

Comparison of different hedgerow measurements

Comparison of radiometric ortho-image characteristics for the different kind of measurements and identification of selected hedgerows relevant for the Common Agriculture Policy (CAP)



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Outline

- Objectives
- Hedgerow detection
- Data and hedgerow selection
- Delineation protocols
- Influences of image characteristics
- Area measurement results
- Protocol comparison
- Lessons learnt

Master thesis' objective:

1. Check the influence of radiometric orthoimage characteristics on the measurement and identification of Hedgerows in Land Parcel Identification System (LPIS).
2. Assessing methods of Hedgerow delineation for LPIS.



Hedgerow approaches (at time of the study)

Commission Regulation (EC) No 1200/2009 of 30 November 2009:

Hedges – rows of shrubs or bushes forming a hedge, sometimes with a central row of trees. [Annex 3, III.3.01.a]

Land Cover Classification System (LCCS): Classification Concepts and User Manual:

Shrubs (A12 and A24) - These are woody perennial plants with persistent and woody stems and without any defined main stem (Ford-Robertson, 1971), being **less than 5 m tall**. The growth habit can be erect, spreading or prostrate.

Executable Test Suite Annex III The Concept of land cover and 'eligible hectares' version 5.3:

Hedgerows - permanently cropped area with small sized field(s) of rainfed tree crop(s)/permanently cropped area with small sized field(s) of rainfed shrub crop(s)



Hedgerow approaches (cont'd) (at time of the study)

Defra's Hedgerow Survey Handbook (2007)

Shrubby hedgerow - a line of woody hedgerow plants that have some or all of their leafy canopies **less than 2m height** from the ground, so that the woody linear feature as a whole appears as a 'shrubby' hedgerow, even though some of the woody species in it are capable of growing into trees. The shrubby component must be less than 5m wide. This hedgerow type may have hedgerow trees along its length, but their canopies should be more than 20m apart.



This study's criteria for hedgerow detection

Inspired by GAEC reported by UK-ENG

Hedgerow - a line of woody hedgerow plants at least 20m long and less than 5m wide with maximum gaps of 5m between plants. Some or all of leafy canopies of hedgerow should have **less than 2m height** from the ground, so that the woody linear feature as a whole appears as a 'shrubby' hedgerow, even though some of the woody species in it are capable of growing into trees.

Note

These criteria served to study the hedge «phenomenon» and the different ways it can be captured into a GIS environment

NOT about:

- eligibility for BPS/SAPS
- eligibility for EFA
- cross-compliance

Other criteria or parameters may apply for the latter!

Experimental setup

Two measurement variables

1. different image (type) as reference basis
 1. Several VHR images
 2. Aerial imagery
2. protocol

applied on hedgerows reported in LpisPolygonZeroState.gml
 anonymous study zone, >10 custodians
 >1 capture within the reporting year must be available
 Bing image used as ancillary image source (assuming stability)

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Imagery

From 83 satellite images and 21 zones covered with aerial images, only 12 satellite images and 4 sets of aerial images were retained.

Why a mere 15% of imagery?

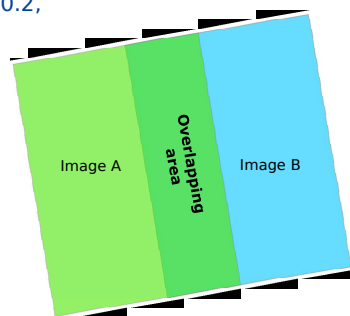
- Only images with overlapping areas were chosen,
- Errors during importing images to ArcGis10.2,
- Errors in coordinate systems,
- Satellite image same as "aerial".



Satellite image

"Aerial" image

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Investigated hedgerows

Despite inspiration on detection criteria, UK-ENG is not part of the study

From 2774 hedgerows from ETS reporting packages, 366 polygons were located where overlapping images were available.

From these 366 hedgerows, 86 were considered consistent with the working definition.



Why only 23,5% retained? ?



→ **BPS/SAP** eligible landscape feature definitions are incompatible with the detection criteria (esp. dimensions)

Hedgerow selection (cont'd)

- Width does not fulfill the detection criteria (max 5m)



Hedgerow selection (cont'd)

- Height doesn't fulfill the detection criteria (max 2m) - line of trees



Based on image metadata maximum height of shadow for a 2m high hedgerow was calculated.

Hedgerow selection (cont'd)

- Wrong classification of Landscape Feature.



Hedgerow selection (cont'd)

- Artefact in database.



Delineation protocols

Each physical hedgerow was delineated by 3 curve protocols:

- Edge curve
- Plants curve
- Canopy curve

and 2 polygons representations:

- Canopy polygon
- Plants polygon

As a bonus, a small number corresponds to

- an ETS observation polygon
- a LPIS reference parcel

Each hedgerow was measured 3 times:

- 2x on each overlapping CwRS/LPIS QA image (same season)
- 1x on Bing (independent)

Delineation practice

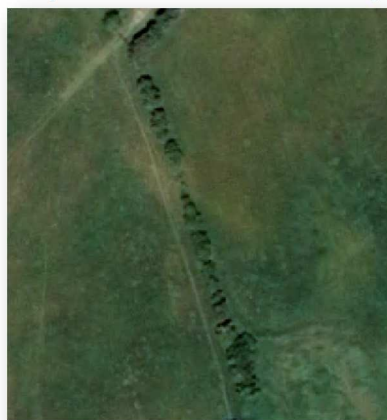
The following delineation rules were applied:

- When the width of hedgerow is not continuous, measure three (or more) different widths and take the average value.
- Any gap over 5m length means the end of the first hedgerow and the beginning of a second one.
Two different database features as a result of the gap
- Any gap over 2m length means the end of the first curve of a hedgerow and the beginning of a second curve (used for both plants curve and plants polygon).
One database feature with 2 or more geometries and internal gap.

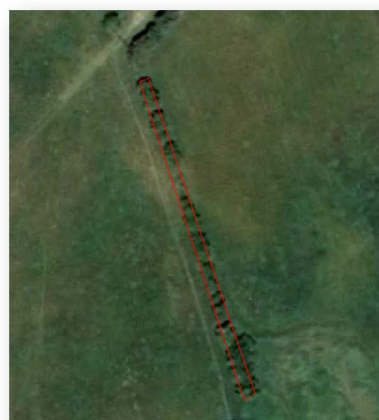
In the “ plants” protocols the gap distance is measured between individual plants, in the “canopy/edge” between canopy extremes.
The total EFA area is not the primary topic! (more gaps, less area with “plants” for a set gap dimension)

Example of bonus data

Only available where the ETS polygon matches detection criteria



Hedgerow X



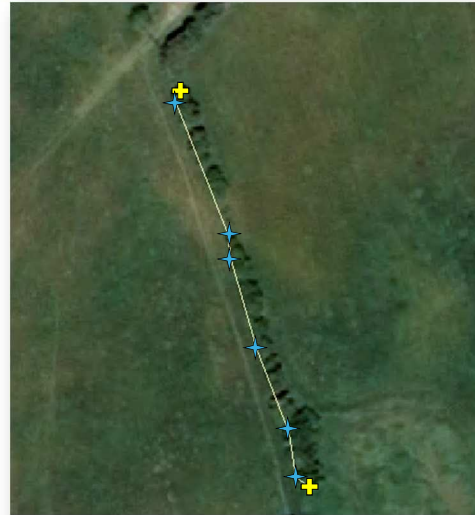
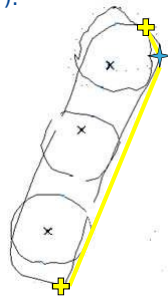
Hedgerow X in ETS package polygon

Delineation (cont'd)

Edge curve:

Curve at canopy's edge (at the side of the inspected parcel), begin/end vertices either at :

- the furthest extend (when rounded)
- the corner (when square/angular).



Delineation (cont'd)

Edge curve:

If the end of hedgerow has a square shape, the edge curve should begin in the corner of ending (not in the middle of end's side).

Square shape of ending



Delineation (cont'd)

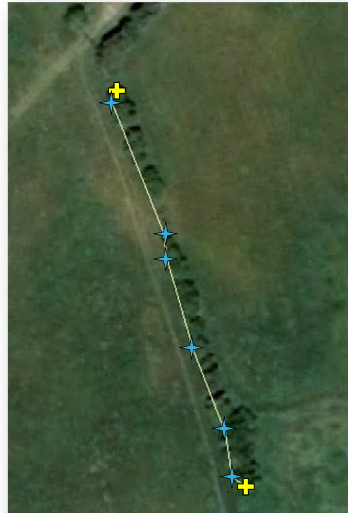
Edge curve:

Appreciated advantages:

- Faster than polygon delineation
- No problems with gaps less than 5m (like in plants curve or plants polygon)

Appreciated disadvantages:

- Heterogeneous rules of delineation related to shape of hedgerow ending: in case of hedgerow with different shape of ends - which end should be delineated?
- Worse representation of hedgerow than plants curve/plants polygon
- Difficult delineation on images with bad contrast
- Delineation depends on acquisition time of image (hedgerow on images from early spring looks different on images from summer)



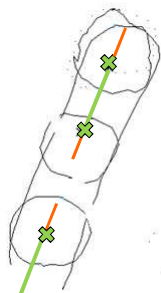
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Delineation (cont'd)

Plants curve:

curve from the centre/trunk of the first plant of to the last plant, as a central, continuous curve.

= as proposed in April



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Delineation (cont'd)

Plants curve:

Appreciated advantages:

- Faster than polygon delineation
- The most intuitive curve representation of hedgerow (gaps less than 5m are taken into consideration during delineation)
- More possible to delineate on images with poor radiometric characteristics than edge curve or polygons
- Influence of acquisition time of image is not so strong as on delineations based on edges of hedgerows

Appreciated disadvantages:

- Requirement of checking width of gaps – difficult and time consuming on images with bad radiometric characteristics
- Less intuitive representation of hedgerow than plants polygon

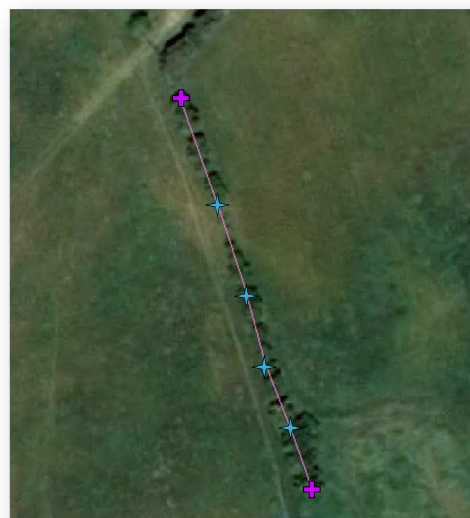
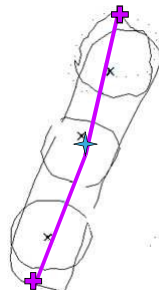


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Delineation (cont'd)

Canopies curve:

Central curve connecting the extreme extend of the hedgerow canopy.



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Delineation (cont'd)

Canopies curve:

Appreciated advantages:

- Faster than polygon delineation
- More possible to delineate on images with poor radiometric characteristics than edge curve or polygons
- No problems with gaps less than 5m (like in plants curve or plants polygon)
- Influence of acquisition time of image is not so strong as on delineations based on edges of hedgerows

Appreciated disadvantages:

- Less intuitive representation of hedgerow than plants curve/plants polygon

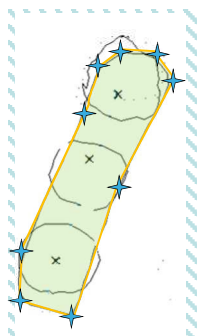


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Delineation (cont'd)

Canopies polygon:

Polygon covering the hedgerow canopy.



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Delineation (cont'd)

Canopies polygon:

Appreciated advantages:

- No problems with gaps less than 5m (like in plants curve or plants polygon)

Appreciated disadvantages:

- Time consuming comparing to curve delineations
- Differences between delineations of hedgerow on images acquired during early spring and summer (width of object is different because of leaves)
- More difficult to delineate on images with poor radiometric characteristics
- More artificial representation of hedgerow than plants polygon

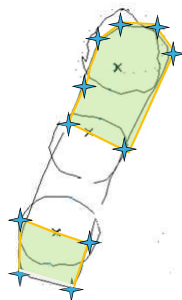


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Delineation (cont'd)

Plants polygon:

Polygon covering the hedgerow canopy, internal gaps detected at plant centers



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Delineation (cont'd)

Plants polygon:

Advantages:

- The most "formal" area representation of hedgerow in perfect conditions of quality images (gaps less than 5m are taken into consideration during delineation)

Disadvantages:

- Time consuming comparing to curve delineations
- Requirement of checking width of gaps – difficult and time consuming on images with poor radiometric characteristics
- Differences between delineations of hedgerow on images acquired during early spring and summer (width of object is different because of leaves)
- More difficult to delineate on images with poor radiometric characteristics



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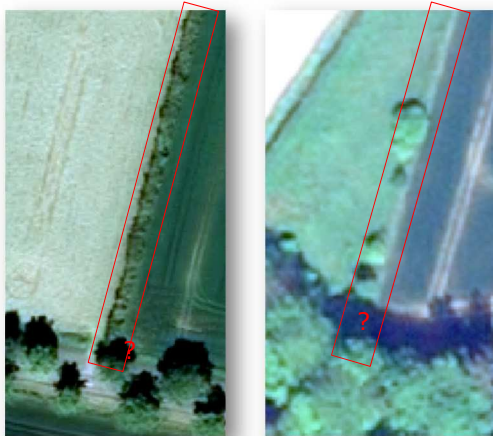
Influences of radiometric ortoimage characteristics on delineation



According to LpisPolygonZeroState.gml, there is a hedgerow. However, it is impossible to delineate a polygon because of the saturated shadow.

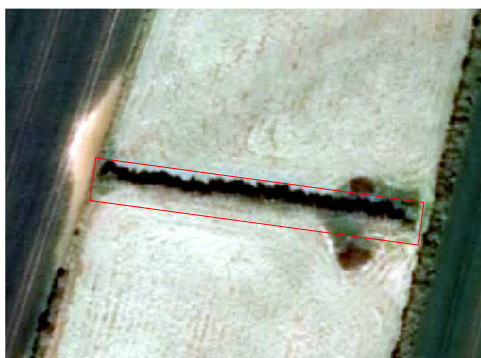
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Influences of radiometric characteristics on delineation of orthoimage (cont'd)



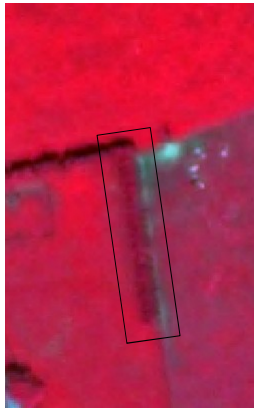
On both images deep shadow hides the ends of hedgerows - it is impossible/difficult to delineate them both by curves and polygons.

Influences of radiometric characteristics on delineation of orthoimage (cont'd)



Both deep shadow and bad contrast makes delineation very difficult.

Influences of radiometric characteristics on delineation of orthoimage (cont'd)



Because of bad contrast it is very hard to see clear edge of hedgerow – plants curve and canopies curve are easier to delineate.



Operator experiences

Using the conventional LPIS/CwRS photointerpretation setup:

- Contrast and shadows are the most important attributes of images during delineation,
- Delineation by axis curves is less demanding than delineation based on edges (especially on images with bad radiometric characteristics),
- Canopy protocols have less gaps to consider than plant protocols

Numerical output

The resulting database for statistics statistical analysis holds:

- ID of each Hedgerow,
- Custodian name,
- Image name,
- Edge curve length (acquired from edge curve),
- Plants curve length (acquired from plants curve),
- Canopies curve length (acquired from canopies curve),
- Canopies polygon perimeter (acquired from canopies polygon),
- Plants polygon perimeter (acquired from plants polygon),
- Canopies area (acquired from canopies polygon),
- Plants area (acquired from plants polygon),
- Composite (NCC/FCC),
- Aerial/Satellite image.

Statistical analysis

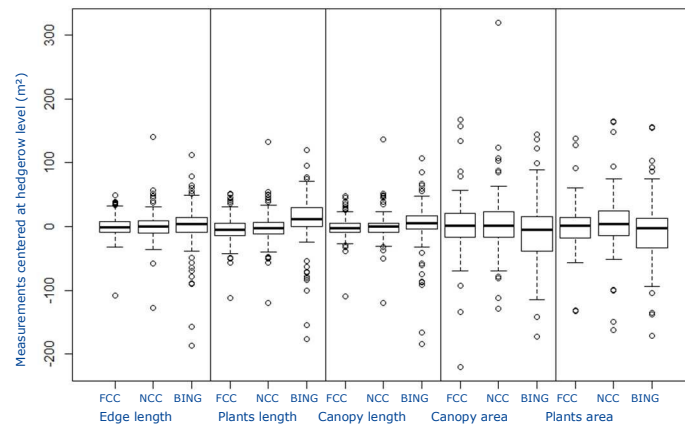
correct = precise and accurate

Precision of the various protocols can be assessed

In absence of a true and known EFA-area reference, absolute accuracy cannot be assessed, various values can be relatively compared but no one can be identified as “most accurate”

In IACS practice, better to be precise than accurate?

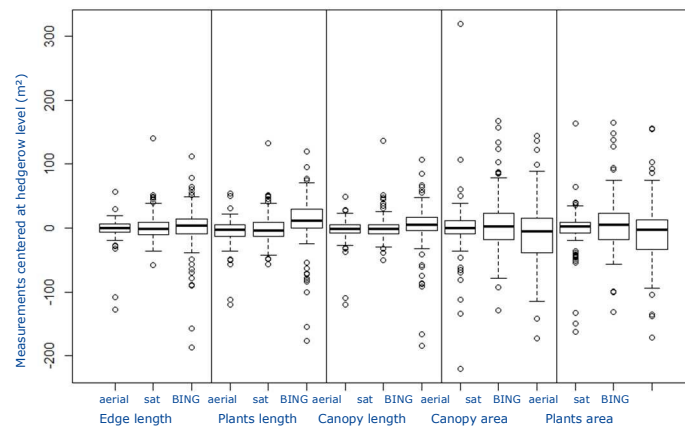
Impact of band selection



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Satellite vs aerial vs Bing



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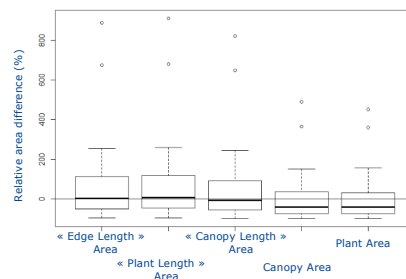
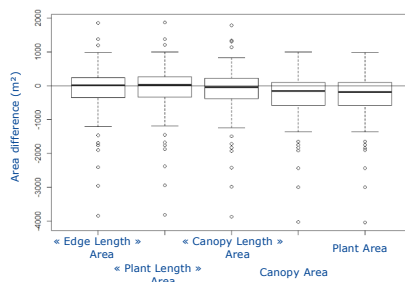
Impact of image characteristics

- Quality of images does not introduce a significant bias.
- However, image quality affects precision:
 - Bartlett test shows FCC composite and aerial imagery are significantly better for delineation because variances of measurements on this images are smaller than on NCC composite and satellite's imageries).
 - According to Student's T-test significant differences between measurements on NCC and FCC compositions are not so common.

BPS/SPS polygon vs EFA protocols

Sample: 30 matching LPIS polygons

- polygon protocols underestimate LPIS reference area
- extreme area differences
- Absolute ($>1000 \text{ m}^2$ or more)
- Relative ($\pm 100\%$ or more)



EFA-element and GAEC-LF

Landscape features eligible through GAEC7 are completely different from the landscape features under EFA due to absence of dimension in the definition.
due to historicity/hierarchy in the reference parcel layer

E.g. hedgerows (BPS) and hedgerows (EFA):
represent different phenomena on the field
distinction must be made very, very clear and communicated to all
both are fruit but no “apples with pears” comparisons possible (e.g. regarding EFA area)!

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ETS protocol vs EFA protocols

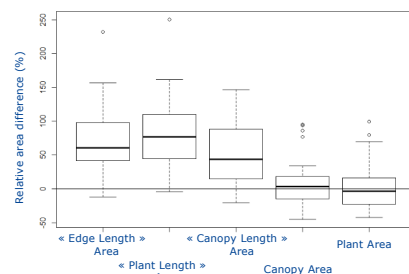
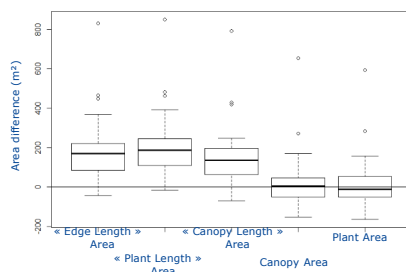
Sample: 25 ETS observation polygons (16 in common with LPIS)

- converted area overestimate polygon area

- All ranges are large

Absolute ($\pm 200 \text{ m}^2$ or more)

Relative ($\pm 40\%$ or more)



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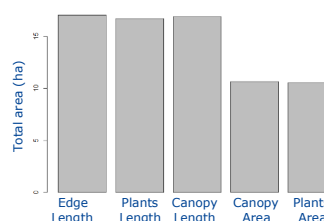
This large range means that not always the same individual field phenomena were measured!

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Comparing the resulting areas

Summing up all measurements:

1. Both polygon protocols are very similar (the gaps have very little impact)
2. All curve protocols are very similar
 1. Edge curve yields the largest overall area
 2. Plant curve area is the closest to the polygon protocols (unlike ETS subset)



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Variation over the years

Basic statistics which were calculated (converted areas for the curves):

- Standard deviation "All images" (**All**),
- Standard deviation "BING" (**BING**), (from another year/season)
- Standard deviation "CwRS/LPIS QA" (**Rest**) (from the same season)
- Bartlett test for equal variability (not shown) but all significantly different.

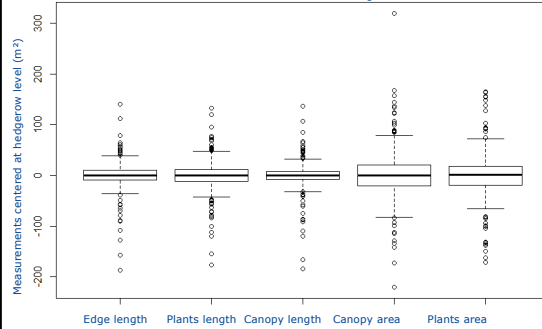
	Edge curve	Plants curve	Canopies curve	Canopies perimeter	Plants perimeter	Canopies area	Plants area
All	31,97 m ²	35,28 m ²	29,56 m ²	11,75 m	12,02 m	51,50 m ²	47,45 m ²
BING	43,09 m ²	53,27 m ²	46,62 m ²	18,63 m	19,02 m	64,76 m ²	63,68 m ²
Rest	27,26 m ²	26,27 m ²	20,98 m ²	8,25 m	8,47 m	45,56 m ²	40,05 m ²

- For curve: multiannual variation is 2X the intra-annual variation
- For polygon: multiannual variation is 1.5x the intra-annual variation

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Variance of the protocols



Protocols	Standard Deviations
Edge Curve	31,97 m ²
Plants Curve	35,28 m ²
Canopy Curve	29,56 m ²
Canopy Area	51,50 m ²
Plants Area	47,45 m ²

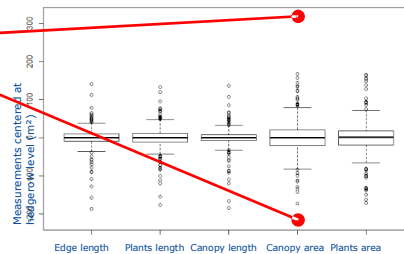
- All curve protocol's variance/SD significantly smaller than any polygon
- No difference between the area protocols
- Plant and canopy curves variance/SD are significantly different
- Edge curve is intermediate

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A warning:

This is from a single operator, using her own guidelines, well supported, very motivated, in laboratory conditions.

still "human errors"



Error prone (too much to be all considered in the analyses)
CLEAR GUIDELINES ARE ESSENTIAL!

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Not straightforward to pick a winner....

Canopy curve

- the lowest variability
- And: Yields the 2nd largest relative area

Edge curve

- The largest relative area (effect of curve ends?)
- Assumed: simplest reproducibility in the field (GNSS)

Plants curve

- Overall intermediate/compromise
- BUT: The highest variability among the curves

Polygon protocols

- intuitive cartographic presentation and compatibility BPS/SAPS
- BUT: low area yield and very high variability for the highest cost

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Lessons learnt

In the customary LPIS setup, EFA Polygon protocols come with higher variance than EFA curve protocols:

1. 2D measurement versus 1D measurement
 - Worse identification precision of individual vertex and more vertices
 - More susceptible to seasonal dynamics (growth/trim)
2. More effect of the 3th dimension of the EFA-element
 - “projected canopy” distorted by oblique views
 - Unstable location of canopy due to perspective displacement
 - Higher phenomena block visibility of phenomena underneath
3. Overall, more susceptible to image radiometry

There are technical solutions to counter these disadvantages but €€

- Multi-temporal acquisitions
- True-ortho (orthorectified with DSM rather than DEM)
- Stereo-restitution

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What to consider for other EFA-types?

- Strips/margins are approached as the edges curve
- Trees (phenomenon) suffer from the 3D effects of canopies
- Tree polygons captures will share the (dis)advantages of the canopy protocols.
- Ditches can be considered topographically inversed hedges
- Conclusions and considerations apply “mutatis mutandis”

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Thank you!

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