and more comfortable in heat and nature. There is no reason but tradition explaining this homogeneity in agriculture in the Grand Valley. People with disabilities and different skills can operate drones for farms, diversifying agriculture. With inclusion in every room, agriculture can be enriched, outside of new technology.

We need all perspectives to address the water-centric problems in the Colorado River basin. Everyone is a stakeholder in natural issues like this, and as the world population grows, we need more food and diverse farming. Use of drones will contribute to optimal water use and land stewardship, but everyone needs to be part of the conversation. Diverse ideas complete our knowledge.

## Applications in Sustainability (ESS)

Drone technology helps to prevent overuse of inputs (water, chemicals, land, fertilizer, etc.). It also monitors soil conditions and large areas of crops. We can interpret data to see fields' nitrogen, water, or chlorophyll levels to gauge when to harvest, for example. Drone technology can be part of sustainably increasing food production for the future.

## Lessons Learned

- Plan for the goals, events, backup plans, and schedules to coordinate people.
- Interview locals and gain personal insights.
- Craft deeper research questions.
- Put the map data on the cloud for sharing.
- Look out for diversity issues, incorporate them into all internships, and take action.
- Encourage all interns and coworkers to share personality test results.

## Futures of Agriculture

We are transitioning into what some have called the Drone Age.

- Give and take farm tours to introduce new practices to youth and farm owners.
- Learn the fundamentals of agriculture and natural resources to understand the changing climate.
- Batteries need to gain run time, be sold in larger quantities and with available service, or be changed to other forms of energy.
- Hydrogen cells to extend time.

As long as they do their job, they are the future.

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