

A large, scenic photograph of a golden wheat field under a bright blue sky with wispy white clouds. The field occupies the lower half of the page, sloping upwards from left to right. A solid green horizontal bar covers the bottom third of the image, containing the text.

# 2016 Product Offering

# farmshots

growing with you

As FarmShots moves into 2016, we're developing exciting additions to our products in our quest to provide value to our growers and agronomists. Our goal is to provide the highest quality information to allow our customers to make the best decisions possible for themselves and their farms.

As always, we're committed to integrating high quality software with scientifically sound agronomic knowledge and decision making. This commitment is, and will continue to be, what has allowed us to develop a strong and differentiated product offering. Although we'll continue to provide value with our current offerings, we're not satisfied in our quest to be the number one solution for remote and drone sensing on the market. This coming year we'll be releasing some groundbreaking product features for our customers.

# Product Features



## Disease Identification

With our 20+ terabyte database of imagery behind us, we're developing machine learning models that will assist agronomists in problem identification by suggesting regions for investigation, and provide possible causes and solutions.



## Integrated Mobile Application

In the coming month, we'll be releasing the first version of the FarmShots mobile application for iOS. The mobile application has all the power of the web application, and more- allowing devices not connected to the internet to retrieve imagery for use while out in the field. We're planning on turning the mobile application into an entirely integrated scouting tool- allowing for the creation of reports, the tagging of pictures, and the ground truthing of remotely sensed data.

## Nutrient Management



New studies on remote sensing of soil composition have shown a great deal of promise in evaluating everything from NPK to organic matter concentrations. This year, we'll be releasing new processing algorithms for evaluating concentrations of a range of different soil elements that will allow for optimized input distribution as well as deficiency identification. Our goal is to supplement- and even, in some cases replace- traditional soil testing.



## Powerful and Flexible API

We're presently in the process of rolling out the second version of our API, which nearly doubles the speed of imagery delivery from ~250ms to ~150ms, allows for the flexible creation of colormaps and indices, and provides direct alerting when a significant change is detected in crop health. The newer version of the API will allow us to quickly and simply integrate into other farm management ERPs.

# Farmshots Profile: Southern Rust



## What is Southern Rust?

- Southern Rust is a fungal disease caused by the *Puccinia polysora* pathogen.
- Southern Rust is simultaneously rarer and more destructive than common rust.
- Southern Rust favors high humidity and temperatures, and is therefore more common in the south.

## Why is it a problem?

- Southern Rust is particularly a concern for growers as new infections may occur every 7 days.
- Southern Rust damages individual fields extremely quickly.
- Southern Rust rapidly spreads to cover a wide swath of the farm.
- Southern Rust affects corn by reducing functional leaf area, resulting in poorly filled kernels and reduced yield.
- Southern Rust also creates the potential for stalk rot by weakening stalks.

# Farmshots Solution: Southern Rust

Southern Rust has a particular notable effect on NDVI - the normalized difference vegetative index, resulting in a 2x reduction at the filling stage and a 2.5x reduction in value at the milky stage of corn. Therefore, our first step is computing a generic NDVI map of the field, as is shown below.



We can see significantly poorer plant health in the left side of the field. However, this is not enough to differentiate a disease versus a nutritional deficiency versus a pest. To do that, we monitor the same spot and compare it to the next image that becomes available from a drone or satellite:



# Farmshots Profile: Frogeye Leaf Spot



## What is Frogeye Leaf Spot?

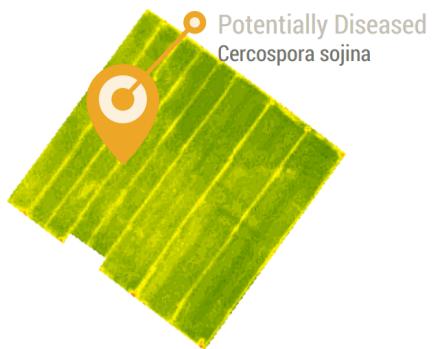
- Frogeye Leaf Spot is a fungal disease caused by the fungus Cercospora sojina.
- Frogeye Leaf Spot is most commonly found in the south, MRD, and southeastern soybean growing regions.
- Frogeye Leaf Spot favors warm, humid conditions and rains may exacerbate the disease.

## Why is it a problem?

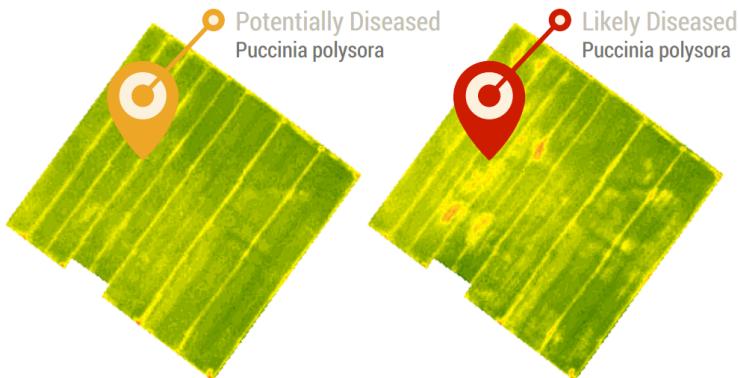
- Frogeye Leaf Spot can result in up to a 30% loss on susceptible varieties. A 30% reduction in yield at 50 bushels per acre selling for \$9.50/bushel results in a loss of \$142.50/acre.
- Frogeye Leaf Spot is often a year to year problem as spores go dormant in soybean residue.

# Farmshots Solution: Frogeye Leaf Spot

Similar to Southern Rust, Frogeye Leaf Spot has a notable effect on NDVI. However, due to its characteristic leaf patterning, there are additional ways to sense it if drone imagery is available. In the case that only satellite data is available, our first step is computing a generic NDVI map of the field, as is shown below.



We can see spots of slightly poorer plant health in the center of the field. However, again, this is not enough to differentiate a disease versus a nutritional deficiency versus a pest. To do that, we monitor the same spot and compare it to the next image that becomes available from a drone or satellite:



# Farmshots Profile: Late Blight



## What is Late Blight?

- Late Blight is a fungal disease caused by the fungus *Phytophthora infestans*
- Late Blight was the cause of the Irish Potato Famine, and it affects both potatoes and tomatoes.
- Late Blight affects nearly all parts of the plant- the leaves, stems, fruits, and tubers. Late Blight favors high moisture and moderate temperatures from 60-80°F.

## Why is it a problem?

- Late Blight is incredibly destructive, affecting both the fruit and tuber, making them inedible.
- Even if only a small portion of the harvested crop is infected, Late Blight makes the tubers especially susceptible to soft rot. Therefore it is usually in the grower's best interest to make sure no tubers are infected at all, requiring early detection and elimination of the disease.

# Farmshots Solution: Late Blight

Late blight is more difficult to detect using NDVI. The ZTM (Zarco Tejada and Miller) is much more sensitive to the effects of the disease. The first step is computing the ZTM index. This requires hyperspectral data, as opposed to NDVI, which only requires multispectral data. Hyperspectral data can be acquired off of a select few satellites like Hyperion, as well as off of drones and planes.



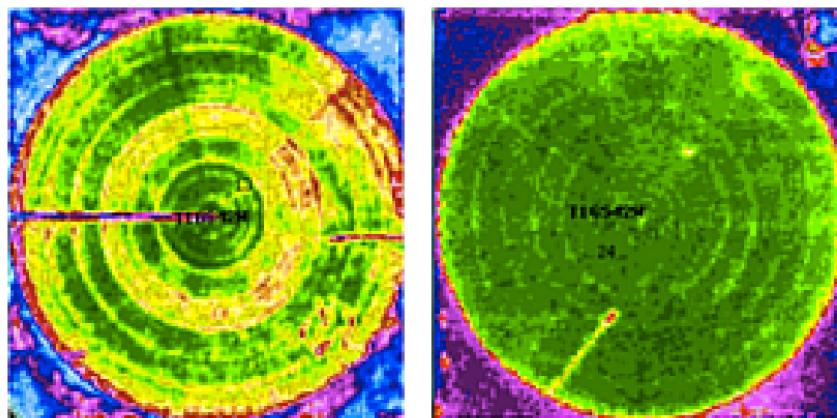
We then again look for signs of disease progression. The select spots in the field in the left image have now darkened to become epicenters of the infection. We can see the fungus has not only spread to multiple spots, but has also infected nearly the entire field. Now that we've again identified the problem as a disease versus a pest or nutritional deficiency, second stage processing begins. Starting with a list of potential diseases, we narrow it down. Once temperature, rainfall, and crop type are taken into account, the disease is narrowed down to Late Blight.



# Farmshots Profile: Center Pivot Irrigation

## What is Center Pivot Irrigation?

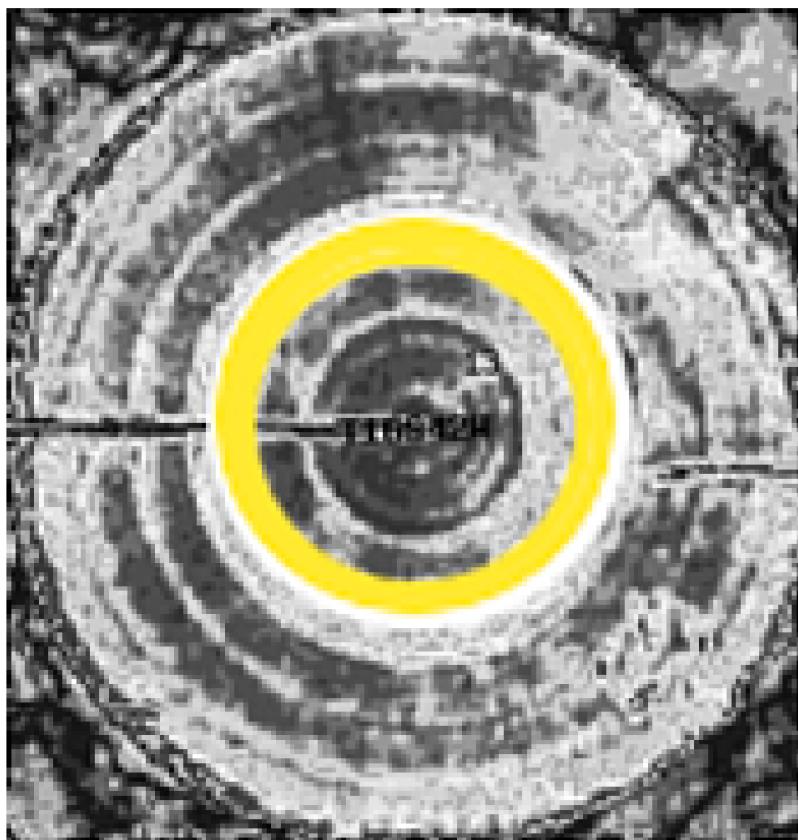
Center pivot irrigation is a relatively common form of irrigation where a large sweeping arm rotates around a circular field, distributing water. There are spray nozzles located at equal intervals along the arm. Sometimes, these nozzles will become clogged, limiting or even preventing water flow. Clogged nozzles can be difficult to detect, and can often leave a large swath of the crop under watered. The example below comes from a farm owned by the International Farming Corporation:



The first image shows broken nozzles leaving circular streaks of poor plant health in the farm- the second image shows the farm after nozzle placement.

# Farmshots Solution: Center Pivot Irrigation Clog

Detecting circular rings of poor plant health can allow us to isolate potential broken nozzles and suggest their repair. For example, circles are easily detected by the well-researched Hough transform. Then, by looking at the distance from the center pivot to the ring of poor health, we can determine the approximate nozzle position.



# Farmshots Solution: Nutrient Management

By analyzing the nutrients in the soil, FarmShots can generate prescriptive maps for variable rate fertilizer distribution, which has been shown to give up to a 40% reduction in usage. For corn, a single year's fertilizer can cost about \$115 per acre, giving a total savings of up to \$46/acre.

