Low-density LiDAR-PNOA data for the study of forest fires in Mediterranean environments

LESSONS LEARNED

MONTEALEGRE, A.L., LAMELAS, M.T., DOMINGO, D., DE LA RIVA, J., GARCÍA-MARTÍN, A., GELABERT, P.J., TANASE, M.

Instituto Universitario de Investigación en Ciencias Ambientales de Aragón Universidad Zaragoza

Geoforest

ERTAlab

1542

Departamento de Geografía y Ordenación del Territorio Universidad Zaragoza

CUD Zaragoza

Background
Our team

Forest fire severity assessment using ALS data in a Mediterranean environment
Remote sensing

A Comparison of Open Source LiDAR Filtering Algorithms in a Mediterranean Forest Environment
IEEE JSTARS

Interpolation routines assessment in ALS-derived Digital Elevation Models development for forestry applications
Remote sensing

Cartografía de modelos de combustible mediante combinación de imágenes LiDAR, SAR y ópticas en el Centro de adiestramiento "San Gregorio"
III Congreso Nacional de i+d en Defensa y Seguridad

Comparison of regression models to estimate biomass losses and CO emissions using low density airborne laser scanning data in a burnt Aleppo pine forest
European Journal of Remote Sensing

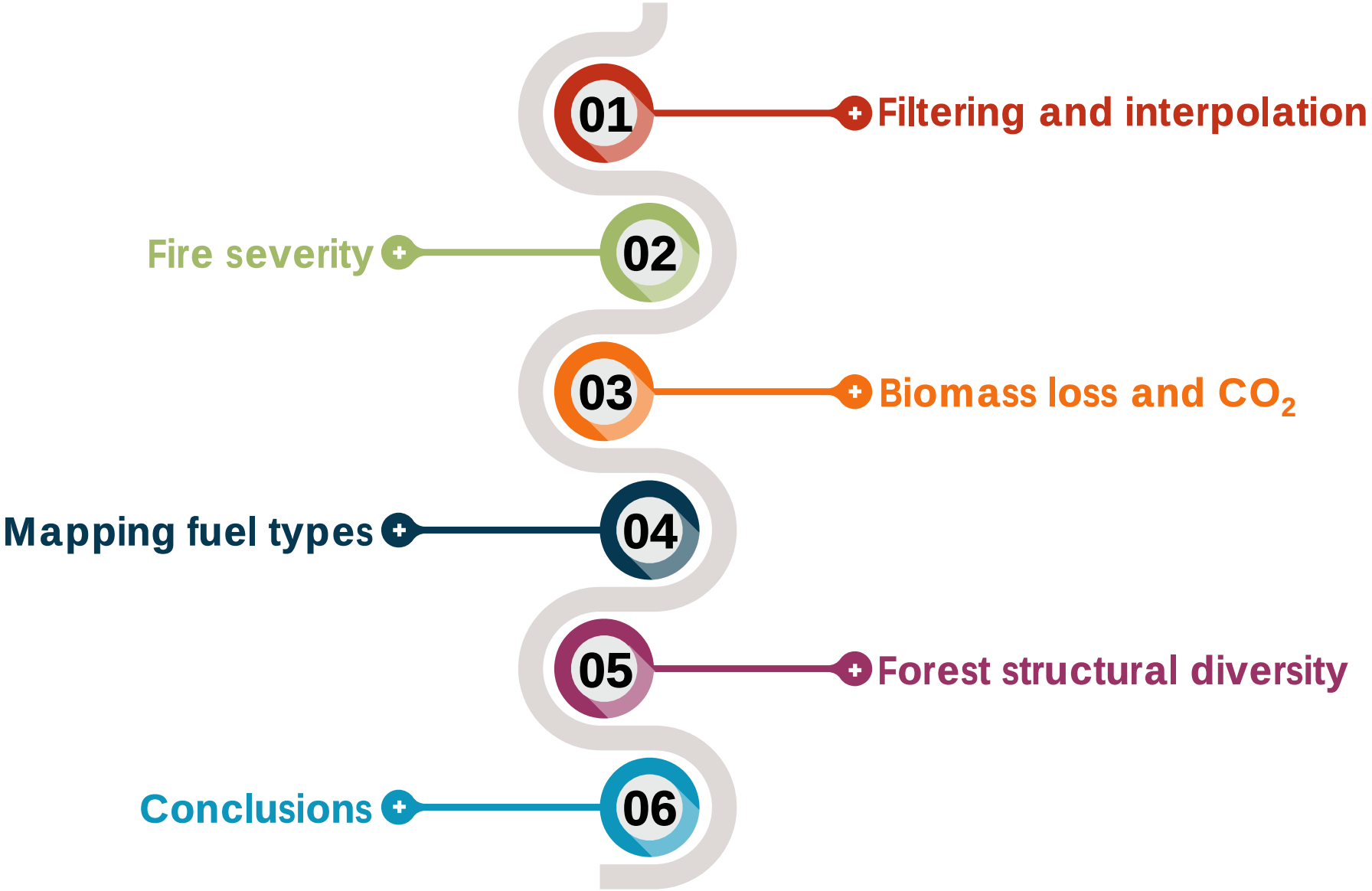
Using low-density discrete Airborne Laser Scanning data to assess the potential carbon dioxide emission in case of a fire event in a Mediterranean pine forest
GIScience and Remote Sensing

Assessment of forest structural diversity differences in Mediterranean landscapes affected by fires using ALS data
Proceedings of the 2018 IEEE International Geoscience and Remote Sensing Symposium

2014 **2015** **2016** **2017** **2018**

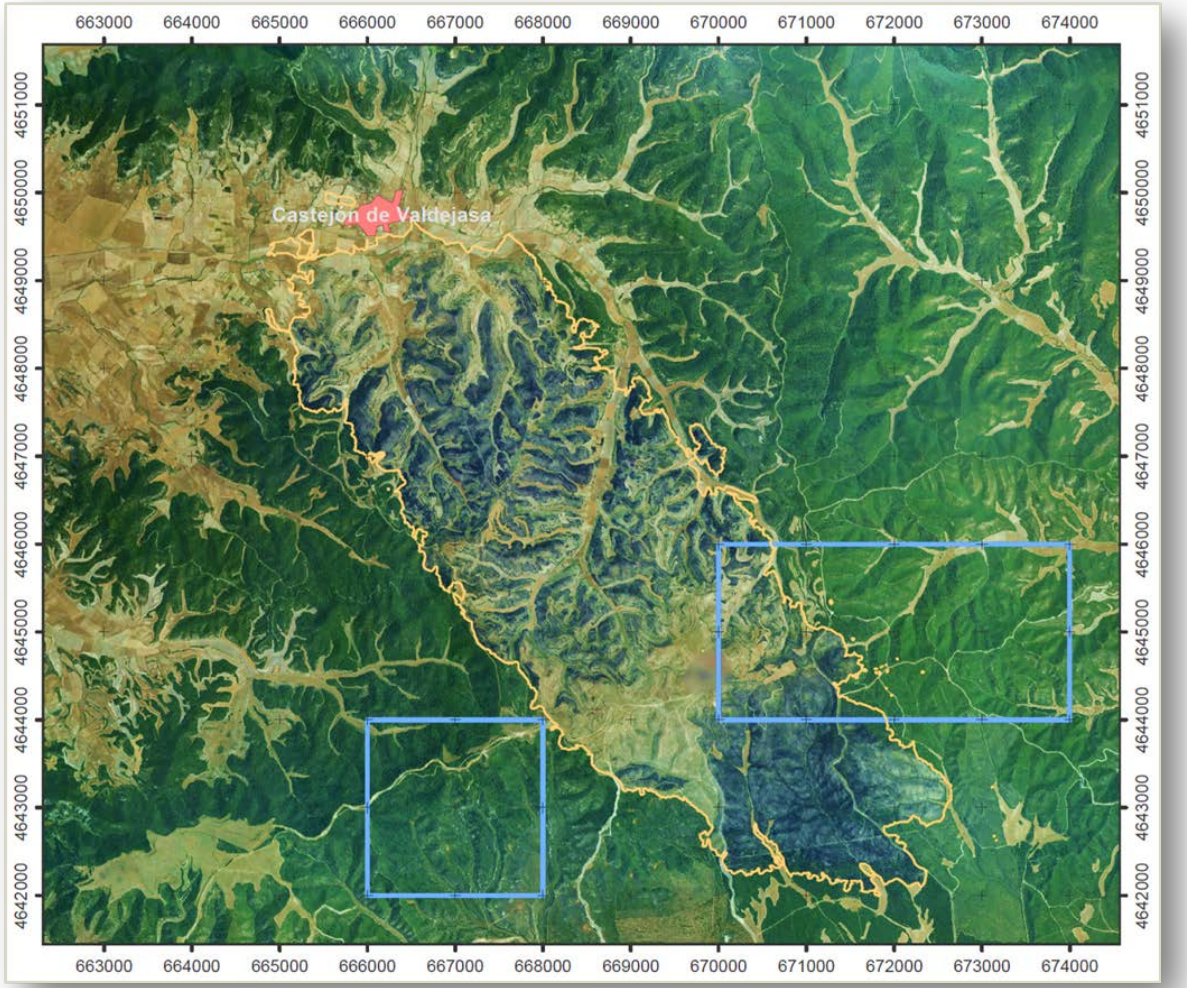
What have we learned?

LESSONS LEARNED



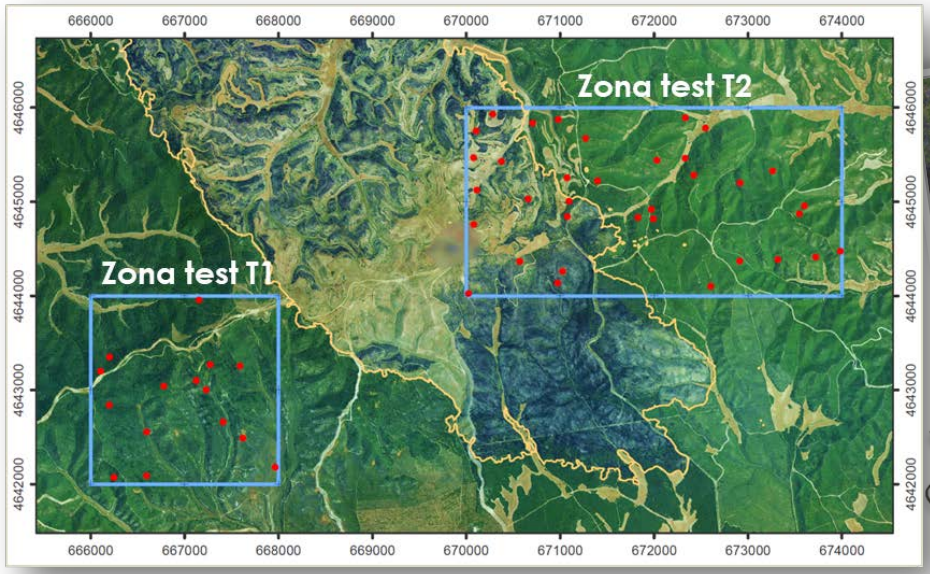
LESSON #1

Filtering and interpolation



LESSON #1
Filtering and interpolation

SOFTWARE/TOOL
LAStools – “lasground.exe”
FUSION – “groundfilter.exe”
MCC–LiDAR
BCAL LiDAR Tools – “Perform Height Filtering”
ALDPAT – “Elevation Threshold with Expand Window (ETEW) filter”
ALDPAT – “Progressive Morphological (PM) filter”
ALDPAT – “Maximum Local Slope (MLS) filter”

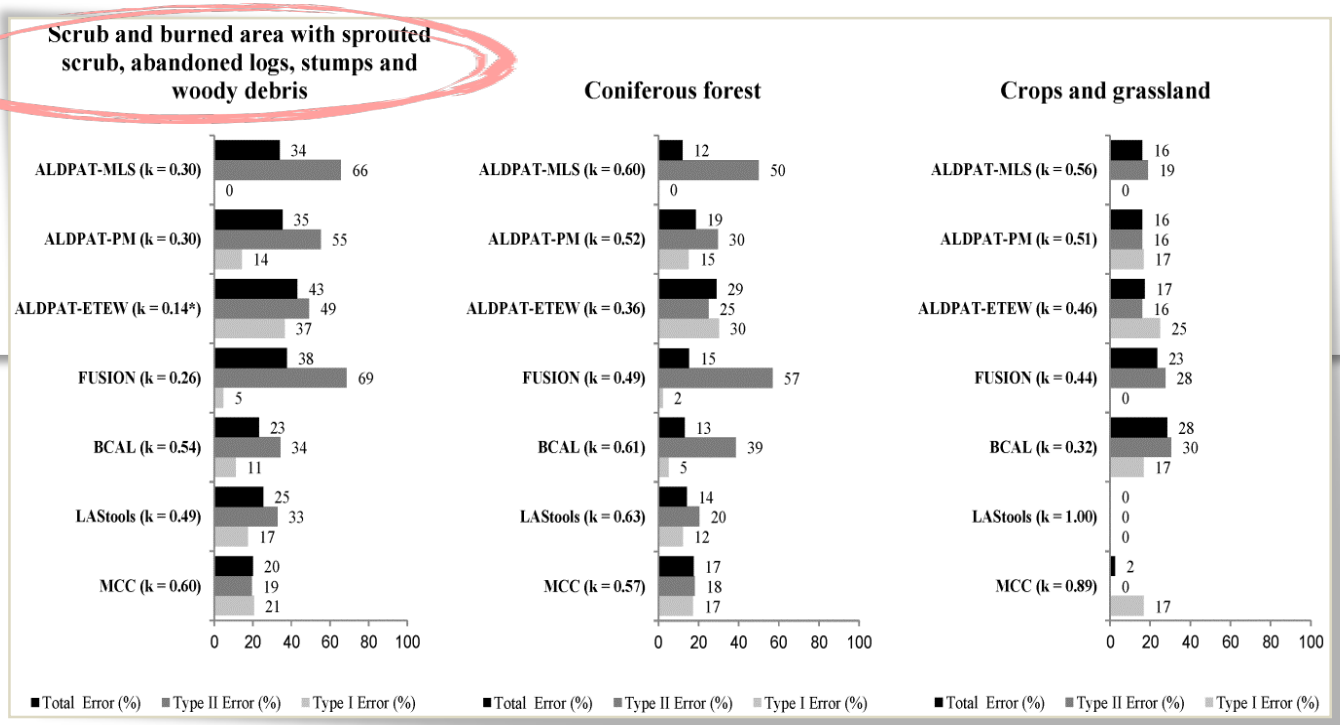


LESSON #1
Filtering and interpolation

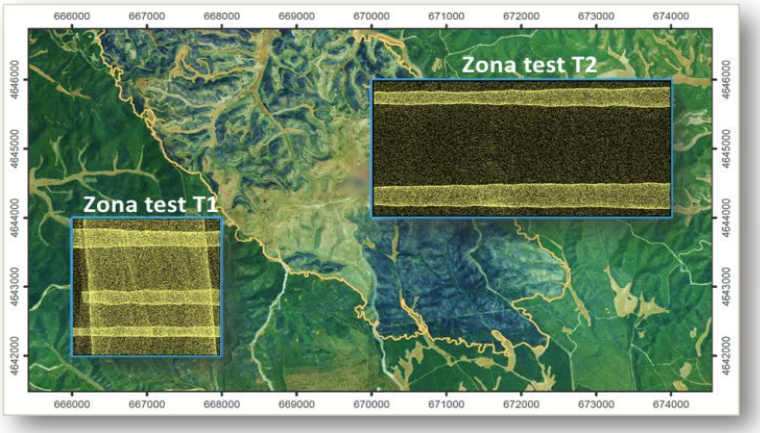
TABLE V

TYPE I AND TYPE II ERRORS, SUCCESS RATE, AND COHEN'S KAPPA INDEX (p-value ≤ 0.05) OF DIFFERENT FILTERING METHODS

Filtering method	Optimum parameters	Type I error (%)	Type II error (%)	Success rate (%)	Kappa index
MCC	Scale 1, curvature 0.3	12.7	20.8	83.3	0.67
LAStools	Terrain type forest and hills, granularity fine	20.8	13.7	82.8	0.66



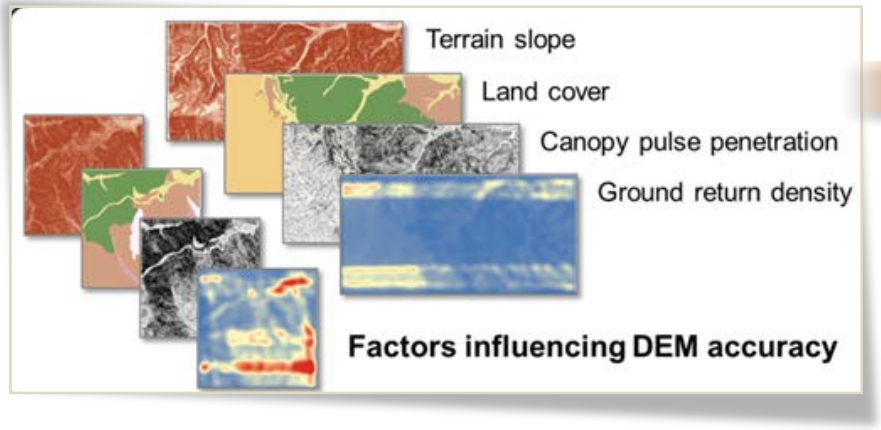
LESSON #1
Filtering and interpolation



Random sampling

Test (20%)

Training (80%)

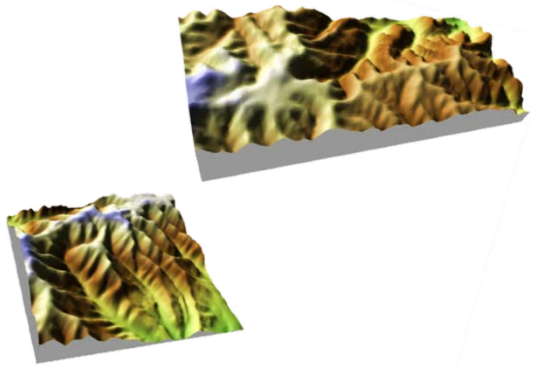


INTERPOLATION METHODS
TIN to raster
Natural neighbor
ANUDEM
IDW
Kriging
Point to raster

LESSON #1

Filtering and interpolation

DEMs generated at **1 m resolution** present a higher accuracy and the **TIN to raster interpolation** method seems to be the most suitable one for all **slope steepness ranges**, with **low point densities** (<0.5 points/m^2) in relatively **complex landscapes**.



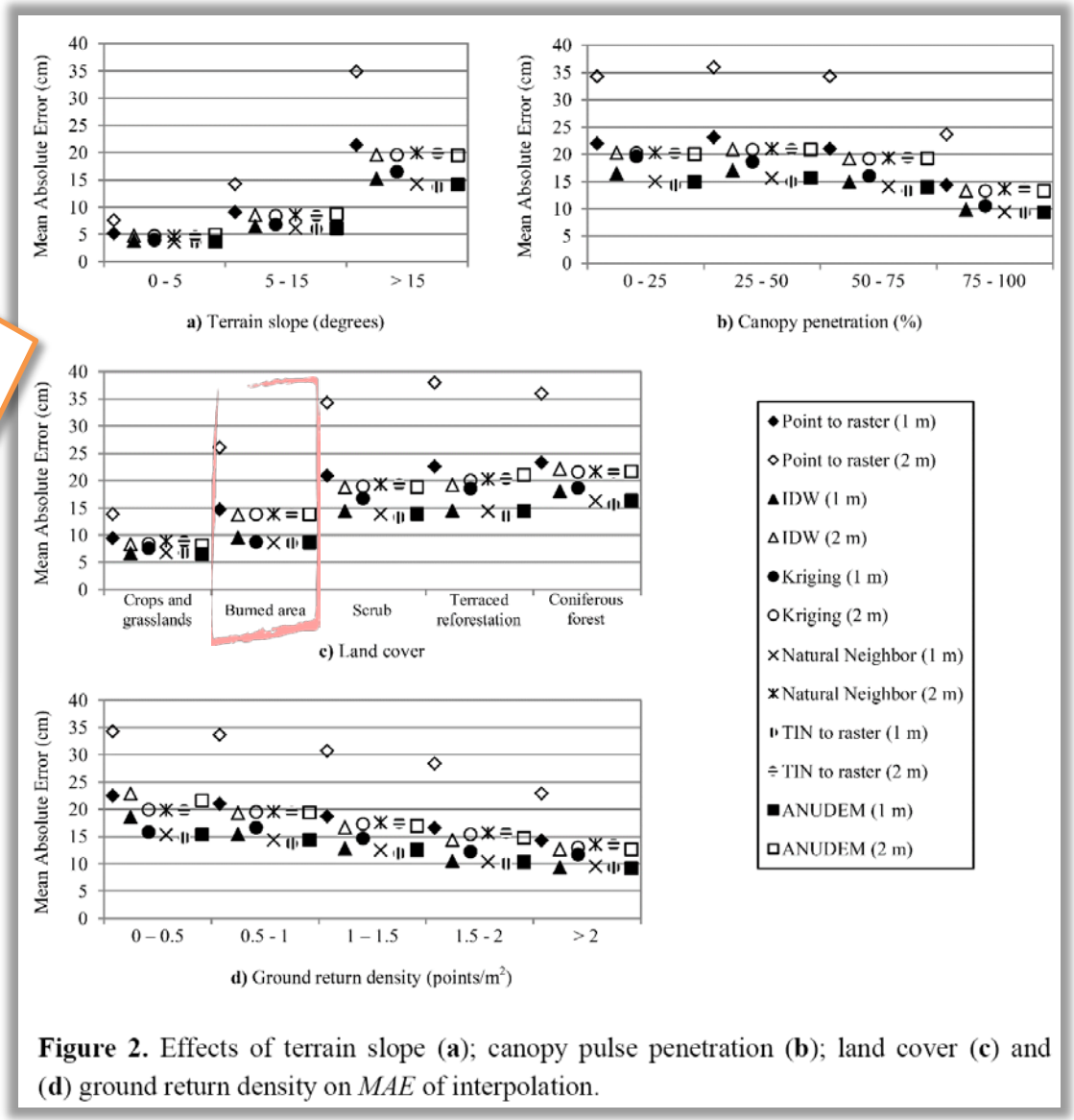
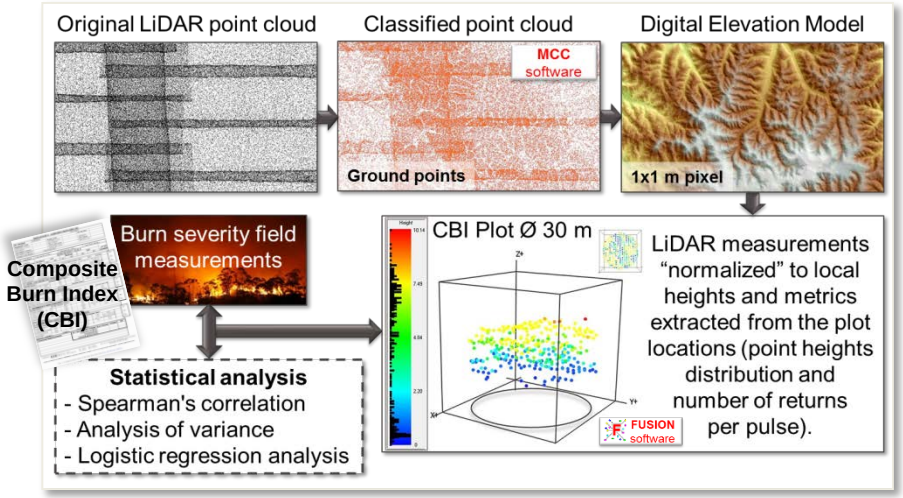


Figure 2. Effects of terrain slope (**a**); canopy pulse penetration (**b**); land cover (**c**) and (**d**) ground return density on *MAE* of interpolation.

LESSON #2
Fire severity

Methodological steps



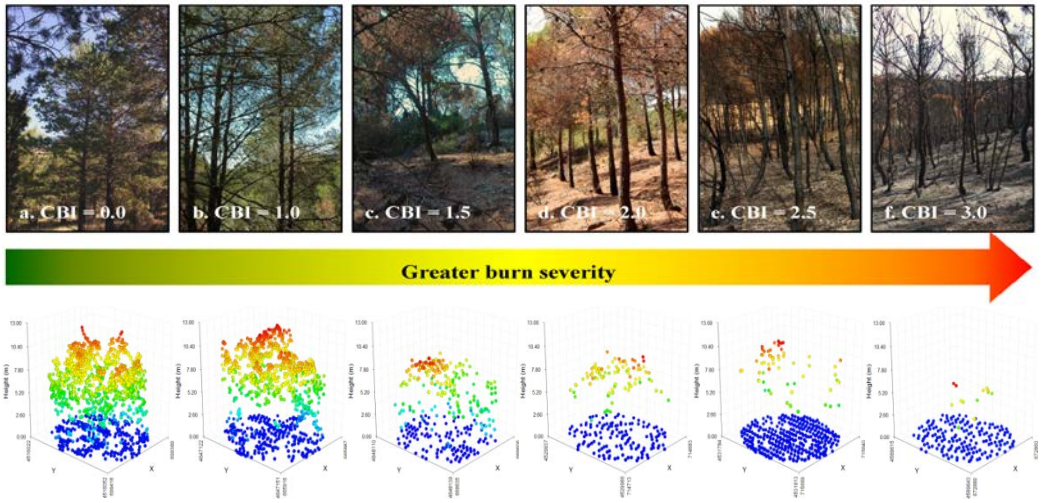
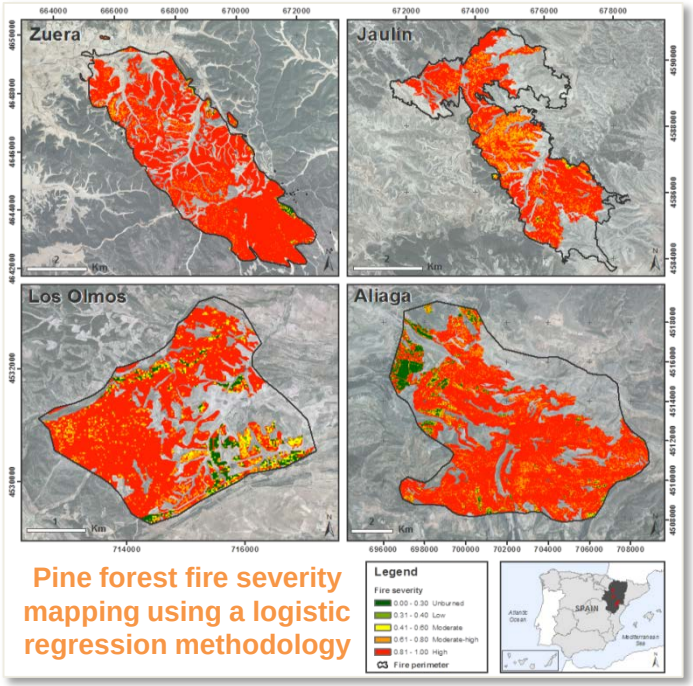


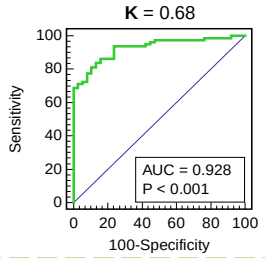
Fig. 8 ALS point clouds at plot level and their correspondence with the CBI values.

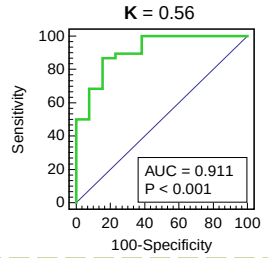


Pine forest fire severity mapping using a logistic regression methodology

Observed and predicted fire severity cross-tabulation for both training and validation datasets, Kappa index (K) and ROC curves.

	Training Dataset					Validation Dataset				
	Predicted					Predicted				
Observed	Low	High	Sum	%		Low	High	Sum	%	
Low	32	6	38	84.2	Low	8	5	13	61.9	
High	11	69	80	86.3	High	3	35	38	92.1	
Sum	43	75	118	85.6	Sum	11	40	51	84.3	





LESSON #3

Biomass loss and CO_2 emissions

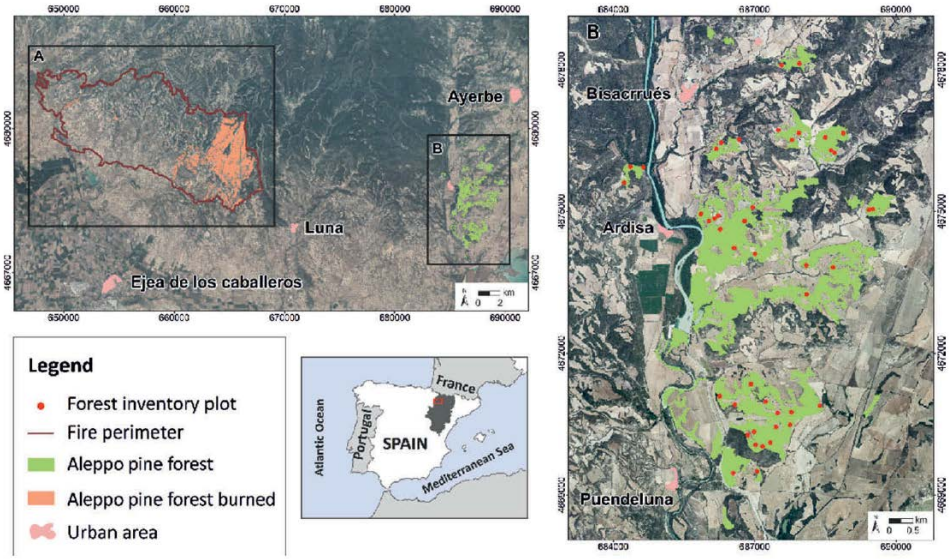


Table 4. Summary of results obtained for the burned area concerning to Aleppo pine forest affected by fire, pre-fire AGB, biomass losses, carbon content and CO_2 emissions.

Burn severity	Aleppo pine area (ha)	Pre-fire AGB (ton)	Biomass losses (ton)	Carbon content (ton)	CO_2 emissions (ton)
Unburned	26.8	20,744.3	0.0	0.0	0.0
Low	117.0	36,022.2	9005.5	4493.7	14,631.7
Medium	594.5	169,908.7	71,361.6	35,609.4	115,944.4
High	1034.2	319,811.4	182,292.5	90,963.9	296,178.6
Total	1772.6	546,486.7	262,659.7	131,067.2	426,754.8

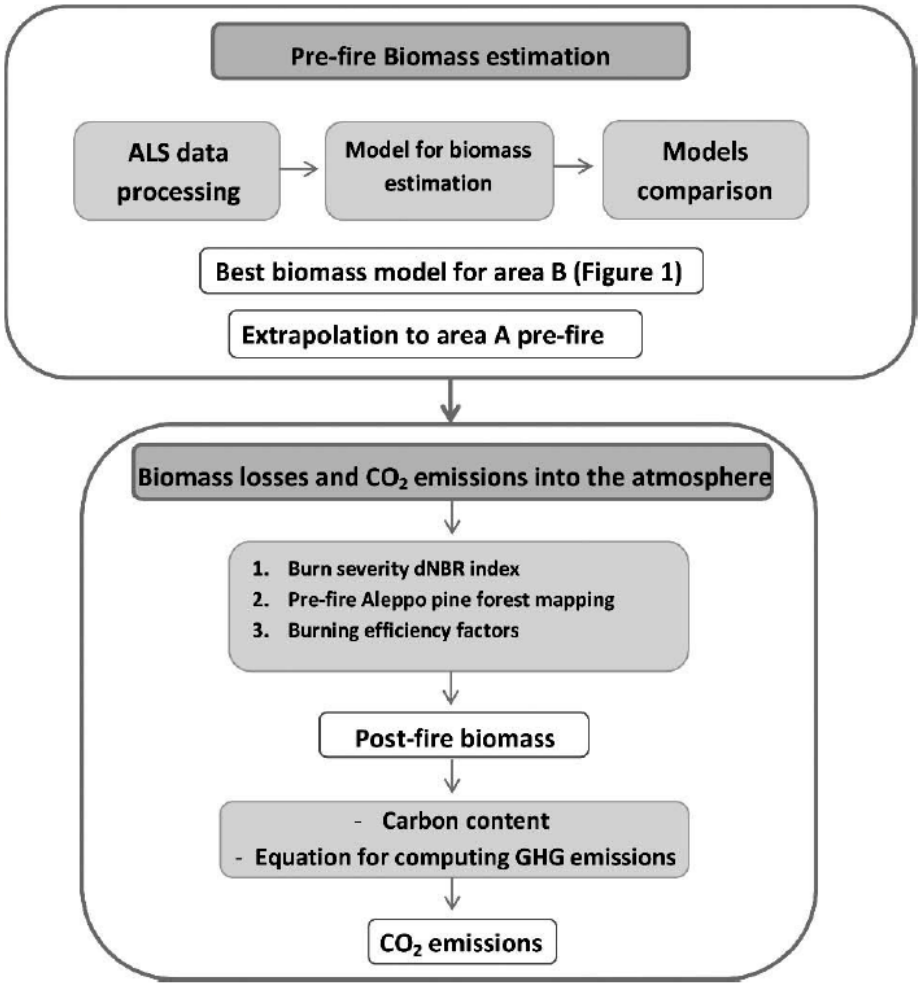
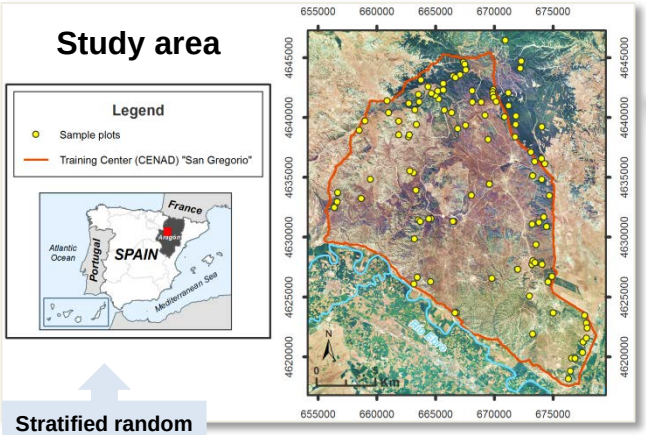


Figure 2. Methodology for biomass losses and CO_2 emissions estimation.

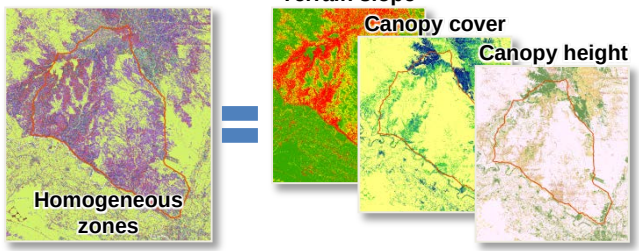
LESSON #4

Mapping fuel types

Study area

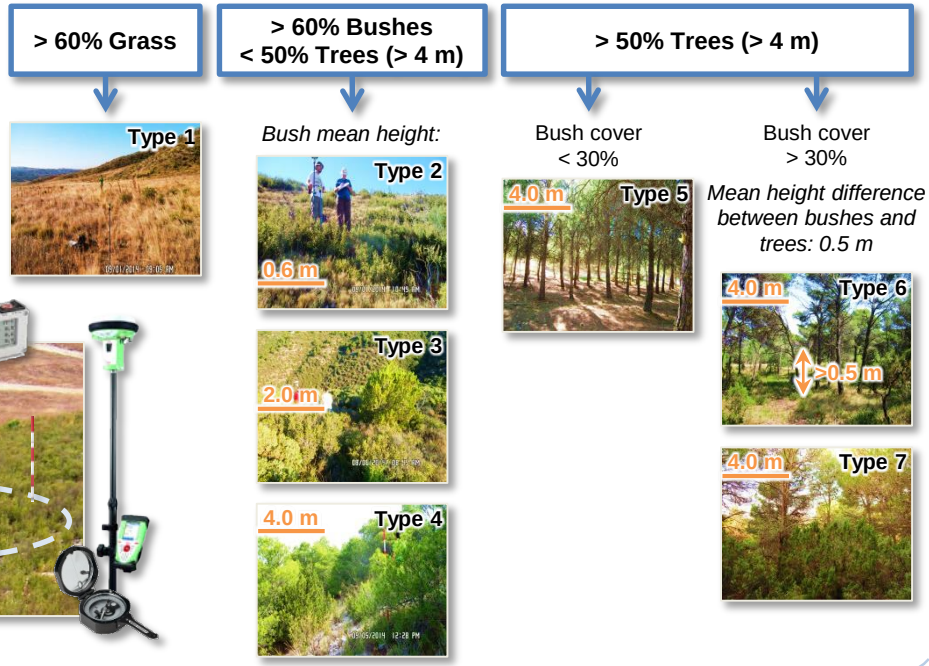


Stratified random sampling



FIELD DATA

Prometheus fuel types



REMOTE SENSING DATA

Imagery processing and derived layers from:

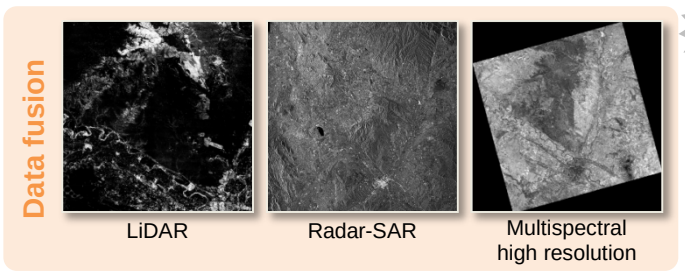
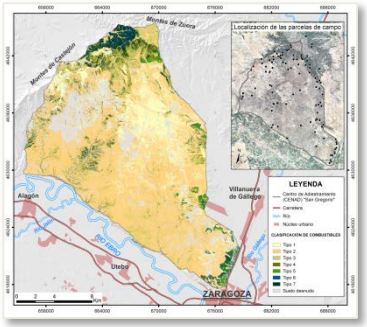
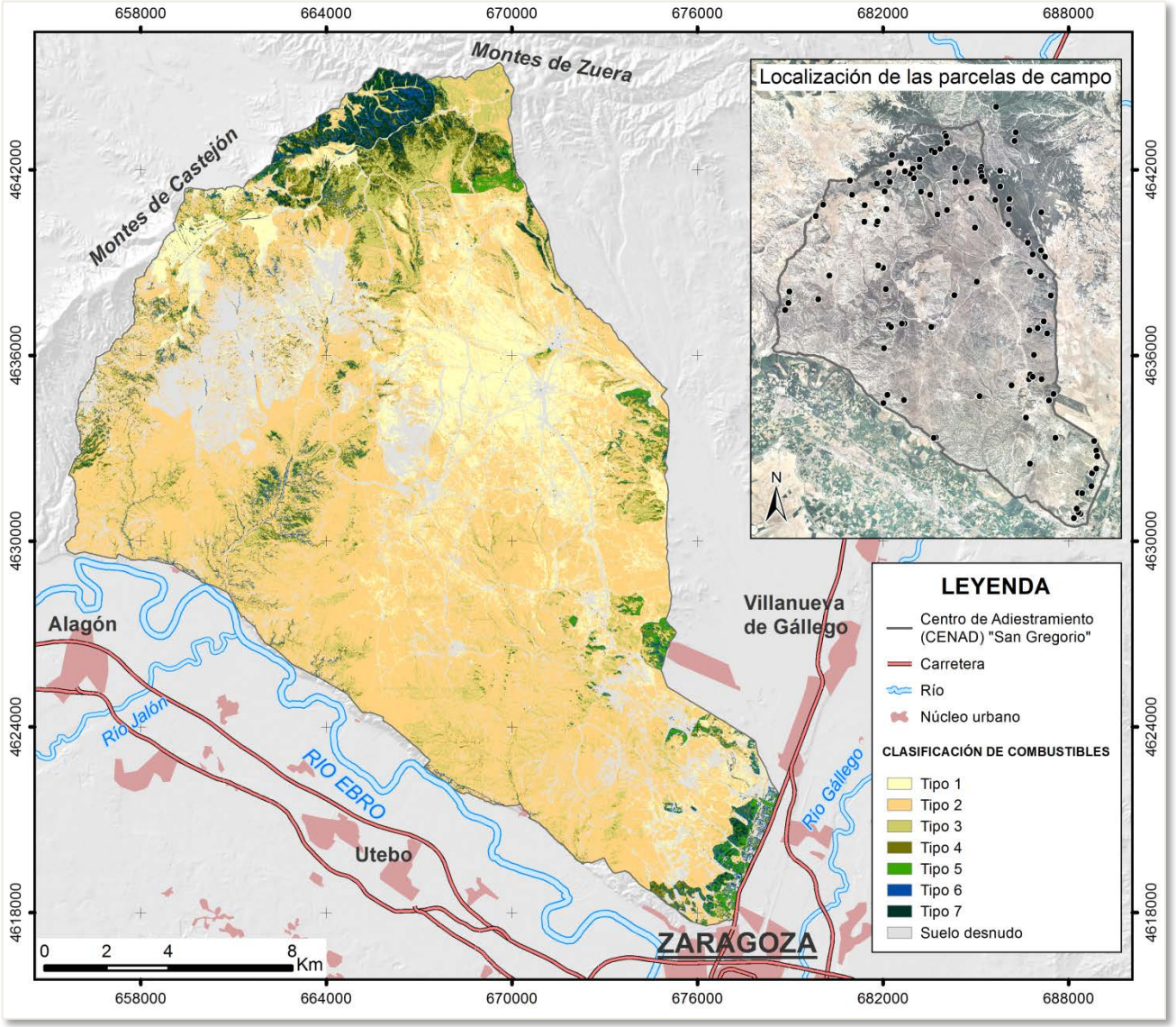


Image classification



LESSON #4

Mapping fuel types



Success rate: 72,7%

LESSON #5

Forest structural diversity

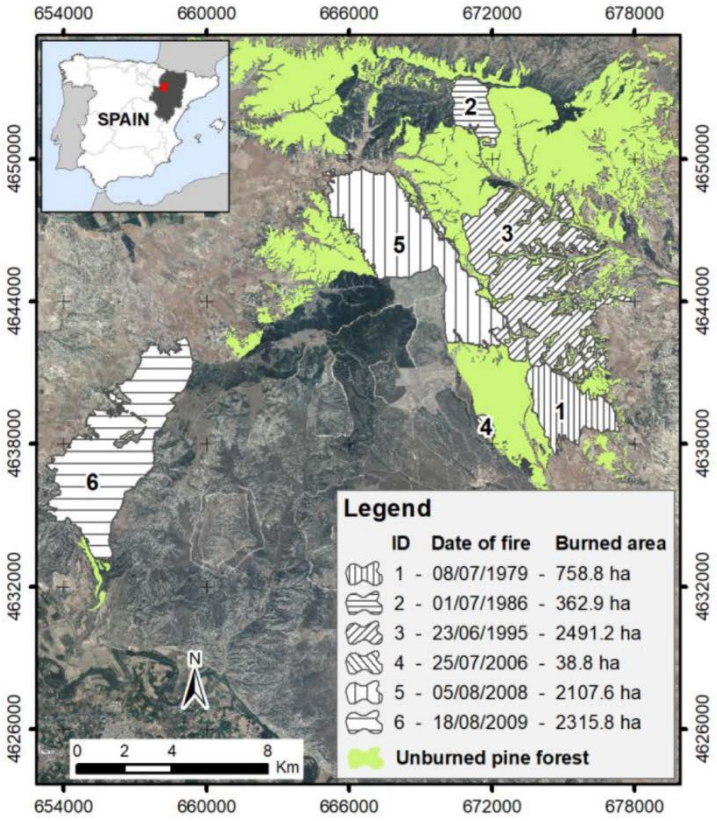


Fig. 1. Location map of the fires and the unburned area.

LiDAR-PNOA data second coverage (year 2016) 1 point/m²

DEM to normalize return heights

VERTICAL STRUCTURE VARIABLES
related to the distribution of laser returns

Height Percentiles

Height metrics

Height variability metrics

BIODIVERSITY INDICES
LHDI (LiDAR Height Diversity Index) and LHEI (LiDAR Height Evenness Index) based on laser return density

Density metrics

HORIZONTAL CONTINUITY VARIABLES
Standard deviation of previously derived raster layers

STATISTICAL ANALYSIS
Assess if there are significant differences between groups with the Kruskal-Wallis test

Group 1 (G1) each burned area vs. unburned area.
Group 2 (G2) old burned areas (1979, 86 and 95) vs. unburned area.
Group 3 (G3) recent burned areas (2006, 08 and 09) vs. unburned area
Group 4 (G4) unburned area vs. burned area.
Group 5 (G5) old burned areas vs. recent burned areas.

LESSON #5

Forest structural diversity

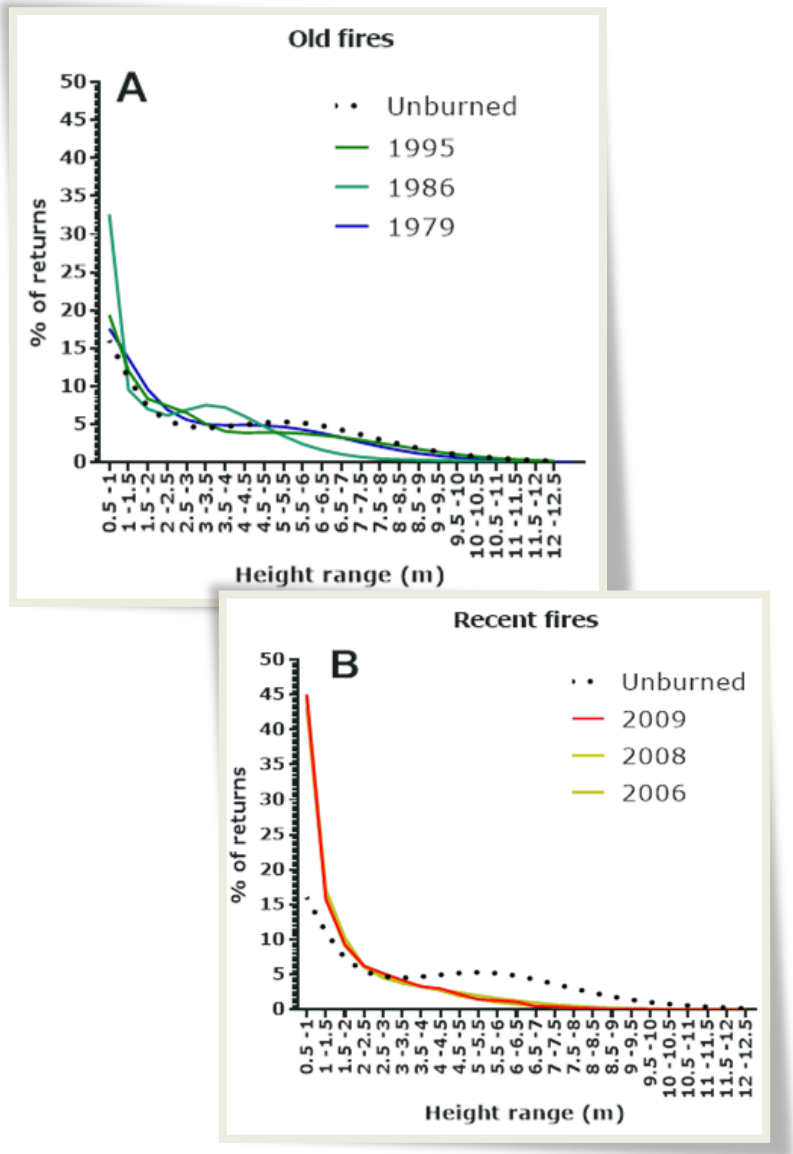
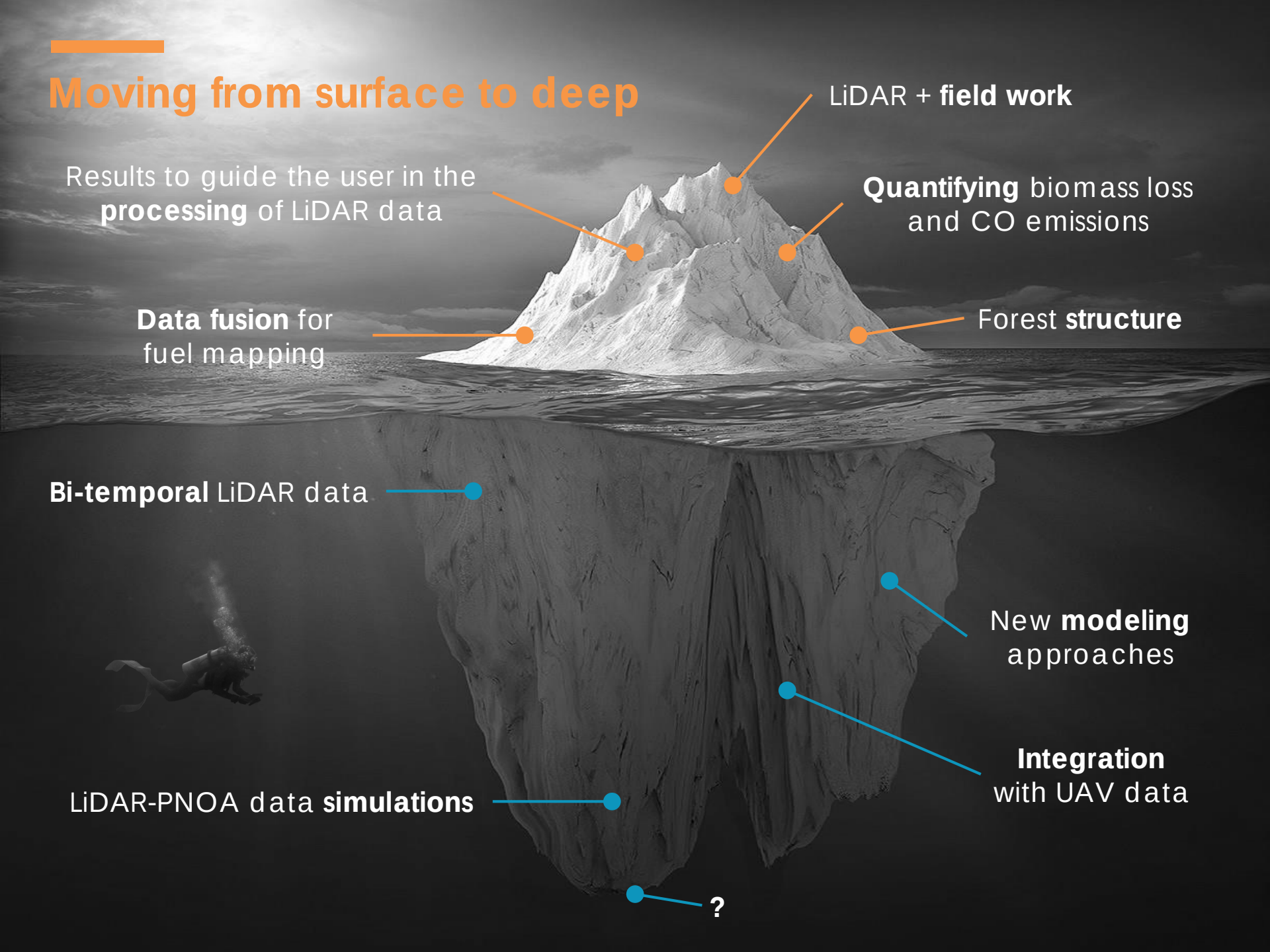


Table 2. Selection of the structural diversity metrics with the highest Chi-squared values for each group.

Group	Variable	Chi-squared
G1	Standard deviation	623,544.4
	P99	622,029.8
	P95	619,492.3
G2	Mean height (Standar deviation)	286,989.3
	P99	277,952.2
	P95	276,707.4
G3	LHDI	7,818.1
	Canopy cover	7,440.9
	LHEI	7,284.8
G4	Mean height (Standard deviation)	575,901.7
	Standard deviation	553,019.2
	P99	547,322.9
G5	Canopy cover	2,637.5
	LHEI	2,580.2
	Canopy relief ratio	2,426.6

Moving from surface to deep



Thanks!

Any questions?

You can find us at
http://geoforest.unizar.es/

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