l a n d C o n s u l t . d e

Spannstattstrasse 40
D 77773 Schenkenzell
Germany

Tel.: +49-7836-307313
Mobile: +49-170-8988393
Fax: +49-721-151 526 996 (on request)
E.mail Link on http://landconsult.de
Internet: http://landconsult.de

International consortium of geo-scientists, land use planners, forest engineers and computer experts

Date: 15.10.2008

Report on Automatic Detection of Individual Trees and Stand Openings from Quickbird Satellite Imagery

This report summarizes the work and deliverables in brief

by
Dr. Markus Weidenbach
Dr. Roeland de Kok
landConsult.de
Schenkenzell

Table of Contents

1 Project Area

The project area covers some 4.800 ha of a Pinus spec., Eucalyptus spec. and Acacia spec. plantations in Southafrica. The topography is hilly with some riparian vegetation between the plantations. The total processing area depended on the shape of the Quickbird imagery which is about 6.400 ha. The entire plantation is divided in 464 compartments which are often composed of several polygons, i.e. parts of plantations on different locations belonging to one compartmet.

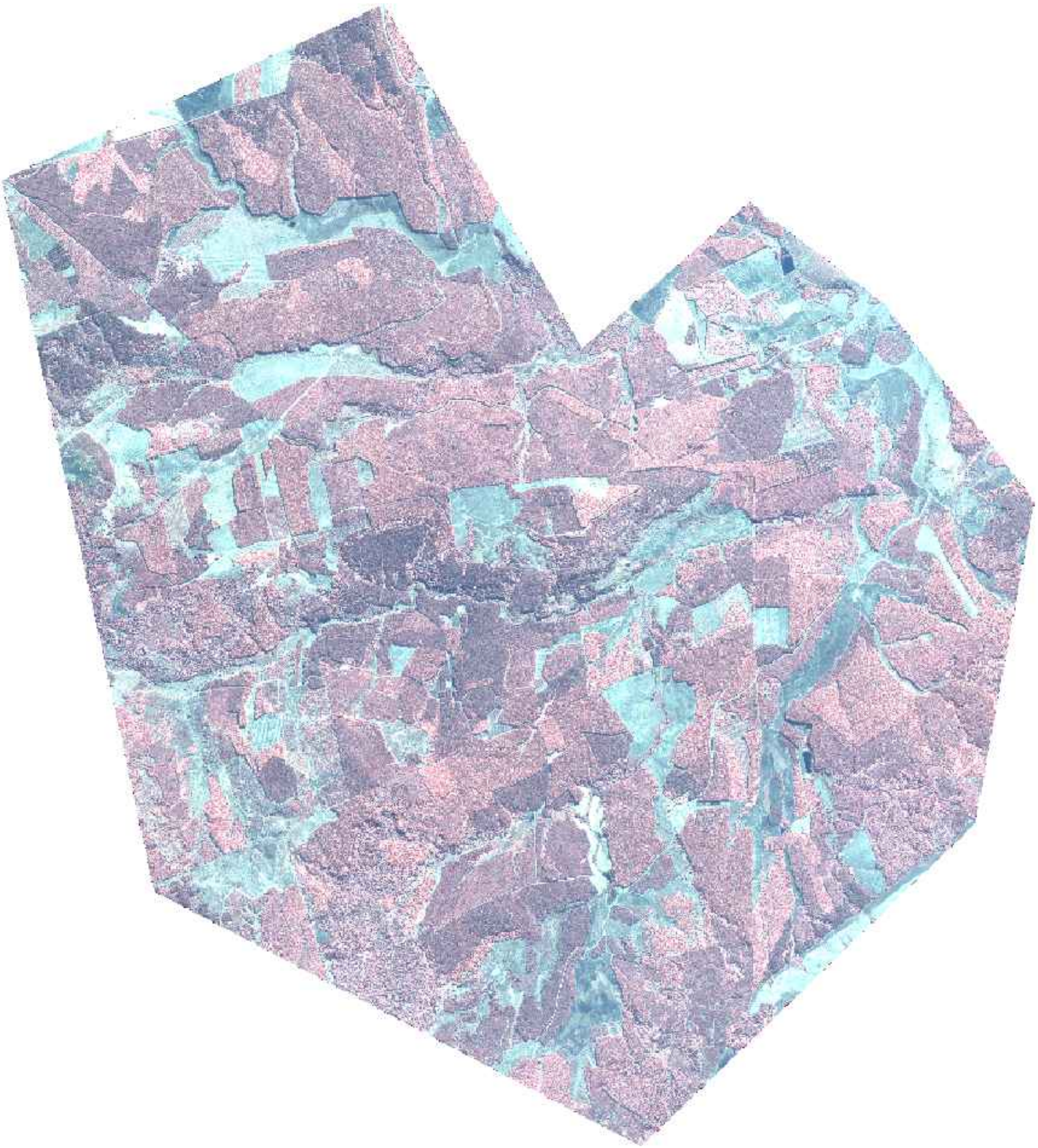


Fig.: Pan-sharpened Near Infrared (NIR) composite, processed from the 240 cm multispectral and the 60 cm panchromatic channels. The composite shows the project area with openings (bluish colours) and planted areas (reddish colours). The file "raster/pansharpened-nir-lowresolution.tif" is a geo-referenced low-resolution copy of the original 800 MB big tif file.

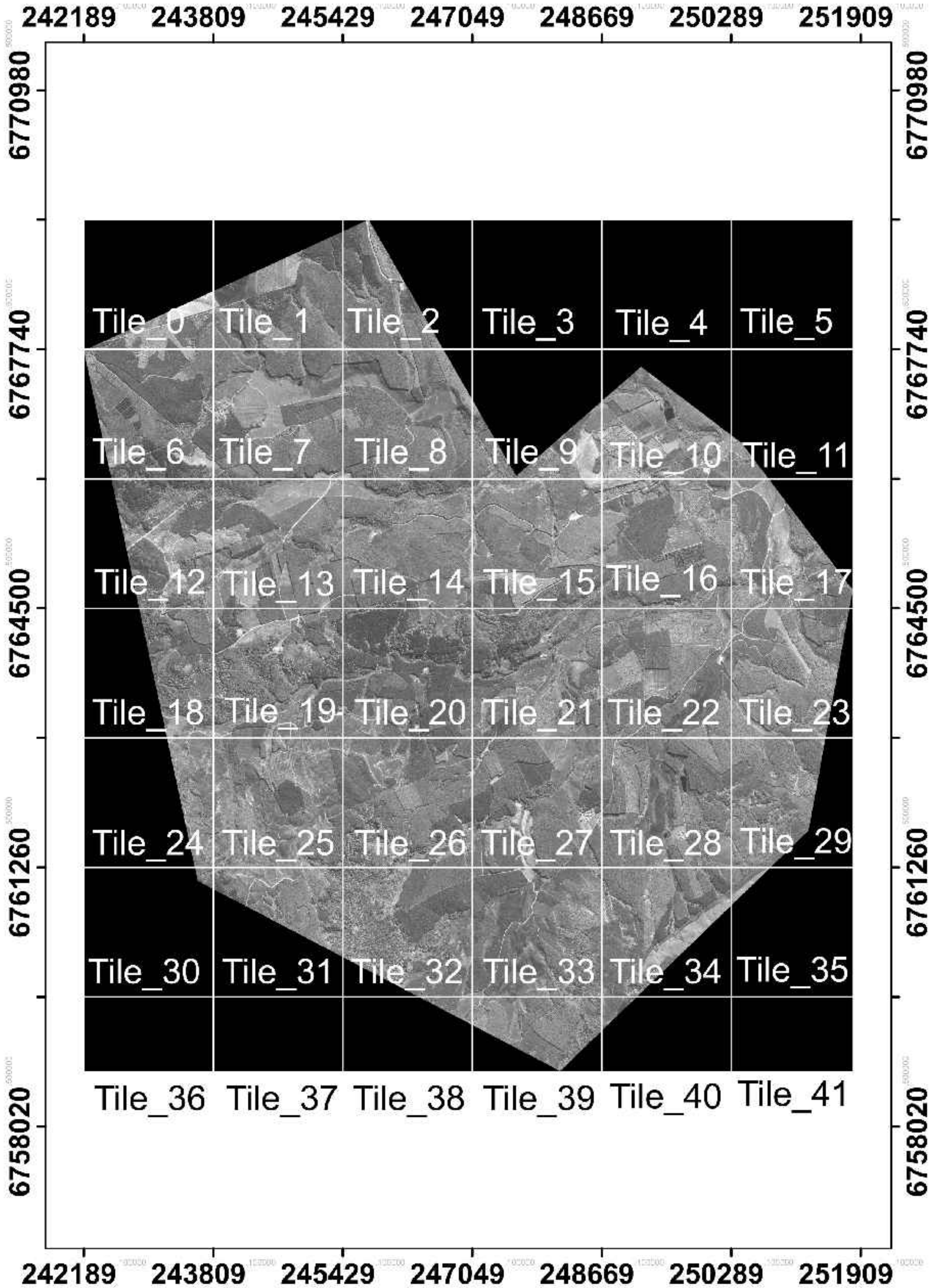


Fig.: The Quickbird Mosaic was organised in different tiles for an efficient data handling. The figure shows the grid "raster/tiles-overview.tif", a lowresolution version of the original Quickbird Pan. Thanks to its smaller size it is suitable as a quick background information in a GIS.

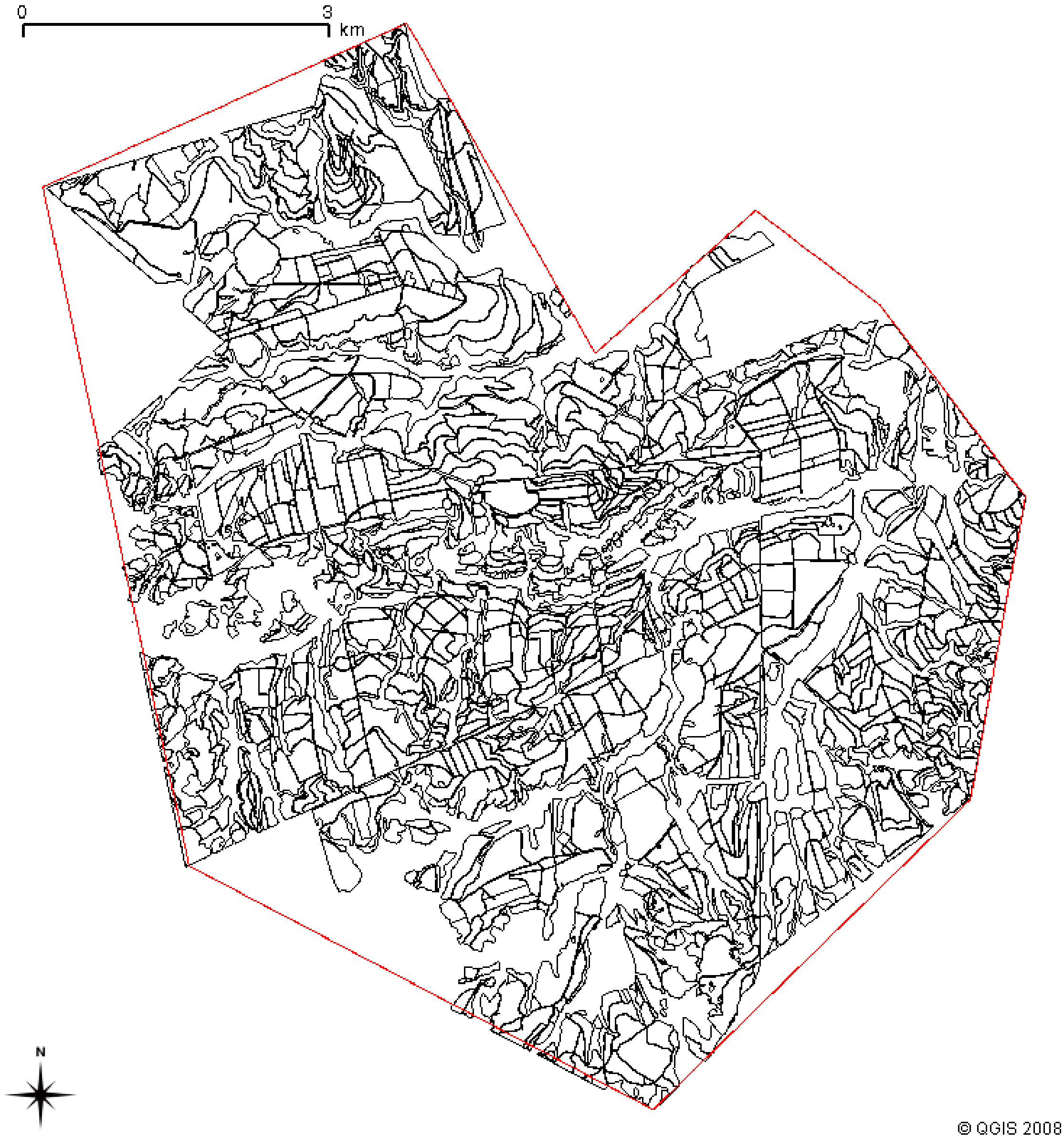


Fig. Showing the compartment polygons in black and the processing area in red (shapes/h_utm.shp).

2 Results

2.1 Automatically detected trees in the reference area

Throughout the entire Quickbird Mosaic some 3.5 Mio. trees have been automatically detected and registered in the attached MS Access database (see /database/trees.mdb) and in different shape files.

2.1.1 Reference area

Shape files:
shapes/h_utm.shp
shapes/h_utm-shifted.shp

The reference area for the compartment-wise analysis are the polygons of the submitted shape file "shapes/H_utm.shp". Unfortunately such polygons are not matching sufficiently the overall geometry of the Quickbird mosaic. This is mainly due to the limited geo-rectification of the Quickbird mosaic (see also chapter Critical Review).
We worked around that problem by shifting the polygons to close the corridors to a minimum, and without changing the geometry of the original shape file at the same time. The resulting shifted polygon shape "shape/h_utm-shifted.shp" has been used to produce the statistics. The results are stored in attribute tables and databases independent from the geometry and can easily be linked (via the OBJECTID or LID item) to the original H_ polygon shapes, no matter if in UTM36S or in Cape_31 projection.

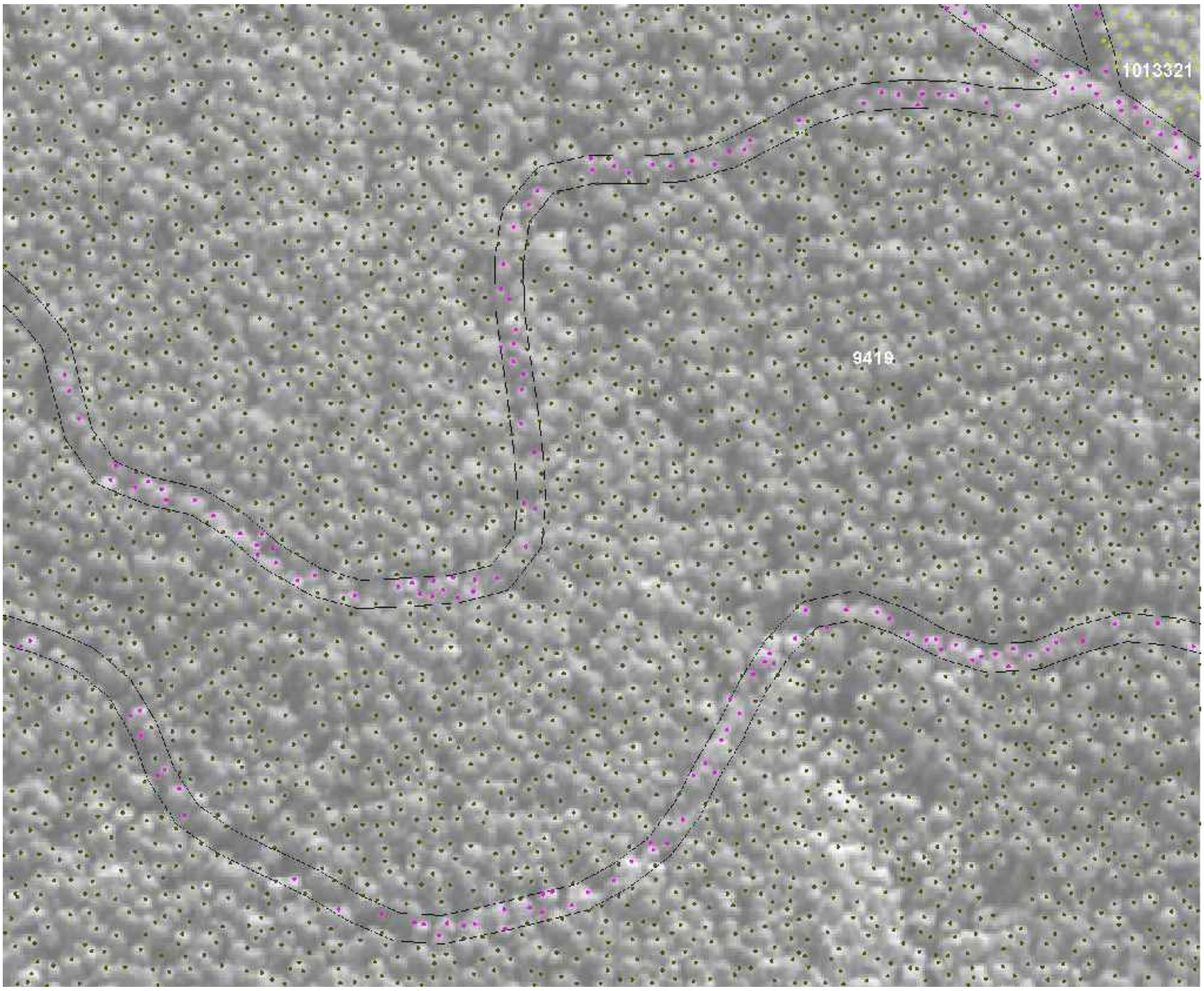


Fig: Due to the specific digitisation of the compartments leaving some 5 - 10 meter wide corridors within closed plantations, one may find some trees in the middle of a plantation, which do not belong to the compartment polygon and consequently are not considered for the statistical analysis (classification of shapes/all-trees.shp with OBJECTID=0 - pink dots, and OBJECTID>0 - green dots).

2.1.2 Detected Trees

Shape Files:
shapes/all-trees.shp
shapes/tiles/tileX-p.shp

It was our intention to process the entire region with one setting of the algorithm. The height information from the original GIS shape file was an important information to stratify the region and fine-tune the algorithm. For the future the tree species could be used as another stratification criteria that will help to improve the results.

The algorithm is designed to accept an error of omission, i.e it rather tends to leave some trees undetected than it classifies to many features as trees.

Detected objects located outside the compartments (classification of shapes/h_utm-shiftedt.shp with OBJECTID=0) have not specifically been researched and are a mixture of individual trees, soil features and others.

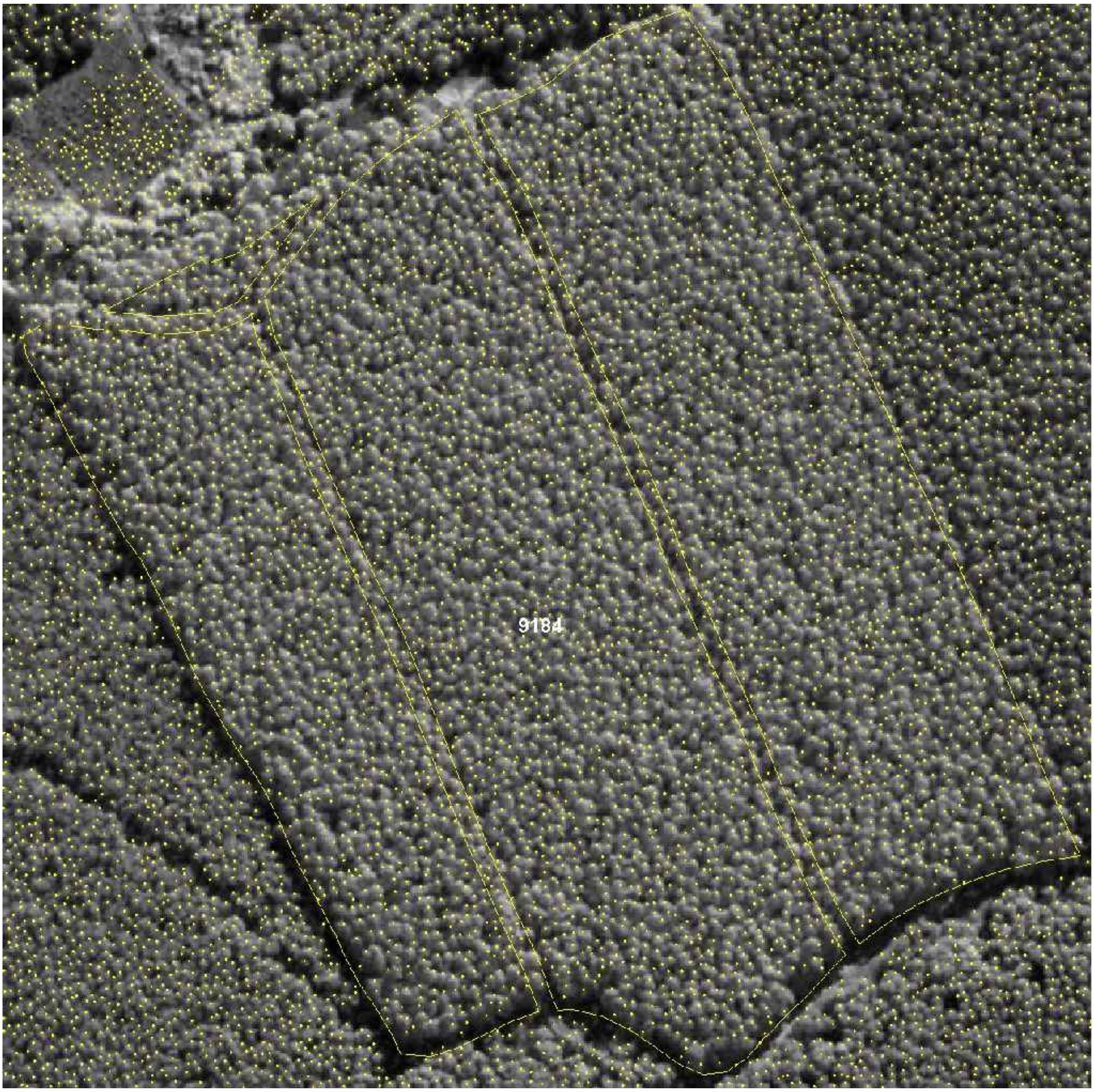


Fig.: Showing a detailed view with detected trees (yellow dots, unclassified from shapes/all-trees.shp) in compartment with LID = 9184. Trees located in the corridors bear the OBJECTID=0 because they are lying outside the polygons and are therefore not considered for the statistical analysis.

In total 2.746.996 trees have been detected inside the official compartment polygons, i.e. inside the shifted polygon "shapes/h_utm-shifted.shp".

737.994 trees and unclassified features are located outside the compartment polygons. They are not considered for the statistics and therefore have not been controlled and checked in more detail.

The shape file shape/all-trees.shp is about 250 MB big and contains all trees - in and outside the compartment polygons.

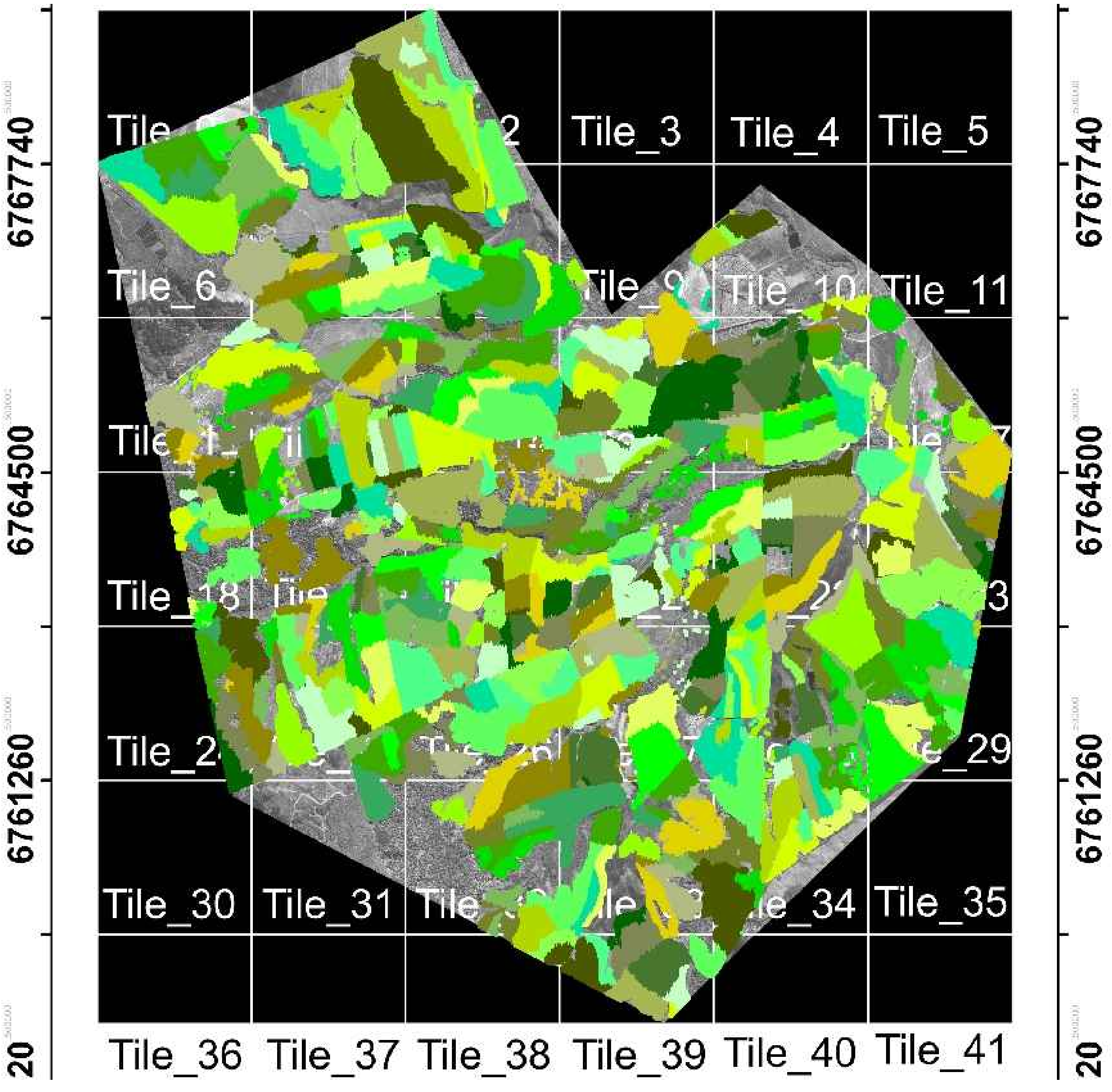


Fig.: Illustrating the shape/all-trees.shp, containing 3.484.990 tree records classified with the OBJECTID item in the attribute table (OBJECTID=0 transparent, OBJECTID>0 colored).

Following shows the structure of the attribute table of the file shapes/all-trees.shp

Shape	OBJECTID	TREE_ID
point	197	3884912
point	197	3884913
point	197	3884914
point	197	3884915
point	197	3884916
point	197	3884917
…	…	…

Table: Excerpt from attribute table of shapes/all-trees.shp. The table is about 100 MB big and contains 3.484.990 records, representing all detected trees. One can link the table to the indvidual tree information in the database (database/all-trees.mdb -- table: all-trees-tile40-0) via the TREE_ID item.

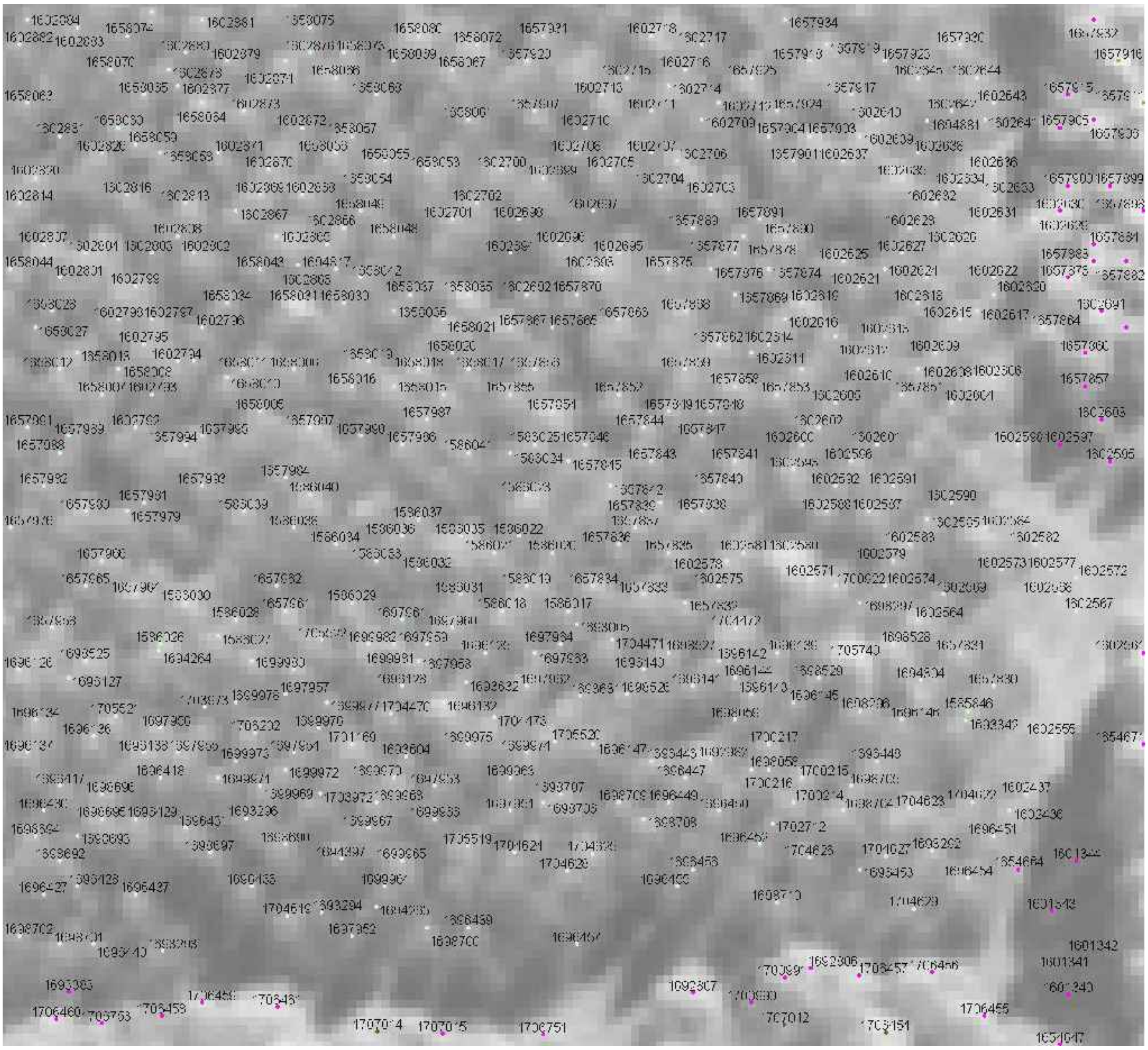


Fig. Each individual tree is labelled with a unique tree-id.

The trees are labelled with a unique TREE_ID and the OBJECTID, which relates to the LID and NAME item of the original H_utm.shp and the shifted polygons shape/H_utm-shifted. The TREE_ID can be used to link each tree to the individual tree information (NDVI, Ratio-red, Height etc.) in the database table database/all-trees.mdb -- table: all-trees-tile40-0.

The OBJECTID can be used to classify all trees according to their location within different compartments (see Fig. above).

The differentiation of "Inside Trees" and "Outside Trees" can be done by classifying all trees in the shape file shape/all-trees.shp using the OBJECTID column. All objects with OBJECTID=0 are outside the borders of the compartment polygons.

2.1.3 Shapes of Tiles Nr. 40 to Nr. 0

Shape and Raster Files:
shapes/tiles/tileX-p.shp (replace X by a number between 0 and 40)
raster/overview

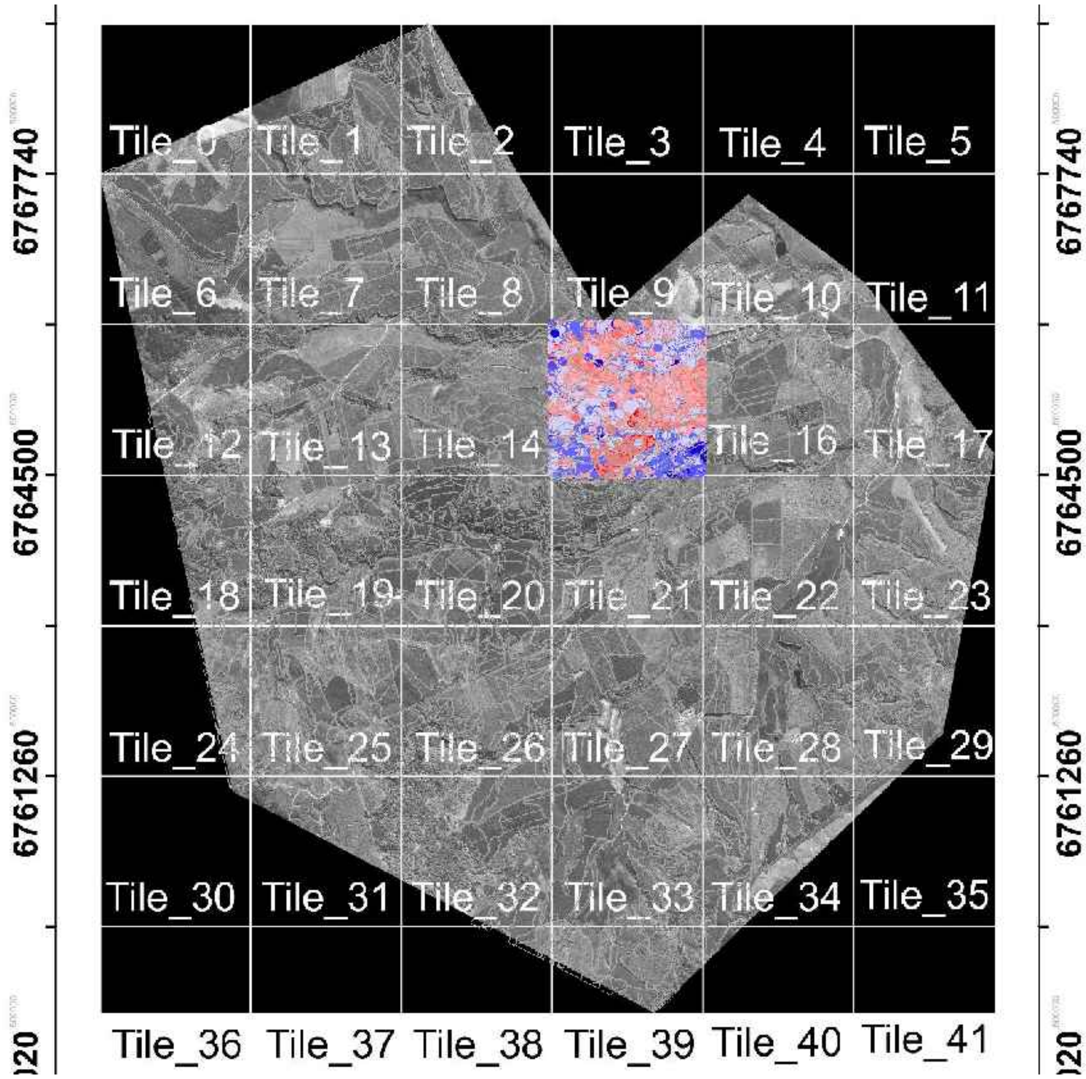


Fig. Showing the tile raster raster/tile-overview.tif and the point shape shape/tiles/tile15-p.shp with the NDVI of the single trees classified by its standard deviation.

The original and smaller shape files are organised in tiles from 0 to 40 and include all detected trees plus information on the NDVI (derived from the 240 cm resolution NIR Quickbird) and the ratio between the red channel and the combination of the Green+Red+NIR+Panchromatic (derived from the 60 cm resolution Quickbird).

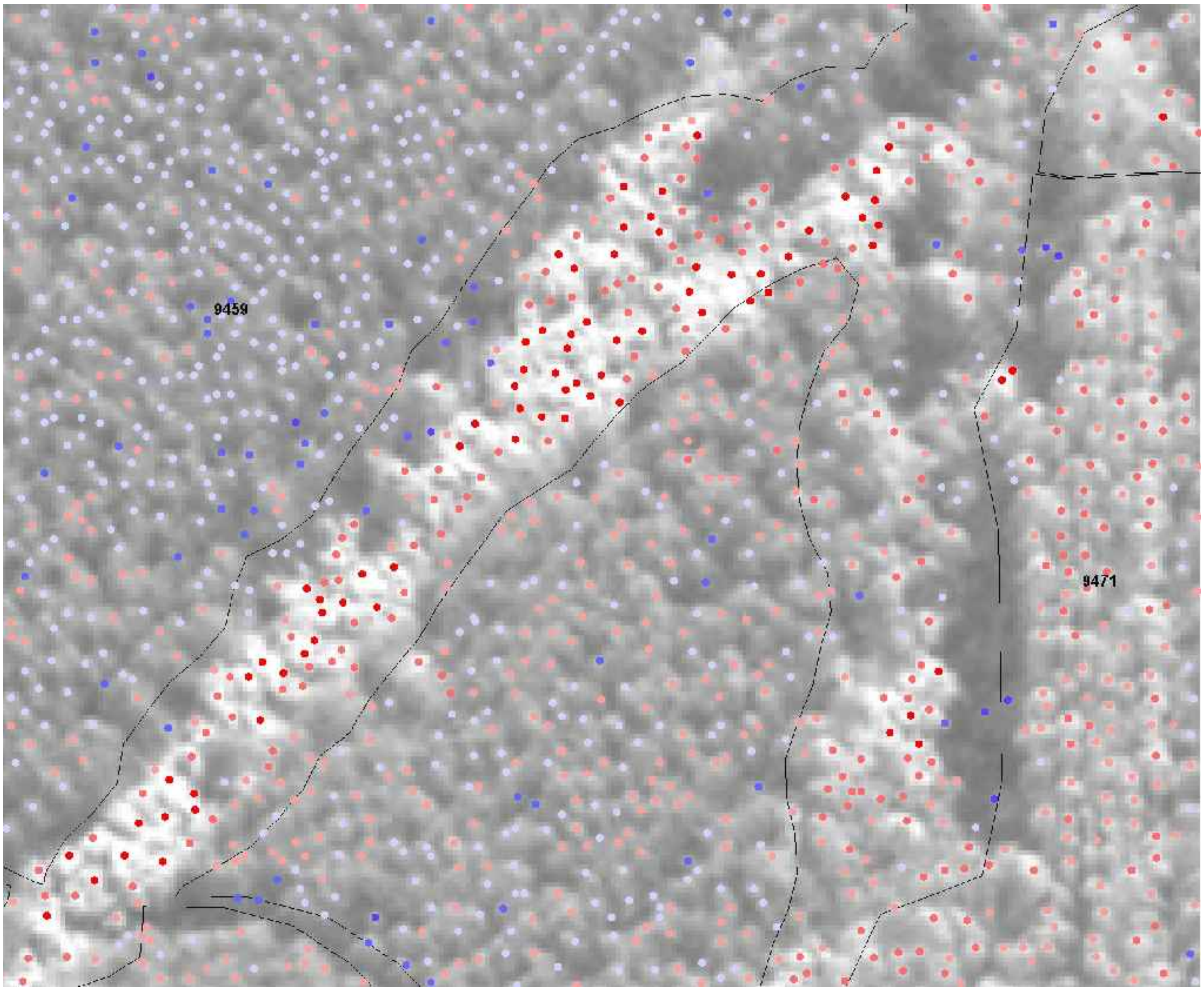


Fig. Showing shape shapes/tiles/tile15-p.shp with trees classified by its NDVI value (Standard Deviation).

Area	MeanHeight	MeanNDVI	Obia-nr	Pine	Ratio-Red	X	Y
0.36	17.42	178.00	219	18	0.10	247644.90	6765248.10
0.36	17.31	195.00	219	18	0.10	247643.70	6765249.30
0.36	18.00	198.00	219	18	0.09	247859.70	6765251.10
0.36	18.00	187.00	219	18	0.10	247870.50	6765270.30
0.36	18.00	180.00	219	18	0.10	247965.30	6765108.90
0.36	16.55	194.00	250	13	0.10	247836.90	6764955.90

Table: Excerpt from attribute table of shape/tiles/tile15-p.shp

Table description:

Area: internal value
MeanHeight: internal value (not necessarily corresponding to the GIS height (DOM_HT)
MeanNDVI: Mean NDVI of the crown area of that tree (derived from 240 cm resolution NIR Quickbird imagery)
Obia-nr (or Obia_nr): equals the unique polygon OBJECTID in the GIS and can be used to link the information to the shape/h_utm.shp file

Ratio-red: ratio between the red channel and the combination of the Green+Red+NIR+Panchromatic (derived from the 60 cm resolution Quickbird)
x;y: X- and Y- coordinates, can also be used to add this table as an x-y-event to the GIS

The shape files use the Item Obia-nr (or Obia_nr) instead of the OBJECTID, but both values are identical and you can replace the column name "Obia-nr" with "OBJECTID". Please note that in the tiles 0, 2, 8, 12, 16 some records of the attribute table are duplicated due to a technical process, this has no effect on the display. There are no duplicates in the final total shapefile "shapes/all-trees.shp" and the database "database/all-trees.mdb" that has been used for the statistical analysis.

2.2 Database

Original Files:
database/all-trees.mdb

all-trees-tile40-0
attribute-table
interior-openings
Interior-openings-per-compartment
Trees-per-compartment-and-ha

Fig. Tables available in the MS Access database "database/all-trees.mdb"

OBJECTID	TREE_ID	PINE_HT	MEANNDVI	RATIO_RED	X	Y	LAYER
206	2910720	0	195.21053	0.09495	245131.81579	6765445.9105	Tile-13-p.shp
289	2945552	0	210.6	0.08672	245131.82	6764506.1	Tile-13-p.shp
324	2056659	20	174.84615	0.10591	245131.82308	6763663.2692	Tile-19-p.shp
200	3846373	24	157.69231	0.10979	245131.82308	6769065.6692	Tile-1-p.shp
197	3881892	0	186.9	0.09998	245131.83	6768387.27	Tile-1-p.shp
170	3629480	0	199	0.09152	245131.83333	6766271.3	Tile-7-p.shp

Fig. Excerpt from database table "all-trees-tile40-0"

The MS Access Database contains the table with all tree records (total of 3.484.990 trees) and the individual tree attributes:
OBJECTID (0 = outside polygons),
TREE_ID (unique number),
PINE_HT encoding the species ("0" = Broadleaf, "1-35" = Pine with number representing the height,
MEANNDVI (mean NDVI of each tree crown),
RATIO_RED
X,Y Coordinates
LAYER (name of the original shape file, stored in the shapes/tiles directory)

In the all-trees-mdb is also a query available to query the table "all-trees-tile40-0" for the statistical analysis.

OBJECTID	COMPT_ID	LID	NAME	SPECIES_ID	ENUMERATIO	HA_NEW	HA_S	TUP_HA	AGE	DOM_HT	SPEC_CODE
0	0	0	OUT3 CC								
1	1020095	1021440	021c*5	Ppat	N	6.0121[illegible]	6.9	0	5.0	5.5	1
2	1054011	9091	01b*5	Ppat	N	0.40264	10	0	1.5	1.5	1
3	1020835	9092	02*4	Ppat	N	9.01352	9	0	7.6	15.8	1
4	1054532	9093	03*4	Ppat	N	5.34326	5.3	0	1.6	1.5	1
5	1046532	9094	04*5	Amea	N	7.96043	8	0	4.5	16.8	3
6	9039	9098	06b*3	Esmi	Y	7.69001	7.9	0	22.6	35.8	2

Table: Showing the "h-attribute-table" used to link different information to other shape files and queries.

Besides the submitted GIS attributes, following have been added:
HA_NEW (compartment size in hectare calculated on the basis of the of the shifted polygons shape/h_utm-shiftet.shp, basically there is no difference to the original shape file shape/h_utm.shp)
SPEC_CODE (1 = Pinus, 2 = Eucalyptus, 3 = Acacia)

Where information was missing or obviously not matching the current situation on-site as visible in the Quickbird imagery, such as AGE or DOM_HT we added data based on our own estimations.

OBJECTID	LID	OPEN_HA	TUP_HA
4	9093	3.24989	0
18	9112	8.19171	0
19	9113	0.28117	0
31	9127	0.01203	0
42	9146	2.02251	0
44	9151	2.53477	0
45	9152	0.58738	0
48	9156	10.72207	14.6
49	9157	3.09218	0
50	9177	3.59565	0
51	9178	0.06536	0
62	9191	19.80494	0

Table: Showing the results of the statistics for interior openings (not considering a buffer zone of 12 meters around the compartment)

OBJECTID, LID (unique polygon Ids)
OPEN_HA (openings per compartment in hectare, considering only the interior area)
TUP_HA (temporarily unplanted, values from received from GIS)

2.2.1 Linking the database with the GIS

There are two ways to bring the data to the GIS:

(a) use the x,y columns in the database table to add an event theme to the GIS
(b) link the GIS shape files, such as shape/h_utm.shp directly to the OBJECTID or LID and the shape/all-trees.shp directly to the Tree_ID item in the table "all-trees-tile40-0".

2.3 Statistical Analysis

The statistical analysis was performed by means of the database query "database/all-trees.mdb -- query: trees-per-compartment-and-ha". The results are visualised in following shape files.

2.3.1 Shape File and Attribute Table with Tree Count Results

Original Files:
shapes/trees-per-copmartment-and-ha.shp
table/trees-per-compartment-and-ha.xls

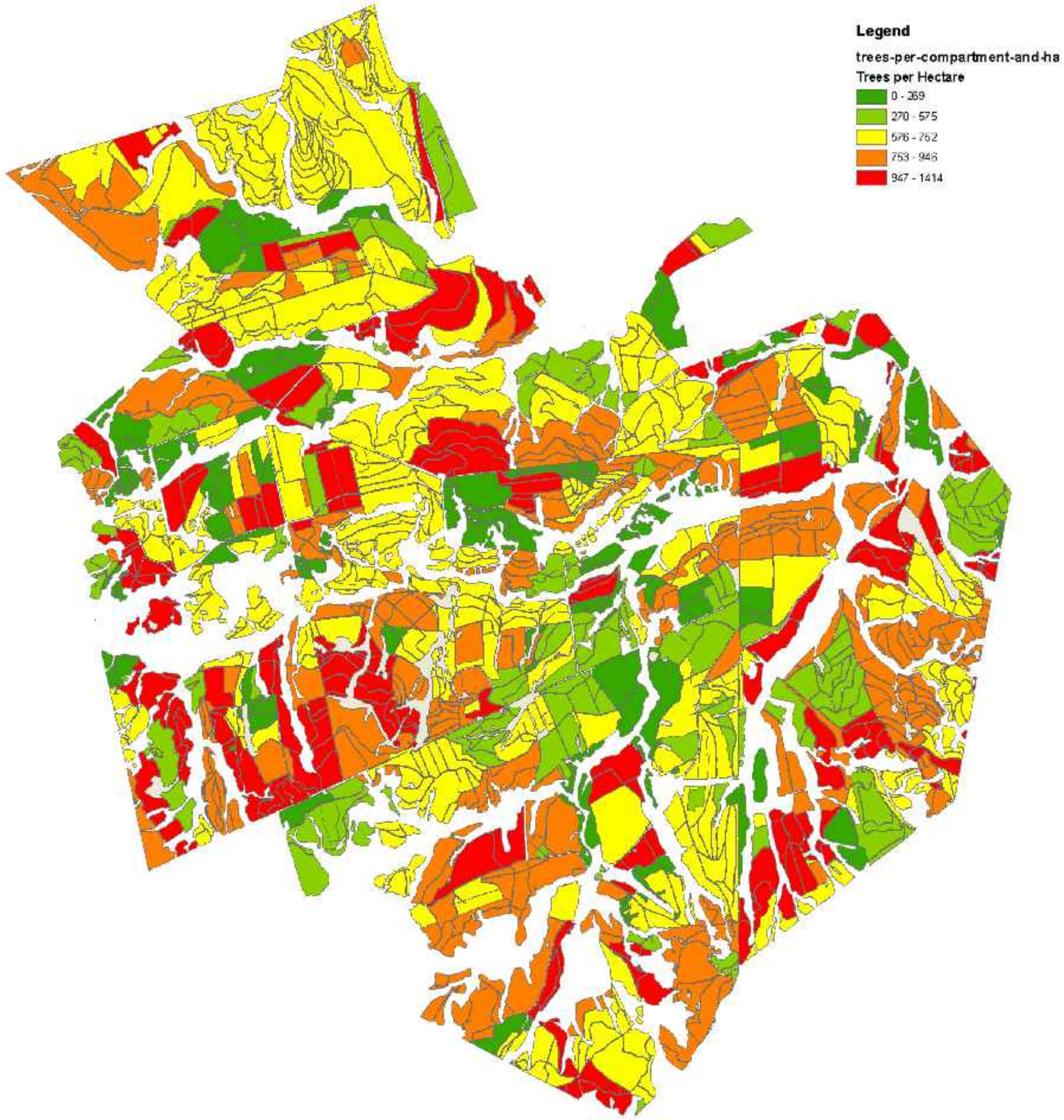


Fig.: The map illustrates the results of the statistical analysis, the trees per hectare and compartment (shapes/trees-per-ha-and-compartment.shp).

Even a small mismatch between the Quickbird image and the shifted compartment polygons can influence the statistics, which becomes obvious in mismatching polygons classified as unplanted areas, but including some trees from neighbouring plantations at the same time. This is illustrated in the following figure:

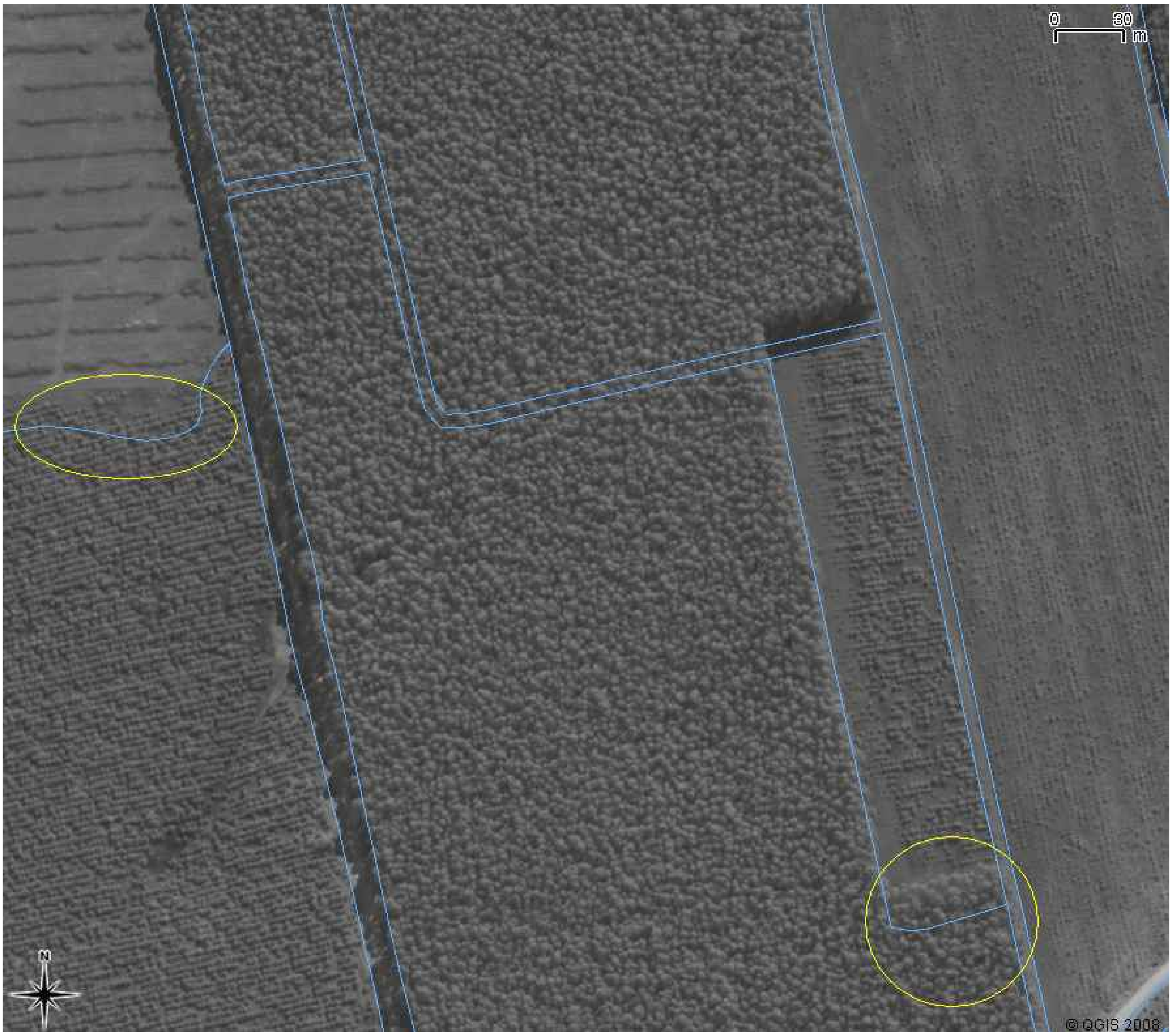


Fig.: The yellow circles outline problematic areas, where a mismatch between compartment polygons and Quickbird Image will influence the statistic: the computer counts trees in unplanted areas, such as the one in the upper left.

The following attribute table of the shape includes different information, which an be used to vary the visualization of the shape.

OBJECTID	LID	NAME	TREES	HECTARE	SPECIES	HEIGHT	TUP_HA	PERHA	SHAPETILE1	SHAPETILE2
1	1021448	D21c*5	4913	6.31	Ppat	10	0.0	779	Tile-32-p.shp	Tile-32-p.shp
2	9091	C1b*5	8542	8.48	Ppat	2	0.0	1007	Tile-11-p.shp	Tile-11-p.shp
3	9092	C2*4	8055	9.02	Ppat	16	0.0	893	Tile-17-p.shp	Tile-17-p.shp
4	9093	C3*4	97	5.34	Ppat	2	0.0	18	Tile-16-p.shp	Tile-16-p.shp
5	…	…	…	…	..	…	…	…	…	…

Table: Attribute table of shapes/trees-per-ha-and-compartment.shp with statistics of trees located inside the shifted compartment polygons. The complete table with all 464 compartment records is part of the Annex

OBJECTID = Unique ID of compartment polygons (minimum 0, maximum 464). This ID has a one-to-one relation to the LID and the NAME column. Because of its short 2 byte form, it was the preferred unique ID for the GIS processing of the compartment polygons. The shape files organised in tiles from 0 to 40 carry the Obia-Nr item, which equals the OBJECTID.
Pleas note: all features labelled with an OBJECTID = 0 are representing objects and trees outside the shifted compartment polygons (H_utm_shifted.shp) and are not considered for the statistical analysis.
LID = Unique ID for compartments
NAME = Name of the compartment
TREES = Number of trees detected within the shifted compartment polygon. Note, that we used the shifted polygons for the statistical analysis to better match Quickbird image and compartment polygons.
SPECIES = Tree Species Abbreviation from client
HEIGHT = Dominant Height from client (DOM_HT). This information has been used to stratify the project area and to fine-tune the algorithm, so please note that missing or not updated heights have been updated with our own estimations.
TUP_HA = Size of temporarily unplanted areas in hectare.
PERHA = Trees per compartment and per hectare. Due to the fact, that even after shifting the original polygons of the compartments to better match the Quickbird imagery, there was still a critical amount of automatically detected trees, which were not covered by the adjusted polygons and hence were not considered for the statistics. in order to minimise this error we decided to normalise the total of trees with the compartment size and give the trees per ha.
SHAPETILE1, SHAPETILE2 = Indicating in which shape files you can find the detected trees, if the compiled shapefile "shapes/all-trees.shp" (about 100 MB big) is too big to handle and join it with the database table "database/trees.mdb - table: all-trees-tile40-0".

2.4 Density Grid and Mapping of Interior Openings

Original Files:
raster/tree-density_esri-ascii-grid.asc (Tree density Grid in Export Format)
shapes/interior-openings.shp
table/interior-openings-per-compartment.xls

We used the tree density to map unplanted areas. The tree density calculation process is searching within a 15m radius for the presence of trees from the shapes/all-trees.shp. The result is a 240 cm resolution grid (available in the export format raster/tree-density_esri-ascii-grid.asc) with values between 0 and 1881, indicating the number of trees per ha.
In a more advanced way, the tree density should be normalised by the tree height, in order to better address the specific stand conditions of old and young plantations.

Fig.: The Tree Density Grid (raster/tree-density_esri-ascii-grid.asc) has been calculated with the point file "shapes/all-trees.shp" and shows areas between 0 and 1881 trees per ha.

For the calculation of openings, only areas inside a plantation (that's why we have chosen the term "interior openings") and pixels with less than 160 trees/ha have been considered. These parameters and the setting for the density calculation can be changed at any time to meet the needs of the plantation owner.

In order to remove the effect of plantation borders, where naturally the density of trees decreases, and in order to mitigate the geometrical inaccuracy between the Quickbird image and the compartment polygons, we decided to shrink the shifted polygons by a 12 meter broad buffer zone. Doing so we masked an area where no processing took place.

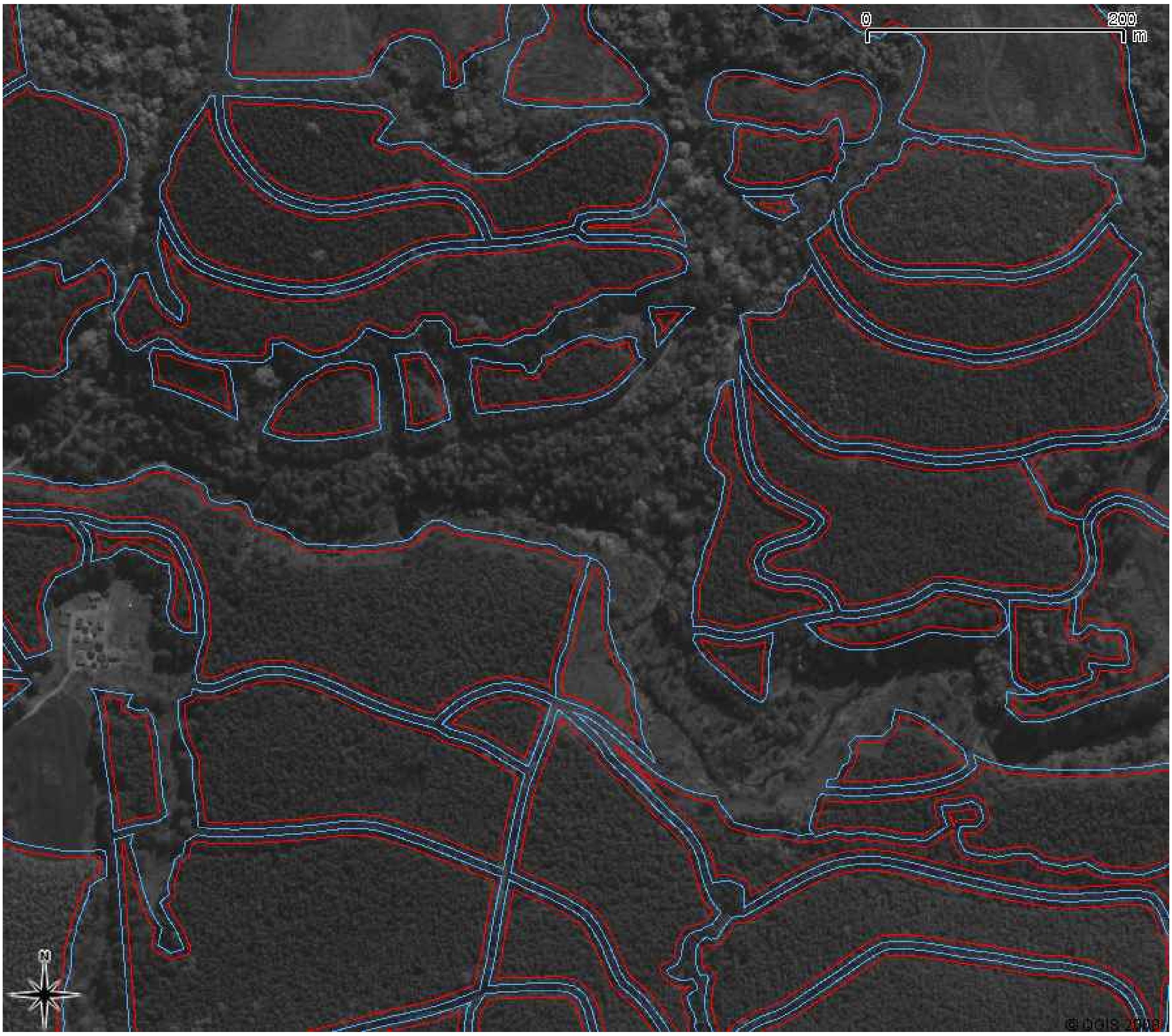


Fig: Showing the Quickbird Pan with the shifted polygons in blue and the decreased polygons in red.

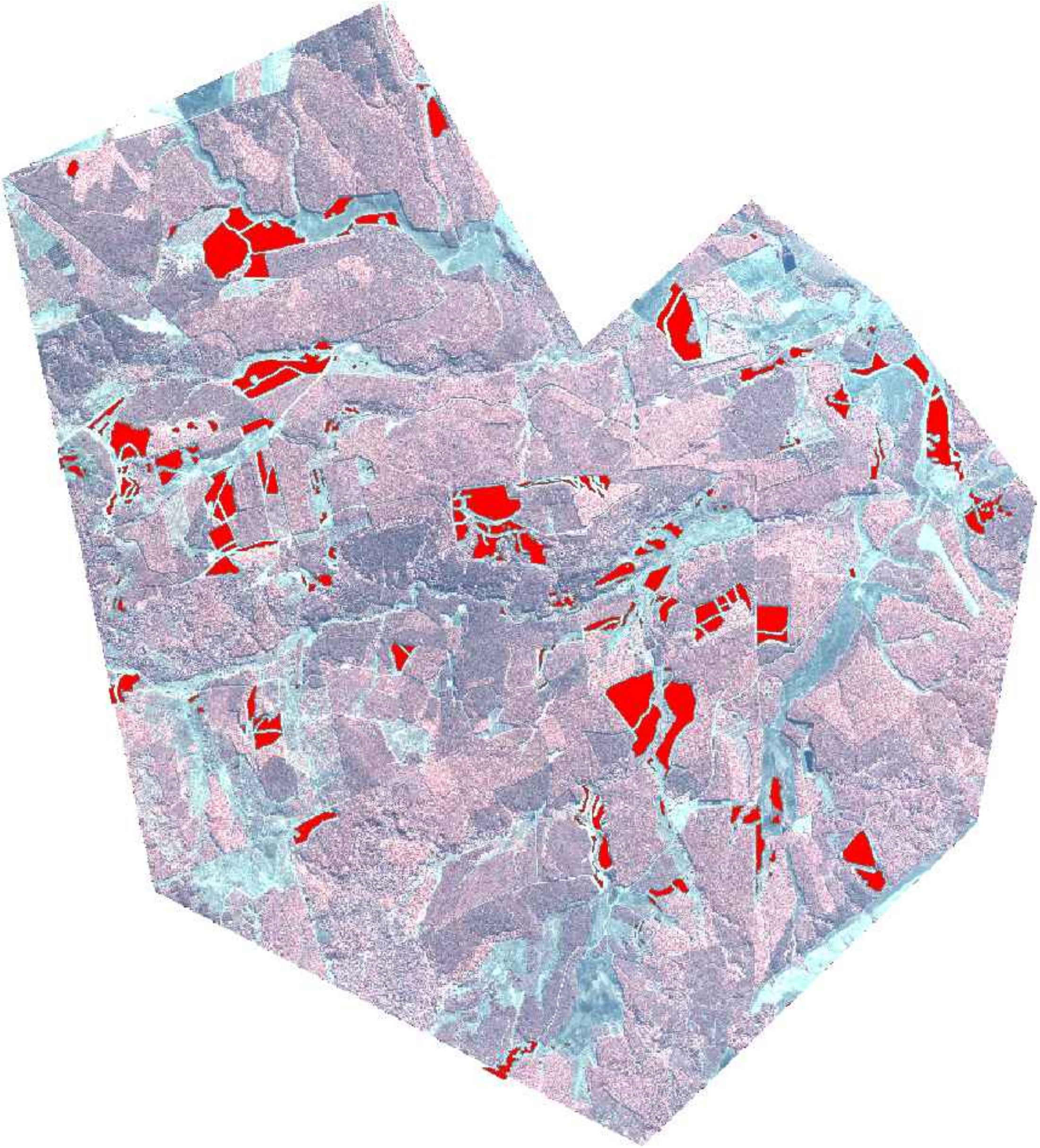


Fig.: Showing the results of the mapping of Interior Openings (red polygons from shape/interior-openings.shp) on the pan-sharpened NIR composite (raster/nir-pansharpened-lowresolution.tif). The red polygons refer only to areas at least 12 meter inside the plantations, including temporarily unplanted areas (in the GIS marked with the TUP_HA item.

OBJECTID	LID	HECTARE	TUP_HA
4	9093	3.25	0.00
18	9112	8.19	0.00
19	9113	0.28	0.00
31	9127	0.01	0.00
42	9146	2.02	0.00
44	9151	2.53	0.00

Table: Excerpt of tables/interior-openings-per-compartment.shp. The complete table is part of the Annex.

3 Critical Review

The basic data were the 4 channels of a Quickbird imagery acquired on 9th Sept. 2008 and the GIS shape file and attribute table from the client, submitted on 22.09.08.

3.1 Radiometry

The Quickbird imagery is a composite of at least three stripes, resulting in heterogeneous radiometric conditions.

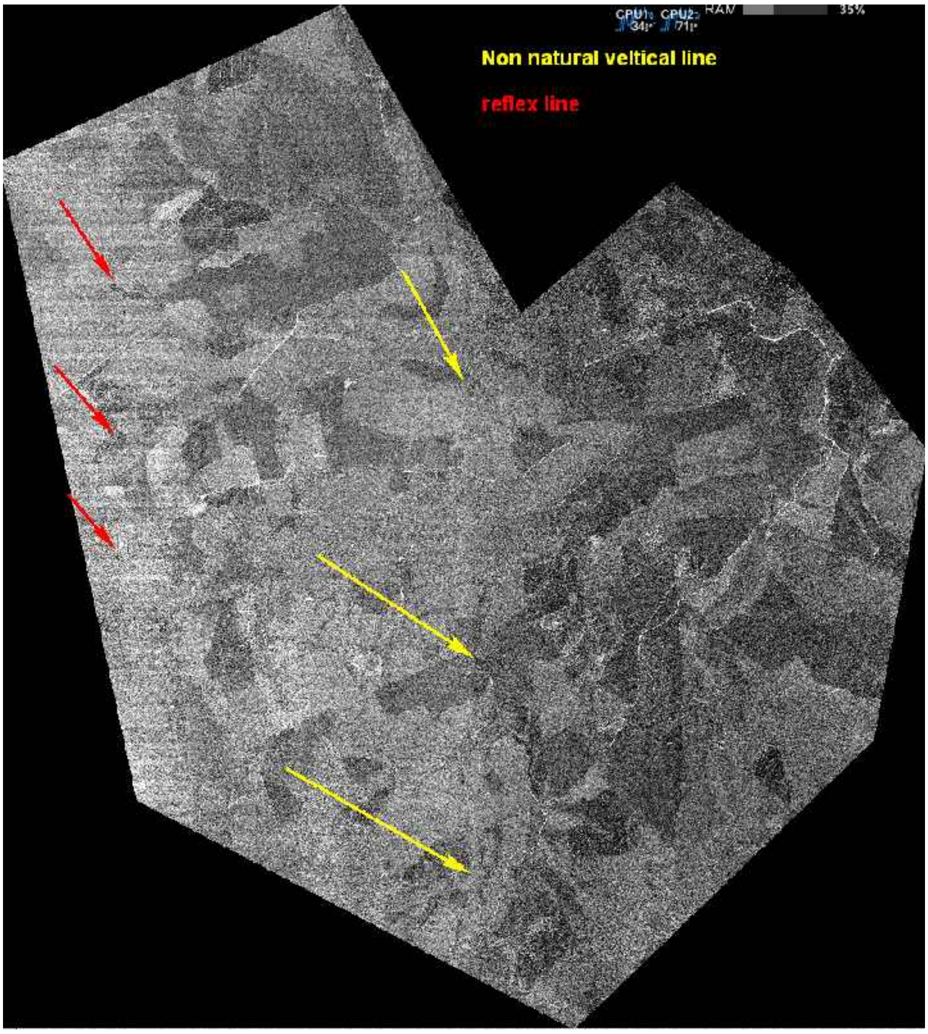
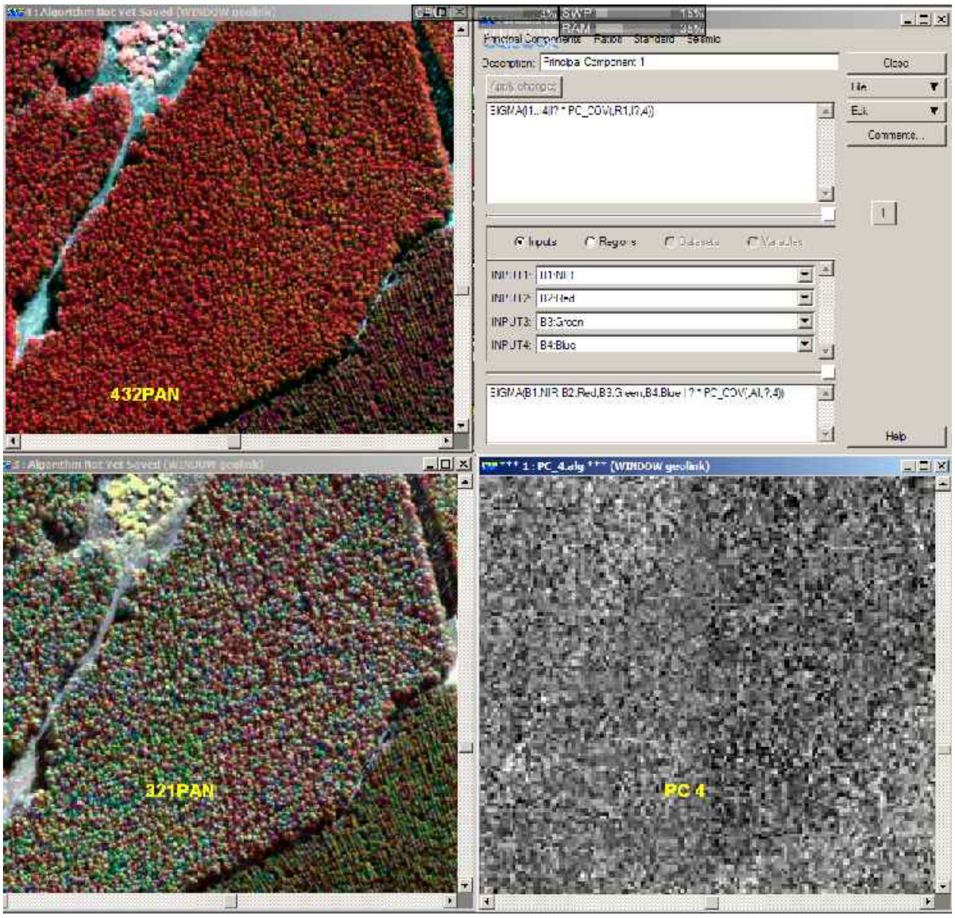


Fig. Indicating the borders of the different stripes within the composite



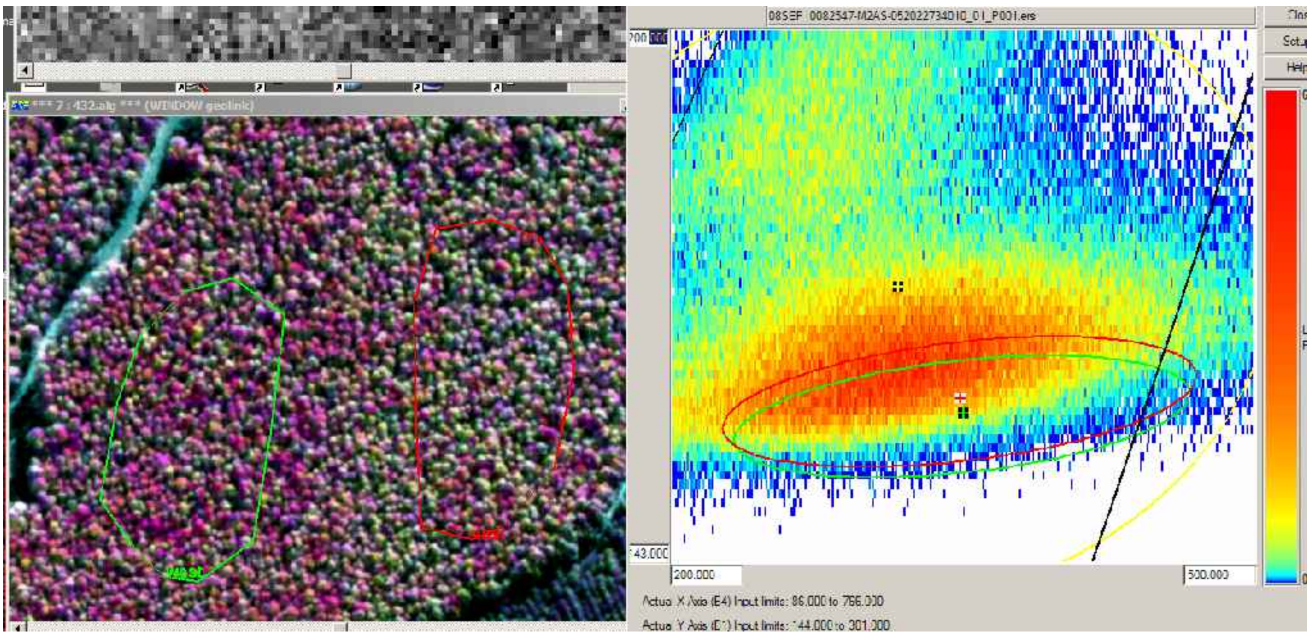


Fig. Illustrating radiometrical differences within the Quickbird Mosaic

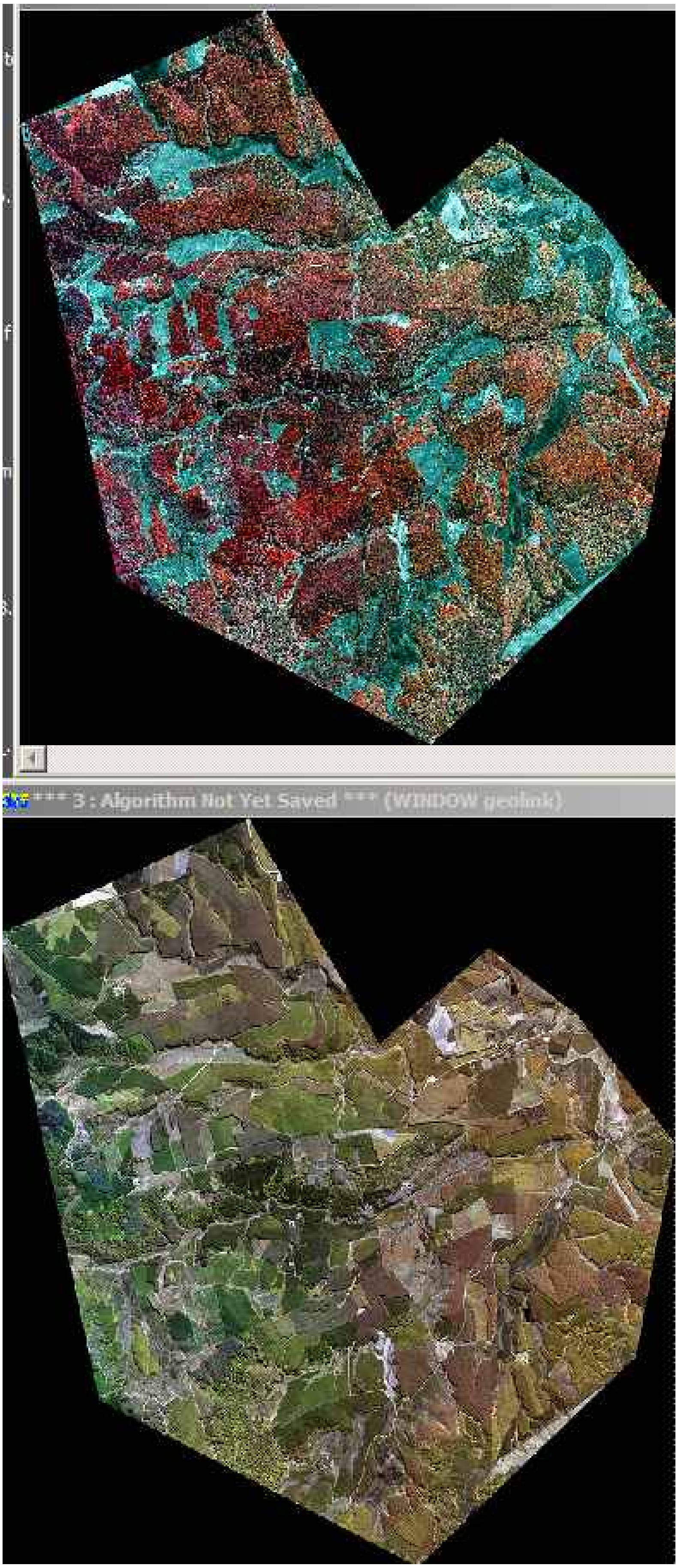
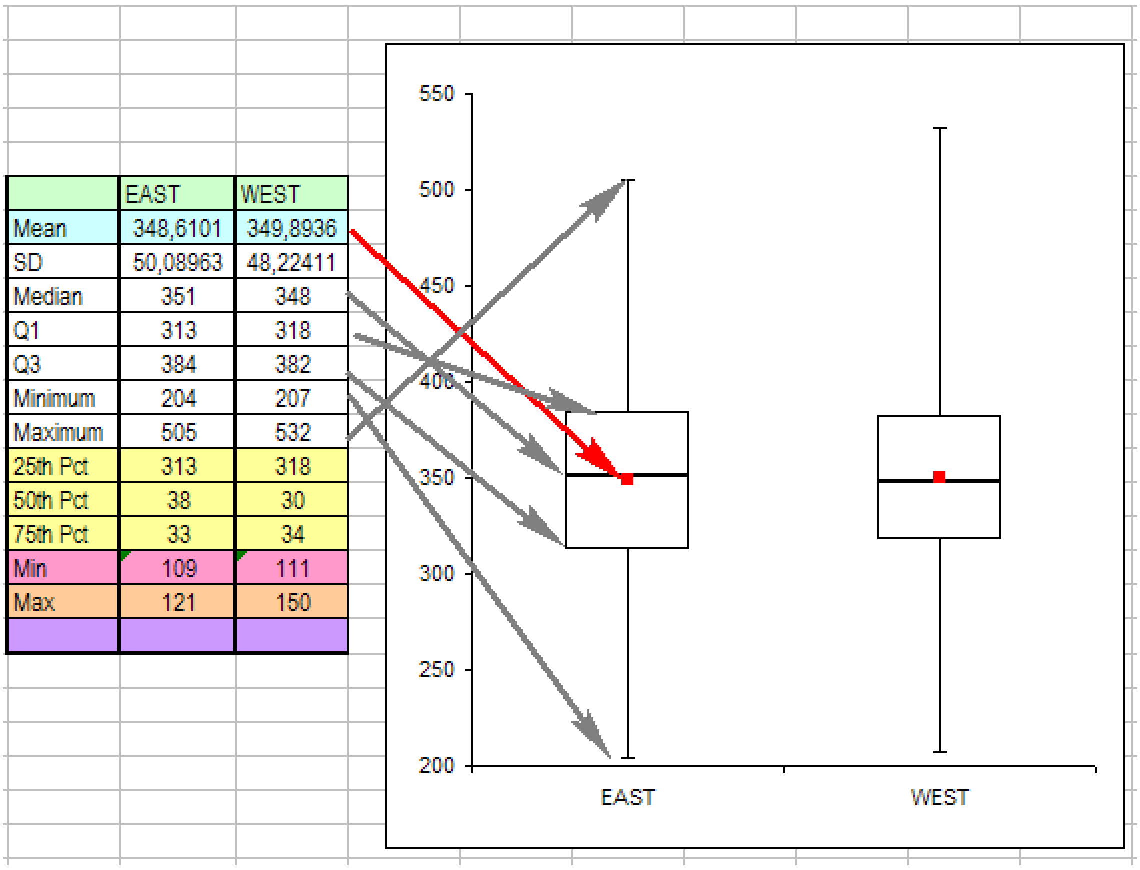


Fig. Illustrating spectral differences between the east and west part of the imagery.



	EAST	WEST
Mean	348,6101	349,8936
SD	50,08963	48,22411
Median	351	348
Q1	313	318
Q3	384	382
Minimum	204	207
Maximum	505	532
25th Pct	313	318
50th Pct	38	30
75th Pct	33	34
Min	109	111
Max	121	150

Fig. Spectral and radiometric differences between east and west part of the mosaic

3.2 Geometric Accuracy

The imagery is projected in UTM Zone 36 South and has a slight shift towards the x and y axis, which is not unusual for this processing level. An exact geo-rectification of the imagery is not possible without a digital elevation model and reliable ground control points (GCPs). This shift increased the problem of matching the GIS shape file with the Quickbird image.

The GIS shape has been re-projected from the regional "TM Cape 31" projection to the common UTM Zone 36 South projection. The matching of the shape file and the Quickbird imagery differs throughout the imagery, in some areas the polygons fit better than in others.

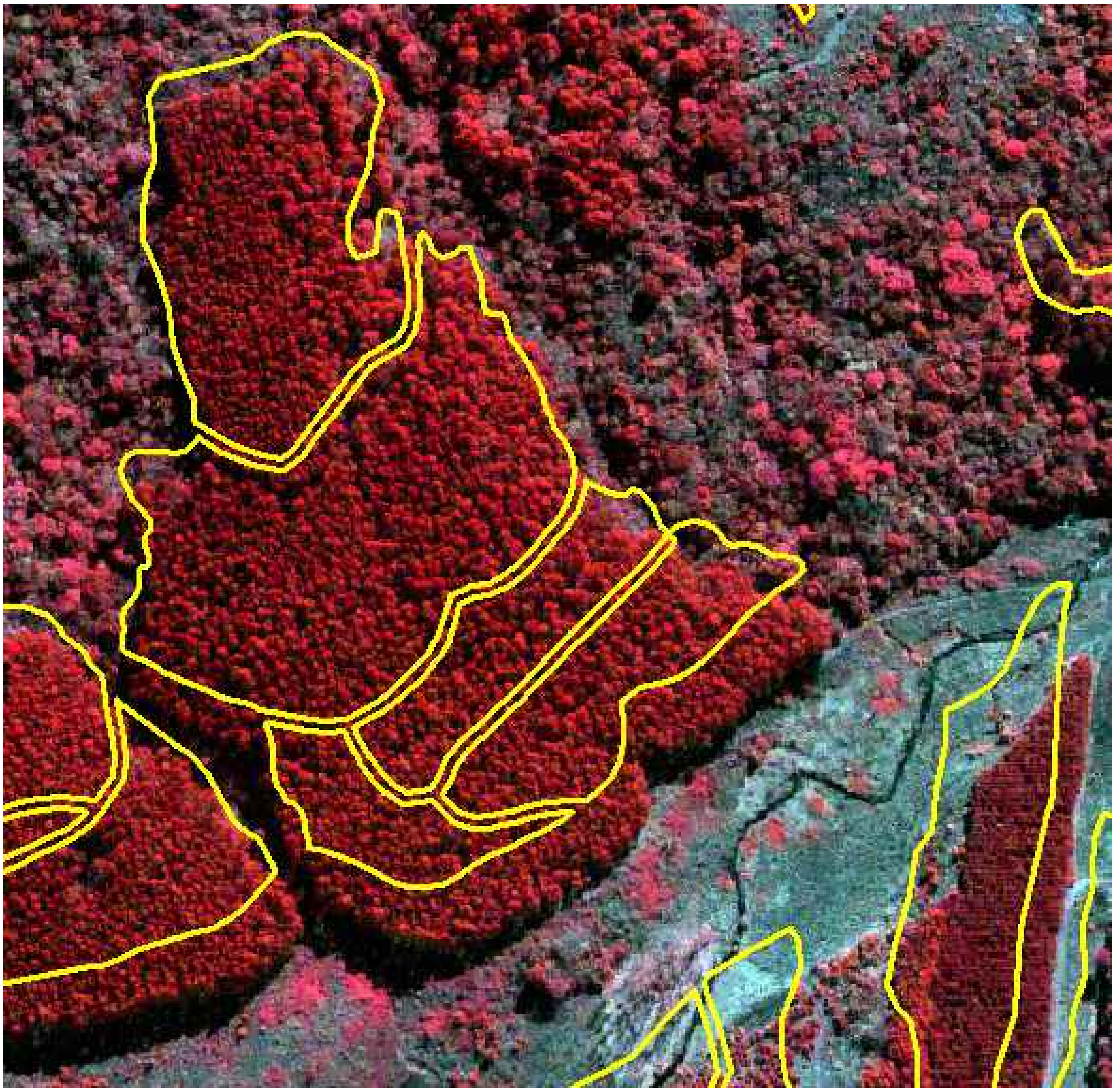


Fig.: Mismatch between Quickbird Image and compartment polygons.

In general the match was not good enough for a tree-wise analysis, and we decided to shift the polygons group-wise and manually to better fit the Quickbird mosaic. Alternatively, the geo-rectification of the Quickbird was not possible due to missing a detailed elevation model and accurate ground control points. In general this process is feasible, by using orthophotos and existing elevation data, but it has to be coordinated with the client.

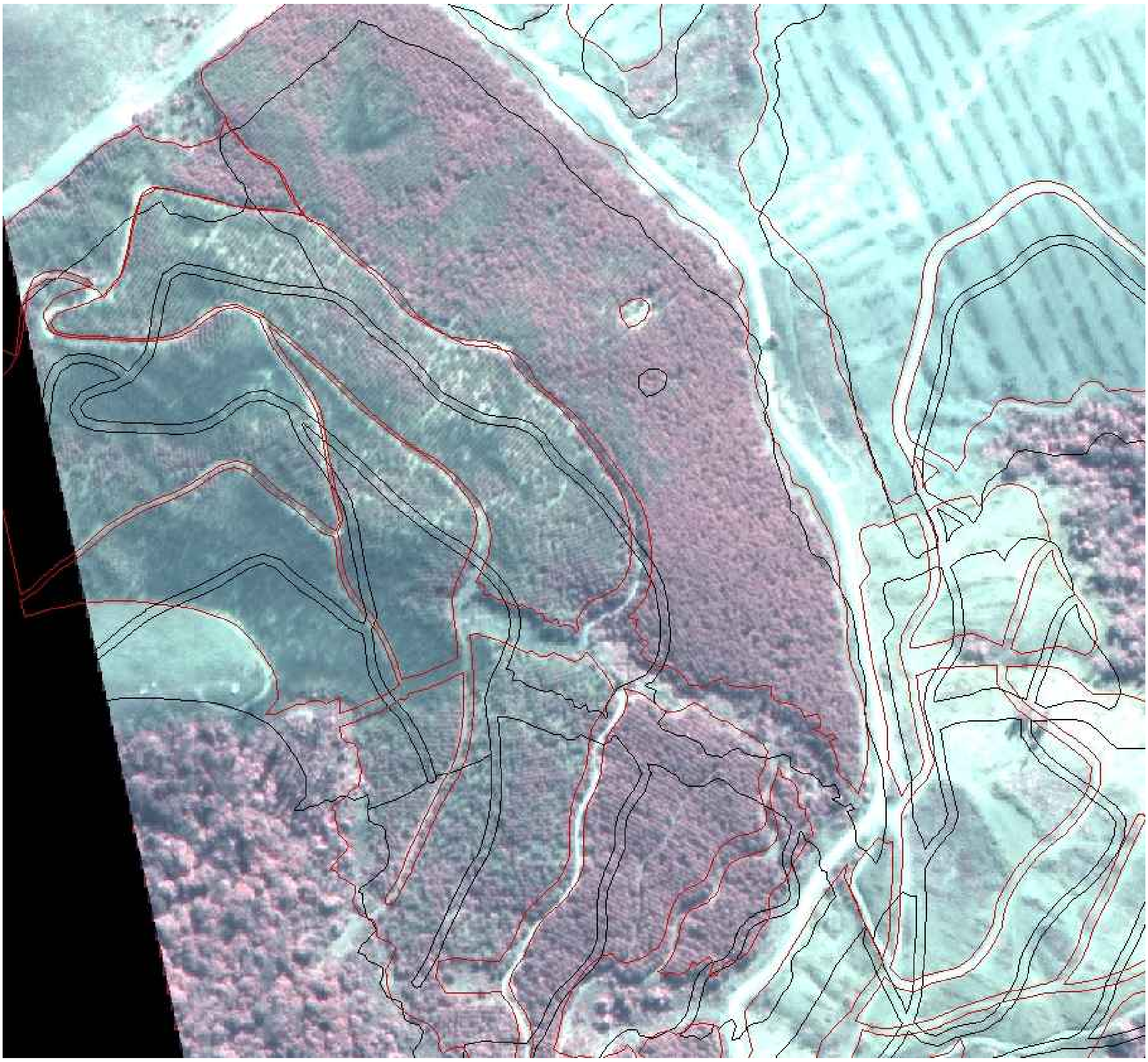


Fig. The black lines represent the original shape file of the client, the red lines show the manually shifted polygons.

Doing so, we could also decrease the impact of relatively large corridors between the individual polygons. Such "corridors" stem from the digitising procedure and are not considered to be "best practice" since they distort the real plantation area by not considering a critical amount of trees and forested areas.

3.3 Attribute Tables

The attribute table of the GIS shape file was not fully consistent; where necessary the height has been estimated and updated on our own assessment.
The attributes, namely the tree height, are essential information to stratify the data for a more efficient processing. Missing and not updated data affects the accuracy of the results.

3.4 Tree Count Results

After adjusting some of the algorithm settings we could improve the results for the submitted control sample compartments significantly. For the compartments, where the client counted the trees we achieved following mean detection rates:

Pinus spec: 96% (ranging from 83% to 111%)
Acacia spec: 79% (ranging from 73% to 90%)
Eucalyptus spec: 61% (ranging from 50% to 90%)

A detailed description on the adjustments we made and the data one can use to control our results are given at the end of this document.

Although we think, that the detection rate of the pinus plantations is acceptable, we are still not satisfied with the rate of the eucalyptus trees, which vary between 50 and 90%.

The following figures may illustrate the problem we are facing:

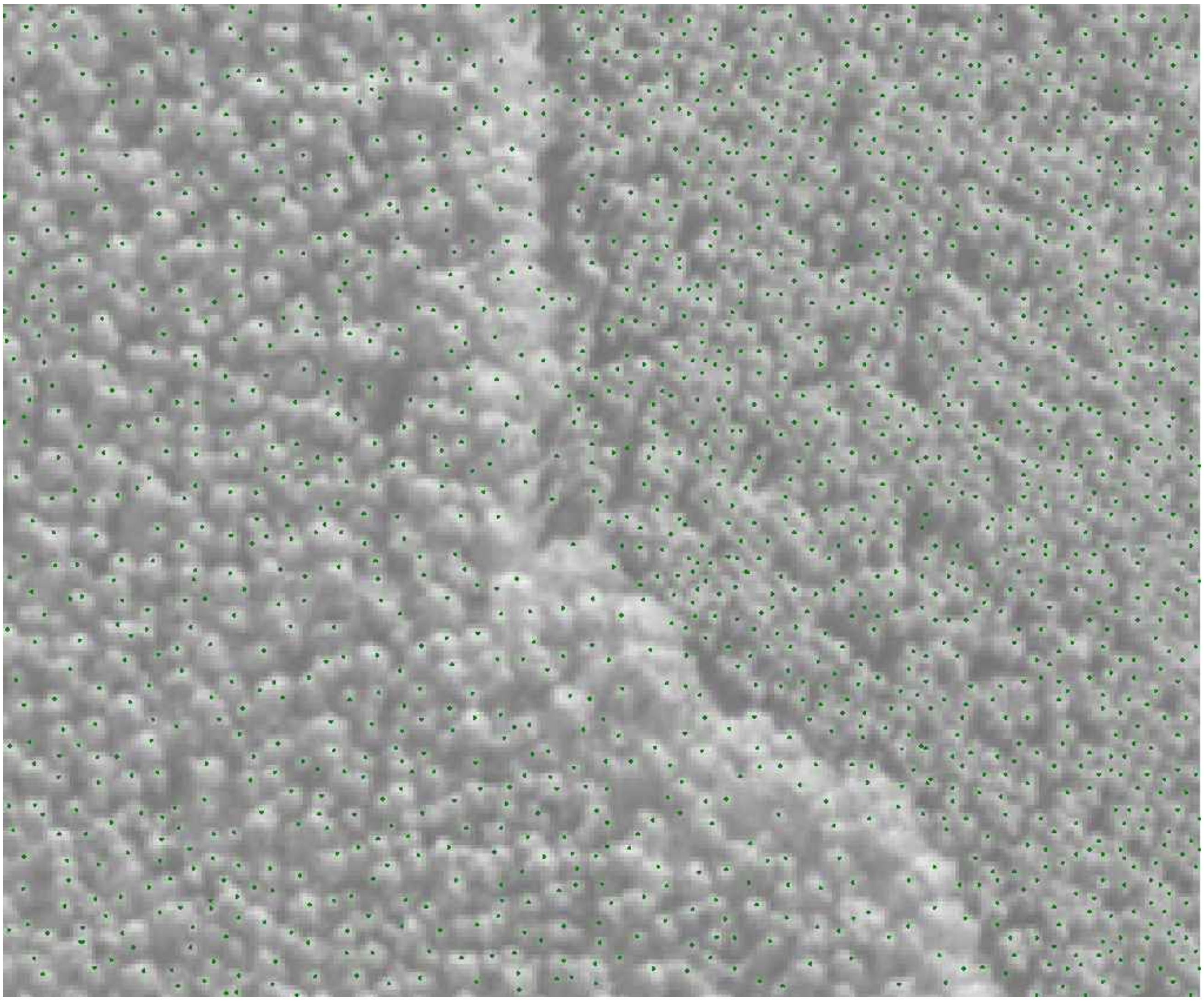


Fig: Quickbird 60 cm Pan. The left part shows a part of compartment with OBJECTID 117 with a 32 m high Eucalyptus Smithii (Esmi) plantation. On the right you see a 17 m high pinus stand (OBJECTID 118). The green dots represent the automatically detected trees.

A visual and manually interpretation of the left and right compartment would assess that at least 80% of all visible tree crowns has been automatically detected (green dots). In fact the results of the field survey showed, that only 37% of all eucalyptus trees in the left compartment has been detected (old algorithm settings), whereas the detection rate of the pinus stand on the right is more than two times higher (referring to the mean detection rate in pinus stands of over 80%).

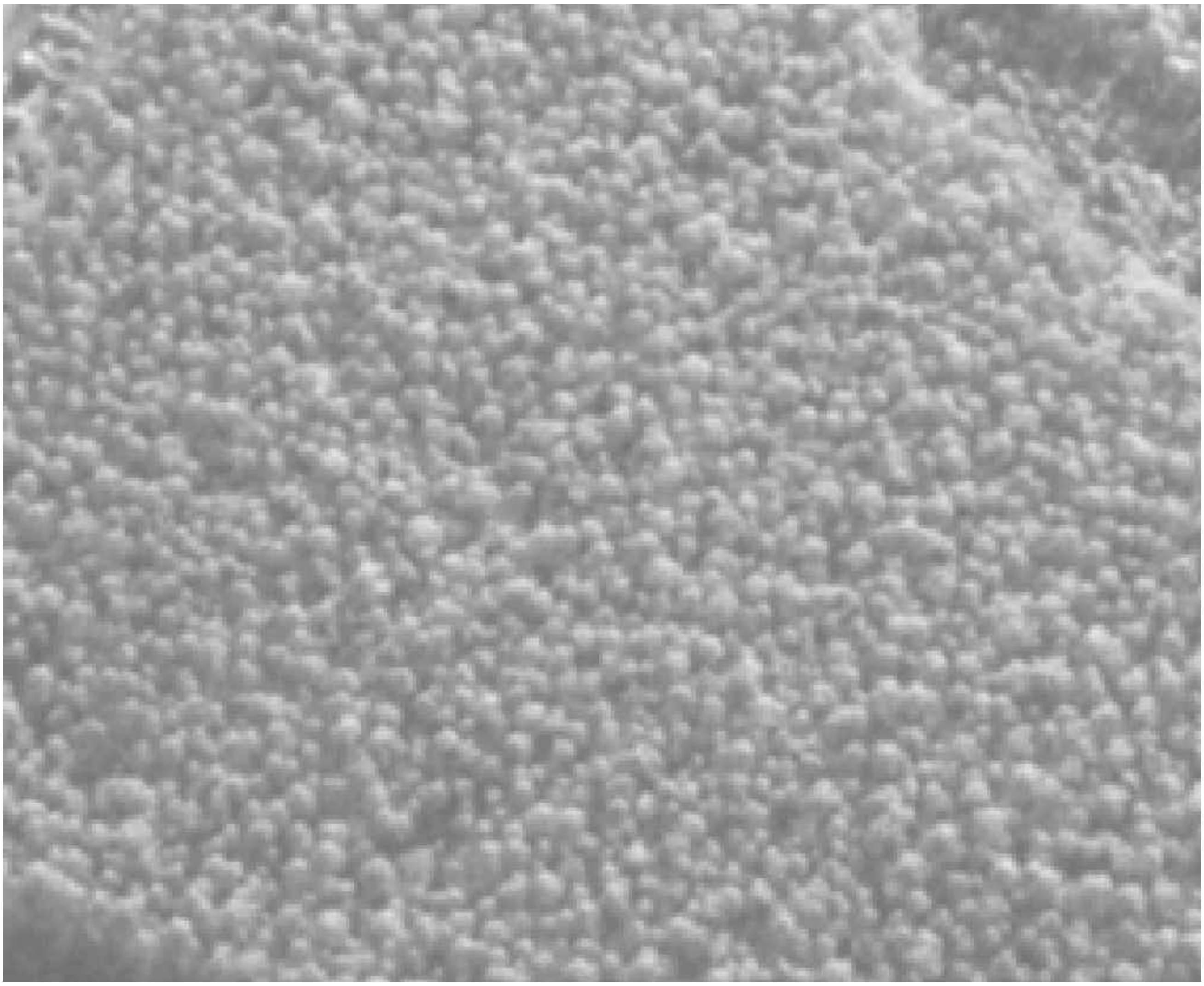


Fig. Another view to the same compartment: OBJECTID 117, Eucalyptus Smithii, 32m high.

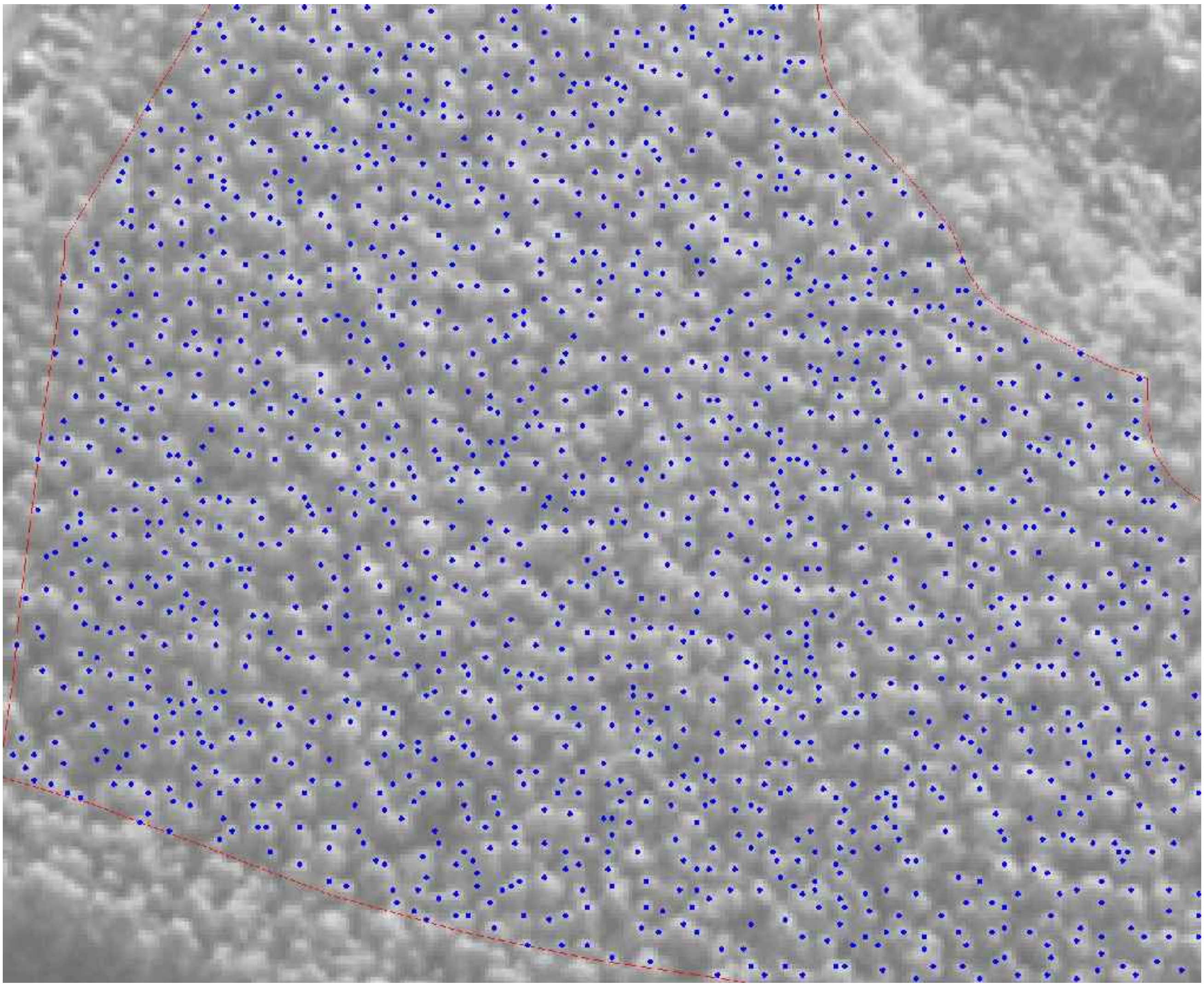


Fig. The same view as above to the compartment with OBJECTID 117 with trees detected by the adjusted algorithm inside the core buffer zone (red line) of the compartment. The detection rate could be improved by 13% up to 50% of all counted trees. Even if this new algorithm setting bares the risk to count one crown two times, there remain still the same amount of trees undetected. In other words, what you could visually count as eucalyptus crowns from the image is only half of all existing crowns.

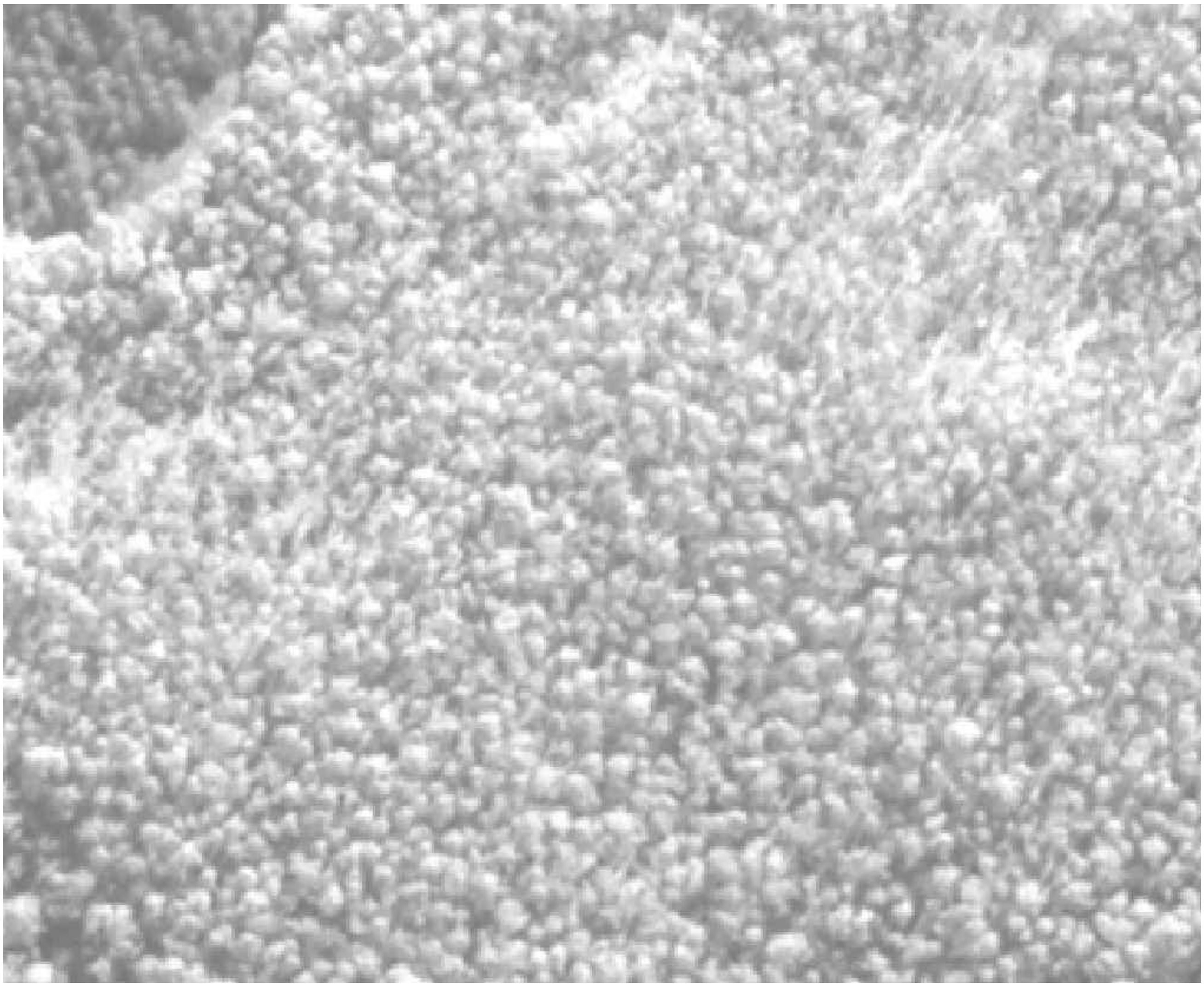


Fig. Quickbird 60 cm Pan with plantation of Eucalyptus Grandis (Egra), 28 m high, OBJECTID 164.

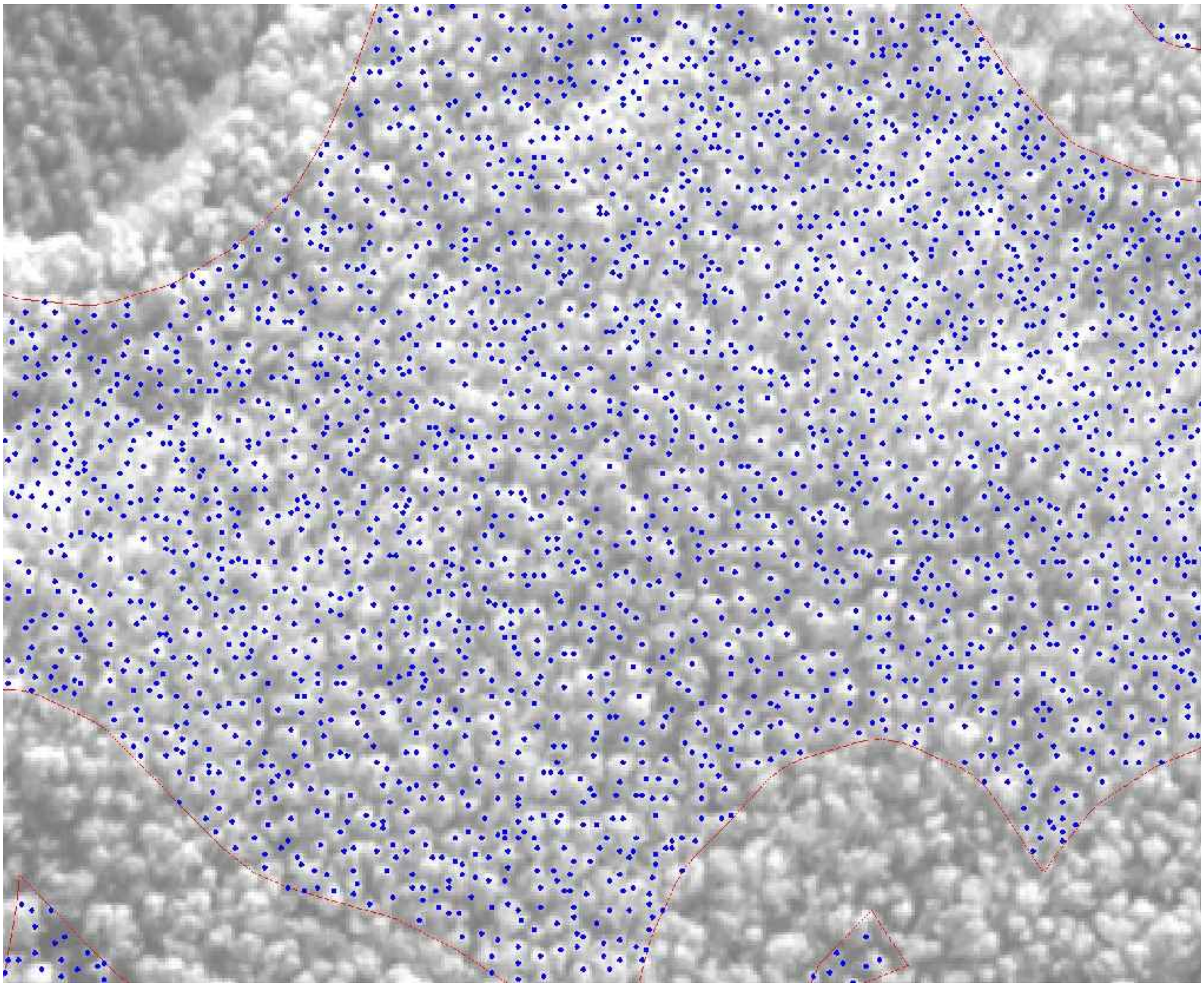


Fig.: Same view as above with detected trees in the core buffer zone (red line). Here the detection rate is 90% of all terrestrially counted trees.

One of the reasons why the second example delivered a much higher detection rate could be the different vertical structure of the two compartments. It is hard to discuss this point from here without knowing the situation on site. In general the detection rate decreases in stands with many sub-dominant and suppressed trees, which we normally don't expect in even-aged plantations.

Another important factor could be the changing quality of the imagery, which occurs when individual Quickbird scenes are put together to an image composite. Some eucalyptus stands appear over-exposed and blurred, which might be an indicator for radiometric distortions.

Finally and after some efforts we made to improve the results for the eucalyptus plantations, we may conclude that controlling the detection of individual eucalyptus tree crowns remains difficult and cannot be solved right away. Further work is needed; including the separate processing of such stands and the usage of the original Quickbird scenes (not the composite). Better results can also be expected when including auxiliary data like the original plantation scheme (plant distance) and eventually the number or removed trees, if there are any.

As a workaround and an additional control method for eucalyptus stands, we propose to deploy the tree density grid (taking the tree numbers as relative numbers) to describe the compartment and detect the size of openings and assess so the number of trees per ha.

The situation with the poor results for the young plantations, such as the one with the OBJECTÍD 81 is less difficult, because we can significantly improve the detection rate if we handle such stands separately.

In general, the price for the compromise to deploy a universal algorithm, which works with all species and height classes the same way, is a lower accuracy on exceptional sites. This becomes evident for extreme areas like very young stands with a broken structure or very old stands with a heterogeneous vertical and horizontal structure.

In the scope of a bigger project one could spend more resources to better stratify the imagery and develop the algorithm more specifically (e.g. a rule set for different age classes, different species, different stand structures etc.). All improved data the client can deliver (including updated height information, DEM, GCPs, etc.) will of course have a positive effect on the results.

The NDVI

The NDVI is a vegetation index calculated from the NIR and Red channel. On the figure page 13 we classified the NDVI by its standard deviation, simply to show a quick result how tree species could be discriminated. For a more profound usage of the NDVI to assess abnormalities within the compartments you have to have some ground truth to statistically relate the data to the values of the Quickbird imagery. In this context it is critical to use a Quickbird Composite like the one we have here, because the radiometry is not comparable all over the scene (we showed that in the previous report). Another critical issue might be the date of recording of the imagery, since the chlorophyll activities (that's basically what's the NDVI indicates) is different over the year.

Description of the attached files

All shape files and tables, you need to control the enhanced results are attached and can be downloaded from our server. The zip file includes:

control-polys-buffer-12m-with-locmaxtrees.shp

This shape file contains the core area of the compartments the client selected for his control. We used this shape file for the reference area to calculate the number of trees per ha in order to eliminate the effects of mismatching polygons and the "corridors". Such core zones stem from the shifted and buffered compartment polygons and fit best to the Quickbird imagery (so far we used this buffered area only for the calculation of the tree density grid). We assume this area is rather comparable to the field conditions of the sample plots used for the client's field survey. The size of the buffered core zones is given for each compartment's object-id in ha.

trees-locmax-in-sample-bufferpoly.shp

This shape file contains all newly calculated trees within the compartments the client measured. The attribute table includes the x-y coordinates of the trees, the number of trees for each core area of all those compartments measured (object-id) and the trees per ha for each object-id, referring to the total size of the core area (Sum_Buf_Ha).

results-lomax-obia-trees-in-sample-bufferpoly.shp

This file contains the results of the comparison with the client´s numbers and our detected trees. The shape file uses the original polygons (not shifted and not buffered), because it only carries statistical data. Consequently the trees of the upper point shape file do not necessarily fit to the borders of this shape file.

The attribute table is explained in detail below:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
OBJECT ID	LID	NAME	SPECIES	HEIGHT	HECTARE	Client TREES	TREES	PER HA	DETECT RATE	SUM_ HA_BUF	TREES	TREES PER HA	DETECT RATE 2	LOMAX TREES	LOMAX PER HA	DETECT RATE 3
228	9476	G35*3	Amea	20	6.23	1273	3839	616	48	4.1900	2618	625	49	3910	933	73
214	9451	G10a*3	Amea	21	16.38	1207	9737	594	49	11.3900	6859	602	50	10185	894	74
213	9450	G9*3	Amea	22	17.88	1101	11118	622	56	13.0800	8163	624	57	11393	871	79
222	9463	G22*3	Amea	23	7.91	1020	4529	573	56	5.6100	3533	630	62	5120	913	90
244	9493	G53*3	Edun	31	8.70	1339	4628	532	40	7.0200	3936	561	42	5626	801	60
164	9381	F3b*3	Egra	28	14.83	910	7544	509	56	10.9300	5366	491	54	9000	823	90
223	9465	G24*3	Emix	24	6.20	1521	3864	623	41	4.6400	3113	671	44	4370	942	62
60	9189	D10b*3	Ereg	32	16.23	1316	8942	551	42	12.2000	6608	542	41	8336	683	52
117	9265	D61*3	Esmi	32	11.24	1535	6396	569	37	7.7800	4544	584	38	5972	768	50
58	9187	D9*3	Esmi	29	16.53	1460	9054	548	38	9.0900	5021	552	38	6763	744	51
218	9457	G16*3	Esmi	27	10.89	1541	6481	595	39	8.8400	5479	620	40	7471	845	55
385	1013327	D7b*3	Esmi	25	16.88	1500	10206	605	40	10.7400	6556	610	41	8211	765	51
370	50061	D10c*3	Esmi	25	18.65	1309	10386	557	43	13.8600	7958	574	44	10075	727	56
212	9449	G8*3	Esmi	26	12.37	1258	7135	577	46	8.8200	5511	625	50	7245	821	65
236	9485	G46*3	Esmi	25	12.19	1230	7342	602	49	9.2500	5743	621	50	7476	808	66
197	9419	F38*3	Esmi	27	64.80	1094	40230	621	57	46.9200	28144	600	55	35769	762	70
119	9267	D63a*3	Pell	20	13.50	1208	12168	901	75	7.5900	7266	957	79	7613	1003	83
333	9624	H56b*3	Pp+e	24	12.39	1085	11161	901	83	8.6700	8124	937	86	8606	993	92
265	9530	G91*3	Ppat	22	7.06	873	4678	663	76	3.7600	2619	697	80	3068	816	93
403	1013351	F31a*3	Ppat	20	16.06	1071	13695	853	80	10.2500	9408	918	86	10154	991	93
200	9422	F41*3	Ppat	25	24.61	803	16561	673	84	12.3300	8683	704	88	9899	803	100
353	9647	H66*3	Ppat	24	9.35	862	6972	746	87	7.3500	5718	778	90	6177	840	97
345	9638	H62a*3	Ppat	24	8.77	887	6880	784	88	7.1000	5595	788	89	6052	852	96
185	9405	F26*3	Ppat	20	39.07	780	29831	764	98	32.5800	25371	779	100	28155	864	111

Explanation of Columns

1 - 5: known

6: Size of compartment in ha

7: Numbers of Trees per ha counted by client

8: Number of trees we counted with first algorithm settings

9: trees per ha with first algorithm settings

10: detection rate (trees per ha found with first algorithm setting in percent of trees per ha counted by client)

11: Size of the core buffer zone in each compartment, used as reference area, eliminating effects of mismatches and corridors

12: Trees counted in the core buffer zones i.e. the new reference area with first algorithm settings

13: Trees per ha found with the first algorithm settings and referred to the core buffer zones

14: Detection rate 2: Detected trees per ha (first algorithm) compared to client´s counts and referred to the new reference area (core buffer zones)

15: Trees found with second and enhanced algorithm settings

16: Trees per ha found with second algorithm setting and referred to the core buffer zones

17: Detection rate 3: Detected trees per ha compared to client´s counts and referred to new reference area (see file "trees-locmax-in-sample-bufferpoly.shp")

We used the buffered polygons now for the calculation of detected trees per ha in order to obtain a comparable reference area to the client´s field samples. The size of the buffer zone inside the compartments is given in the table column "Sum_HA_Buf". Only detected trees in this area have been considered and their number has been normalised on a per ha value.

This correction improved the detection rate (in percent of the client´s measured tree numbers per ha) between 2 and 4 percent (see table column 14).

Secondly, and more important, we adjusted the settings of our algorithm by doing it without the premise of working with an error of omission. The effect was evident and improved the detection rate significantly (see table column 17).

4 Perspectives

The Quickbird Mosaic could be successfully processed and trees in all age classes and species groups could be automatically detected. Nevertheless the overall performance of the process could be improved if following issues are considered in advance:

The mismatch of polygons (reference area) and image leads to errors in the statistic. The geo-rectification of the imagery by means of existing orthophotos and surface models has to be planned in advance to avoid such errors.
Existing GIS information, such as height and species, are helpful to stratify large areas and improve the performance of the algorithm. Therefore the completeness of the polygon attribute tables is essential for the results. Alternatively, image based stratification methods could be tested in the future.
The Mosaicing of the Quickbird Imagery leads to a distortion of the radiometry, which will influence the possibility to do e.g. an overall NDVI analysis. The original scenes are therefore more suitable.
Including height information from satellites, such as Cartosat or Alos/Prism, or airborne laser scanners, will significantly increase the automatic processing and should be considered for future projects.

5 ANNEX

5.1 Shape File Attribute Table with Tree Count Results

Original Files:
shape/trees-per-compartment-and-ha.shp
table/trees-per-compartment-and-ha.xls

OBJECTID = Unique ID of compartment polygons (minimum 0, maximum 464). This ID has a one-to-one relation to the LID and the NAME column. Because of its short 2 byte form, it was the preferred unique ID for the GIS processing of the compartment polygons. The shape files organised in tiles from 0 to 40 carry the Obia-Nr item, which equals the OBJECTID.
Pleas note: all features labelled with an OBJECTID = 0 are representing objects and trees outside the shifted compartment polygons (H_utm_shifted.shp) and are not considered for the statistical analysis.
LID = Unique ID for compartments
NAME = Name of the compartment
TREES = Number of trees detected within the shifted compartment polygon. Note, that we used the shifted polygons for the statistical analysis to better match Quickbird image and compartment polygons.
SPECIES = Tree Species Abbreviation from client
HEIGHT = Dominant Height from client (DOM_HT). This information has been used to stratify the project area and to fine-tune the algorithm, so please note that missing or not updated heights have been updated with our own estimations.
TUP_HA = Size of temporarily unplanted areas in hectare.
PERHA = Trees per compartment and per hectare. Due to the fact, that even after shifting the original polygons of the compartments to better match the Quickbird imagery, there was still a critical amount of automatically detected trees, which were not covered by the adjusted polygons and hence were not considered for the statistics. in order to minimise this error we decided to normalise the total of trees with the compartment size and give the trees per ha.
SHAPETILE1, SHAPETILE2 = Indicating in which shape files you can find the detected trees, if the compiled shapefile "shapes_utm36s/all-trees.shp" (about 100 MB big) is too big to handle and join it with the database table "database/trees.mdb - table: all-trees-tile40-0". The original and smaller shape files are organised in tiles from 0 to 40 and include all detected trees plus information on the NDVI (derived from the 240 cm resolution NIR Quickbird) and the ratio between the red channel and the combination of the Green+Red+NIR+Panchromatic (derived from the 60 cm resolution Quickbird).

The shape files use the Item Obia-nr (or Obia_nr) instead of the OBJECTID, but both values are identical and you can replace the column name "Obia-nr" with "OBJECTID".

OBJECTID	LID	NAME	TREES	HECTARE	SPECIES	HEIGHT	TUP_HA	PERHA	SHAPETILE1	SHAPETILE2
1	1021448	D21c*5	4913	6.31	Ppat	10	0.0	779	Tile-32-p.shp	Tile-32-p.shp
2	9091	C1b*5	8542	8.48	Ppat	2	0.0	1007	Tile-11-p.shp	Tile-11-p.shp
3	9092	C2*4	8055	9.02	Ppat	16	0.0	893	Tile-17-p.shp	Tile-17-p.shp
4	9093	C3*4	97	5.34	Ppat	2	0.0	18	Tile-16-p.shp	Tile-16-p.shp
5	9094	C4*5	5618	7.96	Amea	17	0.0	706	Tile-16-p.shp	Tile-16-p.shp
6	9098	C6b*3	325	7.89	Esmi	36	0.0	41	Tile-16-p.shp	Tile-16-p.shp
7	9099	C7*4	417	0.46	Amea	11	0.0	907	Tile-16-p.shp	Tile-16-p.shp
8	9100	C8a*4	8415	11.95	Amea	17	0.0	704	Tile-17-p.shp	Tile-16-p.shp
9	9101	C9*4	6710	10.88	Amea	20	0.0	617	Tile-16-p.shp	Tile-16-p.shp
10	9102	C10a*3	79	2.33	Ereg	40	0.0	34	Tile-16-p.shp	Tile-16-p.shp
11	9103	C11*3	26714	22.12	Pell	14	0.0	1208	Tile-16-p.shp	Tile-16-p.shp
12	9106	C12*3	9227	10.89	Pell	18	0.0	847	Tile-22-p.shp	Tile-16-p.shp
13	9107	C13a*4	5060	5.17	Ppat	6	0.0	979	Tile-22-p.shp	Tile-17-p.shp
14	9108	C14*5	11805	14.00	Amea	17	0.0	843	Tile-22-p.shp	Tile-16-p.shp
15	9109	C15*4	24800	27.76	Amea	13	0.0	893	Tile-22-p.shp	Tile-22-p.shp
16	9110	C16*4	5257	6.10	Ppat	16	0.0	862	Tile-22-p.shp	Tile-22-p.shp
17	9111	C17a*4	4852	8.34	Esmi	22	0.0	582	Tile-22-p.shp	Tile-22-p.shp
18	9112	C17b*5	88	10.52	Ppat	1	0.0	8	Tile-22-p.shp	Tile-22-p.shp
19	9113	C18*4	15729	21.14	Emix	10	0.0	744	Tile-22-p.shp	Tile-22-p.shp
20	9115	C19*3	2649	4.87	Ppat	20	0.0	544	Tile-22-p.shp	Tile-22-p.shp
21	9116	C20*3	12893	12.34	Pell	15	0.0	1045	Tile-22-p.shp	Tile-22-p.shp
22	9117	C21*4	8223	9.01	Ppat	10	0.0	913	Tile-28-p.shp	Tile-22-p.shp
23	9119	C23*4	21496	37.54	Emix	20	0.0	573	Tile-28-p.shp	Tile-22-p.shp
24	9120	C24*5	11492	14.41	Edun	10	0.0	798	Tile-22-p.shp	Tile-22-p.shp
25	9121	C25*4	18731	22.84	Esmi	15	0.0	820	Tile-29-p.shp	Tile-23-p.shp
26	9122	C26*4	4875	6.68	Esmi	10	0.0	730	Tile-29-p.shp	Tile-29-p.shp
27	9123	C27a*3	530	0.81	Amea	20	0.0	654	Tile-29-p.shp	Tile-29-p.shp
28	9124	C27b*4	12993	12.93	Ppat	10	0.0	1005	Tile-28-p.shp	Tile-28-p.shp
29	9125	C28*3	13331	25.25	Amea	25	0.0	528	Tile-28-p.shp	Tile-28-p.shp
30	9126	C29*3	6614	10.92	Amea	22	0.0	606	Tile-29-p.shp	Tile-29-p.shp
31	9127	C30c*5	2073	2.93	Amea	18	0.0	708	Tile-29-p.shp	Tile-29-p.shp
32	9128	C32*6	10480	16.06	Esmi	22	0.0	653	Tile-23-p.shp	Tile-23-p.shp
33	9129	C33*3	311	0.22	Ppat	2	0.0	1414	Tile-29-p.shp	Tile-23-p.shp
34	9138	C42*4	25342	33.55	Amea	22	0.0	755	Tile-23-p.shp	Tile-23-p.shp
35	9139	C44b*6	3807	4.88	Amea	14	0.0	780	Tile-23-p.shp	Tile-23-p.shp
36	9140	C46*4	20197	21.10	Ppat	9	0.0	957	Tile-22-p.shp	Tile-17-p.shp
37	9141	C47*4	3808	4.30	Ppat	12	0.0	886	Tile-23-p.shp	Tile-17-p.shp
38	9142	C48*4	13734	18.84	Emix	17	0.0	729	Tile-23-p.shp	Tile-23-p.shp
39	9143	C49*4	6047	6.00	Emix	17	0.0	1008	Tile-23-p.shp	Tile-17-p.shp
40	9144	C50*4	6722	9.63	Edun	16	0.0	698	Tile-23-p.shp	Tile-23-p.shp
41	9145	C51*4	2232	2.70	Esmi	12	0.0	827	Tile-23-p.shp	Tile-23-p.shp
42	9146	C52*3	5326	11.02	Amea	19	0.0	483	Tile-17-p.shp	Tile-17-p.shp
43	9148	C53*5	4712	3.94	Ppat	5	0.0	1196	Tile-23-p.shp	Tile-23-p.shp
44	9151	C56*3	8732	22.57	Amea	24	0.0	387	Tile-23-p.shp	Tile-17-p.shp
45	9152	C57*4	981	2.82	Ppat	2	0.0	348	Tile-17-p.shp	Tile-17-p.shp
46	9154	C58*4	8770	7.72	Ppat	2	0.0	1136	Tile-17-p.shp	Tile-17-p.shp
47	9155	C60*4	4914	6.33	Edun	16	0.0	776	Tile-17-p.shp	Tile-17-p.shp
48	9156	C61*4	206	14.66	Ppat	0	14.6	14	Tile-17-p.shp	Tile-17-p.shp
50	9177	D1*4	1275	6.53	Ppat	1	0.0	195	Tile-25-p.shp	Tile-25-p.shp
51	9178	D2*3	6586	11.46	Emac	29	0.0	575	Tile-31-p.shp	Tile-25-p.shp
52	9179	D3a*3	8378	16.44	Esmi	28	0.0	510	Tile-25-p.shp	Tile-25-p.shp
53	9180	D3b*3	2264	4.79	Esmi	23	0.0	473	Tile-25-p.shp	Tile-25-p.shp
54	9181	D4b*4	1824	2.17	Ppat	11	0.0	841	Tile-26-p.shp	Tile-26-p.shp

OBJECTID	LID	NAME	TREES	HECTARE	SPECIES	HEIGHT	TUP_HA	PERHA	SHAPETILE1	SHAPETILE2
55	9183	D6*4	16370	23.09	Amea	21	0.0	709	Tile-26-p.shp	Tile-26-p.shp
56	9184	D7a*3	4327	6.99	Esal	28	0.0	619	Tile-26-p.shp	Tile-26-p.shp
57	9185	D8*3	14752	19.25	Ppat	20	0.0	766	Tile-26-p.shp	Tile-26-p.shp
58	9187	D9*3	9054	16.53	Esmi	29	0.0	548	Tile-26-p.shp	Tile-26-p.shp
59	9188	D10a*3	241	0.48	Esmi	30	0.0	502	Tile-21-p.shp	Tile-21-p.shp
60	9189	D10b*3	8942	16.23	Ereg	32	0.0	551	Tile-27-p.shp	Tile-27-p.shp
61	9190	D11*3	6566	9.48	Ppat	20	0.0	693	Tile-27-p.shp	Tile-27-p.shp
62	9191	D12a*4	98	23.33	Ppat	2	0.0	4	Tile-21-p.shp	Tile-21-p.shp
63	9192	D13*4	1858	2.22	Ppat	14	0.0	837	Tile-27-p.shp	Tile-27-p.shp
64	9193	D14a*4	18166	21.13	Ppat	15	0.0	860	Tile-27-p.shp	Tile-27-p.shp
65	9194	D14b*3	325	0.61	Esmi	31	0.0	533	Tile-27-p.shp	Tile-27-p.shp
66	9195	D14c*3	252	0.50	Esmi	31	0.0	504	Tile-33-p.shp	Tile-27-p.shp
67	9196	D15*4	25028	25.56	Ppat	12	0.0	979	Tile-32-p.shp	Tile-26-p.shp
68	9197	D16*4	14267	15.19	Ppat	17	0.0	939	Tile-32-p.shp	Tile-26-p.shp
69	9198	D17a*4	6203	8.70	Esmi	16	0.0	713	Tile-26-p.shp	Tile-26-p.shp
70	9199	D17b*4	3492	4.91	Esmi	12	0.0	711	Tile-32-p.shp	Tile-32-p.shp
71	9201	D18b*3	3858	4.98	Ppat	17	0.0	775	Tile-32-p.shp	Tile-32-p.shp
72	9203	D20*4	4975	6.54	Esmi	13	0.0	761	Tile-32-p.shp	Tile-32-p.shp
73	9205	D21b*4	4087	4.96	Ppat	15	0.0	824	Tile-32-p.shp	Tile-32-p.shp
74	9206	D22*4	25209	27.18	Ppat	17	0.0	927	Tile-32-p.shp	Tile-32-p.shp
75	9207	D23*2	5972	7.94	Ppat	17	0.0	752	Tile-33-p.shp	Tile-33-p.shp
76	9209	D24*4	326	0.62	Ppat	19	0.0	526	Tile-33-p.shp	Tile-33-p.shp
77	9210	D25*4	4439	4.15	Pell	16	0.0	1070	Tile-33-p.shp	Tile-33-p.shp
78	9211	D26a*4	16708	19.78	Ppat	17	0.0	845	Tile-32-p.shp	Tile-32-p.shp
79	9212	D26b*2	5101	5.33	Ppat	17	0.0	957	Tile-33-p.shp	Tile-33-p.shp
80	9213	D27*4	12734	13.72	Ppat	8	0.0	928	Tile-38-p.shp	Tile-32-p.shp
81	9218	D29b*4	1816	8.07	Ppat	2	0.0	225	Tile-38-p.shp	Tile-32-p.shp
82	9219	D30*5	10215	17.24	Amea	18	0.0	593	Tile-38-p.shp	Tile-38-p.shp
83	9223	D33*3	325	0.70	Ppat	0	3.6	464	Tile-39-p.shp	Tile-39-p.shp
84	9224	D34*5	5475	5.64	Ppat	2	0.0	971	Tile-39-p.shp	Tile-39-p.shp
85	9226	D35*4	16182	13.63	Ppat	3	0.0	1187	Tile-39-p.shp	Tile-39-p.shp
86	9228	D36*4	2828	4.26	Esmi	13	0.0	664	Tile-39-p.shp	Tile-39-p.shp
87	9229	D37*4	13451	21.04	Amea	21	0.0	639	Tile-39-p.shp	Tile-39-p.shp
88	9230	D38a*4	3951	4.70	Ppat	3	0.0	841	Tile-39-p.shp	Tile-33-p.shp
89	9231	D38b*4	9484	16.20	Esmi	21	0.0	585	Tile-39-p.shp	Tile-33-p.shp
90	9233	D41a*4	1385	1.61	Ppat	11	0.0	860	Tile-33-p.shp	Tile-33-p.shp
91	9234	D41b*4	5122	8.63	Esmi	21	0.0	594	Tile-33-p.shp	Tile-33-p.shp
92	9235	D42a*4	10942	10.81	Ppat	9	0.0	1012	Tile-33-p.shp	Tile-33-p.shp
93	9236	D42b*3	3967	4.90	Ppat	16	0.0	810	Tile-33-p.shp	Tile-33-p.shp
94	9238	D44a*4	12526	13.73	Ppat	16	0.0	912	Tile-33-p.shp	Tile-33-p.shp
95	9239	D44b*3	2195	3.97	Amea	26	0.0	553	Tile-34-p.shp	Tile-34-p.shp
96	9240	D45*3	1657	3.23	Amea	24	0.0	513	Tile-33-p.shp	Tile-33-p.shp
97	9241	D46*4	2903	3.32	Ppat	11	0.0	874	Tile-33-p.shp	Tile-33-p.shp
98	9242	D47*4	10018	10.10	Ppat	9	0.0	992	Tile-33-p.shp	Tile-27-p.shp
99	9244	D49a*3	15569	26.36	Esmi	30	0.0	591	Tile-27-p.shp	Tile-27-p.shp
100	9246	D49c*3	18250	17.19	Pell	14	0.0	1062	Tile-27-p.shp	Tile-27-p.shp
101	9247	D50*4	16459	27.84	Esmi	25	0.0	591	Tile-33-p.shp	Tile-28-p.shp
102	9248	D51a*4	14677	25.14	Esmi	28	0.0	584	Tile-27-p.shp	Tile-27-p.shp
103	9249	D51b*3	1372	2.93	Enit	51	0.0	468	Tile-28-p.shp	Tile-28-p.shp
104	9250	D51c*3	2009	3.35	Enit	30	0.0	600	Tile-28-p.shp	Tile-28-p.shp
105	9251	D52b*4	29490	32.16	Ppat	10	0.0	917	Tile-33-p.shp	Tile-33-p.shp
106	9252	D53a*4	6255	9.70	Amea	5	0.0	645	Tile-28-p.shp	Tile-28-p.shp
107	9253	D53b*4	5093	9.79	Amea	5	0.0	520	Tile-28-p.shp	Tile-28-p.shp
108	9256	D55a*5	9532	17.70	Esmi	24	0.0	539	Tile-22-p.shp	Tile-22-p.shp
109	9257	D55b*4	125	17.13	Ppat	2	0.0	7	Tile-27-p.shp	Tile-21-p.shp
110	9258	D55c*3	3875	6.29	Pmix	23	0.0	616	Tile-27-p.shp	Tile-27-p.shp
111	9259	D56*4	9446	16.30	Esmi	5	0.0	580	Tile-27-p.shp	Tile-21-p.shp

OBJECTID	LID	NAME	TREES	HECTARE	SPECIES	HEIGHT	TUP_HA	PERHA	SHAPETILE1	SHAPETILE2
112	9260	D57a*4	3415	6.28	Esmi	28	0.0	544	Tile-27-p.shp	Tile-27-p.shp
113	9261	D58*5	5012	9.44	Esmi	26	0.0	531	Tile-21-p.shp	Tile-21-p.shp
114	9262	D60a*4	1076	1.76	Emix	20	0.0	611	Tile-22-p.shp	Tile-22-p.shp
115	9263	D60b*3	5071	4.43	Pell	14	0.0	1145	Tile-22-p.shp	Tile-22-p.shp
116	9264	D60c*4	4983	7.71	Esmi	18	0.0	646	Tile-28-p.shp	Tile-22-p.shp
117	9265	D61*3	6396	11.24	Esmi	32	0.0	569	Tile-28-p.shp	Tile-22-p.shp
118	9266	D62*3	11648	12.07	Pell	17	0.0	965	Tile-28-p.shp	Tile-28-p.shp
119	9267	D63a*3	12168	13.50	Pell	20	0.0	901	Tile-28-p.shp	Tile-28-p.shp
120	9268	D63b*3	981	1.68	Amea	23	0.0	584	Tile-28-p.shp	Tile-28-p.shp
121	9269	D64*4	8286	7.84	Ppat	11	0.0	1057	Tile-28-p.shp	Tile-28-p.shp
122	9270	D65a*4	307	12.03	Ppat	2	0.0	26	Tile-28-p.shp	Tile-28-p.shp
123	9271	D65b*3	5163	7.95	Ppat	24	0.0	649	Tile-34-p.shp	Tile-34-p.shp
124	9273	D66a*3	2146	2.29	Pell	23	0.0	937	Tile-34-p.shp	Tile-34-p.shp
125	9274	D67*5	10183	10.07	Amea	14	0.0	1011	Tile-28-p.shp	Tile-28-p.shp
126	9275	D68*4	18553	18.92	Amea	13	0.0	981	Tile-34-p.shp	Tile-28-p.shp
127	9276	D69b*4	1474	2.77	Edun	19	0.0	532	Tile-28-p.shp	Tile-28-p.shp
128	9278	D71*3	1148	5.54	Ppat	23	0.0	207	Tile-28-p.shp	Tile-28-p.shp
129	9279	D72*3	5671	7.89	Ppat	25	0.0	719	Tile-34-p.shp	Tile-34-p.shp
130	9280	D73*3	3735	3.52	Pell	16	0.0	1061	Tile-34-p.shp	Tile-34-p.shp
131	9281	D74*3	9036	8.71	Pell	16	0.0	1037	Tile-28-p.shp	Tile-28-p.shp
132	9282	D75*4	1415	3.52	Amea	9	0.0	402	Tile-28-p.shp	Tile-28-p.shp
133	9283	D76*4	7679	9.79	Amea	15	0.0	784	Tile-28-p.shp	Tile-28-p.shp
134	9326	E2*3	8478	11.04	Pell	18	0.0	768	Tile-30-p.shp	Tile-24-p.shp
135	9327	E3*4	14303	14.17	Ppat	2	0.0	1009	Tile-25-p.shp	Tile-24-p.shp
136	9328	E4a*3	9460	18.29	Amea	19	0.0	517	Tile-25-p.shp	Tile-24-p.shp
137	9330	E4c*3	222	0.45	Amea	19	0.0	493	Tile-24-p.shp	Tile-24-p.shp
138	9331	E4d*4	2076	3.14	Amea	12	0.0	661	Tile-25-p.shp	Tile-25-p.shp
139	9332	E5*4	13013	14.12	Amea	12	0.0	922	Tile-25-p.shp	Tile-25-p.shp
140	9333	E6*4	2369	3.13	Ppat	9	0.0	757	Tile-25-p.shp	Tile-25-p.shp
141	9334	E7a*4	2203	4.19	Ppat	8	0.0	526	Tile-25-p.shp	Tile-19-p.shp
142	9335	E8*4	3906	3.75	Ppat	3	0.0	1042	Tile-25-p.shp	Tile-25-p.shp
143	9336	E9a*4	2892	2.58	Ppat	3	0.0	1121	Tile-18-p.shp	Tile-18-p.shp
144	9337	E9b*4	7980	10.66	Amea	15	0.0	749	Tile-24-p.shp	Tile-24-p.shp
145	9339	E11a*4	276	5.43	Esmi	3	0.0	51	Tile-18-p.shp	Tile-18-p.shp
146	9340	E11b*3	300	1.15	Amea	22	0.0	261	Tile-18-p.shp	Tile-18-p.shp
147	9343	E13*4	9133	8.78	Ppat	7	0.0	1040	Tile-18-p.shp	Tile-18-p.shp
148	9346	E15*5	342	2.77	Ppat	2	0.0	123	Tile-18-p.shp	Tile-18-p.shp
149	9347	E16*4	4322	4.38	Ppat	10	0.0	987	Tile-18-p.shp	Tile-18-p.shp
150	9348	E17*3	8372	7.80	Ppat	16	0.0	1073	Tile-18-p.shp	Tile-18-p.shp
151	0		10	0.27				37	Tile-25-p.shp	Tile-25-p.shp
152	9350	E18*3	3004	5.78	Enit	20	0.0	520	Tile-18-p.shp	Tile-18-p.shp
153	9352	E20*4	752	0.92	Ppat	2	0.0	817	Tile-18-p.shp	Tile-18-p.shp
154	9353	E21*4	2552	2.46	Ppat	3	0.0	1037	Tile-18-p.shp	Tile-18-p.shp
155	9354	E22*4	1176	1.11	Ppat	3	0.0	1059	Tile-18-p.shp	Tile-18-p.shp
156	9355	E23*3	1236	2.22	Enit	25	0.0	557	Tile-18-p.shp	Tile-18-p.shp
157	9356	E24*3	7594	11.63	Esmi	25	0.0	653	Tile-18-p.shp	Tile-12-p.shp
158	9359	E26*5	1629	1.93	Ppat	10	0.0	844	Tile-12-p.shp	Tile-12-p.shp
159	9360	E27*3	2731	3.64	Ppat	27	0.0	750	Tile-18-p.shp	Tile-12-p.shp
160	9363	E28b*4	2233	2.64	Ppat	12	0.0	846	Tile-12-p.shp	Tile-12-p.shp
161	9378	F1b*4	3808	9.00	Ppat	11	0.0	423	Tile-12-p.shp	Tile-12-p.shp
162	9379	F2*4	115	14.03	Ppat	1	0.0	8	Tile-12-p.shp	Tile-12-p.shp
163	9380	F3a*3	5388	6.67	Ppat	19	0.0	808	Tile-13-p.shp	Tile-13-p.shp
164	9381	F3b*3	7544	14.83	Egra	28	0.0	509	Tile-13-p.shp	Tile-12-p.shp
165	9384	F7*4	12086	10.48	Ppat	6	0.0	1153	Tile-13-p.shp	Tile-13-p.shp
166	9385	F8*4	56	21.44	Ppat	1	0.0	3	Tile-13-p.shp	Tile-7-p.shp
167	9386	F9*3	3560	5.46	Esmi	26	0.0	652	Tile-7-p.shph	Tile-7-p.shp
168	9387	F10*3	4837	7.12	Amea	22	0.0	679	Tile-7-p.shph	Tile-7-p.shp

OBJECTID	LID	NAME	TREES	HECTARE	SPECIES	HEIGHT	TUP_HA	PERHA	SHAPETILE1	SHAPETILE2
169	9388	F11*3	14638	22.29	Esmi	27	0.0	657	Tile-7-p.shph	Tile-7-p.shp
170	9389	F12*3	9920	15.12	Esmi	27	0.0	656	Tile-7-p.shph	Tile-7-p.shp
171	9390	F13*3	7853	12.21	Esmi	28	0.0	643	tile2_or_tile8	tile2_or_tile8
172	9391	F14a*3	2781	4.49	Enit	18	0.0	619	tile2_or_tile8	tile2_or_tile8
173	9392	F15a*3	3675	6.01	Enit	26	0.0	611	tile2_or_tile8	tile2_or_tile8
174	9393	F16*3	7519	14.65	Enit	27	0.0	513	tile2_or_tile8	tile2_or_tile8
175	9394	F17*3	1938	3.37	Amea	26	0.0	575	Tile-7-p.shph	Tile-7-p.shp
176	9395	F18a*4	7707	7.87	Ppat	15	0.0	979	Tile-7-p.shph	Tile-7-p.shp
177	9396	F19*4	4773	4.71	Ppat	14	0.0	1013	Tile-7-p.shph	Tile-7-p.shp
178	9397	F20a*3	4802	7.19	Amea	20	0.0	668	Tile-7-p.shph	Tile-7-p.shp
179	9398	F20b*3	7013	9.15	Egra	31	0.0	766	Tile-7-p.shph	Tile-7-p.shp
180	9399	F20c*3	763	1.11	Amea	22	0.0	687	tile2_or_tile8	tile2_or_tile8
181	9400	F21*4	3584	4.95	Esmi	14	0.0	724	Tile-7-p.shph	Tile-7-p.shp
182	9401	F22*3	10255	15.75	Esmi	24	0.0	651	Tile-7-p.shph	Tile-7-p.shp
183	9403	F24*4	5078	5.46	Ppat	2	0.0	930	Tile-7-p.shph	Tile-7-p.shp
184	9404	F25*3	17357	23.20	Ppat	20	0.0	748	Tile-6-p.shph	Tile-6-p.shp
185	9405	F26*3	29831	39.07	Ppat	20	0.0	764	Tile-6-p.shph	Tile-6-p.shp
186	9406	F27*4	10174	8.55	Ppat	2	0.0	1190	Tile-6-p.shph	Tile-6-p.shp
187	9407	F28*4	1388	3.68	Ppat	2	0.0	377	Tile-6-p.shph	Tile-6-p.shp
188	9408	F29*3	19622	31.54	Esmi	26	0.0	622	Tile-6-p.shph	Tile-0-p.shp
189	9409	F31b*3	12451	15.12	Ppat	17	0.0	823	Tile-6-p.shph	Tile-0-p.shp
190	9410	F32*3	15856	23.22	Egra	21	0.0	683	Tile-6-p.shph	Tile-0-p.shp
191	9412	F33a*5	9834	10.06	Ppat	12	0.0	978	Tile-1-p.shph	Tile-0-p.shp
192	9413	F34*4	5212	5.86	Ppat	12	0.0	889	Tile-1-p.shph	Tile-1-p.shp
193	9414	F35a*3	8170	12.62	Egra	43	0.0	647	Tile-7-p.shph	Tile-1-p.shp
194	9415	F35b*3	12264	20.54	Esmi	26	0.0	597	Tile-1-p.shph	Tile-1-p.shp
195	9417	F36*3	9041	12.95	Ppat	22	0.0	698	Tile-1-p.shph	Tile-1-p.shp
196	9418	F37*3	17361	28.60	Esmi	25	0.0	607	Tile-1-p.shph	Tile-1-p.shp
197	9419	F38*3	40230	64.80	Esmi	27	0.0	621	Tile-1-p.shph	Tile-1-p.shp
198	9420	F39*4	8089	7.78	Amea	9	0.0	1040	tile2_or_tile8	tile2_or_tile8
199	9421	F40*3	5099	7.69	Esmi	25	0.0	663	tile2_or_tile8	tile2_or_tile8
200	9422	F41*3	16561	24.61	Ppat	25	0.0	673	Tile-1-p.shph	Tile-1-p.shp
201	9423	F44*4	4232	4.76	Ppat	15	0.0	889	Tile-1-p.shph	Tile-1-p.shp
202	9426	F50*4	96	36.69	Esmi	3	0.0	3	Tile-7-p.shph	Tile-7-p.shp
203	9427	F51*4	18	5.20	Amea	3	0.0	3	tile2_or_tile8	tile2_or_tile8
204	9428	F52*4	57	3.29	Esmi	3	0.0	17	Tile-7-p.shph	Tile-7-p.shp
205	9442	G1*4	8787	8.43	Ppat	6	0.0	1042	Tile-13-p.shp	Tile-13-p.shp
206	9443	G2*3	4800	8.42	Amea	20	0.0	570	Tile-13-p.shp	Tile-13-p.shp
207	9444	G3*4	638	3.52	Esmi	3	0.0	181	Tile-13-p.shp	Tile-13-p.shp
208	9445	G4*3	2521	4.07	Amea	24	0.0	619	Tile-13-p.shp	Tile-13-p.shp
209	9446	G5*3	5798	9.43	Amea	21	0.0	615	Tile-13-p.shp	Tile-13-p.shp
210	9447	G6*4	3975	6.66	Ppat	2	0.0	597	Tile-13-p.shp	Tile-13-p.shp
211	9448	G7*3	5665	6.13	Pell	17	0.0	924	Tile-14-p.shp	Tile-14-p.shp
212	9449	G8*3	7135	12.37	Esmi	26	0.0	577	Tile-13-p.shp	Tile-13-p.shp
213	9450	G9*3	11118	17.88	Amea	22	0.0	622	Tile-14-p.shp	Tile-14-p.shp
214	9451	G10a*3	9737	16.38	Amea	21	0.0	594	Tile-14-p.shp	Tile-14-p.shp
215	9452	G10b*3	6846	10.37	Amea	21	0.0	660	Tile-14-p.shp	Tile-14-p.shp
216	9454	G13*3	39884	37.14	Pell	17	0.0	1074	Tile-14-p.shp	Tile-14-p.shp
217	9456	G15*3	5463	6.64	Ppat	16	0.0	823	Tile-14-p.shp	Tile-14-p.shp
218	9457	G16*3	6481	10.89	Esmi	27	0.0	595	Tile-14-p.shp	Tile-14-p.shp
219	9459	G18a*3	12280	15.24	Ppat	19	0.0	806	Tile-13-p.shp	Tile-13-p.shp
220	9460	G19*3	2479	2.82	Ppat	16	0.0	879	Tile-15-p.shp	Tile-15-p.shp
221	9462	G21*3	7272	11.99	Amea	19	0.0	607	Tile-26-p.shp	Tile-15-p.shp
222	9463	G22*3	4529	7.91	Amea	23	0.0	573	Tile-15-p.shp	Tile-15-p.shp
223	9465	G24*3	3864	6.20	Emix	24	0.0	623	Tile-15-p.shp	Tile-15-p.shp
224	9466	G25*3	9434	16.97	Amea	20	0.0	556	Tile-15-p.shp	Tile-15-p.shp
225	9468	G27*3	2505	4.42	Edun	30	0.0	567	Tile-15-p.shp	Tile-15-p.shp

OBJECTID	LID	NAME	TREES	HECTARE	SPECIES	HEIGHT	TUP_HA	PERHA	SHAPETILE1	SHAPETILE2
226	9471	G30*3	25425	42.32	Edun	34	0.0	601	Tile-15-p.shp	Tile-15-p.shp
227	9475	G34*3	3504	7.37	Amea	20	0.0	475	Tile-16-p.shp	Tile-16-p.shp
228	9476	G35*3	3839	6.23	Amea	20	0.0	616	Tile-15-p.shp	Tile-15-p.shp
229	9477	G36*3	12979	22.08	Amea	21	0.0	588	Tile-15-p.shp	Tile-9-p.shp
231	9479	G38*3	161	0.26	Egra	27	0.0	619	Tile-9-p.shph	Tile-9-p.shp
232	9481	G40*4	2430	2.23	Ptae	13	0.0	1090	Tile-9-p.shph	Tile-9-p.shp
233	9482	G41b*5	2124	2.72	Pell	30	0.0	781	Tile-14-p.shp	Tile-14-p.shp
234	9483	G42*4	7918	7.04	Ptae	10	0.0	1125	Tile-14-p.shp	Tile-9-p.shp
235	9484	G43a*3	3562	3.58	Pell	17	0.0	995	Tile-9-p.shph	Tile-9-p.shp
236	9485	G46*3	7342	12.19	Esmi	25	0.0	602	Tile-14-p.shp	tile2_or_tile8
237	9486	G47a*4	34757	32.03	Ppat	7	0.0	1085	Tile-14-p.shp	tile2_or_tile8
238	9487	G47b*3	2744	3.79	Ppat	23	0.0	724	tile2_or_tile8	tile2_or_tile8
239	9488	G48*3	511	0.71	Ppat	25	0.0	720	tile2_or_tile8	tile2_or_tile8
240	9489	G49*3	12615	25.50	Amea	23	0.0	495	tile2_or_tile8	tile2_or_tile8
241	9490	G50*4	257	17.05	Edun	0	17.0	15	Tile-9-p.shph	Tile-9-p.shp
242	9491	G51*4	6853	7.08	Amea	18	0.0	968	Tile-9-p.shph	Tile-10-p.shp
243	9492	G52*3	1403	2.10	Ppat	18	0.0	668	Tile-10-p.shp	Tile-10-p.shp
244	9493	G53*3	4628	8.70	Edun	31	0.0	532	Tile-10-p.shp	Tile-10-p.shp
245	9496	G56*4	1773	3.55	Amea	14	0.0	499	Tile-10-p.shp	Tile-10-p.shp
246	9498	G58*3	11639	11.96	Pp+e	18	0.0	973	Tile-14-p.shp	Tile-14-p.shp
247	9499	G59*4	21	4.06	Ppat	2	0.0	5	Tile-14-p.shp	Tile-14-p.shp
248	9500	G60*3	6650	10.35	Egra	26	0.0	643	Tile-21-p.shp	Tile-15-p.shp
249	9501	G61*3	261	4.49	Ppat	26	0.0	58	Tile-15-p.shp	Tile-15-p.shp
250	9502	G62*4	3692	4.00	Ppat	13	0.0	923	Tile-15-p.shp	Tile-15-p.shp
251	9503	G63*3	1334	2.81	Amea	21	0.0	475	Tile-15-p.shp	Tile-15-p.shp
252	9506	G67*4	324	18.85	Ppat	2	0.0	17	Tile-14-p.shp	Tile-14-p.shp
253	9507	G68*3	872	17.65	Ppat	32	0.0	49	Tile-20-p.shp	Tile-14-p.shp
254	9510	G71*4	7271	7.83	Ppat	7	0.0	929	Tile-14-p.shp	Tile-14-p.shp
255	9511	G72*3	2764	3.05	Pell	16	0.0	906	Tile-32-p.shp	Tile-15-p.shp
256	9514	G75*4	4122	4.85	Ppat	12	0.0	850	Tile-21-p.shp	Tile-15-p.shp
257	9516	G77*4	930	9.98	Ppat	1	0.0	93	Tile-21-p.shp	Tile-15-p.shp
258	9517	G78*4	6539	9.35	Ppat	12	0.0	699	Tile-21-p.shp	Tile-15-p.shp
259	9518	G79*3	997	1.90	Ppat	23	0.0	525	Tile-21-p.shp	Tile-21-p.shp
260	9519	G80*3	490	5.37	Ppat	26	0.0	91	Tile-21-p.shp	Tile-21-p.shp
261	9521	G82*3	861	1.65	Ppat	19	0.0	522	Tile-21-p.shp	Tile-21-p.shp
262	9525	G86*4	11623	14.20	Ppat	17	0.0	819	Tile-21-p.shp	Tile-21-p.shp
263	9527	G88*4	7213	7.42	Ppat	14	0.0	972	Tile-21-p.shp	Tile-21-p.shp
264	9529	G90*5	186	5.56	Ppat	1	0.0	33	Tile-21-p.shp	Tile-21-p.shp
265	9530	G91*3	4678	7.06	Ppat	22	0.0	663	Tile-21-p.shp	Tile-21-p.shp
266	9533	G94*4	1	3.80	Ppat	1	0.0	0	Tile-21-p.shp	Tile-21-p.shp
267	9535	G96*4	1339	2.49	Esmi	10	0.0	538	Tile-21-p.shp	Tile-21-p.shp
268	9537	G98*6	3784	4.35	Ppat	10	0.0	870	Tile-21-p.shp	Tile-21-p.shp
269	9539	G100*4	2572	8.50	Amea	5	0.0	303	Tile-33-p.shp	Tile-22-p.shp
270	9540	G101*5	28	0.97	Amea	3	0.0	29	Tile-22-p.shp	Tile-22-p.shp
271	9541	G102*4	10135	18.93	Esmi	5	0.0	535	Tile-21-p.shp	Tile-21-p.shp
272	9543	G104*4	287	1.48	Amea	5	0.0	194	Tile-21-p.shp	Tile-21-p.shp
273	9544	G105*4	878	7.27	Amea	5	0.0	121	Tile-21-p.shp	Tile-21-p.shp
274	9554	H1*4	925	8.11	Ppat	1	0.0	114	Tile-13-p.shp	Tile-12-p.shp
275	9555	H2*4	3108	4.65	Emac	29	0.0	668	Tile-13-p.shp	Tile-13-p.shp
276	9556	H3*3	1645	2.59	Ppat	27	0.0	635	Tile-13-p.shp	Tile-13-p.shp
278	9558	H5*5	1606	1.66	Ppat	16	0.0	967	Tile-13-p.shp	Tile-13-p.shp
279	9560	H6*4	6729	6.62	Ppat	6	0.0	1016	Tile-13-p.shp	Tile-13-p.shp
280	9561	H7a*4	9806	7.70	Ppat	2	0.0	1274	Tile-18-p.shp	Tile-12-p.shp
281	9562	H7b*3	8721	11.67	Ppat	23	0.0	747	Tile-18-p.shp	Tile-13-p.shp
282	9563	H8*4	13	10.85	Esmi	0	10.8	1	Tile-13-p.shp	Tile-13-p.shp
283	9564	H9*3	2059	3.33	Esmi	27	0.0	618	Tile-7-p.shph	Tile-7-p.shp
284	9565	H10*5	4480	4.98	Ppat	16	0.0	900	Tile-13-p.shp	Tile-13-p.shp

OBJECTID	LID	NAME	TREES	HECTARE	SPECIES	HEIGHT	TUP_HA	PERHA	SHAPETILE1	SHAPETILE2
285	9566	H11*3	1083	1.72	Esmi	27	0.0	630	Tile-13-p.shp	Tile-13-p.shp
286	9567	H13a*4	47	5.01	Esmi	0	5.0	9	Tile-13-p.shp	Tile-13-p.shp
287	9568	H13b*3	1140	1.76	Esmi	27	0.0	648	Tile-13-p.shp	Tile-13-p.shp
288	9569	H13c*4	8660	6.67	Ppat	2	0.0	1298	Tile-13-p.shp	Tile-13-p.shp
289	9570	H14*3	14003	22.01	Esmi	30	0.0	636	Tile-13-p.shp	Tile-12-p.shp
290	9571	H16a*4	1679	1.73	Ppat	2	0.0	971	Tile-13-p.shp	Tile-13-p.shp
291	9572	H16b*3	799	1.28	Esmi	27	0.0	624	Tile-13-p.shp	Tile-1-p.shp
292	9574	H18*4	2188	3.38	Ppat	2	0.0	647	Tile-14-p.shp	Tile-14-p.shp
293	9575	H19*4	12075	9.54	Ppat	3	0.0	1266	Tile-13-p.shp	Tile-13-p.shp
294	9576	H20*5	8816	8.77	Ppat	16	0.0	1005	Tile-13-p.shp	Tile-13-p.shp
295	9577	H21*4	3127	7.60	Ppat	2	0.0	411	Tile-13-p.shp	Tile-13-p.shp
296	9578	H22*4	1110	1.33	Ppat	2	0.0	835	Tile-13-p.shp	Tile-13-p.shp
297	9581	H24*4	7337	6.98	Ppat	12	0.0	1051	Tile-13-p.shp	Tile-13-p.shp
298	9582	H25*3	2700	3.15	Ppat	16	0.0	857	Tile-13-p.shp	Tile-13-p.shp
299	9583	H26*3	1822	2.56	Ppat	24	0.0	712	Tile-19-p.shp	Tile-19-p.shp
300	9584	H27a*3	1937	3.16	Emac	28	0.0	613	Tile-25-p.shp	Tile-19-p.shp
301	9585	H27b*3	2394	3.06	Ppat	27	0.0	782	Tile-19-p.shp	Tile-19-p.shp
302	9586	H28a*4	100	4.22	Ppat	1	0.0	24	Tile-19-p.shp	Tile-13-p.shp
303	9587	H28b*4	16	0.93	Ppat	2	0.0	17	Tile-19-p.shp	Tile-9-p.shp
304	9588	H29a*4	14071	14.74	Ppat	3	0.0	955	Tile-19-p.shp	Tile-19-p.shp
305	9589	H29b*4	18	2.41	Ppat	0	2.4	7	Tile-25-p.shp	Tile-19-p.shp
306	9590	H29c*3	947	1.72	Emac	28	0.0	551	Tile-25-p.shp	Tile-19-p.shp
307	9591	H30*3	161	0.20	Ppat	27	0.0	805	Tile-19-p.shp	Tile-19-p.shp
308	9593	H32*4	70	4.01	Ppat	2	0.0	17	Tile-19-p.shp	Tile-12-p.shp
309	9594	H33*4	269	2.43	Ppat	1	0.0	111	Tile-13-p.shp	Tile-12-p.shp
310	9595	H34*4	3176	5.09	Esmi	4	0.0	624	Tile-19-p.shp	Tile-13-p.shp
311	9597	H37*3	6618	7.79	Ppat	19	0.0	850	Tile-19-p.shp	Tile-19-p.shp
312	9599	H38*4	1607	1.54	Ppat	3	0.0	1044	Tile-19-p.shp	Tile-19-p.shp
313	9600	H39*4	689	5.30	Ppat	1	3.3	130	Tile-19-p.shp	Tile-19-p.shp
314	9602	H40*4	3658	3.93	Ppat	3	0.0	931	Tile-19-p.shp	Tile-13-p.shp
315	9603	H41*3	16063	25.94	Esmi	26	0.0	619	Tile-19-p.shp	Tile-14-p.shp
316	9605	H43*3	2083	3.43	Esmi	27	0.0	607	Tile-20-p.shp	Tile-14-p.shp
317	9606	H44*3	23257	32.84	Ppat	27	0.0	708	Tile-19-p.shp	Tile-14-p.shp
318	9607	H45*3	1177	1.44	Ppat	18	0.0	817	Tile-19-p.shp	Tile-19-p.shp
319	9608	H46*4	2006	2.12	Ppat	14	0.0	946	Tile-19-p.shp	Tile-19-p.shp
320	9609	H36*3	1607	2.86	Enit	18	0.0	562	Tile-19-p.shp	Tile-19-p.shp
321	9611	H48*3	2861	4.29	Ppat	26	0.0	667	Tile-19-p.shp	Tile-19-p.shp
322	9612	H49*4	13248	22.26	Esmi	29	0.0	595	Tile-19-p.shp	Tile-19-p.shp
323	9613	H50*4	1054	1.13	Ppat	12	0.0	933	Tile-19-p.shp	Tile-19-p.shp
324	9614	H51a*3	5104	7.06	Ppat	21	0.0	723	Tile-19-p.shp	Tile-19-p.shp
325	9615	H51b*3	3047	4.51	Ppat	26	0.0	676	Tile-19-p.shp	Tile-19-p.shp
326	9616	H52a*3	2339	3.26	Ppat	25	0.0	717	Tile-20-p.shp	Tile-20-p.shp
327	9617	H52b*3	1219	1.38	Pell	22	0.0	883	Tile-20-p.shp	Tile-20-p.shp
328	9618	H53a*4	1731	3.19	Ppat	32	0.0	543	Tile-21-p.shp	Tile-21-p.shp
329	9619	H53b*3	3835	6.00	Ppat	26	0.0	639	Tile-20-p.shp	Tile-20-p.shp
330	9620	H54*4	1886	6.51	Ppat	34	0.0	290	Tile-20-p.shp	Tile-20-p.shp
331	9622	H55b*3	10758	13.73	Ppat	21	0.0	784	Tile-19-p.shp	Tile-16-p.shp
332	9623	H56a*3	4798	8.01	Esmi	28	0.0	599	Tile-20-p.shp	Tile-20-p.shp
333	9624	H56b*3	11161	12.39	Pp+e	24	0.0	901	Tile-20-p.shp	Tile-20-p.shp
334	9625	H56c*4	43	3.93	Ppat	2	0.0	11	Tile-20-p.shp	Tile-20-p.shp
335	9626	H57*3	11337	16.94	Ppat	25	0.0	669	Tile-20-p.shp	Tile-20-p.shp
336	9627	H58a*3	2923	4.58	Ppat	25	0.0	638	Tile-20-p.shp	Tile-20-p.shp
337	9628	H58b*4	1918	3.16	Esmi	25	0.0	607	Tile-19-p.shp	Tile-19-p.shp
338	9629	H59a*3	9937	13.39	Ppat	21	0.0	742	Tile-20-p.shp	Tile-20-p.shp
339	9630	H59b*4	1360	2.07	Ptae	2	0.0	657	Tile-21-p.shp	Tile-21-p.shp
340	9631	H59c*3	1371	2.20	Ppat	23	0.0	623	Tile-20-p.shp	Tile-20-p.shp
341	9632	H60a*4	4	0.56	Ppat	0	0.0	7	Tile-21-p.shp	Tile-21-p.shp

OBJECTID	LID	NAME	TREES	HECTARE	SPECIES	HEIGHT	TUP_HA	PERHA	SHAPETILE1	SHAPETILE2
342	9633	H60b*3	3825	7.12	Amea	23	0.0	537	Tile-21-p.shp	Tile-21-p.shp
343	9634	H61a*4	7558	8.32	Ppat	12	0.0	908	Tile-20-p.shp	Tile-20-p.shp
344	9637	H61d*3	964	1.16	Ppat	16	0.0	831	Tile-21-p.shp	Tile-21-p.shp
345	9638	H62a*3	6880	8.77	Ppat	24	0.0	784	Tile-20-p.shp	Tile-20-p.shp
346	9639	H62b*3	4539	6.34	Ppat	25	0.0	716	Tile-20-p.shp	Tile-20-p.shp
347	9640	H64a*4	4736	5.27	Ppat	14	0.0	899	Tile-20-p.shp	Tile-20-p.shp
348	9641	H64b*3	1909	2.24	Ppat	17	0.0	852	Tile-26-p.shp	Tile-20-p.shp
349	9642	H64c*3	1928	2.95	Ppat	22	0.0	654	Tile-20-p.shp	Tile-20-p.shp
350	9643	H64d*3	1965	2.42	Ppat	17	0.0	812	Tile-26-p.shp	Tile-20-p.shp
351	9644	H71*4	19020	19.67	Ppat	8	0.0	967	Tile-19-p.shp	Tile-19-p.shp
352	9645	H65*5	8818	8.32	Ppat	7	0.0	1060	Tile-19-p.shp	Tile-19-p.shp
353	9647	H66*3	6972	9.35	Ppat	24	0.0	746	Tile-19-p.shp	Tile-19-p.shp
354	9648	H67*4	8362	9.59	Ppat	5	0.0	872	Tile-25-p.shp	Tile-19-p.shp
355	9649	H68*4	16059	13.75	Ppat	5	0.0	1168	Tile-25-p.shp	Tile-20-p.shp
356	9650	H70a*4	13881	13.22	Ppat	7	0.0	1050	Tile-19-p.shp	Tile-19-p.shp
357	9652	H70b*4	85	7.98	Ppat	0	0.0	11	Tile-25-p.shp	Tile-25-p.shp
358	9653	H70c*3	4364	7.30	Edun	18	0.0	598	Tile-25-p.shp	Tile-25-p.shp
359	9655	H73a*3	8959	10.37	Ppat	20	0.0	864	Tile-25-p.shp	Tile-25-p.shp
360	9656	H73b*4	2935	2.93	Ppat	11	0.0	1002	Tile-25-p.shp	Tile-25-p.shp
361	9657	H74*4	12849	11.14	Ppat	5	0.0	1153	Tile-25-p.shp	Tile-25-p.shp
362	9658	H75a*3	25128	28.89	Ppat	15	0.0	870	Tile-25-p.shp	Tile-25-p.shp
363	9659	H76*4	9878	10.23	Ppat	4	0.0	966	Tile-26-p.shp	Tile-26-p.shp
364	9660	H77*3	7174	8.79	Ppat	17	0.0	816	Tile-26-p.shp	Tile-26-p.shp
365	9661	H78a*3	5128	6.13	Ppat	24	0.0	837	Tile-20-p.shp	Tile-20-p.shp
366	9663	H78c*4	3570	4.01	Ppat	16	0.0	890	Tile-26-p.shp	Tile-20-p.shp
367	9664	H79*3	5658	9.98	Esmi	30	0.0	567	Tile-26-p.shp	Tile-20-p.shp
368	9665	H80*3	5257	8.22	Ppat	25	0.0	640	Tile-21-p.shp	Tile-21-p.shp
369	9666	H81*3	2116	4.09	Esmi	25	0.0	517	Tile-27-p.shp	Tile-21-p.shp
370	50061	D10c*3	10386	18.65	Esmi	25	0.0	557	Tile-27-p.shp	Tile-21-p.shp
371	1001521	F14b*3	776	1.38	Emix	24	0.0	562	tile2_or_tile8	tile2_or_tile8
372	1002161	G18b*3	16060	18.87	Ppat	15	0.0	851	Tile-14-p.shp	Tile-14-p.shp
373	1002901	G41a*1	9287	10.38	Ppat	16	0.0	895	Tile-14-p.shp	Tile-9-p.shp
374	1005229	H55a*3	387	0.46	Ppat	15	0.0	841	Tile-20-p.shp	Tile-20-p.shp
375	1013292	C6d*4	433	0.92	Edun	25	0.0	471	Tile-16-p.shp	Tile-16-p.shp
376	1013293	C6c*3	89	2.15	Edun	30	0.0	41	Tile-16-p.shp	Tile-16-p.shp
377	1013294	C10b*3	5045	8.71	Edun	28	0.0	579	Tile-16-p.shp	Tile-16-p.shp
378	1013296	C8b*4	1073	7.67	Amea	3	0.0	140	Tile-17-p.shp	Tile-16-p.shp
379	1013298	C31*6	299	0.27	Ppat	2	0.0	1107	Tile-29-p.shp	Tile-29-p.shp
380	1013319	F42*3	1123	1.68	Ppat	25	0.0	668	tile2_or_tile8	tile2_or_tile8
381	1013321	F43*3	17928	28.99	Esmi	30	0.0	618	Tile-1-p.shph	Tile-1-p.shp
382	1013323	F45*3	8158	12.72	Esmi	30	0.0	641	Tile-1-p.shph	Tile-1-p.shp
383	1013324	F46*3	828	1.88	Egra	30	0.0	440	Tile-7-p.shph	Tile-7-p.shp
384	1013325	G26*3	2435	4.70	Amea	24	0.0	518	Tile-15-p.shp	Tile-15-p.shp
385	1013327	D7b*3	10206	16.88	Esmi	25	0.0	605	Tile-26-p.shp	Tile-26-p.shp
386	1013328	D10d*3	2695	4.35	Edun	29	0.0	620	Tile-27-p.shp	Tile-27-p.shp
387	1013329	D10e*3	522	0.78	Esal	24	0.0	669	Tile-27-p.shp	Tile-27-p.shp
388	1013330	D12b*5	8	2.35	Esmi	3	0.0	3	Tile-27-p.shp	Tile-27-p.shp
389	1013332	G43b*3	4060	4.07	Pell	16	0.0	998	Tile-14-p.shp	tile2_or_tile8
390	1013334	G47c*3	446	0.80	Amea	24	0.0	558	Tile-14-p.shp	Tile-14-p.shp
391	1013335	D49b*3	1635	12.82	Pell	23	0.0	128	Tile-27-p.shp	Tile-27-p.shp
392	1013336	D57b*5	88	0.36	Esmi	0	0.4	244	Tile-27-p.shp	Tile-27-p.shp
393	1013340	G66*3	3389	5.40	Edun	29	0.0	628	Tile-15-p.shp	Tile-15-p.shp
394	1013341	G95*3	114	0.38	Ppat	25	0.0	300	Tile-21-p.shp	Tile-21-p.shp
395	1013342	H53c*4	9454	11.23	Ppat	16	0.0	842	Tile-20-p.shp	Tile-16-p.shp
396	1013344	E29*3	204	0.81	Pp+t	25	0.0	252	Tile-12-p.shp	Tile-12-p.shp
397	1013345	E12a*3	45	0.00	Ppat	25	0.0		Tile-25-p.shp	Tile-21-p.shp
398	1013346	G64*2	8655	9.27	Ppat	10	0.0	934	Tile-15-p.shp	Tile-15-p.shp

OBJECTID	LID	NAME	TREES	HECTARE	SPECIES	HEIGHT	TUP_HA	PERHA	SHAPETILE1	SHAPETILE2
399	1013347	F14c*3	448	0.79	Enit	24	0.0	567	tile2_or_tile8	tile2_or_tile8
400	1013348	F14d*3	717	1.45	Enit	24	0.0	494	tile2_or_tile8	tile2_or_tile8
401	1013349	F20d*3	362	0.59	Amea	25	0.0	614	Tile-7-p.shph	Tile-7-p.shp
402	1013350	F20e*3	758	1.77	Efra	30	0.0	428	Tile-7-p.shph	Tile-7-p.shp
403	1013351	F31a*3	13695	16.06	Ppat	20	0.0	853	Tile-6-p.shph	Tile-0-p.shp
404	1013353	G73*2	7749	8.34	Amea	15	0.0	929	Tile-16-p.shp	Tile-16-p.shp
406	1014184	D77*3	1828	2.19	Ppat	15	0.0	835	Tile-28-p.shp	Tile-28-p.shp
407	1014185	H78d*3	904	1.47	Esmi	20	0.0	615	Tile-20-p.shp	Tile-20-p.shp
408	1014186	F18b*4	3430	3.68	Ppat	10	0.0	932	Tile-7-p.shph	Tile-7-p.shp
409	1014187	F18c*4	1238	1.39	Ppat	10	0.0	891	Tile-7-p.shph	Tile-7-p.shp
410	1014779	C13c*4	535	1.56	Ppat	0	1.6	343	Tile-17-p.shp	Tile-17-p.shp
411	1014780	F15b*3	681	1.03	Emix	24	0.0	661	tile2_or_tile8	tile2_or_tile8
412	1014781	D14d*3	824	1.02	Esmi	15	0.0	808	Tile-26-p.shp	Tile-26-p.shp
413	1016636	F18d*4	509	0.67	Ppat	10	0.0	760	Tile-7-p.shph	Tile-7-p.shp
414	1017368	D4a*3	3276	7.56	Efra	30	0.0	433	Tile-25-p.shp	Tile-25-p.shp
415	1017369	E28c*4	2284	2.74	Ppat	10	0.0	834	Tile-26-p.shp	Tile-12-p.shp
416	1017370	E28a*5	64	6.55	Ppat	0	6.5	10	Tile-12-p.shp	Tile-12-p.shp
417	1017371	F1a*4	7368	7.28	Ppat	15	0.0	1012	Tile-12-p.shp	Tile-12-p.shp
418	1017372	G54b*4	1921	1.75	Pell	10	0.0	1098	Tile-10-p.shp	Tile-10-p.shp
419	1017374	H72*3	1023	1.54	Pell	25	0.0	664	Tile-19-p.shp	Tile-19-p.shp
420	1017375	H53d*4	203	0.47	Ppat	0	0.5	432	Tile-21-p.shp	Tile-21-p.shp
421	1017589	F33b*5	1175	1.82	Emix	20	0.0	646	Tile-0-p.shph	Tile-0-p.shp
423	1041557	D70*4	853	1.41	Amea	18	0.0	605	Tile-28-p.shp	Tile-28-p.shp
424	1049489	C30b*4	6996	7.76	Ppat	7	0.0	902	Tile-29-p.shp	Tile-29-p.shp
425	1049490	C30a*4	6494	6.36	Ppat	6	0.0	1021	Tile-29-p.shp	Tile-29-p.shp
426	1049492	C44a*4	7009	10.34	Amea	20	0.0	678	Tile-23-p.shp	Tile-23-p.shp
427	1049494	D52a*4	7349	7.88	Ppat	5	0.0	933	Tile-39-p.shp	Tile-34-p.shp
428	1049495	D60d*4	1561	2.12	Esmi	12	0.0	736	Tile-22-p.shp	Tile-22-p.shp
429	1049496	D66b*3	226	0.31	Ppat	30	0.0	729	Tile-34-p.shp	Tile-34-p.shp
430	1049499	E7b*3	140	0.17	Ppat	20	0.0	824	Tile-19-p.shp	Tile-19-p.shp
431	1049500	F33c*5	460	0.62	Emix	20	0.0	742	Tile-0-p.shph	Tile-0-p.shp
432	1049501	G45*4	8861	8.31	Ptae	8	0.0	1066	tile2_or_tile8	tile2_or_tile8
433	1049502	G97*4	3644	4.60	Ppat	15	0.0	792	Tile-21-p.shp	Tile-21-p.shp
434	1049505	H70d*5	409	0.45	Ppat	6	0.0	909	Tile-25-p.shp	Tile-25-p.shp
435	1049511	H73c*5	21895	19.99	Ppat	3	0.0	1095	Tile-25-p.shp	Tile-25-p.shp
436	1053718	C5a*3	35119	41.48	Ppat	20	0.0	847	Tile-16-p.shp	Tile-16-p.shp
437	1053719	C5b*4	3066	4.38	Ppat	2	0.0	700	Tile-16-p.shp	Tile-16-p.shp
438	1053760	G54a*4	10656	11.02	Ppat	15	0.0	967	Tile-10-p.shp	Tile-10-p.shp
439	1053761	G54c*5	1448	2.48	Amea	15	0.0	584	Tile-10-p.shp	Tile-10-p.shp
440	1066293	D48a*4	14858	20.91	Esmi	9	0.0	711	Tile-33-p.shp	Tile-33-p.shp
441	1066294	D48c*5	676	7.78	Esmi	3	0.0	87	Tile-33-p.shp	Tile-33-p.shp
442	1066562	D69a*5	144	6.40	Ppat	1	0.0	23	Tile-28-p.shp	Tile-28-p.shp
443	1067072	D19a*3	2271	3.64	Ppat	20	0.0	624	Tile-32-p.shp	Tile-32-p.shp
444	1067073	D19b*3	2038	2.53	Ppat	20	0.0	806	Tile-32-p.shp	Tile-32-p.shp
445	1067077	D18a*3	3721	5.35	Ppat	16	0.0	696	Tile-32-p.shp	Tile-32-p.shp
446	1067078	D18c*3	3529	4.88	Ppat	16	0.0	723	Tile-32-p.shp	Tile-32-p.shp
447	1067079	D18d*3	5345	6.43	Ppat	16	0.0	831	Tile-32-p.shp	Tile-32-p.shp
448	1067091	G84a*4	8414	13.48	Esmi	10	0.0	624	Tile-21-p.shp	Tile-21-p.shp
449	1067092	G84b*5	8	3.75	Esmi	3	0.0	2	Tile-21-p.shp	Tile-21-p.shp
450	1074137	H61b*3	3	1.47	Ppat	0	0.0	2	Tile-21-p.shp	Tile-21-p.shp
451	1074358	C54*4	315	1.17	Esmi	1	0.0	269	Tile-23-p.shp	Tile-23-p.shp
452	1074359	D54*4	5686	6.57	Esmi	14	0.0	865	Tile-28-p.shp	Tile-22-p.shp
453	1074360	E10a*4	92	0.20	Amea	34	0.0	460	Tile-18-p.shp	Tile-18-p.shp
454	1074361	E10b*4	19463	18.26	Ppat	3	0.0	1066	Tile-18-p.shp	Tile-18-p.shp
455	1074366	F4*3	24877	31.08	Ppat	19	0.0	800	Tile-13-p.shp	Tile-12-p.shp
456	1074367	F5*3	721	1.35	Egra	45	0.0	534	Tile-13-p.shp	Tile-13-p.shp
457	1074368	F6a*3	12916	12.91	Pell	17	0.0	1000	Tile-7-p.shph	Tile-7-p.shp

OBJECTID	LID	NAME	TREES	HECTARE	SPECIES	HEIGHT	TUP_HA	PERHA	SHAPETILE1	SHAPETILE2
458	1074369	F6b*3	2447	4.77	Pell	17	0.0	513	Tile-13-p.shp	Tile-12-p.shp
459	1074370	G55a*3	484	6.21	Pell	23	0.0	78	Tile-10-p.shp	Tile-10-p.shp
460	1074371	G55b*3	499	1.08	Emix	36	0.0	462	Tile-16-p.shp	Tile-16-p.shp
461	1074373	D5*4	2538	3.92	Amea	20	0.0	647	Tile-26-p.shp	Tile-26-p.shp
462	1074374	H75b*4	488	0.76	Ajun	21	0.0	642	Tile-26-p.shp	Tile-26-p.shp
463	1074375	H78b*4	4092	3.85	Ppat	2	0.0	1063	Tile-26-p.shp	Tile-26-p.shp
464	1074376	H78e*4	844	1.29	Egra	48	0.0	654	Tile-26-p.shp	Tile-26-p.shp

5.2 Table with Interior Openings Per Compartment

Original Files:
shapes/interior-openings.shp
table/interior-openings-trees-per-compartment.xls

OBJECTID	LID	HECTARE	TUP_HA
4	9093	3.25	0.00
18	9112	8.19	0.00
19	9113	0.28	0.00
31	9127	0.01	0.00
42	9146	2.02	0.00
44	9151	2.53	0.00
45	9152	0.59	0.00
48	9156	10.72	14.60
49	9157	3.09	0.00
50	9177	3.60	0.00
51	9178	0.07	0.00
62	9191	19.80	0.00
81	9218	3.10	0.00
84	9224	0.08	0.00
89	9231	0.02	0.00
100	9246	0.04	0.00
107	9253	0.94	0.00
109	9257	13.30	0.00
122	9270	9.31	0.00
128	9278	2.69	0.00
132	9282	0.39	0.00
133	9283	0.09	0.00
139	9332	0.01	0.00
141	9334	0.47	0.00
142	9335	0.03	0.00
145	9339	3.24	0.00
148	9346	0.73	0.00
151	0	0.05	
153	9352	0.04	0.00
154	9353	0.04	0.00
161	9378	1.85	0.00
162	9379	9.85	0.00
164	9381	0.98	0.00
166	9385	15.48	0.00
183	9403	0.07	0.00
187	9407	0.64	0.00
190	9410	1.13	0.00
202	9426	30.75	0.00
203	9427	3.00	0.00
204	9428	2.23	0.00
207	9444	0.99	0.00
210	9447	0.17	0.00
240	9489	4.26	0.00
241	9490	13.35	17.00
244	9493	0.16	0.00
245	9496	0.38	0.00
247	9499	0.92	0.00

OBJECTID	LID	HECTARE	TUP_HA
249	9501	1.78	0.00
252	9506	14.42	0.00
253	9507	10.64	0.00
257	9516	3.71	0.00
260	9519	2.85	0.00
264	9529	2.40	0.00
265	9530	0.01	0.00
266	9533	2.14	0.00
267	9535	0.05	0.00
269	9539	2.57	0.00
270	9540	0.55	0.00
271	9541	0.17	0.00
272	9543	0.66	0.00
273	9544	4.52	0.00
274	9554	4.94	0.00
277	9557	2.06	0.00
282	9563	6.88	10.80
286	9567	3.13	5.00
292	9574	0.07	0.00
295	9577	1.02	0.00
302	9586	3.28	0.00
303	9587	0.46	0.00
305	9589	1.44	2.40
308	9593	2.94	0.00
309	9594	1.09	0.00
313	9600	2.12	3.30
330	9620	1.36	0.00
334	9625	2.58	0.00
338	9629	0.13	0.00
339	9630	0.01	0.00
341	9632	0.15	0.00
354	9648	0.07	0.00
357	9652	5.02	0.00
363	9659	0.01	0.00
378	1013296	2.89	0.00
383	1013324	0.06	0.00
388	1013330	0.61	0.00
391	1013335	5.42	0.00
396	1013344	0.24	0.00
416	1017370	2.57	6.50
417	1017371	0.03	0.00
436	1053718	0.21	0.00
437	1053719	0.30	0.00
441	1066294	2.94	0.00
442	1066562	3.78	0.00
448	1067091	0.02	0.00
449	1067092	2.77	0.00
450	1074137	0.53	0.00
451	1074358	0.05	0.00
454	1074361	0.03	0.00
458	1074369	0.11	0.00
459	1074370	3.42	0.00