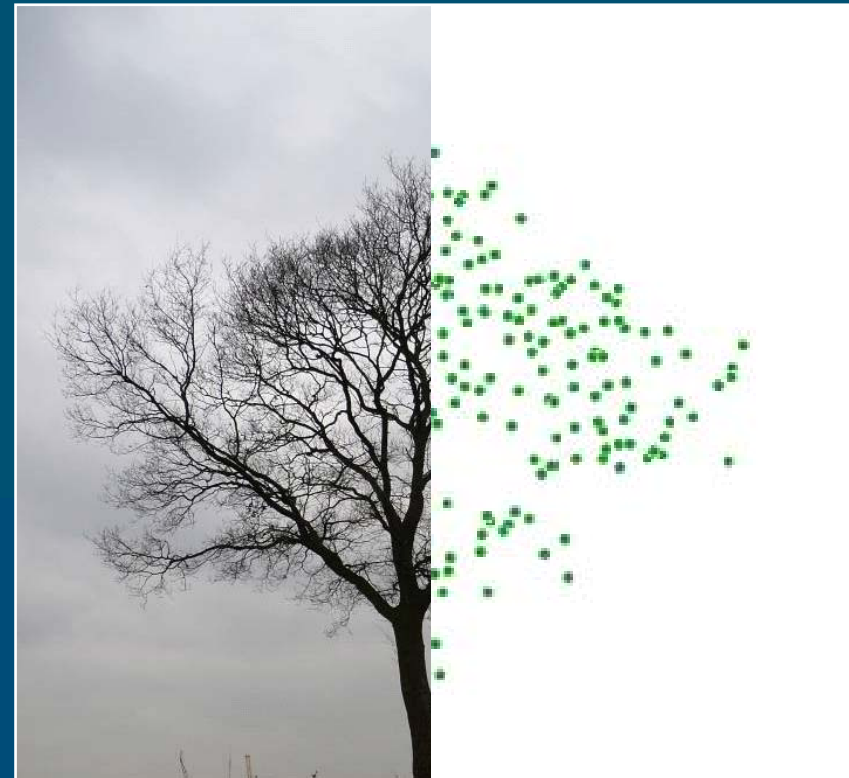


Use of LiDAR to map and monitor habitats

Mücher, Roupioz, Kramer & Bunce

European LiDAR Mapping Forum
World Forum, the Hague
30 November 2010



Objective

Can we use LiDAR data to map and monitor plant life forms and General Habitat Categories (GHC's) according to EBONE (Bunce et al. 2008) methodology ?

EBONE objective

- To consistently collect European habitat information from each country
- To provide consistent European statistics
- To support Natura 2000 monitoring
- To set-up a integrated European Biodiversity Observation Network



Support of European biodiversity policy

EBONE habitat field recording

- Stratified random samples of 1km²
- Mapping of areal, linear and point habitats.
- Estimation % plant life forms per mapping unit.
- **Life form**: vegetative form of a plant based on position growth point during adverse period.
- Vegetation structure central.
- Dominant species per lifeform.
- Provides good opportunities for integration with remote sensing.

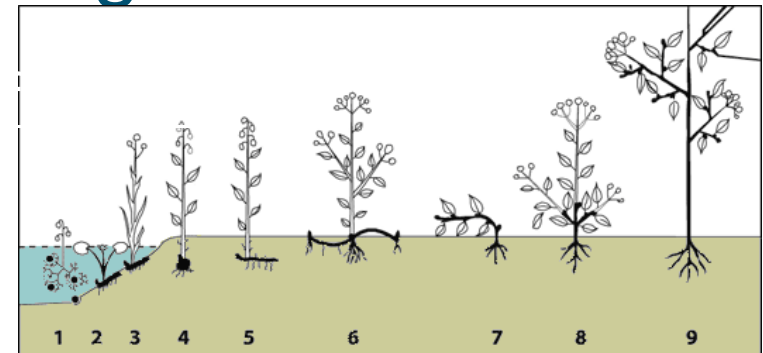


Diagram van de voornaamste levensvormen gebaseerd op de indeling volgens Raunkiaer (1934)

1 en 2	Hydrofyten	(Hydr.)	waterplanten
3	Helofyten	(Helo.)	winterknoppen onder water, bloeiende planten boven water
4 en 5	Cryptofyten of Geofyten	(Geof.)	winterknoppen onder de grond
6	Hemicryptofyten	(Hemi.)	winterknoppen op of iets onder de grond
7 en 8	Chamaefyten	(Cham.)	winterknoppen tot 50 cm boven de grond
9	Phanerofyten	(Phan.)	winterknoppen minstens 50 cm boven de grond (o.a. bomen, heesters en lianen)



Used environmental code:
 5.3 Neutral Moist.
 Used site code:
 1.05 Conventional chert claystone (e.g. sandstone)
 1.02 Brown soil
 2.00 Below 7% tree cover, but above 6 trees/ha
 Used management code:
 104 Active
 115 Growing (best)
 115 Growing (best)
 122 Growing (other exotic animals)
 130 woodland
 132 intensive crop (less than 10 seed spaces per 10 a2)
 148 ploughed
 407 400 to 400
 422 plantation surface species
 used species codes:
 508 wheat
 511 maize
 525 maize
 used codes of linear elements:
 608 irrigation

Areal Unit Recording Sheet

Survey name: Katoel-Dijle

Observer: Bob Duijn, Geert De Groot, Desiré Paolisse

Date: 24/05/2005

Code	Field 1	Field 2	Field 3	Field 4	Field 5	Field 6	Field 7	Field 8
General Habitat Category	Global environmental code	Site code	Local code	Life form	Species	Percentage	Regional Class	Phytosociology
A	105	102	102	102	102	102	102	102
B	105	102	102	102	102	102	102	102
C	105	102	102	102	102	102	102	102
D	105	102	102	102	102	102	102	102
E	105	102	102	102	102	102	102	102
F	105	102	102	102	102	102	102	102
G	105	102	102	102	102	102	102	102
H	105	102	102	102	102	102	102	102
I	105	102	102	102	102	102	102	102
J	105	102	102	102	102	102	102	102
K	105	102	102	102	102	102	102	102
L	105	102	102	102	102	102	102	102
M	105	102	102	102	102	102	102	102
N	105	102	102	102	102	102	102	102
O	105	102	102	102	102	102	102	102
P	105	102	102	102	102	102	102	102
Q	105	102	102	102	102	102	102	102
R	105	102	102	102	102	102	102	102
S	105	102	102	102	102	102	102	102
T	105	102	102	102	102	102	102	102
U	105	102	102	102	102	102	102	102
V	105	102	102	102	102	102	102	102
W	105	102	102	102	102	102	102	102
X	105	102	102	102	102	102	102	102
Y	105	102	102	102	102	102	102	102
Z	105	102	102	102	102	102	102	102

Life forms to record habitats (GHC's)

Herbaceous	HER	
1. Submerged hydrophytes	SHY	Plants that grow beneath the water.
2. Emergent hydrophytes	EHY	Plants that grow in aquatic conditions, mainly above water.
3. Helophytes	HEL	Plants that grow in waterlogged conditions.
4. Leafy hemi-cryptophytes	LHE	Broad leaved herbaceous species, sometimes termed forbs.
5. Caespitose hemi-cryptophytes	CHE	Perennial monocotyledonous grasses and sedges.
6. Therophytes	THE	Annual plants that survive the unfavorable season as seeds.
7. Succulent chamaephytes	SUC	Plants with succulent leaves.
8. Geophytes	GEO	Plants with buds below the soil surface.
9. Cryptogams	CRY	Bryophytes and lichens, including aquatic bryophytes,
10. Herbaceous chamaephytes	HCH	Plants with non-succulent leaves and non-shrubby form.
Shrubs and trees	TRS	
11. Dwarf chamaephytes	DCH	Dwarf shrubs: below 0.05 m
12. Shrubby chamaephytes	SCH	Under shrubs: 0.05-0.3 m
13. Low phanerophytes	LPH	Low shrubs buds: 0.30-0.6 m.
14. Mid phanerophytes	MPH	Mid shrubs buds: 0.6-2.0 m
15. Tall phanerophytes	TPH	Tall shrubs buds: 2.0-5.0 m
16. Forest phanerophytes	FPH	Trees: over 5.0 m
Leaf retention divisions (to be used in conjunction with TRS)		
Winter deciduous	DEC	
Evergreen	EVR	
Coniferous	CON	
Etc.		

Strict height def.

Combinations → > 130 GHC's !

Cabo de Gata – Half-Desert in Almeria (SP)

Bare ground (TER)

C

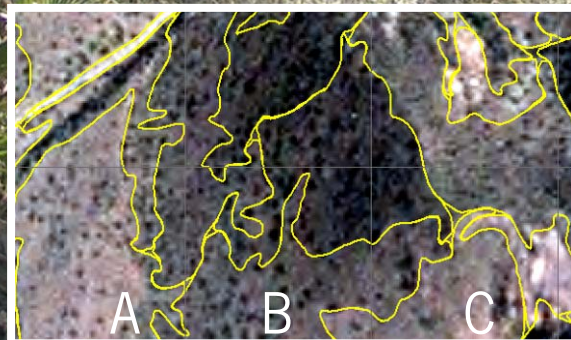
B

Mid Phanerophytes (MPH)

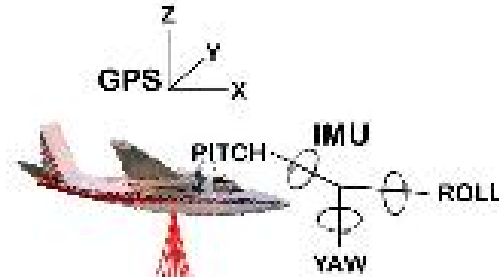
Dwarf Palms (*Chamaerops humilis*)
(0.6 – 2.0 m)

Caespitose hemicriptophytes (CHE)

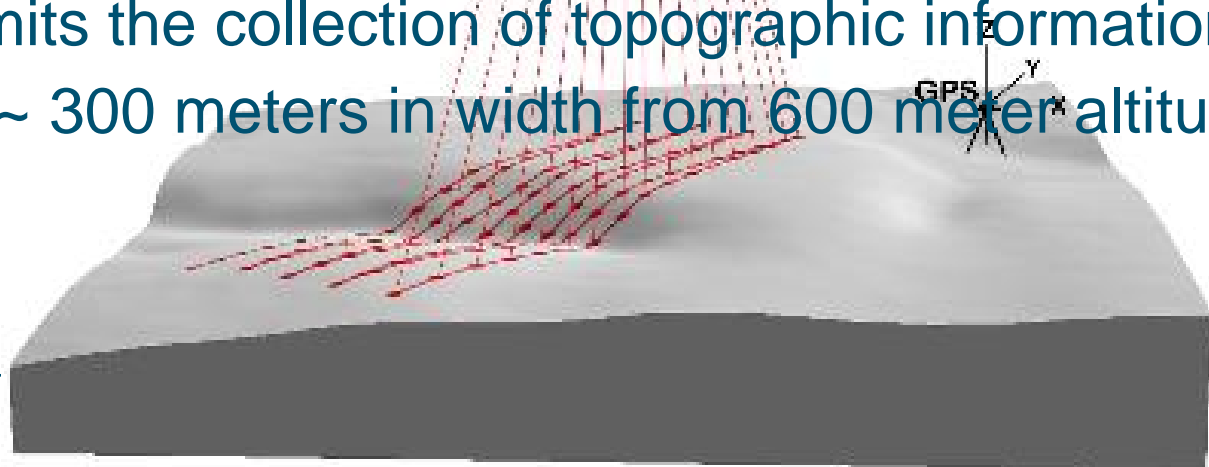
Stipa tenuissima (grasses)



LiDAR



- **LiDAR (Light Detection And Ranging)** is a remote sensing system used to collect topographic data.
- A lidar uses a laser (**emitter**) to send a pulse of light to an object and a telescope (**receiver**) to measure the intensity scattered back (backscattered) to the lidar.
- Aircraft permits the collection of topographic information over a strip ~ 300 meters in width from 600 meter altitude.



LiDAR – NL

■ **AHN-1:** Actual terrain model of the Netherlands.

Very accurate based on LiDAR Completed in 2003

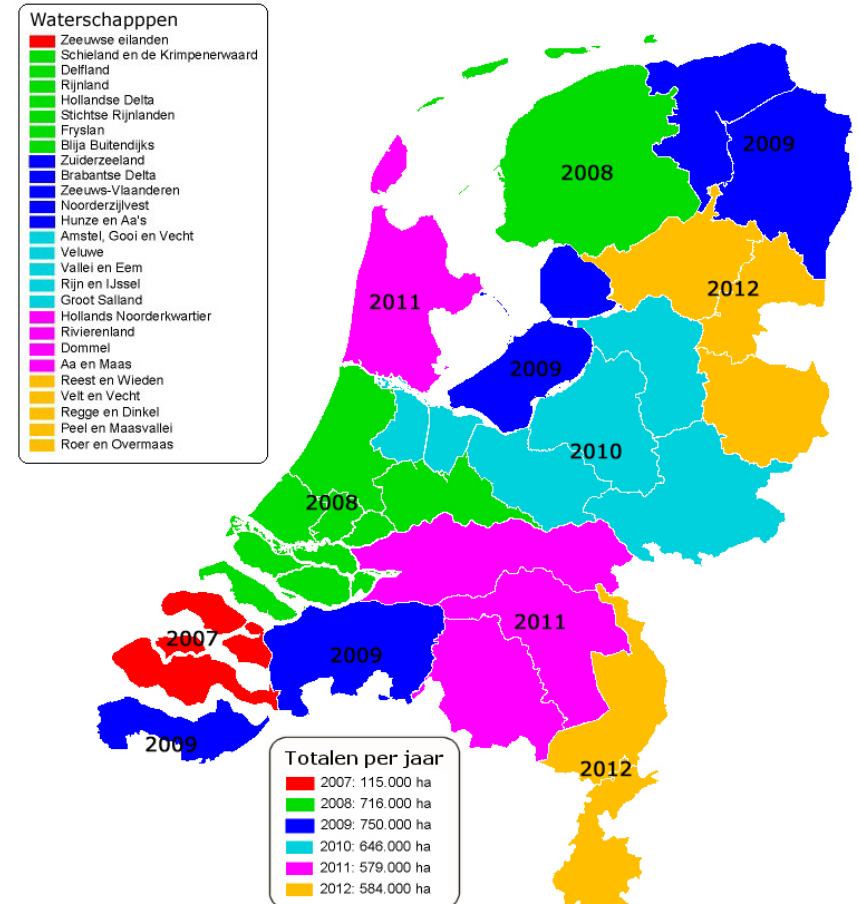
- Precision: 15 centimeters
- 1 point per m² (or 1 p / 16m²)

■ **AHN-2:** more accurate

- Precision: 5 centimeters
- 10 points / m²
- Complete coverage in 2012
- Costs ~ €0,30 / ha

■ Update is planned every 5 years (subscription waterboards)

Planning AHN-2 per juli 2009
actualisatieschema 2007-2012



Study area Chaam (Noord-Brabant)

- Acquired by FUGRO in early March 2009
- Spatial resolution: 10 points/m²
- Three scan angles (nadir, forward, backward 30°)
- Multiple returns, intensity, RGB colours
- Classified into ground points & non-ground points

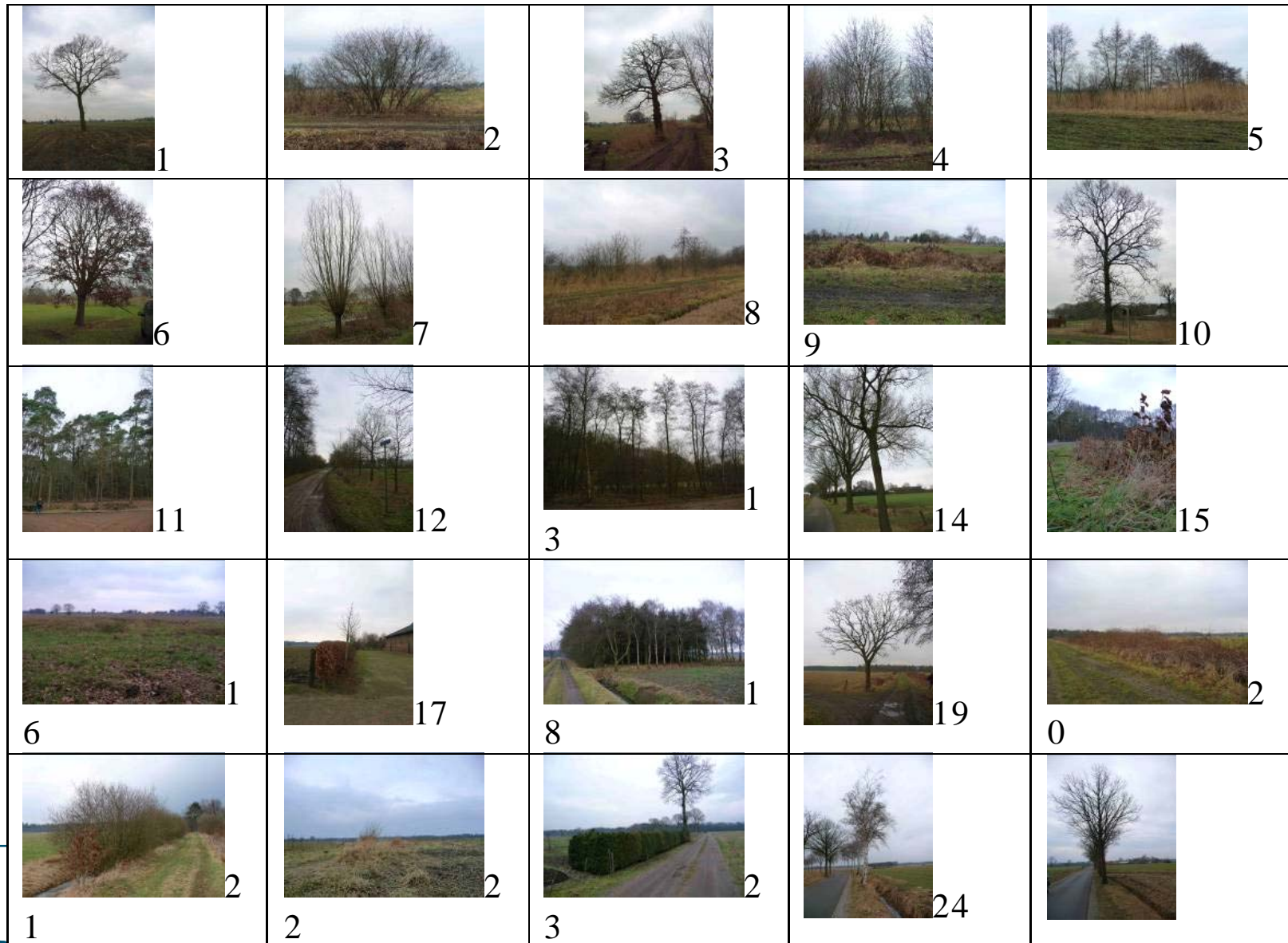
Study area Chaam (3 by 3km)



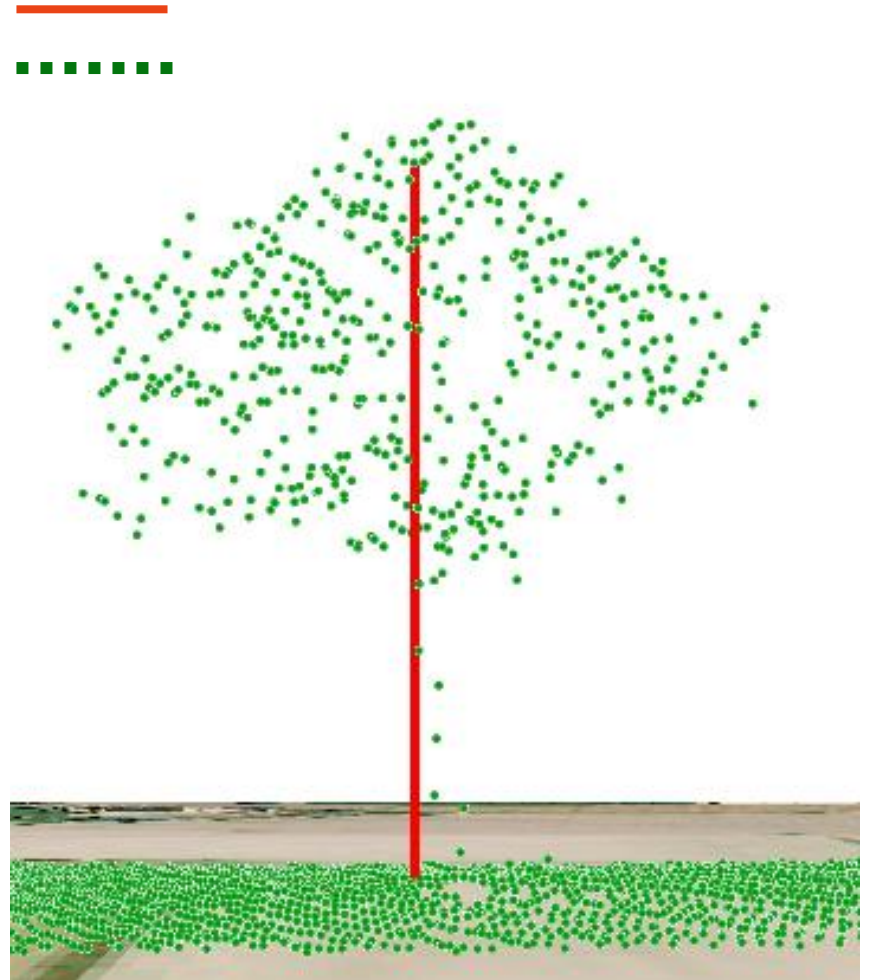
Objects of interest

- 01 Single tree
- 02 Hedge row
- 03 Solitary tree
- 04 Hedge row
- 05 Fringe of reed
- 06 Solitary tree
- 07 Row of willows
- 08 Bushes of blackberry and reed
- 09 Blackberry low vegetation
- 10 Solitary tree
- 11 Forest with pines and birch
- 12 Double line of Oak trees
- 13 Line of trees and bushes
- 14 Oak trees in line
- 15 Rough wood at water fringe
- 16 Pitrus in ditch
- 17 Hedge with hornbeam
- 18 Con. forest with edge of dec. trees
- 19 Solitary tree
- 20 Blackberry, low vegetation
- 21 Hedgerow
- 22 Rough field
- 23 Hedge with conifers
- 24_Row with birch trees
- 25 Oak trees in line
- Tree nursery

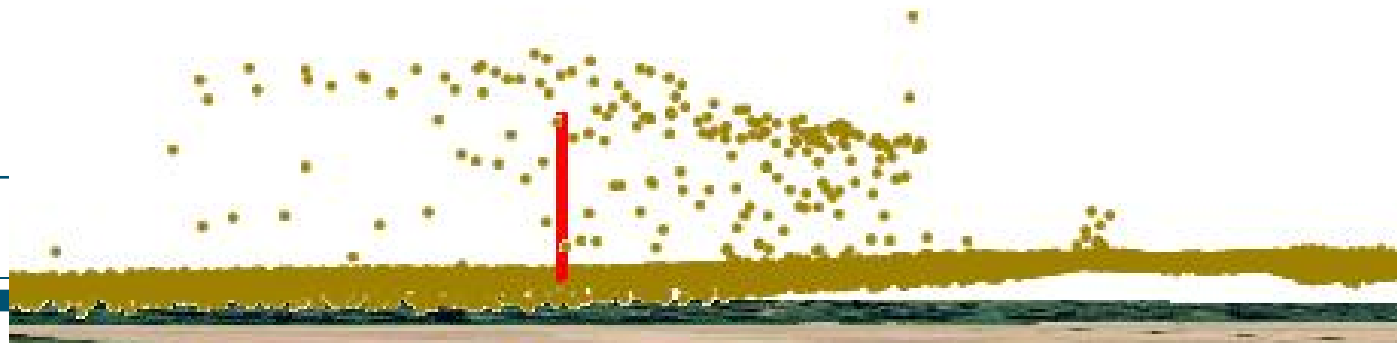
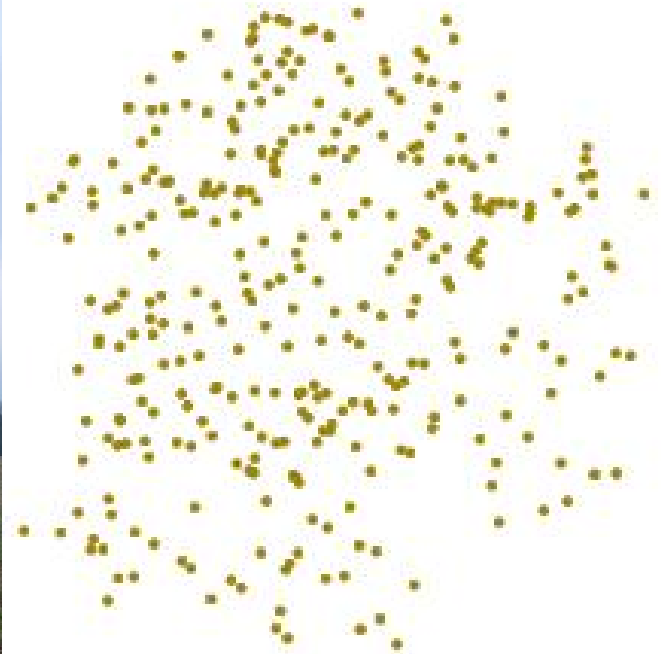
Plant life forms in study area Chaam



Object 1: Single tree

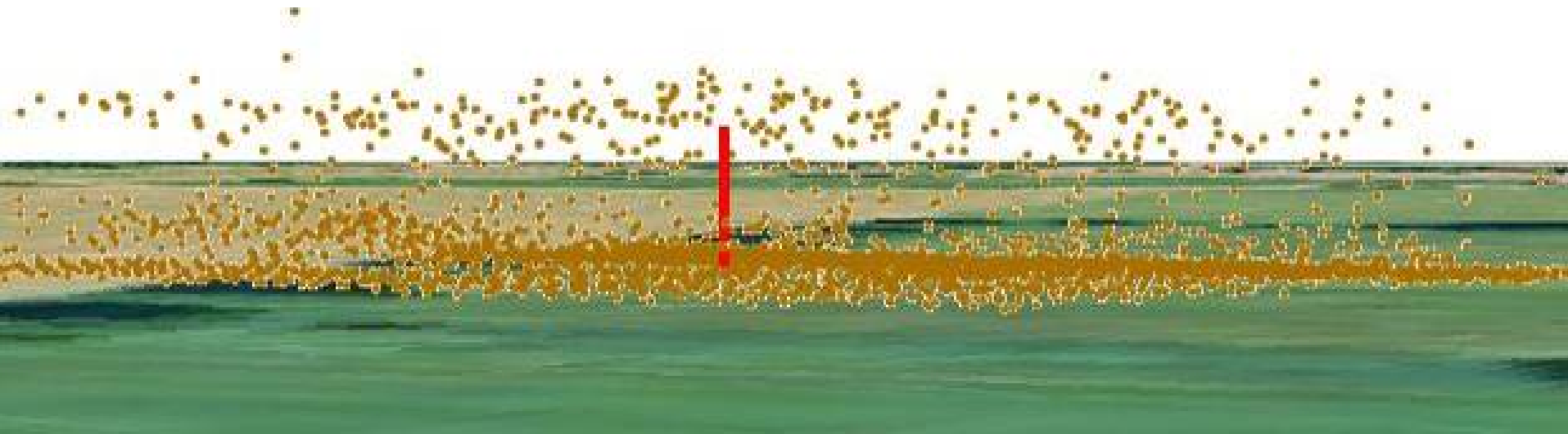


Object 23: hedge & tree



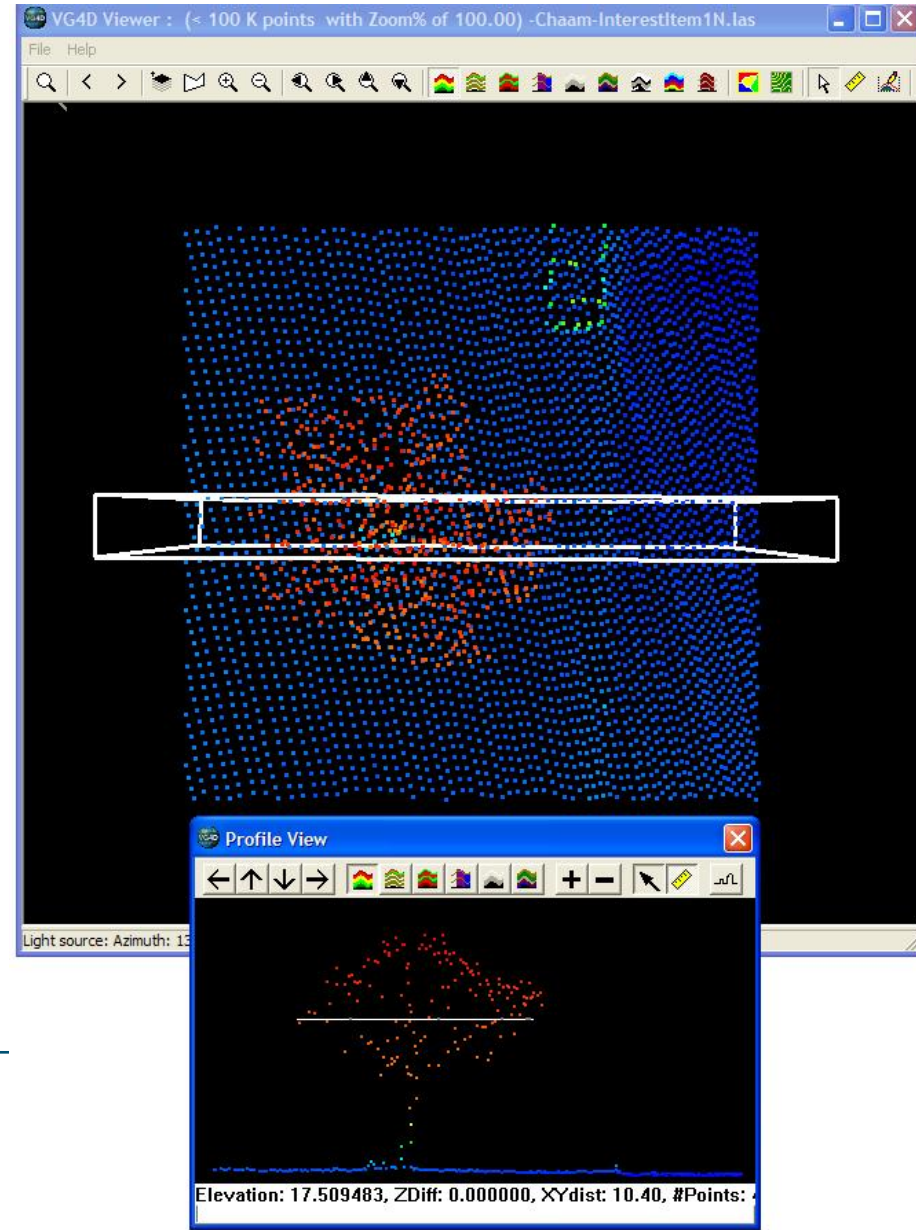
Object 5:

Fringe of reed



Height measurements LIDAR

- The VG4D viewer
 - measurements width and height of selected objects in LIDAR point clouds.



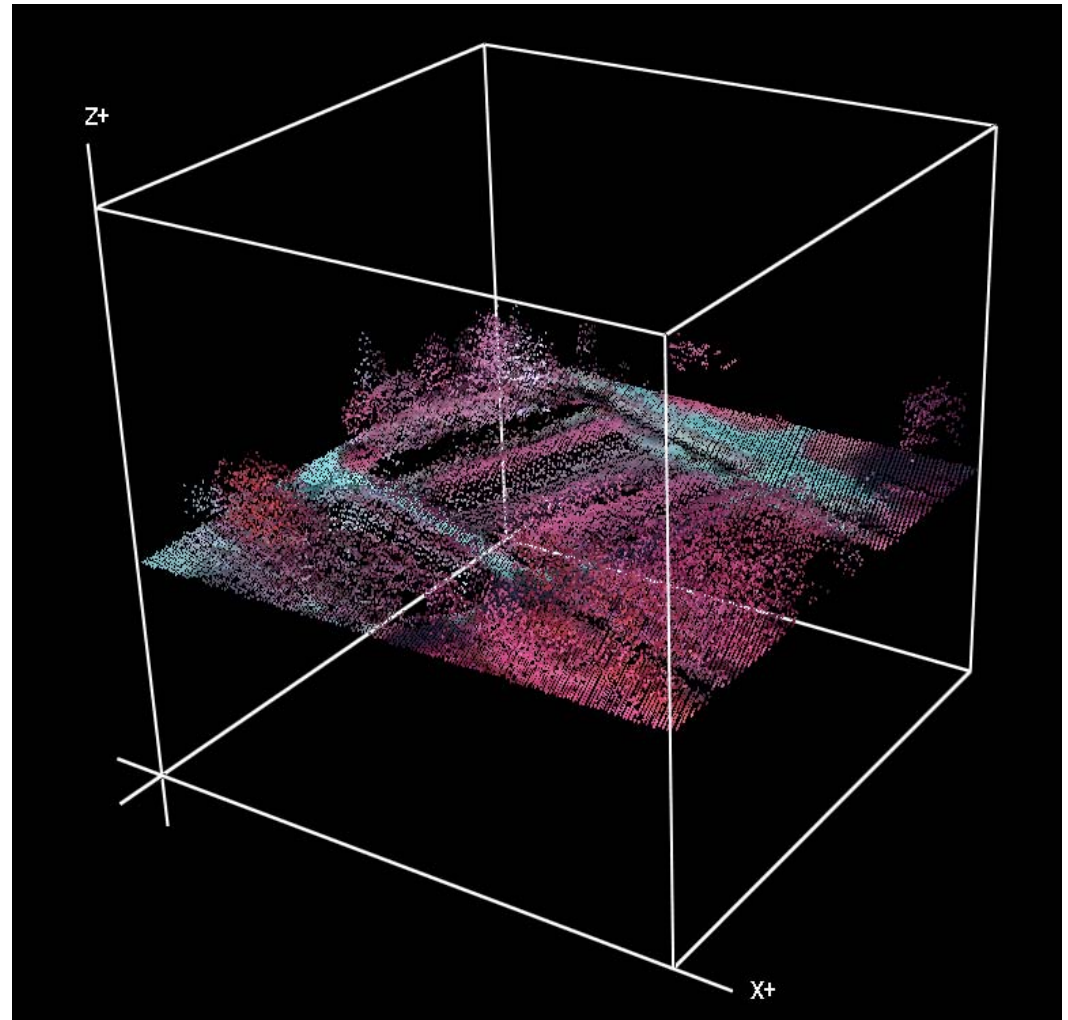
Assessment LiDAR measurements of life forms

object	Lidar		Field work	
	Height	Width	Height	Width
Single tree	11.9	9.8	11.71	8
Hedge row with bush	4.4	2.5 - 5.3	5.20	2.5
Single tree	11.3		11.54	6
Hedge row	7 - 7.8	6.8 - 7.8	8.56	5
Fringe of reed	2.9	3.6 - 5	2.20	4
Solitary tree	11.1	7.8	12.53	8
Row of willows	6.7 - 7	2.0 - 3	9.34	2
Blackberry and reed	1.3 - 5	4.0 - 7	5.20	4
Blackberry, low vegetation	0.25	-	0.75	4
Single tree	17.2	9.0 - 12	19.53	10
Forest with pines and birch	16.4 - 20		17.45 -	
Dould line of Oak trees	8.5 - 8.9	4.7 - 6.4	9.57	5
Line of trees and bushes	15.9	7.0 - 8	15.89	10
Oak trees in line	14.0 - 16	8	16.00	8
Rough wood at water fringe	0.6	0.6 - 2.5	0.75	2
Pitrus in ditch	ruis		0.75	7
Hedge with hornbeam	1.2	0.3 - 0.5	1.10	35
Con. Forest with edge of dec.	10.5		11.10	36
Solitary tree	10.25	8.5 - 10.8	11.28	5
Blackberry, low vegetation	1.2	3.5 - 4	1.70	4
Hedgerow	3.6 - 4.2	4.1 - 5	4.45	4
Rough field	0	-	1.00 -	
Hedge with conifers	1.6	0.6	1.50	0
Row with birch trees	10.6	4.2	11.75	3
Oak trees in line	11.4	5 - 8	12.82	6

Regression Statistics	
Multiple R	0.99
R Square	0.99
Adjusted R Square	0.95
Standard Error	1.00
Observations	24

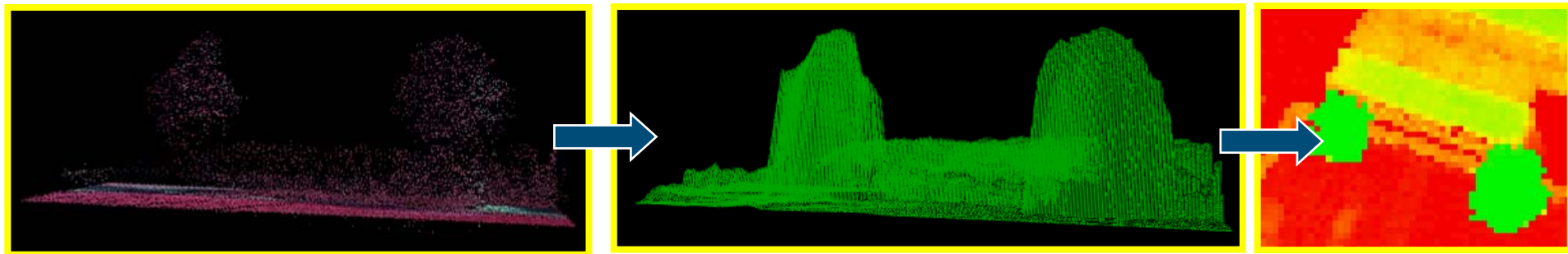
FUSION software

- FUSION is a LiDAR viewing and analysis software suite developed by USDA



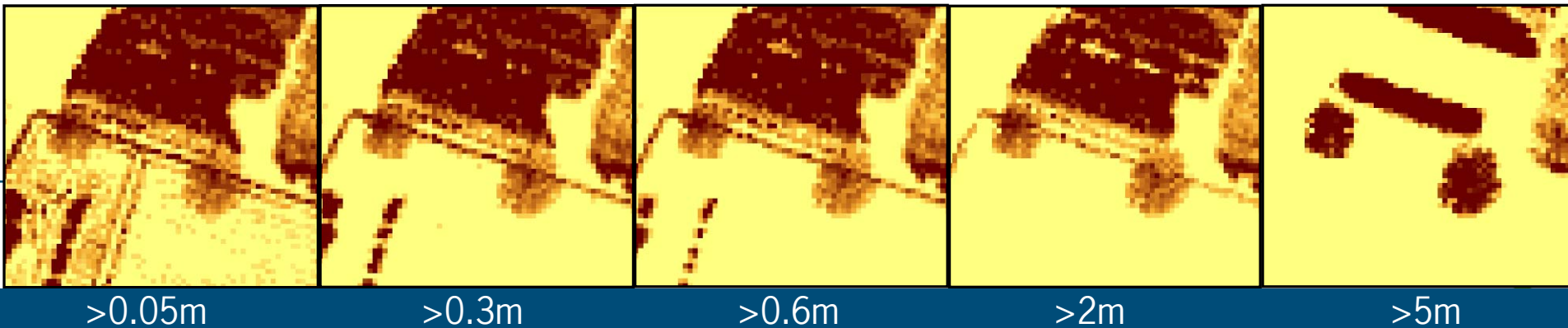
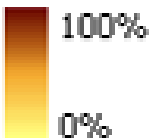
Examples FUSION output

■ Canopy Height Model



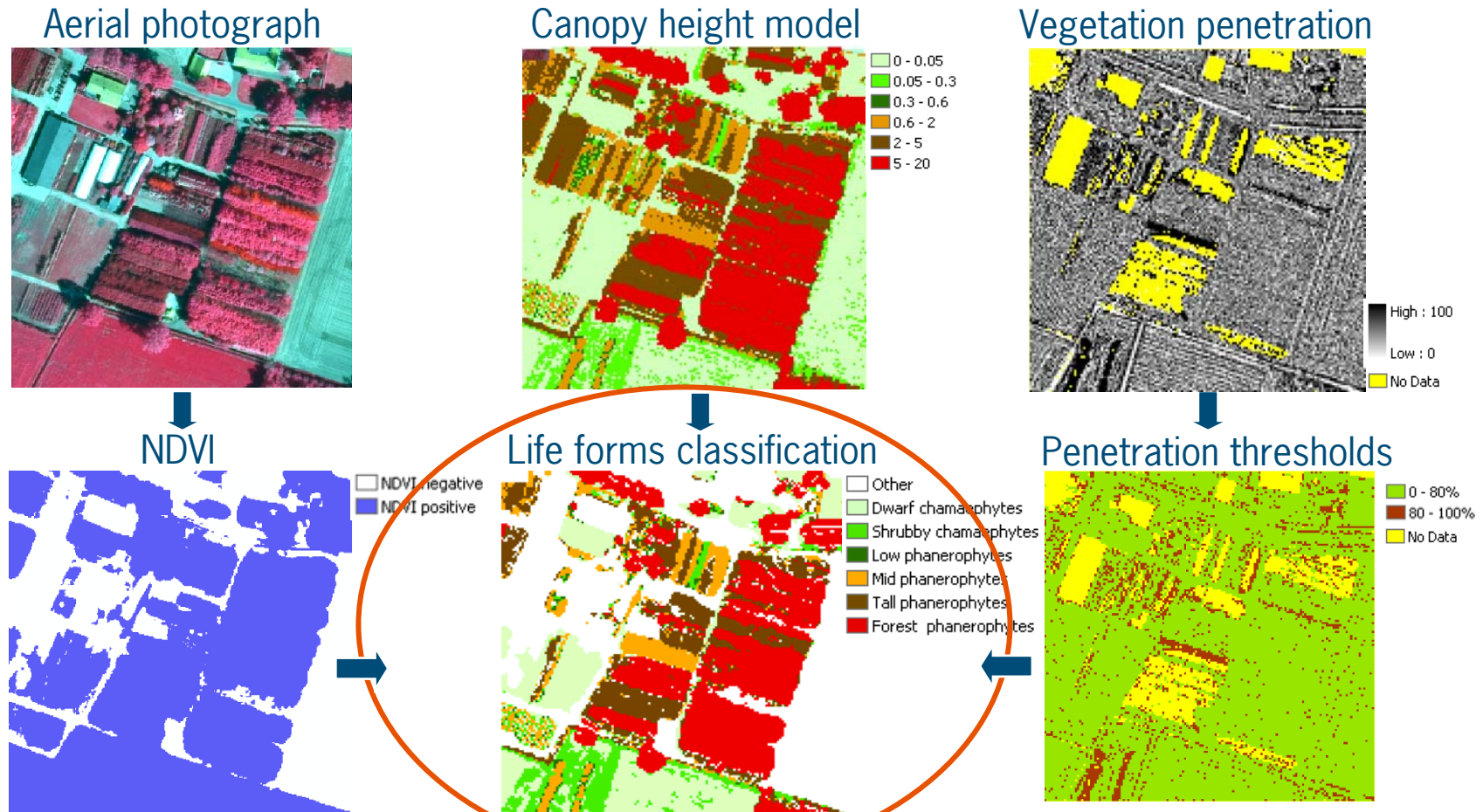
■ Canopy closure and canopy density

- Percentage of return above or between certain height breaks



Decision tree classification method

■ Based on combined use of AP & LIDAR

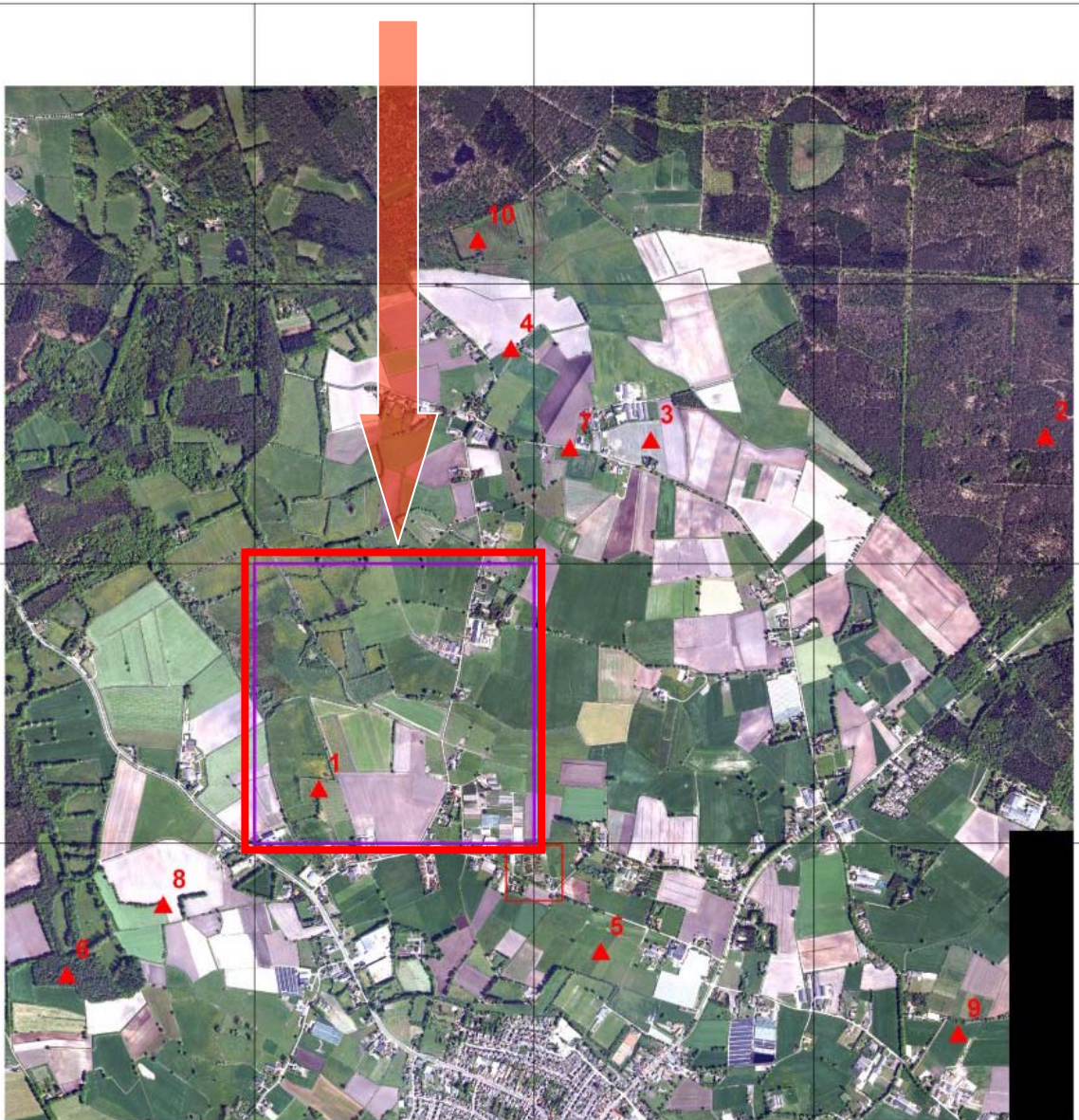


Preliminary classification tree nursery



- ☐ Other
- ☐ Dwarf chamaephytes
- ☐ Shrubby chamaephytes
- ☐ Low phanerophytes
- ☐ Mid phanerophytes
- ☐ Tall phanerophytes
- ☐ Forest phanerophytes

Selection one 1km² sample



Legend

▲ randompoints

Selected_grid_Chaam

1kmgrid

lufo2008_rgb_chaam.img

Integration

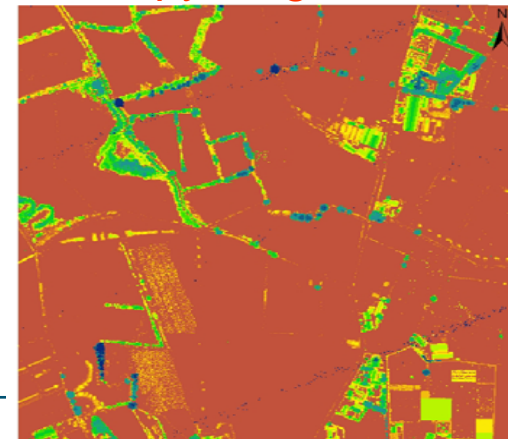
Knowledge rules:

- No vegetation (NDVI information)
- Crop field (top10 data)
- Other (top10 data)
- Tree nursery (top10 data)
- Canopy height model:
 - Canopy height : 0 -10cm (CHE/LHE)
 - Canopy height :10 - 60cm (LPH)
 - Canopy height : 60cm - 2m (MPH)
 - Canopy height : 2 - 5 m (TPH)
 - Canopy height higher than 5m (FPH)

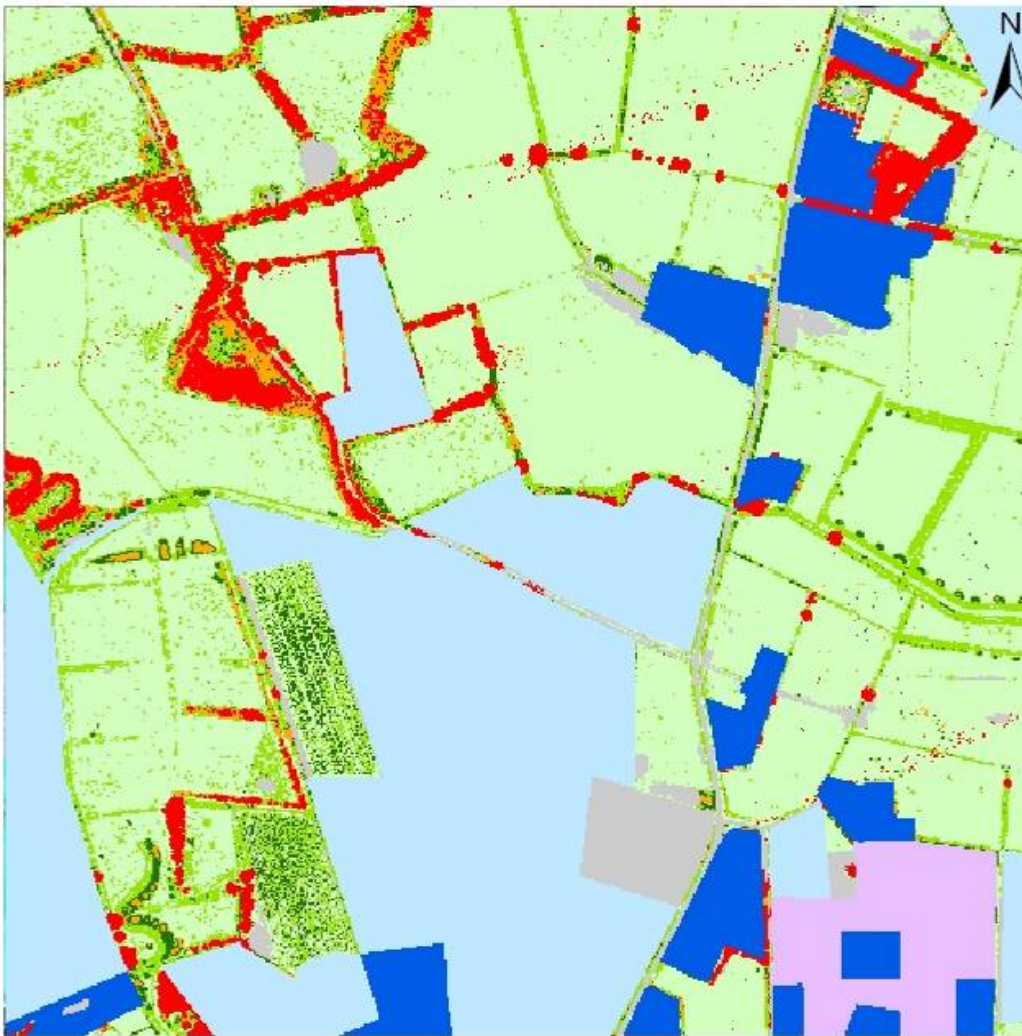
Strata: Urban/Crops/.. Vegetated / Non-veg.



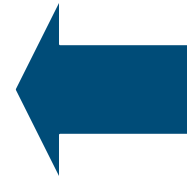
Canopy height model



Classification result



Validation based
on field work
(20-06-2010)



Pixel based classification



Segmentation to identify habitat patches

- The pixel based classification (2*2m) was smoothed with a majority filter (kernel window of 3x3)
- A multi-resolution segmentation and a spectral difference segmentation methods are performed in eCognition in order to define general habitat patches



Automatic object delineation



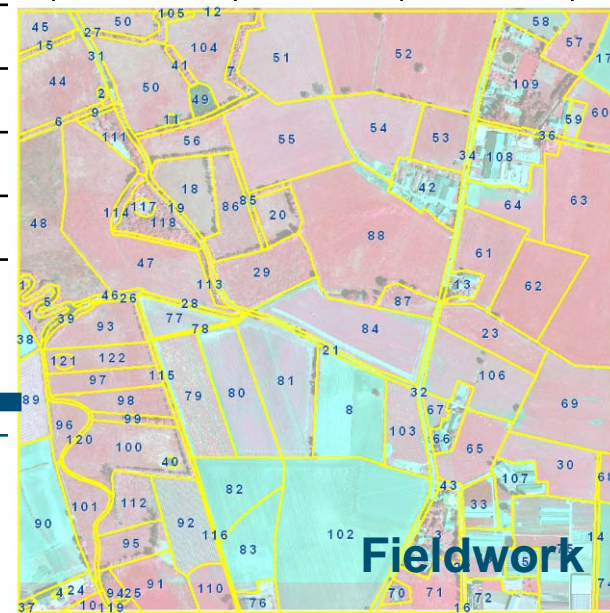
Fieldwork

Validation at level of habitat patch

FIELDWORK

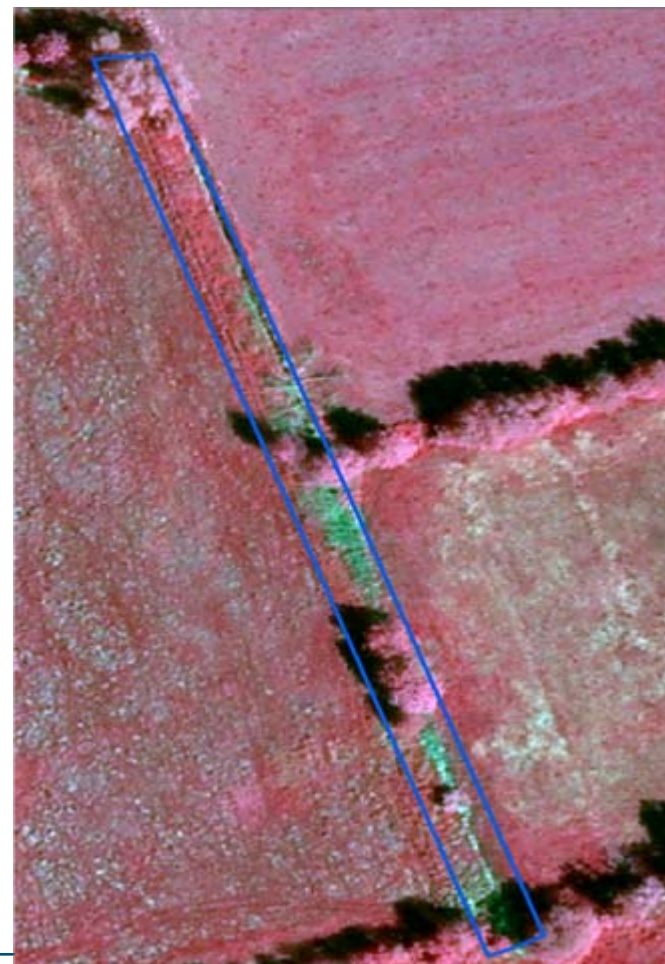
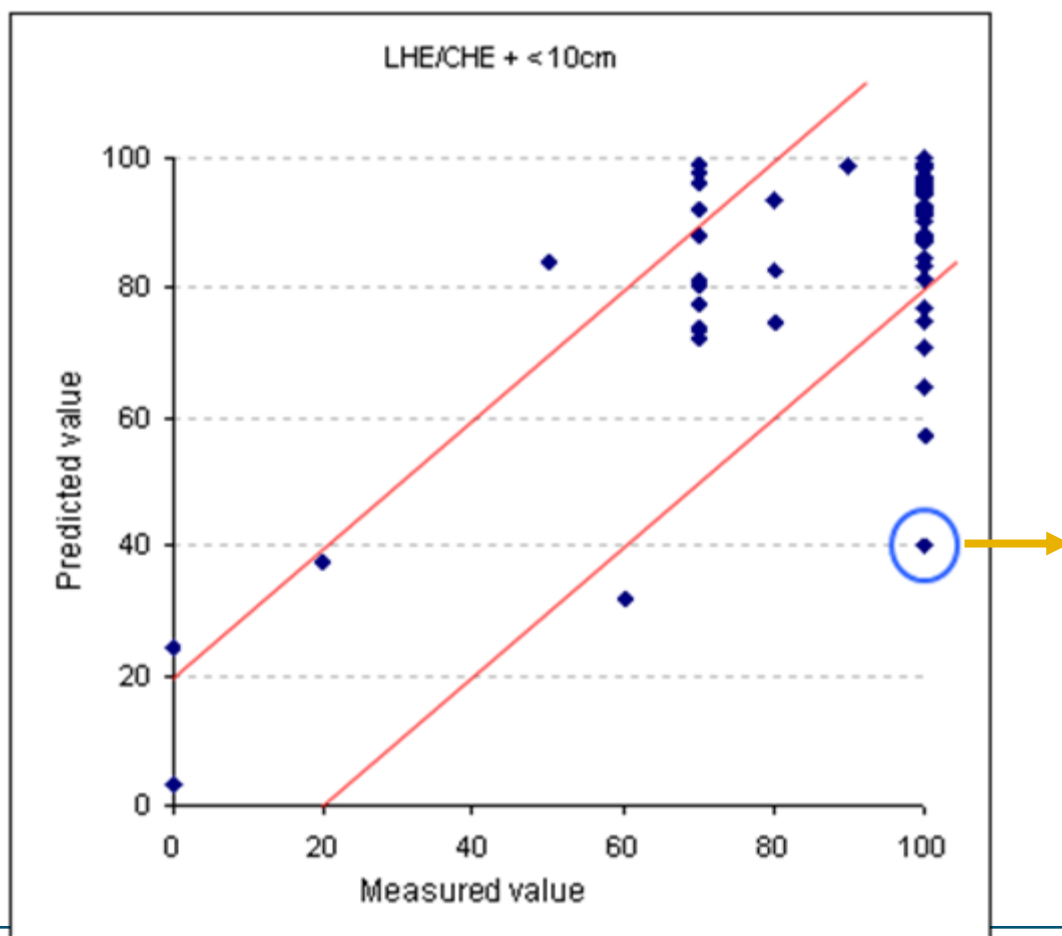
“LIDAR” method

ID	LHE/CHE_f	LHE/CHE + < 10cm	MPH_f	MPH	TPH_f	TPH	FPH_f	FPH
1	100	76.91	0	7.49	0	8.58	0	7.02
10	70	87.92	0	7.17	0	3.40	0	1.51
11	20	27.94	0	42.65	0	26.47	50	2.94
18	100	83.54	0	1.12	0	2.83	0	12.51
20	50	83.67	0	1.67	0	2.03	0	12.63
23	100	97.01	0	1.66	0	0.36	0	0.97
26	80	93.51	0	6.49				
28	90	98.93	0	1.07				
29	100	87.87	0	3.49				
30	100	96.01	0	2.28				



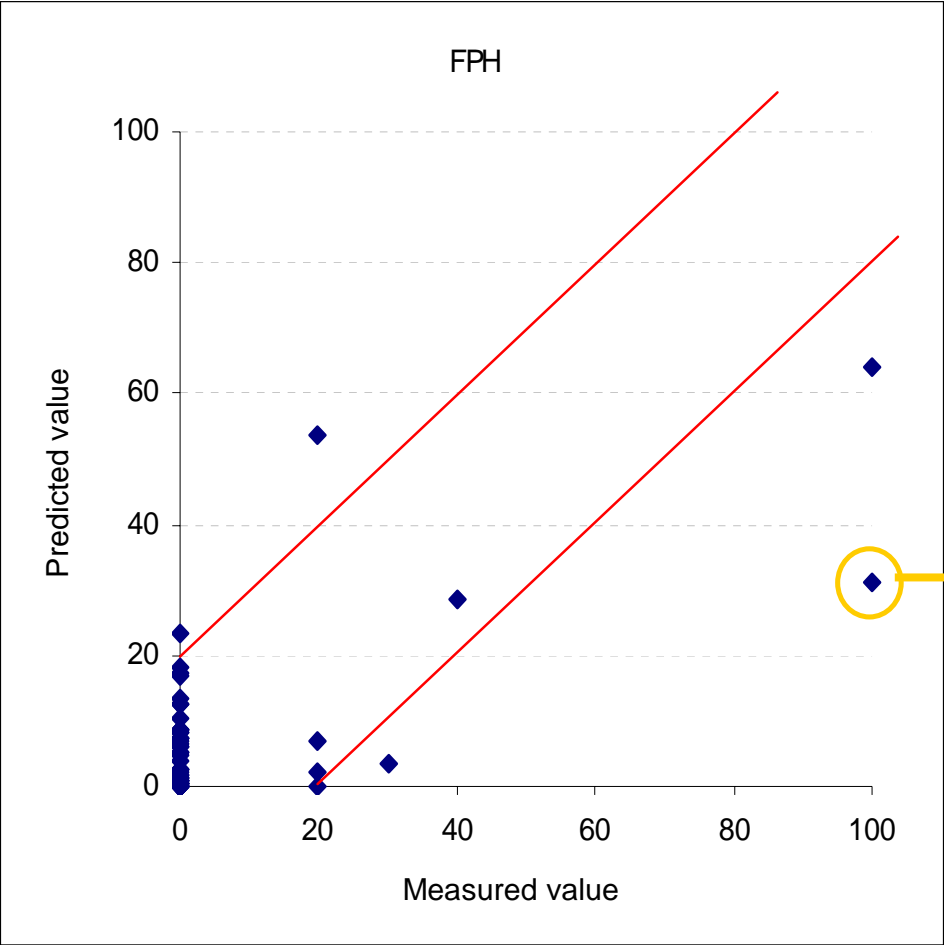
Leafy HEmicryptophytes/

Caespitose HEmicryptophytes < 10 cm



ID	LHE/CHE_f	LHE/CHE + < 10cm	MPH_f	MPH	TPH_f	TPH	FPH_f	FPH
85	100	40	0	11	0	26	0	23

Forest PHanerophytes (FPH)



ID	LHE/CHE_f	LHE/CHE + < 10cm	MPH_f	MPH	TPH_f	TPH	FPH_f	FPH
5	0	24	0	23	0	21	100	31

Conclusions & perspectives

- Accurate height measurements of vegetation with LiDAR, but no species information.
- In spring (no leaves yet) good identification already of woody plant life forms.
- Problems to distinguish forbs (LHE) from grasses (CHE).
- Integration of LiDAR with aerial photographs (or VHRS) recommended for habitat mapping.
- Topographic maps can provide strata to distinguish urban, cultivated areas and semi-natural areas.
- Validation highlights uncertainties in RS method but also in field method !
- Combination of LIDAR (height) with hyperspectral data (thematic) way forward !

Thank you for your attention !

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