Technology: Drones' role in managing turf health **pg14**

Landscaping: Surviving 37 years in the industry **pg30**

Health & Safety: Working amid COVID-19 **pg46**

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P8

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Drones and turf: monitoring health of green spaces

Technology provides another useful tool for turf professionals

By Willie Carroll

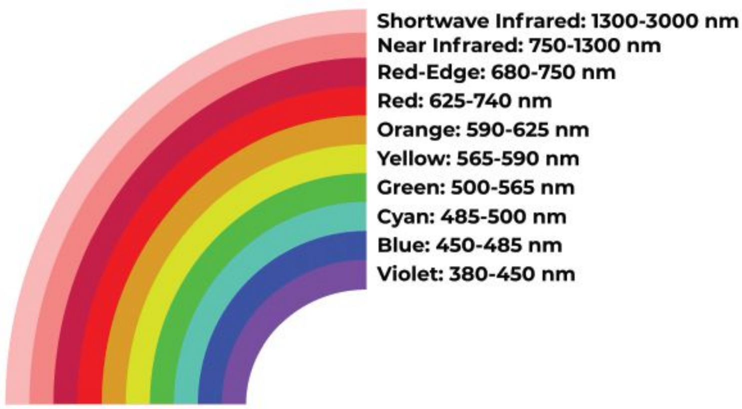
With the advances in technology over the last few years, drones have become more of a regular part of day-to-day life for a lot of industries. From using drones to help create better wines to helping with protection and conservation efforts of the white rhino population in Africa, drone use has become much more popular.

An area that is up and coming is the use of drone technology in the turf management industry to help monitor the health of the turf, especially to help with early detection of disease or fungal infections. One of the methods used to monitor turf health is called Normalized Difference Vegetation Index (NDVI). The NDVI can identify areas with possible fungal or disease infections before these issues become visible to the naked eye. This in turn allows for earlier monitoring or field checks to deal with the infection before it becomes a significant issue.

The who and what of NDVI

NDVI was developed in 1972 by NASA researchers as a way to measure vegetation health across the planet on a large scale from satellites orbiting the earth. The most popular use of NDVI since 1972 has been in the agriculture industry to help assess crop health across large fields. The initial research done to develop NDVI was done using imagery captured of the Great Plains in the Midwest of North America, better known as the "Bread Basket of North America." The process of using NDVI for vegetation health assessments and monitoring has become the standardized method used worldwide.

The traditional method of data acquisition to create NDVI maps was to use satellites and aircraft equipped with multispectral cameras that captured images in multiple different light wavelengths. For crop health monitoring, there are six important light wavelengths that scientists use for their studies: three visible wavelengths of the light spectrum (red, green and blue) and



Fugure 1: Shows the light spectrum with the associated wavelength ranges in nanometres.

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three non-visible wavelengths of the light spectrum (red-edge, near-infrared, short-wave infrared) (Figure 1).

With the advances in technology, the specialized sensors used to capture the data have become miniaturized. This has allowed these sensors to be fit onto drones which has opened up many opportunities to capture imagery in a much more cost effective manner. Using a drone also allows for a higher resolution and quality of data to be collected. These sensors, just like the ones on satellites and aircraft, collect three visible light wavelengths – red, green and blue – but also collect the non-visible red-edge and near-infrared wavelengths. The red-edge wavelength shows the transition zone from the red portion of the light spectrum to the near-infrared zone where the reflectance of light is drastically increased, adding another layer onto vegetation health detection and expanding the capabilities of analysis.

The science behind NDVI

To understand the science behind NDVI, let's look at how these different wavelengths apply to plants that we see every day.

Healthy plants appear green to the human eye as the strongest visible light reflected off the plants is the green wavelength. The amount of green light reflected off of the plant is about five to 10 times less intense than near-infrared light, and the amount of near-infrared light is directly correlated to the health of the plant (Figure 2). Red and blue wavelengths are absorbed by the plant to use with photosynthesis activities. When a plant absorbs energy from the sun's light using photosynthesis, chlorophyll creates energy for the plant to use to grow. Chlorophyll strongly absorbs visible light in the blue and red wavelengths into the cellular structure of leaves, and when there is strong photosynthesis activity within the plant this can be used as an indicator of healthy vegetation.

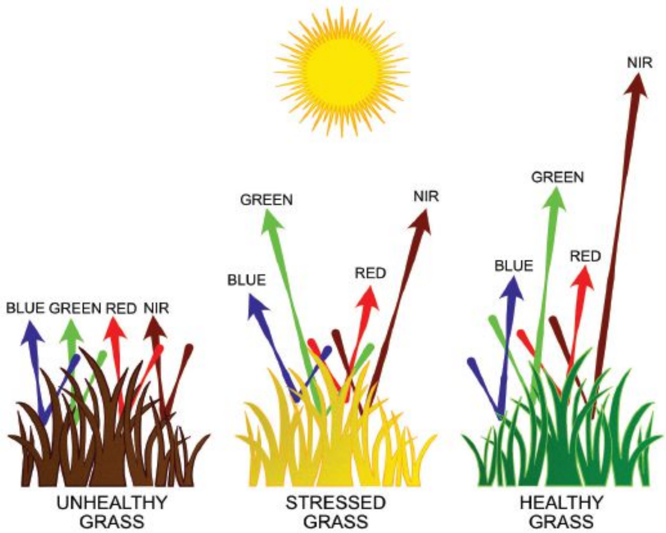

Figure 2:: Turf reflectance with simulated amounts of wavelengths emitted.

Drones with sensors flying over an area collect information including data on the different light wavelengths being reflected off the vegetation. The NDVI maps are created from the reflectance difference between the visible red light wavelength and the non-visible near-infrared wavelength.

When a plant becomes dehydrated, sick or afflicted with a disease, the spongey layer, where the chlorophyll is stored, deteriorates and the plant absorbs more near-infrared light than if it were healthy. Using a drone equipped with a multispectral sensor allows for these sometimes subtle changes to be observed. As the amount of near-infrared light reflected decreases the sensors, it provides the user with an accurate indication of lower amounts of chlorophyll within a plant which correlates to an unhealthy or weakened plant.

When using NDVI to monitor vegetation health, uniform healthy turf will have relatively consistent near-infrared light being reflected and unhealthy or weakened vegetation will reflect lower amounts. These variabilities in an NDVI map can indicate stresses that need to be investigated. When looking at an NDVI image, it will show the range of health for the vegetation, but it will also show other features. Within the image, different surfaces will reflect different amounts of near-infrared light. Water, pavement or bare ground absorbs near-infrared light, so on an NDVI image these will appear as negative values, or red as most NDVI images will have a red to green colour gradient. When analyzing an NDVI image to assess the health of the vegetation, the NDVI values can be affected by a variety of environmental and local stresses such as the amount of plant photosynthesis activity, total plant cover (area covered by vegetation), the amount of available light, the amount of plant biomass, the plant and soil moisture or other plant stress.

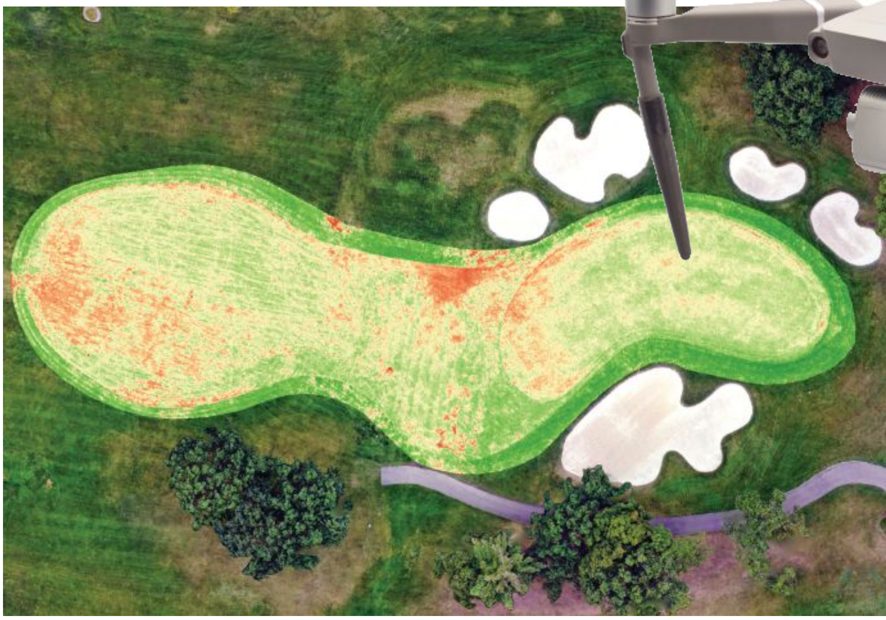

Figure 3: An NDVI map overlay on the fairway and green showing areas of high (green) and low (red) turf health.

Figure 5: A drone that can be used to conduct the surveys of the course to create NDVI images.

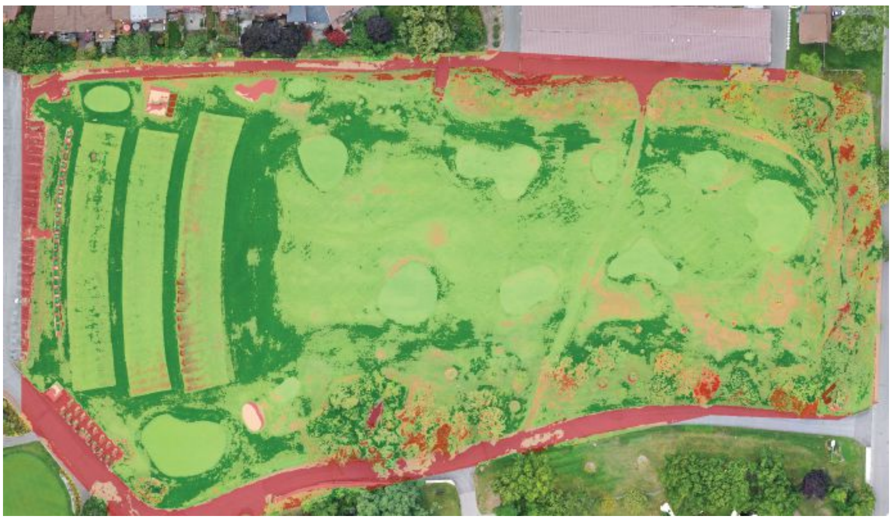

Figure 4: An NDVI map overlay on a driving range showing areas of high (green) and low (red) turf health.

NDVI in the real world

How does NDVI apply in the real world? Let's look at two examples from a flight done over a golf course.

The first is an image of a fairway and green of a par three hole (Figure 3). The NDVI image has been overlaid on a traditional drone aerial view image to allow for a user to see other features surrounding the hole. When looking at the NDVI image, areas in red hues are areas that have been identified as areas of concern or areas with low vegetation health. The reddish area on the left indicates low vegetation health as a result of high pedestrian and golf cart traffic coming from the tee block. In this area there is high soil compaction reducing the amount of available oxygen in the soil to the detriment of the turf. A second area of concern is the dark red area in the centre of the NDVI image. On further investigation it was found that this area has a small depression which allowed for water to pool. As there was active water on the surface when the drone flight was done, the amount of near-infrared light being reflected was significantly lower as water absorbs near-infrared light.

The second example is a driving range on a golf course (Figure 4). This example can have similar characteristics to any large open turf field which could be used for sports such as soccer, football, baseball, or rugby. On the tee deck of the driving range (lower left side of the NDVI image), it is possible to view the divots that golfers have made. It is also possible to see the area of soil that gets thrown forward when the golfers create these divots. Using NDVI can allow golf course operators to know when and where a new tee deck should be placed, allowing heavily used areas to regrow.

With the use of NDVI technology, vegetation health and stresses can be identified before they become visible to the naked eye which would allow for the early detection of issues. This will allow operators to target areas needing more attention throughout the season of use and is an extra tool that maintenance staff can use. Using drone technology and NDVI technology is not about making maintenance staff redundant, it is about making their efforts more efficient and cost effective through utilizing new technology and methods (Figure 5).

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