

Spectral Reflectance Analysis Can Detect Internal Abnormalities

REVEAL SUBTLE CHANGES OF INTERNAL TREE HEALTH

◀ This flourishing tree appears healthy externally
but has poor internal health

HOW DOES OUR NEW TECHNOLOGY REVEAL THE INTERNAL TREE HEALTH?

- ✓ New technology of spectral reflectance analysis
can detect internal changes
- ✓ Analogous to diagnostic imaging of X-rays, CT Scans
and MRI Scans

SPECIAL FEATURES OF THIS TECHNOLOGY

HIGH-RESOLUTION DATA

The satellite data for this innovative technology has undergone atmospheric compensation through a proprietary algorithm, so that the spectral reflectance value will represent the surface reflectance. WorldView-2 /-3 satellite data of 50cm-30cm panchromatic resolution are merged with 2m - 1.2m multispectral resolution data using a "lossless" pansharpening tool to retain the original multispectral value for analysis. Satellite data of the same month/season and similar sensor direction are used to accomplish consistent and reliable results.

DIRECT MEASUREMENT

As our methodology is based on direct measurement of the spectral reflectance percentage of a few selected foliage pixels from a single tree, instead of a polygon covering an area of the canopy, the interference from leaf shadows, ground features and pruning will be avoided. Hence it is different from Normalized Difference Vegetation Index (NDVI) and other vegetation indices which involve mathematical calculation.

APPLICABLE TO ALL SPECIES

Our approach is to compare the changes in spectral reflectance of the same tree over a period, so it is applicable to trees of different species.

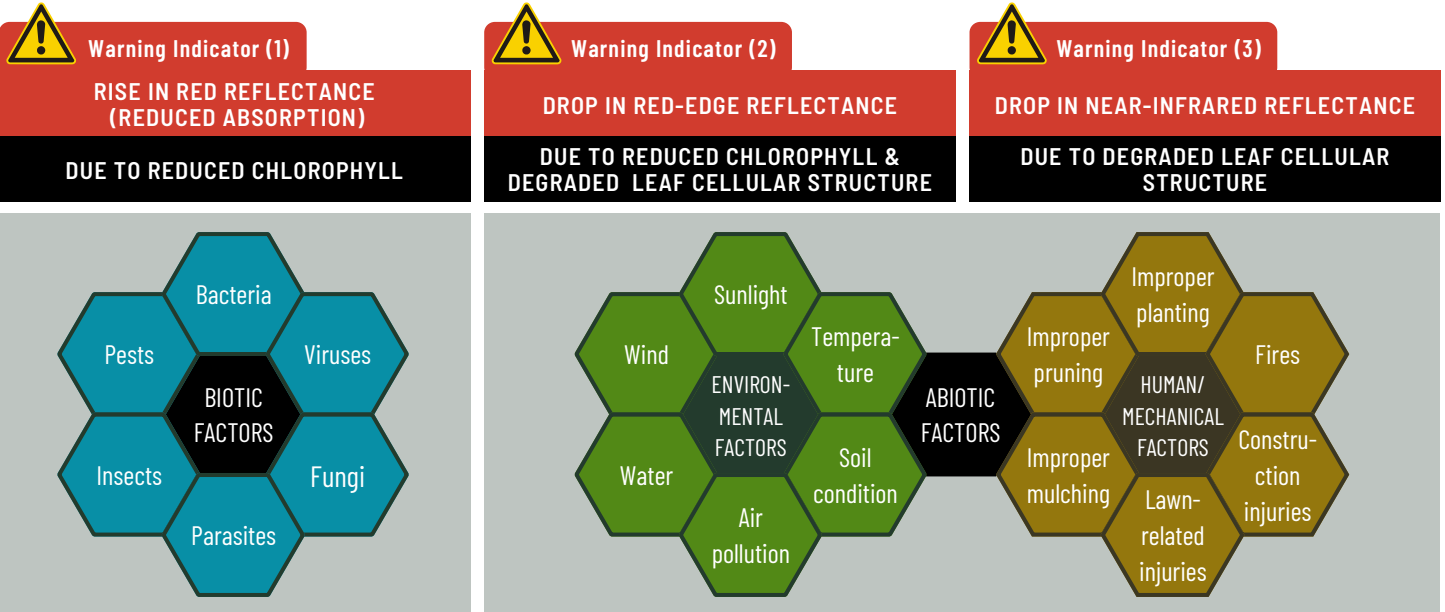
INDOOR ANALYSIS

The spectral reflectance analysis technology was developed by Geocarto International Centre Limited in 2015. This new technology reveals internal health warning indicators directly which are not always shown in onsite inspection, and does not require specialised instruments or calculation to obtain the spectral reflectance. It is a cost-effective, non-invasive, and objective analysis. This new technology has been verified by various case studies in different countries. Details have been presented in 3 papers published in *Arborist News* by the International Society of Arboriculture (ISA). They are available online at www.geocarto.hk/articles

3 Analytical Aspects of Internal Tree Health

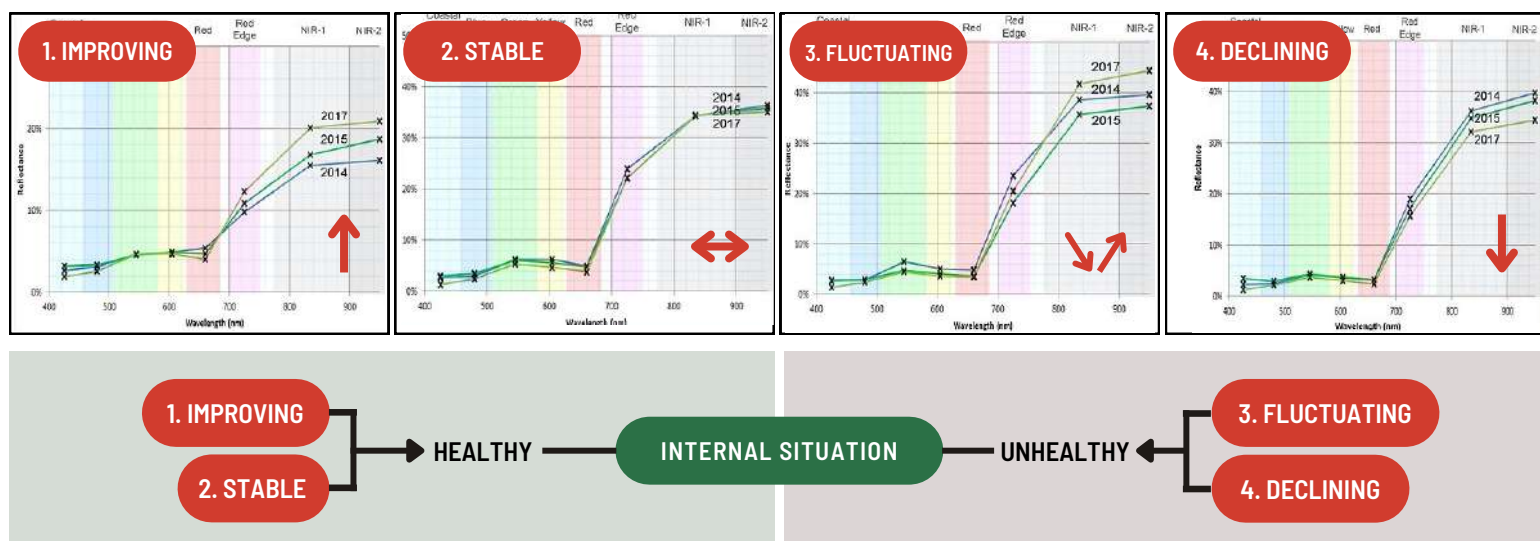
1 3 INTERNAL WARNING INDICATORS

These 3 internal warning indicators are derived from spectral reflectance of tree foliage in **(1) red**, **(2) red edge** and **(3) near-infrared** bands of the Sun's electromagnetic spectrum. The impact on changes in spectral reflectance is caused by biotic and/or abiotic factors as shown below.



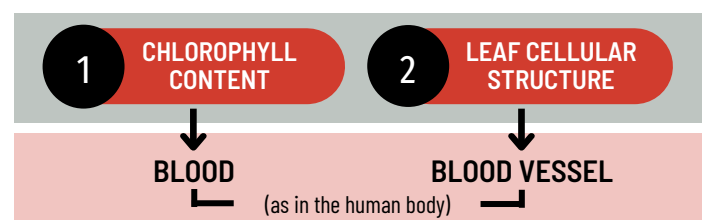
2 4 CATEGORIES OF INTERNAL TREE HEALTH

By comparing 3 or more sets of satellite data, we can identify 4 categories of internal tree health:



3 THE EFFECTS OF CHLOROPHYLL & LEAF CELLULAR STRUCTURE

They are analogous to blood and blood vessels in the human body. If the blood values are normal but the blood vessels are abnormal, it is still a serious health problem. Since the chlorophyll content is stable, its leaves will appear green, but the internal health of the tree is actually declining, due to the deterioration in leaf cellular structure. The tree on the front page is one of the examples.



A New Case Study with Breakthrough Discovery

How can we detect those trees with "healthy" external appearance but are deteriorating internally without onsite inspection?

The present case study covers 25 stressed trees (*Ficus microcarpa*) growing along a section of Paramount Boulevard, between Deerford Street and Greenmeadow Street in Lakewood City, Los Angeles, U.S.A. These trees, infected by Bot canker (*Botryosphaeria canker*) in recent years, were all removed in June 2019. We have undertaken a retrospective case study of these trees using WV-2 satellite data collected on 2010-04-07, 2012-04-28, 2016-05-24, 2018-04-11 and 2019-05-29.

Photos were taken on 14th May 2018

This case study of 25 stressed trees has demonstrated positively that trees showing dense canopy and green leaves may not necessarily indicate "healthy" condition, because we have to consider two separate factors affecting internal tree health. They are **(a) chlorophyll content** and **(b) leaf cellular structure**. They are analogous to blood and blood vessels in the human body. If the blood values are normal but the blood vessels are abnormal, it is still a serious health problem.

Over the period from 2010 to 2019, the chlorophyll content of **Tree 20** and **Tree 23** as revealed by the red band was quite consistent, with a variation of only 2.02% and 1.82% respectively, as the spectral reflectance value in red band will be lower when there is higher chlorophyll content for absorption.

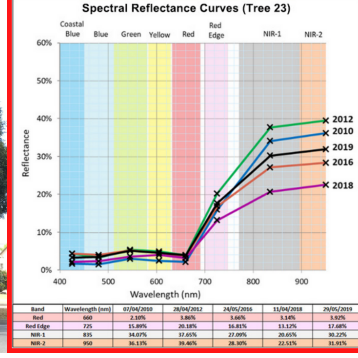
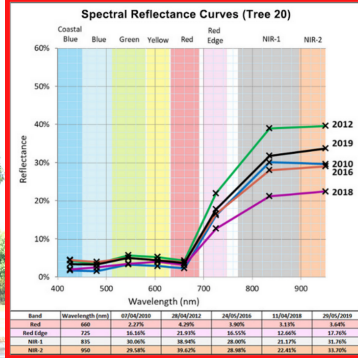
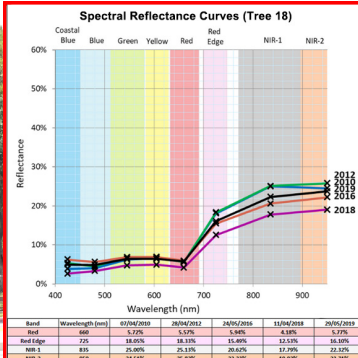
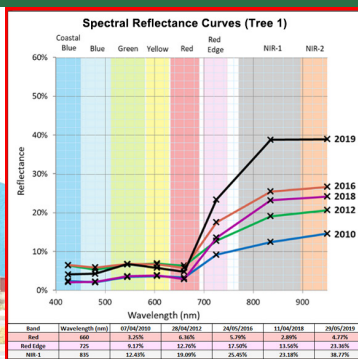
This means that the dense canopy was supported by consistent chlorophyll content to provide a subjective "healthy" appearance. But on the contrary, the changes in leaf cellular structure of these 2 trees were as high as 17.49% and 16.975% respectively in the near-infrared band. This means that both trees were actually deteriorating internally.

On the other hand, for **Tree 1**, both the chlorophyll content and the leaf cellular structure were declining markedly, by 3.47% in the red band and 25.34% in the near-infrared band, so its "unhealthy" appearance was obvious.

The fluctuating condition was mild for **Tree 18**, because the changes were only 1.76% in the red band and 7.07% in the near-infrared band. Therefore, in assessing internal tree health, we have to consider both chlorophyll content and leaf cellular structure. Its appearance does not reveal such internal health condition of a tree.

As **Tree 20** and **Tree 23** were internally abnormal, they could not be rated as "healthy" by visual observation. These 4 examples show that spectral reflectance analysis would provide a more effective approach to detect internal tree abnormalities than from visual observation. In fact, all these infected trees were subsequently removed in June 2019, as they varied greatly in fluctuating level and declining condition, indicating poor internal health and instability, which mean two different situations.

In our various case studies with spectral reflectance analysis, we have found that when a tree was fluctuating markedly or declining continuously over a period, that stressed tree might eventually result in failure, death or collapse, unless it had developed compartmentalization or received appropriate treatment. However, it must be emphasized that this technology is not designed to foretell when or whether a stressed tree will collapse. Instead, it provides objective internal health information about a tree to improve monitoring, management and maintenance.



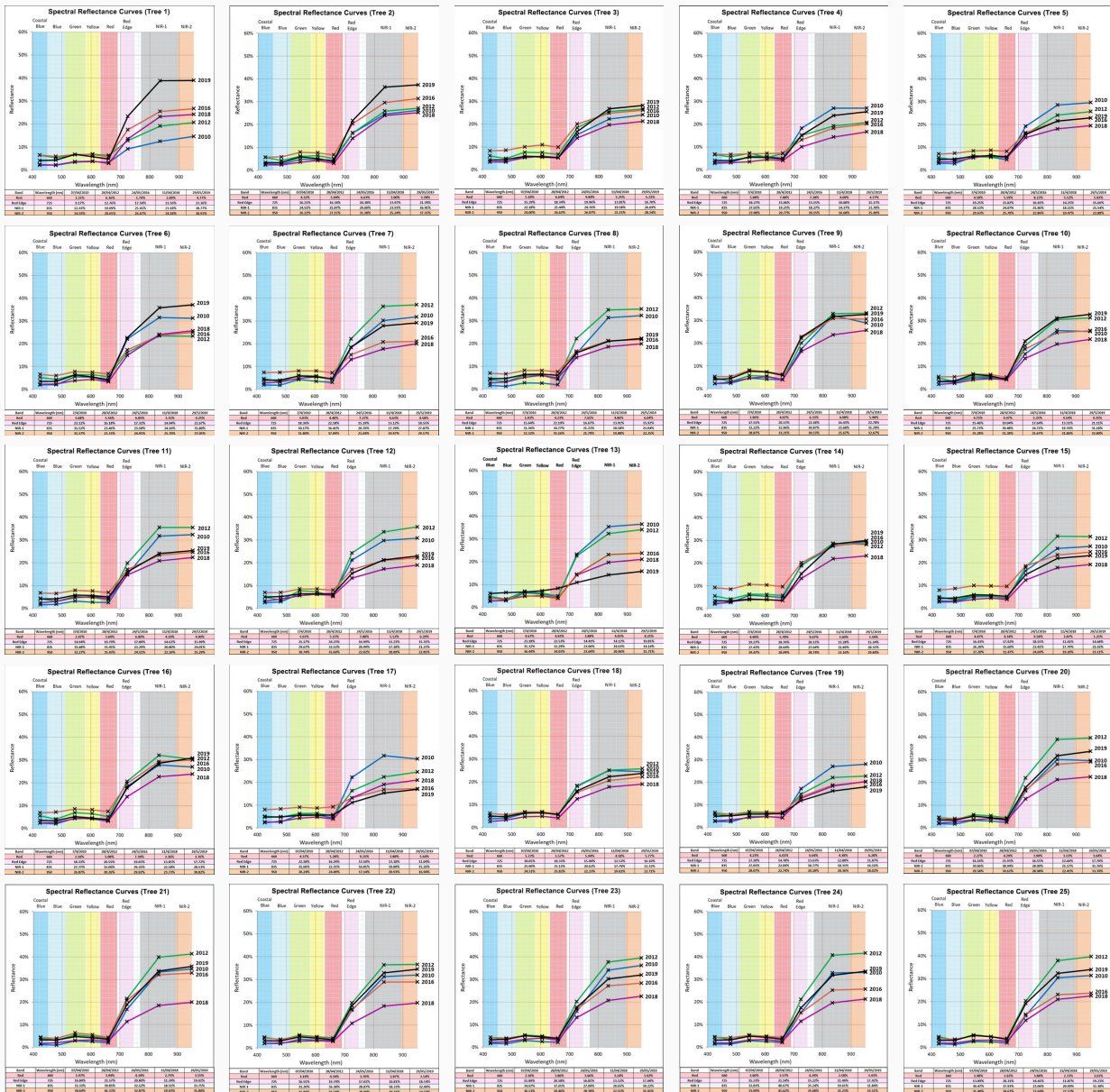
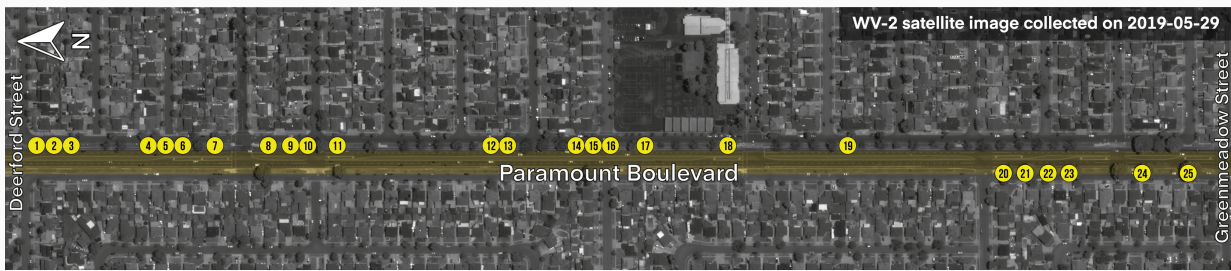
We are grateful to James Komen for providing the tree photos taken on 14th May 2018.

Spectral Reflectance Analysis Curves

Reveal the Internal Health Conditions of Trees:

Could you identify which trees were deteriorating more seriously?

LOCATION OF 25 STRESSED TREES ALONG THE PARAMOUNT BLVD IN LAKEWOOD CITY, LOS ANGELES



Let's check out the answers by visiting our website or scan the QR code below!



www.geocarto.com.hk/answers



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