

Landscape ecological modelling as an image analytical knowledge base for the automatic extraction of cultural landscape elements

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Monitoring Duties on a European Level

Since thousands of years people have changed European landscapes, which has led on the one hand to poorly structured landscapes with an intensive agricultural use and on the other hand to heterogeneous cultural landscapes with high biodiversity. You cannot say that anthropogenic intervention in landscapes equates with destruction, because over thousands of years a complex interaction between human and natural influences has taken place. As a historically grown, culturally affected and still rapidly changing part of the environment, cultural landscapes must be seen as a cultural heritage of mankind which should not be conserved in a museum-like way. These landscapes must rather be protected in the context of a sustainable development. Because the monitoring of a sustainable landscape development is legally dictated by initiatives on a European level (e. g. the Natura 2000 network of the European Union), there is an urgent need for objective, transparent and standardized systems that are able to describe and value the condition of landscapes. Currently this acquisition of geodata is mainly done by manual digitizing, so the automatic extraction of landscape elements can improve the monitoring processes.

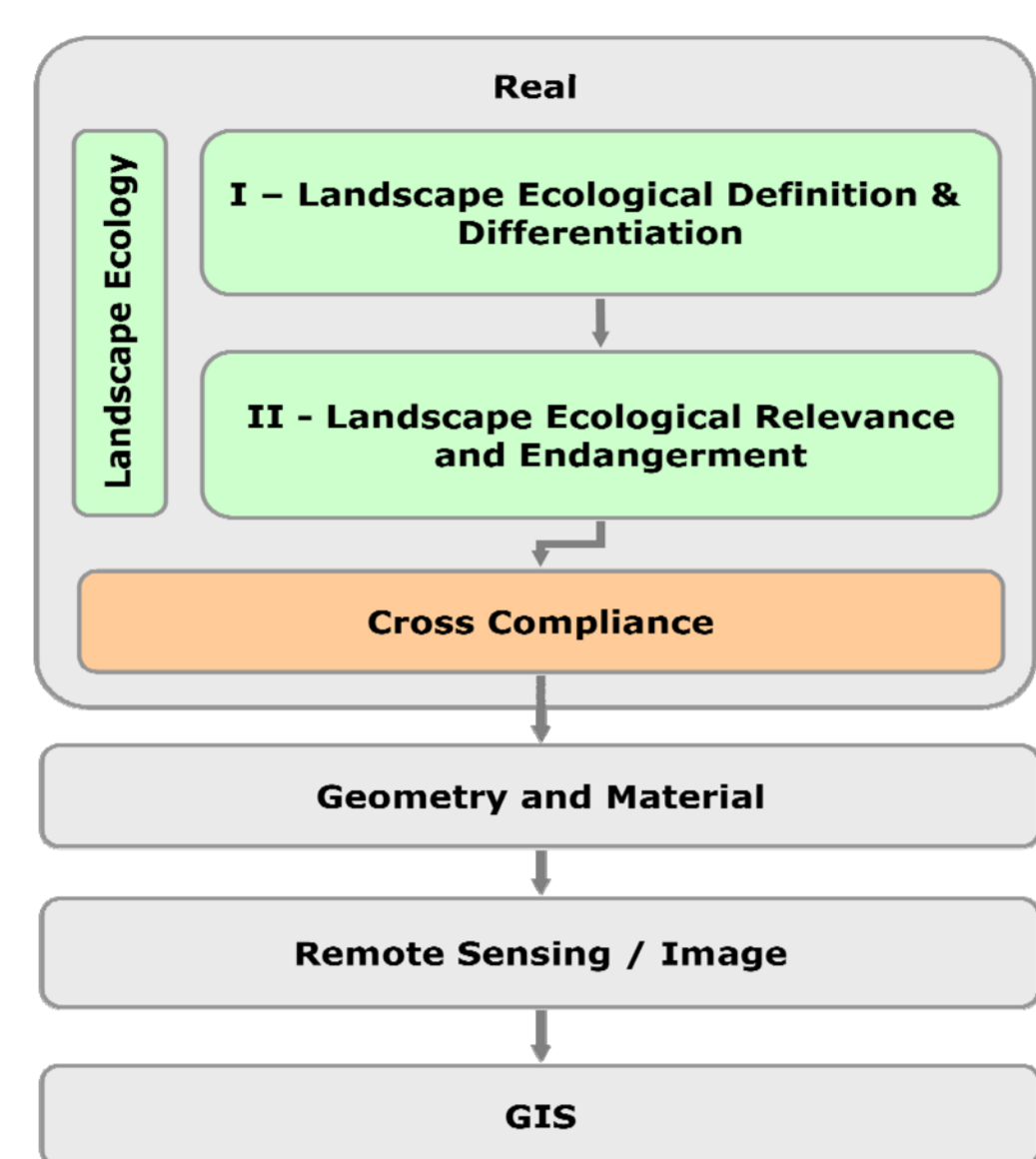


Figure 1: Information layers of the Image analysis definition model

Landscape Ecological Knowledge Base

To the existing models for automatic image analysis (using "real world", "Geometry/material", "remote sensing/image" and "GIS" as information layers) are expanded with the following items are added (fig. 1):

- 1) "Landscape Ecology I (LE I)" defines the landscape elements in their ecological surrounding and determines their spatial and ecological separation from similar classes and neighbouring objects.
- 2) The information layer "LE II" is not directly linked to image analysis, but acts as an external input of knowledge of the ecological relevance and endangerment of the specified objects.
- 3) The information layer "Cross Compliance" directly links the described objects to guidelines introduced by the monitoring duties within the scope of agricultural subsidies in connection to Cross Compliance and the Integrated Administration and Control System (IACS) of the European Union (e. g. geometrical specifications).

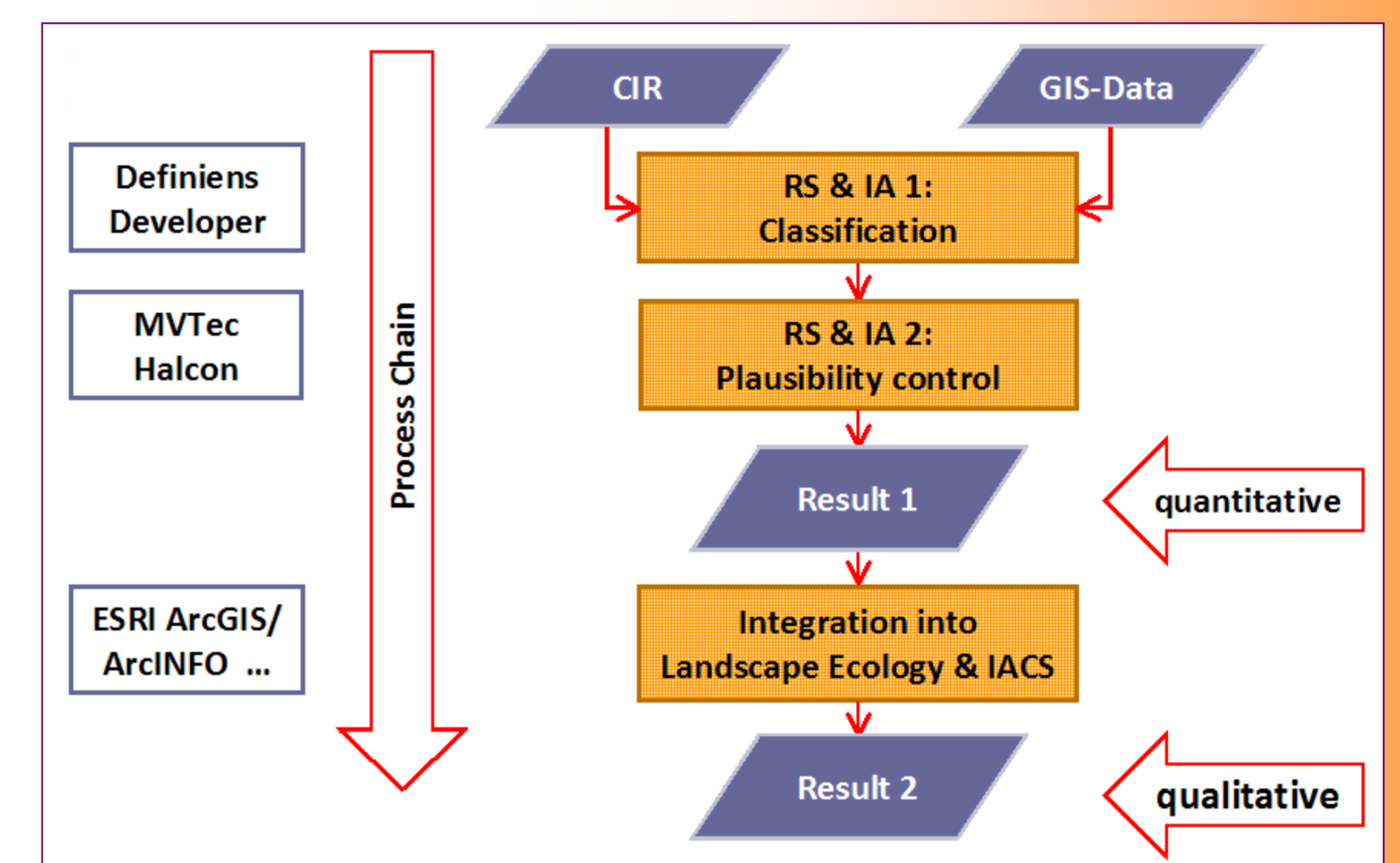


Figure 2: Process chain for landscape element extraction

Process Chain

The image analysis process is divided into two classification sections (fig. 2): In the 1st section (RS & IA 1 = remote sensing and image analysis 1) an object-based classification is performed. The classification results are verified in a plausibility validation (RS & IA 2) in order to achieve trustworthy quantitative results that can be integrated into landscape ecological analysis (e. g. landscape structure indices) or agricultural monitoring (e. g. IACS) tasks in order to produce qualitative information on the condition of landscapes.

Classification of Hedges and Tree Rows

In order to detect hedges and tree rows, the landscape-ecological definition model is implemented as an object-based hierarchical classification (fig. 3): In the 1st step the test site is divided by GIS data of the agricultural administration into "agricultural" and "non-agricultural" areas. In the 2nd step "non-agricultural" areas are classified by spectral NDVI-information into "vegetated" and "non-vegetated" areas. The "vegetation" is divided by spectral and textural information into the classes "shadow", "wood" and "other vegetation". The last classification step divides the "wooden" vegetation areas into "forests", "single trees/shrubs" and "tree rows/hedges" by geometrical and structural information.

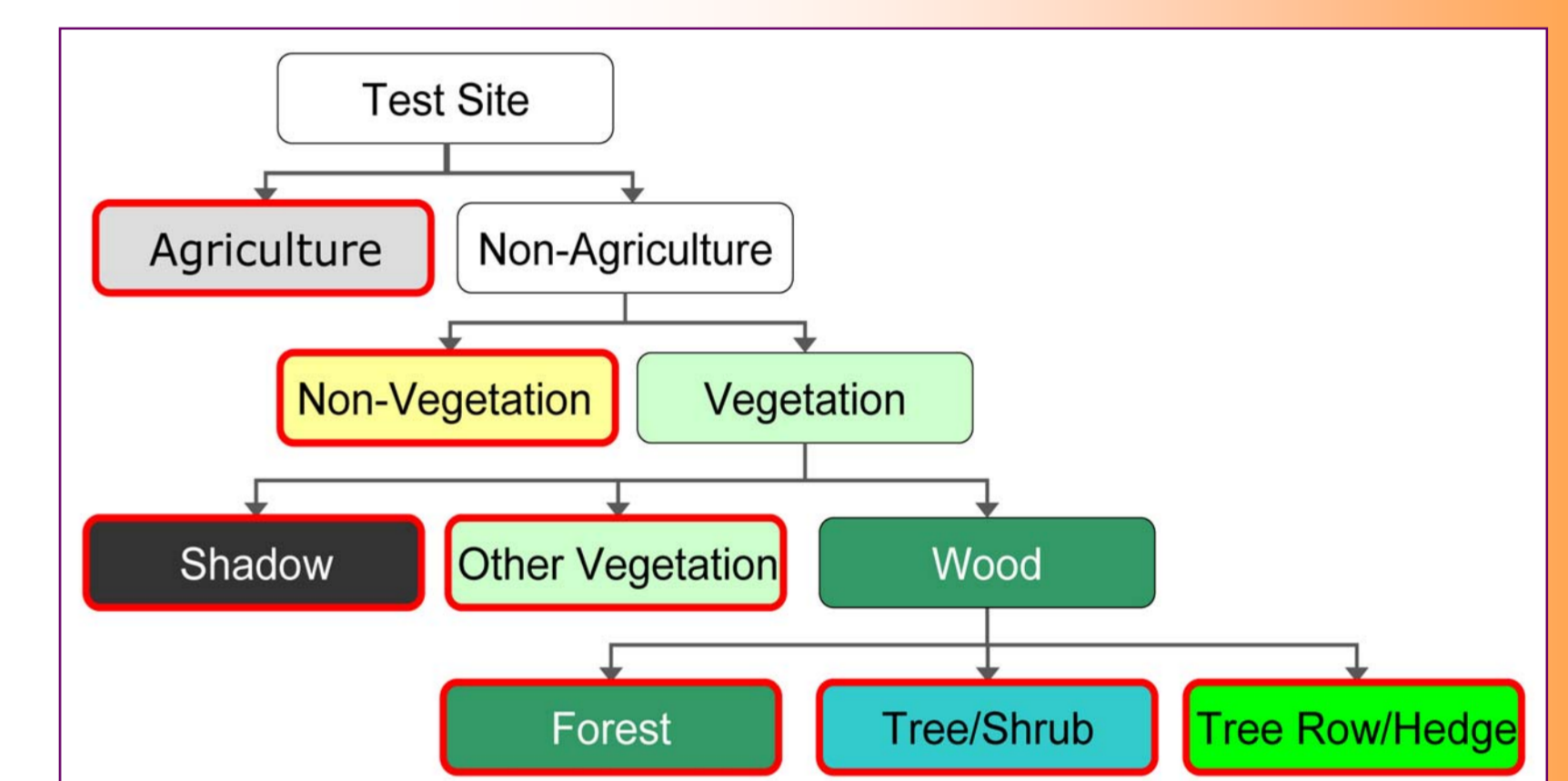


Figure 3: Hierarchical classification tree

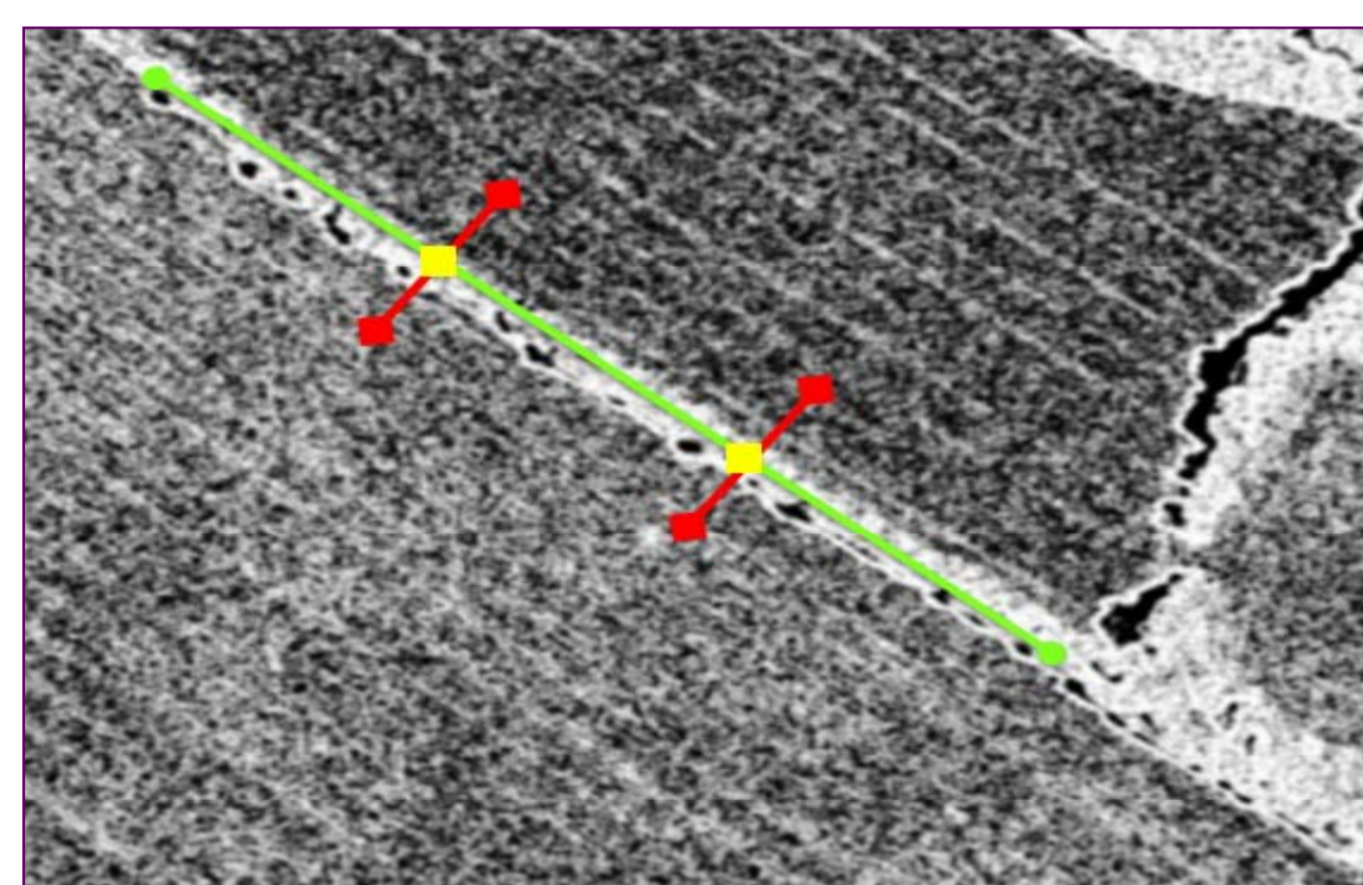


Figure 4: Schematic illustration of the plausibility calculation

Plausibility Validation

In order to check the classification results in an independent processing step, an additional plausibility validation (fig. 2: RS & IA 2) is realized: For all objects resulting from the previous step the centerline is calculated (fig. 4: green line). On each side of this centerline, the mean of infrared texture (entropy) of the surrounding surface is calculated within a 9x9-pixel matrix (fig. 4: red squares). These texture values are compared to the corresponding value on the centerline of the potential hedge (fig. 4: yellow squares). If the mean value of all four of the surrounding squares is below the mean value of the hedge square, the reliable existence of a hedge can be assumed, because normally hedges and tree rows in agricultural landscapes are surrounded by surfaces with less spectral heterogeneity (e. g. grassland and arable land). The assumption of an existing hedge is rejected, if all four outer mean values are higher than the mean value of the inner squares.

First Results and Perspectives

A short accuracy assessment with 50 points per class for the RS & IA 1 results shows an overall accuracy of 85 % (kappa 0,70). The more detailed information within the producer accuracy (pa) and user accuracy (ua) (table 1) points out, that all hedges and tree rows could be extracted (pa: 100 %), but there are still too much falsely positive classified areas (ua: 70 %).

As an objective and standardised method for quantitative and qualitative capturing of landscape characteristics the automatic extraction of landscape elements by the usage of a landscape ecological image analysis model can support the monitoring, protection and development of a heterogeneous cultural landscape. Further research will focus on additional landscape elements and on the implementation of a large-scale generally applicable monitoring system.

Table 1: Accuracy assessment results

Class	Reference Totals	Classified Totals	Number Correct	Producer Accuracy	User Accuracy
Hedge/ Treerow	35	50	35	100 %	70 %
Background	65	50	50	76,9 %	100 %

Overall accuracy: 85 % (kappa: 0,7)

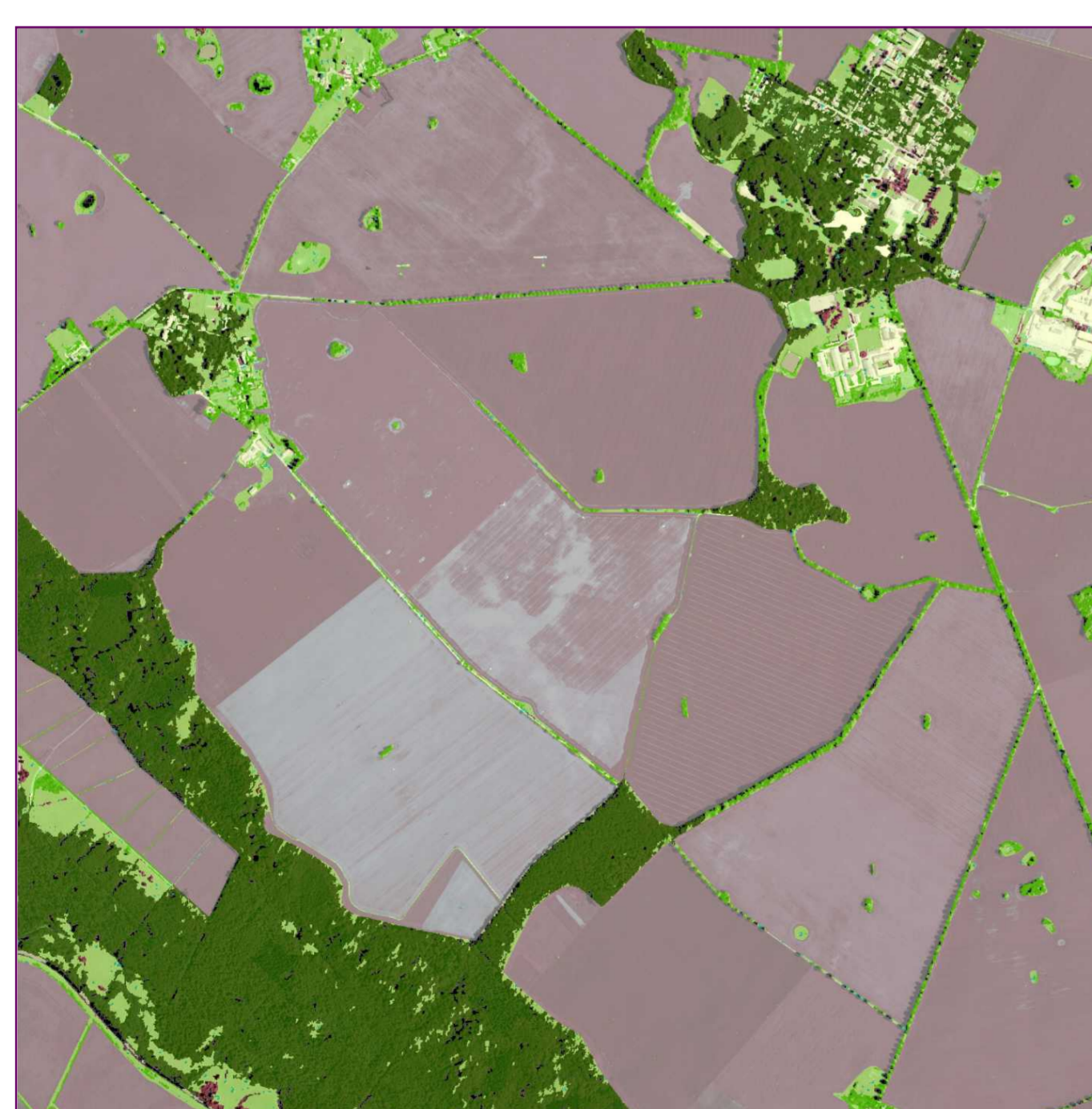


Figure 5: Classification overview (caption: colours in fig. 3)

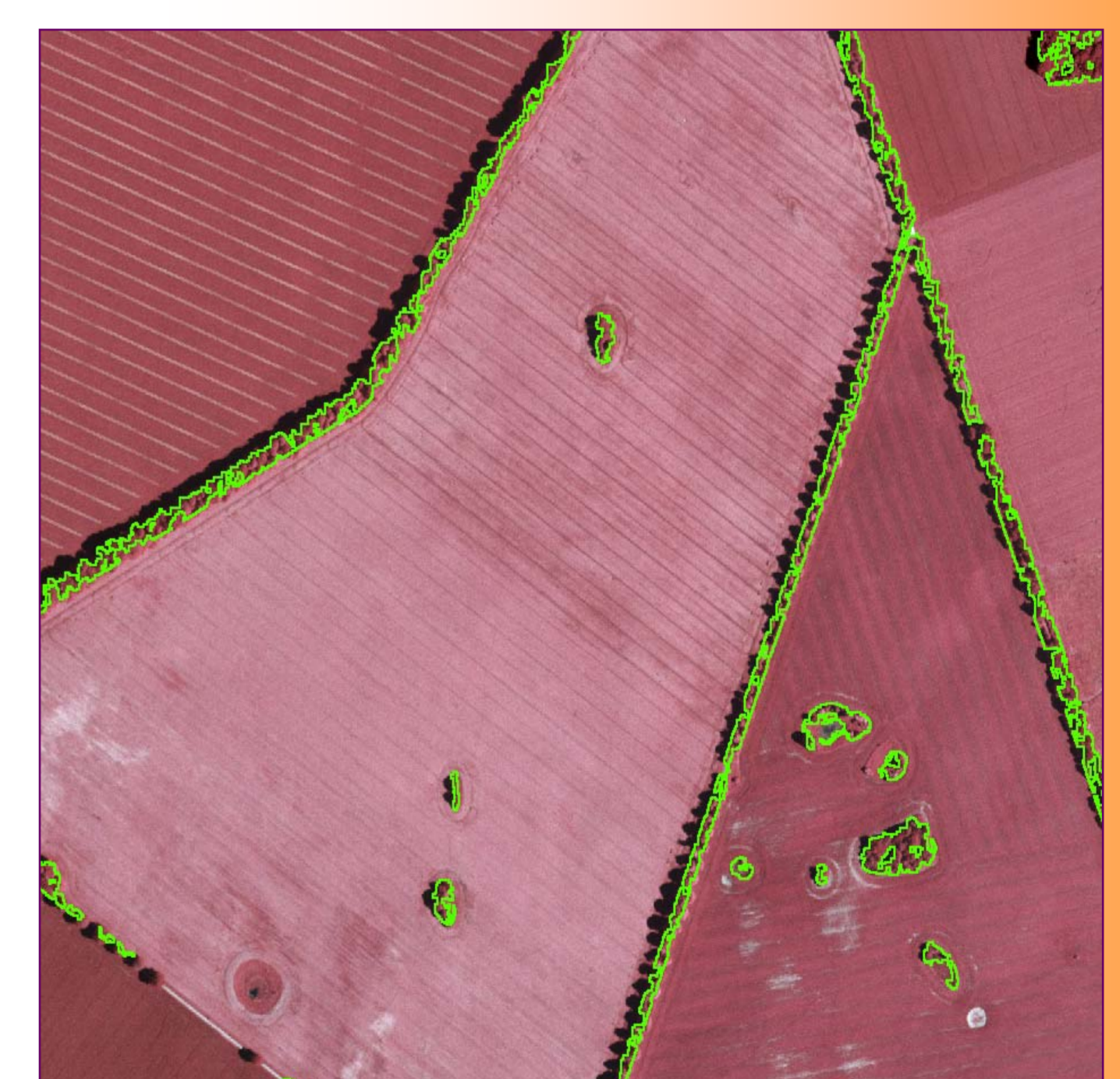


Figure 6: Classification details: tree rows/hedges