# The method of delimiting forest areas with the use of airborne laser scanning data and hyperspectral imaging

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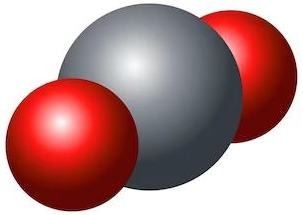
Promoter – Prof. Krzysztof Stereńczak

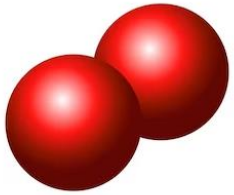
# Publication cycle

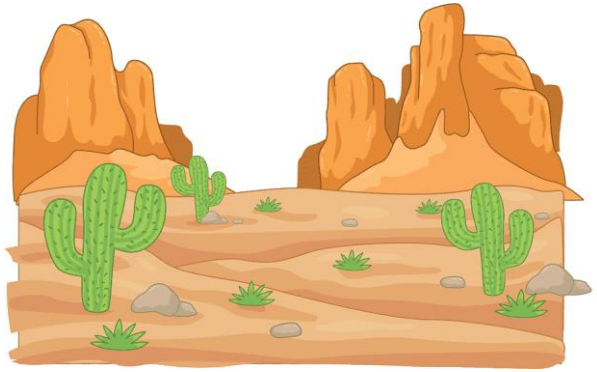
1. Hycza T., Kamińska A., Stereńczak K. 2021. The use of remote sensing data to estimate land area with forest vegetation cover in the context of selected forest definitions. Forests 12(11): 1489.
2. Hycza T., Kupidura P. 2021. Methods for separating orchards from forest using airborne LiDAR. Annals of Forest Science 78: 101.
3. Hycza T., Stereńczak K., Bałazy R. 2018. Potential use of hyperspectral data to classify forest tree species. New Zealand Journal of Forestry Science 48.
4. Hycza T., Lisiewicz M., Waraksa P., Stereńczak K. 2022. Classification of 'potential' forests. Sylwan, 166(3): 194-210.

Summary IF = 9,044, Total number of points of the MEiN= 380.

# The importance of forests







# Forest definitions

| Variables | Law on Forests | FAO* | UNFCCC** |
|---|---|---|---|
| **Geometric parameters of trees and forest complexes** | | | |
| **Minimal area** | 0,1 ha | 0,5 ha | 0,1 ha |
| **Minimal height** | - | 5 m | 2 m |
| **Minimal coverage** | - | 10 % | 10 % |
| **Minimal width** | - | - | 10 m |
| **Land use** | | | |
| **Land intended for renovation and natural succession** | yes | yes | yes |
| **Fallow lands with natural succession** | no | yes | yes |
| **Orchards and urban greenery** | no | no | yes |
| **Land related to forest management** | yes | yes | no |

*FAO - Food and Agriculture Organization of the United Nations
**UNFCCC - United Nations Framework Convention on Climate Change

# Objectives of the doctoral thesis

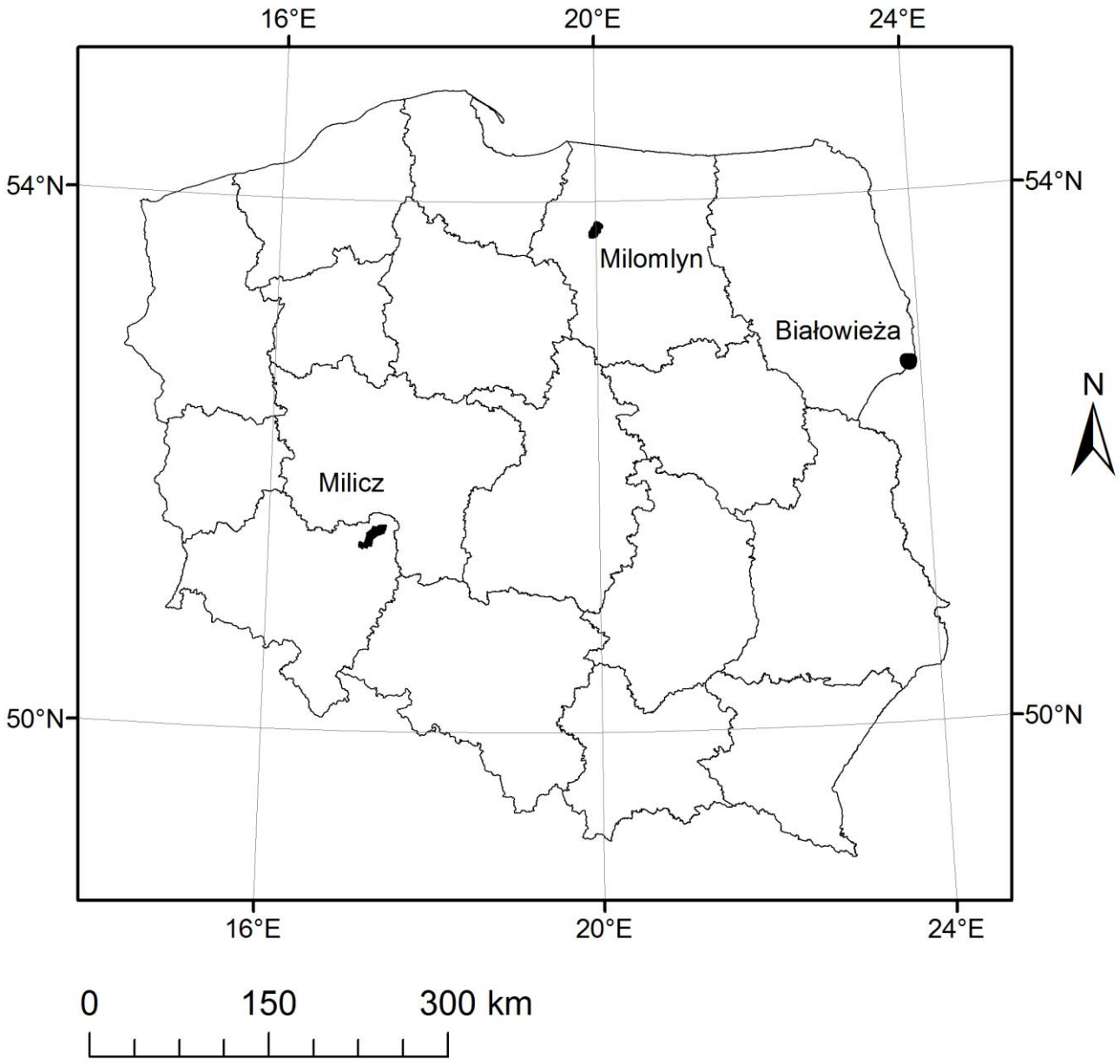
**Main goal:**

The aim of the work was to develop and test effective and repeatable methods of detecting/mapping forest lands, using remote sensing data, for reporting purposes.

**Specific goals:**

1. indication of the optimal method for determining the area covered by tree crowns as an initial criterion in the definition of areas covered by forests, based on data from airborne laser scanning
2. indication of the optimal method of distinguishing orchards from other lands with woody vegetation, based on data from airborne laser scanning
3. indication of the optimal method for classifying types or species of forest-forming trees, based on hyperspectral data
4. indication of the optimal method for classifying land with natural succession into forest-forming and other types or species, based on hyperspectral data and airborne laser scanning data
5. comparison of the results of land classification with forest, potentially forest and other vegetation, based on hyperspectral data and airborne laser scanning data

# Research area – Milicz, Miłomłyn, Białowieża

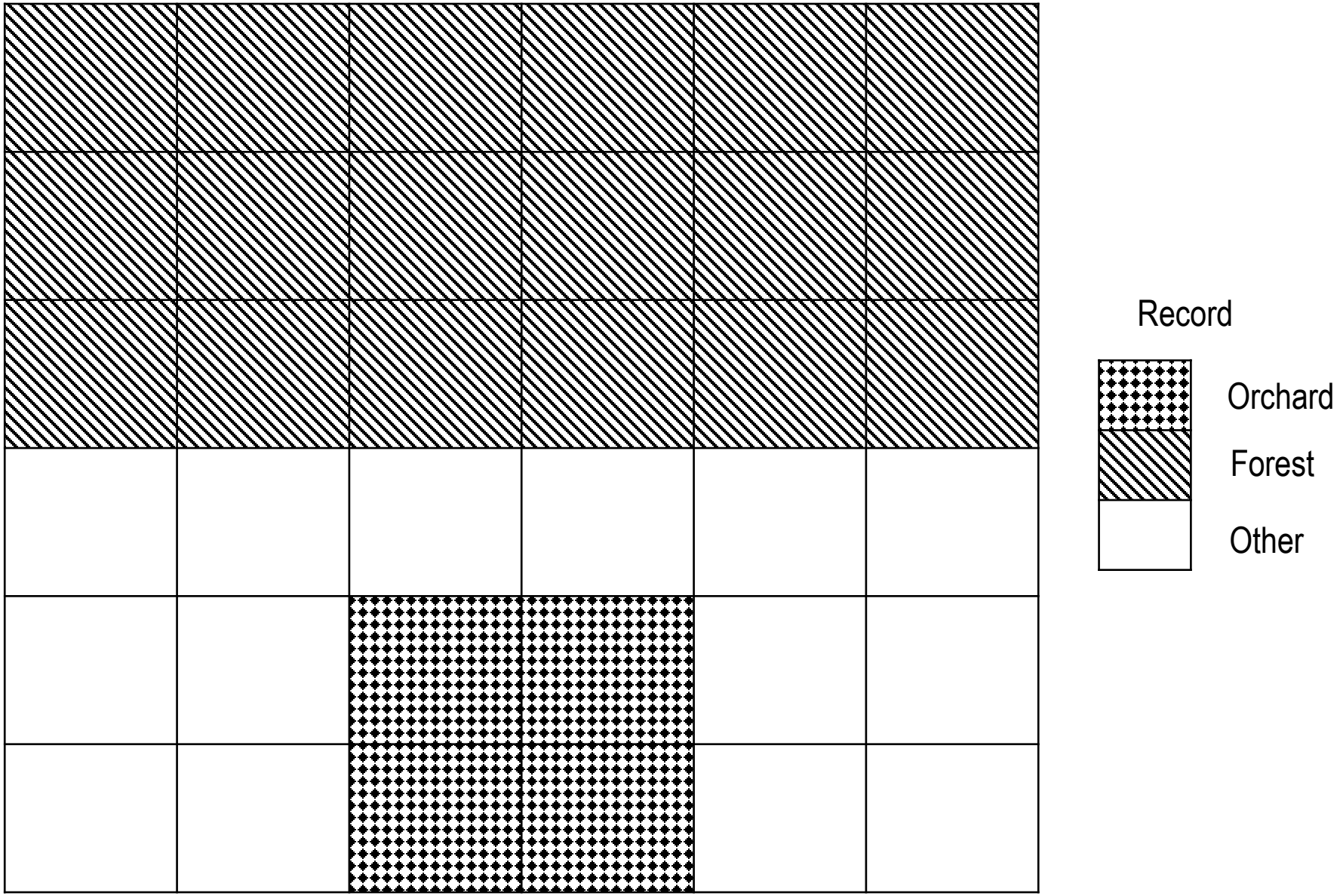


# Data

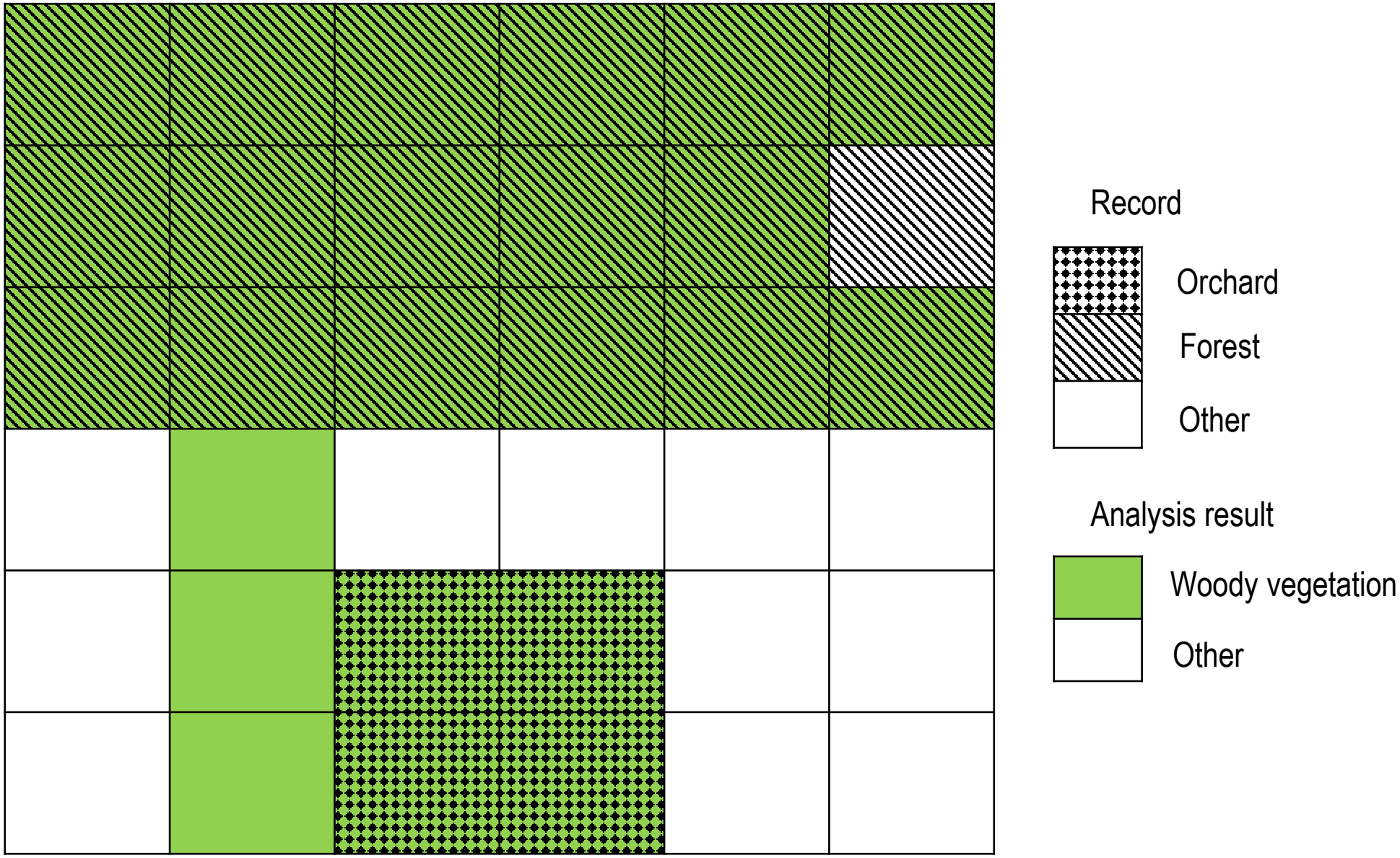
| Data | Stage 1 | Stage 2 | Stage 3 | Stage 4 |
|---|---|---|---|---|
| **Source data** | | | | |
| Point cloud | | | | X |
| Hyperspectral image | | | X | X |
| **Derivatives of source data** | | | | |
| Canopy Height Model | X | X | | X |
| Polygons representing the crowns of individual trees | X | | | X |
| **Additional data** | | | | |
| Vegetation Mask | | X | | |
| Polygons with BDL*/LPIS**and object segmentation | | X | | |

*BDL – Forest Data Bank
**LPIS - Agricultural Plot Identification System

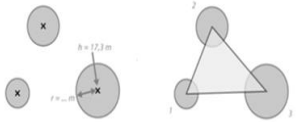
# Forest land in the register

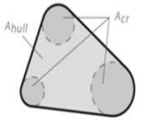


# Land with woody vegetation

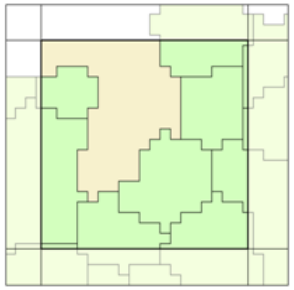


# Land with woody vegetation

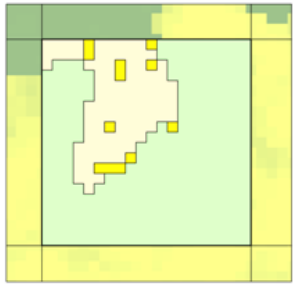




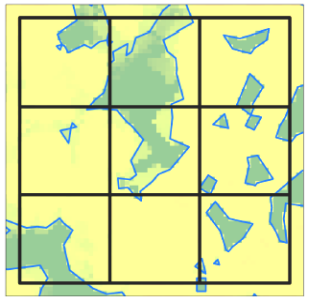

Method 1 - vector: taking into account the area of polygons representing individual trees and the space between them.



Method 2 - vector: taking into account only the area of polygons representing single trees.



Method 3 – raster: taking into account the area of pixels above a certain height threshold.

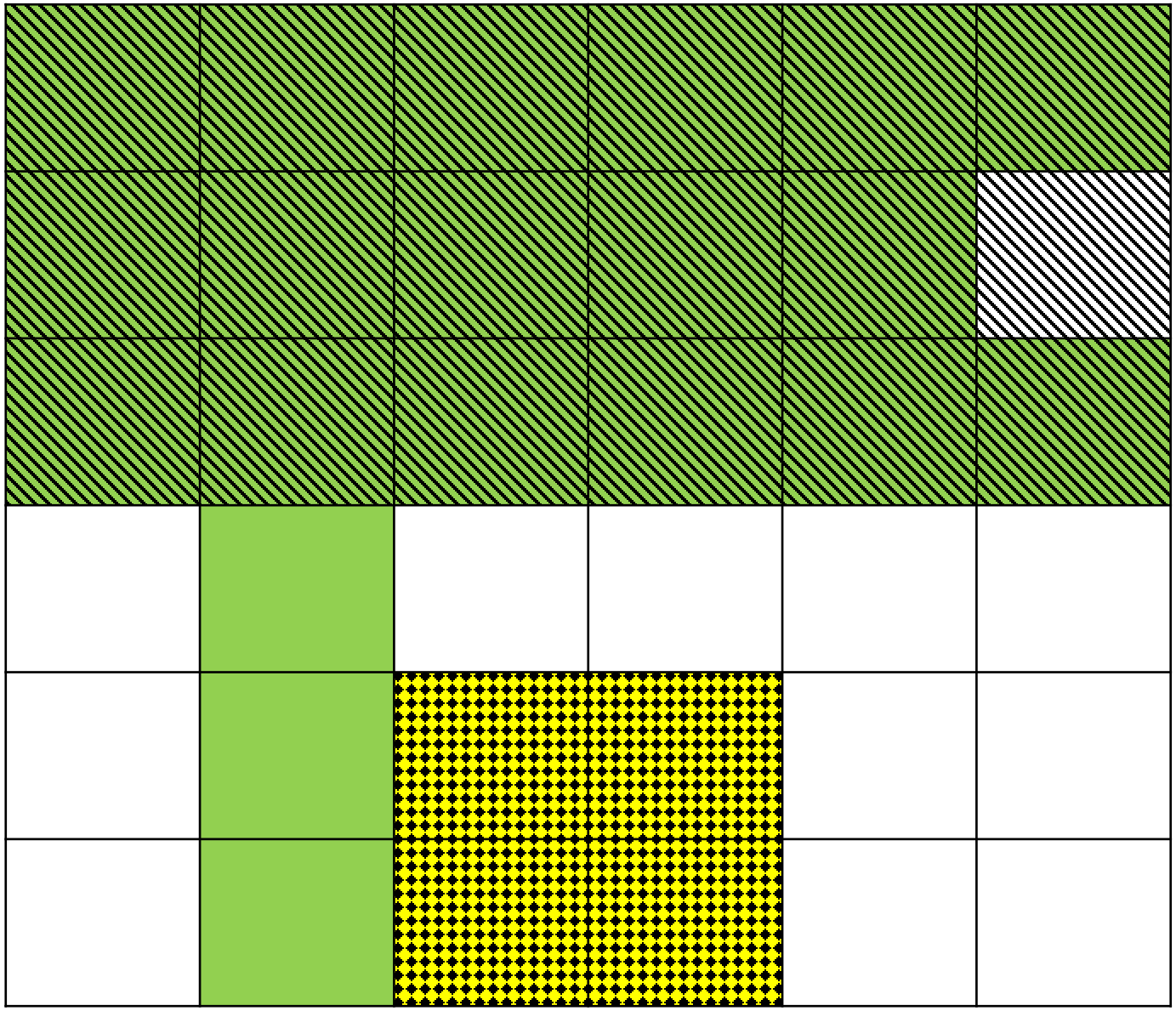


Accuracy analysis: the analysis results were compared with the results of manual vectorization on 30 and 270 (30 x 9) sample surfaces.

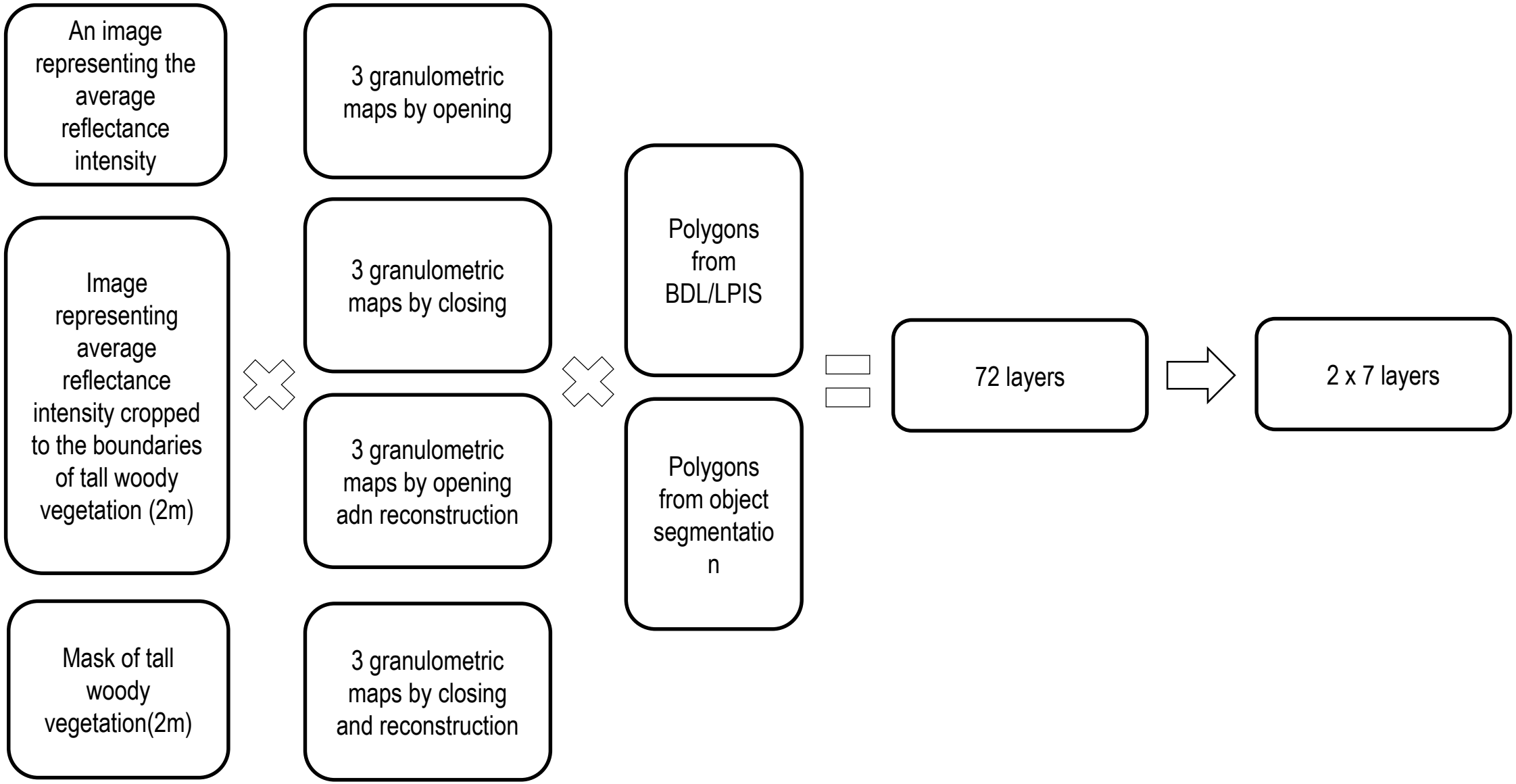
# Land with woody vegetation

| | Method 1 | Method 2 | Method 3 |
|---|---|---|---|
| **270 test plots 10 x 10 m according to FAO/UN** | | | |
| **Total accuracy** | 87,8% | **97,8%** | 94,8% |
| **270 test plots 10 x 10 m according to UNFCCC** | | | |
| **Total accuracy** | 84% | **97,4%** | 96,7% |
| **30 test plots 30 x 30 m according to FAO/UN** | | | |
| **Total accuracy** | 93,3% | **100%** | 93,3% |
| **30 test plots 30 x 30 m according to UNFCCC** | | | |
| **Total accuracy** | 83,3% | **100%** | 100% |

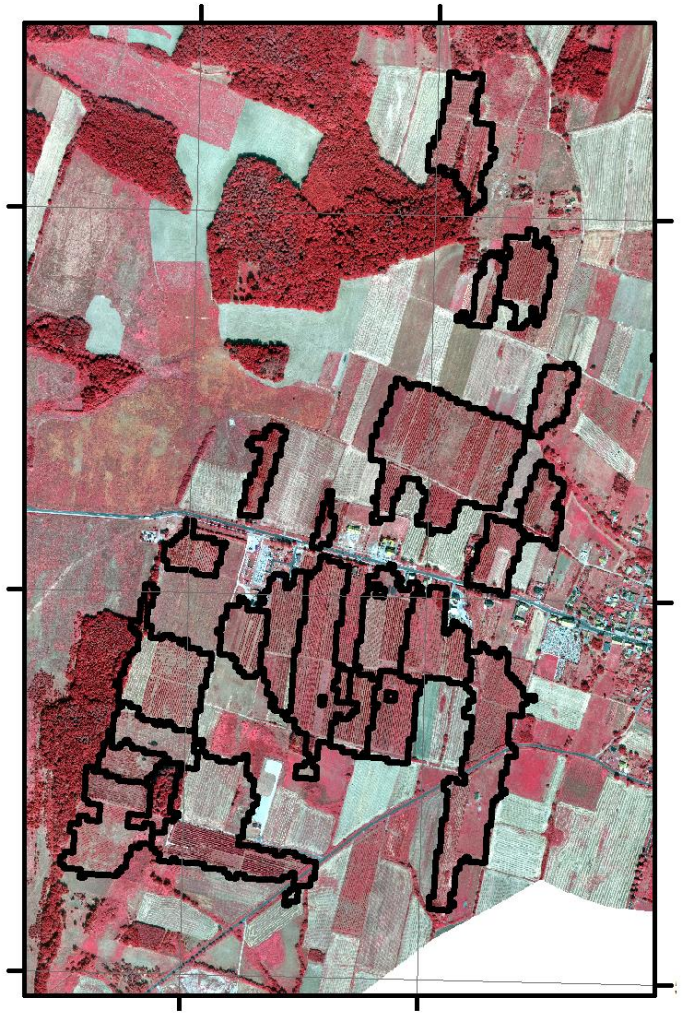
# Orchards


Record
Orchard
Forest
Other
Analysis result
Woody vegetation
Orchard

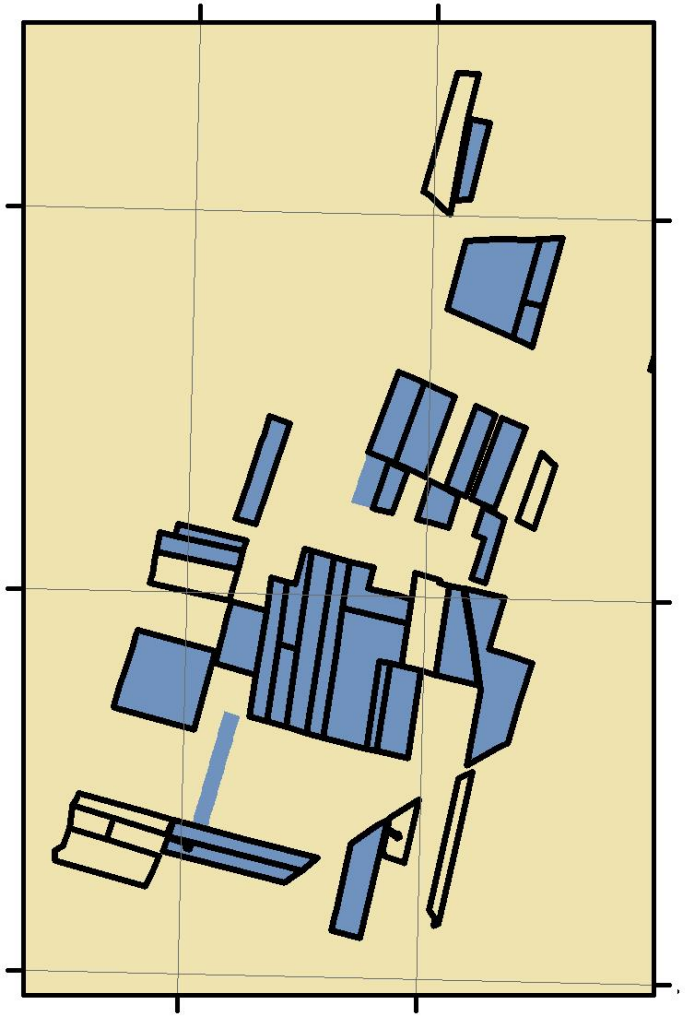
# Orchards


An image representing the average reflectance intensity
Image representing average reflectance intensity cropped to the boundaries of tall woody vegetation (2m)
Mask of tall woody vegetation(2m)
3 granulometric maps by opening
3 granulometric maps by closing
3 granulometric maps by opening adn reconstruction
3 granulometric maps by closing and reconstruction
Polygons from BDL/LPIS
Polygons from object segmentatio n
72 layers
2 x 7 layers

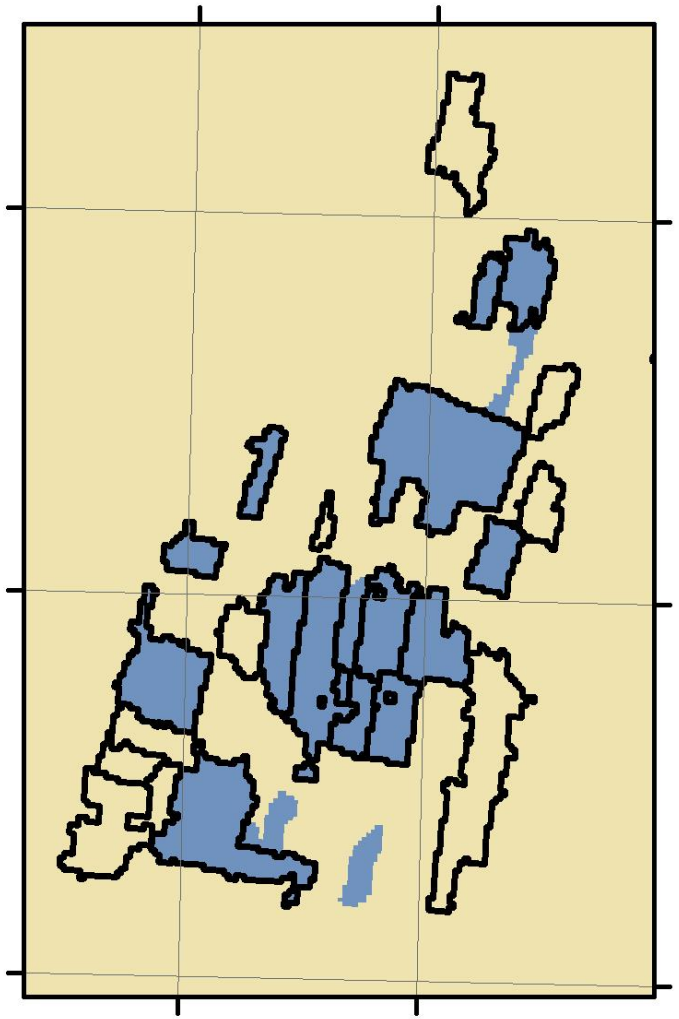
# Orchards



Orthophotomap (CIR)



Composition classification
(polygons from BDL/LPIS)



Composition classification
(segmentation polygons)

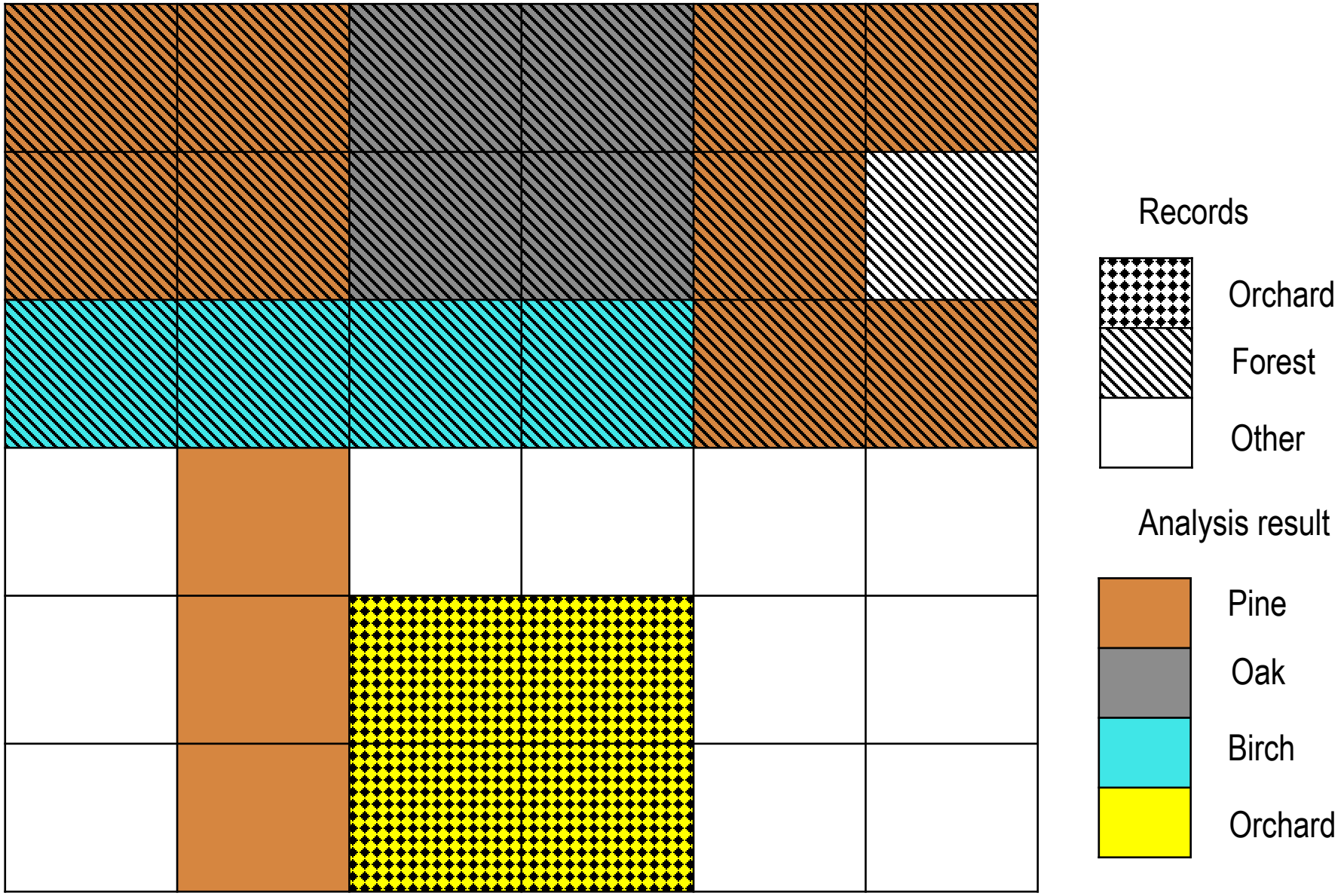
Orchards

Other

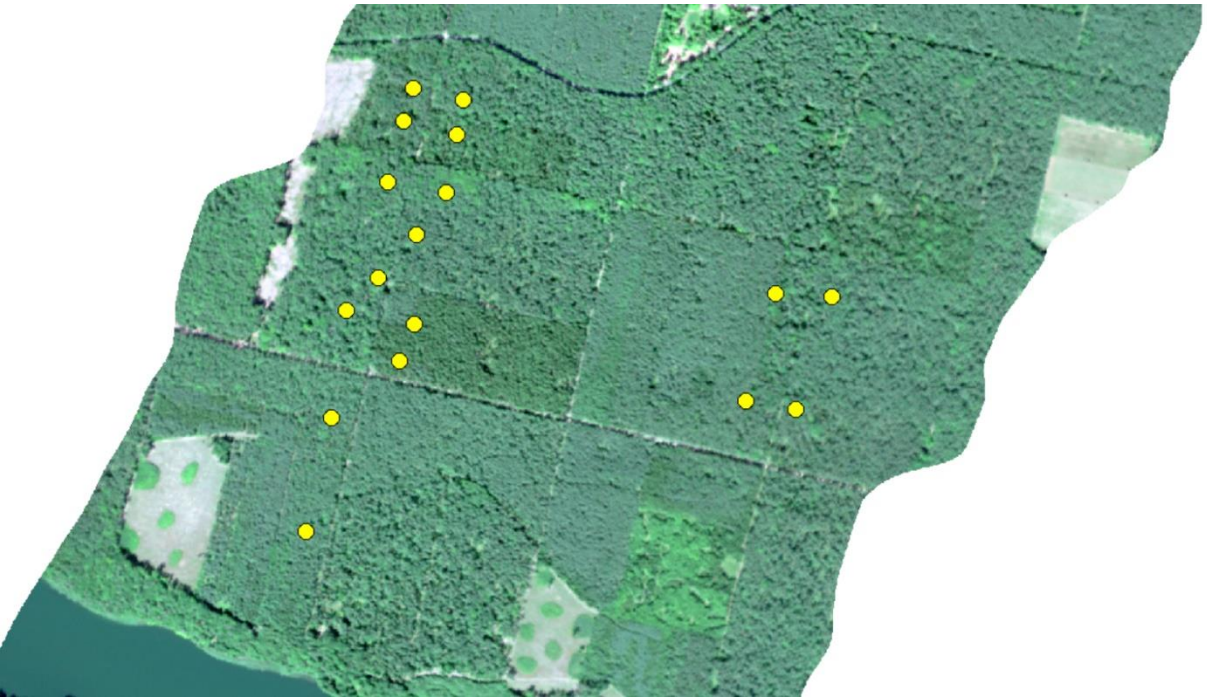
# Orchards

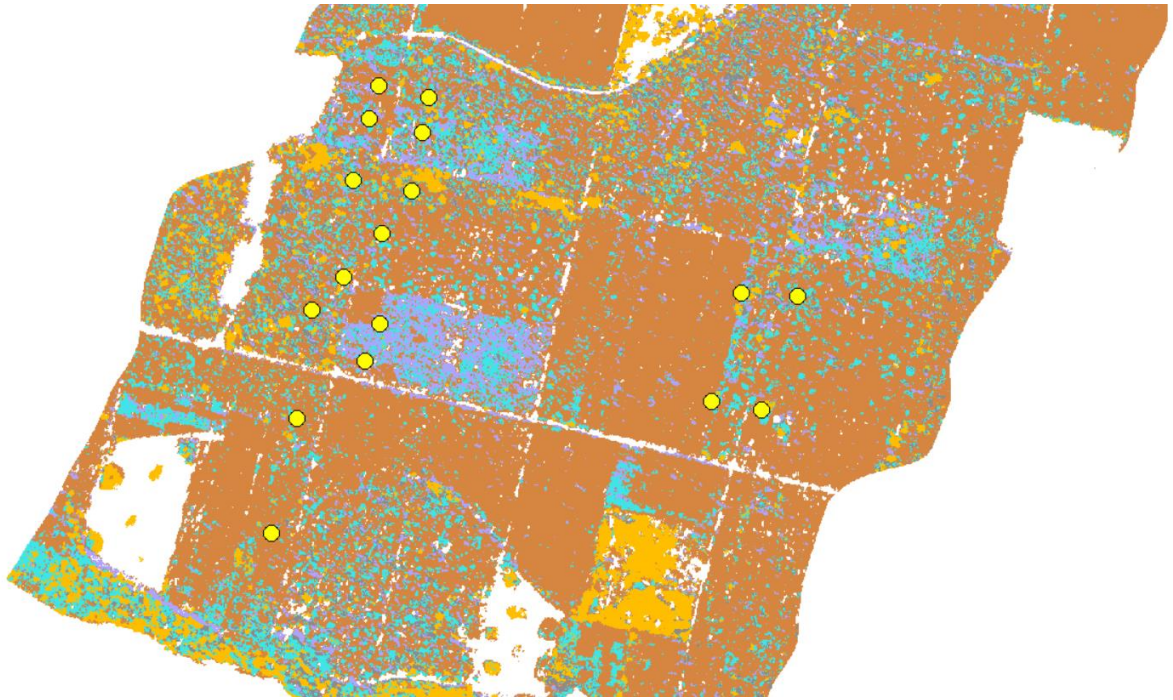
| Total accuracy | Kappa Coefficient | Orchards – producer's accuracy | Orchards – user's accuracy | Other lands – producer's accuracy | Other lands – user's accuracy |
|---|---|---|---|---|---|
| **Composition classification (polygons from BDL/LPIS)** | | | | | |
| 97,9% | 95,3% | 99,9% | 97,1% | 94,1% | 99,7% |
| **Composition classification (segmentation polygons)** | | | | | |
| 96,4% | 92,8% | 98,2% | 94,8% | 94,7% | 98,1% |

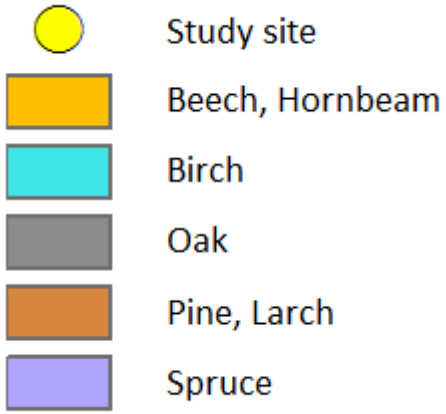
# Classification into forest-forming types or species



# Classification into forest-forming types or species

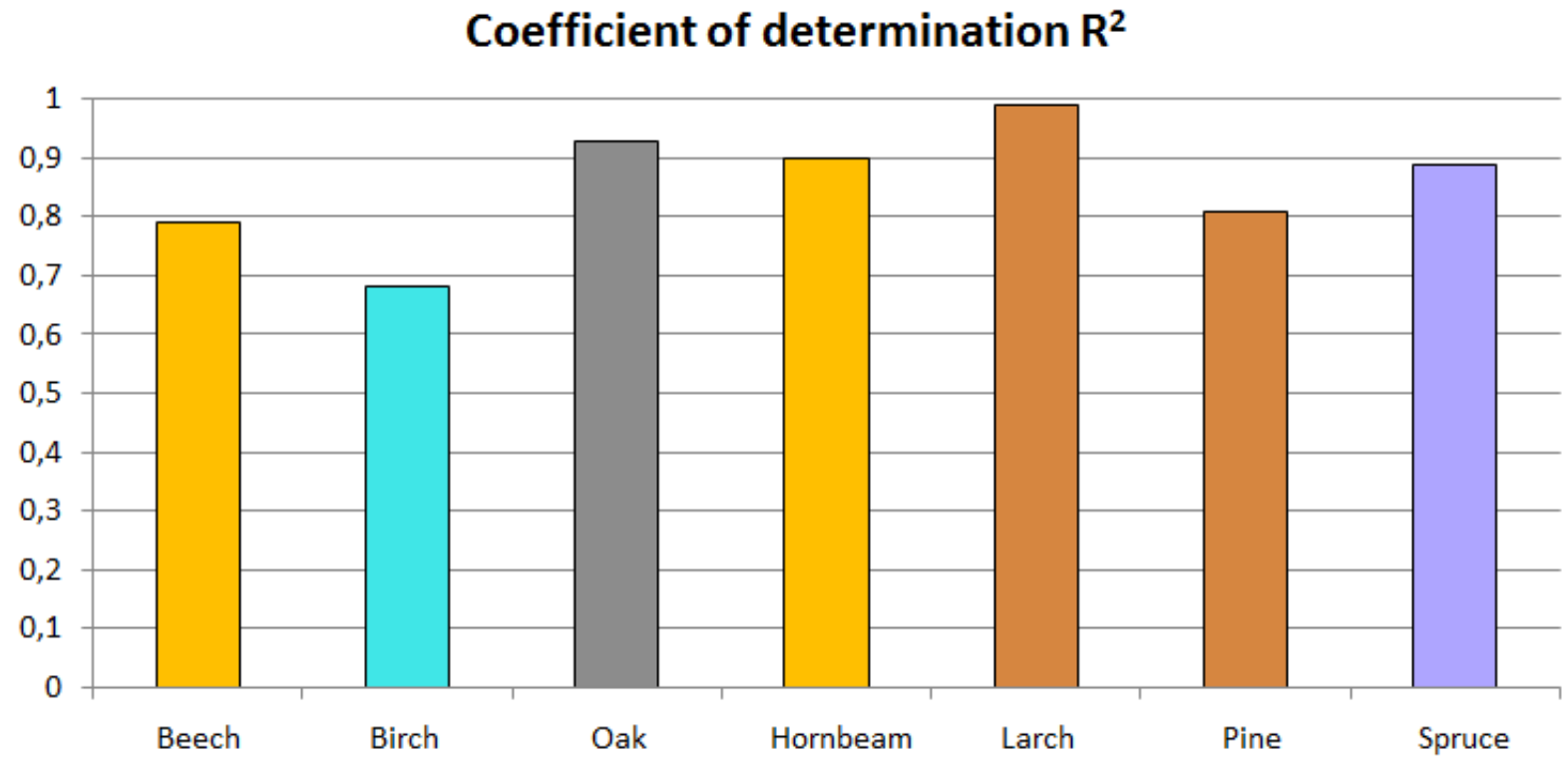


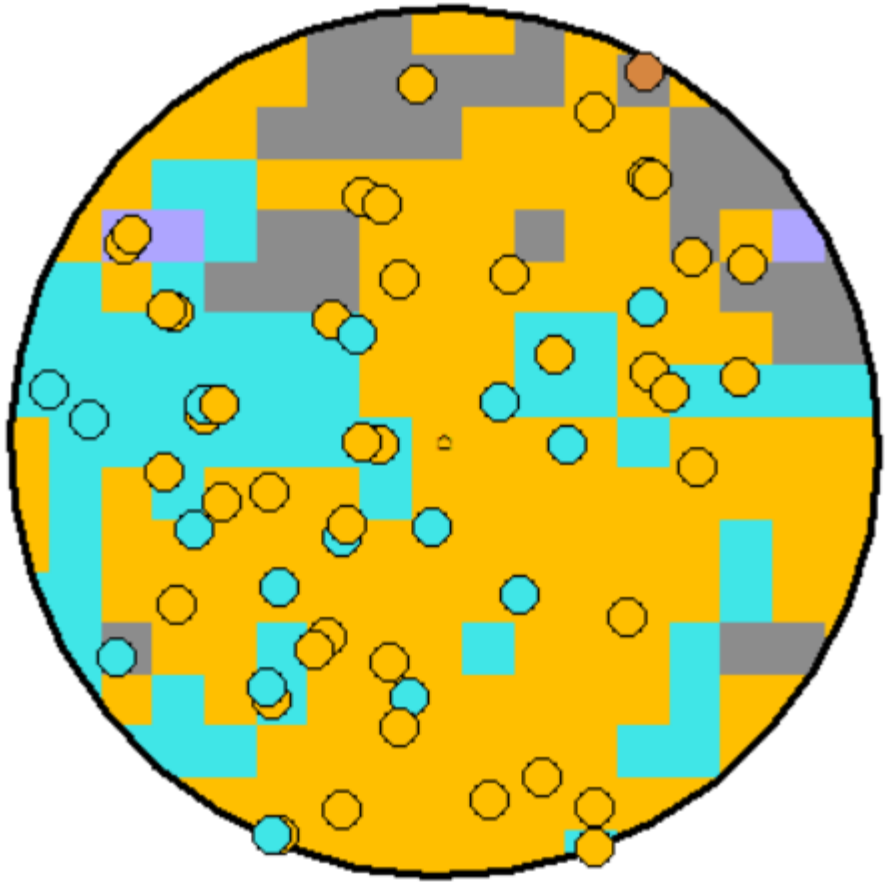




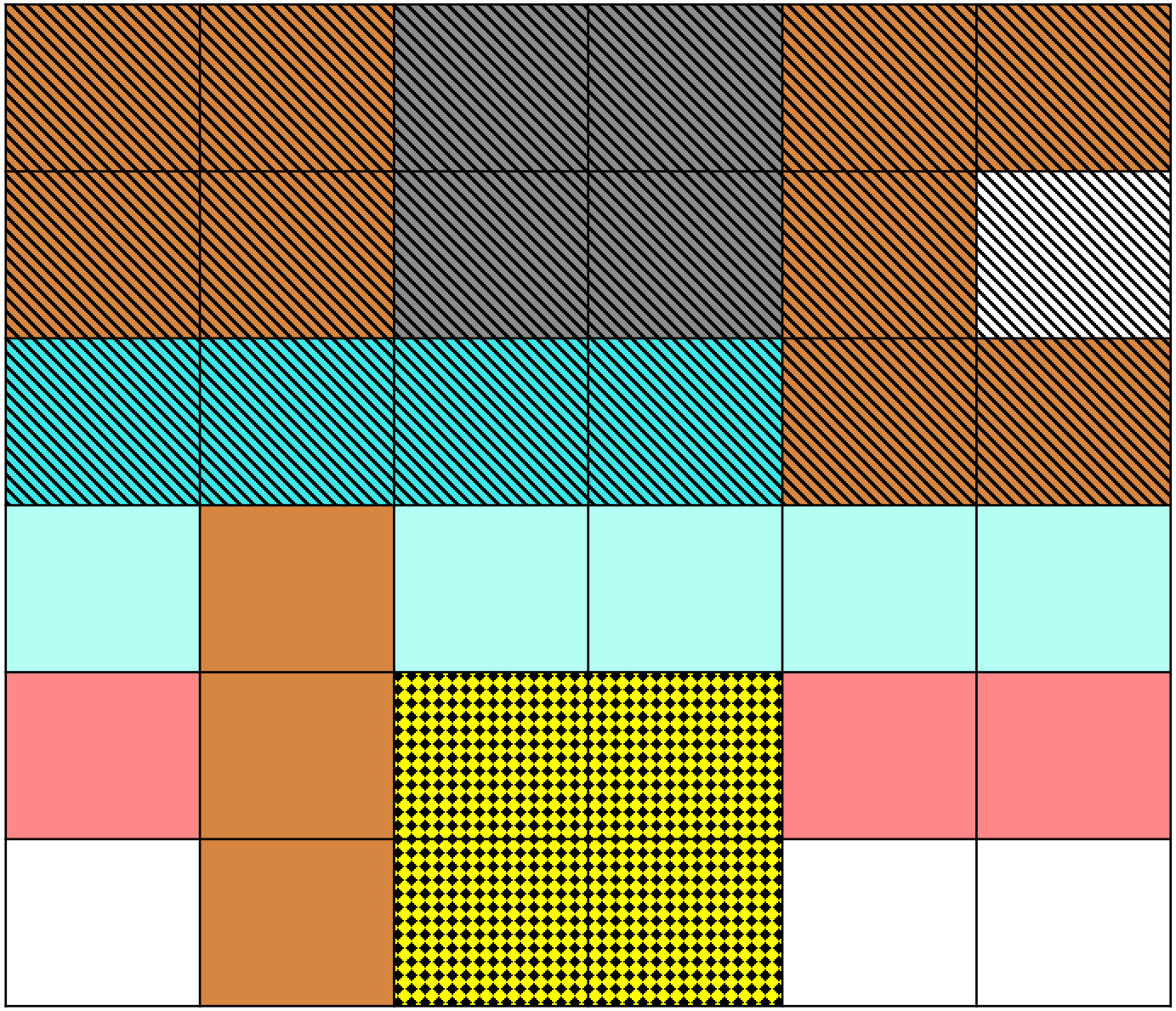

| Data | Algorythm | Total accuracy | Kappa Coefficient |
|---|---|---|---|
| 7 bands after MNF transformation | Maximum Likelihood | 90,7% | 0,89 |

# Classification into forest-forming types or species



# Land with potentially forest vegetation



Record

Orchard

Forest

Other

Analysis result

Pine

Oak

Birch

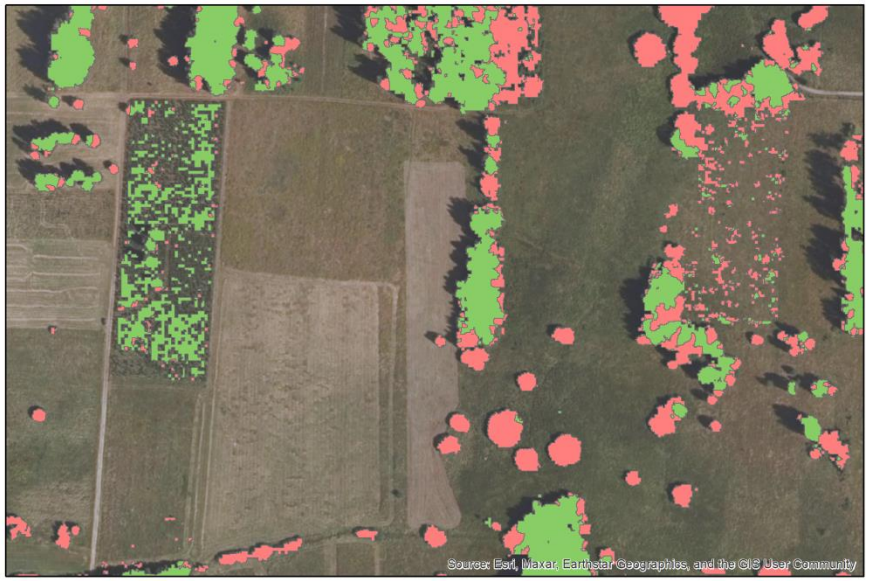
Orchard

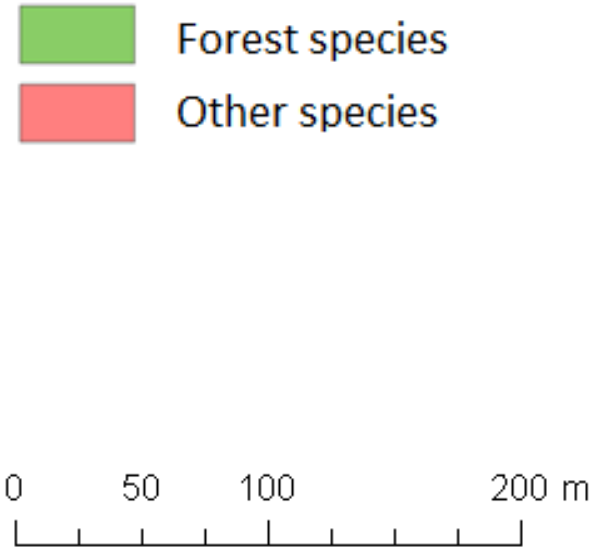
Young birch

Young Grey Willow

# Land with potentially forest vegetation

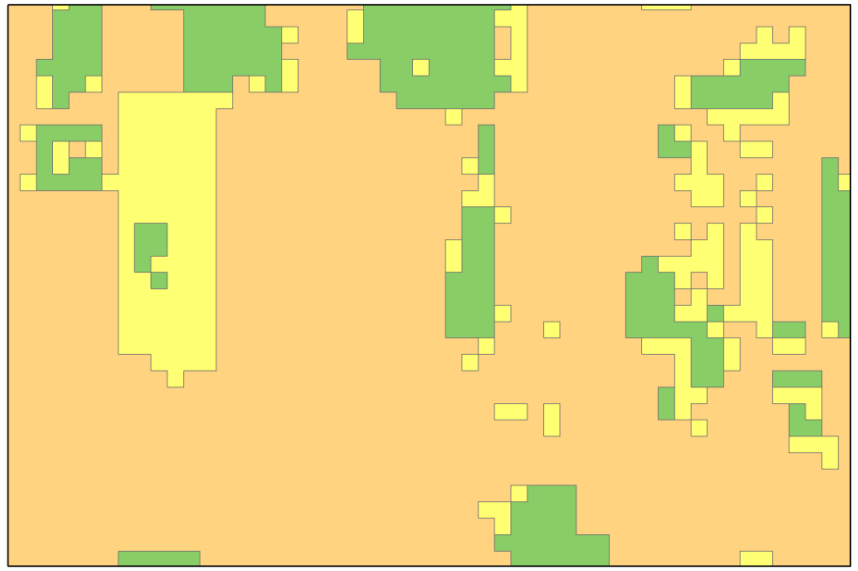
| | Total accuracy | Kappa Coefficient |
|---|---|---|
| **Airborne laser scanning data** | | |
| **Forest species / other** | **0,95** | **0,88** |
| Individual species | 0,81 | 0,79 |
| **Hyperspectral data** | | |
| **Forest species / other** | **0,96** | **0,88** |
| 6 species groups | 0,93 | 0,82 |
| Individual species | 0,67 | 0,64 |

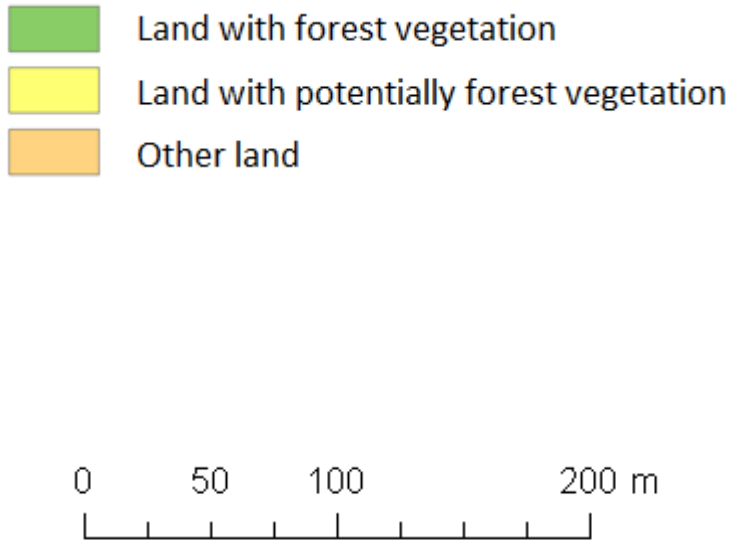



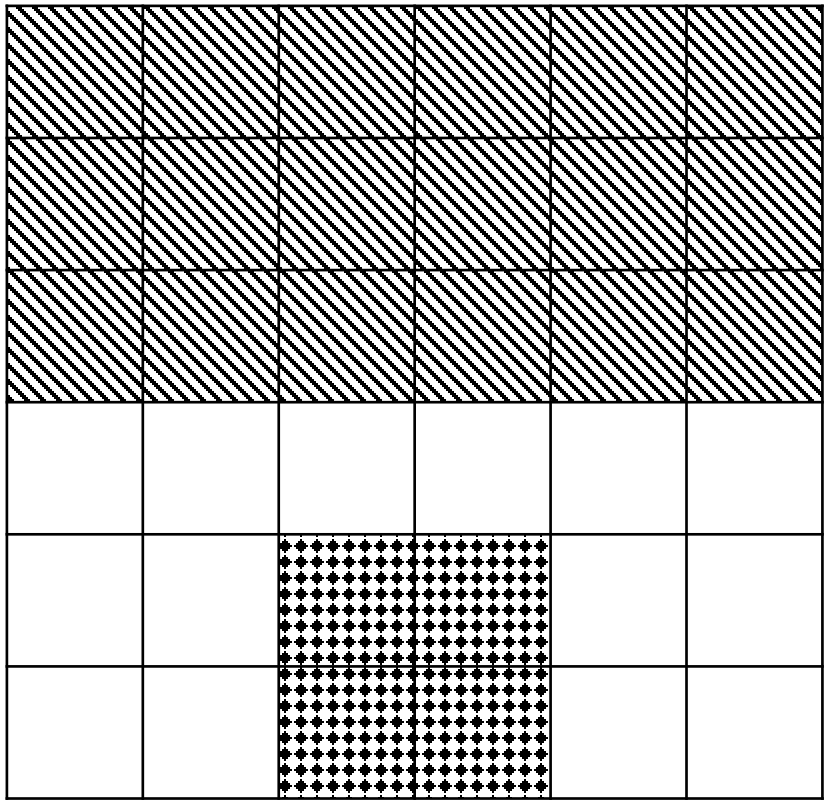
# Land with potentially forest vegetation

| Accuracy | Hyperspectral data | ALS data |
|---|---|---|
| **Classification accuracy into three classes** | | |
| Total accuracy | 92,5% | 90% |
| Kappa Coefficient | 88,8% | 85% |
| **Land with potentially forest vegetation** | | |
| Producer's accuracy (p%) | 80% | 72,5% |
| User's accuracy (u%) | 97% | 96,7% |

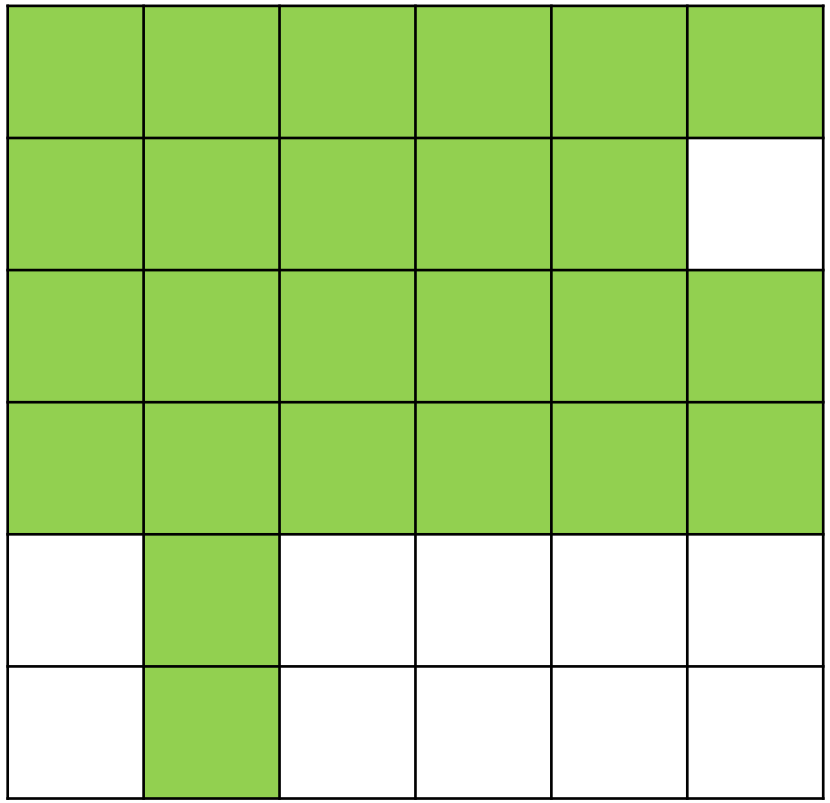





# Result



Status in the records



The actual situation
(according to the adopted definition)

Record

Orchard

Forest

Other

Analysis result

Forest

Other

# Conclusions

**Main conclusion:**

It is possible to determine the area of forest land for reporting to the Climate Change Convention (UNFCCC) and the Food and Agriculture Organization of the United Nations (FAO/UN), using remote sensing data, with an accuracy of > 85%.

**Detailed conclusions:**

1. It is possible to determine the coverage of a given area by single tree crowns, based on data from airborne laser scanning, with an accuracy of > 85%,

2. It is possible to distinguish orchards from other lands with woody vegetation based on airborne laser scanning data with an accuracy of > 85%,

3. It is possible to classify types or species of forest-forming trees, based on hyperspectral data, with an accuracy of > 85%,

4. It is possible to classify land with natural succession into forest-forming and other types or species, based on hyperspectral data and airborne laser scanning data, with an accuracy of > 85%,

5. It is possible to classify land with forest vegetation, potentially forest vegetation and other land, based on hyperspectral data and airborne laser scanning data, with an accuracy of > 85%.

# Thank You!