Sampling for landscape elements – A case study from Lower Saxony, Germany

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Background

- Landscape elements like trees outside forest (TOF), hedgerows or other woody vegetation outside the forest can play a significant role for carbon sequestration on landscape level, are a resource for energy purposes and contribute to landscape- and species diversity,

- Common sampling techniques as applied in forest inventories are not suitable to assess these element, as they are usually “rare events” because of their relatively low coverage,
  - Automatic classification based on remote sensing is also affected by many restrictions

False color composite of RapidEye (5m res.)

General aim of the study

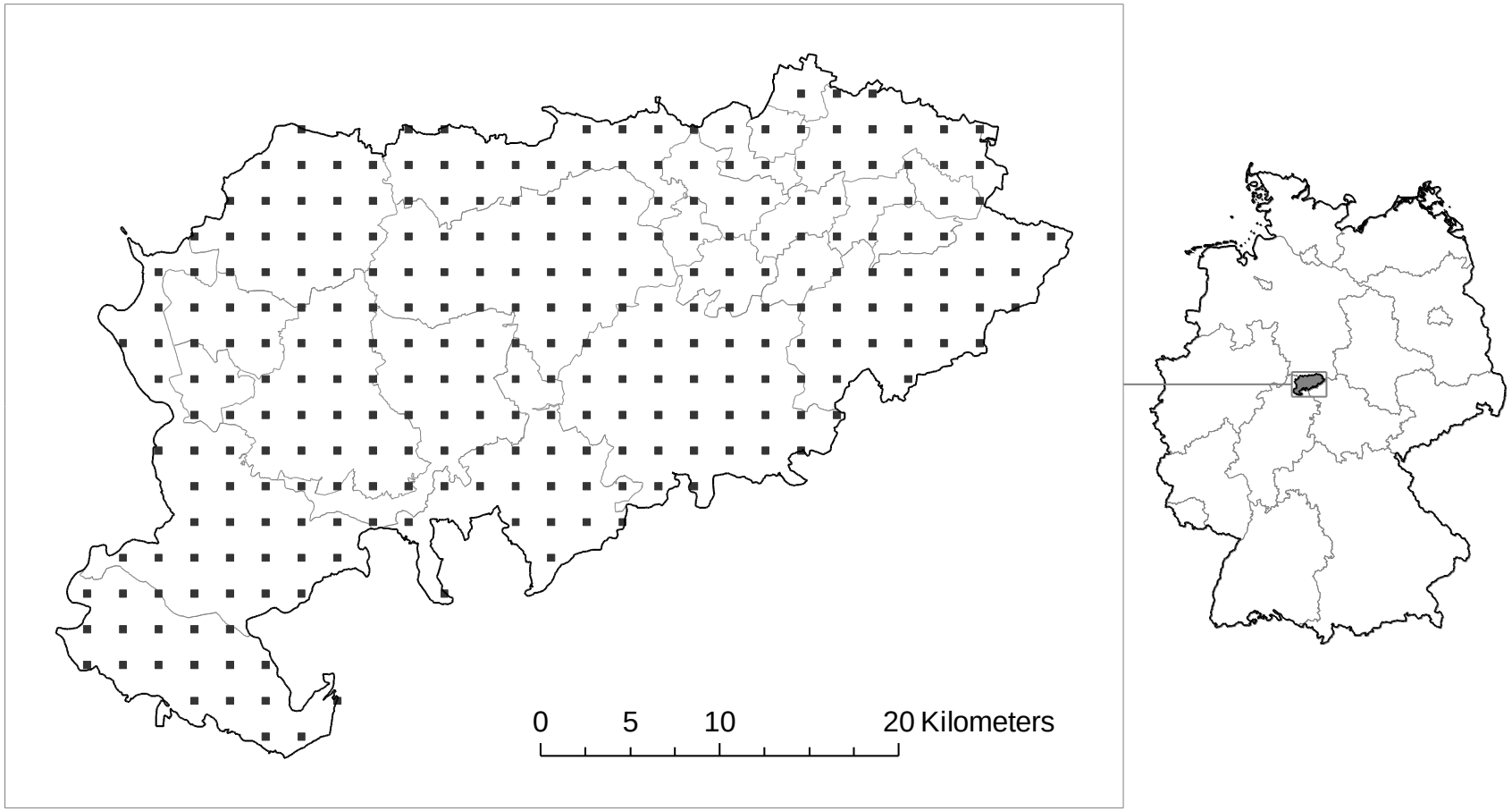
- Evaluate the suitability of different observation designs for visual interpretation in aerial imagery for the purpose of cover estimation of different land-use classes with special focus on woody vegetation outside forest,

- The design choices under study are characterized by very different complexity and effort (reaching from full mapping inside aerial photo plots up to the classification of points in small clusters).

Methodology

- Study area: the administrative district of Göttingen (1117.7 km²),
- A complete coverage of high relolution aerial images (20 cm ground resolution) was aquired (however, similar imagery is also available in Google Earth and Bing),
- The whole district was overlaid with a systematic grid (2x2 km) leading to n=279 sampling locations,
- At each sample point a quadratic aerial photo plot of 400x400 m (16 ha) was established and land cover mapped in different classes,
  - The total observed area was 4.464 ha, which is equivalent to a sampling intensity of 3.9%.

Study area and sampling grid

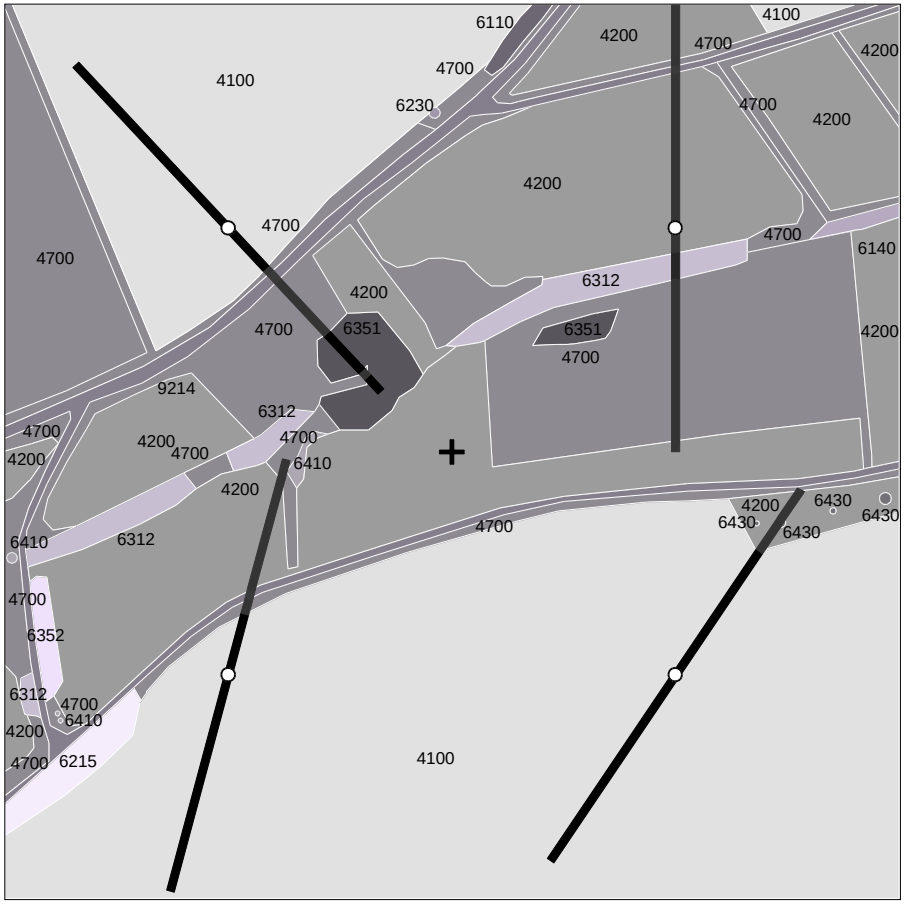


Hierarchical land cover classification key

LCC level I	LCC level II	LCC level III
Water	Water body	River
		Lake
Agriculture	Crop field	
	Grassland	
	Field margin	
Woody vegetation outside forest (WOF)	Hedge	Hedge (bushes dominant)
		Hedge (bushes and trees)
		Hedge (trees dominant)
	Grove	Grove (with bushes)
		Grove (mainly trees)
	Bush/Shrub	Single Bush
		Group of bushes
	Single tree (TOF)	
	Woody vegetation along roads	
Forest	Forest (FAO definition)	
Infrastructure	Settlement area	
	Road	Road (usually public)
		Way (forest roads, field tracks)
	Railway	

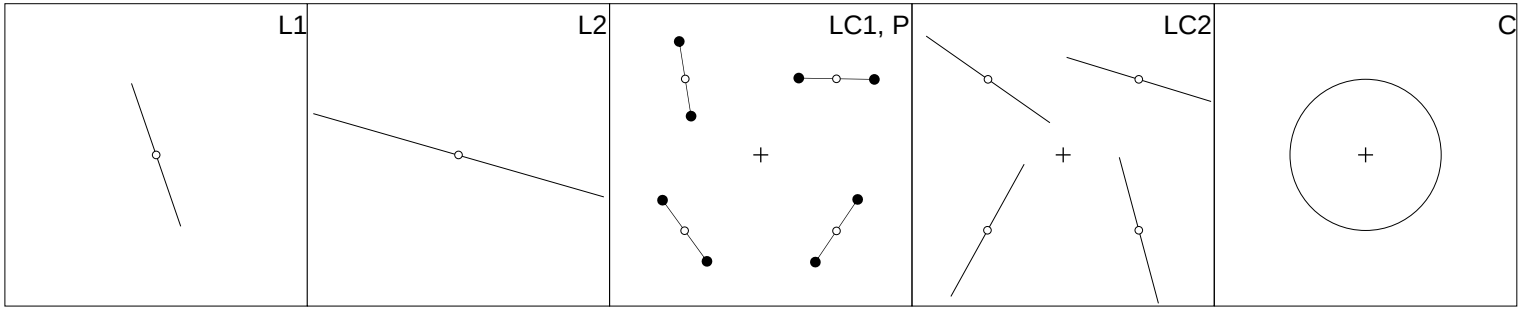
Observation designs

- Example of a photo plot (left) and completely mapped land cover superimposed with a cluster of lines (right):



Observation designs

- For each of the following designs the respective observations were derived by superimposing the observation units over the completely mapped land cover classes:



Design	Description	Unit	Total size
F	400 by 400 m aerial photo plot	Area	16 ha
L1	Single line of 200 m	Length	200 m
L2	Single line of 400 m	Length	400 m
LC1	Cluster of 4 lines à 100 m	Length	400 m
LC2	Cluster of 4 lines à 200 m	Length	800 m
C	Circle of 100 m radius	Length	628 m
P	Start- and endpoints of lines in LC1	Count	8 points

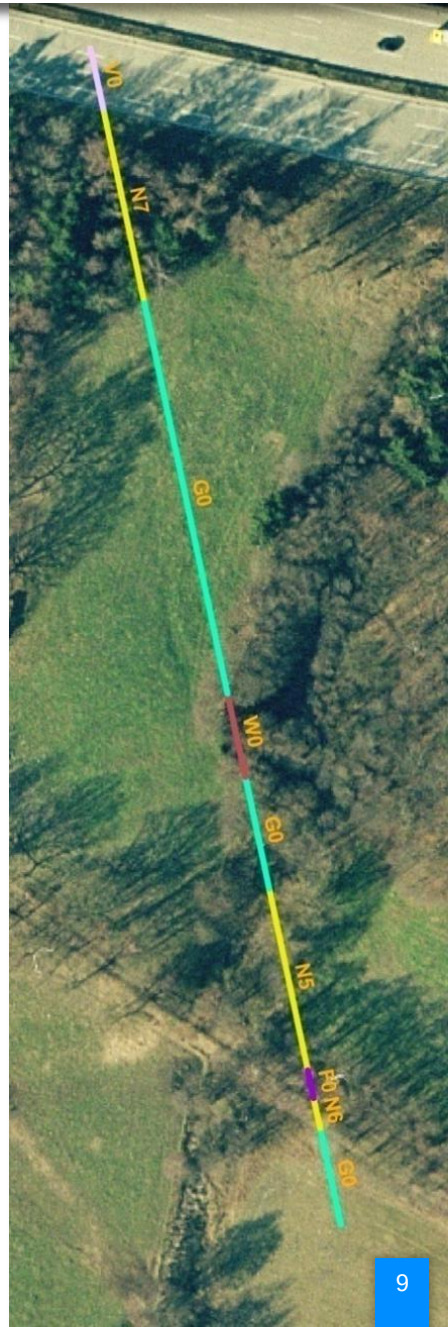
Estimation design

- The proportion of the respective land cover for each of these observation units was calculated on the relative share (line length per class/ total line length):

$$\widehat{p}_{ij} = \frac{l_{ij}}{l_i},$$

where *lij* is the length of the line in a certain land cover class and *li* is the total length per observation unit *i.*

- We calculated the relative standard error of estimation as measure of precision.



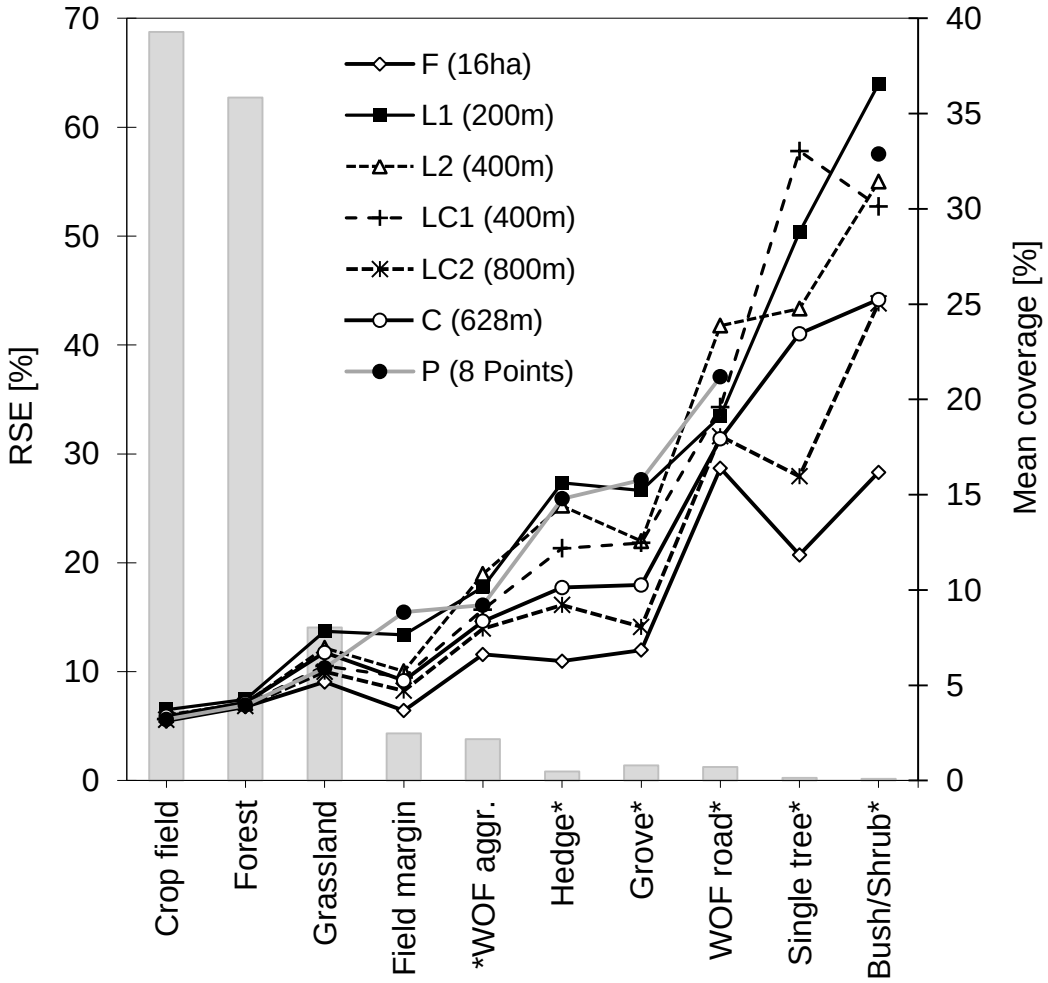
Results

- For large cover classes (forest, fields) the difference in precision is very small,
- For single trees or small groups of bushes, the errors are relatively high (these are “rare events”),
- For all woody vegetation outside forest together (WOF) errors vary between 11.6% and 19%)

LCC	Observation design						
	F	L1	L2	LC1	LC2	C	P
Crop field	39.31 (5.5)	38.00 (6.5)	39.58 (6.0)	40.37 (5.6)	39.99 (5.6)	39.60 (5.9)	39.56 (5.6)
Forest	35.87 (6.8)	35.89 (7.4)	35.88 (7.1)	35.51 (7.0)	35.88 (6.8)	35.86 (7.1)	35.57 (6.9)
Infrastr.	11.91 (10.9)	12.59 (12.6)	12.07 (11.9)	11.61 (11.4)	11.66 (11.3)	11.87 (11.9)	11.78 (11.5)
Grassland	8.05 (9.1)	8.61 (13.7)	7.66 (12.2)	8.13 (10.5)	7.83 (10.0)	7.84 (11.8)	8.38 (10.3)
Field margin	2.48 (6.4)	2.59 (13.4)	2.60 (10.0)	2.04 (9.5)	2.31 (8.2)	2.49 (9.2)	2.37 (15.5)
Grove*	0.79 (12.0)	0.74 (26.6)	0.58 (22.0)	0.72 (21.8)	0.72 (14.1)	0.70 (18.0)	0.76 (27.6)
WOF al. road*	0.70 (28.7)	0.81 (33.5)	0.73 (41.8)	0.70 (34.3)	0.76 (31.6)	0.71 (31.4)	0.49 (37.1)
Hedge*	0.47 (11.0)	0.60 (27.3)	0.55 (25.2)	0.61 (21.3)	0.49 (16.1)	0.52 (17.7)	0.72 (25.9)
Single tree*	0.14 (20.7)	0.10 (50.3)	0.03 (43.3)	0.08 (57.8)	0.12 (27.9)	0.14 (41.0)	0.00 (n.d.)
Bush/Shrub*	0.08 (28.3)	0.05 (64.0)	0.09 (55.0)	0.07 (52.7)	0.08 (43.8)	0.09 (44.2)	0.13 (57.5)
*WOF	2.18 (11.6)	2.30 (17.7)	1.98 (19.0)	2.18 (15.7)	2.16 (14.0)	2.15 (14.6)	2.11 (16.1)

Results

- It is interesting to note that simple designs (like 8 points in a cluster) are able to derive estimates that are as precise as full mapping for larger classes,
- However, for rare events a full mapping of landscape elements in sample plots is most promising.



Reference

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