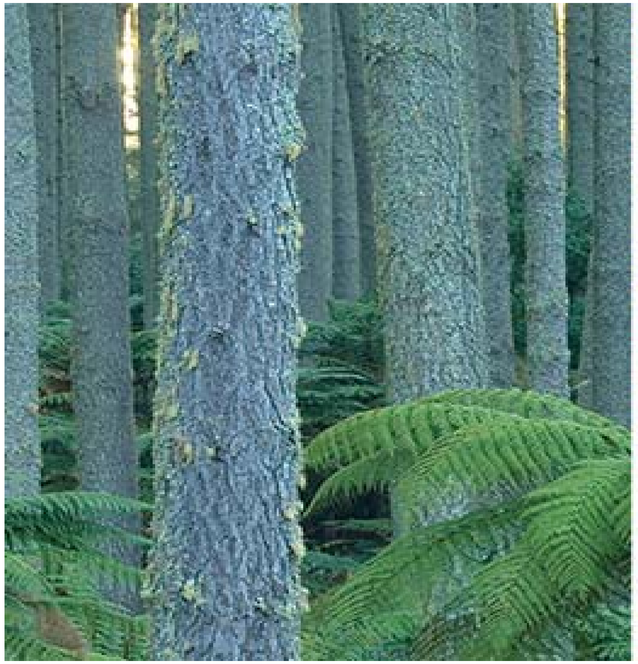
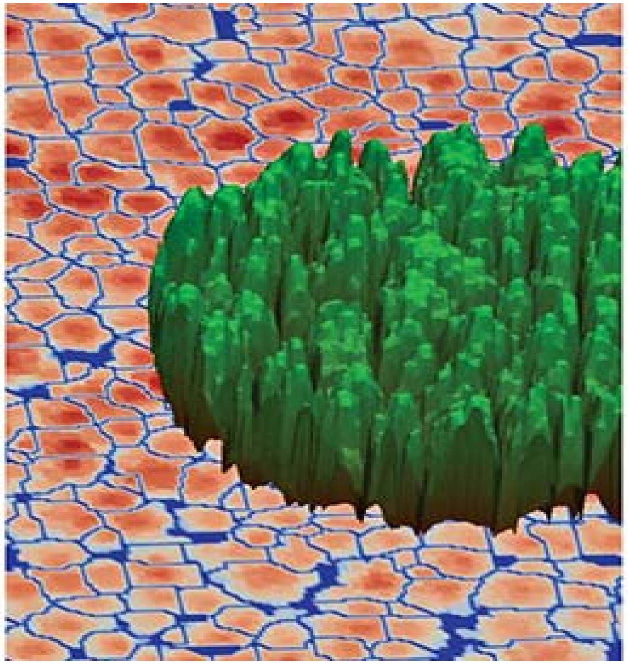
Growing confidence in forestry's future Research Programme

Use of hyperspectral imagery within forestry to detect nutritional deficiencies

Michael Watt, Grant Pearse, Jonathan Dash, Nathanael Melia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FOREST GROWERS RESEARCH

Outline

- What is hyperspectral imagery?
- Platforms that could supply imagery
- Potential uses within NZ forestry – focus on detection of nutritional deficiencies
- Further research in this area

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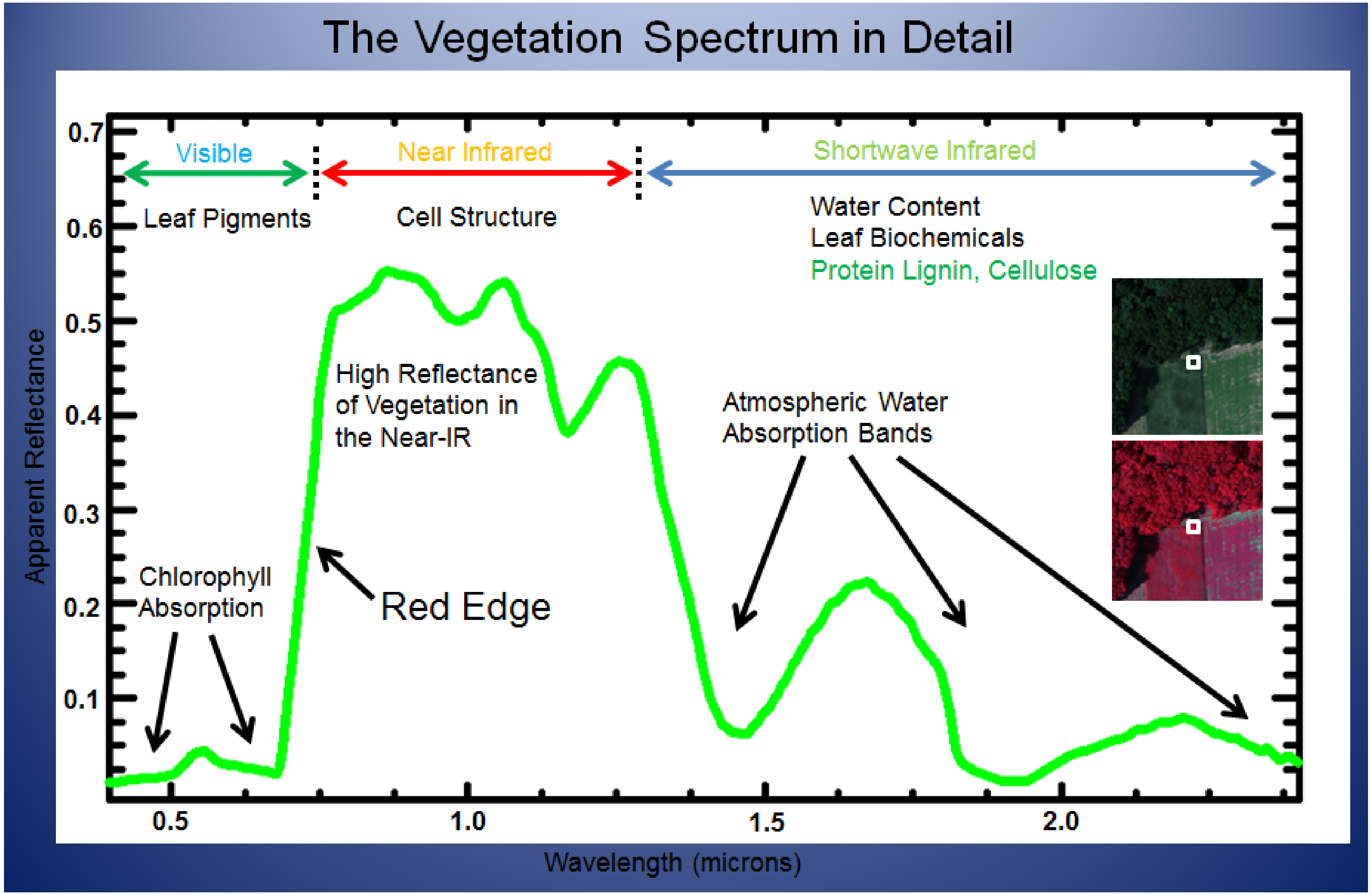
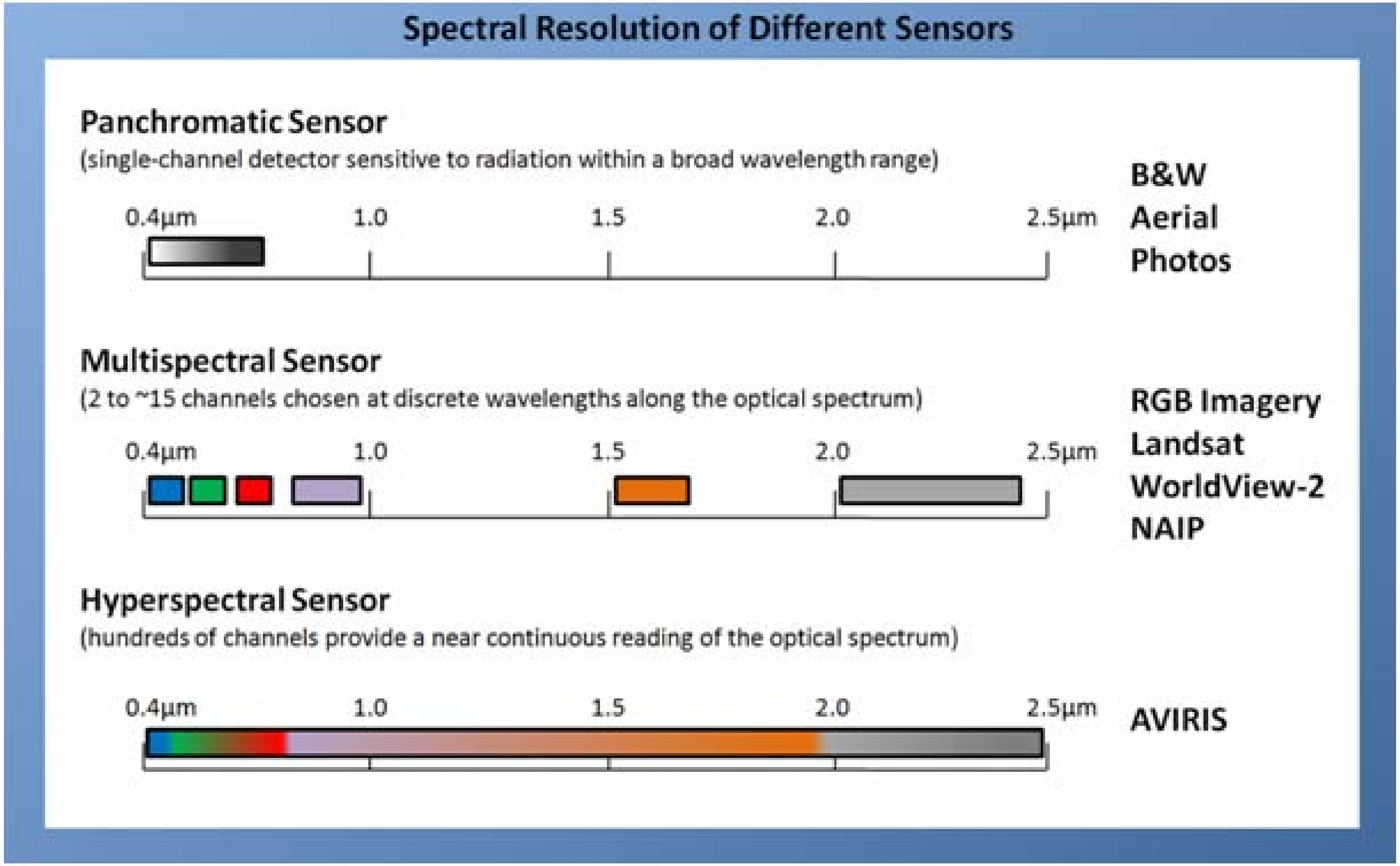
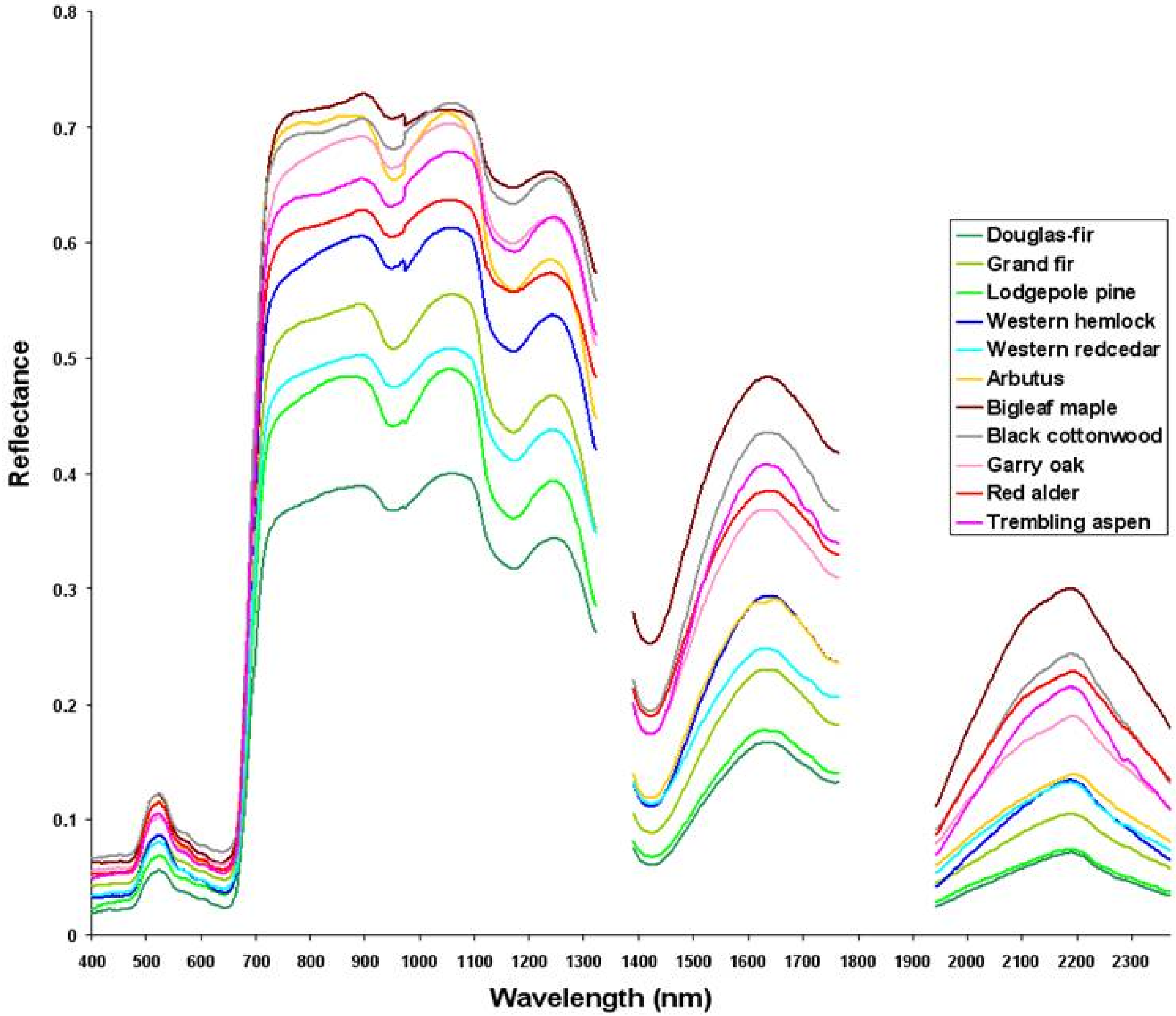


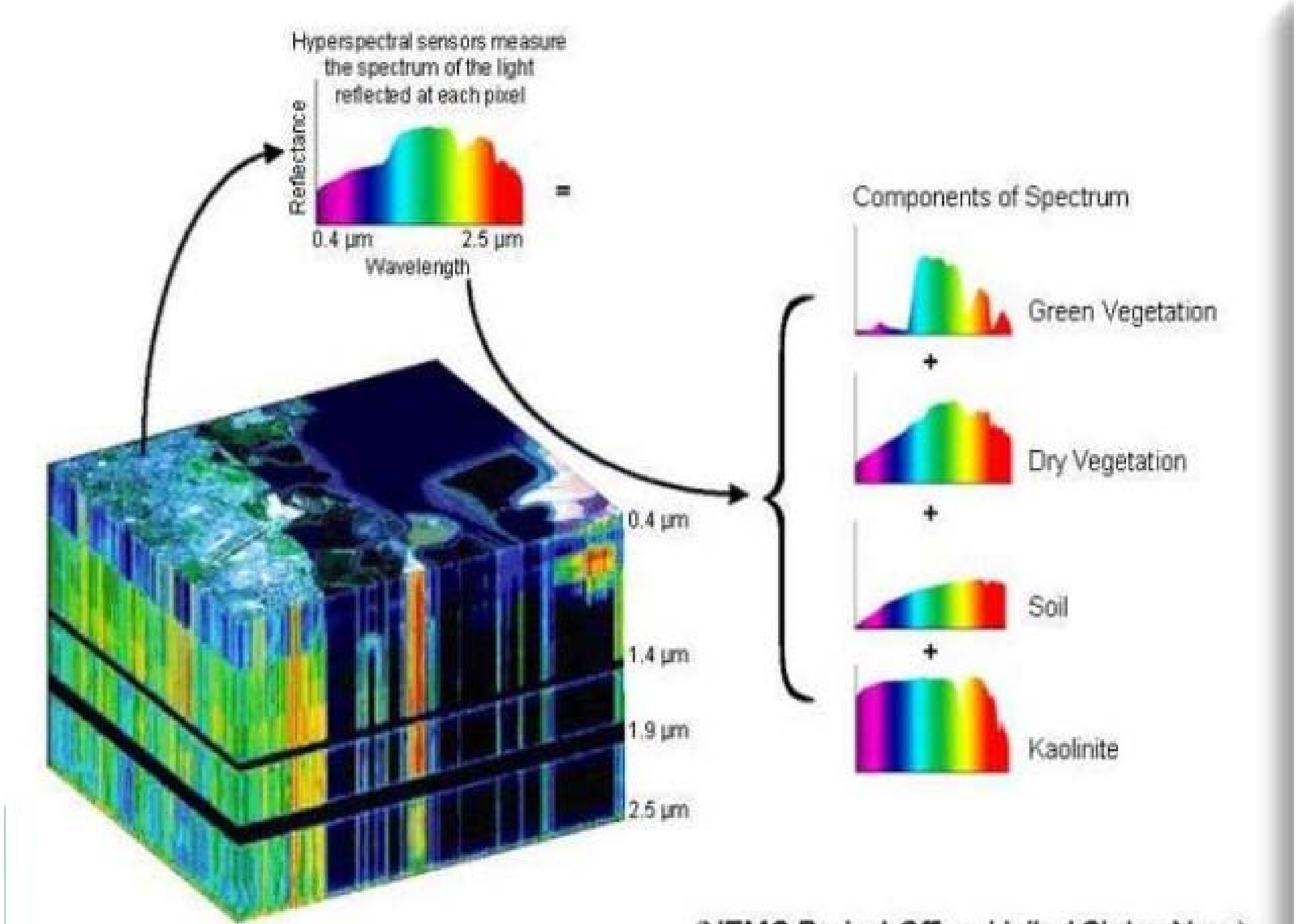
Source: Elowitz, Mark R. "What is Imaging Spectroscopy (Hyperspectral Imaging)?". Retrieved from www.markelowitz.com/Hyperspectral.html



Source: Vegetation Analysis: Using Vegetation Indices in ENVI. *Retrieved from http://www.harrisgeospatial.com*



Source: Jones, T. Integrating advanced and structural remotely sensed data to improve vegetated terrestrial ecosystem mapping http://irsslab.forestry.ubc.ca/research/data-fusion/



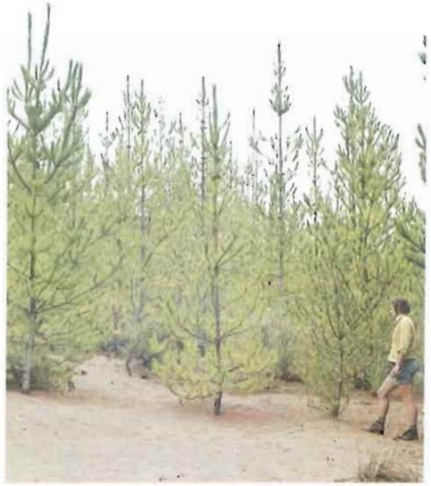
(NEMO Project Office, United States Navy)

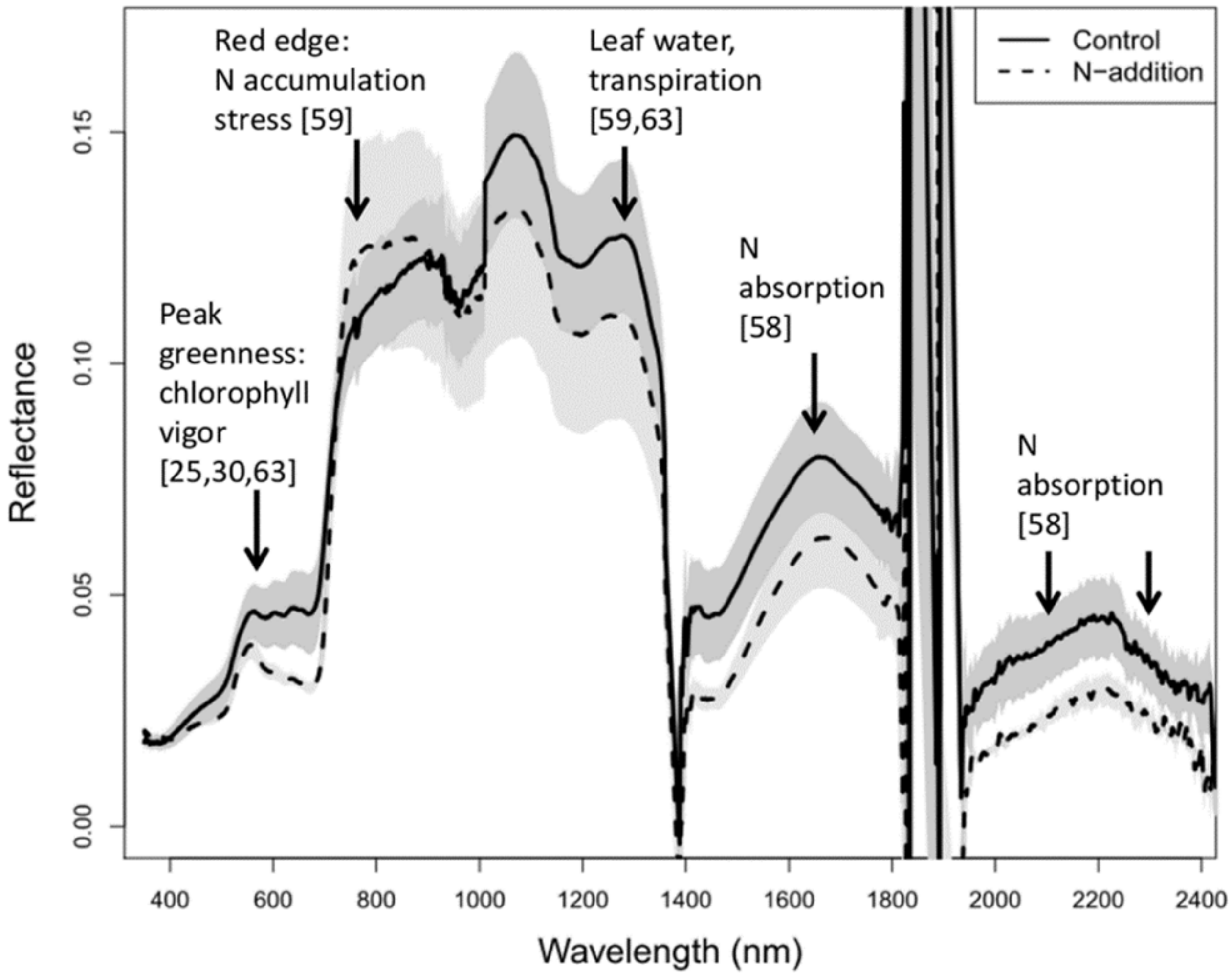
Comparison between platforms

	Satellite	Aircraft	UAV
Spectral range	400 – 2500 nm (Hyperion)	380 – 2,500 nm (AISA FENIX)	Mainly 400 – 1000 nm, with separate sensors covering 1000 – 2500 nm
Spectral resolution	10 nm	3.5 nm (VNIR) 10 nm (SWIR)	2 – 10 nm, ca. 5 nm
Spatial resolution	18 m (Proba-1) – 30 m (Hyperion)	1 m	< 1m potential
Cost	Moderate	$10 – 15/ha	High cost/ha but small areas possible

Use of hyperspectral imagery to detect nutrient deficiency

- Fertilisation important practice – provides significant growth gains at mid-rotation
- Stands respond well to N and P additions
- Identifying stands where there will be a cost effective response is difficult
- Use of hyperspectral imagery could assist with this as symptoms are often quite visible



O'Connell, J. L., Byrd, K. B., & Kelly, M. (2014). Remotely-sensed indicators of N-related biomass allocation in *Schoenoplectus acutus*. *PloS one*, *9*(3), e90870

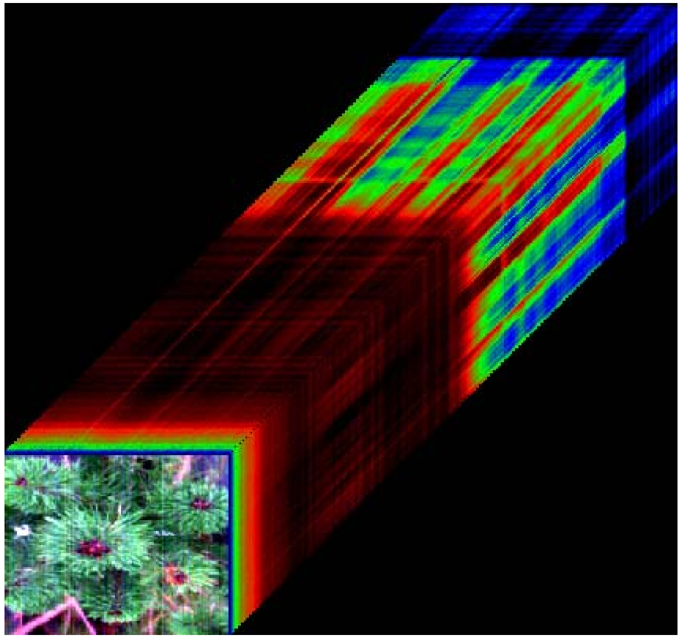
Precision of models (R^2) developed for predicting foliar element concentration

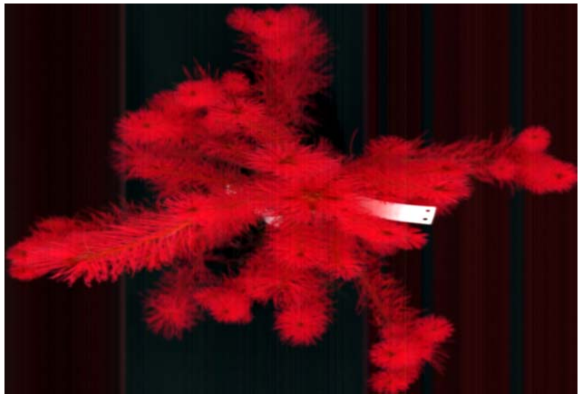
Species	N	P	Ca	K	Mg	Zn	Fe	B	Mn	Cu
In situ										
Slash pine	0.99	0.88								
Loblolly pine	0.99									
Mixed species	0.99	0.94	0.95							
Aleppo pine	0.94	0.95								
Maple	0.92									
Loblolly pine	0.81	0.70	0.42	0.68	0.51					
Tropical	0.81	0.68	0.69	0.55	0.61	0.27	0.48	0.43	0.29	
Tropical	0.76	0.62								
Balsam fir	0.66									
Scots pine	0.37	0.32	0.31	0.16	0.04	0.33	0.07	0.11	0.24	0.04
Airborne										
Eucalyptus	0.88									
Mixed sp.	0.87									
Mixed Oak	0.85									
Range	0.83									
Mixed sp.	0.79	0.23	0.63	0.56	0.64					
Temperate	0.79									
Mixed sp.	0.76									
Mixed sp.	0.72									
Mixed sp.	0.63									
Mixed sp.	0.53									
Satellite										
Mixed Oak	0.98									
Range	0.82									
Eucalyptus	0.62									
Temperate	0.60									
Radiata pine	0.44	0.28		0.68		0.14	0.41	0.56		0.45

- Prediction using in-situ data for N, P - high strength
- Using fixed wing airborne data predictions low. – high strength
- Using satellite data predictions low – high strength
- Predictions other elements lower strength than N
- UAV data has not been used

Scion Hyperspectral Pilot study

- Specim FX10 VNIR Sensor (400-1000 nm)
- Collaboration with University of Trier, Germany
- Herbicide induced mortality of *Pinus contorta*
- UAV mountable sensor





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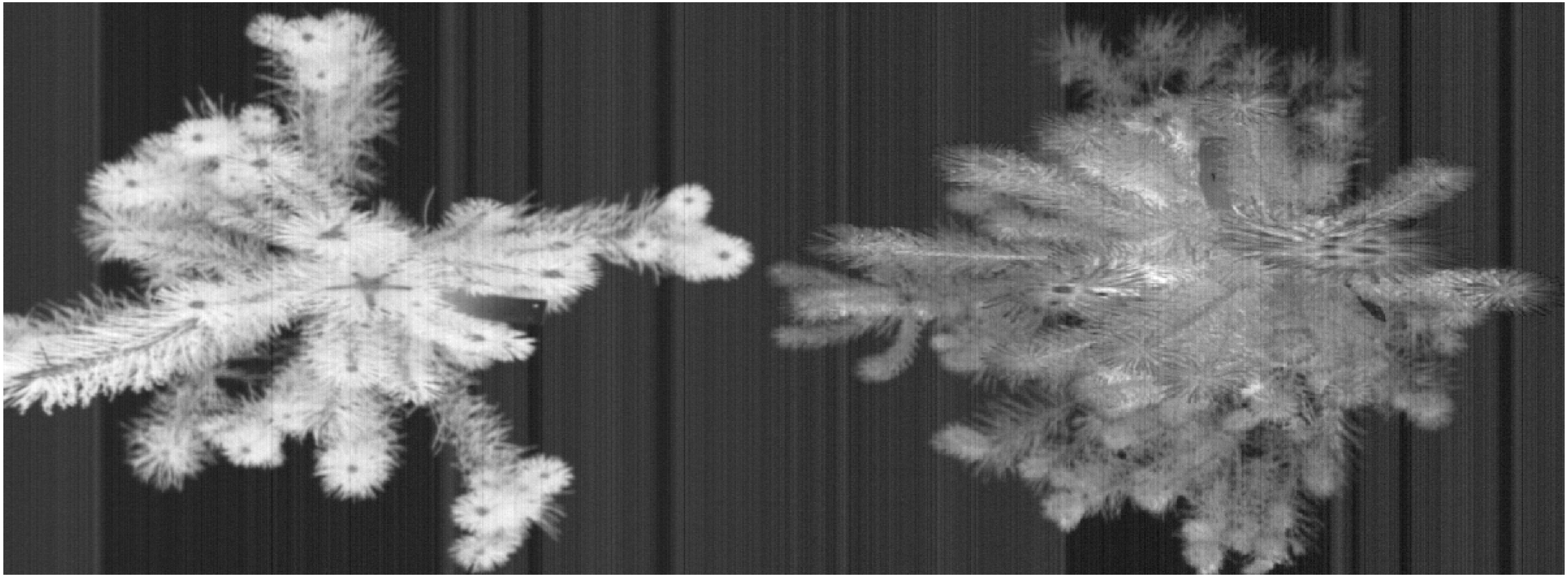
- Modified Chlorophyll index – Artificially induced stress (right)



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Experiment at Scion

- Plants will be grown in pots for two years under range of N and P
- Hyperspectral data obtained from fixed platform and UAV
- Models of N, P and chlorophyll content will be developed
- Should provide insight into viability of detecting nutrient deficiencies
- Further research will look at scaling models to larger areas using satellite (EnMAP) data

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Michael Watt
Research Leader – Geomatics
michael.watt@scionresearch.com

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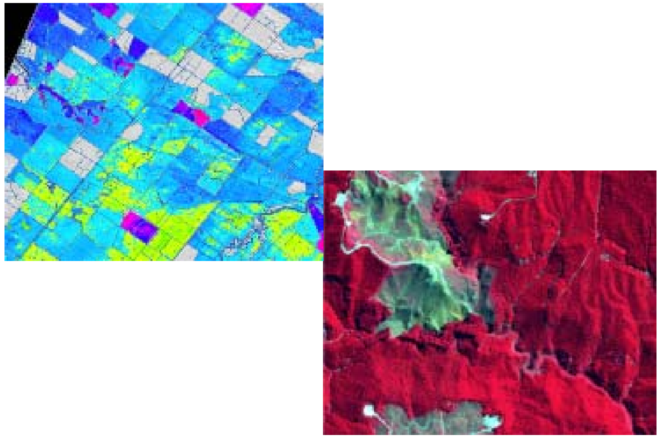

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