Validation of CESBIO OSO 2016 products

CESBIO OSO 2016

FINAL VALIDATION REPORT

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Executive Summary

This report provides the evaluation results of the CESBIO OSO 2016 10m layer and the CESBIO OSO 2016 20m layer.

The thematic accuracy assessment was conducted in a two-stage process:

1. An initial blind interpretation in which the validation team did not have knowledge of the product's thematic classes.
2. A plausibility analysis was performed on all sample units in disagreement with the production data to consider the following cases:
   - 1: Uncertain code, both producer and operator codes are plausible. Final validation code used is producer code
   - 2: Error from first validation interpretation. Final validation used is producer code
   - 3: Error from producer. Final validation code used is from first validation interpretation
   - 4: Producer and operator are both wrong. Final Validation code used is a new code from this second interpretation.

Resulting to this two-stage approach, it should be noticed that the plausibility analysis exhibit better results than the blind analysis.

The thematic accuracy assessment was carried out over 1,428 sample units covering France and Corsica.

The final results show that the CESBIO OSO product meet the usually accepted thematic validation requirement, i.e. 85 % in both blind interpretation and plausibility analysis. Indeed, the overall accuracies obtained are **81.4 +/- 3.68%** for the blind analysis and **91.7 +/- 1.25%** for the plausibility analysis on the CESBIO OSO 10m layer. The analysis on the 20m layer shows us that the overall accuracy for the blind approach is **81.1 +/-3.65%** and **88.2 +/-3.15%** for the plausibility approach.

Quality checks of the validation points have been made by French experts. It should be noticed that for the blind analysis, the methodology of control was based mostly on Google Earth imagery, no additional thematic source of information that could provide further context was used such as forest stand maps, peatland maps, etc. .

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List of Abbreviations

CI	Confidence Interval
CLC	CORINE Land Cover
LUCAS	Land Use/Cover Area frame Survey
MMU	Minimum Mapping Unit
PSU	Primary Sample Unit

1. Validation Framework

The validation framework is defined by a comprehensive analysis of the product specifications to determine the criteria to be used for the validation exercise.

1.1. Products to be validated

The CESBIO OSO datasets were initiated for the reference year 2016 with Sentinel-2 data from end of 2015 to end of 2016. The map applies a pragmatic nomenclature of 17 land cover/land use classes with a pixel size of 10 and 20m resulting in a notional Minimum Mapping Unit (MMU) of 100 square meters for the 10m layer and 400 square meters for the 20m layer.

The nomenclature in 17 classes was adapted: the 2 classes “Summer cropland” (11) and “Winter cropland” (12) have been merged into an unique class “Cropland” (10) to better assess the product without discrepancies on these two classes.

The CESBIO nomenclature has also been associated with the Corine Land Cover nomenclature. The following table showing the correspondence between these two classification schemes:

Table 1: Correspondence between CLC and CESBIO nomenclatures

CESBIO CODE	CLASS NAME	CLC CODE
10	Cultures	211 Terres arables hors périmètres d’irrigation 212 Périmètres irrigués en permanence 213 Rizières 242 Systèmes culturaux et parcellaires complexes
31	Forêt de feuillus	311 Forêts de feuillus 313 Forêts mélangées 141 Espaces verts urbains
32	Forêt de conifères	312 Forêts de conifères 324 Forêt et végétation arbustive en mutation 334 Zones incendiées
34	Pelouses	321 Pelouses et pâturages naturels
36	Landes ligneuses	322 Landes et broussailles 323 Végétation sclérophylle 411 Marais intérieurs 412 Tourbières
41	Urbain dense	111 Tissu urbain continu
42	Urbain diffus	112 Tissu urbain discontinu 133 Chantiers
43	Zones industrielles et commerciales	121 Zones industrielles ou commerciales et installations publiques 123 Zones portuaires 124 Aéroports 131 Extraction de matériaux 132 Décharges
44	Surfaces routes	122 Réseaux routier et ferroviaire et espaces associés
45	Surfaces minerales	332 Roches nues 333 Végétation clairsemée
46	Plages et dunes	331 Plages, dunes et sable

CESBIO CODE	CLASS NAME	CLC CODE
51	Eau	421 Marais maritimes 422 Marais salants 423 Zones intertidales 511 Cours et voies d'eau 512 Plans d'eau 521 Lagunes littorales 522 Estuaires 523 Mers et océans
53	Glaciers ou neige	335 Glaciers et neiges éternelles
211	Prairies	231 Prairies et autres surfaces toujours en herbe à usage agricole
221	Vergers	222 Vergers et petits fruits 223 Oliveraies
222	Vignes	221 Vignobles

1.2. Validation Criteria

The validation exercise focus on thematic accuracy. The expected overall accuracy is greater than 85% for both products (10 and 20m).

2. Validation approach

The validation approach will provide guidance on how the products will be validated by defining suitable indicators or metrics.

Thematic accuracy will represent the bulk of the work undertaken as part of this validation exercise.

2.1. Thematic Accuracy

2.1.1. Level of reporting

The level of reporting for the validation results is at national level (metropolitan France).

2.1.2. Stratification and sample design

The stratification and sample design was the one used initially for the assessment of CLC2012. The stratification applied is thus not optimised for the assessment of the CESBIO OSO datasets, but this should only have consequences in terms of the confidence intervals of the accuracy metrics which may be wider than if the stratification had been optimised. However, the accuracy metrics obtained should probably reflect the quality of the product.

A stratified systematic sampling approach based on the LUCAS sampling frame is used for all thematic layers adapting the number of replicates to each stratum. The LUCAS sampling is densified for small strata based on a 200m grid. Using LUCAS sampling ensures coherence between the different layers and traceability.

A set of 81 points located on an 18x18 km square constitutes a group (red points shown in Figure 1) in which every point is associated with a number comprised between 0 and 81 (the numbers do not follow each other spatially). The same pattern with the same numbers allocation is repeated all over the grid. A replicate refers to the points with the same number selected on the whole LUCAS grid.

At first, the number of samples to allocate to each stratum (or land cover class) was calculated as a function of their area. In this manner the sampling design is not only systematic but also stratified. A minimum number of sample units per stratum was defined to ensure that even small strata are represented in the sample.

The number of replicates to be selected for a stratum depends on its area and the number of LUCAS points intersecting the stratum.

For land cover classes covering a large proportion of the study area, 1 replicate may already exceed the defined number of samples for this class. To solve this problem, replicates are split into four sub-replicates, as illustrated by the blue numbers in Figure 1.

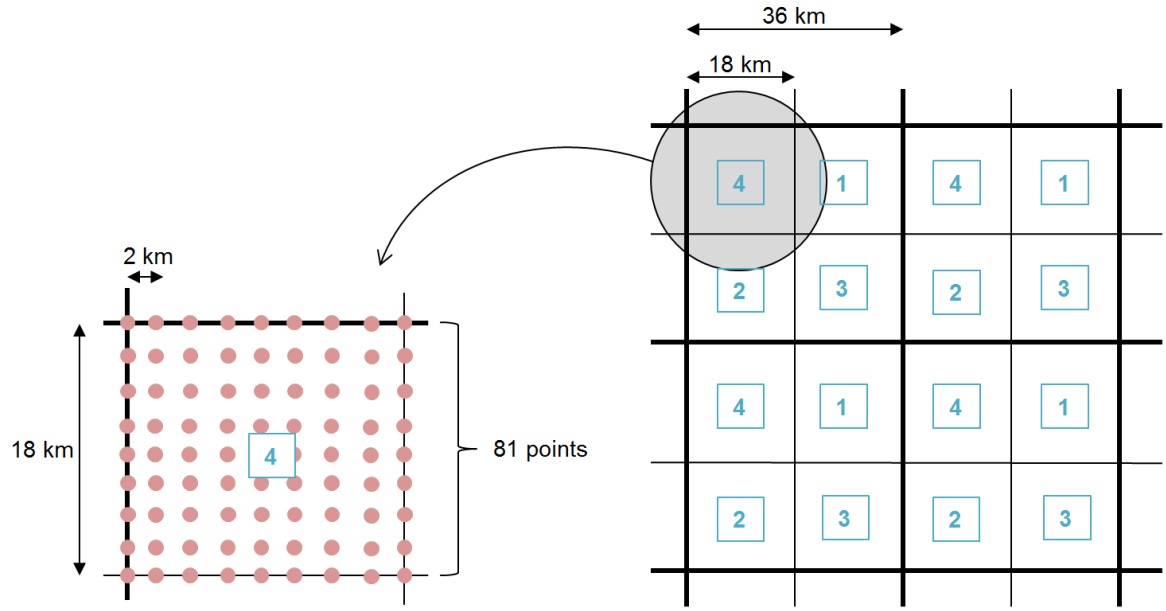


Figure 1: Replicates and sub-replicates used on LUCAS grid

The opposite problem is encountered for land cover classes covering a small proportion of the study area: even by selecting 81 replicates (the maximum number), the intersecting area between the stratum and LUCAS points is too small to reach the required number of samples. Therefore, LUCAS grid was densified by creating one point every 200 m.

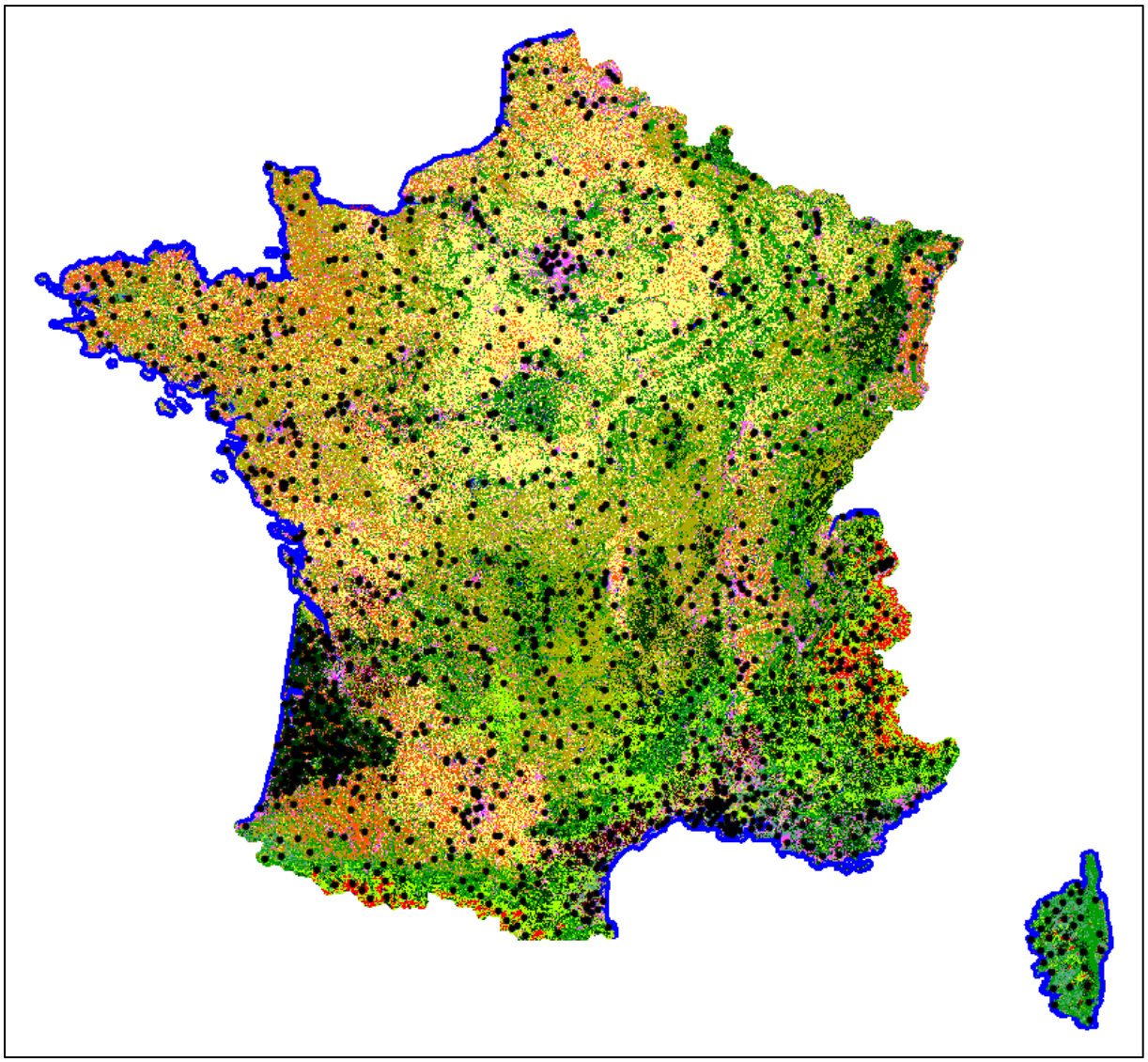


Figure 2: Distribution of the sample units according to the stratification

The number of sample units per stratum should be such to ensure a sufficient level of precision at reporting level. The minimum number of sample units per stratum should be set at 5 if possible. Priority is given to strata which are known to be difficult to map: i.e. difficult classes.

In addition, to be valid over the entire study area, the sampling frame should also cover the whole study area in order.

There were a total of 1,428 sample units selected and covering France and Corsica, based on the distribution of 25,182 sample units for the CLC2012 validation over the entire of EEA39 area (distribution in the Table 2).

Table 2: Distribution of sample units per main strata and substrata for the CLC012 product

		TR	FR	ES	SE	DE	FI	NO	PL	IT	IE+UK	RO	EL	BG	IS	HU	PT	AT+CH+LI	BE+LU+NL+DK	AL+ME+MK+RS+XK	BA+HR+SI	CZ+SK	EE+LT+LV	DOM	
	CLASS/ZONE	Z1	Z2	Z3	Z4	Z5	Z6	Z7	Z8	Z9	Z10	Z11	Z12	Z13	Z14	Z15	Z16	Z17	Z18	Z19	Z20	Z21	Z22	Z23	Total général
111	Continuous urban fabric	25	10	20	5	10	0	15	10	20	20	2	15	1	0	2	20	20	20	2	5	10	2	1	**235**
112	Discontinuous urban fabric	29	50	20	20	50	20	20	20	50	30	50	25	20	20	20	20	20	20	30	20	30	20	20	**624**
121	Industrial or commercial units	30	20	20	15	30	20	20	20	20	20	20	20	20	15	20	20	20	20	20	20	20	20	1	**451**
122	Road and rail networks and as	8	10	10	10	10	1	15	20	20	20	15	15	15	1	20	20	20	20	4	20	20	20	1	**315**
123	Port areas	2	10	5	5	10	5	15	5	20	20	5	5	2	5	1	10	2	20	2	2	1	10	1	**163**
124	Airports	8	10	10	10	10	10	15	15	20	20	10	10	5	3	5	10	10	15	3	3	10	10	2	**224**
131	Mineral extraction sites	25	10	10	10	20	20	20	20	20	20	20	15	20	5	20	20	20	20	23	20	20	20	1	**399**
132	Dump sites	3	5	10	10	10	15	3	20	10	20	10	1	5	0	15	10	1	15	4	3	20	10	1	**201**
133	Construction sites	10	5	10	5	5	5	5	20	20	20	10	10	2	2	10	15	5	50	3	10	10	10	1	**243**
141	Green urban areas	6	10	10	10	20	20	20	20	20	20	15	5	10	5	20	10	20	20	11	10	20	20	1	**323**
142	Sport and leisure facilities	8	20	10	15	20	20	20	20	20	20	20	15	20	20	20	20	20	20	16	20	20	20	1	**405**
211	Non-irrigated arable land	70	50	50	50	60	50	20	20	50	50	50	35	50	5	50	50	50	50	35	20	50	20	20	**955**
212	Permanently irrigated land	60	0	40	0	0	0	0		5	0	3	30	0	0	0	50	0	0	2	2	0	0	0	**192**
213	Rice fields	30	10	20	1	0	0	0	0	20	1	5	15	5	0	2	20	0	0	1	0	0	0	2	**132**
221	Vineyards	30	50	40	0	20	0	0	0	20	0	20	20	20	0	20	20	20	2	20	20	20	0	0	**342**
222	Fruit trees and berry plantatior	40	20	40	5	20	0	0	20	20	15	20	25	20	0	50	20	10	20	25	20	30	20	10	**450**
223	Olive groves	21	10	40	0	0	0	0	0	20	0	0	30	0	0	0	20	0	0	11	20	0	0	0	**172**
231	Pastures	40	50	20	20	50	20	20	20	20	50	50	25	50	30	50	20	20	20	30	20	50	20	10	**705**
241	Annual crops associated with p	1	5	10	0	0	0	0	0	20	0	0	15	0	0	0	20	0	1	2	1	0	0	0	**75**
242	Complex cultivation patterns	60	50	40	20	20	0	20	20	50	20	20	30	20	20	20	20	20	50	30	20	20	20	10	**600**
243	Land principally occupied by ag	60	50	40	30	20	50	20	20	50	50	50	35	20	0	20	20	20	20	53	50	20	20	20	**738**
244	Agro-forestry areas		1	40	0	0	0	0	0	20	0	0	0	0	0	0	20	0	0	1	0	0	0	1	**83**
311	Broad-leaved forest	60	50	40	50	50	50	50	20	50	20	50	35	50	20	50	50	50	20	53	50	50	20	40	**978**
312	Coniferous forest	60	50	40	50	50	50	50	20	50	50	50	30	50	10	50	50	50	50	30	50	50	20	1	**961**
313	Mixed forest	40	50	40	50	50	50	50	20	20	50	50	30	50	15	50	50	50	50	30	20	30	20	1	**866**
321	Natural grasslands	80	50	40	20	20	15	50	20	20	20	20	35	20	20	20	20	20	20	30	20	20	20	10	**610**
322	Moors and heathland	1	20	40	50	20	20	50	5	20	20	20	20	15	20	0	20	20	20	20	20	15	20	10	**466**
323	Sclerophyllous vegetation	21	20	40	0	0	0	0	0	50	0	0	40	0	0	0	20	0	0	30	20	0	0	10	**251**
324	Transitional woodland-shrub	60	50	40	50	30	50	15	20	50	50	50	35	50	20	50	50	50	20	53	50	50	20	20	**933**
331	Beaches, dunes, sands	20	10	10	5	10	3	15	10	20	20	20	15	10	50	0	15	5	20	13	2	0	15	1	**289**
332	Bare rocks	40	20	20	20	10	20	20	5	20	20	15	15	20	20	0	9	20	0	20	20	5	0	1	**340**
333	Sparsely vegetated areas	80	20	20	30	10	20	50	10	20	20	10	25	20	30	5	20	20	0	30	20	10	5	10	**485**
334	Burnt areas	2	1	10	4	0	0	1	0	20	5	0	15	1	0	0	30	0	0	8	3	1	0	0	**101**
335	Glaciers and perpetual snow	1	10	1	10	0	0	20	0	20	0	0	0	0	30	0	0	50	0	0	1	0	0	0	**143**
411	Inland marshes	30	10	10	15	10	20	1	20	20	20	20	15	20	20	20	5	20	20	18	20	20	20	30	**404**
412	Peat bogs		5	1	50	20	50	50	15	1	50	0	0	1	20	10	3	5	20	1	1	10	20	0	**333**
421	Salt marshes	21	10	10	5	10	20	0	0	20	20	1	15	0	10	0	20	0	20	2	1	0	1	1	**187**
422	Salines	5	10	10	0	0	0	0	0	5	0	0	5	1	0	0	10	0	0	2	1	0	0	0	**49**
423	Intertidal flats		5	2	0	10	0	20	0	0	20	0	15	0	20	0	5	0	15	0	1	0	0	1	**114**
511	Water courses	20	20	10	20	20	20	20	10	20	10	20	0	5	20	10	5	5	5	10	10	10	10	10	**290**
512	Water bodies	30	20	20	50	30	50	50	20	20	20	20	20	20	20	20	20	20	20	25	20	20	20	1	**556**
521	Coastal lagoons	11	10	5	5	3	0	0	1	20	5	1	5	1	15	0	5	0	10	4	1	0	2	1	**105**
522	Estuaries	1	10	5	5	3	0	0	0	1	20	0	3	0	5	0	2	0	1	0	0	0	0	10	**66**
523	Sea and ocean	12	1	10	10	3	15	15	1	2	3	1	5	1	1	0	1	0	1	4	1	0	1	10	**98**
	TOTAL CLC 2012 classes	1161	908	939	740	744	709	775	487	1004	859	743	774	640	497	650	865	683	715	711	638	662	476	272	**16652**
	CLCCH2006-2012	535	520	530	360	355	590	195	470	570	450	171	326	220	135	620	525	250	355	223	195	455	340	140	**8530**
Total général		**1696**	**1428**	**1469**	**1100**	**1099**	**1299**	**970**	**957**	**1574**	**1309**	**914**	**1100**	**860**	**632**	**1270**	**1390**	**933**	**1070**	**934**	**833**	**1117**	**816**	**412**	**25182**

The sample units were provided to the bulk interpretation team as one shapefile in which all the information on strata or thematic classes was removed to ensure the independence of the interpretation. However, the product polygon was provided to the validation team together with the point sample unit to consider boundary effects and geometric differences between the validation and production data to ensure that actual thematic interpretation errors are separated from thematic errors due to potential geometric shifts.

2.1.3. Response Design

LUCAS points are re-interpreted based on available in situ data. LUCAS thematic information is not used directly. In addition, the sample units were initially interpreted for the CLC2012 assessment. CLC classes were regrouped according to the CESBIO OSO nomenclature as shown in Table 1. It should be noted that 2 CESBIO OSO classes had to be regrouped to be assessed, these are: classes 11 and 12 which were regrouped as class 10.

Response design for most data set are based on the interpretation of thematic class at the point level taking into account product specifications (MMU, class definitions,…) based on combination of available in situ data. For CESBIO OSO, virtual globes (Google Earth, Bing) were used as illustrated in Figure 3. Imagery as close as possible from 2016 were used. However, discrepancies between the imagery acquisition date used in production and validation may still occur but, in this case, the plausibility analysis provides a means to resolve this issue.

A double-blind approach guarantees complete independence from the map products, but may underestimate their accuracy for complicated and difficult classes when sometimes several LC / LU classes are possible. This is resolved by the plausibility approach for which the interpreter checks the map value to assess whether it can be considered correct or not, within the frame of accepted product specifications. However, the plausibility analysis should be combined with the double-blind approach to ensure full traceability and transparency of the validation process.

Figure 3: Example of a sample unit used for the validation of CESBIO OSO

A double-blind approach was first applied. This consists in constructing the validation data set without any knowledge about the corresponding map layer information, i.e. the validation team did not have knowledge of the product's thematic classes for the selected sample units.

The expert only interpreted the area surrounding the sample unit taking the pixel size / MMU into consideration. For each sample unit, one thematic field have to be filled: code VAL_BLIND: the land-cover class value for 2016 (one of the 17 CESBIO codes).
Additional fields could be filled if necessary:

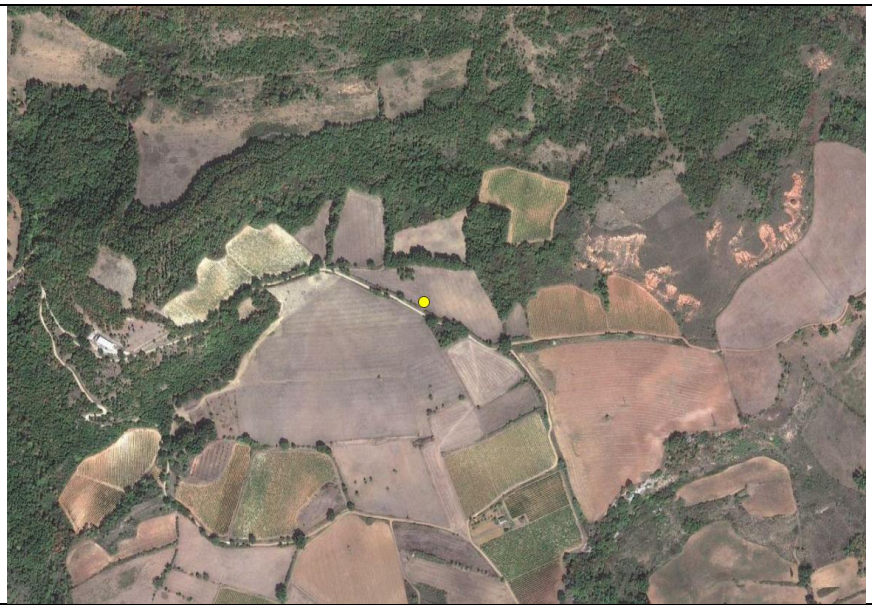
- uncertain: drop-down menu in case of uncertainty of the interpretation
- comment: free text if any comment is needed

The sample unit was first blindly interpreted by the validation expert, i.e. without knowing the CESBIO thematic attribute of the area. Interpretation decided on the thematic class to be interpreted in the surroundings of the sample point.

A second interpretation, carried out by a second interpreter as part of the plausibility analysis, was performed only with the interpreted sample units in disagreement with product codes. The operator provided a QC code and corrected the validation code if necessary (illustrated in Table 3):

- 1: Uncertain code, both producer and operator codes are plausible. Final validation code used is producer code
- 2: Error from first validation interpretation. Final validation used is producer code
- 3: Error from producer. Final validation code used is from first validation interpretation
- 4: Error of both producer and operator. The controller should inform the new CLC field by a new land cover classes. Final validation code used is the new CLC code.

Table 3: Illustrations of QC codes


Case 1: Uncertain code, both producer and operator codes are plausible. Final validation code used is producer code
Code Product CESBIO 10m = 211 Code Validation Blind = 10 Code QC = 1 Code Validation Plausibility = 211
This farm plot was classified as 211 “Prairies” by the CESBIO OSO 10m layer. The blind analysis was coded as 10 ”Cultures” however, 211 was accepted in the plausibility analysis because this field parcel could also be a temporary grassland (rotation of cropland, bare soil and meadows).

Case 2: Error from first validation interpretation. Final validation used is producer code

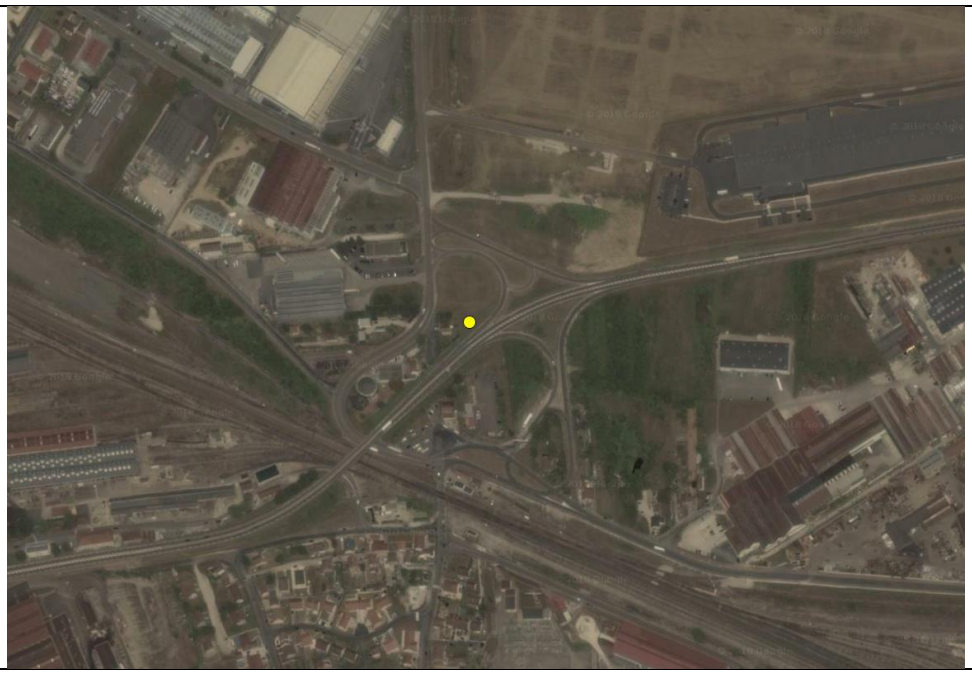
Code Product CESBIO 10m = 34
Code Validation Blind = 31
Code QC = 2
Code Validation Plausibility = 34

This point was misinterpreted as a forest but the CESBIO OSO code is correct.

Case 3: Error from producer. Final validation code used is from first validation interpretation

Code Product CESBIO 10m = 34
Code Validation Blind = 221
Code QC = 3
Code Validation Plausibility = 221

This parcel was wrongly classify in 34 “Pelouses” by CESBIO OSO. The blind interpretation is correct with the class 221 “Vergers”.



Case 4: Error of both producer and operator. The controller should inform the new CLC field by a new land cover classes. Final validation code used is the new CLC code

Code Product CESBIO 10m = 42
Code Validation Blind = 43
Code QC = 4
Code Validation Plausibility = 211

The Plausibility Analysis results in revised accuracy metrics based on the results from this second interpretation.

2.1.4. Estimation and analyses procedures

Thematic accuracy should be presented in the form of an error matrix. Unequal sampling intensity resulting from the stratified systematic sampling approach should be accounted for by applying a weight factor (p) to each sample unit based on the ration between the number of samples and the size of the stratum considered:

$$\hat{p}_{ij} = \left(\frac{1}{N}\right) \sum_{x \in (i,j)} \frac{1}{\pi^*_{uh}}$$

Where i and j are the columns and rows in the matrix, N is the total number of possible units (population) and π is the sampling intensity for a given stratum.

Overall accuracy and User and producer accuracy should be computed for all thematic classes and 95% confidence intervals should be calculated for each overall accuracy.

The standard error of the error rate can be calculated as follows: $\sigma_h = \sqrt{\frac{p_h(1-p_h)}{n_h}}$ where nh is the sample size for stratum h and ph is the expected error rate. The standard error is calculated for each stratum and an overall standard error is calculated based on the following formula:

$$\sigma = \sqrt{\sum w_h^2 . \sigma_h^2}$$

In which is the proportion of the total area covered by each stratum. The 95% Confidence Interval is +/- 1.96.

2.2. Temporal Quality

Temporal quality is evaluated by providing an indication of the closeness of the acquired image data to the reference year, e.g. the percentage area covered outside the accepted reference period as defined in the tender/product specification i.e. 2016 +/- 1-2 year(s).

2.3. Usability

Usability relates to the appropriateness of the metadata description and accompanying documentation to describe the processes and workflows involved in the production of the data. Although it is difficult to describe usability in quantitative terms, it provides a clear evaluation based on objective criteria of any limitation in the intended use of the data.

2.4. INSPIRE compliant metadata

Presence of INSPIRE compliant metadata should be verified.

3. Thematic accuracy

This section provides the evaluation results of the CESBIO OSO 10m layer and the CESBIO OSO 20m layer. This analysis was performed over 100% of the coverage. The thematic accuracy assessment was conducted in a two-stage process: an initial blind interpretation in which the validation team did not have knowledge of the product's thematic classes and a plausibility analysis performed on all sample units in disagreement with the production. This chapter provides both results.

3.1. CESBIO OSO 10m

3.1.1. Results

The overall accuracies obtained in the frame of the Validation exercise are **81.4 +/- 3.68%** for the blind interpretation and **91.7 +/- 1.25%** for the plausibility analysis, so the results are above the 85% threshold expected. The confusion matrices including the blind and plausibility analysis are provided in Annex 1.

Table 4 and Table 5 summarizes Producer and User accuracies obtained by land cover classes, for the blind and plausibility interpretations.

Table 4: Producer and user accuracy of CESBIO OSO 10m given by land cover classes – Blind analysis

		Blind			
Class	**Name**	**Producer Accuracy**	**Confidence Interval of 95%**	**User Accuracy**	**Confidence Interval of 95%**
10	Cultures	87,58%	3,65%	86,69%	3,53%
31	Forêt de feuillus	79,85%	3,26%	90,02%	1,91%
32	Forêt de coniféres	86,57%	0,61%	80,74%	3,76%
34	Pelouses	73,39%	0,38%	48,49%	2,10%
36	Landes ligneuses	46,55%	1,68%	35,25%	0,67%
41	Urbain dense	42,26%	0,03%	100,00%	0,00%
42	Urbain diffus	86,87%	0,40%	85,61%	3,67%
43	Zones industrielles et commerciales	48,50%	0,09%	63,37%	0,05%
44	Surfaces routes	7,51%	0,05%	100,00%	0,00%
45	Surfaces minerales	69,09%	0,24%	82,53%	0,24%
46	Plages et dunes	66,32%	0,03%	25,99%	0,00%
51	Eau	87,04%	0,03%	88,55%	0,00%
53	Glaciers ou neige	67,75%	0,68%	67,75%	0,68%
211	Prairies	78,44%	1,81%	79,09%	1,49%
221	Vergers	18,69%	0,12%	75,05%	0,00%
222	Vignes	59,27%	6,84%	75,52%	7,55%

Table 5: Producer and user accuracy of CESBIO OSO 10m given by land cover classes – Plausibility analysis

		Plausibility			
Class	Name	Producer Accuracy	Confidence Interval of 95%	User Accuracy	Confidence Interval of 95%
10	Cultures	95,88%	1,70%	93,01%	1,96%
31	Forêt de feuillus	92,67%	2,78%	95,69%	1,73%
32	Forêt de conifères	95,13%	0,39%	94,41%	3,48%
34	Pelouses	88,40%	0,29%	67,18%	0,74%
36	Landes ligneuses	91,75%	0,14%	68,98%	4,85%
41	Urbain dense	73,19%	0,04%	100,00%	0,00%
42	Urbain diffus	89,41%	0,37%	87,12%	3,67%
43	Zones industrielles et commerciales	55,91%	2,04%	78,91%	0,01%
44	Surfaces routes	14,83%	0,06%	100,00%	0,00%
45	Surfaces minerales	83,59%	0,20%	82,70%	0,24%
46	Plages et dunes	88,34%	0,02%	100,00%	0,00%
51	Eau	87,04%	0,03%	88,55%	0,00%
53	Glaciers ou neige	100,00%	0,00%	100,00%	0,00%
211	Prairies	88,26%	6,53%	96,60%	0,66%
221	Vergers	29,84%	0,16%	75,05%	0,00%
222	Vignes	67,13%	4,66%	93,32%	0,00%

3.1.2. Main findings and discussion

The CESBIO OSO 10m product exceeds the accuracy requirements for both blind interpretation and plausibility analysis.

The differences between the blind interpretation and plausibility results highlights the complexity of the nomenclature in liaise with the complexity of the landscape and suggests that for a given land unit several interpretations are sometimes possible.

The CESBIO OSO 10m product shows low producer accuracy (***omission errors***) for the following land cover classes (illustrated in Annex 3 Table 12):

- **Class 41** “Urbain dense”: possible confusion with class 42 “Urbain diffus” due perhaps to the fact that this class is more a mixture between land cover and land use.
- **Class 43** “Zones industrielles et commerciales”: The only use of production imagery might be not sufficient to characterise this kind of land use. This is also largely related to the fact that this is more of a land use than land cover class
- **Class 44** “Surfaces routes”: Depending of the width, some roads were not detected in the final product. This class was easily generalized with other surrounding classes (like class 10 “Cultures”) or interpreted as “Urbain diffus”.
- **Class 45** “Surfaces minérales”: confusion with classes 10 and 46.
- **Class 221** “Vergers”: We noticed some confusion with class 10 “Cultures” (due to crop rotation) or class 31 “Forêt feuillus” (due to the height of the trees).

Commission errors were also detected on the CESBIO OSO 10m layer for the following land cover classes (illustrated in Annex 3 Table 13):

- **Class 34** “Pelouses”: The main confusion was with the class 211 “Prairies”.
- **Class 36** “Landes ligneuses” characterizes by a complex definition depending on the dynamic aspect of the vegetation. Mainly confused with the class 10 “Cropland”.
- **Class 43** “Zones industrielles et commerciales": confusion with class 45 "Surfaces minerals" especially in natural areas.

3.2. CESBIO OSO 20m layer

3.2.1. Results

The overall accuracies obtained in the frame of the Validation exercise of this 20m layer are **81.1 +/- 3.65%** for the blind interpretation and **88.25 +/- 3.15%** for the plausibility analysis, so the results are, respectively, under and above the 85% threshold expected. The confusion matrices including the blind and plausibility analysis are provided in Annex 2.

Table 6 and Table 7 summarizes Producer and User accuracies obtained by land cover classes, for the blind and plausibility interpretations.

Table 6: Producer and user accuracy of CESBIO OSO 20m given by land cover classes – Blind analysis

		Blind			
Class	**Name**	**Producer Accuracy**	**Confidence Interval of 95%**	**User Accuracy**	**Confidence Interval of 95%**
10	Cultures	86,58%	3,99%	88,22%	2,85%
31	Forêt de feuillus	76,23%	3,38%	89,86%	1,95%
32	Forêt de conifères	87,14%	0,57%	74,91%	4,13%
34	Pelouses	73,71%	0,35%	45,89%	0,85%
36	Landes ligneuses	42,26%	1,71%	47,25%	0,96%
41	Urbain dense	28,17%	0,03%	100,00%	0,00%
42	Urbain diffus	87,73%	2,10%	89,92%	0,37%
43	Zones industrielles et commerciales	50,62%	0,07%	75,86%	0,03%
44	Surfaces routes	7,51%	0,05%	100,00%	0,00%
45	Surfaces minerales	69,04%	0,24%	82,70%	0,22%
46	Plages et dunes	66,32%	0,03%	23,92%	0,02%
51	Eau	87,10%	0,03%	78,09%	0,06%
53	Glaciers ou neige	63,80%	0,68%	100,00%	0,00%
211	Prairies	81,92%	1,81%	74,71%	15,25%
221	Vergers	28,03%	0,12%	81,86%	0,00%
222	Vignes	72,25%	0,31%	82,32%	7,22%

Table 7: Producer and user accuracy of CESBIO OSO 20m given by land cover classes – Plausibility analysis

		Plausibility			
Class	**Name**	**Producer Accuracy**	**Confidence Interval of 95%**	**User Accuracy**	**Confidence Interval of 95%**
10	Cultures	91,41%	3,47%	89,43%	2,83%
31	Forêt de feuillus	84,65%	3,28%	95,22%	1,81%
32	Forêt de conifères	94,10%	0,39%	89,85%	3,76%
34	Pelouses	92,16%	0,23%	67,55%	7,80%
36	Landes ligneuses	78,25%	1,70%	79,06%	5,80%
41	Urbain dense	48,79%	0,04%	100,00%	0,00%
42	Urbain diffus	92,37%	0,31%	90,96%	0,40%
43	Zones industrielles et commerciales	53,40%	0,07%	84,17%	0,01%
44	Surfaces routes	12,41%	0,06%	100,00%	0,00%
45	Surfaces minerales	81,13%	0,22%	93,74%	0,20%
46	Plages et dunes	95,66%	0,00%	92,03%	0,02%
51	Eau	90,98%	0,03%	83,55%	0,04%
53	Glaciers ou neige	94,18%	0,01%	100,00%	0,00%
211	Prairies	85,91%	1,57%	83,02%	9,68%
221	Vergers	30,68%	0,12%	81,86%	0,00%
222	Vignes	78,83%	0,29%	97,11%	0,14%

3.2.2. Main findings and discussion

The findings for the 20m products are similar than that of the 10m product and there is no substantial improvement in terms of accuracy between the 10 and 20m product.

4. Conclusions and recommendations

This validation work shows satisfactory overall accuracies, both for CESBIO OSO 10m and for 20m layer, for the blind and the plausibility analysis.

There are some “minor error or expected confusion” met regarding data source resolution and difficult to discriminate without field true or other very precise thematic data. They happen in transitions between neighbouring classes with uncertain thresholds such as shrubs vs. natural grassland.

Some other errors were noticed and can be explained by various reasons:

- A correct identification of certain CESBIO classes requires the use of topical ancillary data. These were missing during our control work (Forest, urban density, OSM data …).
- Some land cover are hard to classify in the CESBIO nomenclature such as clear forest cut (classify in class 31 or 32 or possibly in 34 or 36 when the forest cut is older).
- The limit between class 211 “Prairies” and class 34 “Pelouses” is not clear.
- The class 51 “Eau” include some wetland and temporary flooded areas that are hard to interpreted without the image used in production.
- The location of the validation points could sometimes be confusing (on the boundary between two land cover types).
- The spatial resolution of Sentinel2, appears to be insufficient for the identification of young vineyards and orchards.
- Generalisation of some polygon which contain different land cover type (20m product).
- Problem of the absence of effective MMU for the CESBIO OSO 10m layer. Some isolated pixels distort the interpretation. In this example, a pixel coded in class 36 can be seen in the middle of a cropland parcel (Figure 4).

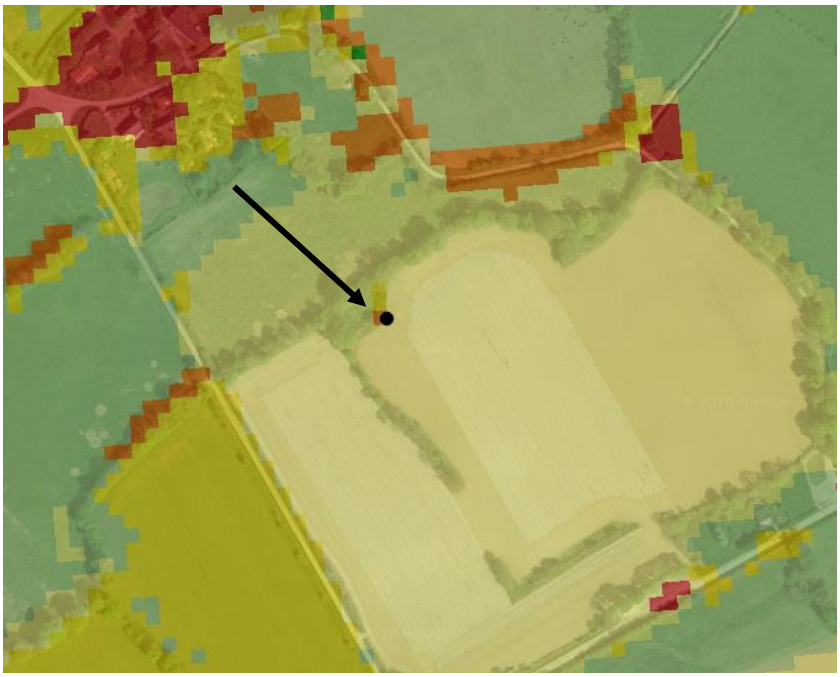


Figure 4: Example on isolated pixel

It should be stressed that even though the validation dataset can reasonably be expected to exhibit a higher accuracy than the CESBIO OSO product, it is not exempt from errors. This was to a large extent overcome by implementing a plausibility analysis, but some errors might still remain that could have further minimised if the imagery used in the production (i.e. Sentinel 2 time series) had been also used in the validation process.

The analysis of the **validation results at class level** should provide insights on where the product could be improved thematically focusing on weaker classes. However, it should also be stressed that some of the error found are perhaps linked to the nomenclature used which is not fully land cover based and include some element of usage (e.g. industrial and commercial and other urban related classes). These could perhaps be replaced by a built-up and/or an artificial surface classe(s). The same would apply for the “prairies”, “pelouses” and “landes ligneuses” which can overlap and include perhaps a distinction between herbaceous and ligneous vegetation dominated areas may be more appropriate.

ANNEX

Annex 1. Confusion matrix of CESBIO OSO 10m – Blind and plausibility analysis

A total of 1,428 sample units located according to the sampling design have been interpreted by an independent expert's team. Table 8 and Table 9 shows the confusion matrix between the validation results in column and the production map in line for both blind and plausibility analysis.

Table 8: Confusion matrix of CESBIO OSO 10m – Blind analysis

CESBIO OSO 10m Blind Analysis		REFERENCE																		
		10	31	32	34	36	41	42	43	44	45	46	51	53	211	221	222	Total	User Accuracy	CI95%
MAP	10	420,0123	21,5060	0,7843	0,5378	0,2131	0,0112	7,1620	5,2031	0,4178	0,0235		0,2363		22,9746	0,7813	4,6288	484,4922	86,69%	3,53%
	31		247,9248	10,4451	2,7193	8,0856		0,0112					0,7794		5,2087	0,2258		275,4000	90,02%	1,91%
	32	0,0084	23,3704	135,5385	1,2173	4,7020							0,0322		2,9915			167,8603	80,74%	3,76%
	34	0,7121	6,0592	3,9490	30,3137	6,8228		1,1611			0,2768			0,5314	11,3216	0,0273	1,3349	62,5099	48,49%	2,10%
	36	9,0501	4,4747	4,6250	3,6690	17,3838			0,0116	0,1311	1,2023		0,1699		8,1191	0,4789		49,3157	35,25%	0,67%
	41						0,3380											0,3380	100,00%	0,00%
	42	5,7100	1,5588	0,9544	0,0596		0,2253	79,6812	0,7046	0,6259	0,0802		0,1699		1,0805		2,2221	93,0723	85,61%	3,67%
	43			0,1295			0,2253	1,2523	7,1224	0,2804	1,3262	0,1222			0,2250		0,5555	11,2387	63,37%	0,05%
	44									0,1182								0,1182	100,00%	0,00%
	45			0,0167	1,0936			0,1127	0,4890		8,0879							9,7999	82,53%	0,24%
	46										0,6848	0,2405						0,9253	25,99%	0,00%
	51				0,6266								9,3237		0,5791			10,5293	88,55%	0,00%
	53				0,5314									1,1162				1,6476	67,75%	0,68%
	211	41,1284	5,6119	0,1295	0,5371	0,1408		2,3129	0,0084						191,5867	0,2258	0,5555	242,2370	79,09%	1,49%
	221														0,1501	0,4516		0,6017	75,05%	0,00%
	222	2,9623						0,0273	1,1454		0,0242					0,2258	13,5287	17,9138	75,52%	7,55%
	Total	479,5837	310,5058	156,5720	41,3055	37,3481	0,7998	91,7206	14,6846	1,5733	11,7059	0,3627	10,7114	1,6476	244,2369	2,4166	22,8255	1428,00001		
	Producer Accuracy	87,58%	79,85%	86,57%	73,39%	46,55%	42,26%	86,87%	48,50%	7,51%	69,09%	66,32%	87,04%	67,75%	78,44%	18,69%	59,27%		81,43%	Overall Accuracy
	CI95%	3,65%	3,26%	0,61%	0,38%	1,68%	0,03%	0,40%	0,09%	0,05%	0,24%	0,03%	0,03%	0,68%	1,81%	0,12%	6,84%		3,68%	CI95%

The overall accuracy obtained for CESBIO OSO 10m is **81.43 +/- 3.68%** so the blind interpretation results do not meet the product specification.

Table 9: Confusion matrix of CESBIO OSO 10m - Plausibility analysis

CESBIO OSO 10m Plausibility Analysis		REFERENCE																		
		10	31	32	34	36	41	42	43	44	45	46	51	53	211	221	222	Total	User Accuracy	CI95%
MAP	10	450,6400	8,2122	0,7843	0,5435	0,2074	0,0112	6,0165	5,1750	0,2866	0,0361		0,2363		8,2697	0,5555	3,5178	484,4922	93,01%	1,96%
	31		263,5181	2,9146	1,9862	0,7672							0,7794		5,2087	0,2258		275,4000	95,69%	1,73%
	32	0,0084	5,4951	158,4784	0,0439	0,8108							0,0322		2,9915			167,8603	94,41%	3,48%
	34		5,2195	2,3240	41,9944	1,2736		1,1454							9,1907	0,0273	1,3349	62,5099	67,18%	0,74%
	36	9,0501	0,1184	1,4059	0,6266	34,0197			0,0116	0,1311	0,1241		0,1699		3,4051	0,2531		49,3157	68,98%	4,85%
	41						0,3380											0,3380	100,00%	0,00%
	42	5,7100	1,5588	0,6848	0,0596		0,1127	81,0813	0,1628	0,1311	0,0802		0,1699		1,0992		2,2221	93,0723	87,12%	3,67%
	43							0,0112	8,8685	0,1302	1,3262	0,1222			0,2250		0,5555	11,2387	78,91%	0,01%
	44									0,1182								0,1182	100,00%	0,00%
	45				1,0936			0,1127	0,4890		8,1045							9,7999	82,70%	0,24%
	46											0,9253						0,9253	100,00%	0,00%
	51				0,6266								9,3237		0,5791			10,5293	88,55%	0,00%
	53													1,6476				1,6476	100,00%	0,00%
	211	4,5982	0,2515		0,5314			2,2909	0,0084						234,0010		0,5555	242,2370	96,60%	0,66%
	221														0,1501	0,4516		0,6017	75,05%	0,00%
	222							0,0273	1,1454		0,0242						16,7168	17,9138	93,32%	0,00%
	Total	470,0067	284,3735	166,5920	47,5058	37,0787	0,4618	90,6854	15,8608	0,7973	9,6953	1,0475	10,7114	1,6476	265,1201	1,5134	24,9026	1428,00001		
	Producer Accuracy	95,88%	92,67%	95,13%	88,40%	91,09%	73,19%	89,41%	55,91%	14,83%	83,59%	88,34%	87,04%	100,00%	88,26%	29,84%	67,13%		91,75%	Overall Accuracy
	CI95%	1,70%	2,78%	0,39%	0,29%	0,14%	0,04%	0,37%	2,04%	0,06%	0,20%	0,02%	0,03%	0,00%	6,53%	0,16%	4,66%		1,25%	CI95%

The overall accuracy obtained for CESBIO OSO **is 91.75 +/- 1.25%**, so the plausibility results are above the 85% threshold expected.

Annex 2. Confusion matrix of CESBIO OSO 20m – Blind and plausibility analysis

The 1,428 sample units located according to the sampling design have been interpreted by an independent expert's team. This following tables shows the confusion matrix between the validation results in column and the production map in line for both blind and plausibility analysis.

Table 10: Confusion matrix of CESBIO OSO 20m – Blind analysis

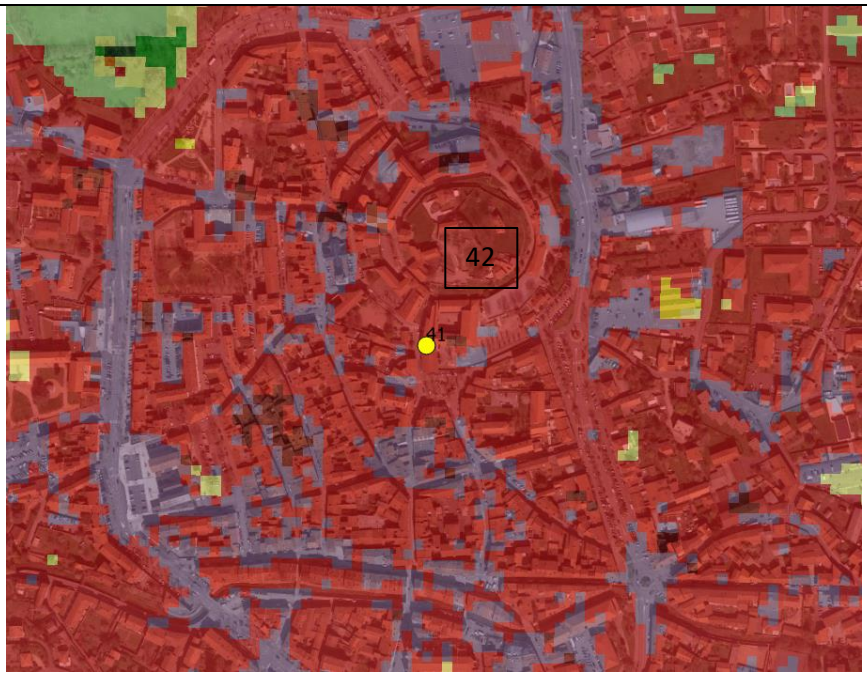
CESBIO OSO 20m Blind Analysis		REFERENCE																		
		10	31	32	34	36	41	42	43	44	45	46	51	53	211	221	222	Total	User Accuracy	CI95%
MAP	10	415,2348	15,4425	0,6848	0,5193	0,2074	0,0112	8,0542	5,1069	0,4178	0,0235		0,0563		22,4654	0,7813	1,6665	470,6719	88,22%	2,85%
	31	0,7794	236,6859	10,4209	0,7331	8,6405		0,1423					0,7794		4,9829	0,2258		263,3903	89,86%	1,95%
	32	4,5822	30,2254	136,4417	2,3266	5,3868							0,1823		2,9915			182,1364	74,91%	4,13%
	34	1,2676	15,5578	5,3861	30,4476	7,0189		1,2855			0,5525			0,5314	2,9341	0,0273	1,3349	66,3437	45,89%	0,85%
	36	0,6495	0,1830	2,1389	4,4245	15,7838			0,0116	0,1311	0,5314	0,0802	0,1829		8,2510	0,4789	0,5555	33,4024	47,25%	0,96%
	41						0,2253											0,2253	100,00%	0,00%
	42	1,3828	0,1594	1,2240	0,0626		0,3380	80,4643	1,8609	0,6259	0,0802		0,1756		0,8851		2,2221	89,4809	89,92%	0,37%
	43			0,1295			0,2253	0,3655	7,4333	0,1302	1,3262	0,0420			0,1467			9,7986	75,86%	0,03%
	44									0,1182								0,1182	100,00%	0,00%
	45			0,0167	1,6096						8,0822			0,0650				9,7734	82,70%	0,22%
	46										0,7650	0,2405						1,0055	23,92%	0,02%
	51		0,4266		0,6266	0,1699			0,1631	0,1501	0,2768		9,3292		0,8040			11,9464	78,09%	0,06%
	53													1,0512				1,0512	100,00%	0,00%
	211	52,7251	11,8253	0,1295	0,5556	0,1408		1,4088	0,1087		0,0439		0,0057		200,0705	0,2258	0,5555	267,7952	74,71%	15,25%
	221														0,1501	0,6774		0,8275	81,86%	0,00%
	222	2,9623									0,0242				0,5555		16,4910	20,0330	82,32%	7,22%
	Total	479,5837	310,5058	156,5720	41,3055	37,3481	0,7998	91,7206	14,6846	1,5733	11,7059	0,3627	10,7114	1,6476	244,2369	2,4166	22,8255	1428,00001		
	Producer Accuracy	86,58%	76,23%	87,14%	73,71%	42,26%	28,17%	87,73%	50,62%	7,51%	69,04%	66,32%	87,10%	63,80%	81,92%	28,03%	72,25%		81,15%	Overall Accuracy
	CI95%	3,99%	3,38%	0,57%	0,35%	1,71%	0,03%	2,10%	0,07%	0,05%	0,24%	0,03%	0,03%	0,68%	1,81%	0,12%	0,31%		3,65%	CI95%

Table 11: Confusion matrix of CESBIO OSO 20m - Plausibility analysis

CESBIO OSO 20m Plausibility Analysis		REFERENCE																		
		10	31	32	34	36	41	42	43	44	45	46	51	53	211	221	222	Total	User Accuracy	CI95%
MAP	10	420,9010	14,6631	0,6848	0,5193	0,2074	0,0112	5,0429	5,0789	0,2809	0,0235		0,0286		21,3379	0,7813	1,1110	470,6719	89,43%	2,83%
	31		250,8118	4,5357	0,0057	2,5444		0,1311					0,7794		4,3564	0,2258		263,3903	95,22%	1,81%
	32		12,6968	163,6548	0,0731	2,4943									3,2173			182,1364	89,85%	3,76%
	34	1,2403	10,1808	3,4545	44,8172	1,7960		1,2855			0,5525				1,6547	0,0273	1,3349	66,3437	67,55%	7,80%
	36	0,6495	0,1830	0,6266	1,4455	26,4064			0,0116	0,1311					3,6955	0,2531		33,4024	79,06%	5,80%
	41						0,2253											0,2253	100,00%	0,00%
	42	1,3536	0,1594	0,9544	0,0626		0,2253	81,3881	1,8488	0,1311	0,0802		0,1756		0,8797		2,2221	89,4809	90,96%	0,40%
	43							0,0242	8,2475	0,1302	1,3262	0,0420			0,0285			9,7986	84,17%	0,01%
	44									0,1182								0,1182	100,00%	0,00%
	45				0,5468						9,1616			0,0650				9,7734	93,74%	0,20%
	46										0,0802	0,9253						1,0055	92,03%	0,02%
	51		0,2768		0,6266	0,1699			0,1631	0,1501			9,9808		0,5791			11,9464	83,55%	0,04%
	53													1,0512				1,0512	100,00%	0,00%
	211	36,3007	7,3187		0,5314	0,1295		0,2414	0,0957	0,0108	0,0439		0,0057		222,3189	0,2430	0,5555	267,7952	83,02%	9,68%
	221														0,1501	0,6774		0,8275	81,86%	0,00%
	222										0,0242				0,5555		19,4533	20,0330	97,11%	0,14%
	Total	460,4451	296,2904	173,9107	48,6283	33,7480	0,4618	88,1132	15,4456	0,9526	11,2923	0,9673	10,9701	1,1162	258,7735	2,2080	24,6768	1428,00001		
	Producer Accuracy	91,41%	84,65%	94,10%	92,16%	70,70%	48,79%	92,37%	53,40%	12,41%	81,13%	95,66%	90,98%	94,18%	85,91%	30,68%	78,83%		88,25%	Overall Accuracy
	CI95%	3,47%	3,28%	0,39%	0,23%	1,70%	0,04%	0,31%	0,07%	0,06%	0,22%	0,00%	0,03%	0,01%	1,57%	0,12%	0,29%		3,15%	CI95%

Annex 3. Illustrations of main omission and commission errors met during the validation process (based on Google Earth imagery on all illustrations)

Table 12: Omission Errors

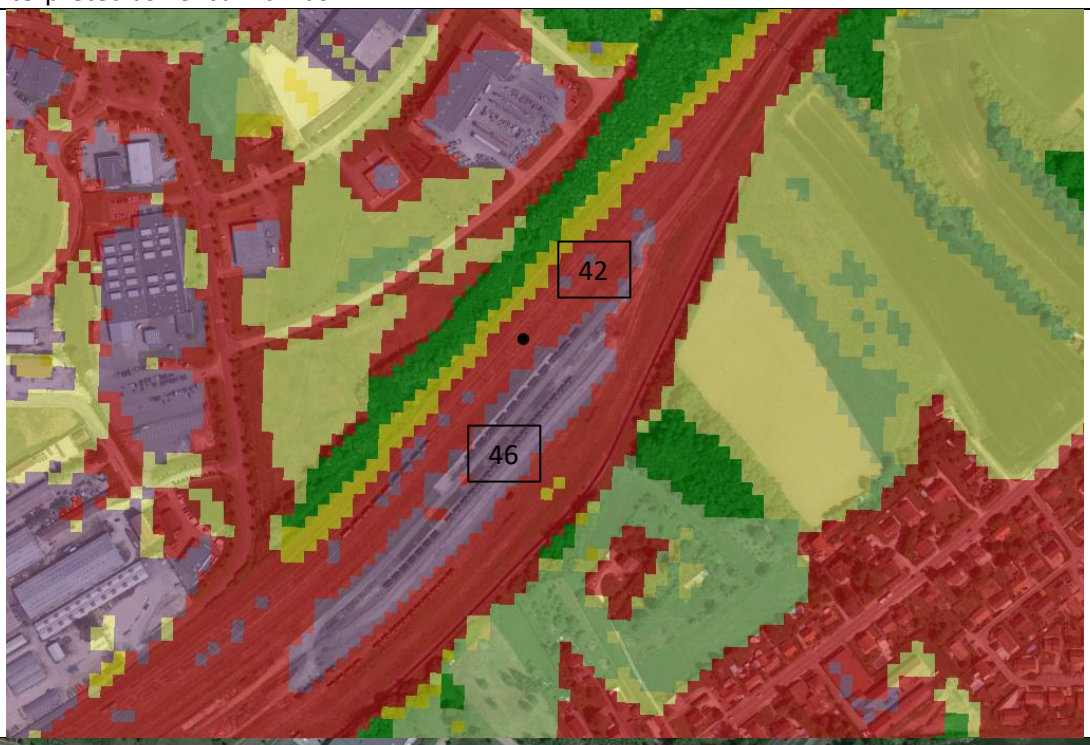
Class 41 "Urbain dense": possible confusion with class 42 "Urbain diffus" due to the fact that the urban density cannot be really appreciated on a VHR Image.


Code Product CESBIO 10m = 42 Code Validation Plausibility = 41
A very few patches of class 41 "Urbain dense" in brown but the rest of the city is classify in class 42 "Urbain diffuse" even if the density is quite high.

Class 43 “Zones industrielles et commerciales”: The only use of production imagery might be not sufficient to characterise this kind of land use.

Code Product CESBIO 10m = 10
Code Validation Plausibility = 43

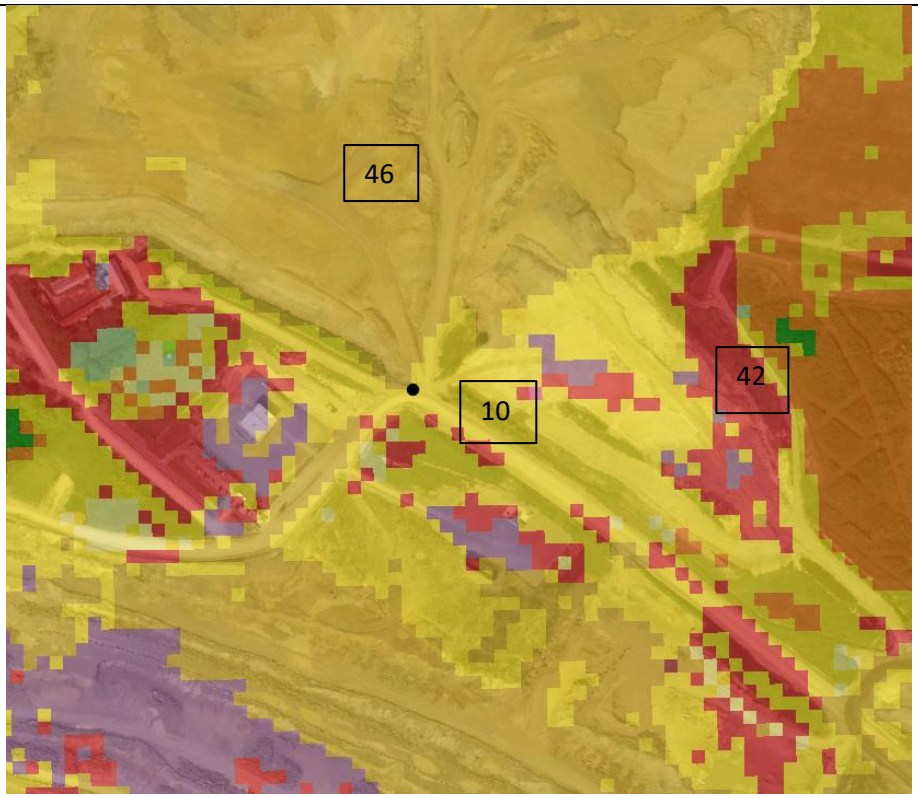
Class 44 “Surfaces routes”: Depending of the width, some roads were not detected in the final product. This class was easily generalized with other surrounding classes (like class 10 “Cultures”) or interpreted as “Urbain diffus”.

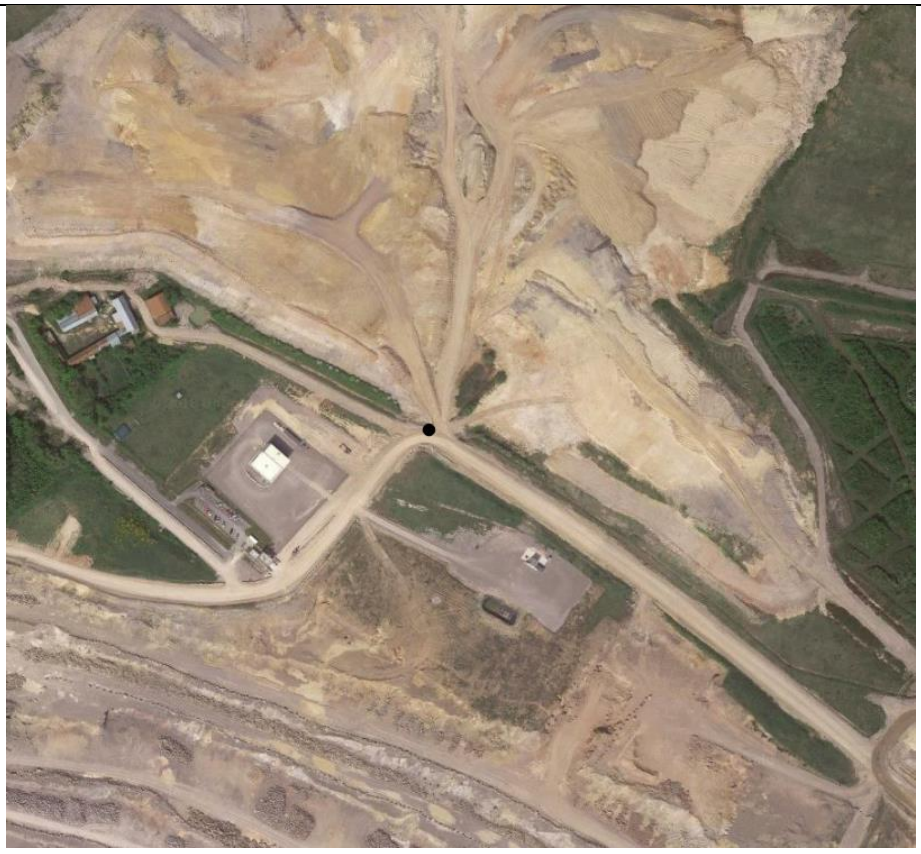


Code Product CESBIO 10m = 42
Code Validation Plausibility = 44

This railway was classified in 42 “Urbain diffus” and in 43 “zones industrielles et commerciales”.

Class 45 “Surfaces minérales”: confusion with classes 10, 42 and 46

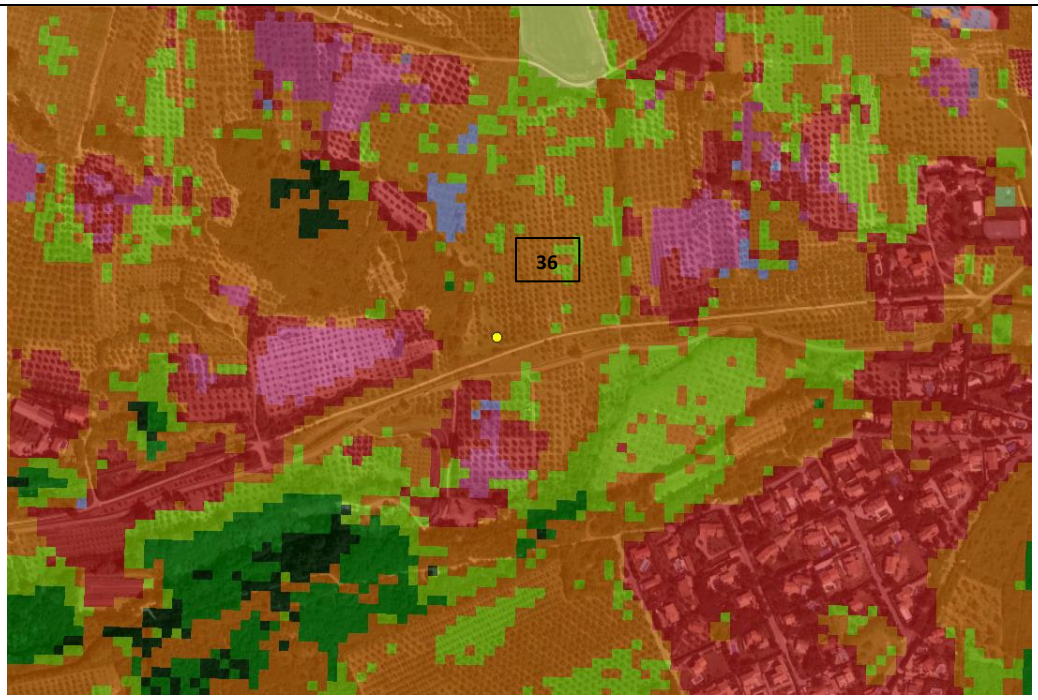


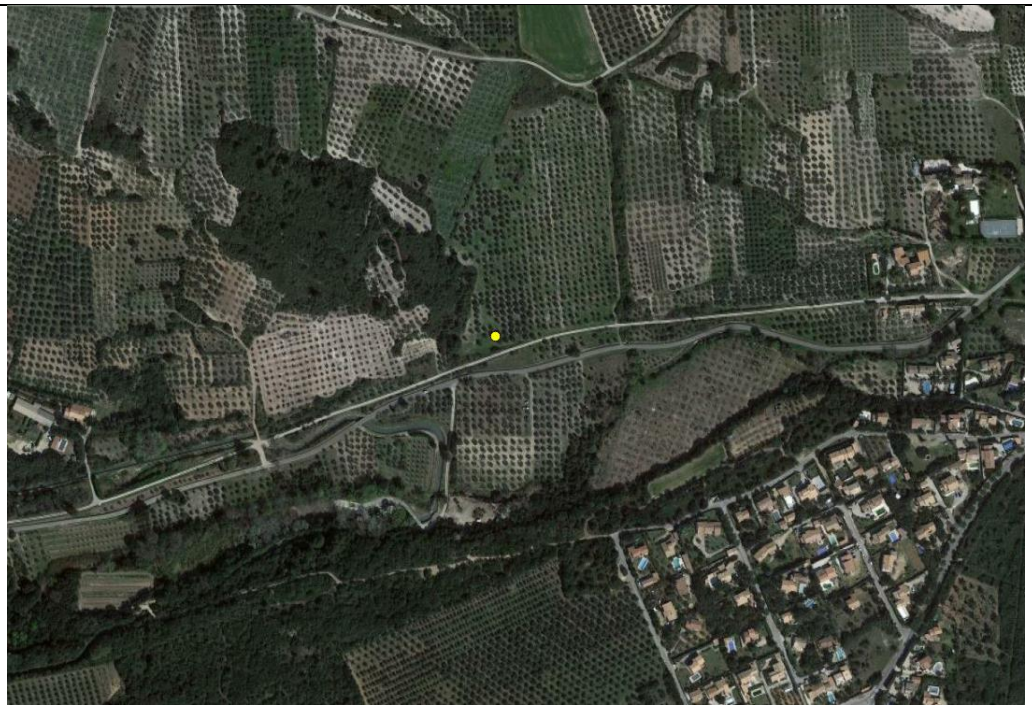


Code Product CESBIO 10m = 10
Code Validation Plausibility = 45

This quarry was not well classify by the CESBIO product.

Class 221 “Vergers”: We noticed some confusion with class 10 “Cultures” (due to crop rotation) or class 31 “Forêt feuillus” (due to the height of the trees).





Code Product CESBIO 10m = 36
Code Validation Plausibility = 221

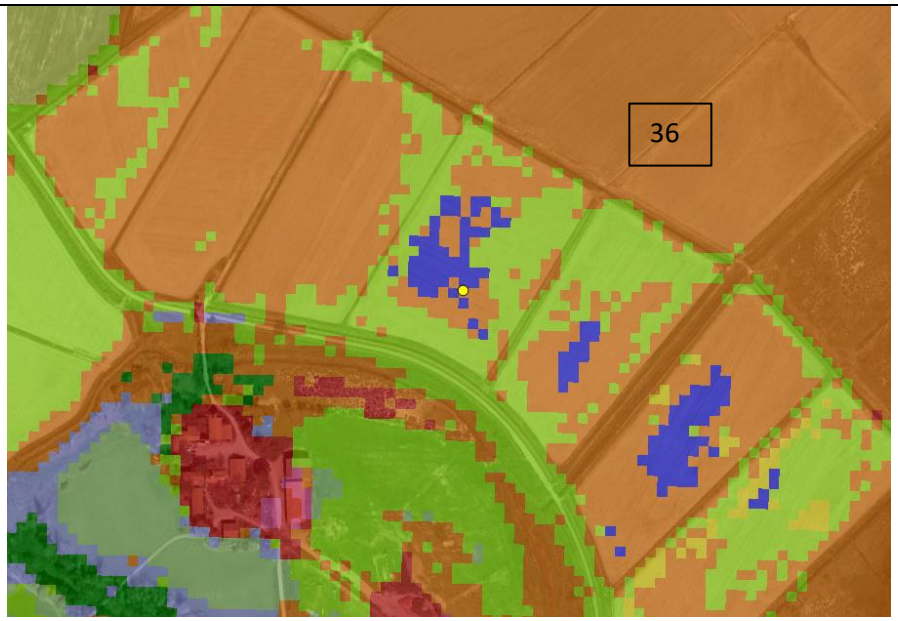
These areas were classified in 36 "Landes ligneuses" instead of 221 "Vergers".

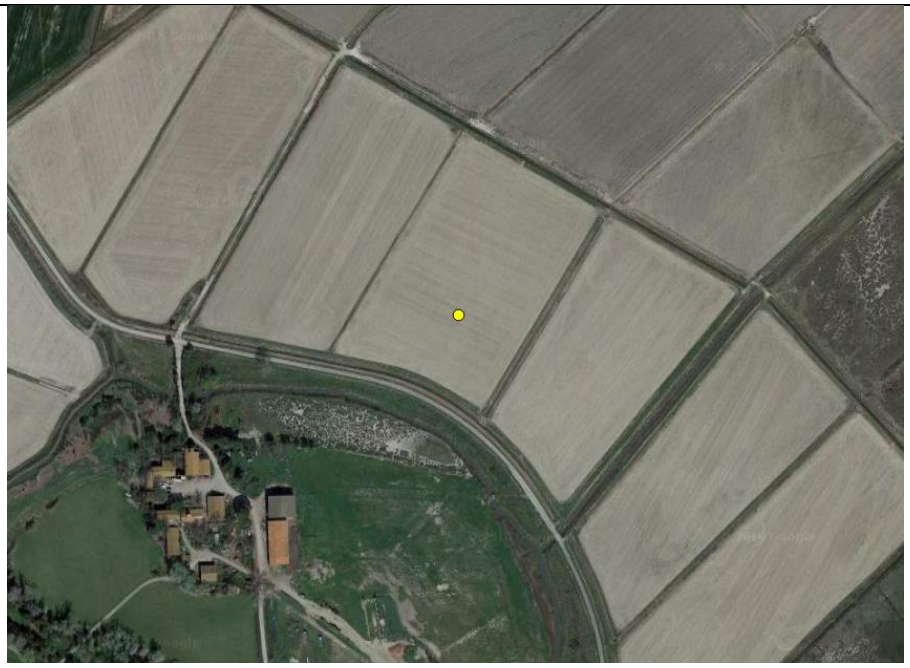
Table 13: Commission Errors

Class 34 “Pelouses”: The main confusion was with the class 211 “Prairies”.


Code Product CESBIO 10m = 34 Code Validation Plausibility = 211
This grassland cannot be interpreted as a "Pelouses" in this urban area.

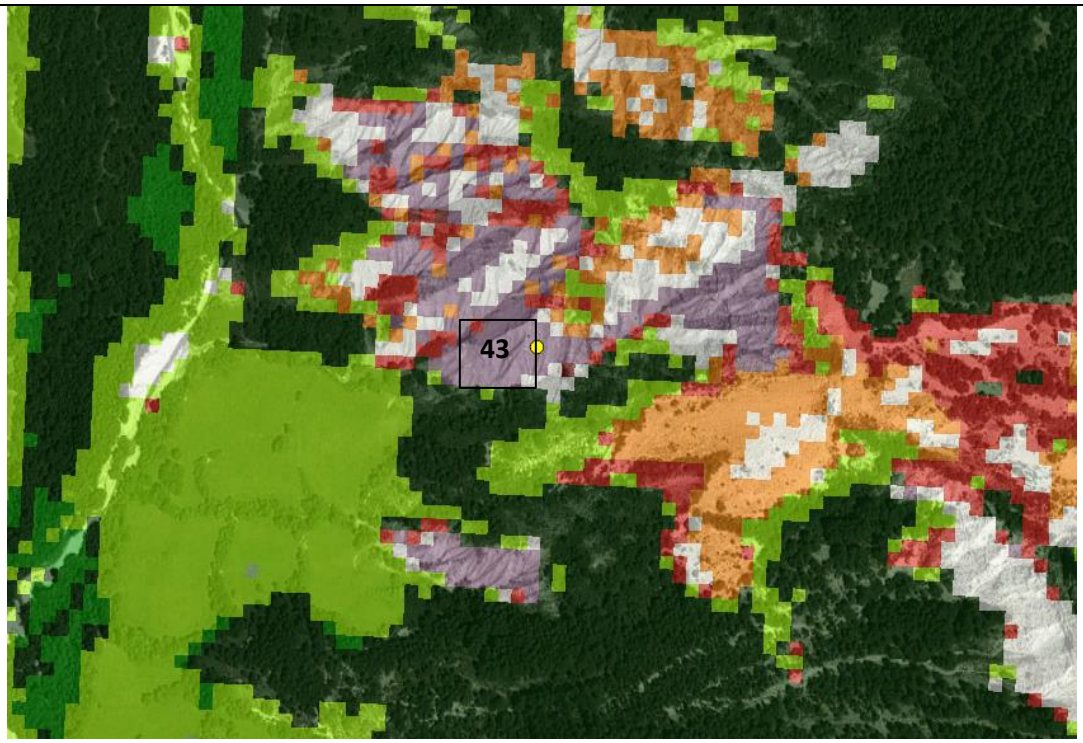
Class 36 “Landes ligneuses” characterizes by a complex definition depending on the dynamic aspect of the vegetation. Mainly confused with the class 10 “Cropland”.





Code Product CESBIO 10m = 36
Code Validation Plausibility = 10

Class 43 “Zones industrielles et commerciales": confusion with class 45 "Surfaces minerals" especially in natural areas.



Code Product CESBIO 10m = 43
Code Validation Plausibility = 45

Industrial areas classified in a mountain area instead of bare rocks.