Hardwood Species Identification using random forest classification on multitemporal Sentinel 2 multispectral imagery in the Willamette Valley

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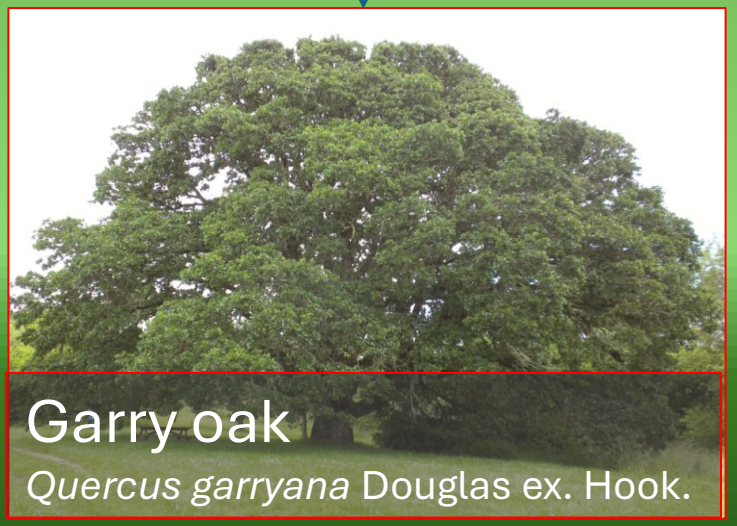
Emerging Forest Pests

emerald ash borer
Argillus planipennis
Fairmaire, 1888

Mediterranean oak borer
Xyleborus monographus
Fabricius, 1792

sooty bark disease
Cryptostroma corticale
Ellis & Everh., 1889

Oregon ash
Fraxinus latifolia Benth.

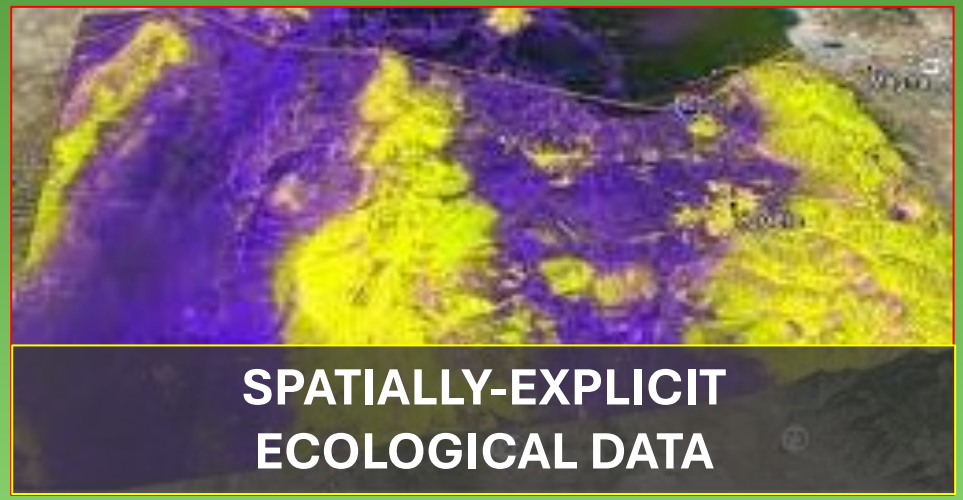


Garry oak
Quercus garryana Douglas ex. Hook.

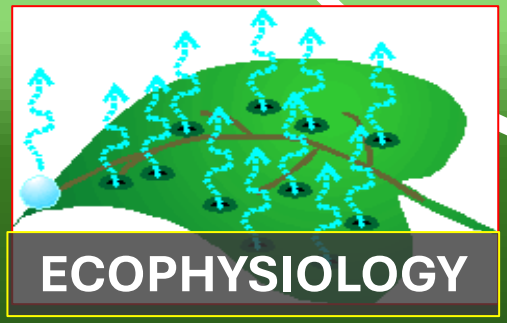
bigleaf maple
Acer macrophyllum Pursh.

Remote Sensing for Vegetation Ecology

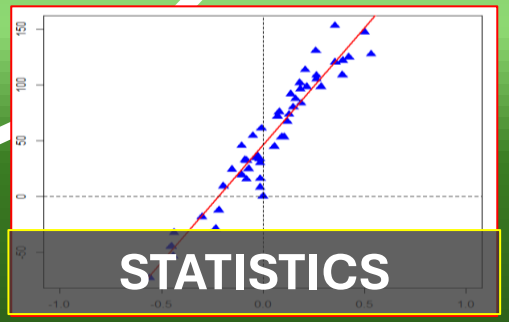
OPTICS



SPATIALLY-EXPLICIT
ECOLOGICAL DATA

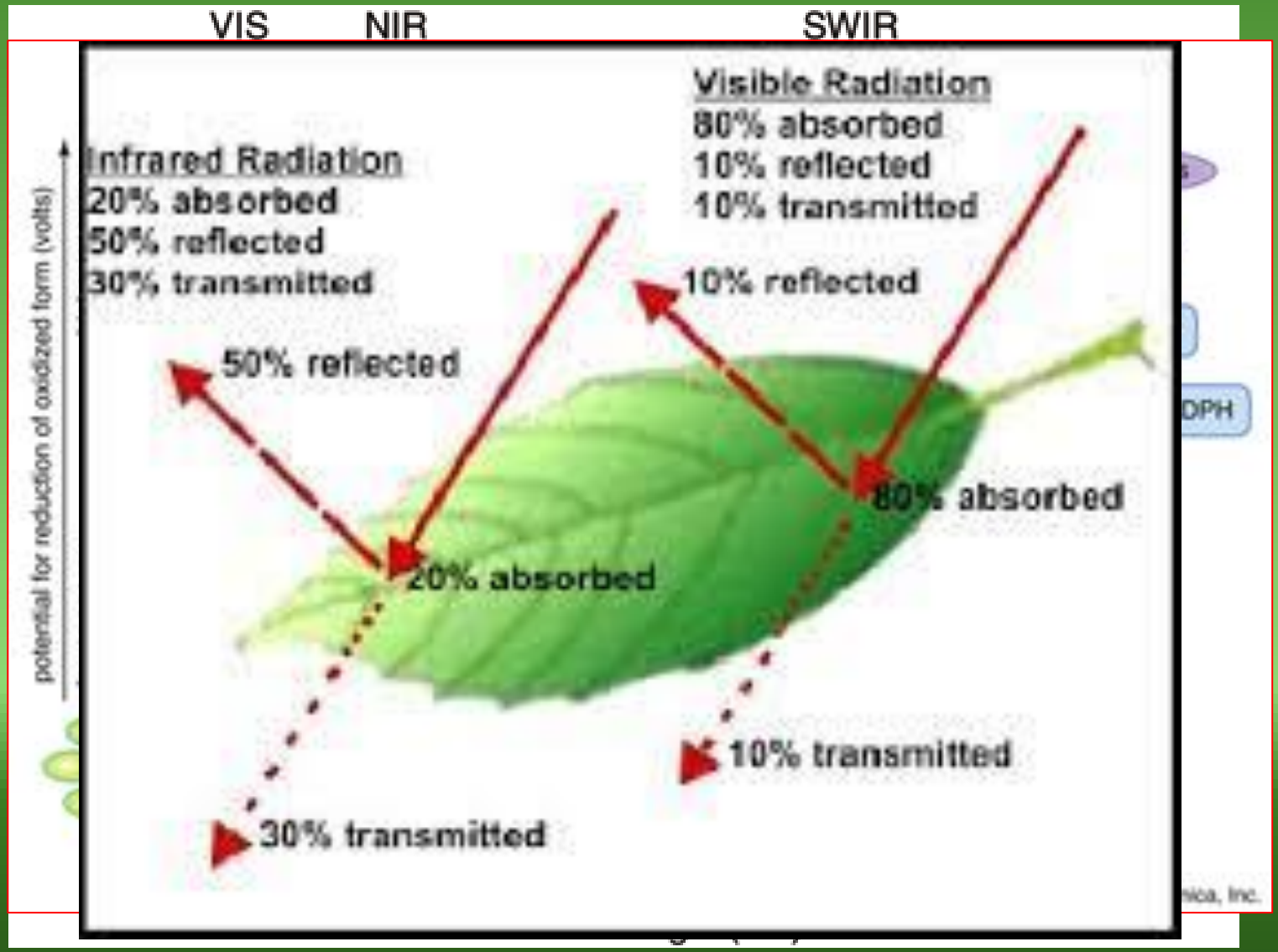


ECOPHYSIOLOGY

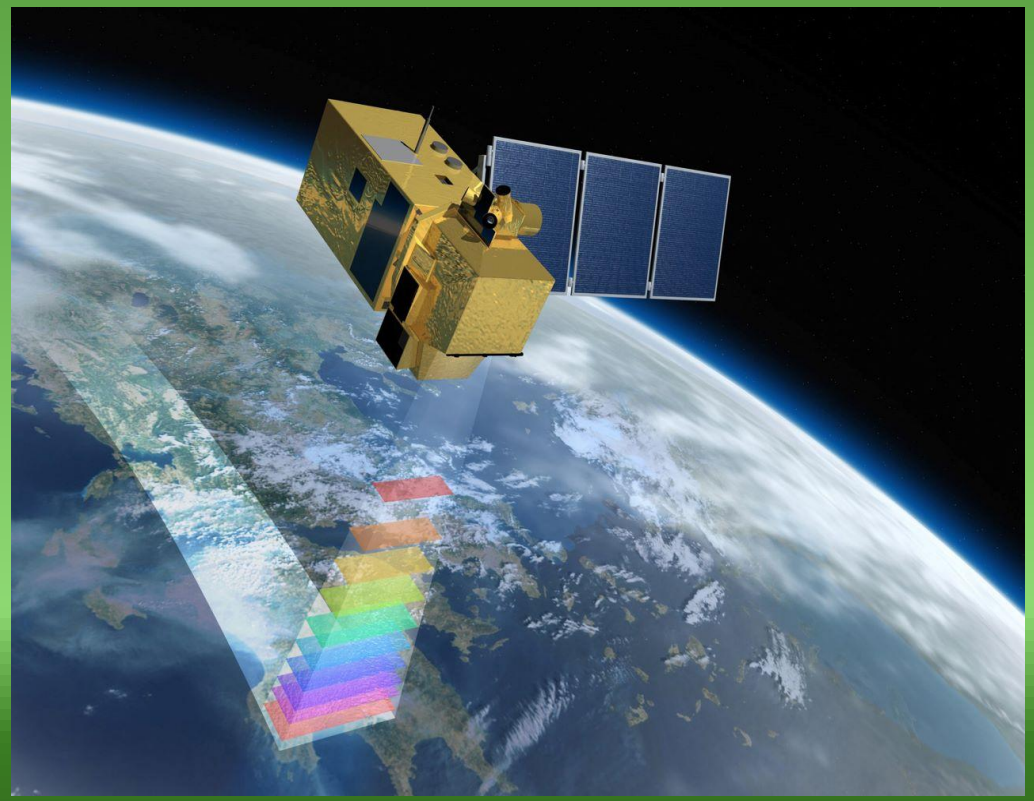


STATISTICS

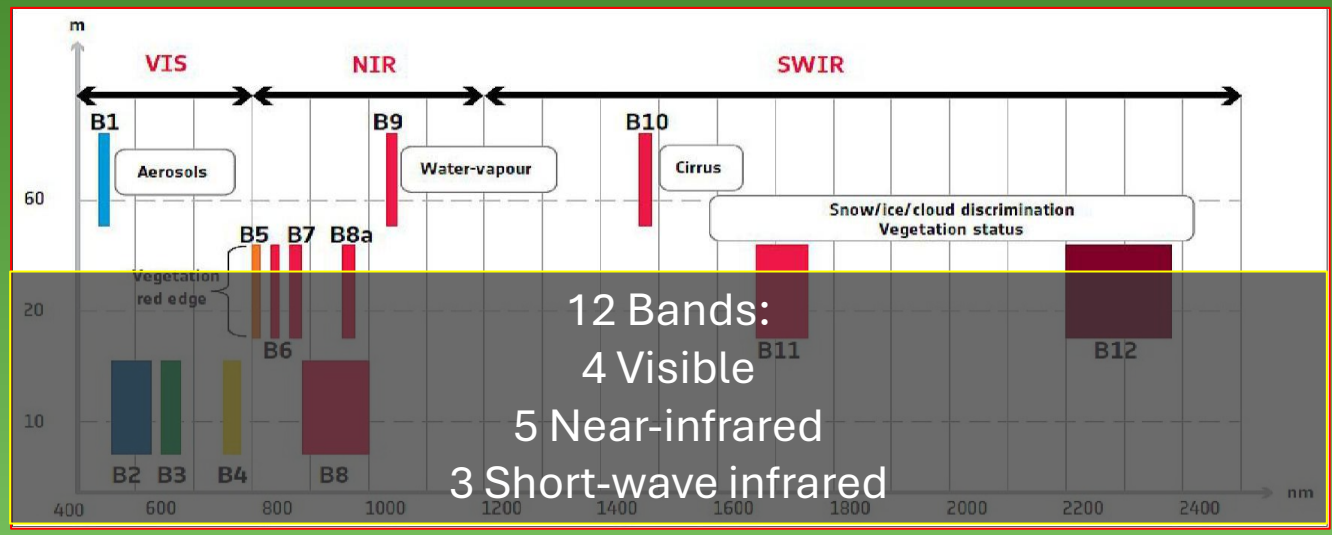
The interaction of ecophysiology and optics



Sentinel 2 Imagery

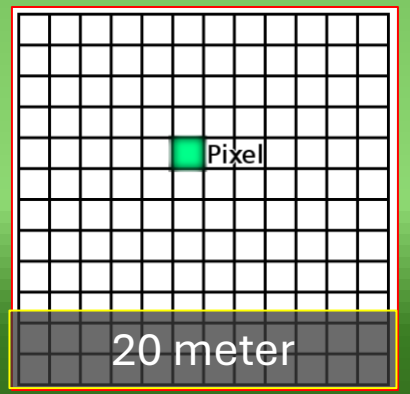


Spectral



12 Bands:
4 Visible
5 Near-infrared
3 Short-wave infrared

Spatial

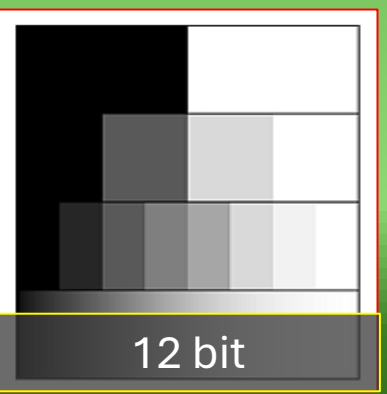


20 meter

Temporal

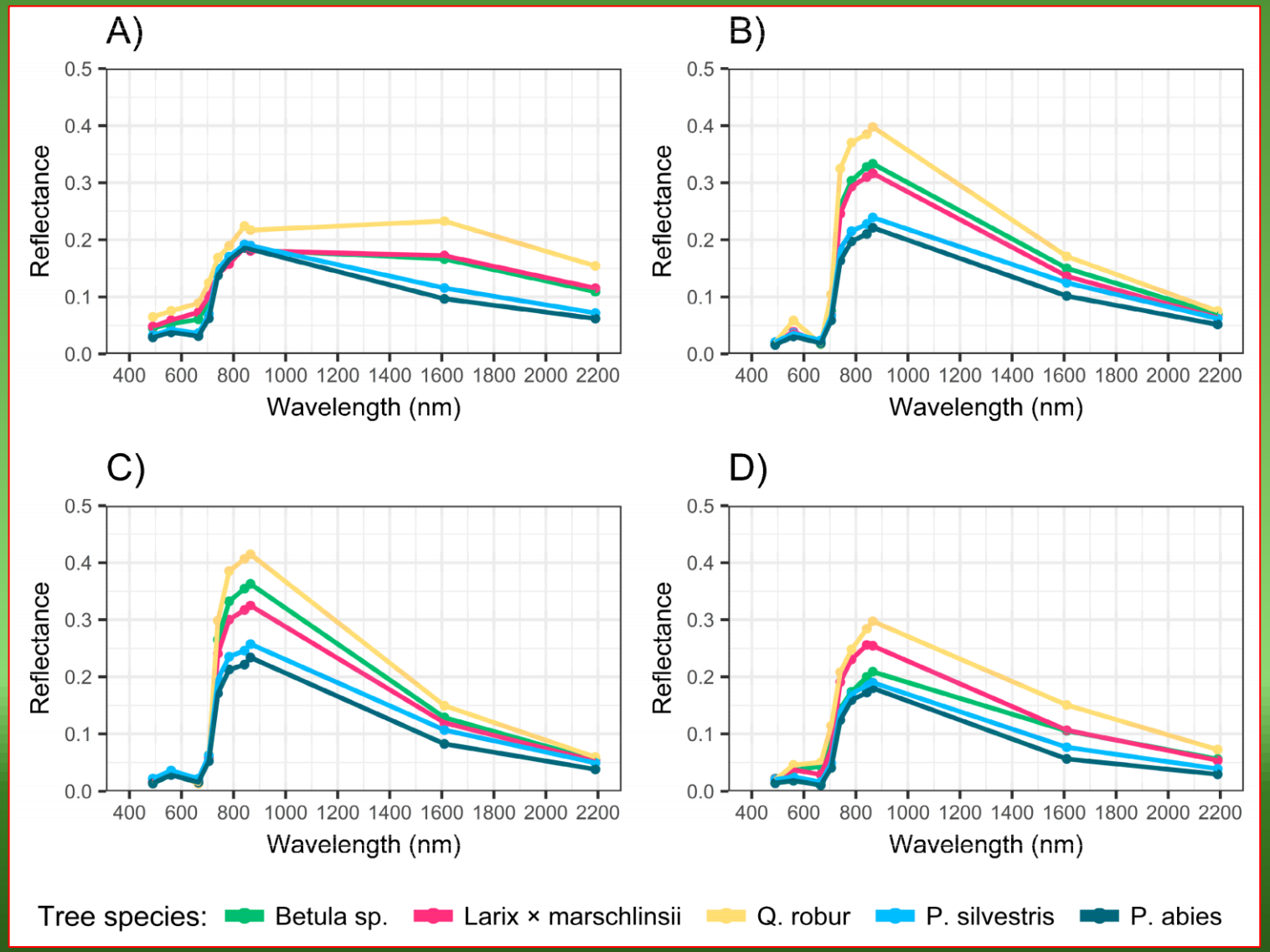
5 days

Radiometric



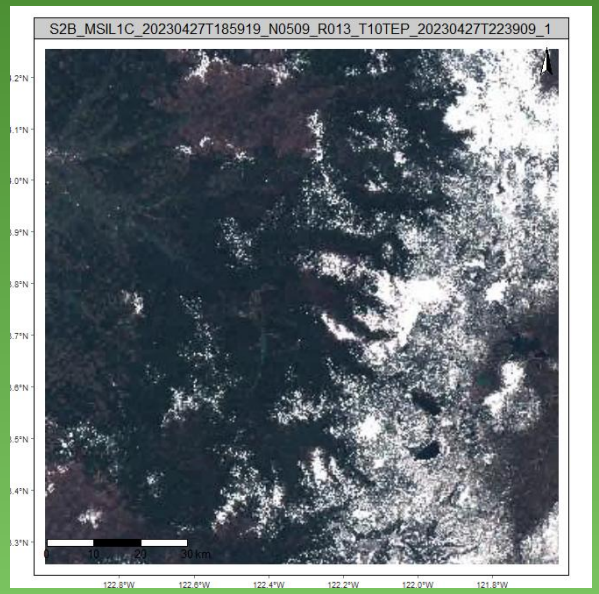
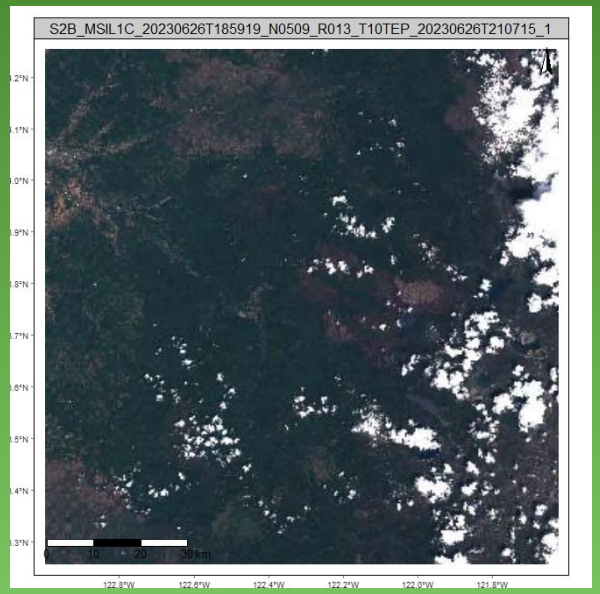
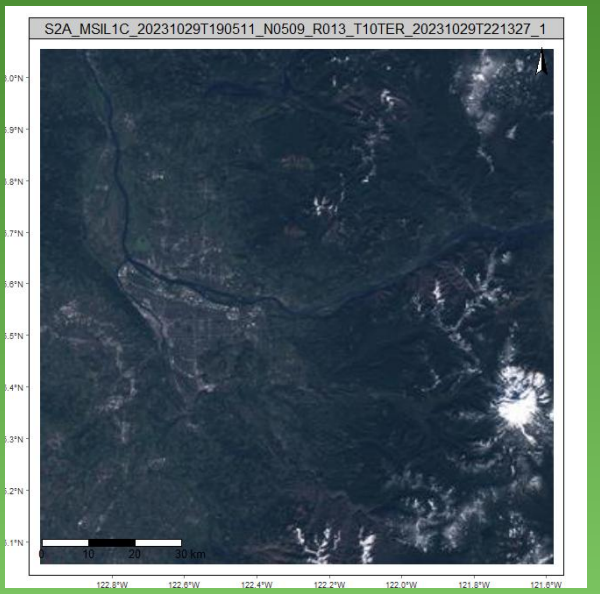
12 bit

Exploiting Interspecific Phenological Variability



Persson et al., 2018

Sentinel 2 Scenes

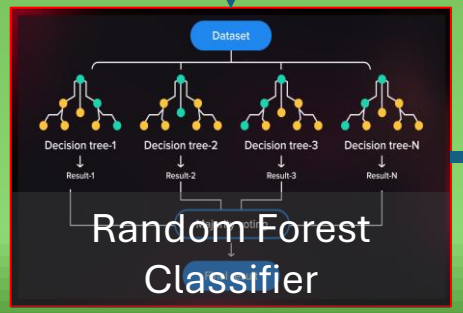
April	June	August	October
			
 Budbreak	 Leaf expansion	 Peak Photosynthesis	 Senescence

Modeling Process Overview

Pre-processing

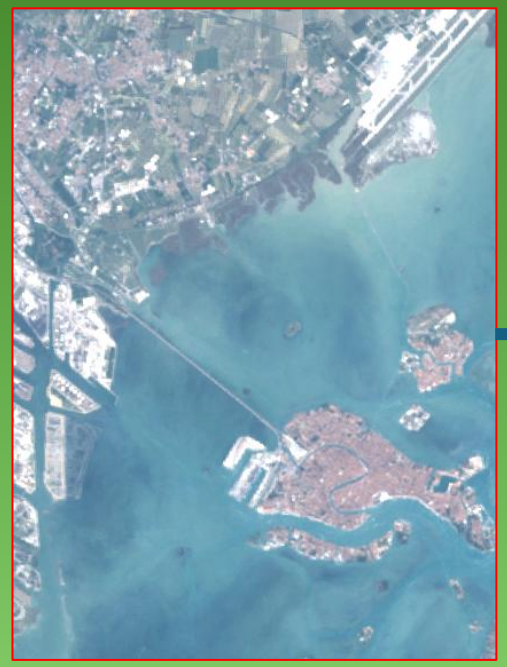
Canopy Masking

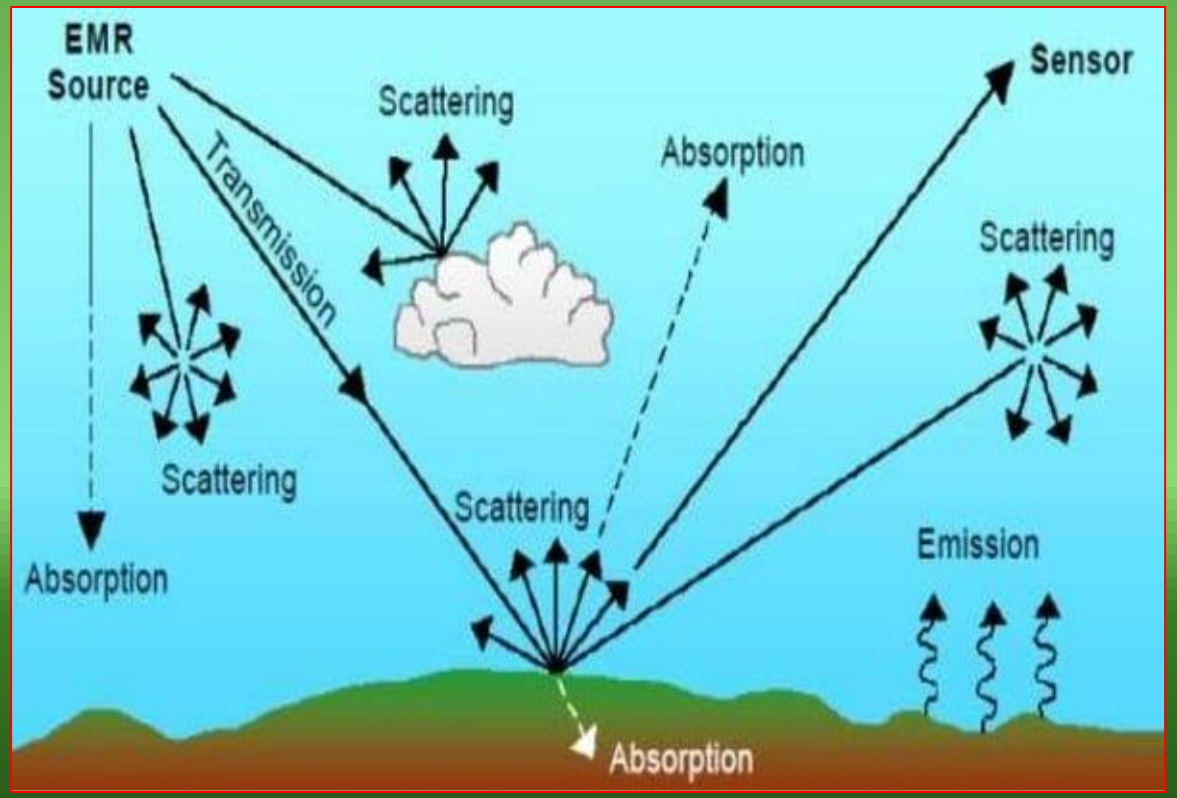
Data Extraction



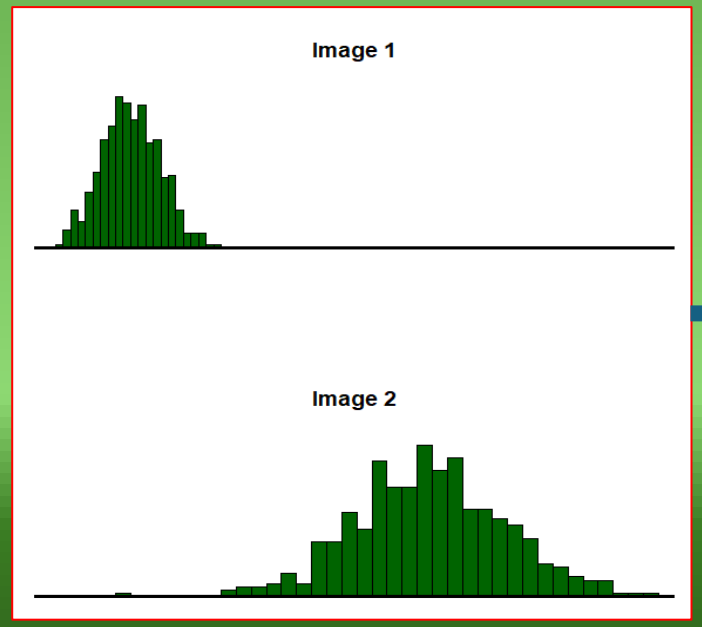
Prediction

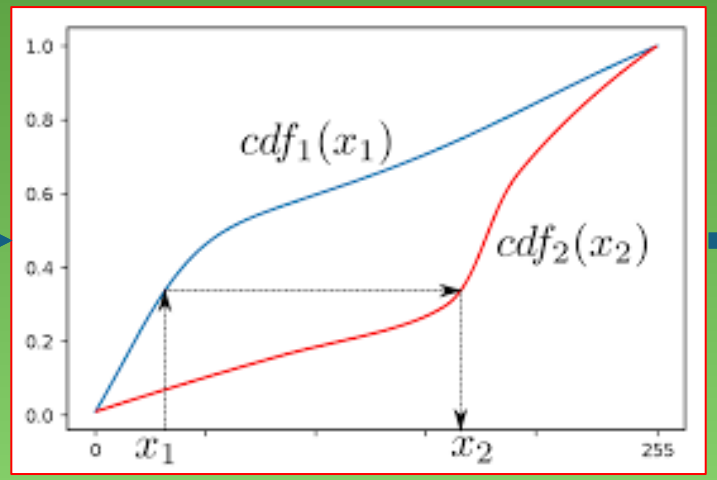
Atmospheric Correction

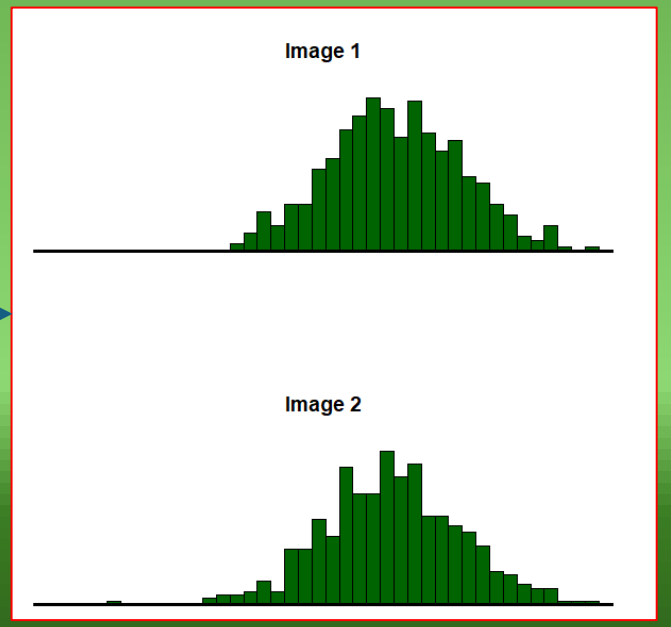




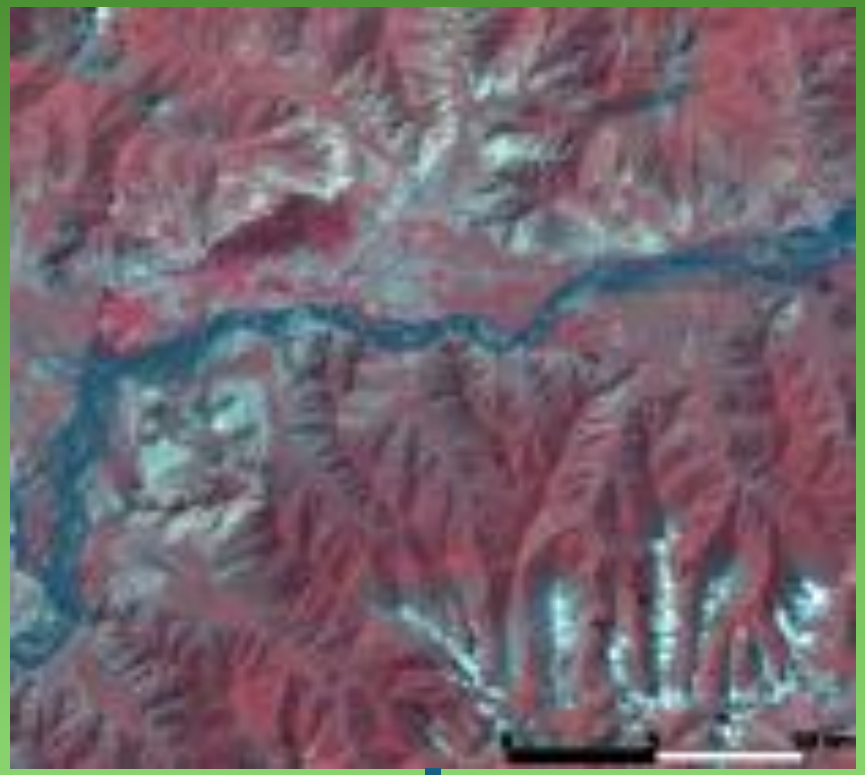
Tile-to-Tile Color Balancing

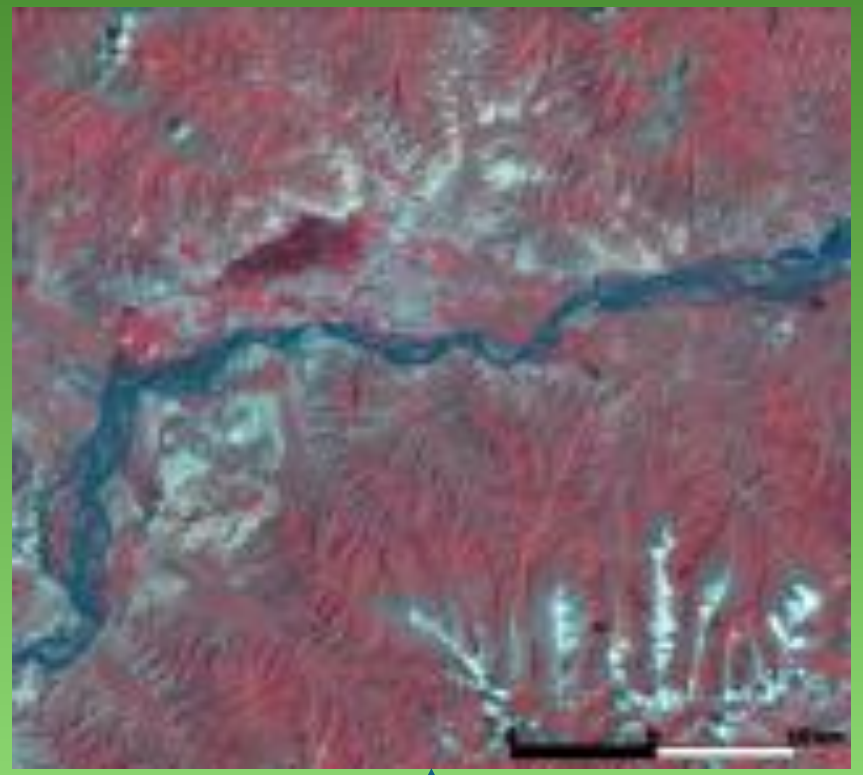






Topographic Correction





$$L_H = L_T - \cos(i)\, m_k + b\, \overline{L_T}$$

Statistical-empirical correction

$$\cos(i) = \cos(e)\cos(z) + \sin(e)\sin(z)\cos(a - a^*)$$

- **Solar incident angle** — i
- **Slope angle** — e
- **Solar zenith** — z
- **Solar azimuth** — a
- **Topographic aspect** — a^*

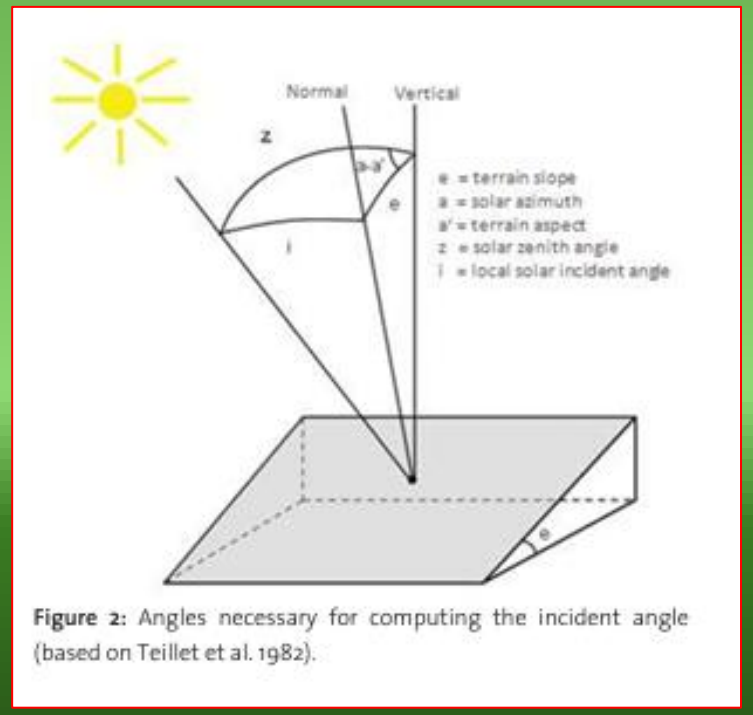
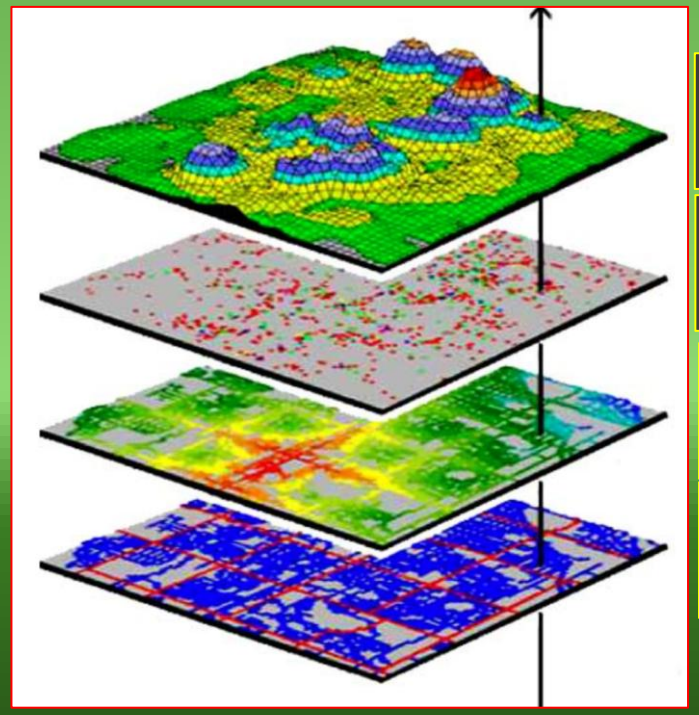


Figure 2: Angles necessary for computing the incident angle (based on Teillet et al. 1982).

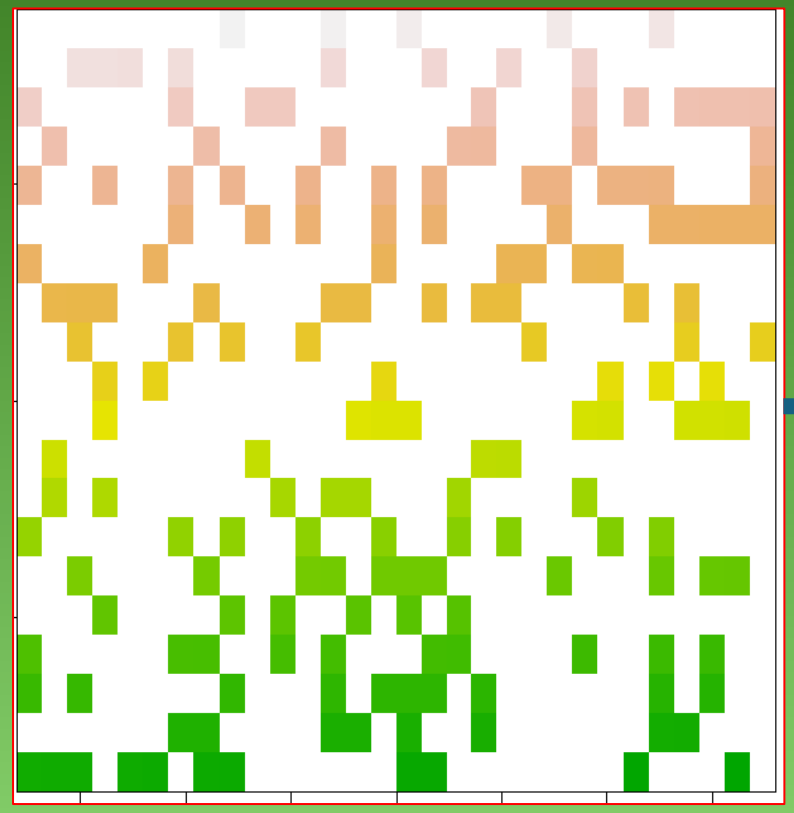


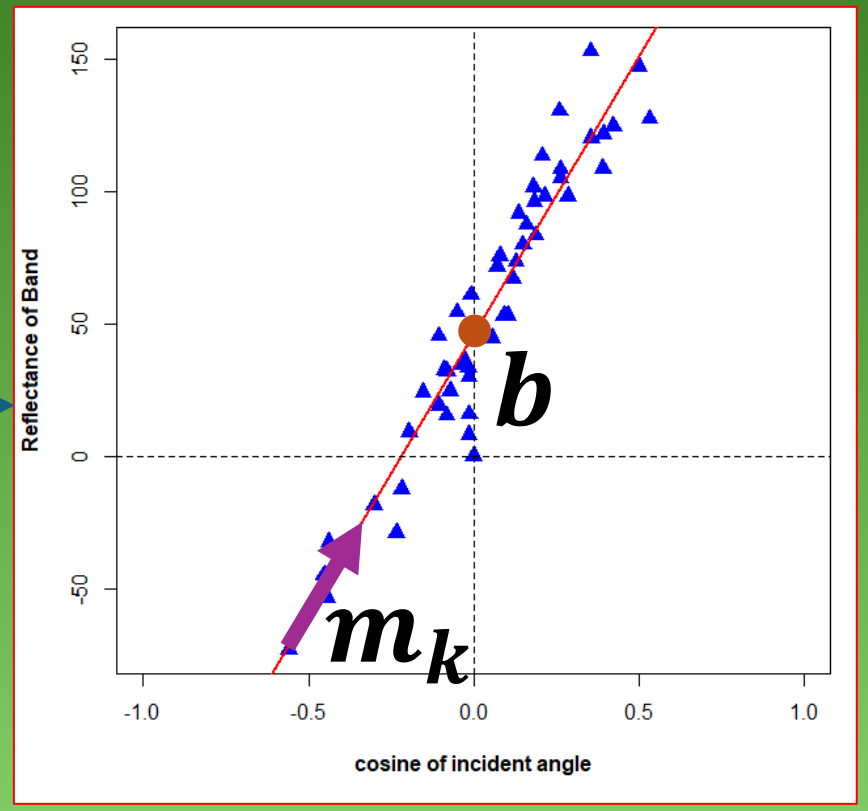
Slope angle

Topographic aspect

Solar zenith

Solar azimuth





Raw Reflectance

Mean Reflectance

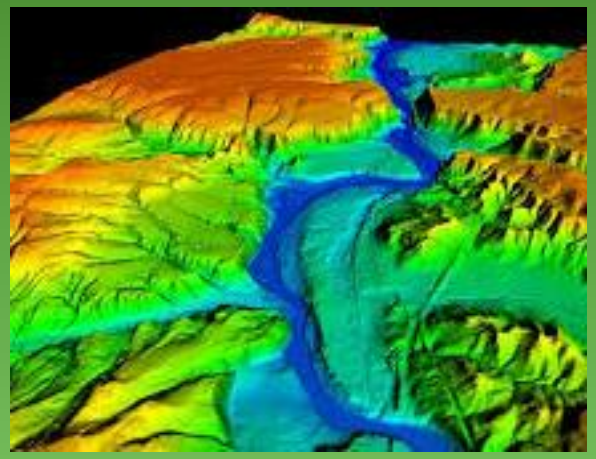
Reflectance on horizontal surface

$$L_H = L_T - \cos(i)\, m_k + b\, \overline{L_T}$$

Canopy Masking

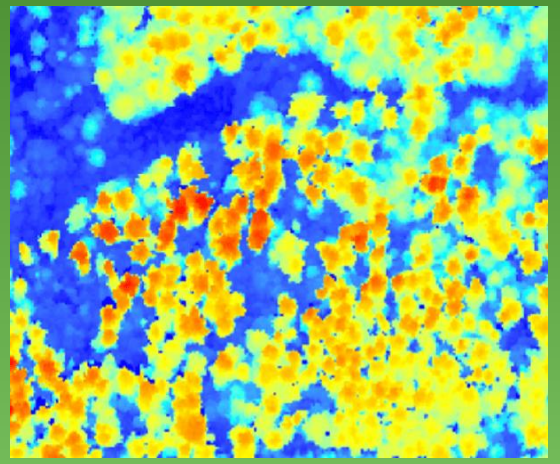
Digital Surface Model

–

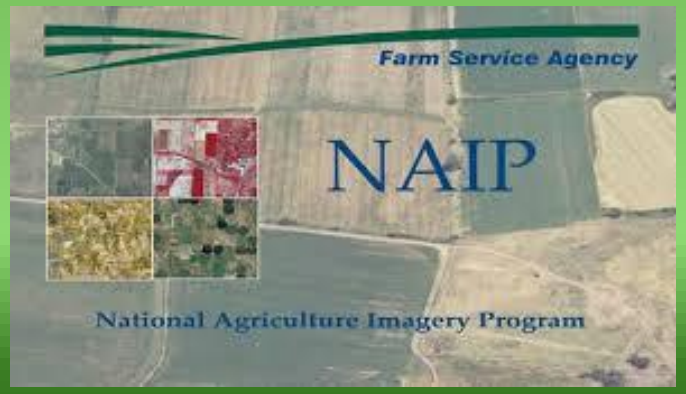


Digital Terrain Model

=



Canopy Height Model



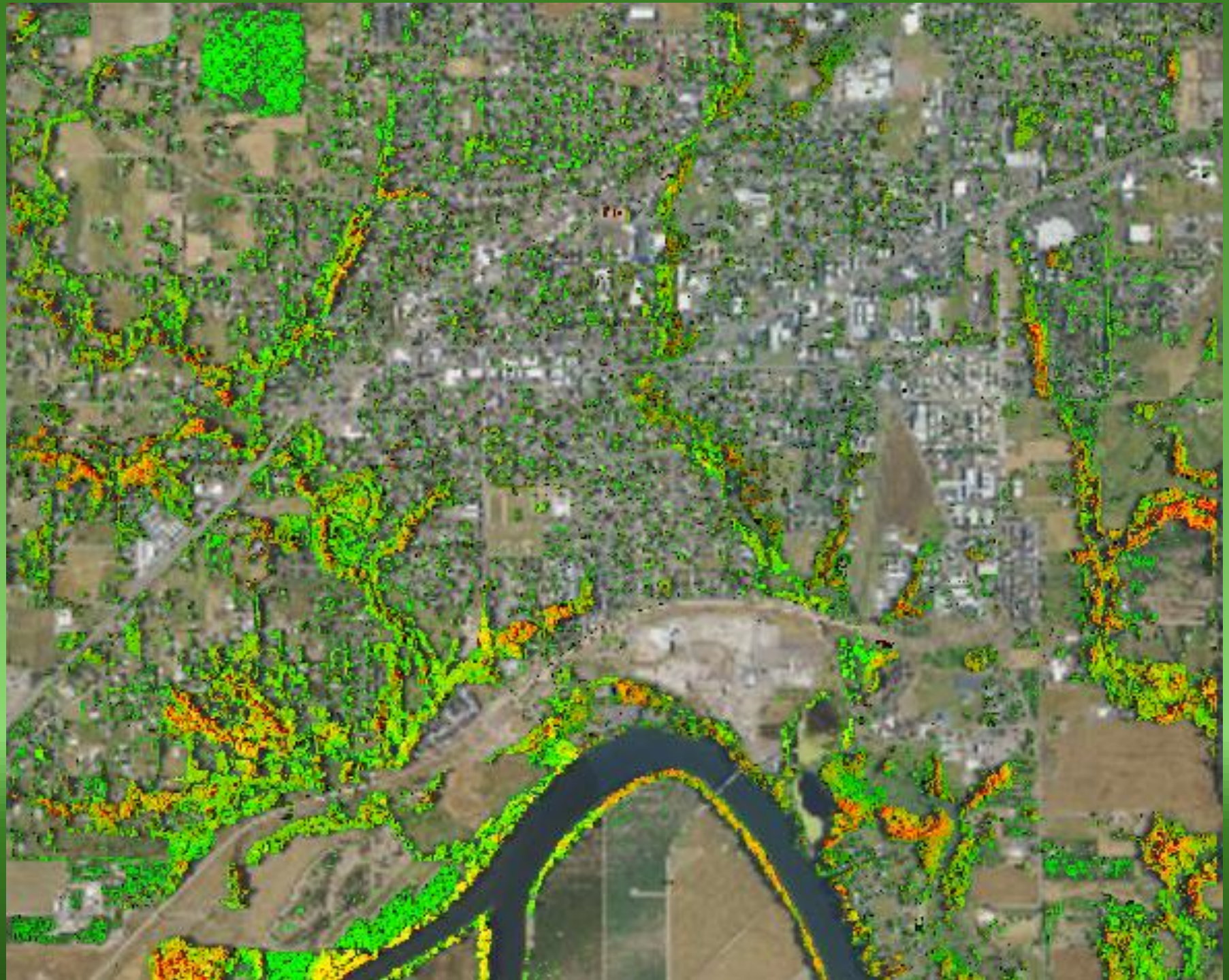
4-band
NAIP imagery

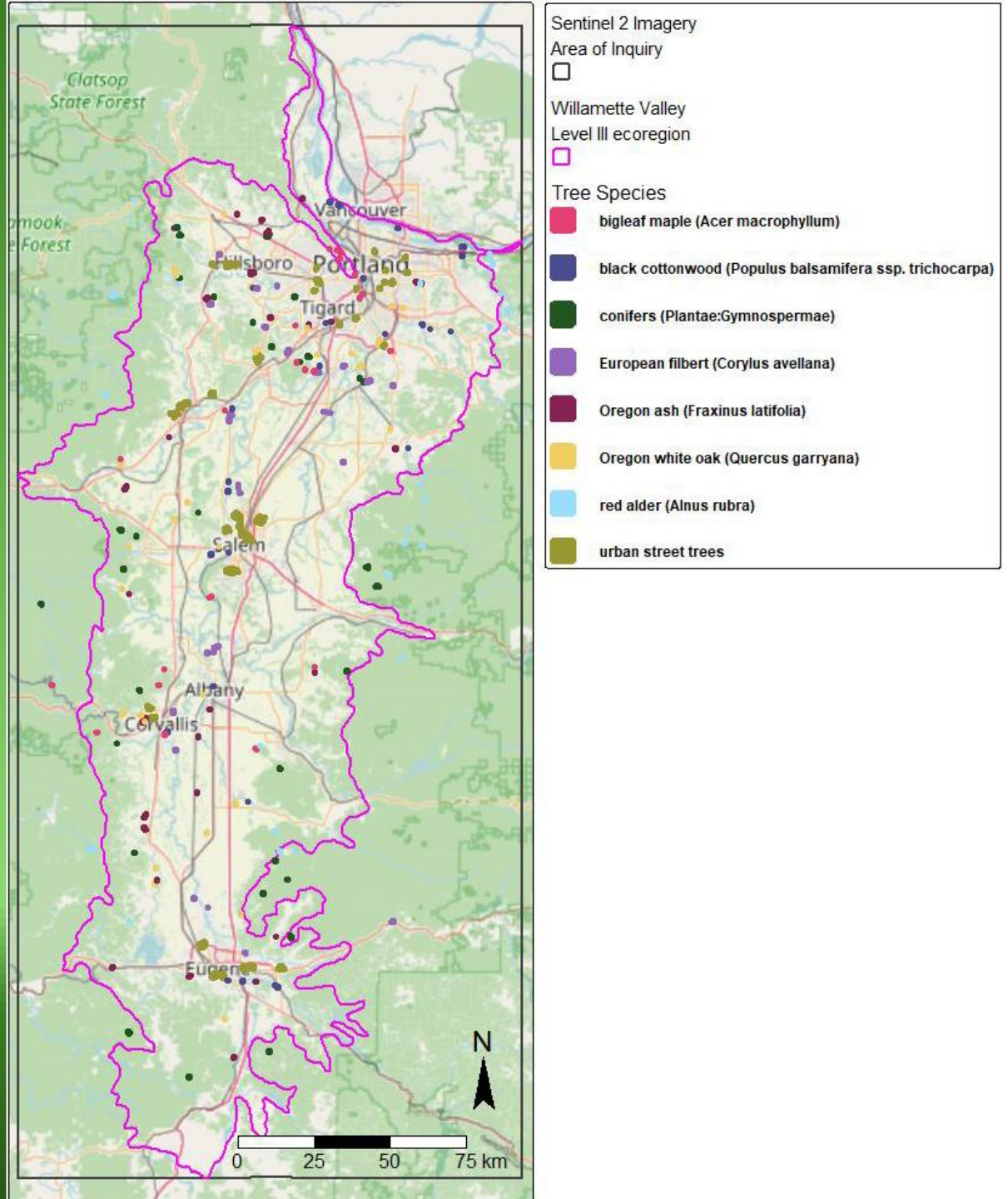
$$\text{NDVI} = \frac{NIR - Red}{NIR + Red}$$

Normalized Difference
Vegetation Index Threshold

=

Vegetation Mask





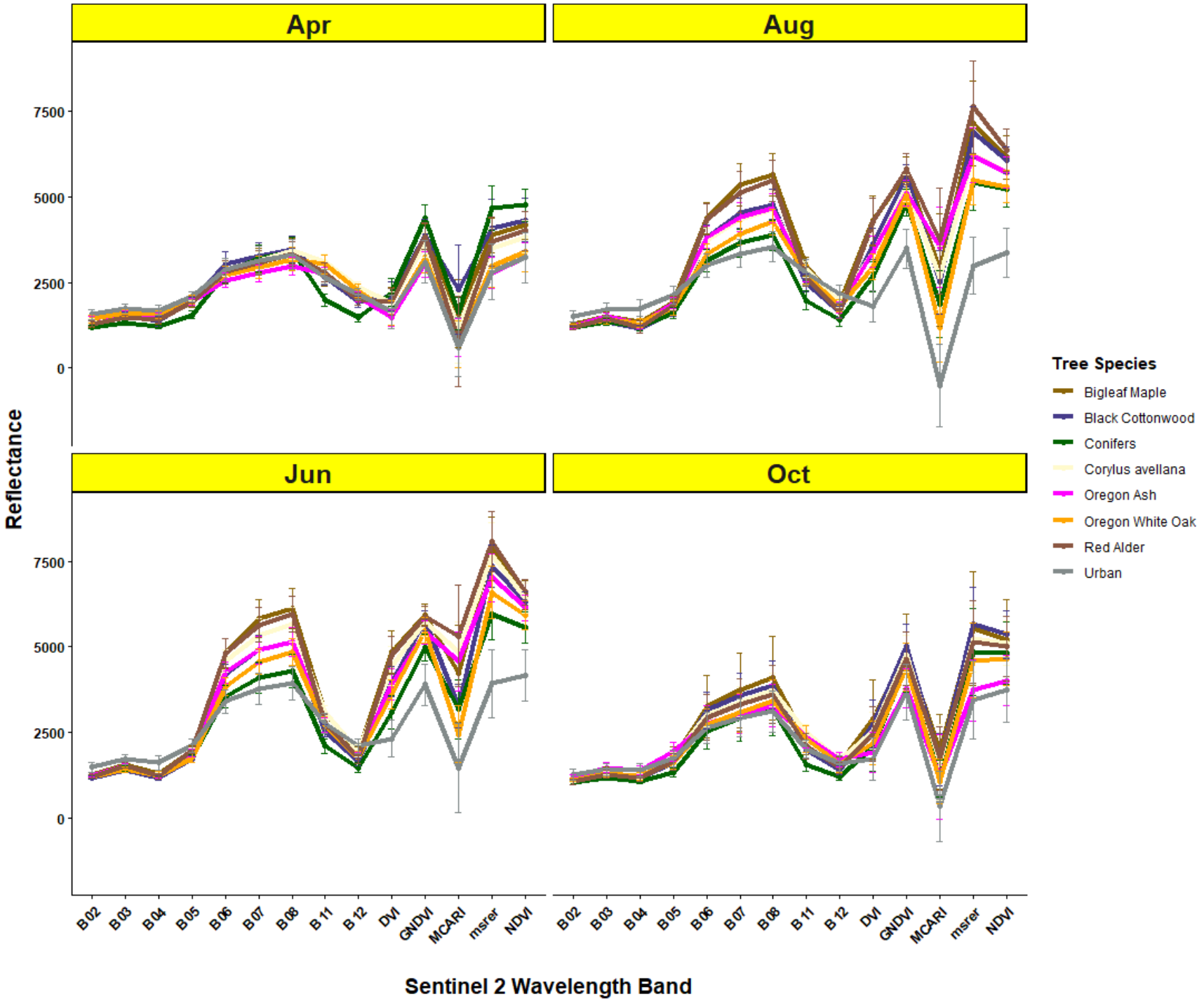
Sentinel 2 Imagery

Area of Inquiry

Willamette Valley
Level III ecoregion

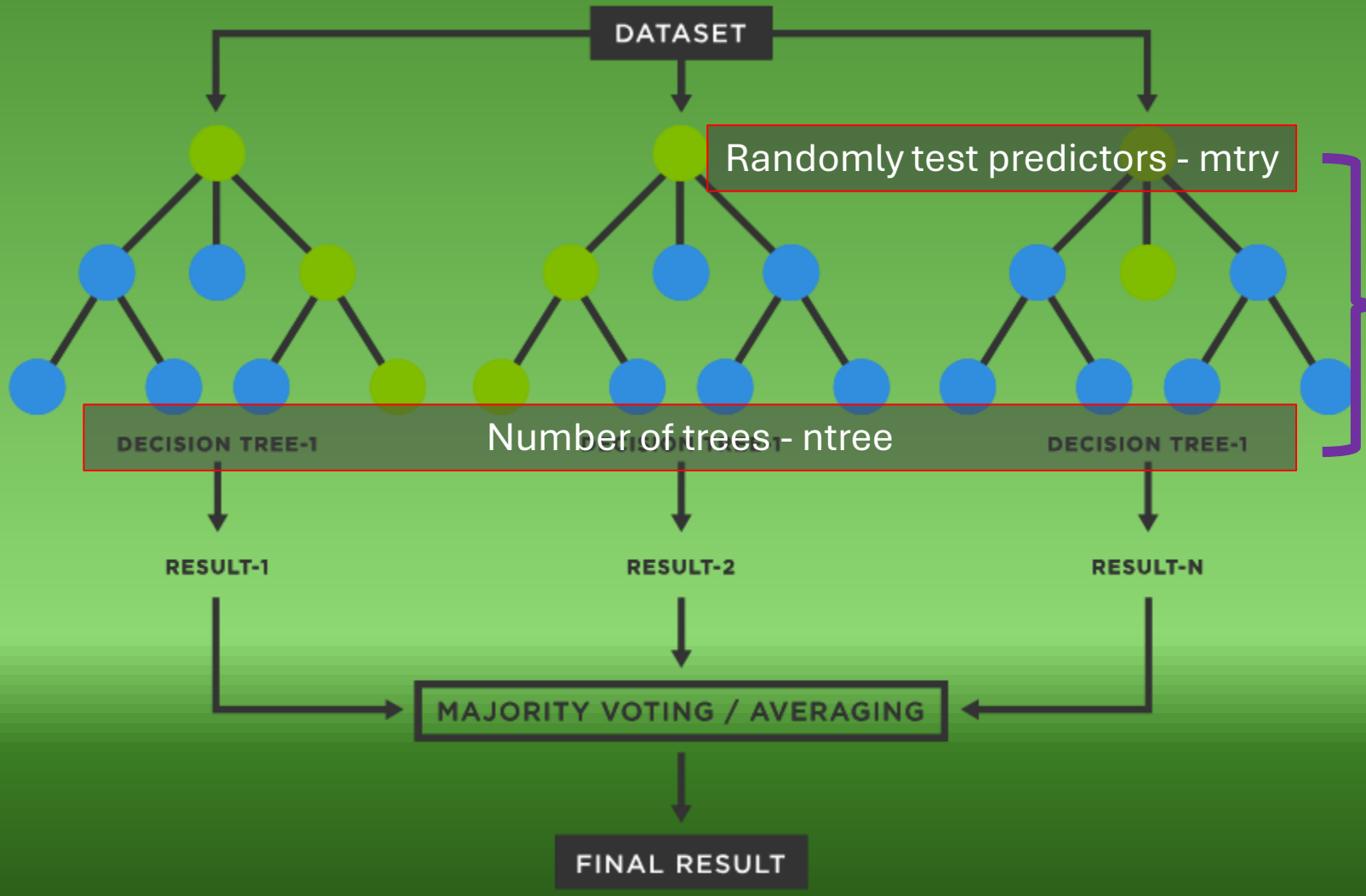
Tree Species

- bigleaf maple (Acer macrophyllum)
- black cottonwood (Populus balsamifera ssp. trichocarpa)
- conifers (Plantae:Gymnospermae)
- European filbert (Corylus avellana)
- Oregon ash (Fraxinus latifolia)
- Oregon white oak (Quercus garryana)
- red alder (Alnus rubra)
- urban street trees

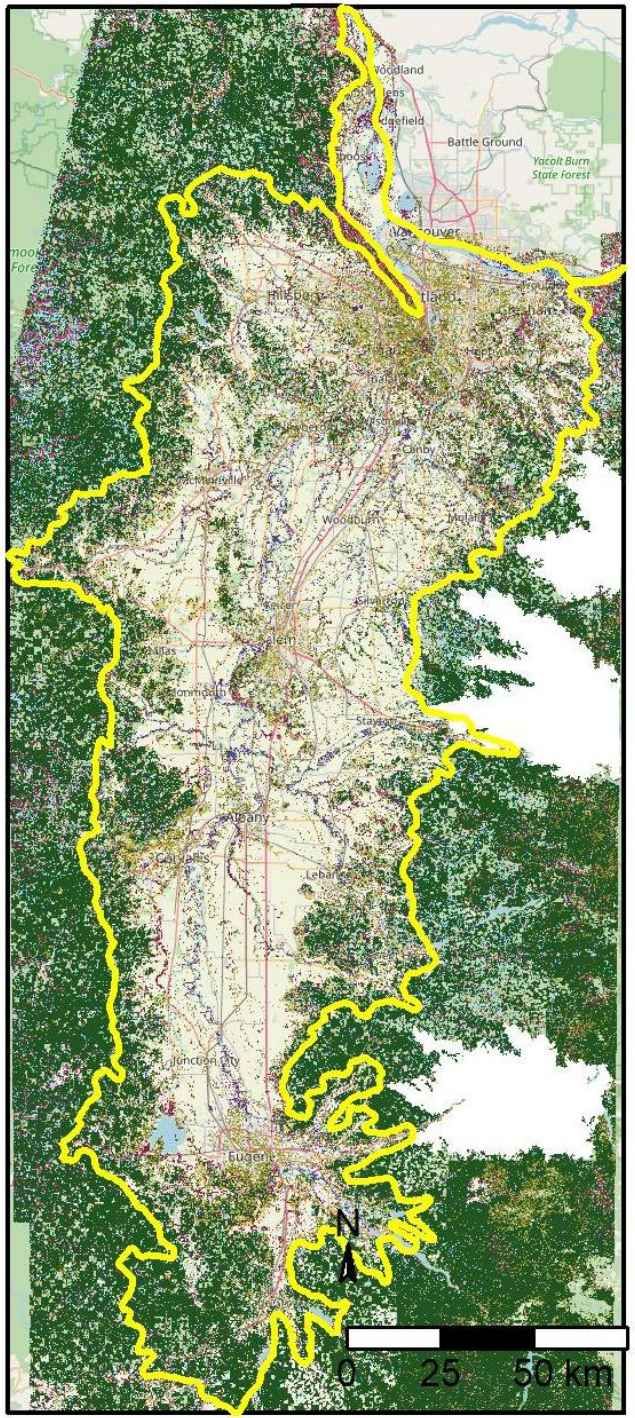

Apr
Aug
Jun
Oct
Reflectance
7500
5000
2500
0
B 02
B 03
B 04
B 05
B 06
B 07
B 08
B 11
B 12
DVI
GNDVI
MCARI
msrer
NDVI
Sentinel 2 Wavelength Band
Tree Species
Bigleaf Maple
Black Cottonwood
Conifers
Corylus avellana
Oregon Ash
Oregon White Oak
Red Alder
Urban

Vegetation Index	Abbreviation	Formula	Reference
Normalized Difference Vegetation Index	NDVI	$\frac{NIR - R}{NIR + R}$	Kriegler (1969): Rouse et al. (1974)
Difference Vegetation Index	DVI	$DVI = NIR - R$	Richardson et al. (1977)
Greenness Normalized Difference Vegetation Index	GNDVI	$\frac{NIR - 0.5(B - G)}{NIR + 0.5(B + G)}$	Wu (2014)
Modified Red-Edge Simple Ratio	MRESR	$\frac{NIR - B}{RE - B}$	Sims and Gannon (2002)
Mean Chlorophyll Absorption Ratio Index	MCARI	$(Re - R) - 0.2(RE - G)(\frac{RE}{R})$	Daughtry et al. (2000)

Modeling – Random Forest Classifier



Tuning Hyperparameters
mtry: 8-15
ntree:{500, 1000, 1500, 2000}



Tree Species

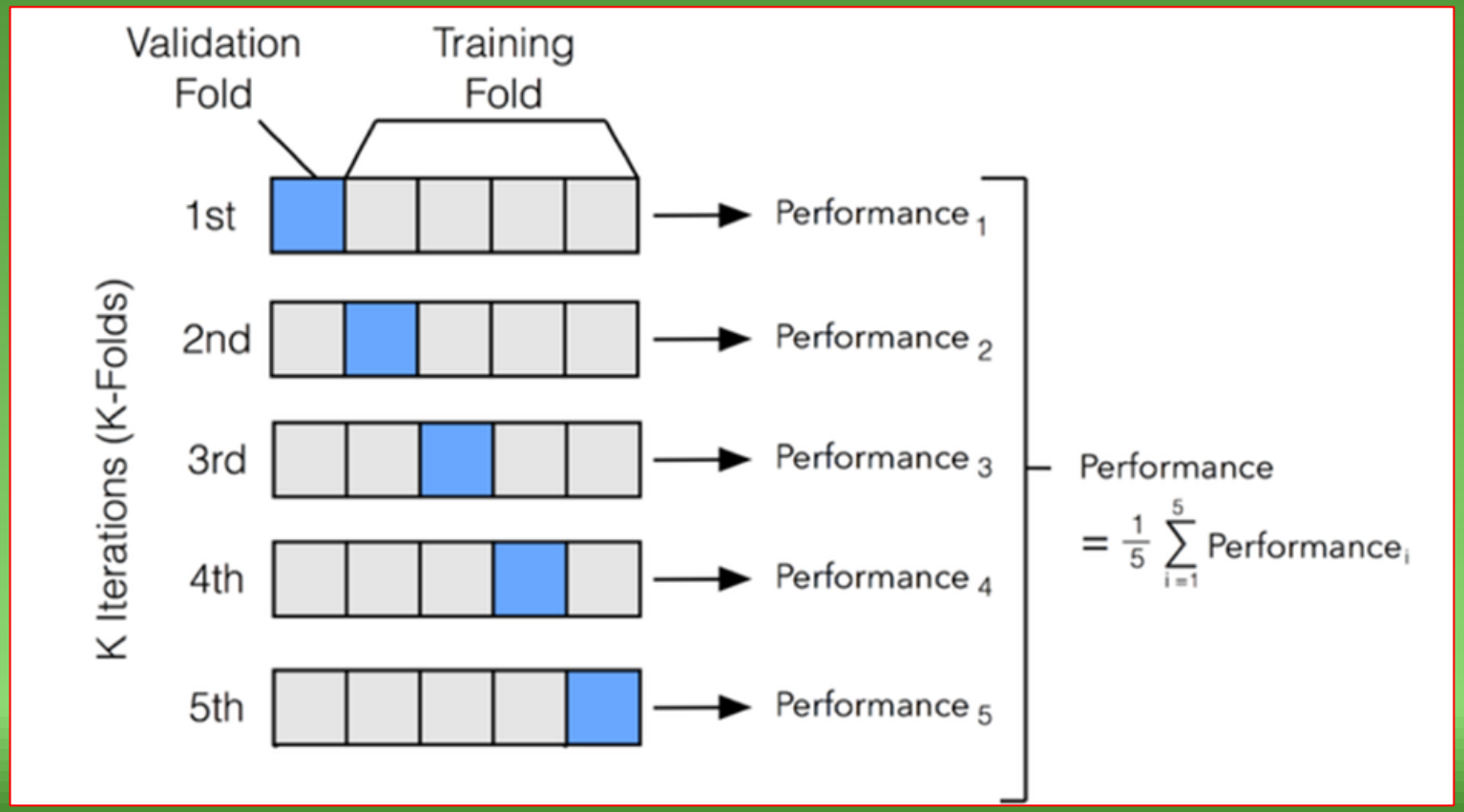
- bigleaf maple (Acer marcophyllum)
- black cottonwood (Populus balsamifera ssp. trichocarpa)
- conifers
- European filbert (Corylus avellana)
- Oregon ash (Fraxinus latifolia)
- Garry oak (Quercus garryana)
- red alder (Alnus rubra)
- urban stree tree
- burn scar

Sentinel 2 Imagery

Area of Inquiry

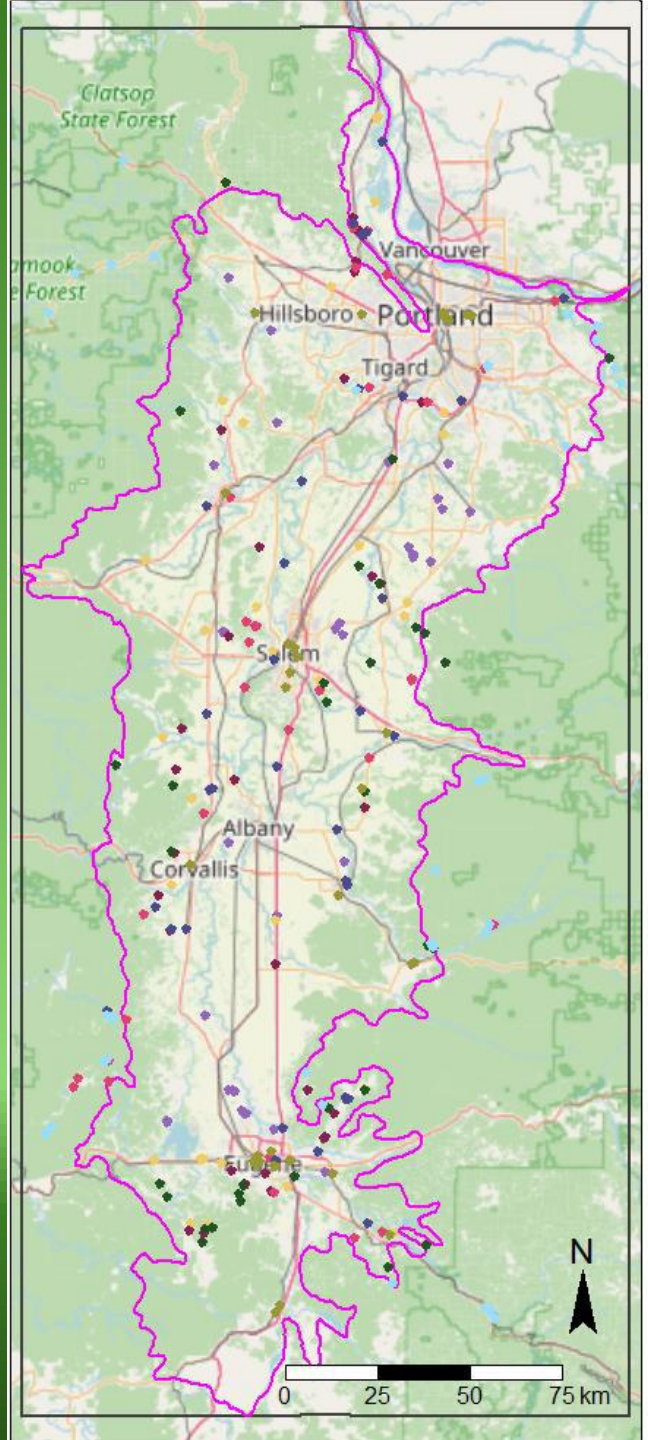
Willamette Valley Level III Ecoregion

Model Validation



10 Folds
5 Repeats

K-folds cross-validation 5 repetitions of 10 folds Overall accuracy: 98.1% Cohen's κ: 0.97		Predicted tree species								
		bigleaf maple	black cottonwood	conifers	European filbert	Oregon ash	Garry oak	red alder	urban street trees	omission error rate
True tree species	bigleaf maple	1.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.4%
	black cottonwood	0.0%	4.7%	0.1%	0.0%	0.1%	0.0%	0.0%	0.1%	5.6%
	conifers	0.0%	0.0%	13.0%	0.0%	0.0%	0.0%	0.0%	0.2%	2.6%
	European filbert	0.0%	0.0%	0.0%	9.5%	0.0%	0.0%	0.0%	0.0%	0.9%
	Oregon Ash	0.0%	0.1%	0.1%	0.0%	7.0%	0.0%	0.0%	0.1%	3.1%
	Oregon white oak	0.0%	0.1%	0.0%	0.0%	0.1%	2.8%	0.0%	0.2%	4.1%
	red alder	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	0.0%	5.0%
	urban street trees	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	57.8%	1.1%
	commission error rate	10.4%	6.9%	2.0%	0.5%	4.6%	11.7%	6.0%	0.4%	98.1%



Sentinel 2 Imagery

Area of Inquiry

Willamette Valley
Level III ecoregion

Tree Species

- **bigleaf maple (Acer macrophyllum)**
- **black cottonwood (Populus balsamifera ssp. trichocarpa)**
- **conifers (Plantae:Gymnospermae)**
- **European filbert (Corylus avellana)**
- **Oregon ash (Fraxinus latifolia)**
- **Oregon white oak (Quercus garryana)**
- **red alder (Alnus rubra)**
- **urban street trees**

264 validation sites 33 sites per species Overall accuracy: 70.5% Cohen's kappa: 0.67		Predicted tree species								
		bigleaf maple	black cottonwood	conifers	European filbert	Oregon ash	Garry oak	red alder	urban street trees	omission error rate
True tree species	bigleaf maple	4.5% (12/264)	0.4% (1/264)	1.5% (4/264)	0.8% (2/264)	1.5% (4/264)	0.0% (0/264)	2.7% (7/264)	1.1% (3/264)	63.0% (21/33)
	black cottonwood	0.0% (0/264)	7.6% (20/264)	0.8% (2/264)	0.0% (0/264)	1.9% (5/264)	0.4% (1/264)	0.8% (2/264)	1.1% (3/264)	28.6% (13/33)
	Conifers	0.0% (0/264)	0.4% (1/264)	12.1% (32/264)	0.0% (0/264)	0.0% (0/264)	0.0% (0/264)	0.0% (0/264)	0.0% (0/264)	3.0% (1/33)
	European filbert	0.8% (2/264)	0.0% (0/264	0.0% (0/264)	10.6% (28/264)	0.4% (1/264)	0.8% (2/264)	0.0% (0/264)	0.0% (0/264)	15.2% (5/33)
	Oregon Ash	0.8% (2/264)	0.4% (1/264)	0.4% (1/264)	0.0% (0/264)	10.2% (27/264)	0.0% (0/264)	0.0% (0/264)	0.4% (1/264)	15.6% (6/33)
	Garry Oak	0.0% (0/264)	0.0% (0/264)	0.4% (1/264)	0.0% (0/264)	0.0% (0/264)	9.8% (26/264)	0.0% (0/264)	2.3% (6/264)	18.2% (6/33)
	red alder	0.8% (2/264)	1.5% (4/264)	1.9% (5/264)	0.0% (0/264)	2.7% (7/264)	0.0% (0/264)	5.3% (14/264)	0.4% (1/264)	57.6% (19/33)
	urban street trees	0.0% (0/264)	0.4% (1/264)	0.0% (0/264)	0.0% (0/264)	1.5% (4/264)	0.0% (0/264)	0.0% (0/264)	10.2% (27/264)	15.6% (6/33)
	commission error rate	33.3% (6/18)	28.6% (8/28)	28.9% (13/45)	6.7% (2/30)	43.8% (21/48)	10.3% (3/29)	39.1% (9/23)	34.1% (14/41)	70.5% (188/264)

Questions?