ESTIMATING THE SEVERITY OF DEFOLIATION CAUSED BY PINE PROCESSIONARY MOTH USING LANDSAT AND UAV IMAGERY

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JORNADA "OBSERVACIÓ DE LA TERRA I ESPAI FORESTAL, EINES DE DIAGNÒSTIC

ICGC, 8 NOVEMBER 2018

UAB Universitat Autònoma de Barcelona

CREAF

CTFC

CSIC Consejo Superior de Investigaciones Científicas

ICGC Institut Cartogràfic i Geològic de Catalunya

Background

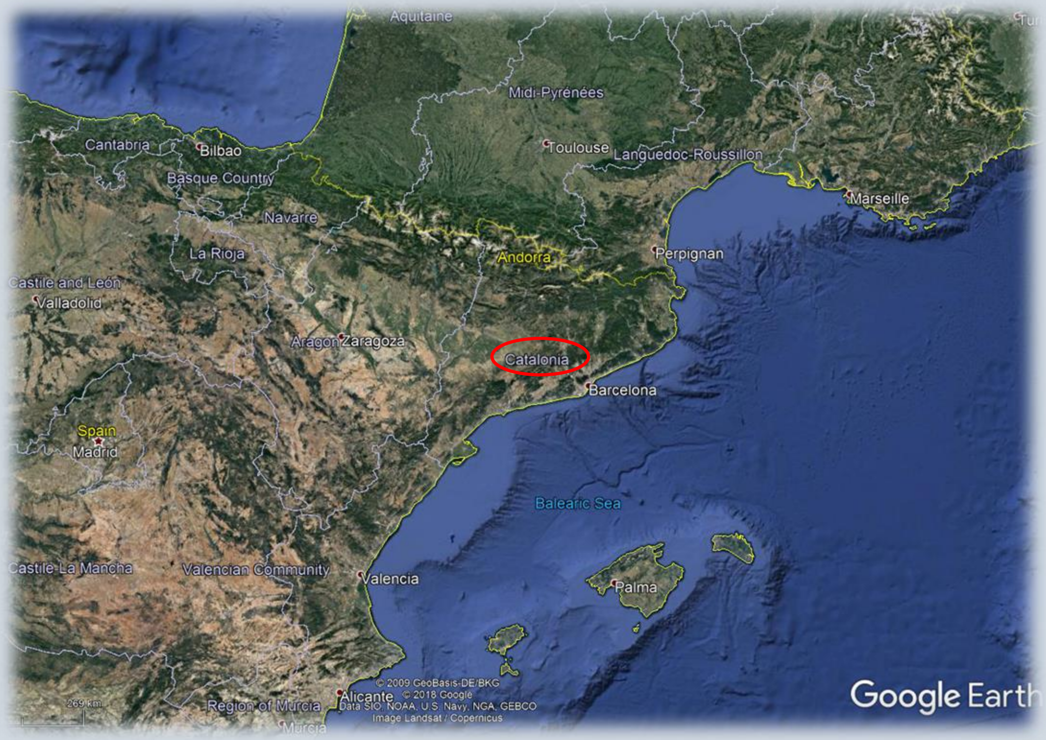
Defoliator, pine processionary moth (PPM), since 1990s in the Mediterranean region

Expansion of host and insect distribution

Severely infested stands by PPM outbreaks

Increased demands for forest monitoring

PPM Monitoring



- Annual field survey and mapping in Catalonia
  - From 2010 by Rural Agents (Generalitat de Catalunya)
- Data entry
  - Severity levels 1-4
  - Tree species
  - Elevation and orientation
- Outbreak in winter over 2015-2016

Study Area (2015)

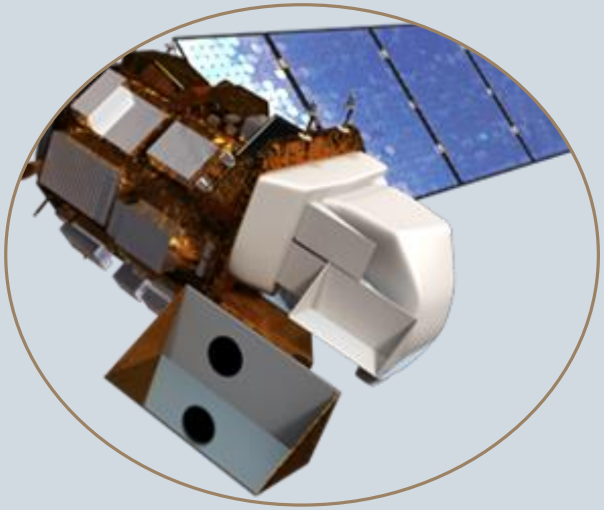
Study Area (2016)

- ❖ Severely affected areas with level 4
  - 6800 ha near Solsona, Catalonia
  - Elevation at 600-1100 m
  - Mediterranean continental climate
  - *Pinus nigra*, *P. sylvestris*
- ❖ Sketch mapping concerns
  - Qualitative classification
  - Coarse spatial resolution
  - Inclusion of non-forest stands

Study Area (2017)

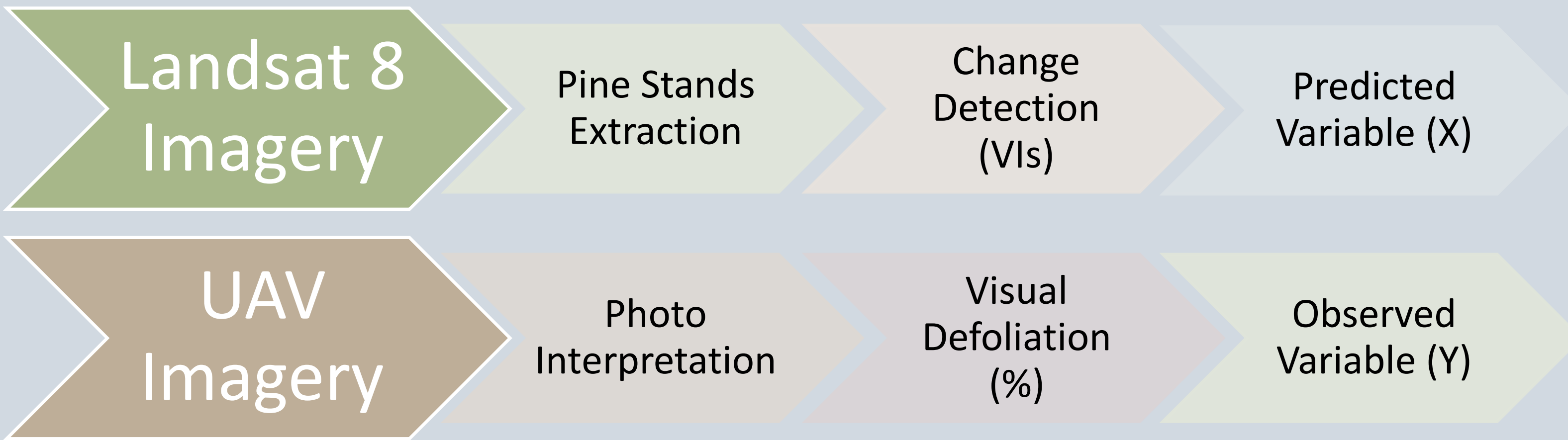
Objectives

- To quantify the severity of defoliation by the recent PPM outbreak with Landsat-based vegetation indices (VIs)

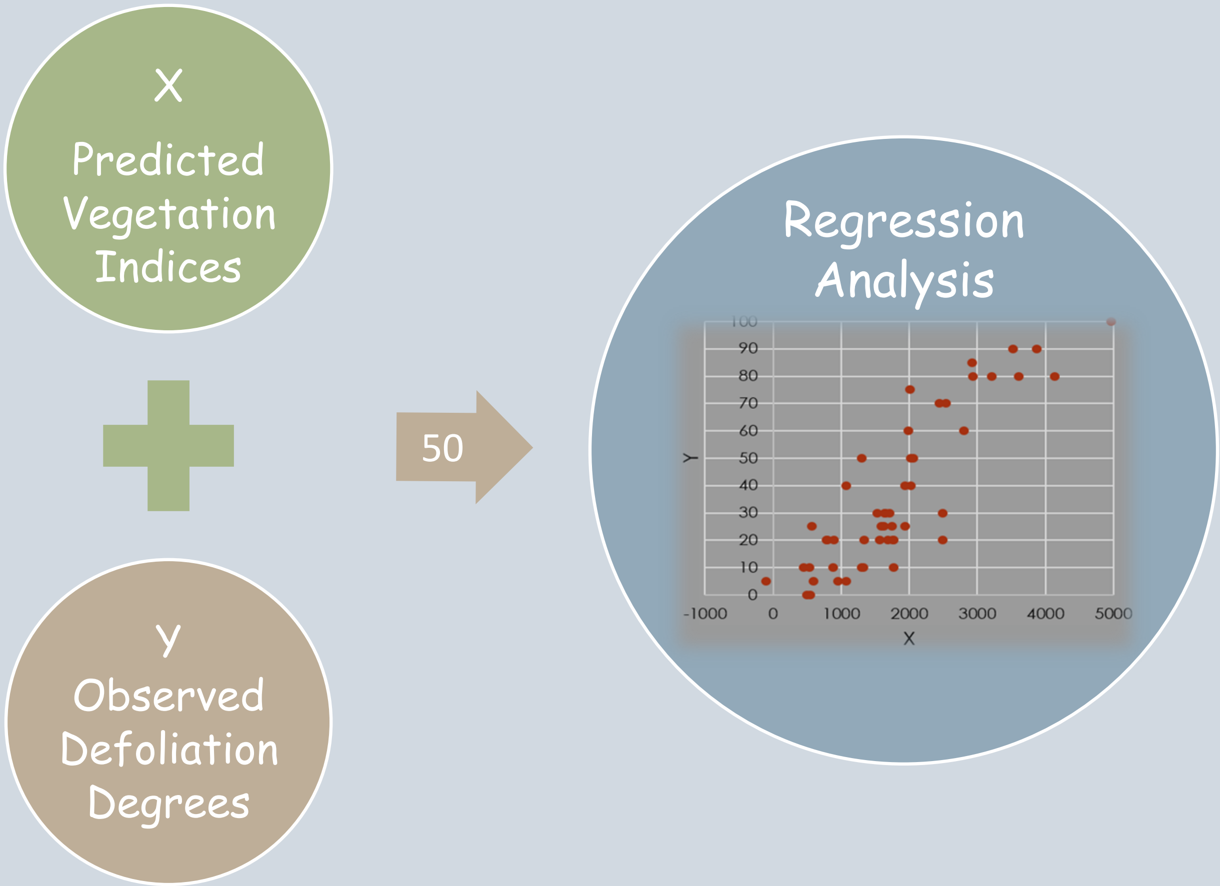


- To calibrate the VIs with defoliation degrees interpreted by unmanned aerial vehicle (UAV) imagery

Methodology Workflow

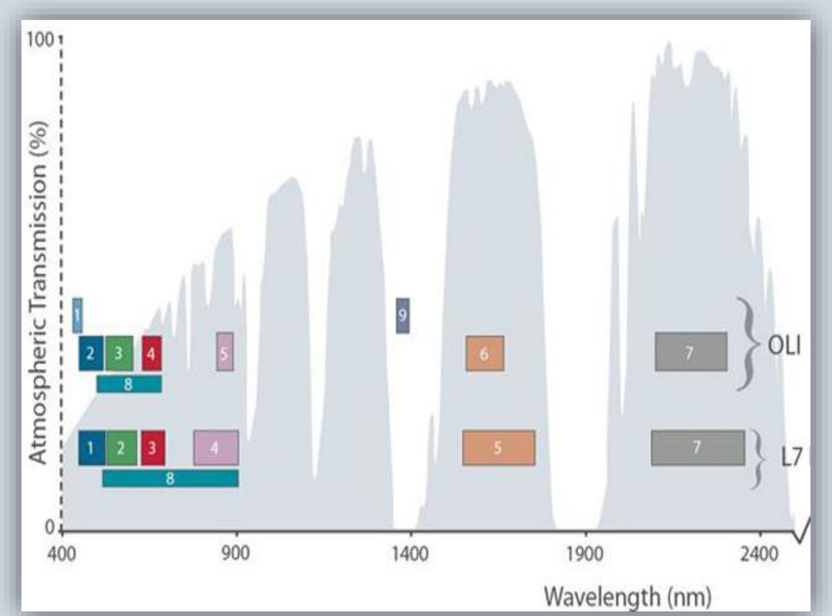


Methodology Workflow



X = d(Vegetation Index)

Multispectral Bands (OLI)

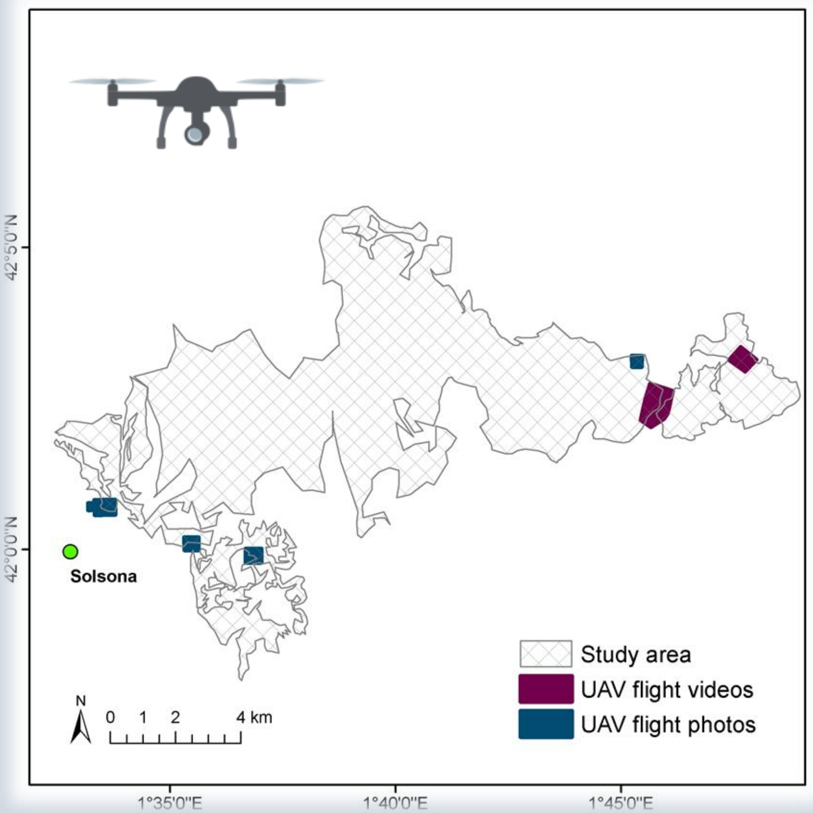


Landsat 8 Vegetation Indices

Index	Acronym	Formula
Middle Infrared Wavelengths	MID	b6 + b7
Moisture Stress Index	MSI	b6 / b5
Normalized Difference Moisture Index	NDMI	(b5 – b6) / (b5 + b6)
Normalized Difference Vegetation Index	NDVI	(b5 – b4) / (b5 + b4)
Normalized Burn Ratio	NBR	(b5 – b7) / (b5 + b7)
Change detection in VI	dVI	VI (2015) - VI (2016)

(b4 = Red, b5 = Near Infrared, b6 = Shortwave Infrared 1, b7 = Shortwave Infrared 2)

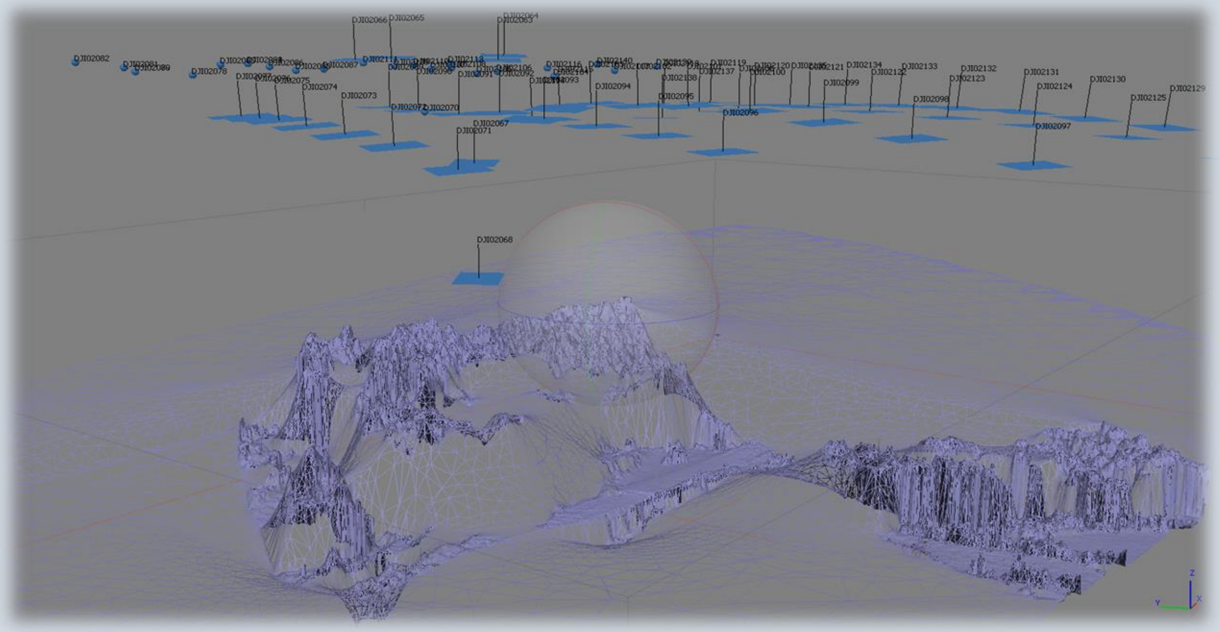
Y = UAV Images



- RGB camera
  - DJI Phantom 2 Vision FC200
- UAV flight
  - Altitude 50-100 m
  - 7 surveys in winter 2016 (post-outbreak)
  - Image processing for orthomosaic
  - Ground resolution 2.0-3.5 cm

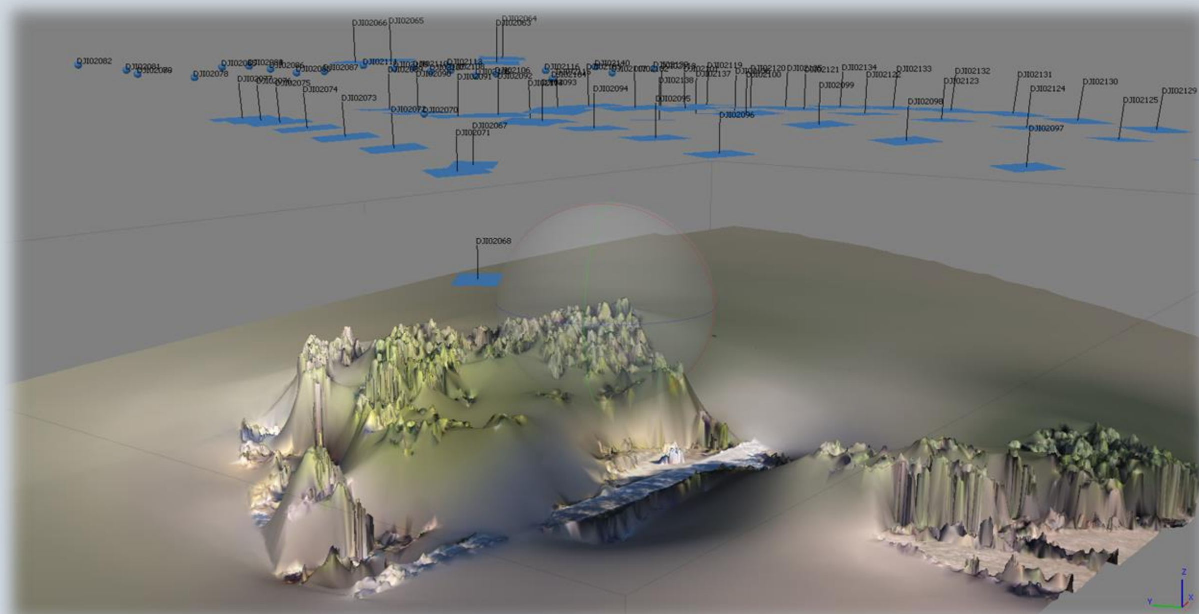
Y = UAV Images

3D model by PhotoScan



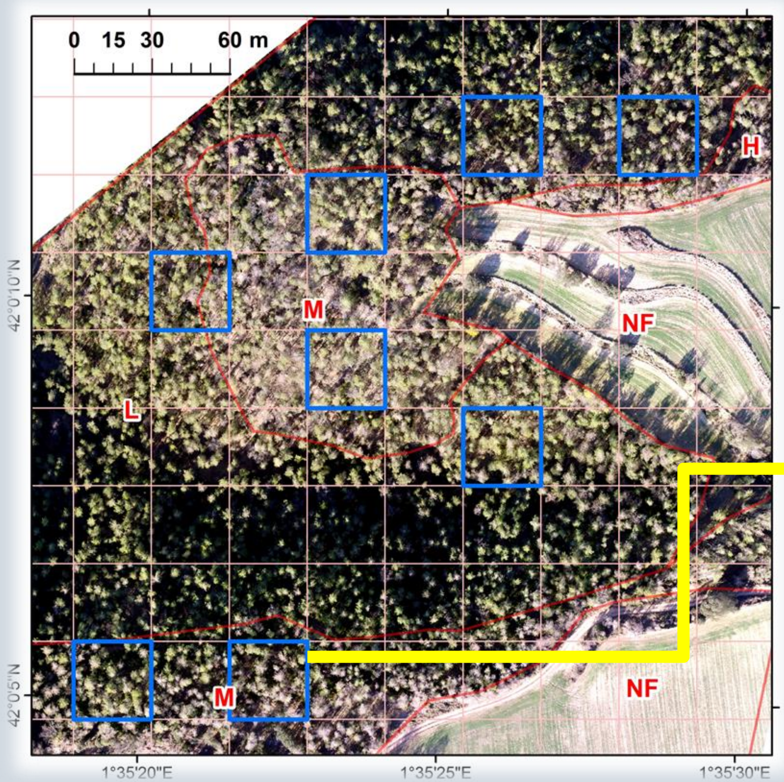
Y = UAV Images

3D model by PhotoScan



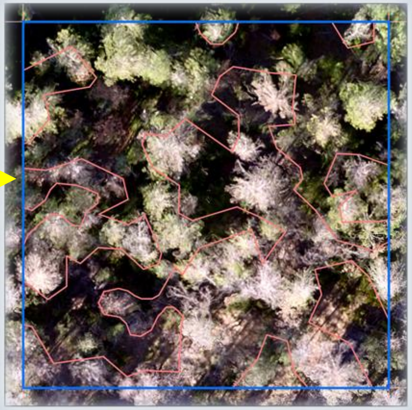
Y = UAV Images

Orthomosaic

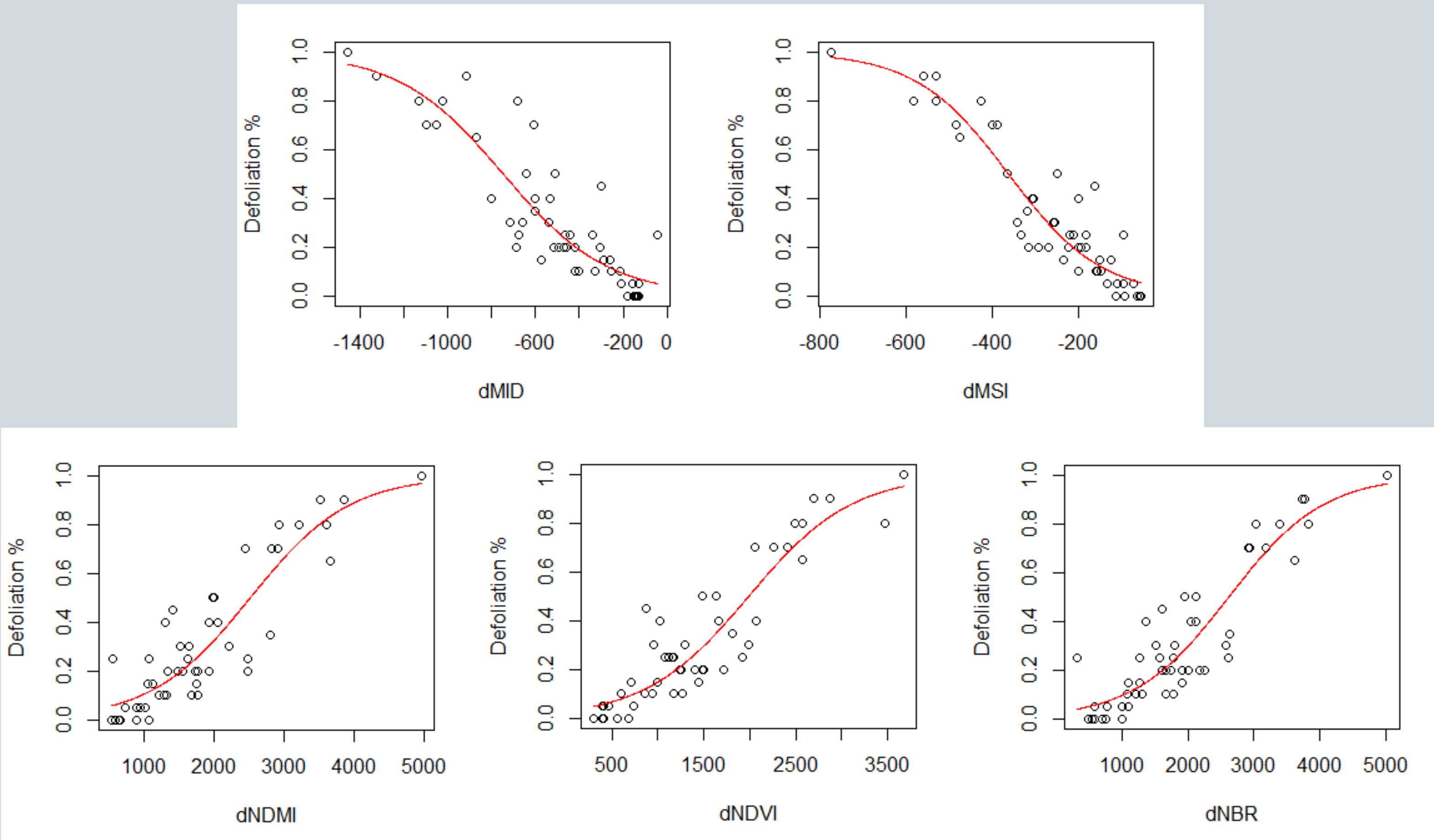


Visual interpretation

Severity	Defoliation (%)	Samples
Nil	0 - 5	10
Low	10 - 30	23
Medium	35 - 65	8
High	70 - 100	9



Regression Analysis



Regression Analysis

Logistic Regression Models

Index	Equation	R^2 (McFadden's)
dMID	$Y = \frac{1}{1+e^{-(-3.1299111-0.0041928X)}}$	0.740
dMSI	$Y = \frac{1}{1+e^{-(-3.3570352-0.0092755X)}}$	0.815
dNDMI	$Y = \frac{1}{1+e^{-(-3.5552389+0.0014107X)}}$	0.749
dNDVI	$Y = \frac{1}{1+e^{-(-3.509468+0.001767X)}}$	0.787
dNBR	$Y = \frac{1}{1+e^{-(-3.6323329-0.0013874X)}}$	0.776

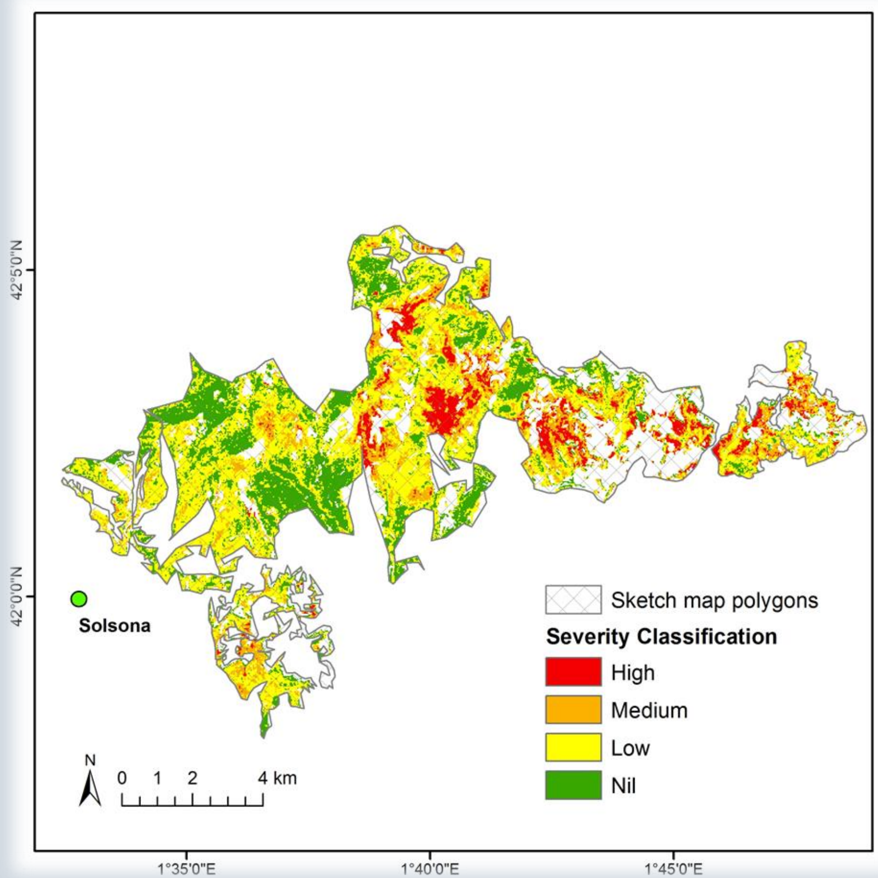
$$Y = \frac{1}{1+e^{-(a+bX)}}$$

Threshold Classification

X	Y = Defoliation (%)		
	Low (10)	Medium (35)	High (70)
dMID	-222	-599	-949
dMSI	-125	-295	-453
dNDMI	963	2081	3121
dNDVI	743	1636	2466
dNBR	1034	2172	3229

$$X = \frac{ln\left(\frac{Y}{1-Y}\right) - a}{b}$$

Predicted Defoliation Map



Classification Accuracy

Confusion Matrix

Class		Predicted (Landsat 8)					
		Nil	Low	Medium	High	Total	Producer's Accuracy
Observed (UAV)	Nil	**9**	1	0	0	10	0.90
	Low	2	**17**	4	0	23	0.74
	Medium	0	3	**4**	1	8	0.50
	High	0	0	3	**6**	9	0.67
	Total	11	21	11	7	**50**	
	User's Accuracy	0.82	0.81	0.36	0.86		**0.72**

Discussions

- **Robust VI for defoliation**
  - Moisture Stress Index
  - Normalized Difference Vegetation Index
- **Classification accuracy**
  - Sample size
  - Non-parametric algorithms
  - Spectral bands of dVIs
- **Data resolution trade-off = spatial + temporal + spectral**
  - Ground & aerial sketch mapping
  - Spaceborne Landsat
  - Airborne UAV

Conclusions and Future Study

Validation

Additional UAV images in a new study area may increase the robustness of VI models.

Ground Truth

The UAV technology holds great potential for cost-effectively monitoring forest health.

Ecosystem Service

Combining satellite and UAV data may serve as a tool to provision pest distribution and forest production.

Publication

Otsu, K.; Pla, M.; Vayreda, J.; Brotons, L. Calibrating the Severity of Forest Defoliation by Pine Processionary Moth with Landsat and UAV Imagery. *Sensors* **2018**, *18*, 3278.

https://www.mdpi.com/1424-8220/18/10/3278/htm

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PPM Life Cycle (*Thaumetopoea pityocampa*)