# Forestry applications using LiDAR

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Soil orders in Catalonia

Forest presence

15%

30%

41%

8%

6%

56% Forest

Woodland
Scrubland
Crop
Urban area
Other
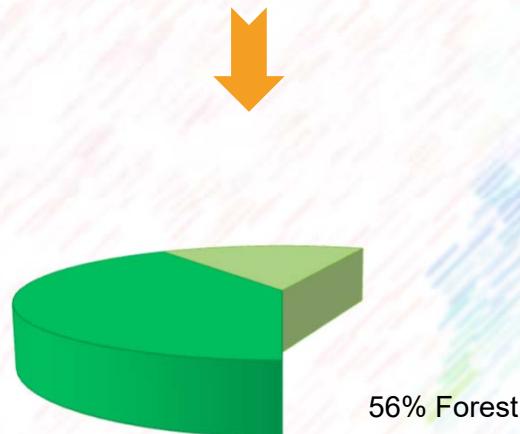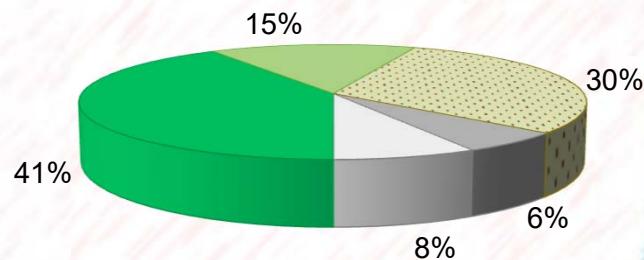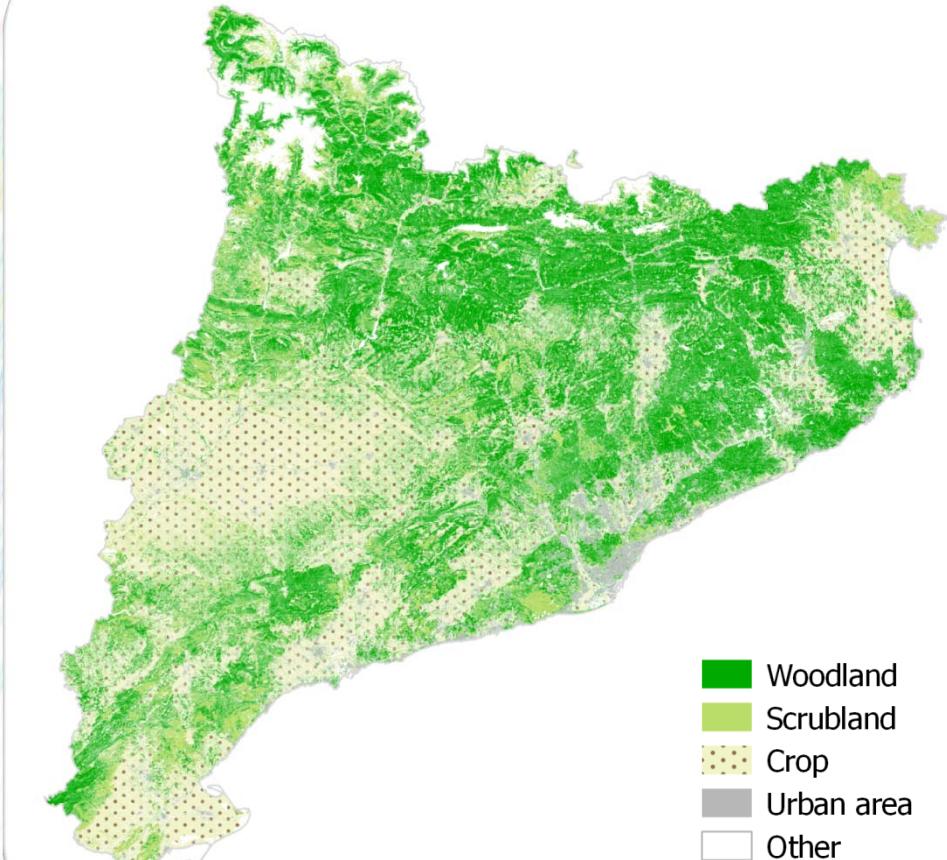
Source: **BIOLULIA**

Existing forestry maps

Forest land cover

SPANISH FOREST MAP: MFE50

Arbolado
Arbolado ralo
Arbolado disperso
Desarbolado
Cultivos
Artificial
Agua

MAPA FORESTAL DE ESPAÑA
Elaboración: Banco de Datos de la Biodiversidad
Mayo 2010

- Resolution: 1:50000

- Coverage: Spain

- Epoch represented: 1997-2006

- Distributor: MAGRAMA. Ministry of Agriculture, food and environment.
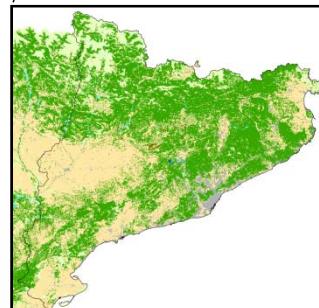
LAND COVER MAP OF CATALONIA: MCSC
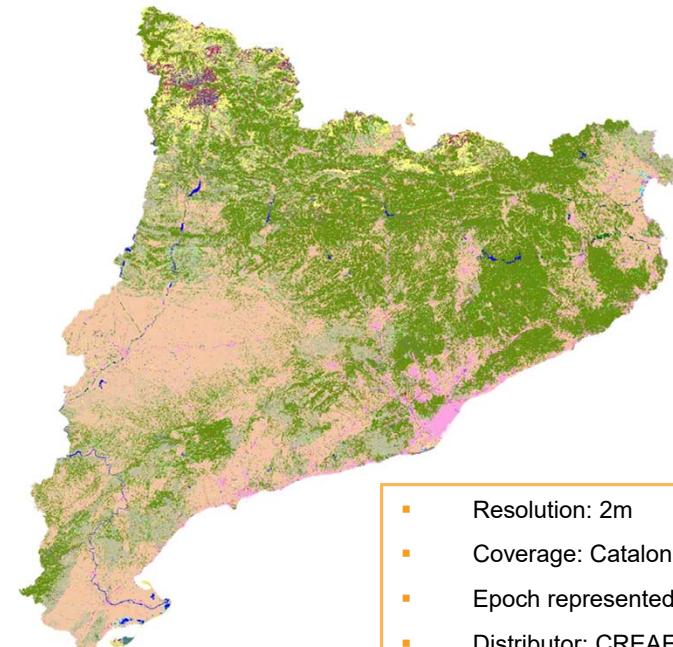
- Resolution: 2m

- Coverage: Catalonia

- Epoch represented: 2009

- Distributor: CREAF, Ecological and Forestry Applications Research Centre

OTHER LAND COVER MAPS:

- CTFC: Map of Pure and mixed forest formations of Catalonia

Existing forestry maps

Forest structure

National forest inventory: IFN3 (2000-2001)

Other forest inventories

Applications:

Total aerial carbon

0 (t/ha)
1-10 (t/ha)
10-20 (t/ha)
20-30 (t/ha)
30-40 (t/ha)
40-50 (t/ha)
50-60 (t/ha)
60-70 (t/ha)
>=70 (t/ha)

Source: SIBosC

% Trees in Catalonia

% DE ÁRBOLES EN CATALUNYA
0-1   1-2   2-3   3-4   4-5   5-6   6-7   7-8
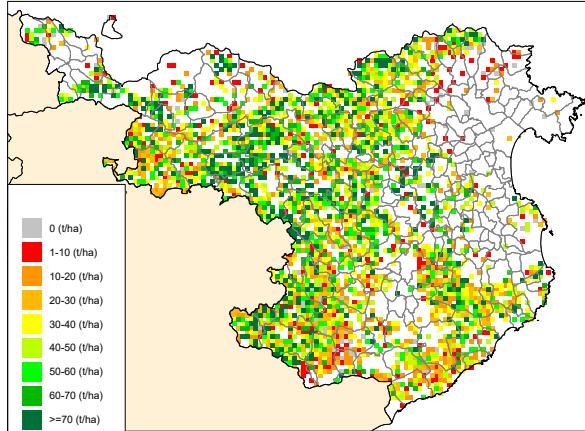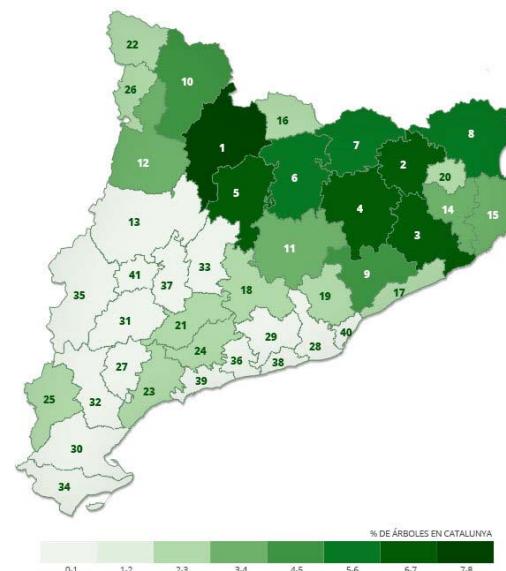
Source: Vangdata

Bark volume growth
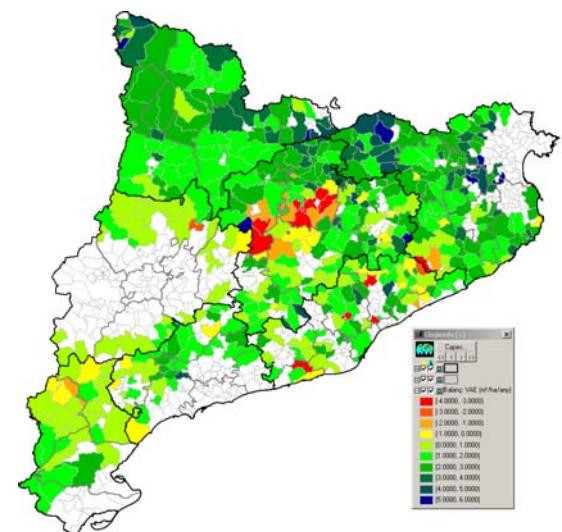
Source: SIBosC

ICGC. Cartography of Catalonia

Existing cartography

- Topographic maps:
  - From 1:5000 to 1:50000 over Catalonia
  - 1:1000 in urban areas

- Ortophotos:
  - 25cm, 50cm, 2.5m over Catalonia
  - 10cm on the coast

- Geological cartography

- Digital Terrain Models

LiDAR Forestry maps

High resolution forestry maps: mvba20m

NEW

Maps of biophysical variables of the woodland

Total Aerial Carbon

CAT (t/ha)
- 0
- <= 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 80
- 80 - 100
- 100 - 150
- 150 - 200
- > 200

erial Biomass

BAT (t/ha)
- 0
- < 20
- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 100
- 100 - 120
- 120 - 160
- 160 - 200
- 200 - 300
- 300 - 400
- > 400

Canopy Cover

FCC (%)
- 0
- < 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 100
- 100 - 125
- 125 - 150
- > 150

Bark volume

VAE (m3/ha)
- 0
- < 25
- 25 - 50
- 50 - 75
- 75 - 100
- 100 - 125
- 125 - 150
- 150 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- > 500

Basal Area

AB (m2/ha)
- 0
- < 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 40
- 40 - 50
- 50 - 75
- 75 - 100
- > 100

Breast Height

DBH (cm)
- <= 7.5
- 7.5 - 10
- 10 - 12.5
- 12.5 - 15
- 15 - 17.5
- 17.5 - 20
- 20 - 22.5
- 22.5 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- > 40

oliage Biomass

BF (t/ha)
- 0
- < 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- > 10

edium Height

Hm (m)
- < 3
- 3 - 5
- 5 - 7
- 7 - 9
- 9 - 11
- 11 - 13
- 13 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- > 30

LiDAR Forestry maps

High resolution forestry maps: mvba20m

LiDAR data

Land Cover Map
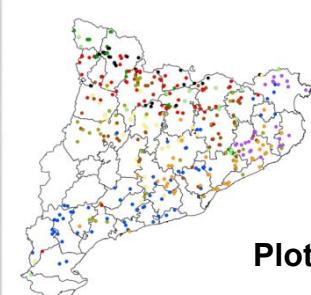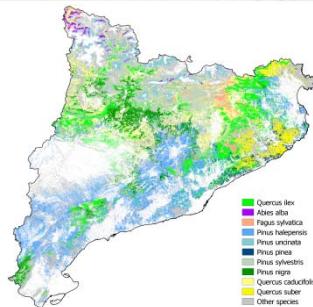
Plots of forest inventory

Cartography of Catalonia forest biophysical variables (mvba20m)

- Total aerial carbon (t C/ha)
- Total aerial biomass (t/ha)
- Bark volume (m3/ha)
- Basal area (m2/ha)
- Foliage biomass (t/ha)
- Diameter at breast height (cm)
- Forest canopy cover (%)
- Medium height (m)

LiDAR Forestry maps

High resolution forestry maps: mvba20m

Main characteristics:

- Resolution: 20m

- Coverage: Catalonia woodland

- Epoch represented: 2005

- Distribution:

  - WMS OGC service http://geoserveis.icc.cat/icgc_varbiofisiques_forest/wms/service?

  - Download as GeoTIFF format: http://www.icc.cat/vissir/ or http://www.icc.cat/appdownloads/index.html?c=dlfxmvba

More info: http://www.icgc.cat/Administracio-i-empresa/Descarregues/Capes-de-geoinformacio/Mapes-de-variables-biofisiques-de-l-arbrat-de-Catalunya

LiDAR Forestry maps

High resolution forestry maps: mvba20m

Comparison of different variables in La Garrotxa Volcanic Zone Natural Park

DBH (cm)	
	<= 7.5
	7.5 - 10
	10 - 12.5
	12.5 - 15
	15 - 17.5
	17.5 - 20
	20 - 22.5
	22.5 - 25
	25 - 30
	30 - 35
	35 - 40
	> 40

BAT (t/ha)	
	0
	< 20
	20 - 40
	40 - 60
	60 - 80
	80 - 100
	100 - 120
	120 - 160
	160 - 200
	200 - 300
	300 - 400
	> 400

Hm (m)	
	< 3
	3 - 5
	5 - 7
	7 - 9
	9 - 11
	11 - 13
	13 - 15
	15 - 20
	20 - 25
	25 - 30
	> 30
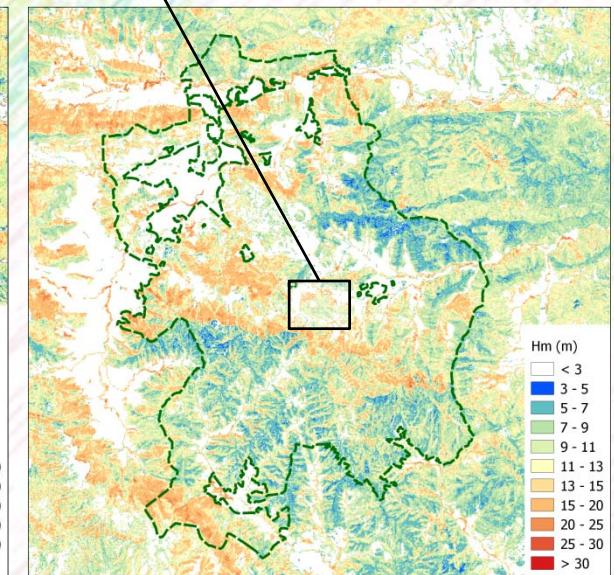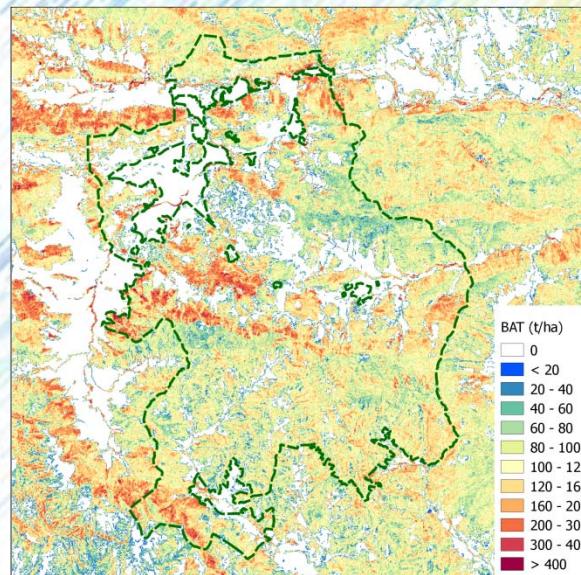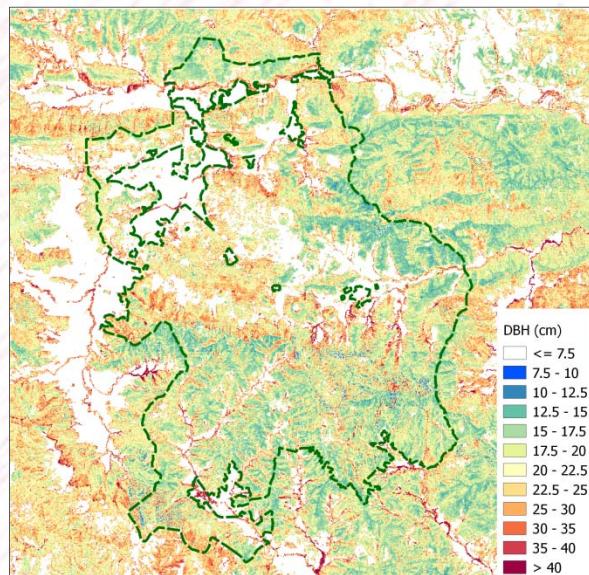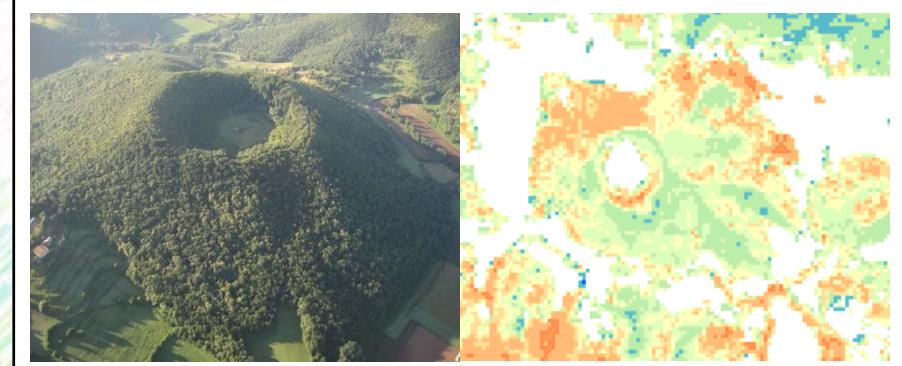
LiDAR Forestry maps

High resolution forestry maps: mvba20m

Resolution 2500 larger than the traditional forest inventories

Total Aerial Carbon (t C/ha)

Before 2016
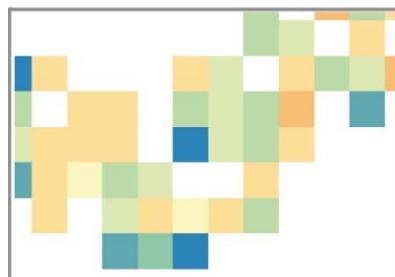
Nowadays

Resolution: 1000x1000m
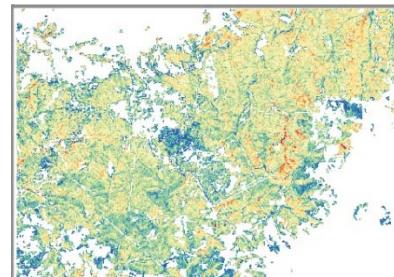
Resolution: 20x20m

Source: CREAF

LiDAR Forestry maps

Workflow

Initial data	→	LiDAR metrics	→	Model adjustment	→	Product Generation

LiDAR data

Land cover map

Forest inventory

LiDAR point cloud statistics

Forest inventory

Land cover map

LiDAR point statistics

Statistic models

Cover maps
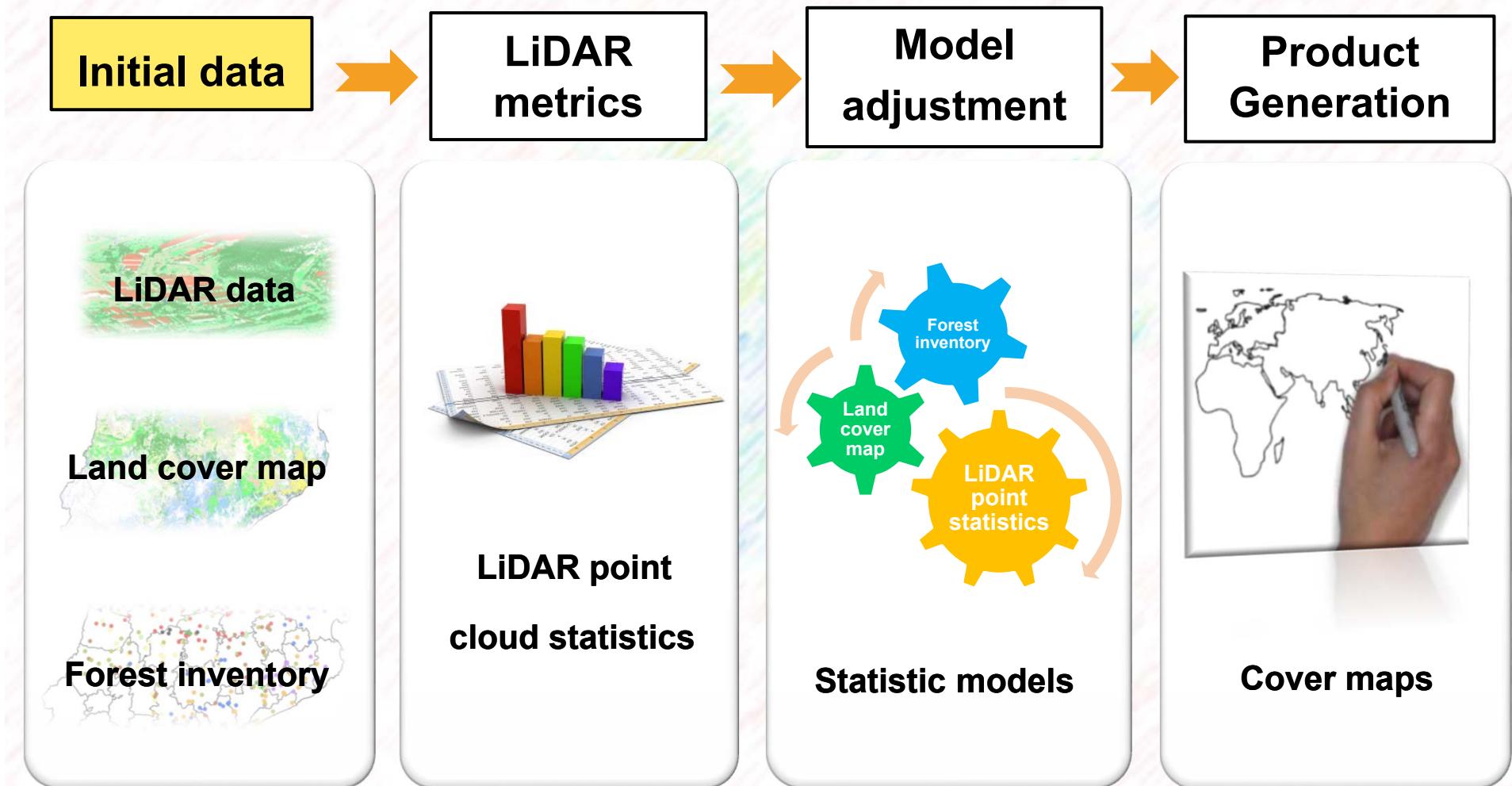
LiDAR Forestry maps

Workflow – Initial data

LiDARCAT

LiDAR data capture

- Flight dates: 2008 - 2011
- Sensor: ALS50 II Leica
- Point density: 0.5pt/m^2

LiDAR data processing

- Trajectory calculation
- Sensor calibration
- Point cloud generation
- Point cloud QC
- Strip adjustment
- Adjustment QC
- Automatic classification
- Editing (Manual classification)
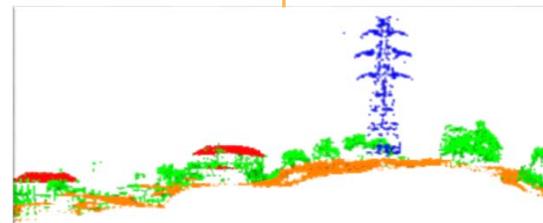
LiDAR data distribution

- Format: LAS & LAZ 1.2
- Classes: Ground, vegetation, building, towers, wires, noise, low points, air points
- Download: http://www.icgc.cat/en/Public-Administration-and-Enterprises/Downloads/Elevation/Dades-lidar2
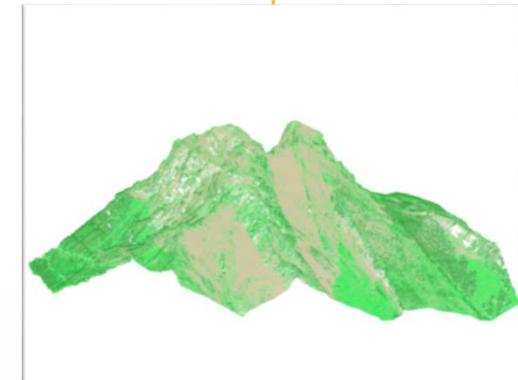
LiDAR Forestry maps

Workflow – Initial data

Land Cover Map of Catalonia

- Resolution: 2m
- Epoch represented: 2009
- Coverage: Catalonia
- Distributor: CREAF, Ecological and Forestry Applications Research Centre
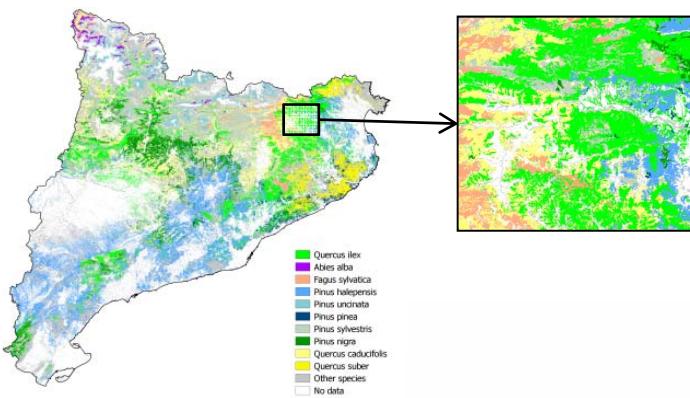
Plots of forest inventory

- IFN3, 3rd National Forest Inventory (2000-2001)
- CREAF forest inventories (2004, 2007, 2008, 2010, 2011)

Quercus ilex
Abies alba
Fagus sylvatica
Pinus halepensis
Pinus uncinata
Pinus pinea
Pinus sylvestris
Pinus nigra
Quercus caducifolis
Quercus suber
Other species
No data

LiDAR Forestry maps

Initial data ➤ **LiDAR metrics** ➤ **Model adjustment** ➤ **Product Generation**

LiDAR data

Land cover map

Forest inventory

LiDAR point

cloud statistics

Forest inventory

Land cover map

LiDAR point statistics

Statistic models

Cover maps
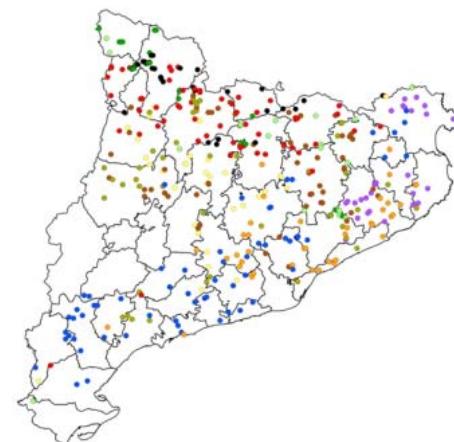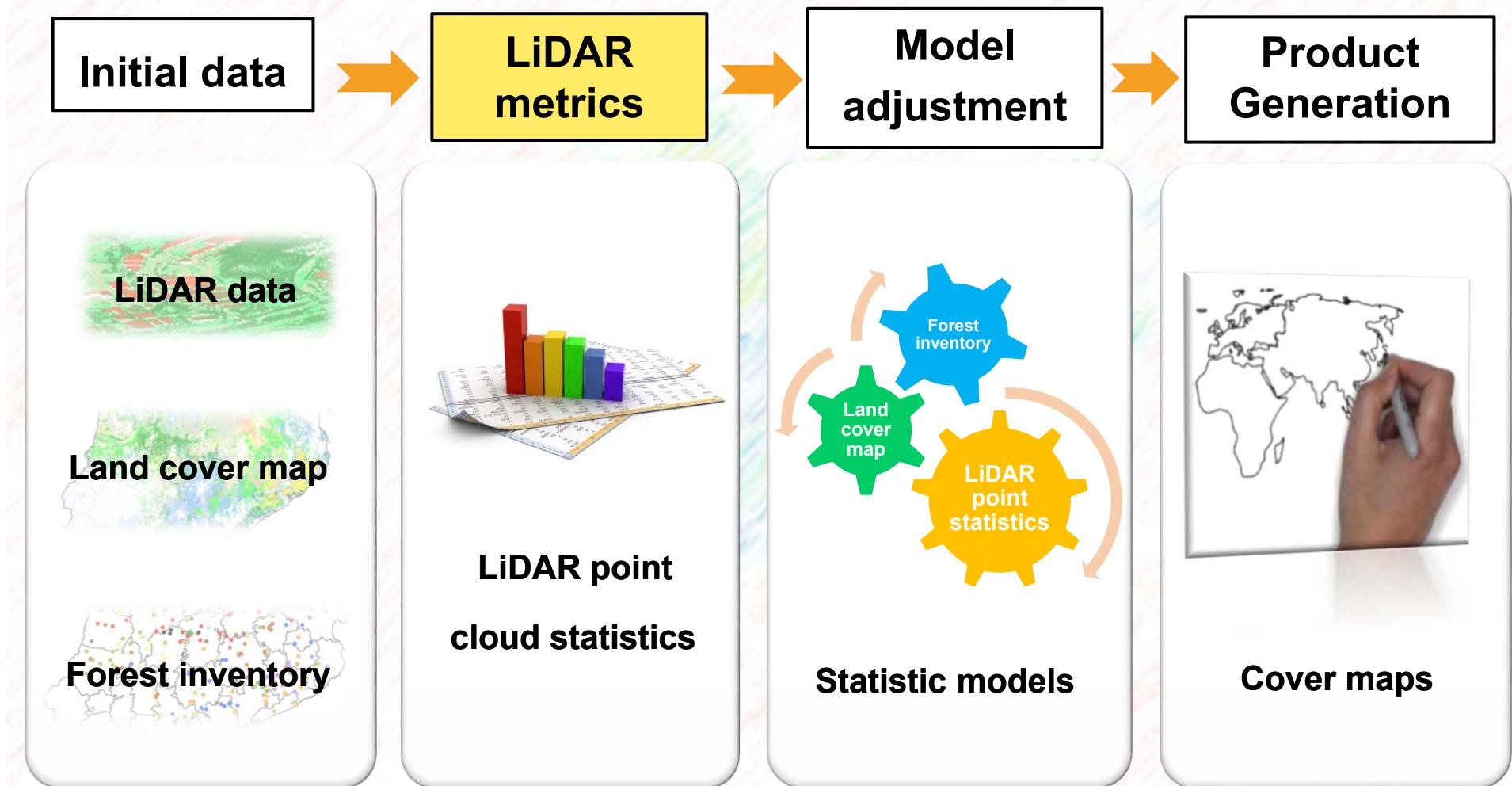
LiDAR Forestry Applications
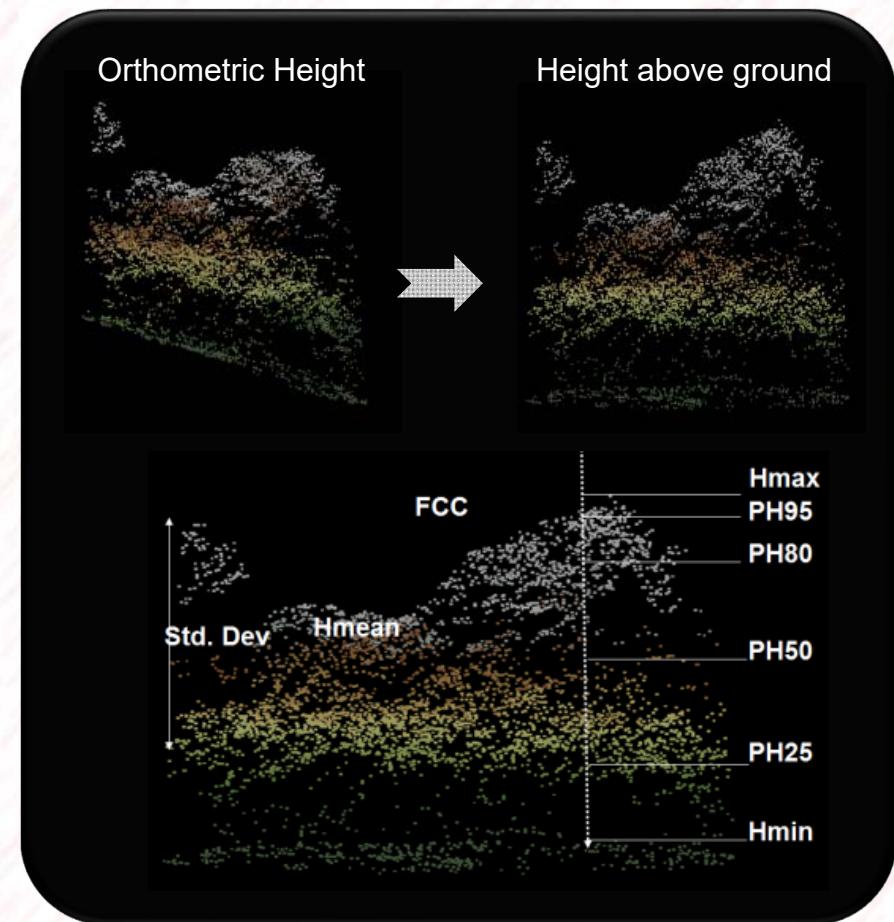
Workflow – LiDAR metrics

Orthometric Height

Height above ground

$$OH_{\text{all point cloud}} - OH_{\text{TIN terrain}} = H_{\text{above ground}}$$

From 3m

FCC

Hmax
PH95
PH80

Std. Dev   Hmean

PH50

PH25

Hmin
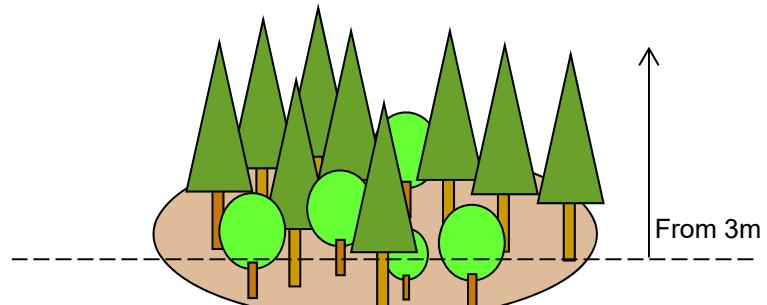
ID	X	Y	MAXZ	MINZ	NTOT	NVEG	NPTOT	NP3	NP4	NP5	P5	P10	P15	P20	P25	P35	P50
2659342	373415	4631375	3.24	0.22	30	12	30	3	7	2	22	29	29	44	44	68	78
2659343	373425	4631375	2.37	0.24	30	9	30	3	4	2	24	24	43	43	49	55	61
2659344	373435	4631375	4.27	0.26	32	22	32	3	6	13	28	42	68	91	95	121	228
2659345	373445	4631375	3.95	0.3	37	26	37	2	8	16	44	51	71	92	96	146	173
2659346	373455	4631375	4.9	0.24	33	28	33	1	4	23	62	65	85	152	168	205	233
2659347	373465	4631375	5.18	0.28	33	27	33	1	5	21	51	58	95	125	154	208	272
2659348	373475	4631375	3.8	0.18	32	16	32	2	6	8	18	23	52	66	66	84	149
2659349	373485	4631375	3.9	0.34	37	11	37	2	4	5	34	49	49	53	53	91	133
2659350	373495	4631375	3.34	0.21	35	14	35	7	2	5	21	21	22	22	25	26	34
2659351	373505	4631375	4.03	0.46	31	7	31	1	1	5	46	46	135	135	135	164	228
2659352	373515	4631375	1.47	0.21	33	4	33	3	1	0	21	21	21	21	21	22	22
2659353	373525	4631375	0.98	0.2	35	4	35	3	1	0	20	20	20	20	20	26	26
2657736	373355	4631385	1.24	0.28	37	11	37	4	7	0	28	37	37	41	41	44	58
2657737	373365	4631385	2.13	0.3	39	10	39	4	4	2	30	30	33	33	33	45	55
2657738	373375	4631385	3.02	0.31	38	17	38	8	7	2	31	33	34	36	36	36	63
2657739	373385	4631385	1.14	0.21	36	13	36	8	5	0	21	29	29	30	31	31	37
2657740	373395	4631385	1	0.22	38	13	38	8	5	0	22	26	26	28	33	34	42
2657741	373405	4631385	1.14	0.25	33	10	33	4	6	0	25	25	27	27	28	33	50
2657742	373415	4631385	2.17	0.42	36	8	36	2	4	2	42	42	47	47	47	54	66
2657743	373425	4631385	3.63	0.2	34	13	34	4	5	4	20	31	31	33	49	61	101
2657744	373435	4631385	2.02	0.27	33	11	33	7	0	4	27	35	35	36	36	44	48
2657745	373445	4631385	3.77	0.25	38	13	38	3	6	4	25	30	30	41	67	81	107

LiDAR Forestry maps

Initial data → **LiDAR metrics** → **Model adjustment** → **Product Generation**

LiDAR data

Land cover map

Forest inventory

LiDAR point

cloud statistics

Forest inventory

Land cover map
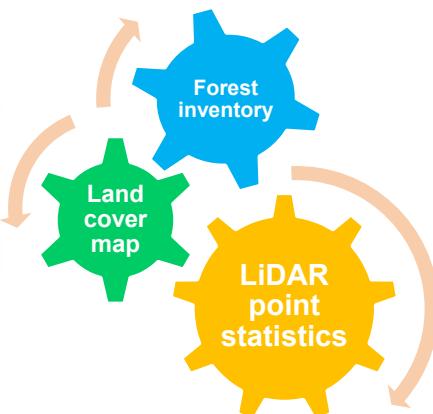
LiDAR point statistics

Statistic models

Cover maps

LiDAR Forestry Applications

Workflow – Model adjustment

CREAF

LiDAR explanatory variables

    Hmean, Hmax, percentiles,

    Num Points, Elev Skewness,

    FCC, Diff years, etc.

Plots of forest inventories

List of main species

Model adjustment

    Stepwise regression

Statistical model for each specie and a general model

Model validation

$$CAT = e^{(intercept+CoefEspecie+Coeff_{P80}*P80+Coeff_{lnFCC}*lnFCC-Coeff_{SKEW}*SKEWN+Coeff_{Dif\ anys}*Dif\_Anys)}$$

LiDAR Forestry maps

Initial data ➜ **LiDAR metrics** ➜ **Model adjustment** ➜ **Product Generation**

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LiDAR point cloud statistics

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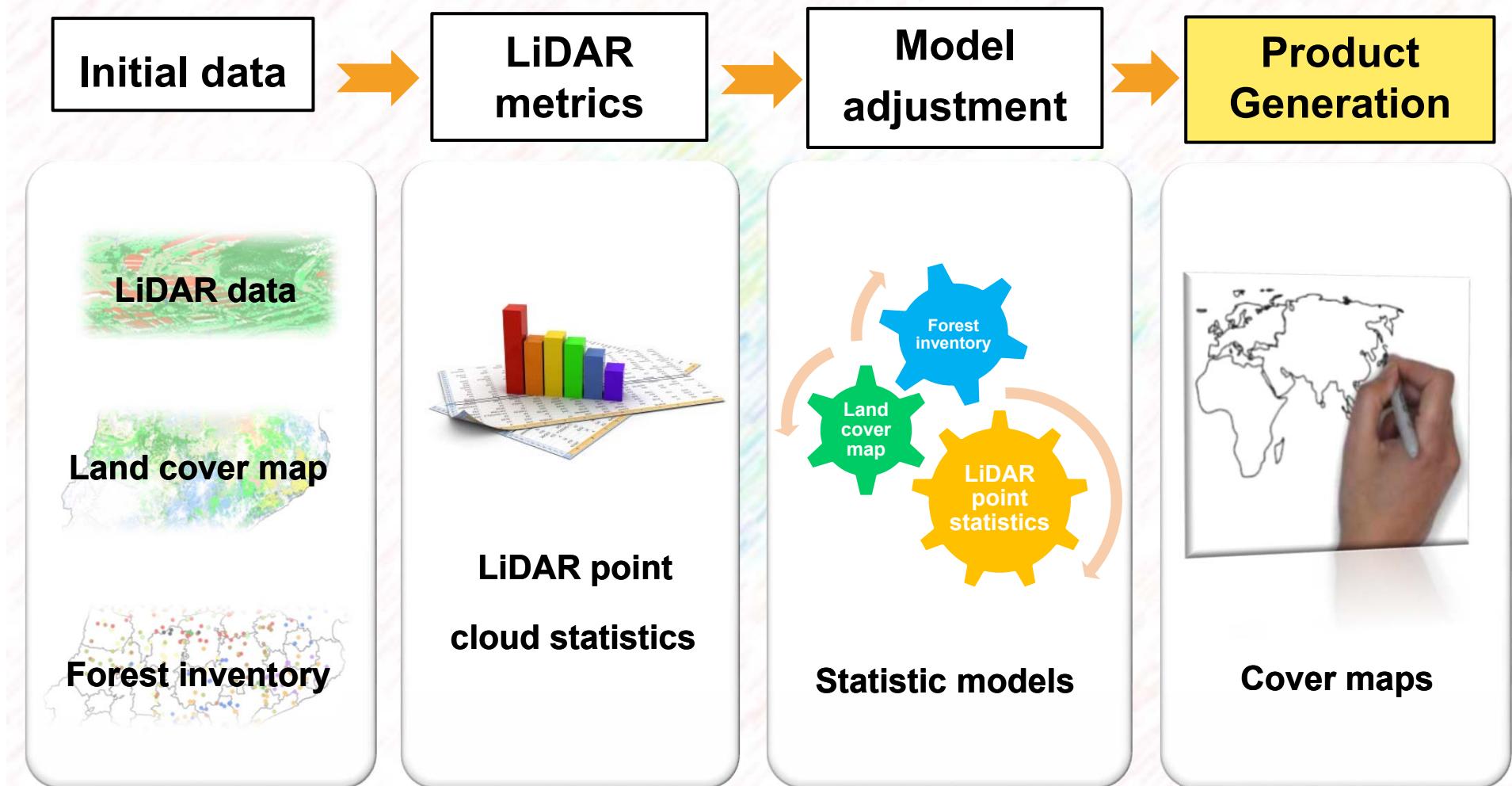
LiDAR Forestry maps

Workflow – Product generation

The model is applied to each 20x20m pixel

$$CAT = e^{(intercept+CoefEspecie+Coeff_{P80}-Coeff_{SKEW}*SKEWN)}$$

Statistical model

Land cover map

LiDAR data

CAT (t/ha)
- 0
- <= 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 80
- 80 - 100
- 100 - 150
- 150 - 200
- > 200

Total Aerial Carbon

LiDAR Forestry Applications
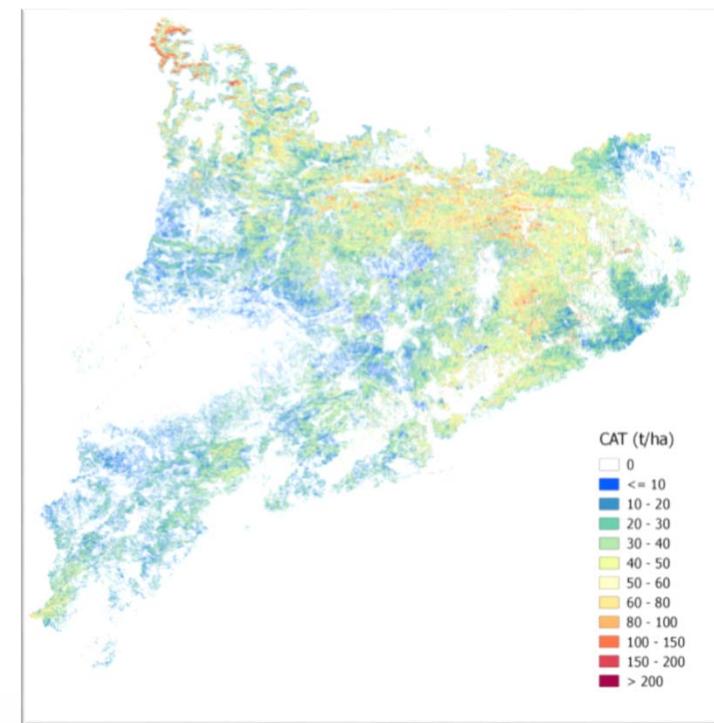
Mbva20 - Applications

- Forest resources management planning

- Management/planning of estates or protected areas (Natura 2000, ENPEs…)

- Location and characterisation of mature forests

- Forest inventories (with or without field support)
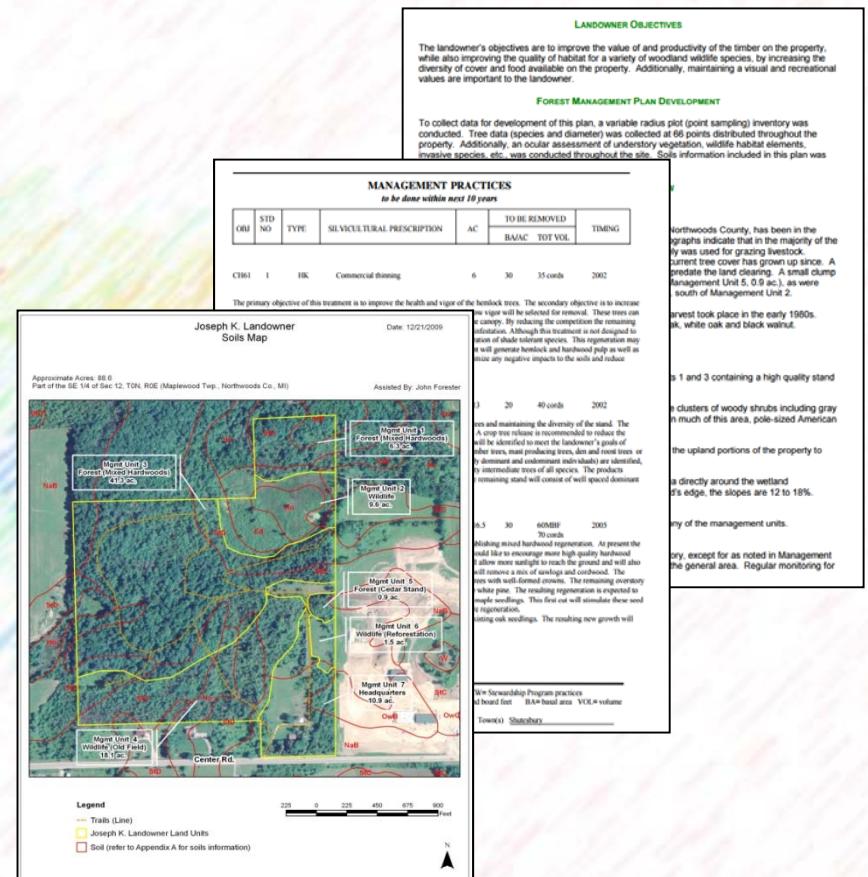
LiDAR Forestry Challenges

Challenges

Challenges:

- Update mvba20 for the next decade (2015-2025)

  - LIDARCAT2. Flight dates: 2016

  - IFN4. Publication: by the end of 2016

- Maps of biophysical variables for the scrubland cover

  - Applications: Fire danger maps…

- Increase the amount of forestry products

- INSPIRE directives

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