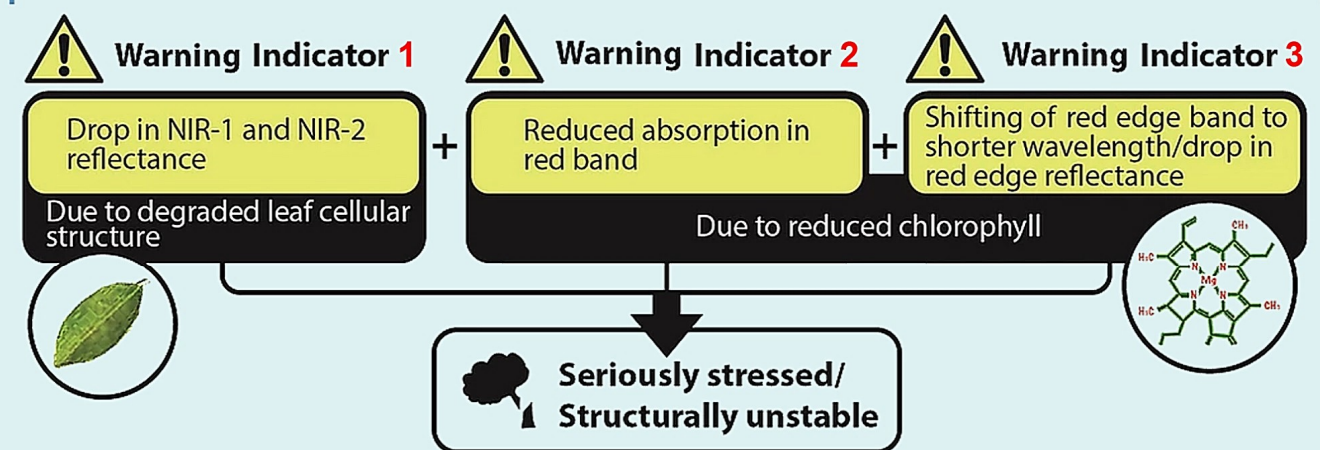


What Do Stressed Trees Reveal Before Collapse?

Our New Technology Reveals 3 Internal Warning Indicators
Determined remotely with no field visit! Time-saving and Cost-effective



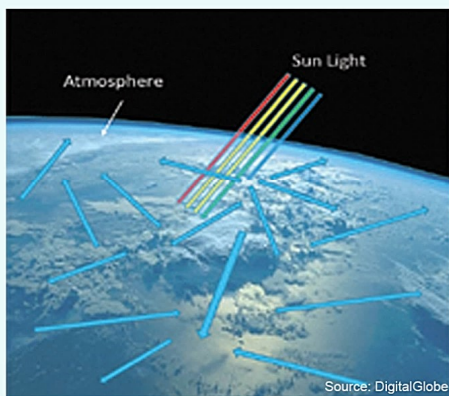
This new technology is not designed to foretell when or whether a stressed tree will collapse but it reveals **changes in internal health condition** of stressed trees objectively and quantitatively **before external symptoms are observable**

Monitoring System Developed by Geocarto

with the following processing components

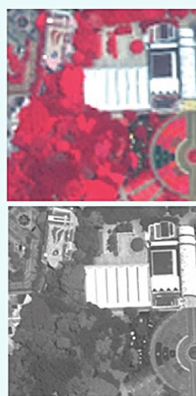
WorldView-2/3
AComp Satellite Data

AComp (Atmospheric Compensation) is a proprietary DigitalGlobe algorithm. It normalizes digital number (DN) values to surface reflectance values, by removing imagery variation due to illumination, viewing geometrics, and atmospheric effects.



“Lossless”
Pansharpening Technique

A “Lossless” pansharpening tool is used to fuse multispectral data of 1.2m - 2.0m resolution with panchromatic data of 30cm-50cm resolution. This will retain the fidelity of the original data without losing the spectral information content from each pixel.

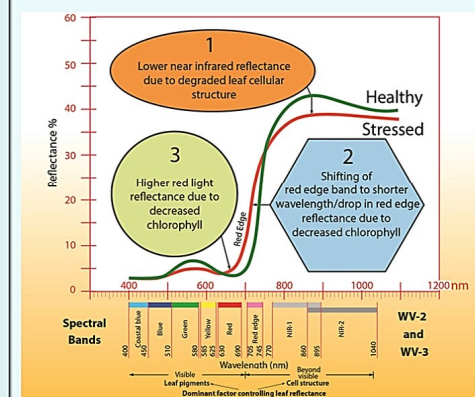


WorldView-2
Multispectral image
with pixel size of 2m.

WorldView-2
Panchromatic image
with pixel size of 50cm.

Spectral Reflectance
Analysis

Spectral reflectance reveals stress caused by biotic and abiotic factors. It is indicated by drop in NIR reflectance, reduced absorption in red band, and shift or drop in red edge band. Changes arise from subtle variation in chlorophyll content and leaf cellular structure.



Confirmed by Case Studies in North America, Asia, Australia and Europe ➡



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Since 1985

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WV-2 Satellite Data
Provided by Digital Globe
Distributed by Geocarto

An Integrated Approach

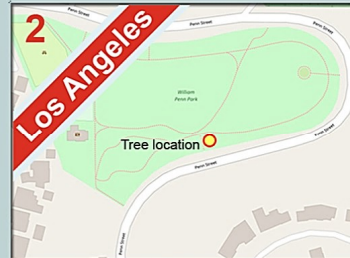
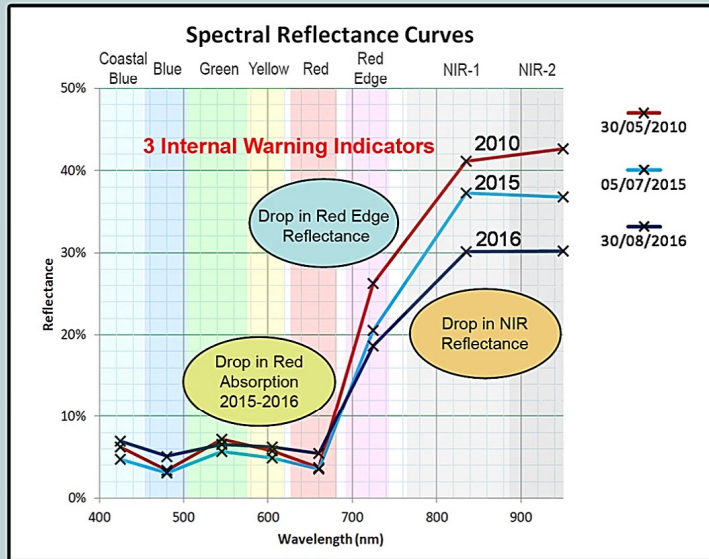
Spectral Reflectance Analysis

Onsite Inspection, Diagnosis Treatment



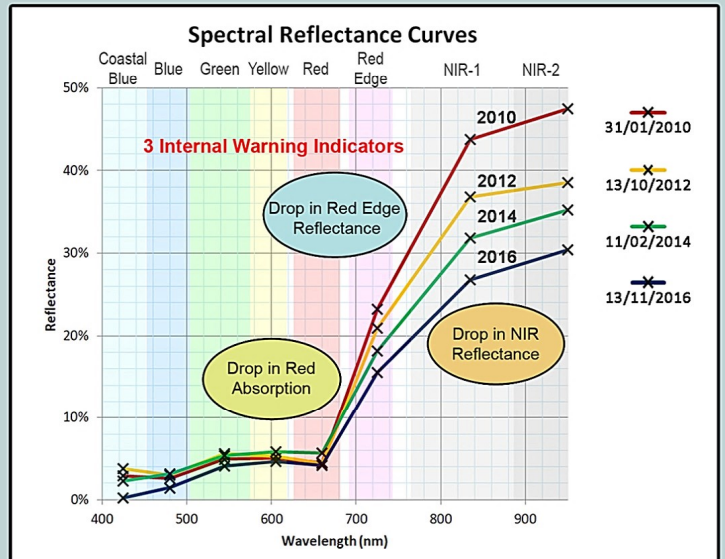
Location of Tembusu Tree
1.31304°N, 103.8155°E

This heritage tree of more than 270 years old collapsed on **February 11, 2017** in Botanic Gardens, killing one person and injuring four others. According to the press report, this tree was inspected twice a year and was found to be healthy in September 2016. Our system has detected progressive deterioration since 2010.



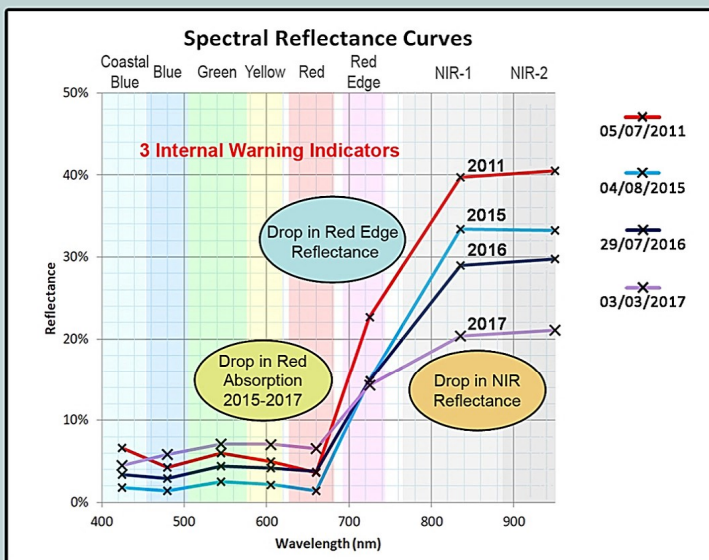
Location of Eucalyptus Tree
33.9745°N, 118.0236°W

This tree collapsed on **December 17, 2016** in Penn Park, Whittier, California, U.S.A., killing one person and injuring seven others. It was reported that a visual inspection of the park had been undertaken in the morning on that date, and no apparent issues had been found. Our system has detected continued aggravation since 2010.



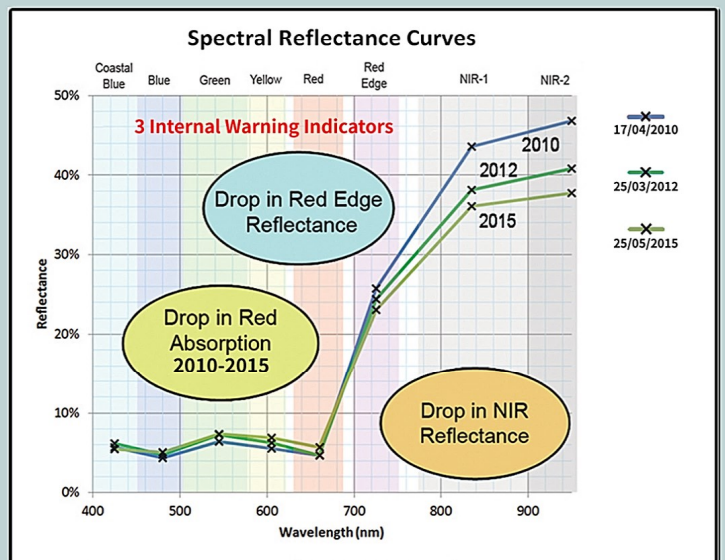
Location of Flame of Forest
22.4922°N, 114.1403°E

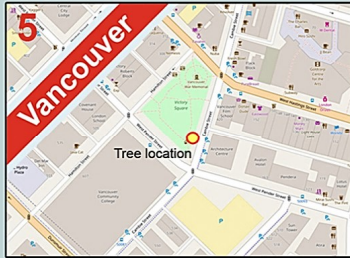
This tree collapsed on **July 24, 2017** in San Wan Road, Fanling, Hong Kong, injuring one person and crashing two mini-buses, two buses as well as one private car. That tree was last inspected on November 29, 2016 and no apparent issues had been found. Our system has detected continued declining condition since 2011.



Location of Big Leaved Fig
22.2840°N, 114.1404°E

This tree collapsed on **April 19, 2015** in Bonham Road, opposite King's College, crashing a car on the road and damaging a window air conditioner in the nearby college. According to press report, that tree was last inspected in March, 2015. Our system has detected declining condition since 2010. That tree was imaged on April 17, 2015.

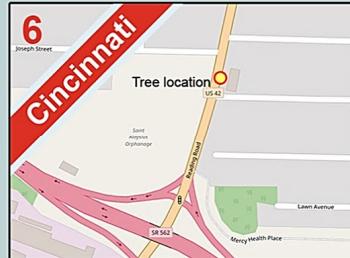
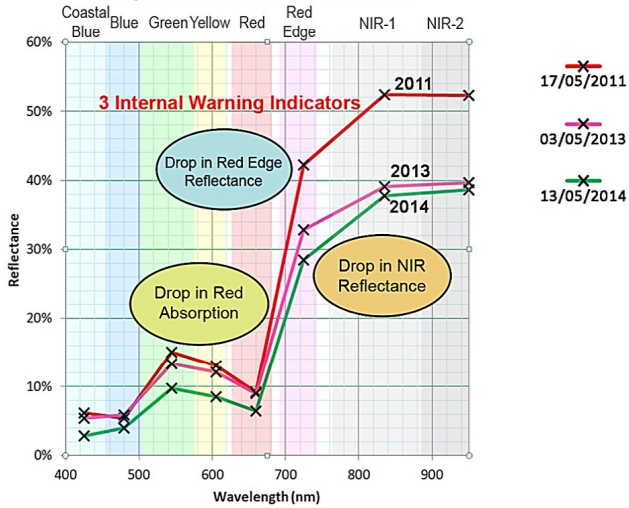




Location of Maple Tree
49.2819°N, 123.1100°W

This tree collapsed on **May 27, 2014** near Victoria Square, Vancouver, trapping two men in their vehicles. It was reported that according to the last safety inspection in December 2013, there were no significant visible defects on this tree or other problem. Our system has detected significant deterioration from 2011 to 2014.

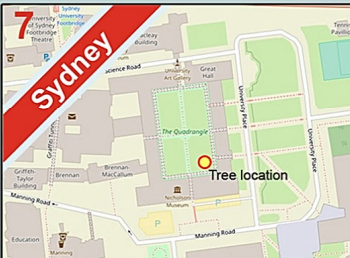
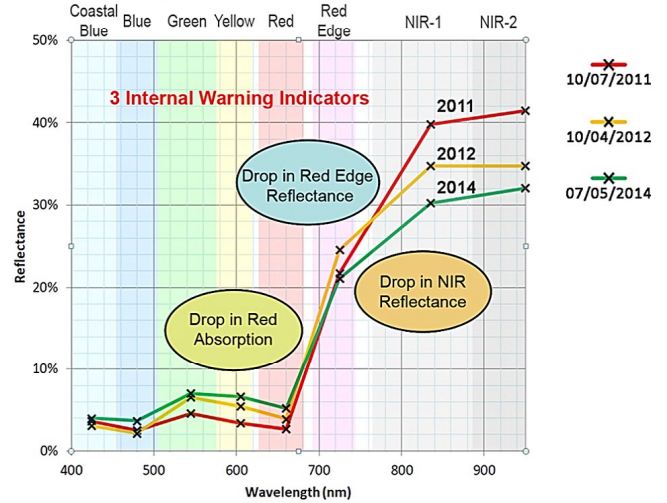
Spectral Reflectance Curves



Location of Pin Oak Tree
39.1724°N, 84.4677°W

This tree collapsed on **April 19, 2015** in Bond Hill, Cincinnati, killing a woman in her car as she drove in Reading Road. It was reported that this tree was last inspected in July 2014 and was marked for removal, but not immediately, as it did not demonstrate an imminent danger or threat. Our system has detected significant deterioration since 2011.

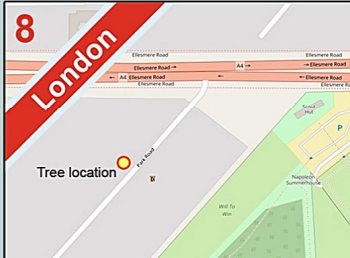
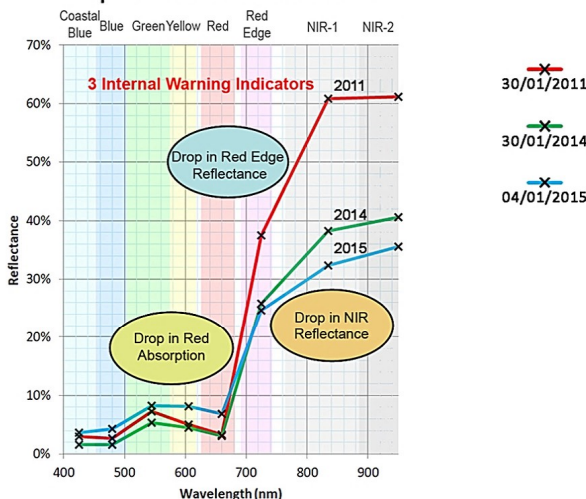
Spectral Reflectance Curves



Location of Jacaranda Tree
33.8862°S, 151.1891°E

This tree, which had thrived in the Quadrangle of Sydney University for 88 years since 1928, collapsed on **October 28, 2016**. It was 12 metres high with a canopy spread of 18 metres. Tests on the tree were conducted in 2014 and it was diagnosed with the fungal disease ganoderma. Our system has detected declining health condition since 2011.

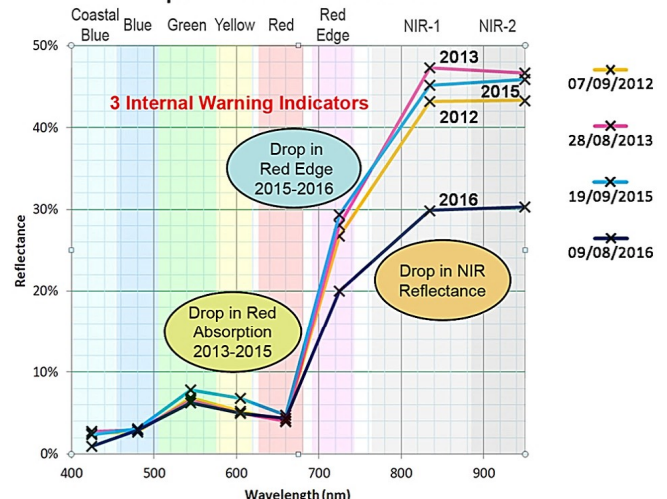
Spectral Reflectance Curves



Location of Tree
51.4871°N, 0.2618°W

This tree collapsed on **February 23, 2017** crashing cars and narrowly missing residential home on Park Road in Chiswick, west London. The collapse was attributed to storm Doris which battered the UK with strong winds. Our system has revealed that this tree fluctuated in health condition from 2012 to 2015 and deteriorated markedly from 2015 to 2016 before its collapse in February 2017.

Spectral Reflectance Curves

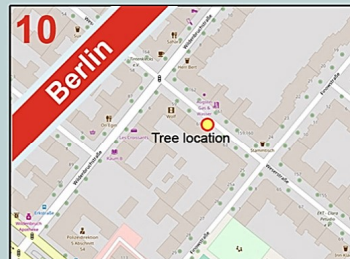
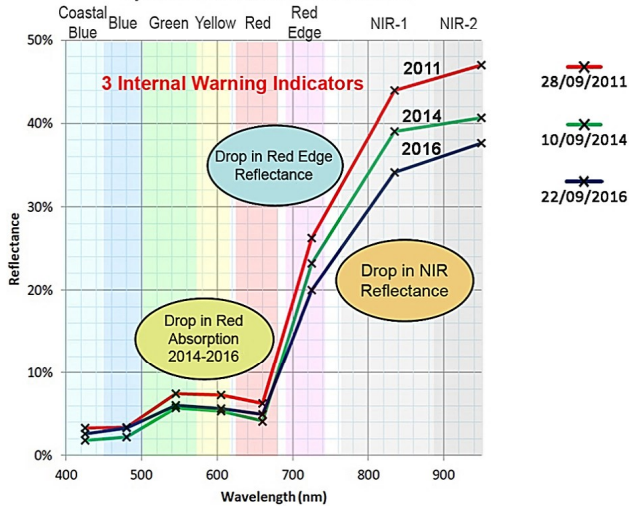




Location of Tree
48.8090°N, 2.4596°E

This tree collapsed on **April 20, 2017** in Maisons-Alfort, southeast Paris, injuring a woman. It was reported that the trees there dated from the construction of buildings in the fifties and that tree showed no external signs of disease. Our system has detected continued decline in health condition over the period from 2011 to 2016.

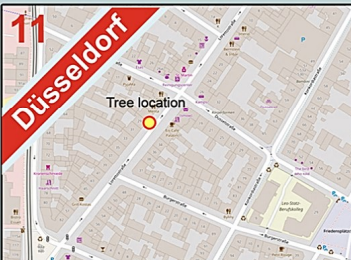
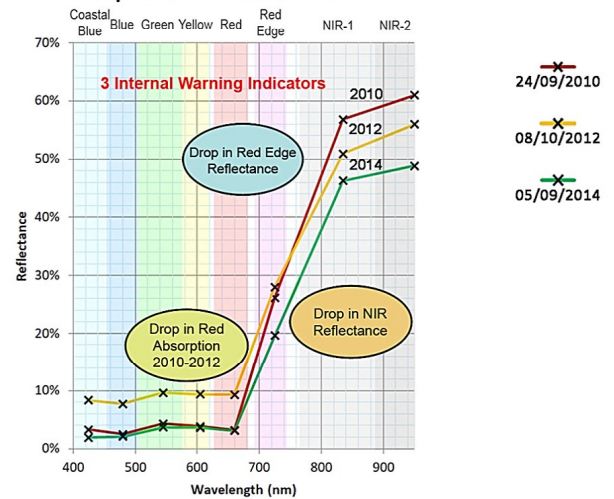
Spectral Reflectance Curves



Location of Tree
52.482614°N, 13.4424°E

This tree collapsed on **May 30, 2016** in Weserstraße, southeast Berlin, completely destroying a vehicle and smashing a window of a house. According to the first findings, the root system was rotten, which was not found in tree examination. Our system has detected progressive deterioration from September 2010 to September 2014.

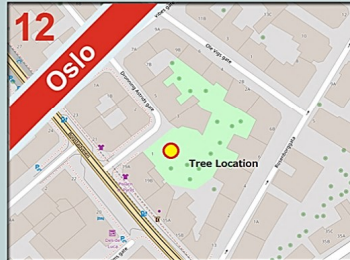
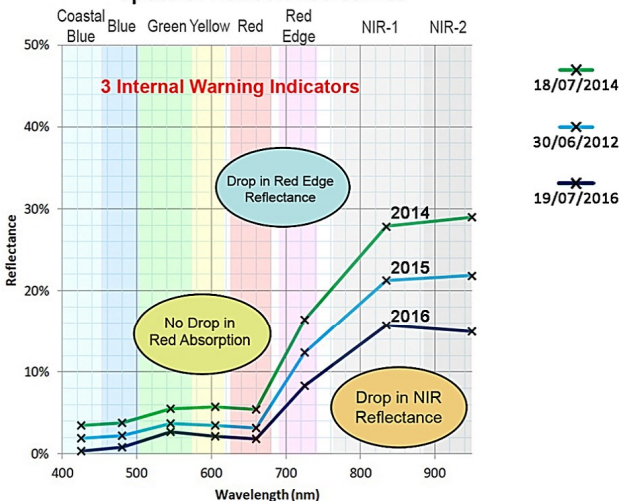
Spectral Reflectance Curves



Location of Tree
51.2136°N, 6.7655°E

This tree collapsed on **October 20, 2016** in Lorettostraße, Düsseldorf, damaging a residential building and buried several parked cars underneath. Our system has detected marked declining health condition from July 2014 to July 2016. This is indicated by major drop in NIR and red edge reflectance, but without reduction in red band absorption.

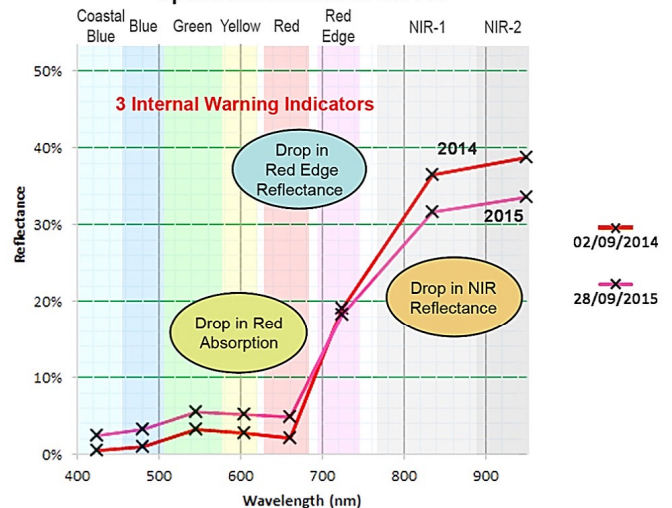
Spectral Reflectance Curves



Location of Elm Tree
59.9257°N, 10.7234°E

This giant tree of 100 years old and 20 metres high collapsed on **August 10, 2016** in the backyard of Bogstadveien 19 in downtown Oslo, damaging the terrace of the building. Our system has detected that this tree was already severely stressed in 2015 as revealed by the marked drop in NIR reflectance and significant reduction in red band absorption in the short period within a year.

Spectral Reflectance Curves



An Integrated Approach Onsite Inspection by Arborists in Los Angeles Remote Monitoring by Geocarto in Hong Kong

Using Spectral Reflectance Analysis of 50cm Resolution Satellite Data and Basing on Subtle Changes in Chlorophyll Content and Leaf Cellular Structure

Two arborists were invited on separate occasions to inspect and assess the health condition of two stressed trees (Coast Live Oak/*Quercus agrifolia*) which grew in close proximity in a private property at Hacienda Dr., Arcadia, Los Angeles. Inspection and risk assessment of these two trees were performed by the first arborist on March 9, 2018 and by the second arborist on August 9, 2018. These two trees are indicated as A and B in Figure 1 and Figure 2.

Mr. James Komen, the second consulting arborist, has afforded Geocarto the opportunity to compare the findings from our new technology and the conclusions reached by the first arborist and his risk assessment of these two stressed trees.

Tree A was identified by the first arborist as having *Phytophthora* and being “potentially hazardous”. Tree B was identified as having missing bark at the root crown and being in “poor health and condition”. In the summary section, the first arborist stated that both trees “must be removed because they are diseased and are in danger of falling.”

The second arborist, while agreeing with the observations of the first arborist, does not concur with his assessment of the risk posed and his decision that both trees must be removed. The conclusion of the second arborist is that the overall risk rating of Tree A is low and the overall risk rating of Tree B is moderate.

Geocarto has carried out spectral reflectance analysis of these two trees using WorldView-2 and 3 high resolution satellite data collected on 2010-03-27, 2013-02-01, 2014-02-11 and 2018-02-01. Our retrospective study of their spectral reflectance is provided in Figure 3 and Figure 4. As revealed by the spectral reflectance curves, the health condition of both trees has declined markedly from 2010 to 2013. But from 2013 to 2018 it remains quite stable and has no further deterioration. Therefore our findings from spectral reflectance analysis concur with the conclusion reached by the second arborist.

While risk assessment through visual observations may be subjective and differ, interpretation from spectral reflectance analysis is objective and consistent. Hence an integrated approach by using both onsite diagnosis and spectral reflectance analysis will greatly improve tree monitoring, management and maintenance.

International Society of Arboriculture (ISA) has published our papers entitled “A New Technology Warns of Stressed Trees” and “An Integrated Approach to Tree Stress Monitoring” in *Arborist News*, April 2017 issue and August 2018 issue. A white paper entitled “Detecting Stressed Trees with Satellite Imagery” was published by DigitalGlobe in June 2017. They are available online at www.geocarto.hk



Since 1985

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**Further details are available
online at: www.geocarto.hk**

WV-2/3 images: © DigitalGlobe
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Figure 1: WorldView-2 Image (Natural Colour) captured on 1 Feb 2018



Figure 2: WorldView-2 Image (Colour Infrared) captured on 1 Feb 2018

Spectral Reflectance Curves of Tree A

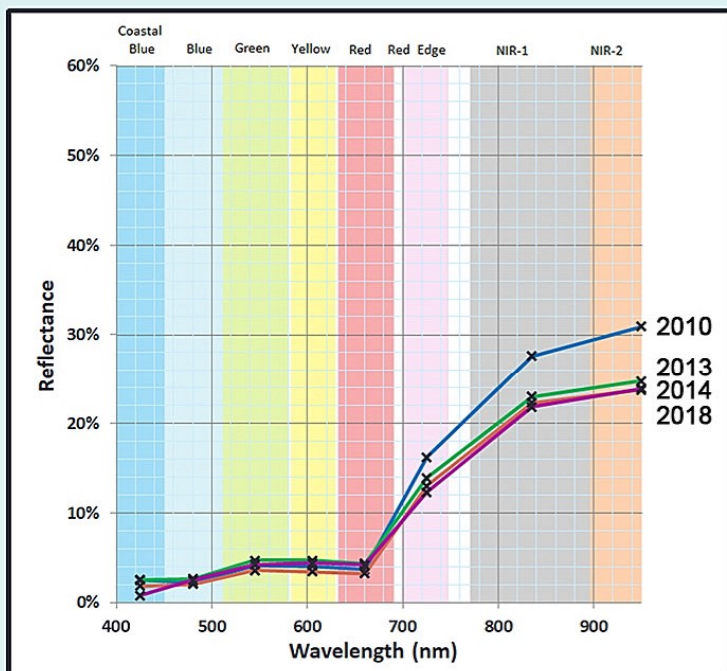


Figure 3

Spectral Reflectance Percentage of Tree A

Band	Wavelength (nm)	27/03/2010	01/02/2013	11/02/2014	01/02/2018
Coastal Blue	425	2.51%	2.52%	1.83%	0.80%
Blue	480	2.21%	2.65%	2.02%	2.47%
Green	545	4.14%	4.68%	3.57%	4.24%
Yellow	605	4.03%	4.70%	3.46%	4.39%
Red	660	3.71%	4.36%	3.22%	4.21%
Red Edge	725	16.22%	13.91%	13.00%	12.30%
NIR-1	835	27.61%	22.98%	22.29%	21.87%
NIR-2	950	30.93%	24.75%	23.75%	23.90%

—x— 27/03/2010
 —x— 01/02/2013
 —x— 11/02/2014
 —x— 01/02/2018

Spectral Reflectance Curves of Tree B

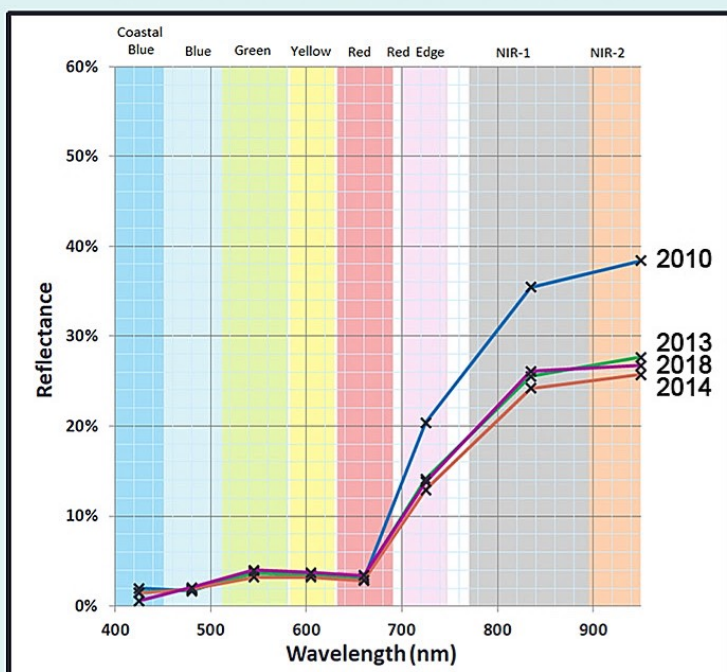


Figure 4

Spectral Reflectance Percentage of Tree B

Band	Wavelength (nm)	27/03/2010	01/02/2013	11/02/2014	01/02/2018
Coastal Blue	425	1.98%	1.51%	1.47%	0.59%
Blue	480	1.68%	1.84%	1.87%	2.06%
Green	545	3.89%	3.68%	3.23%	3.99%
Yellow	605	3.44%	3.47%	3.23%	3.74%
Red	660	2.90%	3.20%	2.87%	3.41%
Red Edge	725	20.41%	14.15%	12.94%	13.80%
NIR-1	835	35.44%	25.54%	24.21%	26.07%
NIR-2	950	38.37%	27.66%	25.74%	26.74%

—x— 27/03/2010
 —x— 01/02/2013
 —x— 11/02/2014
 —x— 01/02/2018