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UAVs in Agriculture

The following information has been gathered together for use by customers, and potential customers of M3 Aerial Productions. If you have any questions, please contact Matthew Johnson at m3aerial@gmail.com, or by phone at (204)800-0220 or toll free at 1-866-814-4855

1) Very new technology in North America
    - The first Section 333 (FAA) exemption was issued for precision agriculture drone operations in January 2015

2) UAV can be used to gather a variety of image-based data including:
    - Plant height
    - Plant count
    - Plant health
    - Presence of nutrients, disease, weeds
    - Relative biomass estimates
    - 3D / volumetric data (piles, patches, holes, and hills)
    - Orthomosaics
        - Georeferenced aerial imaging with homogenous scale

3) UAV data is used for:
    - Crop scouting
    - Crop health monitoring (biggest ROI)
    - Field surveying/scouting (before planting)
    - Nitrogen recommendation
    - Yield monitoring
    - Plant stress monitoring
    - Drought assessment

4) NDVI
    - Normalized Difference Vegetation Index
        - Green is not always good, red is not always bad
        - Very high green value could mean high weed pressure
    - NDVI is one piece of the puzzle
        - Still need boots on the ground (ground truthing)
        - Should have an understanding of the crop varietal, history of the field, growth stage, applications, and environment (moisture and temp)
    - Best when used over several months or years to get the best understanding of the growing patterns
        - To accurately gauge the savings would need to use for 2 or more seasons

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- Makes crop scouting more effective and efficient
- Can be applied extremely well in grain-corn areas
    - Often, nitrogen requirements exceed what is applied by seeding time
    - Nitrogen is key limiting growth factor when under-applied in spring
    - NDVI can help calculate nitrogen topdressing rates

5) The Problem
    - About half the inputs in farming (water, fertilizers, pesticides, fungicides and herbicides) are typically wasted because they're applied in greater amount than needed or in the wrong place (the ground between plants rather than the plants themselves)
    - Every crop is different – each crop needs to be measured differently to generate actionable data

6) Thermal Infrared
    - CWSI (crop water stress index) measures temperature differentials to detect/predict water stress in plants

7) Results?
    - Less fertilizer, water, chemicals and fuel.
    - Save 10-30% (huge variability with many factors/dependents)
        - Past practice
        - Yield price that year
        - Weather/environmental factors
    - Higher yield
    - Being able to identify an insect infestation days, or weeks before they explode
        - If bugs don't show up normally, maybe no savings in that area…
    - After a mild winter, can detect damage earlier

8) Drawbacks?
    - With fertilizer, the cost benefit of finagling around with 75# vs 100# vs 125# for VR based on the aerial imaging can be somewhat nullified due to the cost of the service
        - dependent on size of fields

9) Two mind sets:
    - "Prices are low so I should do everything I can to get the most yield out of every acre I can"
    - Prices are low so I can't spend a cent on anything but the bare bones to get the crop to harvest

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10)Why drones vs. other forms of crop management?

- Cheaper
- Greater precision
- Earlier detection of problems due to ease/higher frequency flights
- Total field scouting
- 3D / volumetric data to calculate volume of piles, holes, hills and patches. These can be compared to infrared images to detect density issues like hot spots in a crowded potato field or identify contour problems such as a north slope shade issue
- Autonomous flight
- Manage multiple irrigation pivots and nozzle inspections

11)Why **M3 Aerial Productions** & Ag Eagle RX60

- 45-60 min flight times = 400+ acres per flight
- Provide training
- Provide servicing
- Consulting

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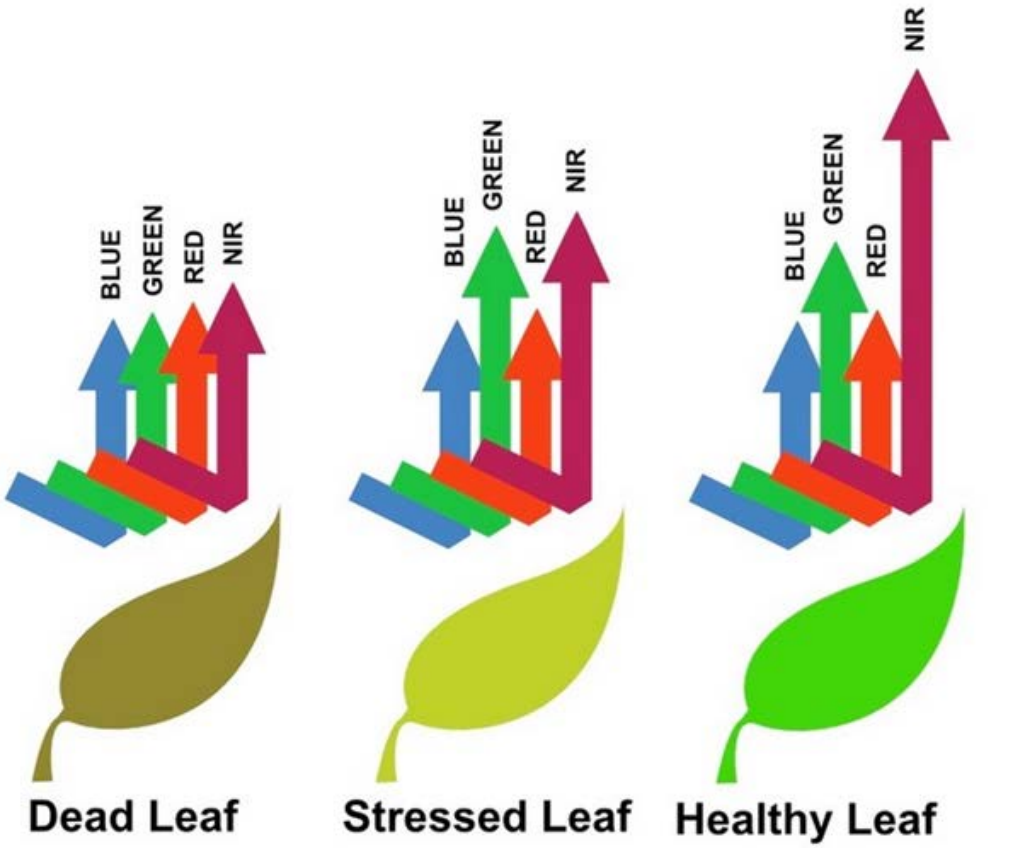
- Includes software subscription for first year, free wing replacement



The basic principle of NDVI relies on the fact that, due the their spongy layers found on their backsides, leaves reflect a lot of light in the near infrared, in stark contrast with most non-plant object. When the plant becomes dehydrated or stressed, the spongy layer collapses and the leaves reflect less NIR light, but the same amount in the visible range. Thus, mathematically combining these two signals can help differentiate plant from non-plant and healthy plant from sickly plant.