

Manual of CORINE Land Cover changes

EEA subvention 2011



Final Draft

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1 INTRODUCTION

1.1 PURPOSE OF THE MANUAL

CORINE Land Cover (CLC) data provide information on the physical characteristics of the earth surface. CLC and CLC-Change data are widely used by the EEA and its member states in reporting, indicator development and environmental modelling. Currently the 4th CLC inventory is under preparation as part of GIO (GMES Initial Operations). The brief history of CLC is summarised in Table 1.

Table 1 Brief history of CLC inventories

Inventory	Duration	Number of countries	Main features
CLC1990	1988-1998	26	1 st inventory; drawing on plastic overlay
CLC2000	2001-2005	28	Computer-aided photointerpretation (drawing on screen); correction of geometry; 1 st change mapping
CLC2006	2007-2011	38	2 nd change mapping with improved methodology
CLC2012	2013-2014	38	In planning; no major change in methodology

In the course of 1st change mapping EEA placed a strong emphasis on mapping CLC changes with higher detail than CLC. This is reflected in the size of the Minimum Mapping Unit, which is **25 ha in CLC** and **5 ha in CLC-Change** databases. For technical realization the "change mapping first" technology has been preferred and applied by the majority of participating countries since the CLC2006 project [1].

CLC-Change₂₀₀₀₋₂₀₀₆ was the primary product of the CLC2006 project. The aim was to produce the European coverage of real land cover changes that

- were larger than 5 ha and wider than 100 m;
- occurred between 2000 and 2006;
- reflected real evolution process (e.g. urban sprawl, new forest plantation, new water reservoir).

This will apply to the CLC2012 project as well. The main benefits of the "change-mapping first" approach are:

- changes are interpreted directly (the interpreter has to think about what the real process was),
- all changes larger than 5 ha can be easily delineated regardless of their geometric position (whether attached to an existing CLC polygon or not).

The weakness is that some small (< 5 ha) deficiencies of new CLC (CLC2012) cannot be avoided [2].

There is a consolidated manual regarding the use of the standard CLC nomenclature [3]. A similar document about mapping CLC changes was felt to be useful in order to improve harmonisation of mapping CLC changes in Europe. In CLC2006 project, majority of countries (>30) applied computer-assisted photointerpretation for mapping changes between 2000 and 2006. 2-3 countries derived forestry changes through computerized processing of remotely sensed data and other changes by using in-situ information. These changes were usually controlled visually on satellite images. In CLC2006 project

only a single country has performed a semi-automatic change detection to map CLC changes.

The "knowledge base" of this Manual is the more than 100 verification missions the authors conducted to the participating countries during CLC2000 and CLC2006 projects. Discussions with experts of the national teams were exceptionally important in shaping the content of the Manual.

1.2 DEFINITION OF CORINE LAND COVER CHANGE

CORINE Land Cover is implemented in Europe in 5 – 10 - year periods (Table 1). This fits rather well to the observed CORINE Land Cover Change dynamics, which is below 1% change per year for all countries, except Portugal (Figure 1, [5]). Repetition of CLC in every 5-6 years in the future seems to be a good compromise between user needs and financial constraints.

Logically, CLC changes should characterise those changes of the earth surface that have longer than yearly / seasonal periodicity. Urban sprawl, plantation of olive trees to replace arable land, melting of glaciers or creation of a new water reservoir are such long-term land cover changes to be mapped as CLC change. On the other hand, transient changes and short-term periodical changes are phenomena not to be mapped as CLC change.

Transient changes (lasting only for short time), not to be mapped as CLC change:

- Changes along rivers due to floods (temporary inundations)
- Changes inland due to heavy rains (temporary water-logging)

What to do with periodical changes, where LC status alternates between two different land covers?

Several processes have periodicity shorter than 1 year, therefore are not to be considered as CLC change:

- Water level changes in coastal areas due to tidal phenomena (high tide, low tide)
- Changes in lake / wetland area due to seasonal water level differences
- Regular changes of water cover of fishponds due to maintenance
- Seasonal phenological changes in forests (status of leaves)
- Seasonal phenological changes of natural grassland and sparse vegetation (green in spring, yellow in summer)
- Seasonal difference in crop development (bare soil, green crop, mature crop, harvested crop)
- Seasonal changes in annual snow cover (esp. high mountains and Northern Europe).

There are some changes that are periodic, but the periodicity is longer than 1 year or even longer than the CLC mapping repetition period. These processes have to be mapped. E.g.:

- Alternation of arable land and set-aside/pasture land (211-231, 231-211). Periodicity is usually several years, however being country / region dependent. (In countries where grass is planted as one-year (fodder) crop, being part of crop rotation, these changes are NOT considered to be CLC change.)
- Forest clearcut (31x-324) and new plantation growth (324-31x). After clearcutting minimum 5-10 years are needed for a new forest to develop.

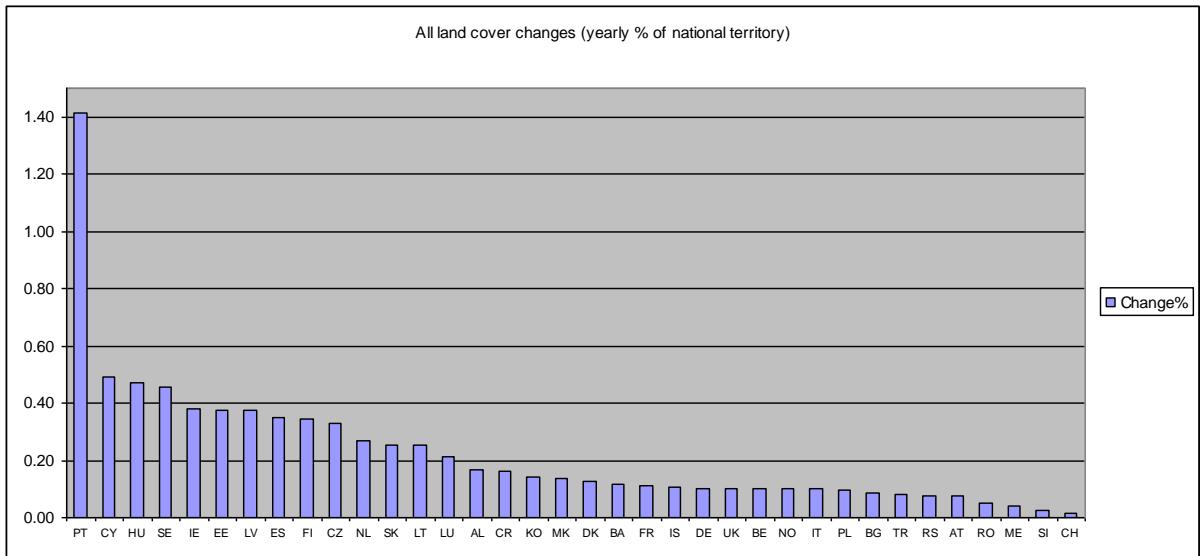


Figure 1 Comparison of total land cover changes in Europe provided by CLC-Change₂₀₀₀₋₂₀₀₆ (V15).

1.3 COMPILED AND STRUCTURE OF THE MANUAL

Considering the 44 level-3 classes in CLC, theoretically there are $44 \times 43 = 1892$ different CLC change types. Even if not all of them are possible or do actually happen (Table 2), there is no way to discuss hundreds of different change types. Based on the statistics of CLC-Change₂₀₀₀₋₂₀₀₆ database, the most important (i.e. most frequent) CLC change types – providing 90% of all change area (Table 2, Table 3) - were selected for discussion in this Manual. In most of the cases several level-3 change types were grouped into a CLC change process for discussion. Altogether 27 different CLC change groups are discussed in this Manual.

There are four main chapters in the Manual, discussing the most frequent changes of:

- Chapter 2: Artificial surfaces (anything developed from Artificial surfaces)
- Chapter 3: Agriculture areas (anything developed from Agriculture areas)
- Chapter 4: Forests and semi-natural areas (anything developed from Forests and semi-natural areas)
- Chapter 5: Wetlands and water areas (anything developed from Wetlands and water areas)

An additional chapter discusses general technical issues:

- Chapter 6: Technical issues.

Change processes are discussed in a standard way, including the following items:

A) Textual description

- **Change process:** general description of the change process (e.g. construction process has finished) and list of change types given as CLC code pairs (e.g. 133-121)
- **Overview and rationale:** short description of the change process and its significance
- **Number of changes** belonging to the change process in European CLC-Change₂₀₀₀₋₂₀₀₆: indicating the “importance” of the process in terms of CLC change polygons
- **Area of changes** belonging to the change process in European CLC-Change₂₀₀₀₋₂₀₀₆: indicating the “importance” of the process in terms of CLC change area

- **Type:** more detailed definition of the change process with reference to the relevant CLC level-3 classes. E.g. Construction of residential units finished: 133-112. Several types might be listed under a change process.
- B) **Interpretation example(s)** in the form of the screen-shot(s) made by InterCheck tool [6] during CLC2006 - in exceptional cases CLC2000 - verification missions. In most of the examples dual window screen-shots are shown with IMAGE2000 and CLC2000 on the left side, and IMAGE2006 and CLC-Change Change₂₀₀₀₋₂₀₀₆ on the right side. In a few cases a CLC2000 example is shown with similar arrangement including IMAGE1990 and CLC-Change₁₉₉₀₋₂₀₀₀ on the left, while IMAGE2000 and CLC2000 on the right. Reference year of satellite imagery is shown in small number on top left of the respective image windows (e.g. 2000, 2006).
- C) List of **frequent** associated **mistakes** as observed during verification missions (usually with an example), followed by advice how to avoid these mistakes. Some of the mistakes are illustrated by screen-shots with arrangement similar to good examples. Caption of figures showing a mistake starts with the word "Mistake" and is written with **red** characters.
- D) **Particularity** (optional): this includes additional, interesting example(s), which are not necessarily typical. Sometimes a particularity includes an example that does not belong to the 90% mentioned above.

Finally, Chapter 6 is about "Technical issues". This is a collection of typical mistakes that are usually not connected to a single discussed change process.

Table 2 Figures characterising the CLC-Change₂₀₀₀₋₂₀₀₆ Europe database (V15)

Total changed area:	70 824 km ²
Part of Europe (without sea and ocean) that changed between years 2000 and 2006	1,24 percent
Number of change polygons	358 969
Number of change types occurring	935
Number of change types altogether providing 90% of total change area	73
Number of sporadic change types (each giving less than 0.1% of total change area)	853
Change types providing 50% of total change area	312-324, 24 547 km ² 324-312, 6 311 km ² 311-324, 5 729 km ²
Largest change in Artificial surfaces group	133-112, 2492 polygons
Largest change in Agriculture group	231-211, 3210 polygons
Largest change in Forests and semi-natural group	312-324, 146 596 polygons
Largest change in Wetlands and Water groups	412-324 1017 polygons

Table 3 The largest change types in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database (V15) discussed in the Manual

change type	polygons	area (ha)	percent of all change areas	cumulative percent	Chapter in Manual
312-324	146596	2454697	34.66	34.66	4.5
324-312	34719	631129	8.91	43.57	4.6
311-324	24633	572909	8.09	51.66	4.5
324-311	12327	317649	4.49	56.14	4.6
313-324	21625	314292	4.44	60.58	4.5
324-313	19491	288285	4.07	64.65	4.6
334-324	630	102241	1.44	66.10	4.8
231-211	3210	91832	1.30	67.39	3.8
211-231	2583	89132	1.26	68.65	3.8
211-324	3182	76021	1.07	69.72	3.10
211-133	3528	74679	1.05	70.78	3.1
211-212	1089	70370	0.99	71.77	3.4
211-112	5983	69411	0.98	72.75	3.1
211-121	4031	57040	0.81	73.56	3.1
323-324	693	56904	0.80	74.36	4.8
211-223	1573	56234	0.79	75.16	3.7
242-112	3386	51108	0.72	75.88	3.1
133-112	2492	50031	0.71	76.58	2.1
211-221	1439	41823	0.59	77.17	3.5
231-324	1993	41359	0.58	77.76	3.10
211-222	1531	40882	0.58	78.34	3.5
312-334	321	34075	0.48	78.82	4.7
211-131	1980	33712	0.48	79.29	3.2
321-324	652	32299	0.46	79.75	4.8
133-121	1365	31827	0.45	80.20	2.1
412-324	1017	31090	0.44	80.64	5.2
334-323	91	28942	0.41	81.05	4.8
231-112	2399	25519	0.36	81.41	3.1
324-334	428	23885	0.34	81.74	4.7
335-332	589	23368	0.33	82.07	4.9
324-244	428	23140	0.33	82.40	4.4
242-133	1457	22285	0.31	82.71	3.1
231-133	1353	22172	0.31	83.03	3.1
412-211	949	20496	0.29	83.32	5.1
243-324	755	19449	0.27	83.59	3.10
321-211	319	18172	0.26	83.85	4.3
211-242	292	18107	0.26	84.10	3.9
323-334	148	17669	0.25	84.35	4.7
324-211	1770	17305	0.24	84.60	4.3
242-121	1284	16409	0.23	84.83	3.1
131-324	405	16263	0.23	85.06	2.2
133-122	370	16207	0.23	85.29	2.1
331-511	118	15539	0.22	85.51	4.10
222-211	547	15096	0.21	85.72	3.6
511-331	175	15096	0.21	85.93	5.3
211-142	522	14958	0.21	86.14	3.3
244-324	335	14319	0.20	86.35	3.11
243-112	847	14193	0.20	86.55	3.1
231-242	266	13989	0.20	86.74	3.9

211-122	690	13931	0.20	86.94	3.1
211-512	800	13829	0.20	87.14	3.12
313-334	227	12975	0.18	87.32	4.7
311-334	205	12855	0.18	87.50	4.7
231-121	968	12688	0.18	87.68	3.1
322-324	369	11585	0.16	87.84	4.8
311-244	245	11294	0.16	88.00	4.4
324-131	687	10721	0.15	88.15	4.1
312-323	79	10678	0.15	88.31	4.7
212-222	247	10036	0.14	88.45	3.5
312-131	820	9710	0.14	88.58	4.1
324-323	65	9443	0.13	88.72	4.7
323-231	241	9338	0.13	88.85	4.3
323-133	386	8879	0.13	88.97	4.2
333-324	140	8797	0.12	89.10	4.8
231-131	612	8733	0.12	89.22	3.2
321-133	350	8039	0.11	89.34	4.2
131-231	235	8034	0.11	89.45	2.2
312-211	1027	8010	0.11	89.56	4.3
221-211	284	7886	0.11	89.67	3.6
243-133	527	7866	0.11	89.78	3.1
312-133	558	7783	0.11	89.89	4.2
131-512	191	7397	0.10	90.00	2.2
242-223	152	7395	0.10	90.10	3.7

2 MOST FREQUENT CHANGES OF THE ARTIFICIAL SURFACES CLASSES

2.1 CONSTRUCTION PROCESS COMPLETED

Change process: Construction process being completed: 133-112/121/122

Overview and rationale:

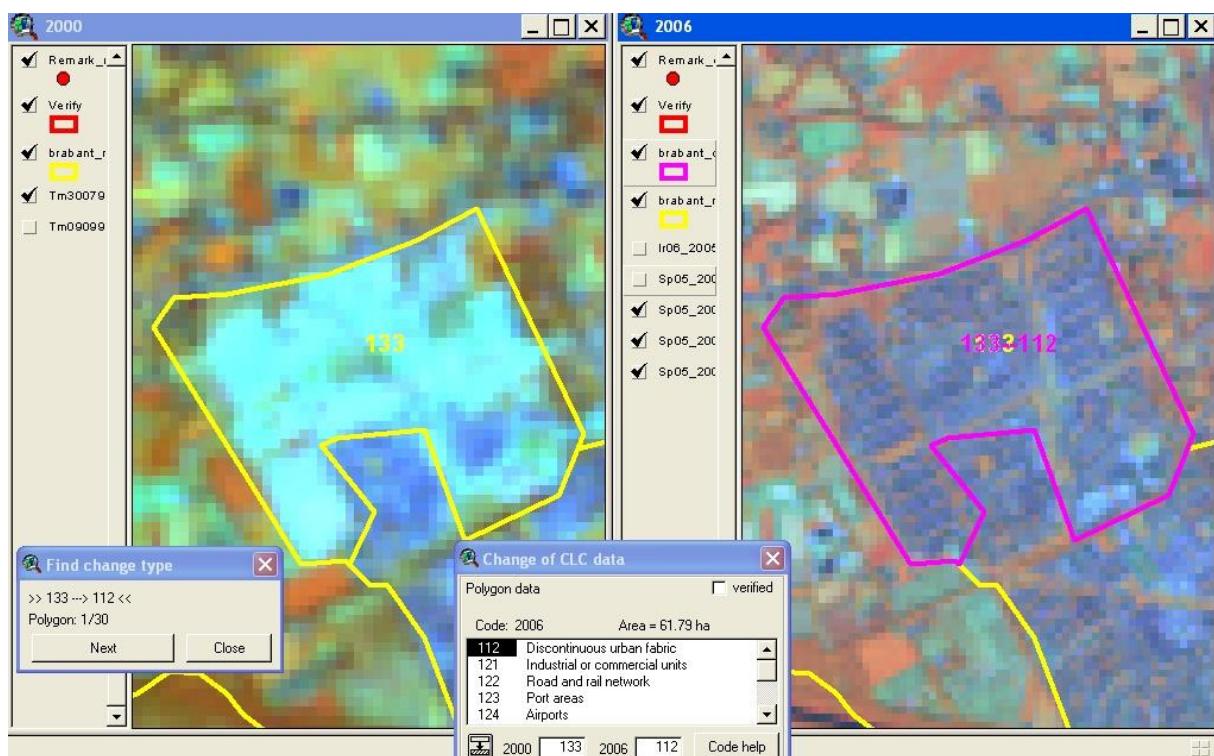
Modern society continuously needs new residential areas, new industrial facilities and new transport infrastructure. Sometimes former infrastructures are modernized (brown-field investment), but frequently constructions occupy areas formerly used for agriculture or covered by (semi-)natural vegetation (green-field investment). In CORINE Land Cover this process is mapped as two (connected) subsequent steps: 1) agricultural or forest/semi-natural area becomes a construction site, resulting loss of agricultural land / semi-natural area. 2) construction site turns to new housing area or new industrial area or new transport infrastructure. The duration of construction process depends on the object being constructed and on economic conditions. A construction mapped in the parent stock layer is normally expected to be finished by the time of the new CLC inventory. This chapter deals with the second process, i.e. constructions being finished.

Number of changes in European CLC-Change : 4227 polygons

Area of changes in European CLC-Change: 1.38 % of all change area

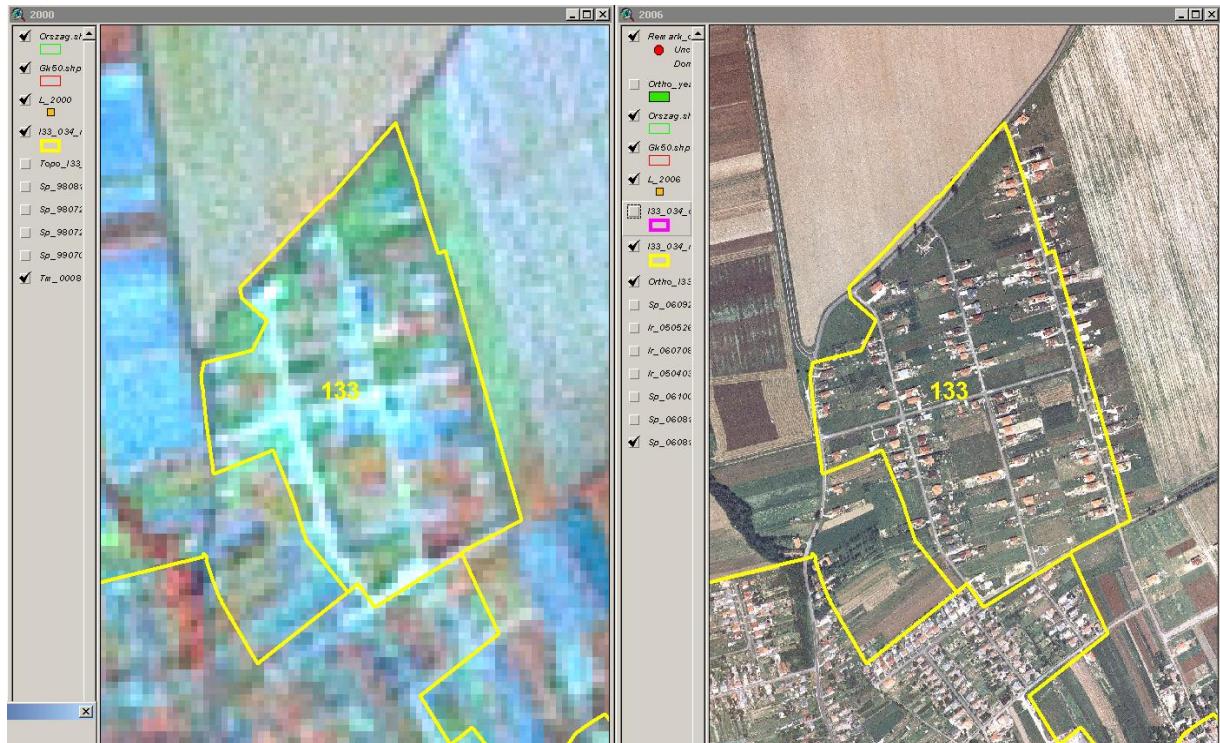
Type: Construction of residential area being completed: 133-112

Interpretation example (the Netherlands):

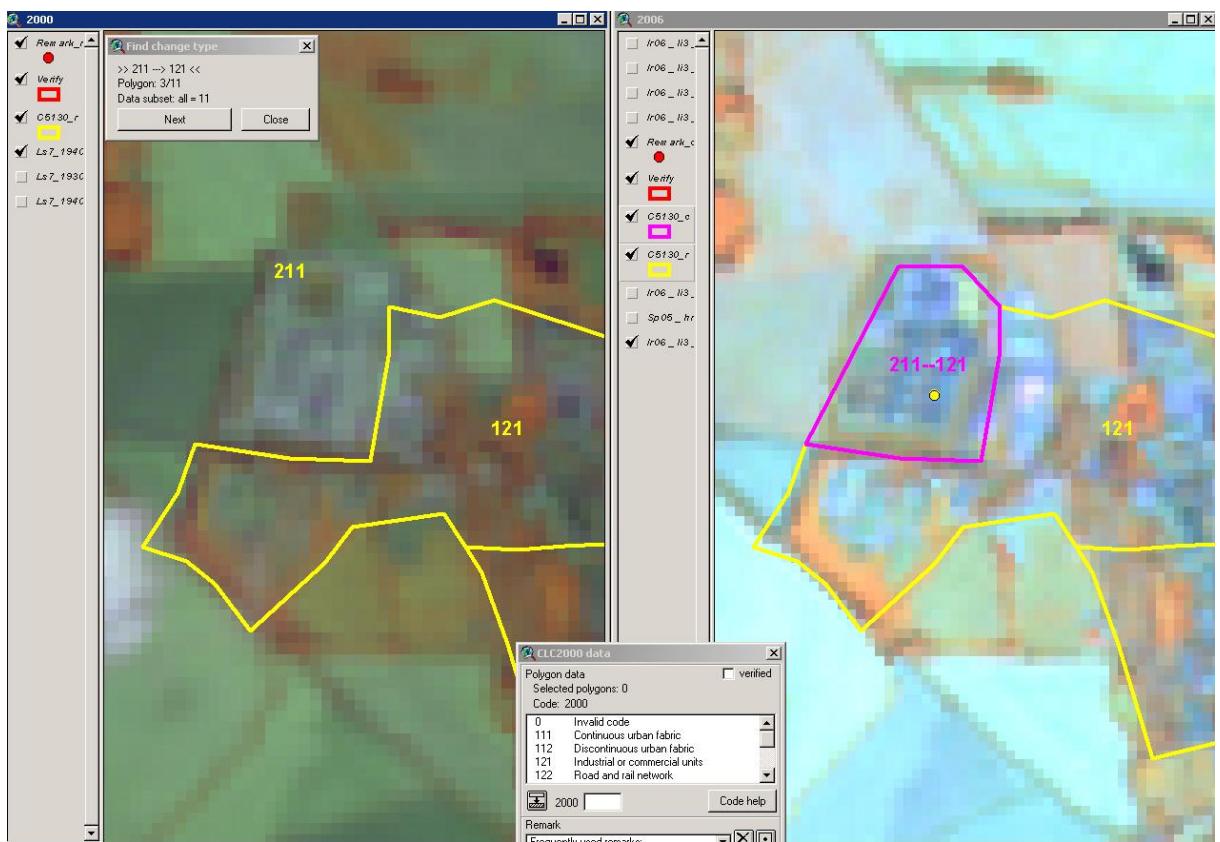


Change 133-112 means construction site turned to discontinuous urban area. In 2000 (left) earthwork and/or construction was going on. No urban structures are visible. In 2006 (right) the area shows the characteristic street pattern similar to neighbouring older urban area in the southeast. Note the colour and structure difference between construction and residential areas. There are 2492 polygons of this type covering 0.71 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Frequent mistakes: Construction of residential or industrial area completed	How to avoid the mistake
Omitted change associated to 133 polygon	All 133 polygons in the parent stock layer have to be examined whether the construction has been finished. Keep in mind that "permanent construction" (i.e. lasting more than 5-6 years) is not usual.
False change (wrong change code pair) associated to construction sites with size smaller than the 25 ha MMU (in stock layer generalised to 11x, 2xx or 3xx)	Real process should be reflected in codes, i.e. 133-1xx, based on what is visible on satellite images. Orthophoto helps to recognize current status.
Omitted change associated to construction sites with size smaller than the 25 ha MMU (in stock layer generalized to 11x, 2xx or 3xx)	Better examination of input satellite imagery to recognize the change (see example).
Omitted change due to not using the latest available image.	Constructions can proceed quickly. Check and use the latest available image.

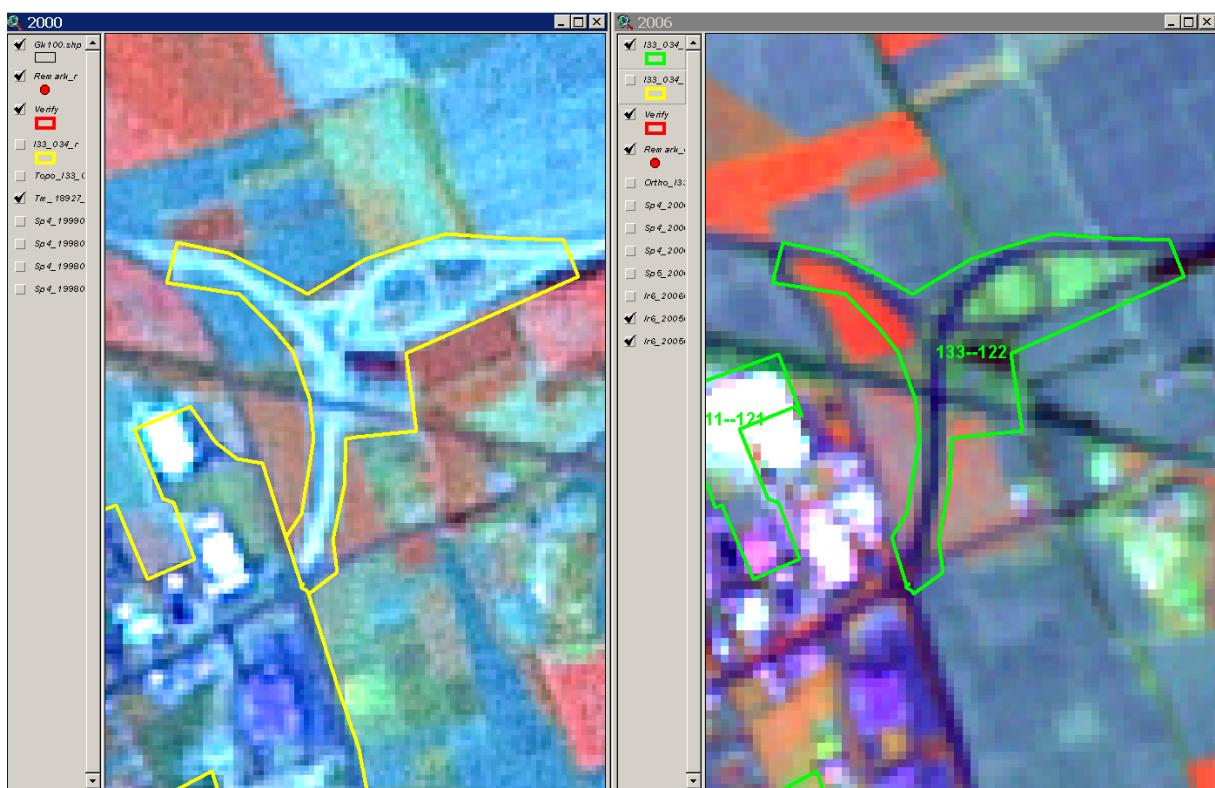


Mistake: completed construction omitted (133-112). The 133 polygon in 2000 (left) shows less structures and evidence of earthwork, while on the corresponding 2006 orthophoto (right) street pattern and houses are clearly visible.



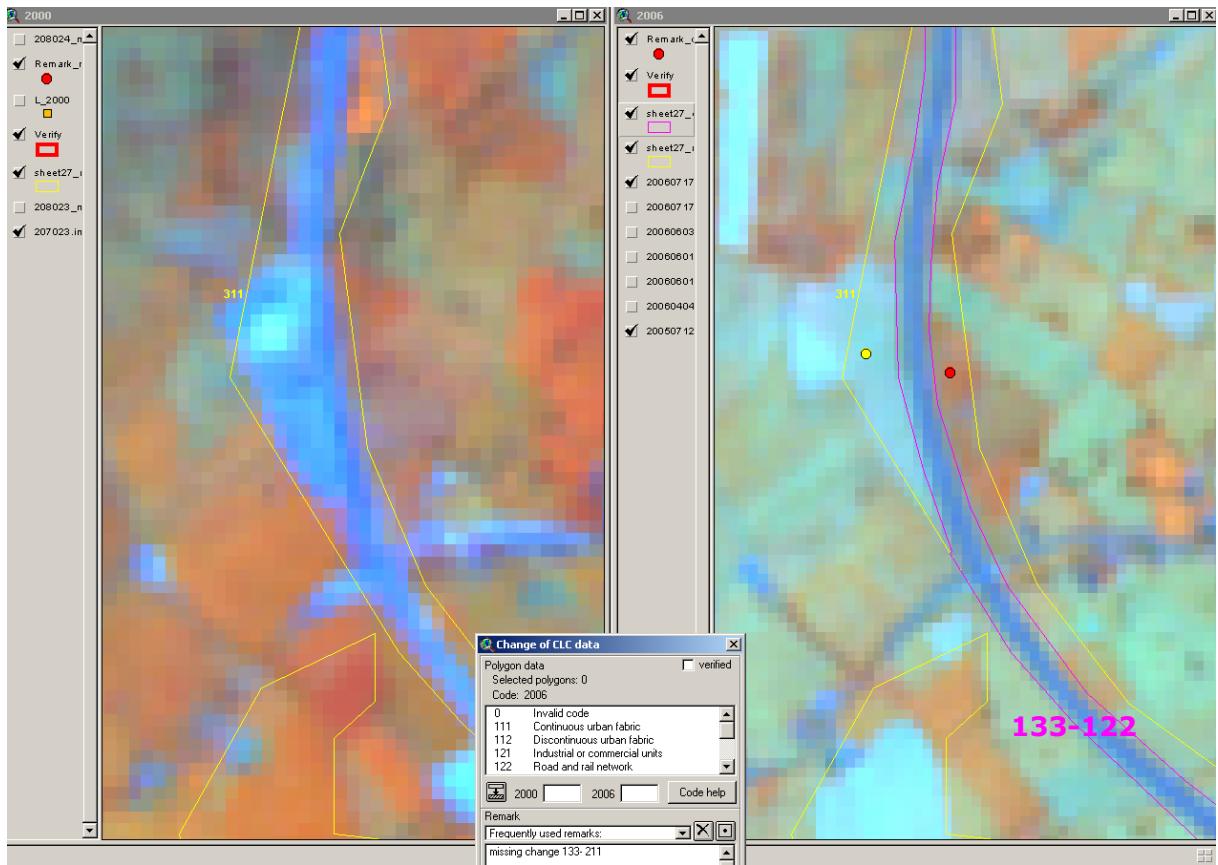
Mistake: false change associated to construction site with size smaller than the 25 ha MMU. 211-121 was wrongly used in mapping the construction process. The left image (IMAGE2000) shows that construction was going on already in 2000, consequently the right change process is 133-121 and not 211-121.

Type: Road construction being completed: 133-122
Interpretation example (Hungary):



In 2000 (left) a road construction site is visible on the edge of a settlement. White colour is a proof of earthwork and the ongoing construction. In 2006 (right) no more construction is visible, i.e. the road crossing is finished. There is however a conflict with the 100 m width rule. The construction site reaches the 100 m width limit and it is precisely mapped. In the completed road crossing the width of the roads finished is below the 100 m limit, thus the polygon also includes some arable land. However, as the total area just exceeds the 25 ha, there is no better way to map 133-211 change without loosing the 122 polygon in CLC2006. Artificial surfaces are characteristic elements of the landscape therefore, keeping them in the database is important. There are 370 polygons of this type covering 0.23 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Frequent mistakes: Road construction completed	How to avoid the mistakes
Omitted change associated to 133 polygon	All 133 polygons in the parent database have to be examined whether the construction is completed. Keep in mind that "permanent construction" (i.e. lasting more than 5-6 years) is not usual.
Omitted changes related to the completion of the road construction, like reclamation of the area associated to the construction process.	A better characterization of the phenomena is needed: the reclamation process (e.g. 133-211/231) should be reflected in changes. Frequently, there is a conflict between mapping real changes and keeping the minimum mapping width of 100 m.
The road (highway) in the new stock layer is exaggerated in width (to >100 m), as the width of construction exceeded 100 m.	A better characterisation of the phenomena is needed: the reclamation process should be separately mapped. Frequently, there is a conflict between mapping real changes and keeping the minimum mapping width of 100 m.
Change is omitted due to not using the latest available image.	Constructions can proceed quickly. Check and use the latest available image.



Mistake: After the road construction being completed (133-122 mapped correctly), other changes, such as 133-211 also occur due to reclamation of the construction area (marked by red and yellow dots on the right). If not mapped as a change, the areas indicated with dots will be still 133 in the new stock layer or if <25 ha will be generalized into the 122 polygon. Often there is a conflict between mapping real changes and keeping the minimum mapping width of 100 m.

Particularity-1:

Type: Construction of a golf course completed: 133-142

Interpretation example (Spain):

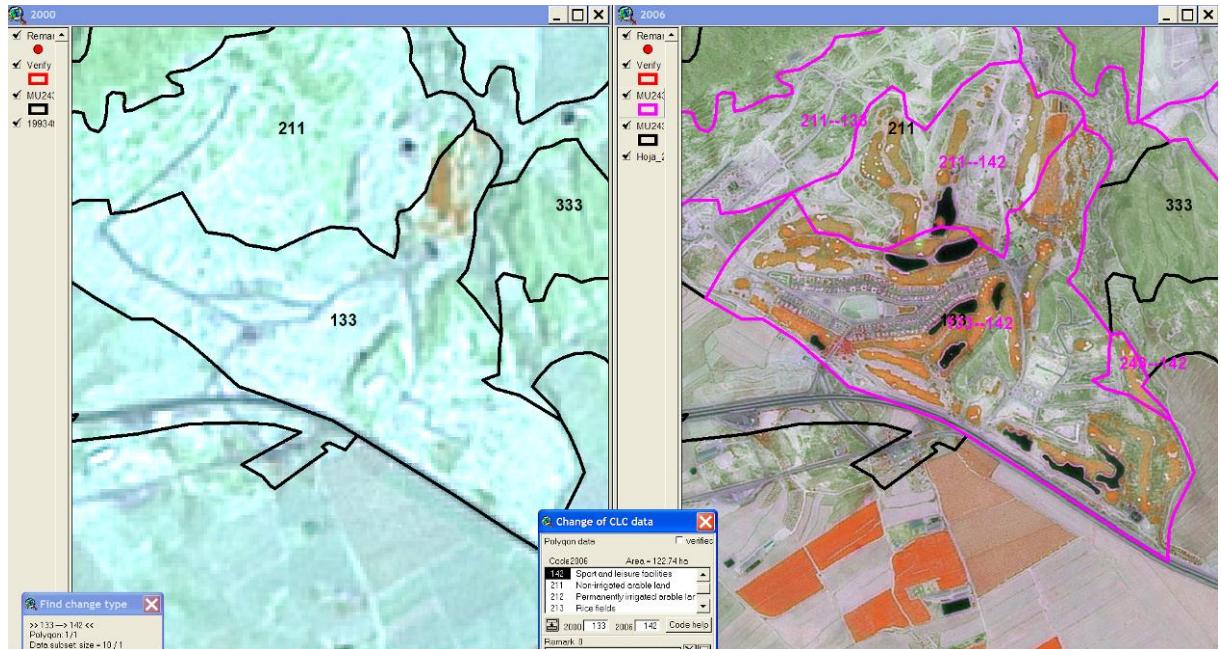
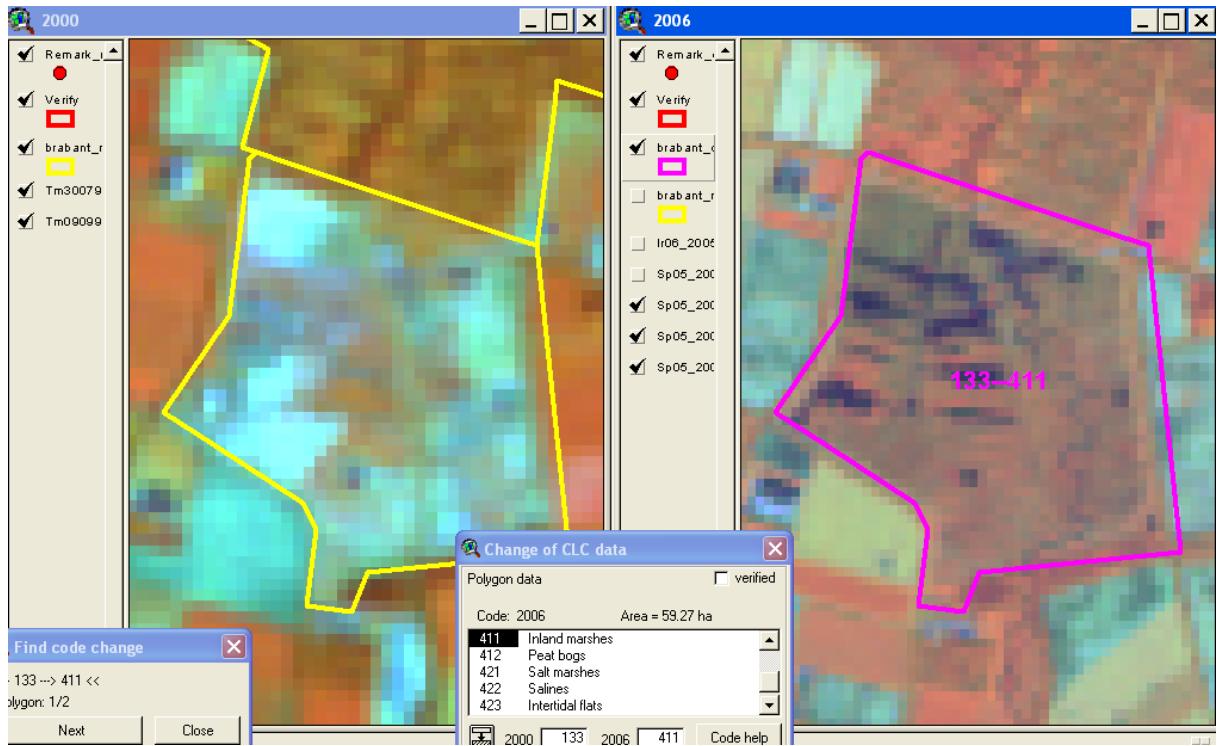


IMAGE2000 (left) shows a construction area (133, not very much different from the neighbouring dry agricultural land), which has turned to golf course (142) by 2006. The golf course can be recognized on IMAGE2006 (right) from the typical ("spaghetti") pattern of patches of greens (grass-covered surfaces) and small lakes. On some parts the construction was still going on in 2006 (not interpreted). There are 215 polygons of this type covering 0.10 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Particularity-2:

Type: Construction of artificial wetland being completed: 133-411 (nature reconstruction)

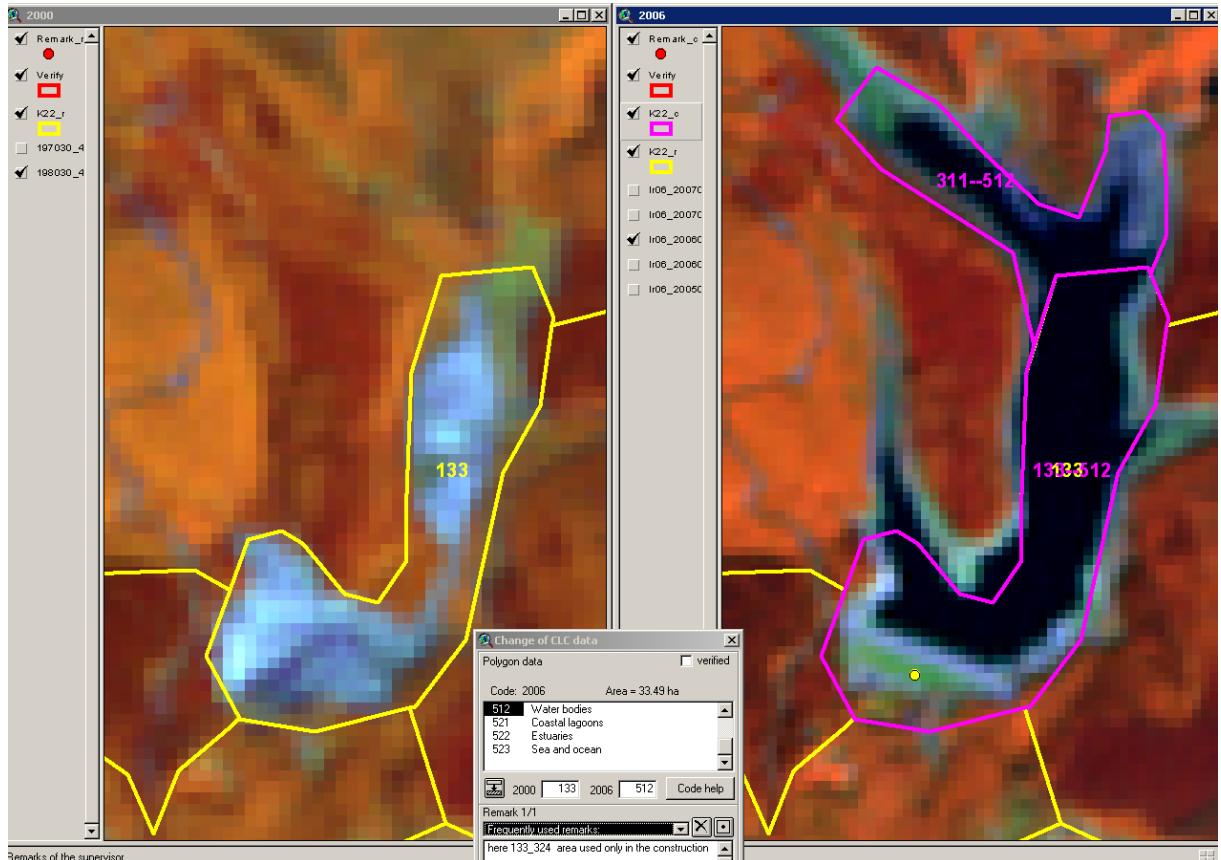
Interpretation example (the Netherlands):



Particularity-3:

Type: Construction of water reservoir being completed: 133-512

Interpretation example (France):



Based on IMAGE2000 (left) one cannot tell what is being constructed, only the construction area is visible in a forest. In 2006 (right) it is evident that a new dam has been raised and a water reservoir has been filled up behind it. The proper change is 133-512. Concerning the northern change polygon, the construction phase is not visible therefore 311-512 is the right change code pair. **Southern part of the southern polygon, which was not inundated, should have been mapped as 133-324, to indicate the reclamation process after completion of construction.** There are 70 polygons of this type covering 0.03 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

2.2 RECLAMATION OF MINERAL EXTRACTION SITES

Change process: Reclamation of mineral extraction sites: 131-231/324/512

Overview and rationale:

Reclamation of mineral extraction sites is the process of creating useful landscapes that meet a variety of goals, typically creating productive ecosystems (or sometimes industrial or municipal land) from mined land. After mining finishes, the mine area must undergo rehabilitation.

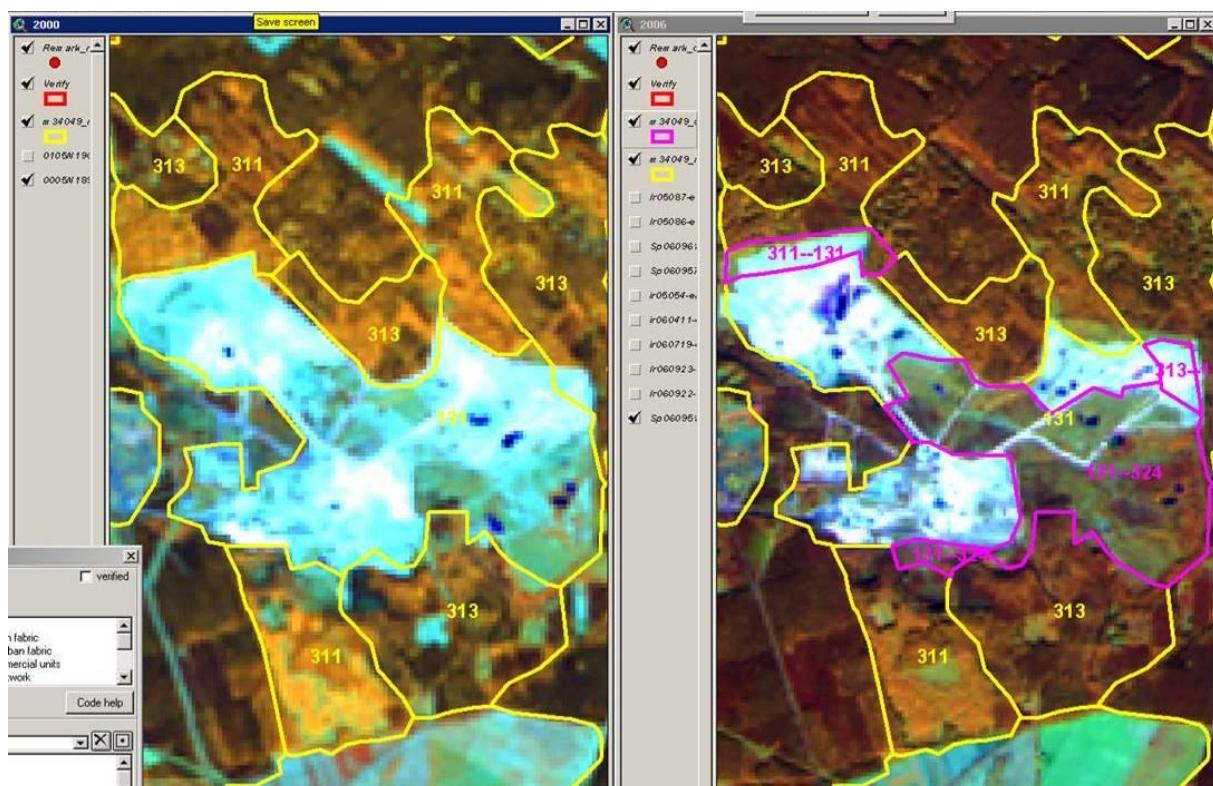
Mine rehabilitation aims to minimize and mitigate the environmental effects of modern mining. Backfilling the open pit mine, rehabilitation usually involves the movement of significant volumes of rock. Later the former open pit is covered with topsoil, and vegetation is planted to help consolidate the material [8].

Number of changes in European CLC-Change: 831 polygons

Area of changes in European CLC-Change: 0.45% of all change area

Type: Reclamation of mineral extraction sites by afforestation: 131-324

Interpretation example (Poland):



Bare areas in 2000 (left) indicating open-pit mining activities became vegetated by 2006 (right). The colour of new vegetation cover on the right is similar to the colour of neighbouring forests. We have a good reason to suspect that reclamation was done by afforestation. Because of the short time elapsed the forest is not mature yet (indicated also by IMAGE2006), therefore the right process is: 131-324. There are 405 polygons of this type covering 0.23 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Type: Reclamation of mineral extraction sites by grassland: 131-231
Interpretation example (Poland):

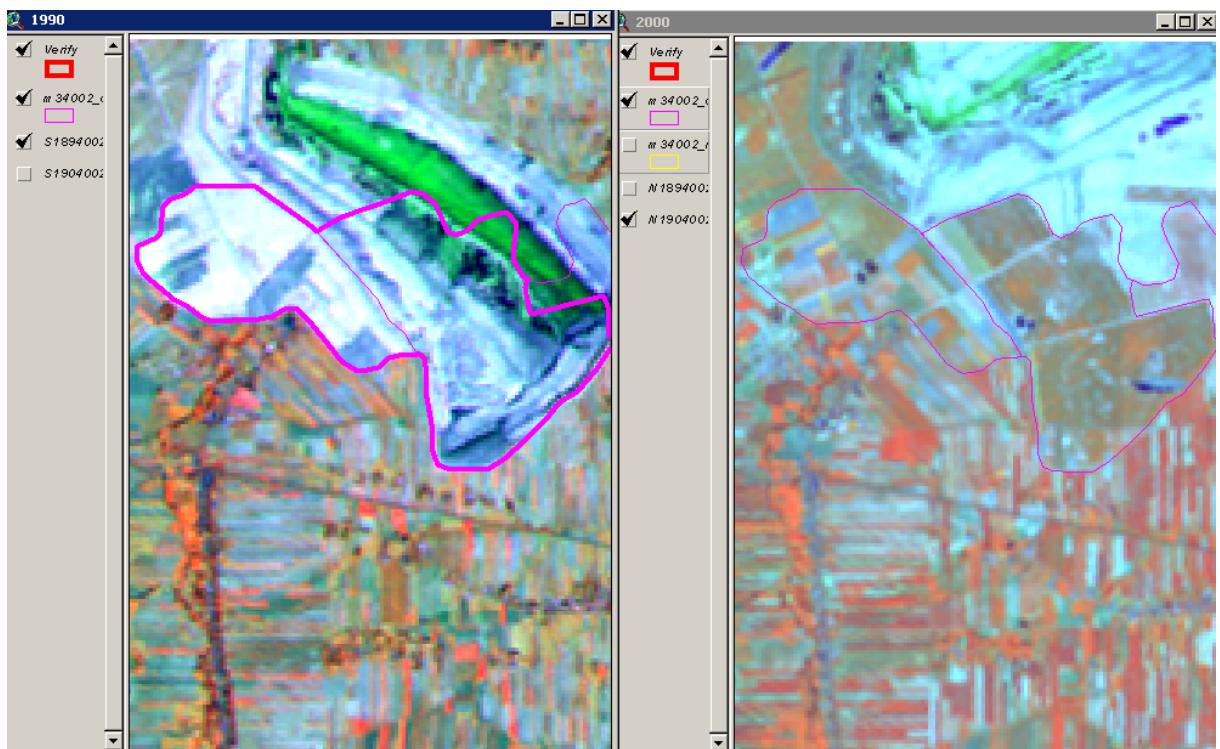
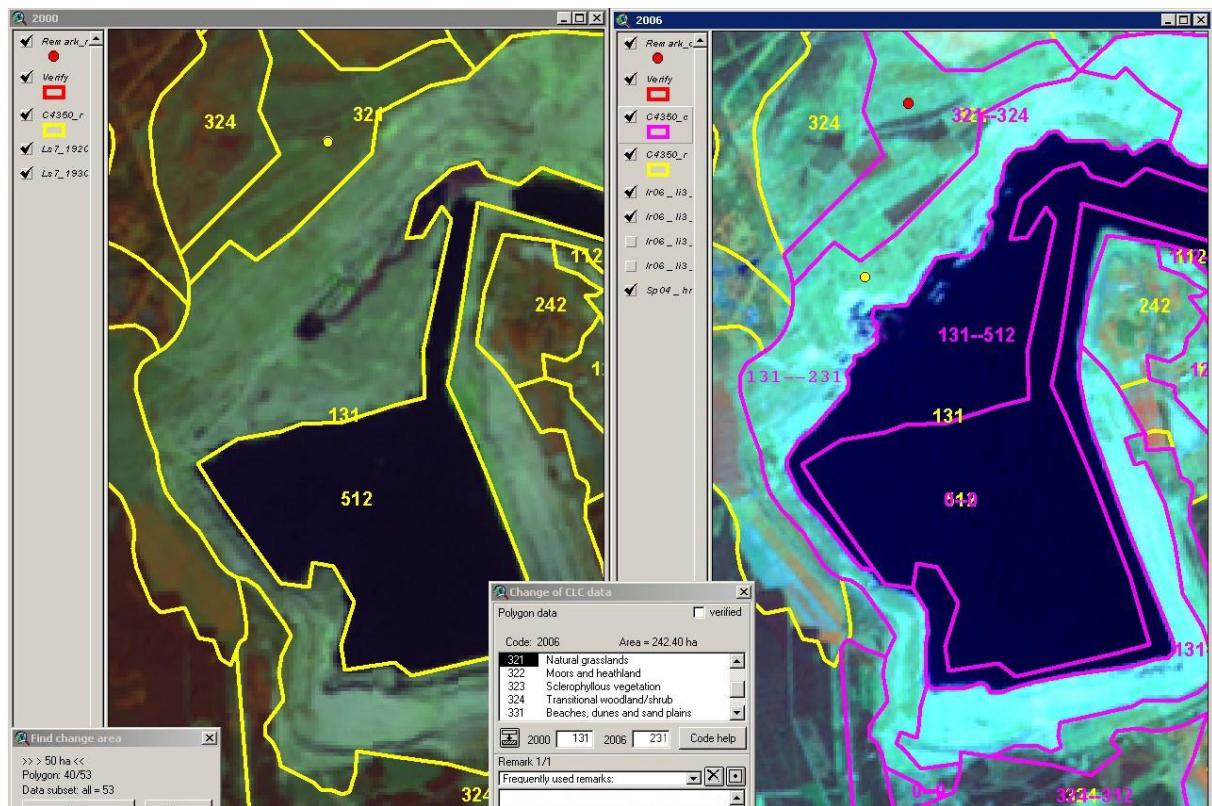


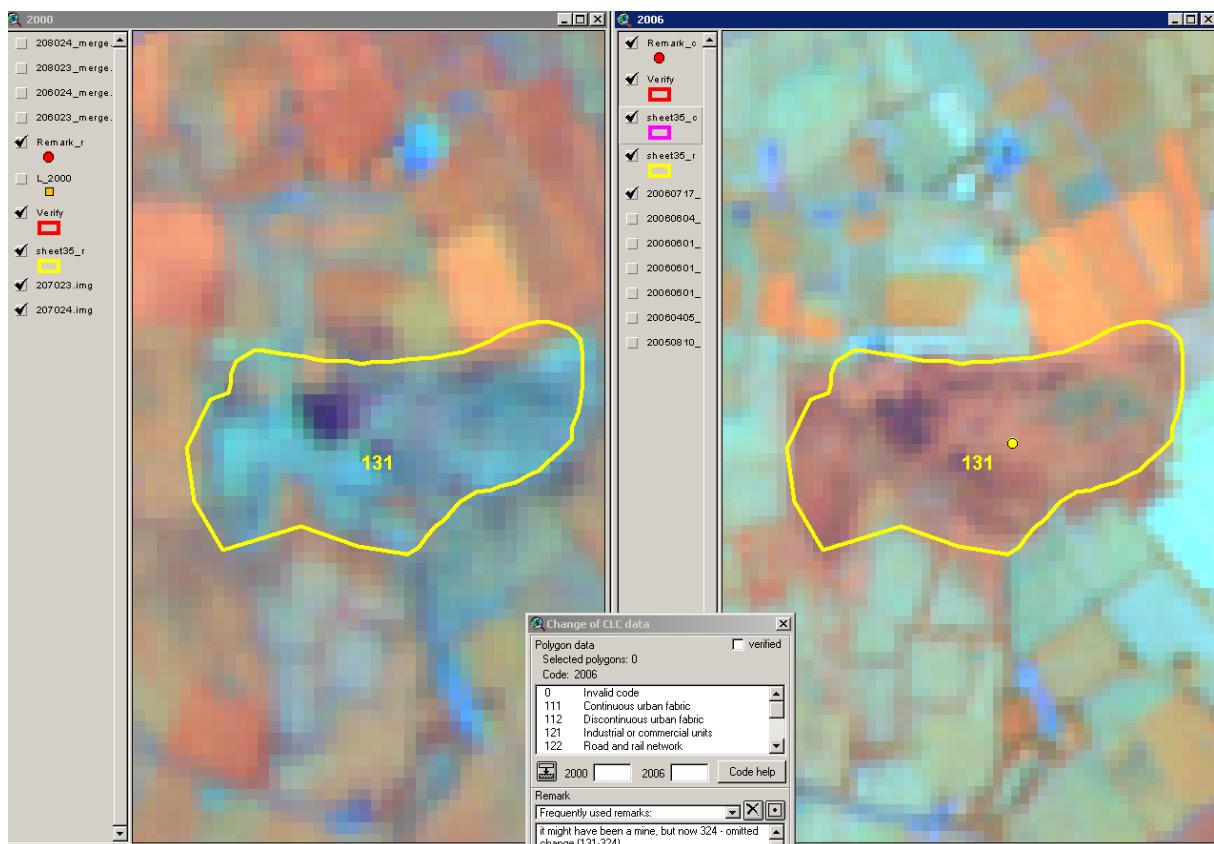
IMAGE1990 (left) shows a large mineral extraction area north from the agricultural landscape. Large part of the mineral extraction site was reclaimed by 2000, as shown by IMAGE2000 (right). The change with largest area is coded as 131-231. (The polygon in the west is 131-242, while the one in the east is 131-324). There are 235 polygons of the 132-231 type covering 0.11 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Type: Mineral extraction site converted to water body: 131-512
Interpretation example (Germany):

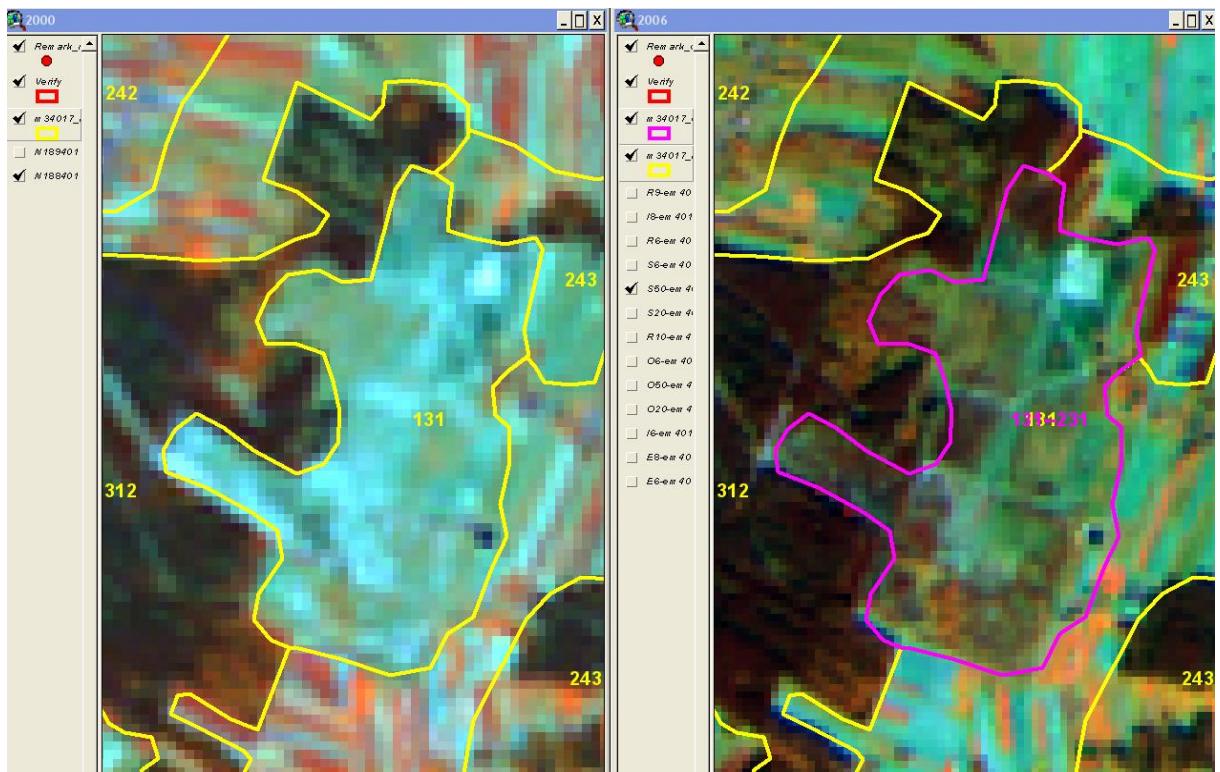


The open-pit mine in 2000 (left) lost parts of its area by two processes: enlargement of an already existing lake (131-512), and reclamation by grass (131-231). There are 191 polygons of 131-512 type covering 0.1 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

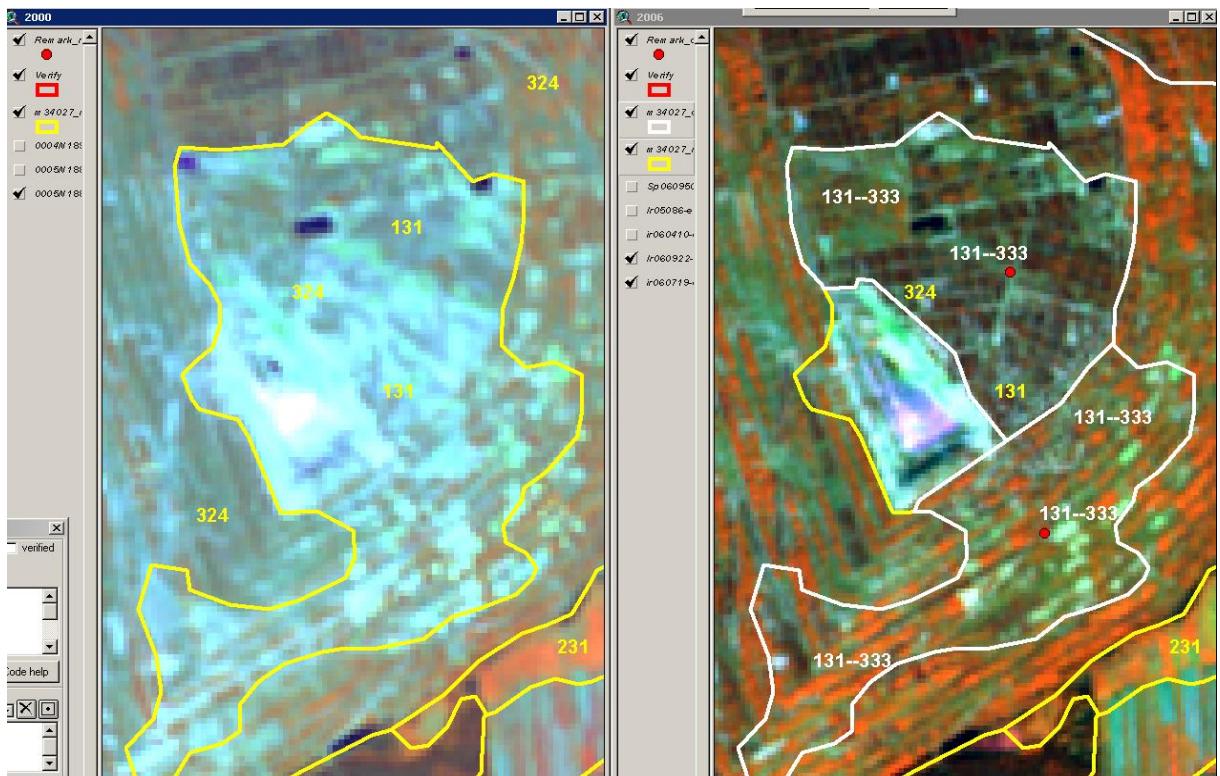
Frequent mistakes: Reclamation of mineral extraction sites	How to avoid the mistakes
Omitted mapping of reclamation process	All 131 polygons in the parent stock layer have to be examined if the mineral extraction site is still active. Special care should be paid to mineral extraction from lakes (e.g. gravel); if the mining activity is finished the area usually should be mapped as water body (512).
False changes applied for mapping of the reclamation process	<p>The next general rules are to be followed:</p> <ul style="list-style-type: none"> • 131-211 or 131-231 is a common process in case of reclamation of "non-toxic" extraction sites (e.g. gravel, sand). • In case of reclamation by grass use 131-231. Do not use 131-321, because this grass is artificial, under human impact. (Only exceptions are nature reconstruction processes, typical in e.g. NL) • Use 131-324 for any kind of reclamation by afforestation, even if trees are very small (high resolution images is useful to confirm plantation). • 131-333: use this in exceptional case only, if the mine is abandoned and no formal reclamation by grass or afforestation took place; i.e. reclamation is going as a natural process.



Mistake: missing mine reclamation. The mineral extraction site was active in 2000 (right), as indicated by the light colours. In 2006 (right) the site does not seem to be active mineral any more. Based on colour we can conclude that forest plantation was used for reclamation (131-324).



Mistake: The 131-231 code pair was used for characterizing the process, meaning reclamation of mineral extraction site (left) with grass. However, IMAGE2006 (right) indicates that reclamation was done by forest plantation. This is confirmed by colours, which are similar to neighbouring coniferous forest. Therefore the right process is 131-324.

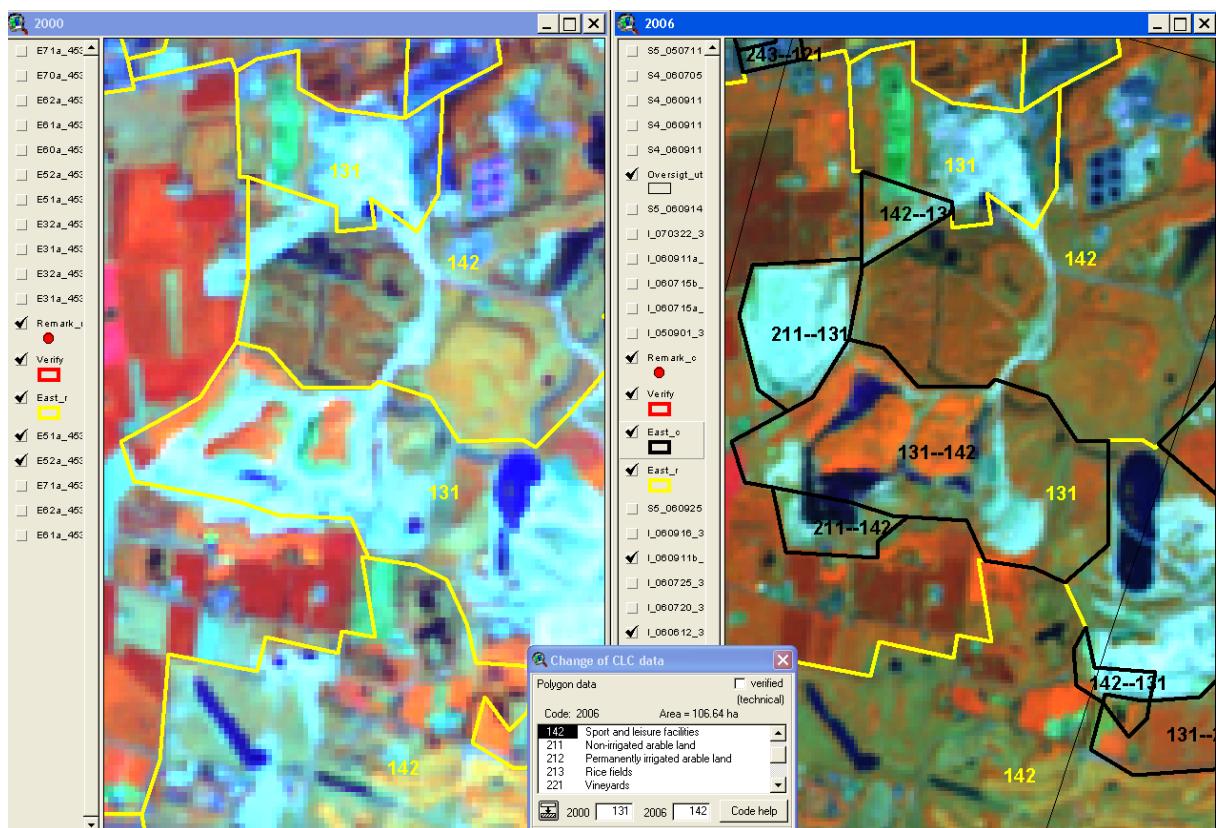


Mistake: Reclamation of a mineral extraction site (left, IMAGE2000) by afforestation (right, IMAGE-2006) wrongly mapped as 131-333. Rows of newly planted trees are clearly visible on 2006 image. Note that change polygon in the south is false, rows of forest plantation are visible already in 2000, therefore should have been mapped as correction of the old stock layer (CLC2000).

Particularity-1:

Type: Mineral extraction site reclaimed as (transformed to) sport and recreation facility:
131-142

Interpretation example (Denmark):



A mining area shown on IMAGE2000 (left) was transformed to sport and recreation area (IMAGE2006, right), as continuation of existing 142 establishments (golf courses and additional infrastructure) in the north and in the south. There are 16 polygons of this type covering 0.01 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Particularity-2:

Type: Mineral extraction sites converted to arable land: 131-211

Interpretation example (Germany):

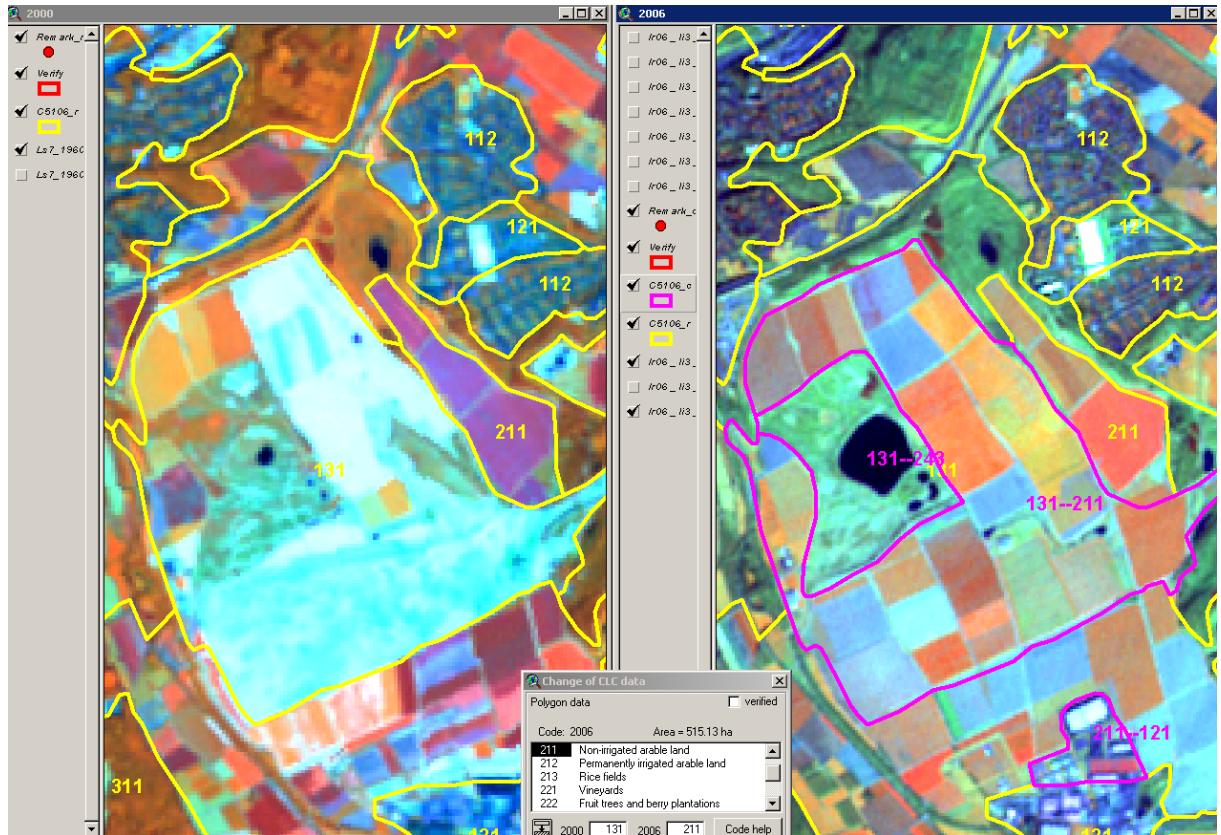
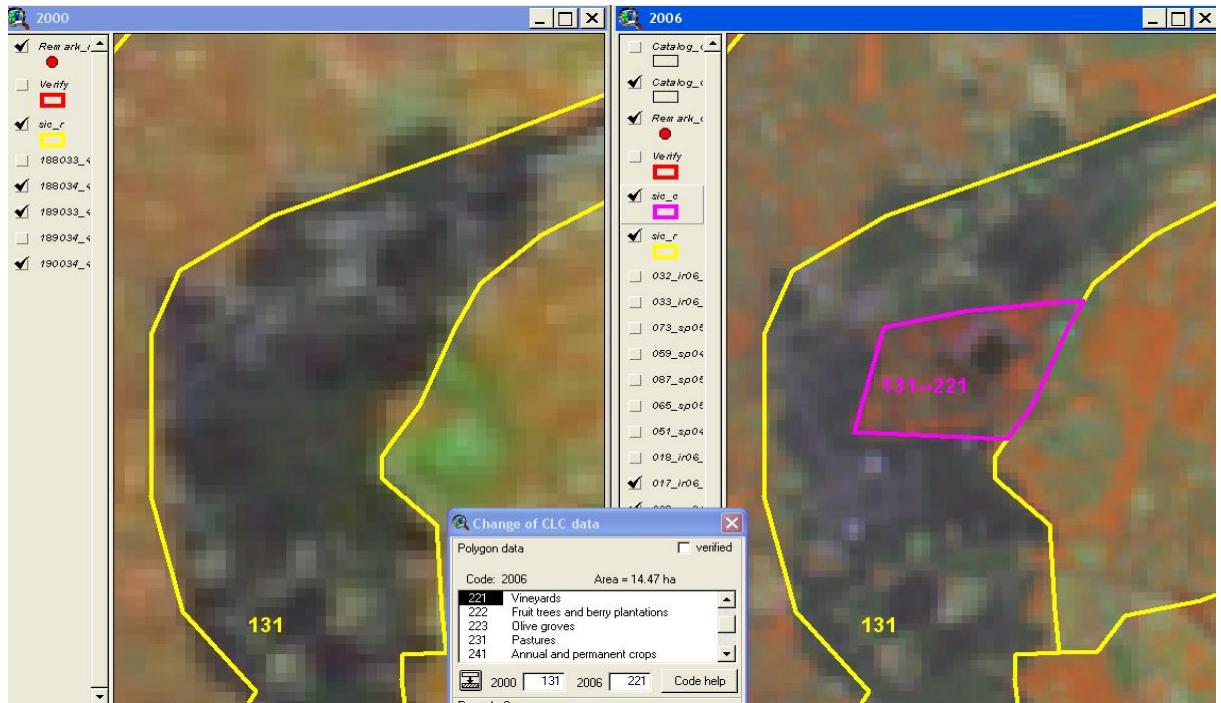


IMAGE2000 (left) shows a mining area in 2000 (see north-west part). According to IMAGE2006 (right) the mine has been reclaimed and a large new arable land was created. The field structure inside the mapped 131-211 polygon is similar to that east and south from the polygon. Reclamation with arable land suggests that mine used to produce non-toxic material. (Mistake: note, that there is a slight overestimation of the change area, in north-west corner of the change polygon the area was reclaimed as 211 already in 2000.) There are 164 polygons of this type covering 0.06 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Particularity-3:

Type: Mineral extraction sites converted to vineyard: 131-221

Interpretation example (Italy):

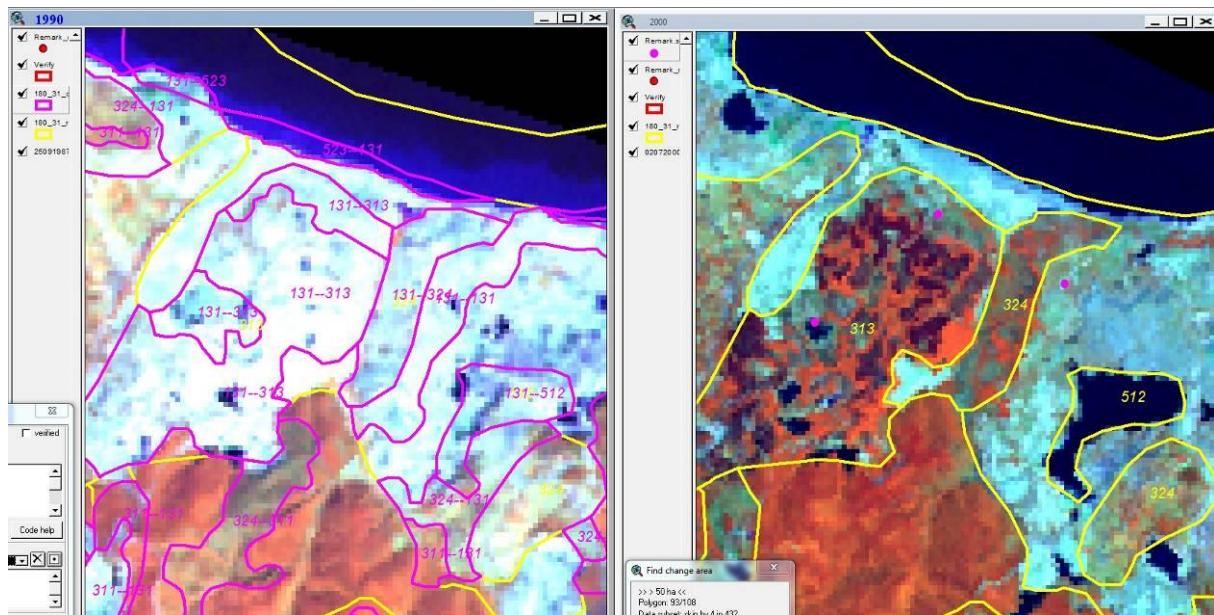


Part of a mineral extraction site (probably quarry) shown by IMAGE2000 was transformed to vineyard, the same land cover as that of the surrounding site (IMAGE2006). Similarly to the previous example, reclamation with agricultural land use suggests that mine used to produce non-toxic material. There are 3 polygons of this type covering 0.00 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Particularity-4:

Type: New forest on mineral extraction sites: 131-313

Interpretation example (Turkey):

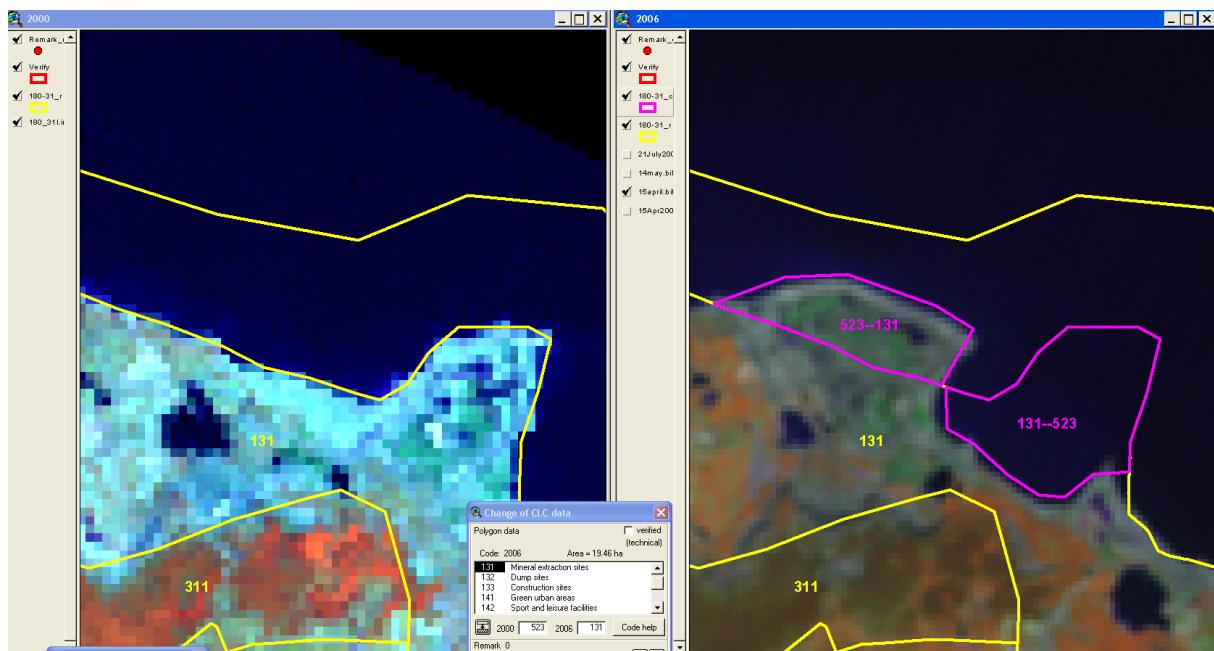


If the time lapsed between two CLC inventories is long or fast growing tree species are planted to reclaim the mine a mature forest might be observed on the former mine area. Left image was made in 1987, while right image was made in 2000. A large mixed forest replaced the former mineral extraction site (131-313). There is 1 polygon of this type covering 0.00 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Particularity-5:

Type: Mineral extraction sites reclaimed by inundation with seawater: 131-523

Interpretation example (Turkey):



In 2000 (left) mineral extraction site (quarry) is seen on the coast. In 2006 (right) we see reclamation by inundation with seawater coded 131-523, as well as a new mining area 523-131. Evidence of conventional reclamation is also visible as vegetated area (not mapped) in the southeast. There are 3 polygons of the 131-523 type covering 0.00 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

3 MOST FREQUENT CHANGES OF THE AGRICULTURE CLASSES

3.1 URBAN-INDUSTRIAL SPRAWL ON AGRICULTURE LAND

Change process: Urban-industrial sprawl on agriculture land: 211/231/242/243-112, 211/231/242-121, 211/231/242/243-133, 211-122

Overview and rationale:

Modern society continuously requires new residential areas, new industrial facilities and new transport infrastructures. Most frequently urban sprawl occupies agricultural area, surrounding existing settlements (green-field investments). This process results loss of (usually valuable) agricultural land. New highways and high-speed train lines connecting settlements also contribute to this loss.

Number of changes in European CLC-Change: 26453 polygons

Area of changes in European CLC-Change: 5.47 % of all change areas

Type: New residential areas on arable land and agricultural mosaic: 211/242-112

Interpretation example (the Netherlands):

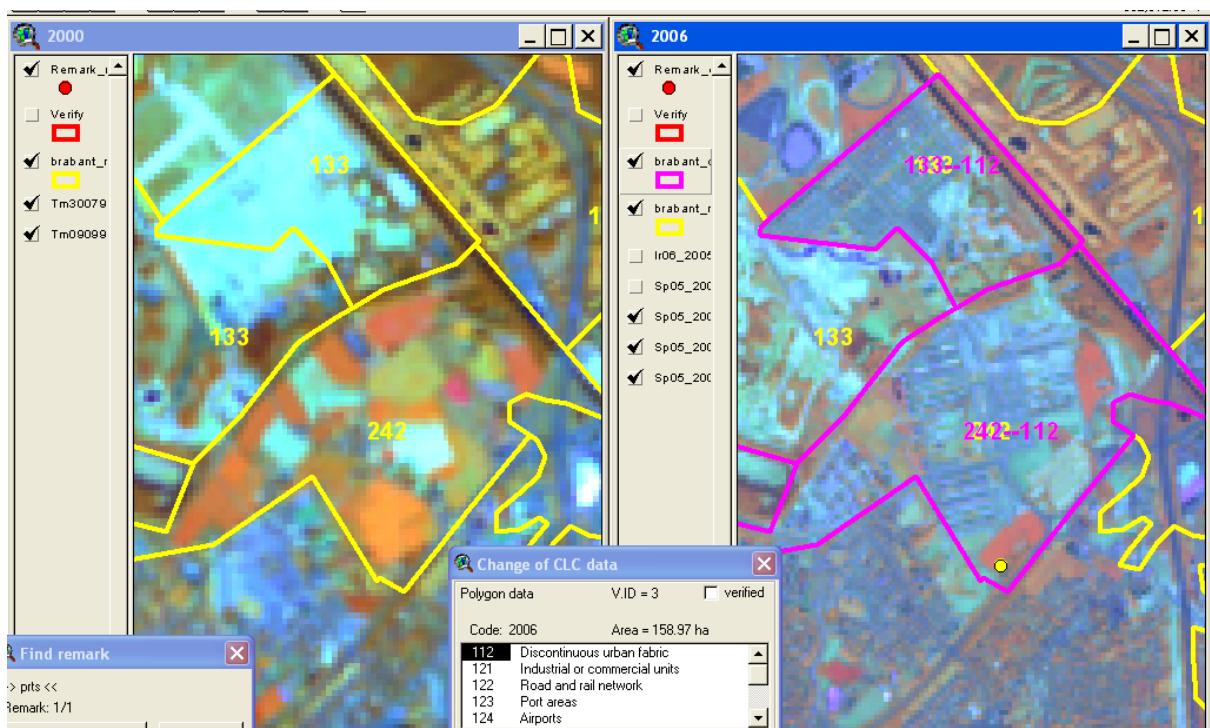
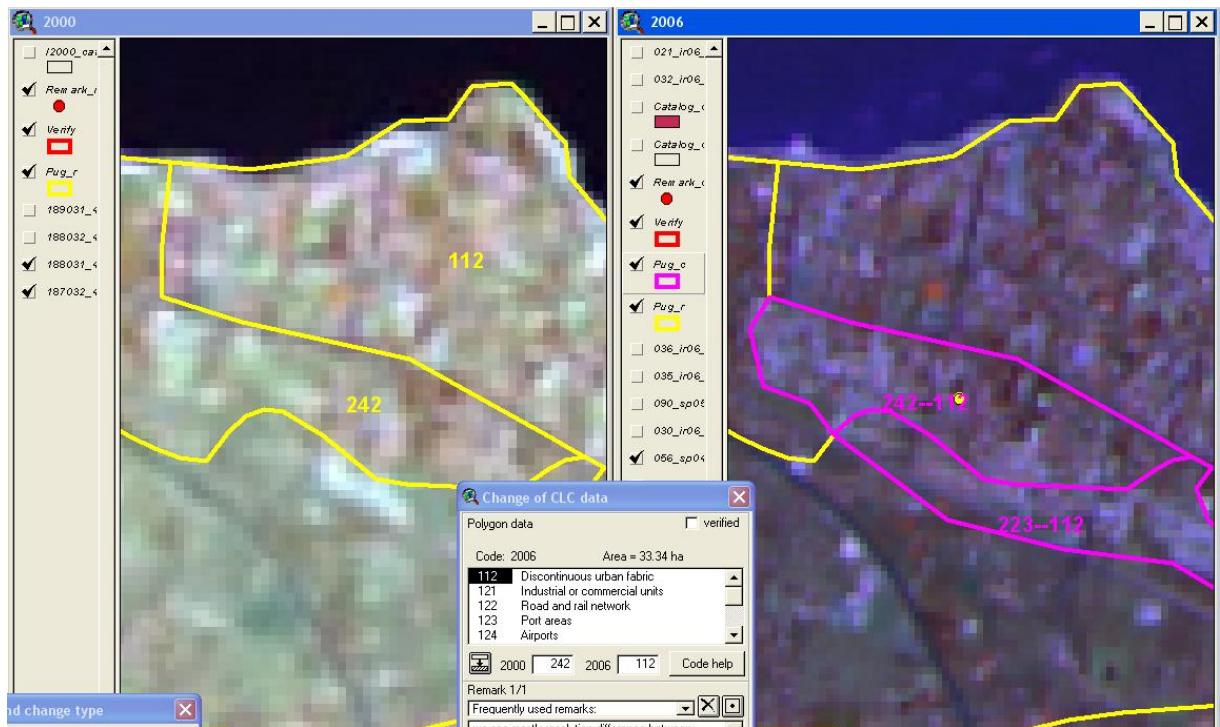
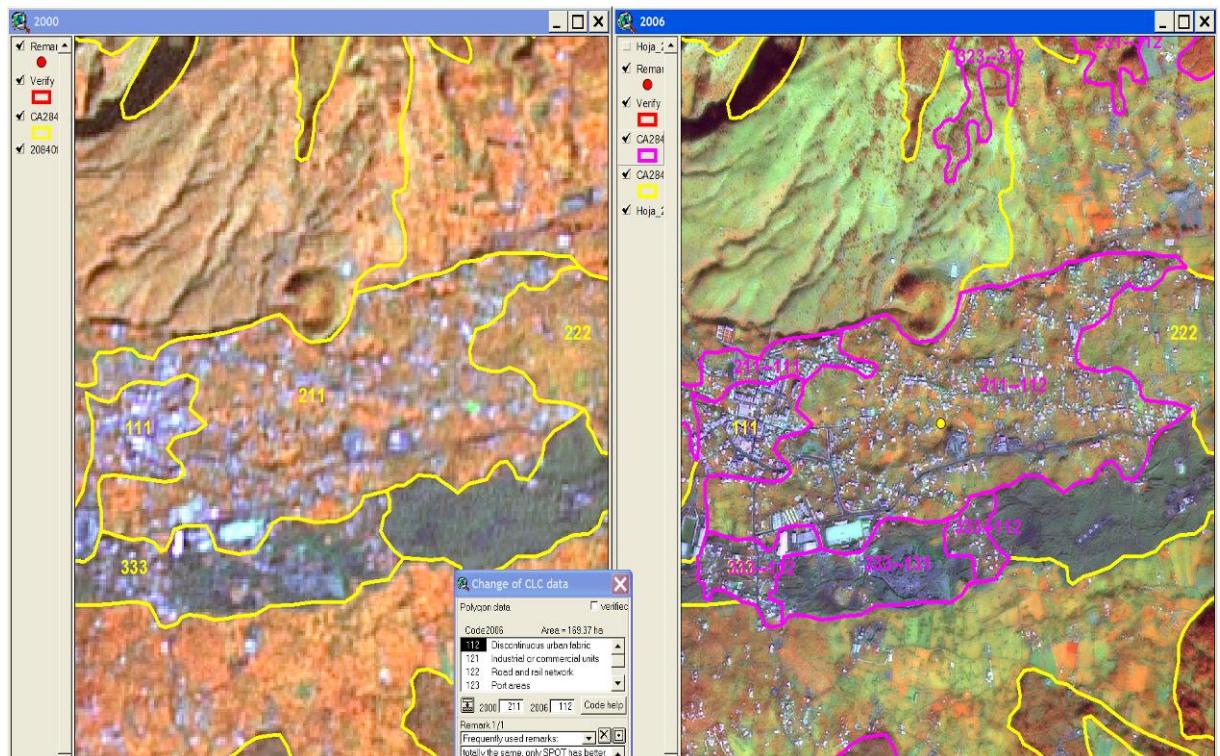


IMAGE2000 (left) shows an agricultural mosaic (242) on the edge of an urban area. Red colour indicates arable land fields with green crops, light-blue fields indicate bare soil (recently ploughed/sown), while green colour indicates pasture. IMAGE2006 (right) shows that the agricultural area has disappeared and been turned to discontinuous urban fabric (242-112). This change is typical of edges of larger settlements, where agricultural land is usually characterized by multiple uses, coded as 242. There are 3386 polygons of the 242-112 type covering 0.72 % of all changes in CLC-Change2000-2006 Europe database. There are 5983 polygons of 211-112 type covering 0.98 % of all changes in CLC-Change2000-2006 Europe database (no example here).

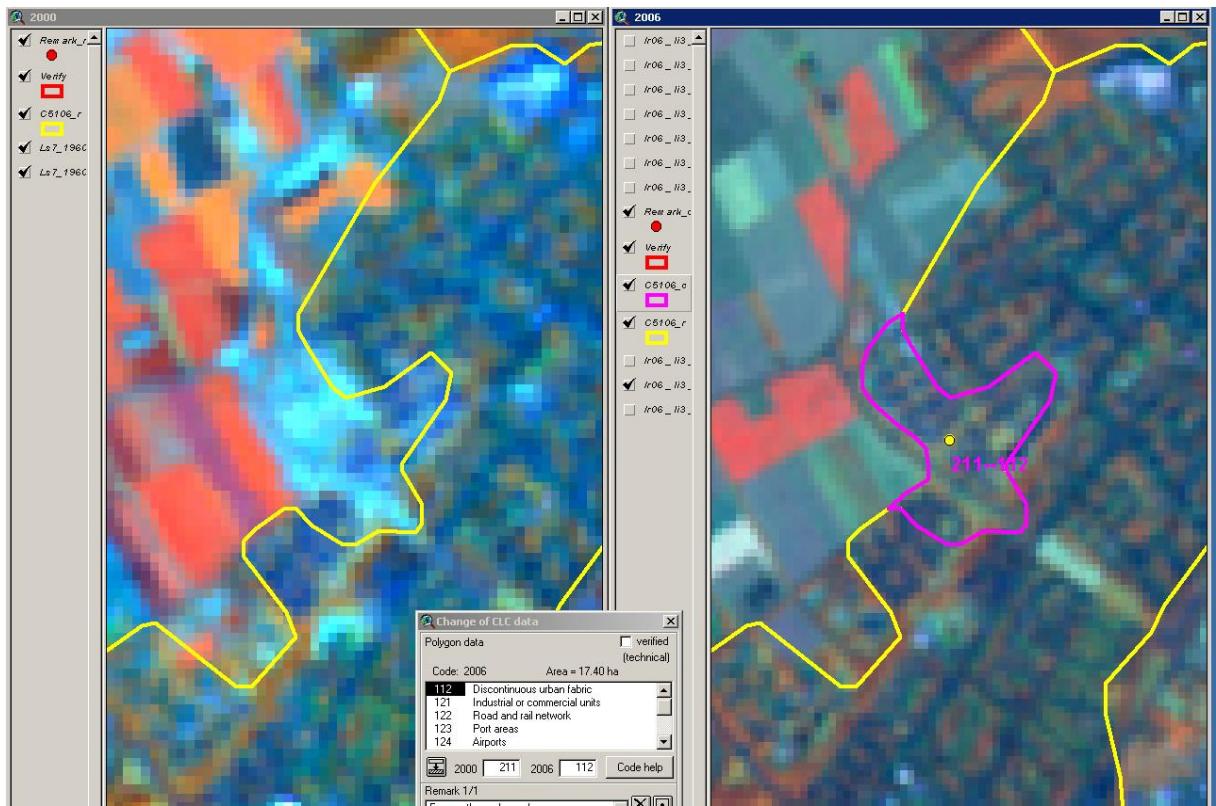
Frequent mistakes: New residential area on arable land and agricultural mosaic	How to avoid the mistake
Omitted change associated to a 211/231/242/243 polygon	In the parent stock layer, all 211/231/242/243 polygons at least around larger settlements have to be examined if any new residential areas (> 5 ha) have emerged there.
False change associated to 242 polygons due to differences in image resolution.	242 class is often used to characterize agriculture areas with scattered houses. Try not to be confused by image resolution differences. On e.g. SPOT XI imagery houses are much better recognizable than on Landsat TM. 242-112 change is true if the percentage of houses has increased to above 30% during the period, the houses are closer to each other than 300 m and the agriculture activity is not dominant anymore. VHR imagery helps the correct interpretation of recent status.
Wrong change code pair because of omitted construction in parent stock layer.	If a construction is visible on parent stock layer, the right change code pair is not 211/231/242/243-11x, but 133-11x.
Wrong change code pair because of misclassification of construction site (133) as residential area (112) in the new stock layer.	If the construction has not reached its final status yet (lots of earth work is visible, no street structure and green areas among houses), the right change code is not 211/242-11x, but 211/231/242/243-133.
Wrong change code pair or missing change due to using not the latest image. Construction of residential areas can proceed quickly. If not the latest available image was used, it might result false changes (e.g. 211-133 instead of 211-112) or missing changes.	Check and use the latest available satellite image.



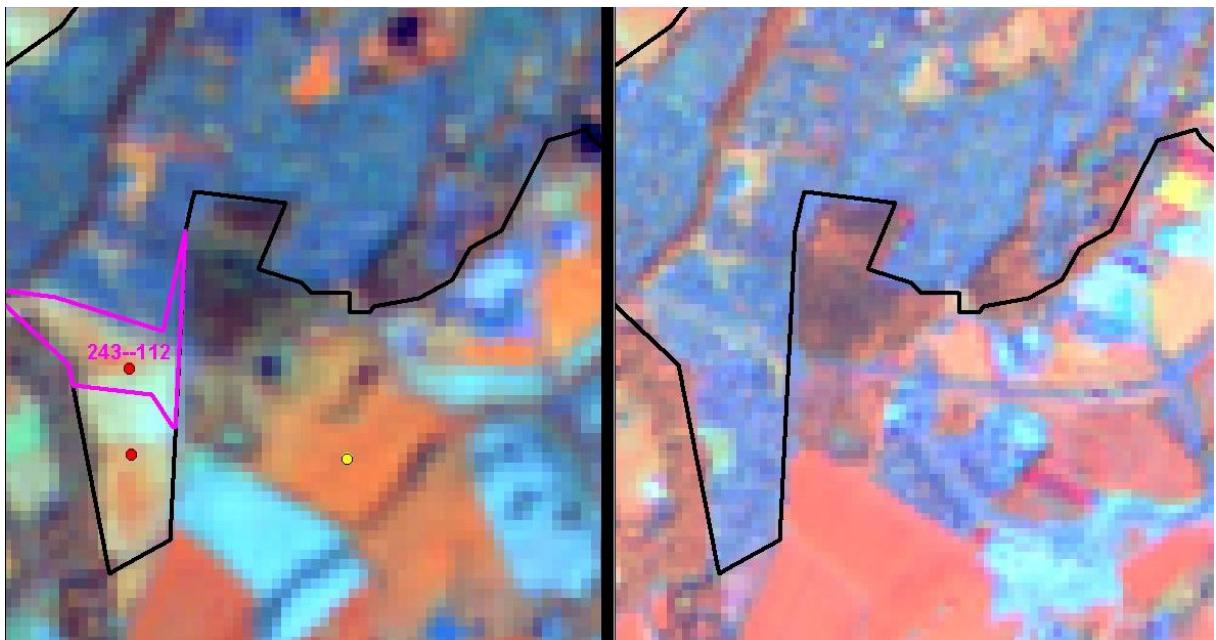
Mistake in mapping 242-112. IMAGE2000 (left) was taken by Landsat TM sensor (30 m pixels), while IMAGE2006 (right) was taken by SPOT satellite (20 m pixels). Although there are large colour differences between the two images, there is hardly any difference between the structures of the area (same houses, green areas). The 242-112 polygon outlined over IMAGE2006 is therefore false, so the area should be corrected to 112 in CLC2000 instead of mapping a change.



Mistake in mapping 211-112. IMAGE2000 (left) was taken by Landsat TM sensor (30 m pixels), while IMAGE2006 (right) was taken by SPOT-5 satellite (2.5 m pixels). No change occurred between 2000 and 2006, we see only resolution differences. The area includes several buildings with agriculture between the houses. It is hardly possible to consistently divide the area into residential and agriculture patches based on the 25 ha MMU. The solution would be mapping most of the area as 242 and interpreting no change.

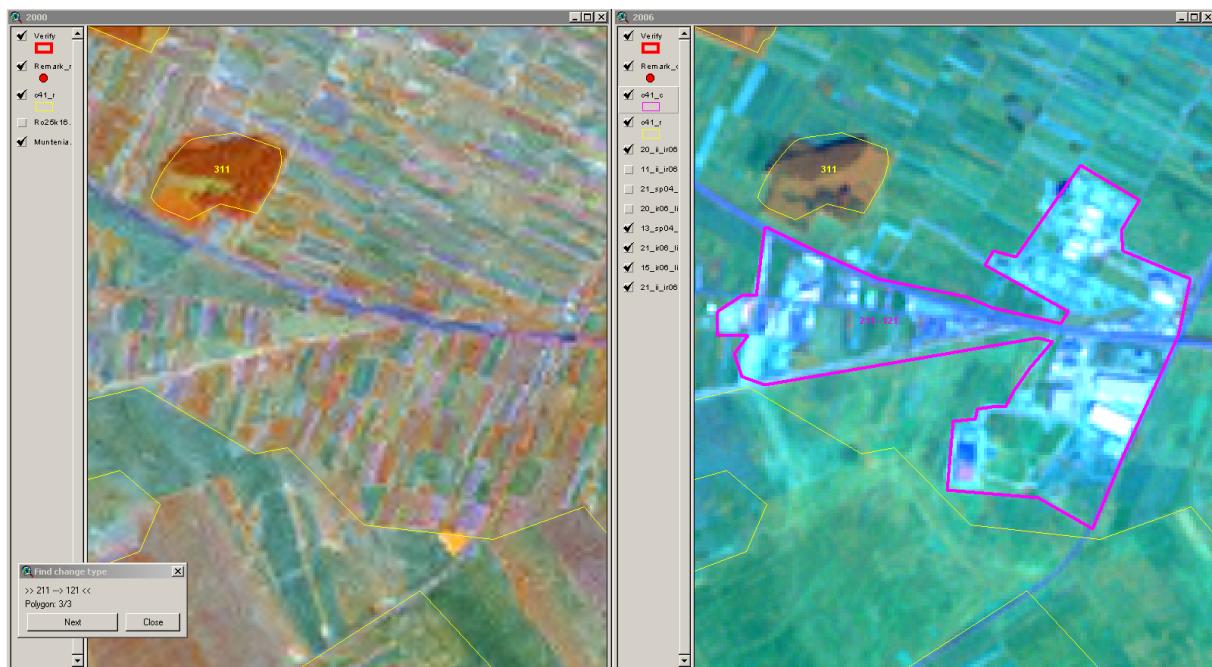


Mistake: IMAGE2000 shows that construction (left, whitish blue area in the centre) was going on already in 2000 in the area indicated as 211-112 change. IMAGE2006 (right) shows that the residential area has increased. The real change process here is 133-112. (The construction area should have been generalized to 112 in CLC2000, because it was smaller than 25 ha.)



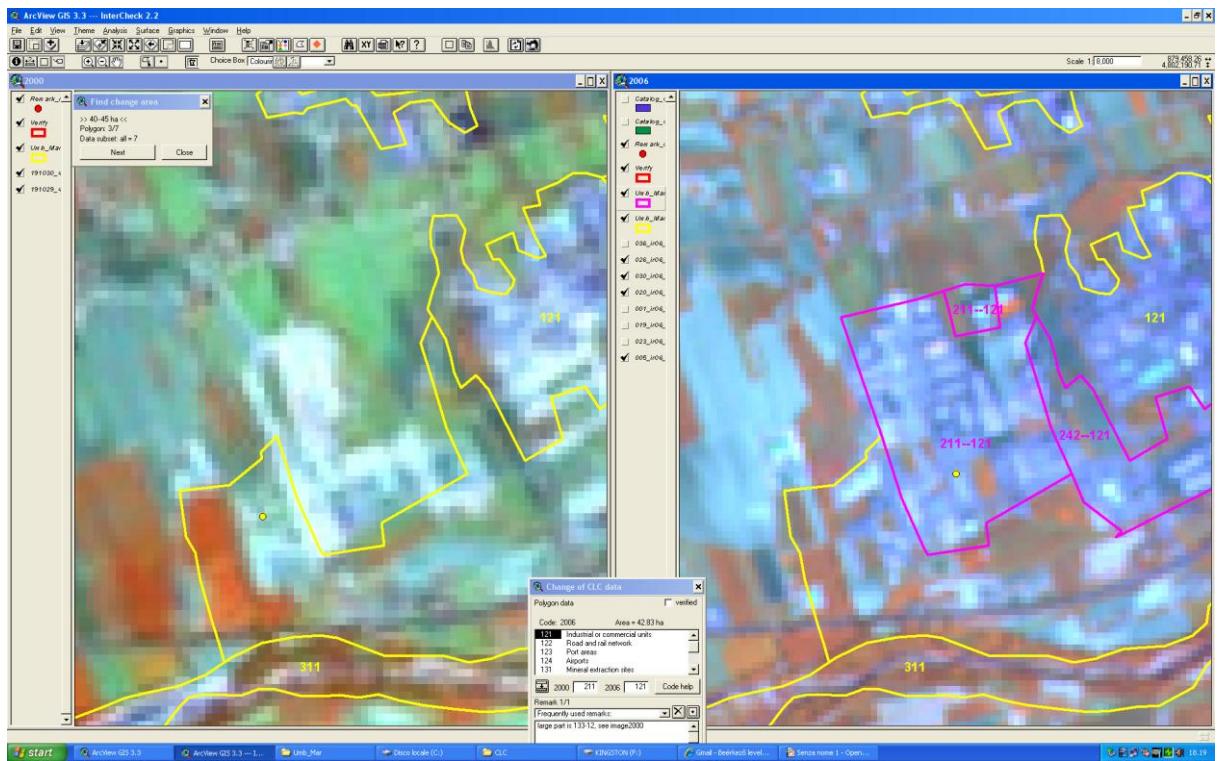
Mistake: Missing urban sprawl on arable land. IMAGE2000 (left) shows a suburban area. Red and yellow dots indicate arable land areas that have been built up by 2006 (see IMAGE2006, right). As the 243-112 polygon is correct, we claim that the source material used by the national team was not up-to-date, i.e. it did not contain areas built up later in time. (See also Ch. 6.4.)

Type: New industrial area on arable land: 211-121
Interpretation example (Romania):



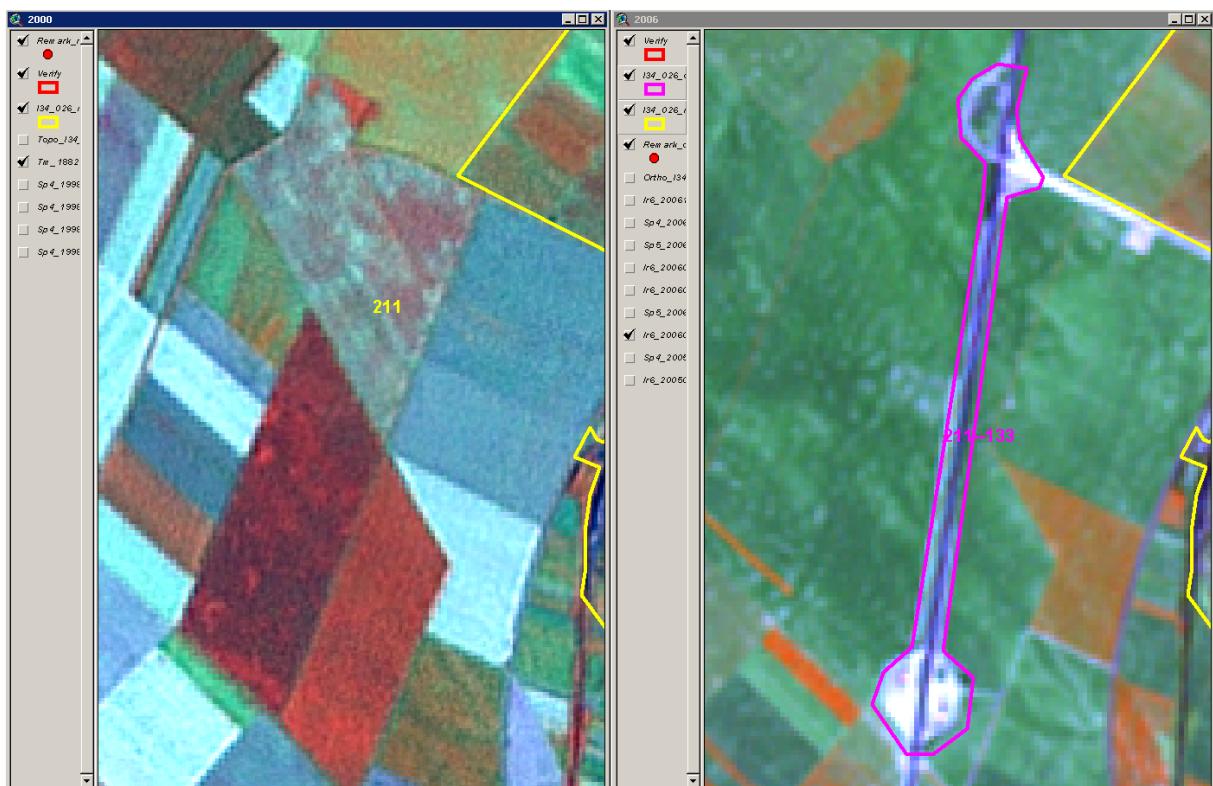
Arable land area shown by IMAGE2000 (left) was converted into industry, as indicated by IMAGE2006 (right). Notice the large size of industrial buildings (compared to the usually small size of residential structures). There are 4031 polygons of this type covering 0.81 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Frequent mistakes:	How to avoid the mistake
Industrial sprawl on agriculture land	
Omitted change associated to 211/231/242/243 polygons	In the parent stock layer, all 211/231/242/243 polygons at least around larger settlements have to be examined if any new industrial areas (> 5 ha) have emerged there. Note that new industrial areas might appear far from settlements, too. All road / rail constructions should be mapped if wider than 100 meters.
Wrong change code pair due to misclassification of industry (121) as construction site (133) in the new stock layer.	If the new installation has not yet reached its final status (lots of earthwork is visible), the right change is 211/231/242/243 -133 and not 211/231/242/243.
Wrong change code pair due to omitted construction in parent stock layer.	Check if there is a non-mapped (omitted) construction site (133) coded as agriculture in parent stock layer . If this is the case, map 133-12x instead of 211/231/242/243-12x.
Wrong change code pair or missing change due to using not the latest image. Construction of industrial / transport units can proceed quickly. If not the latest available image was used, it might result wrongly coded (e.g. 211-133 instead of 211-121) or omitted changes.	Check and use the latest available satellite image.



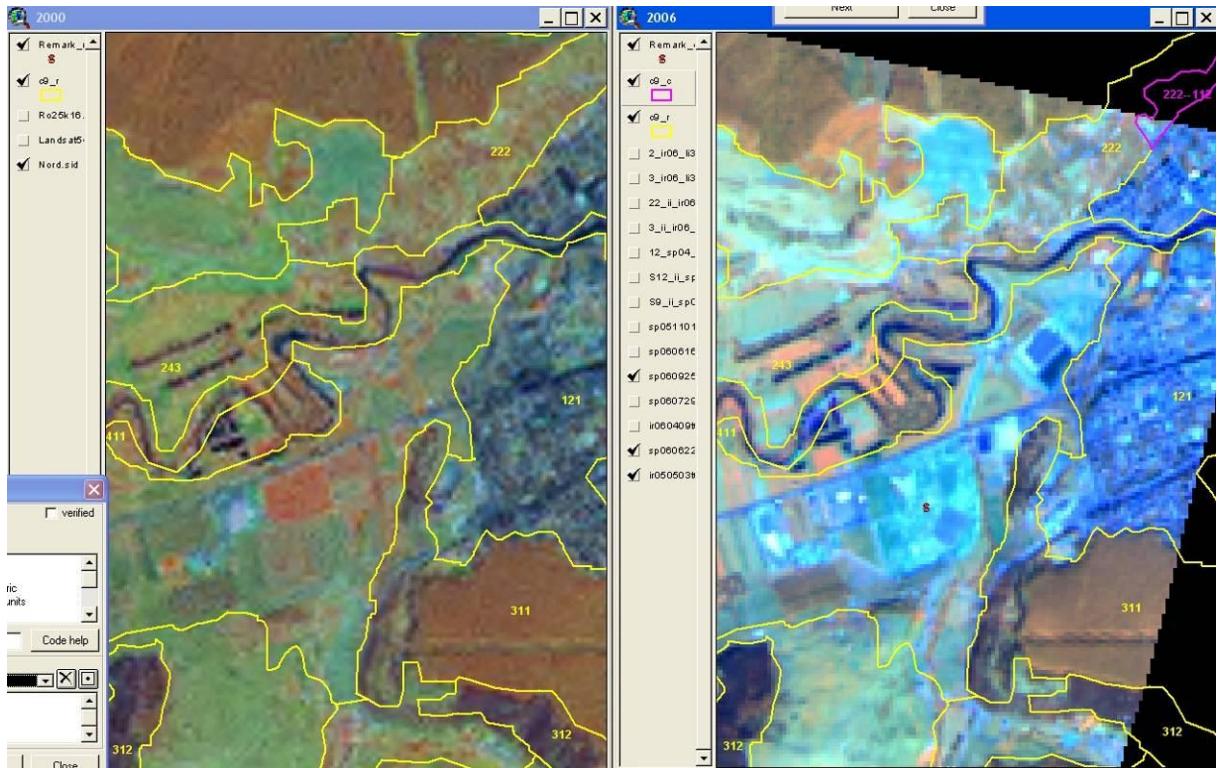
Mistake in mapping 211-121. IMAGE2000 shows that construction was going on on large part of the area indicated as change (left, white area in the centre). IMAGE2006 (on right) shows that the former industrial area has significantly increased. Real changes here are 133-121 in most of the polygon and 211-121 in smaller (north) part of the polygon. Note that the industrial area is even larger than indicated: Around the yellow dot (on left) there is another missing 133-121 polygon. This example also highlights the importance of the correction of the parent stock layer.

Type: New construction on arable land: 211-133
Interpretation example (Hungary):

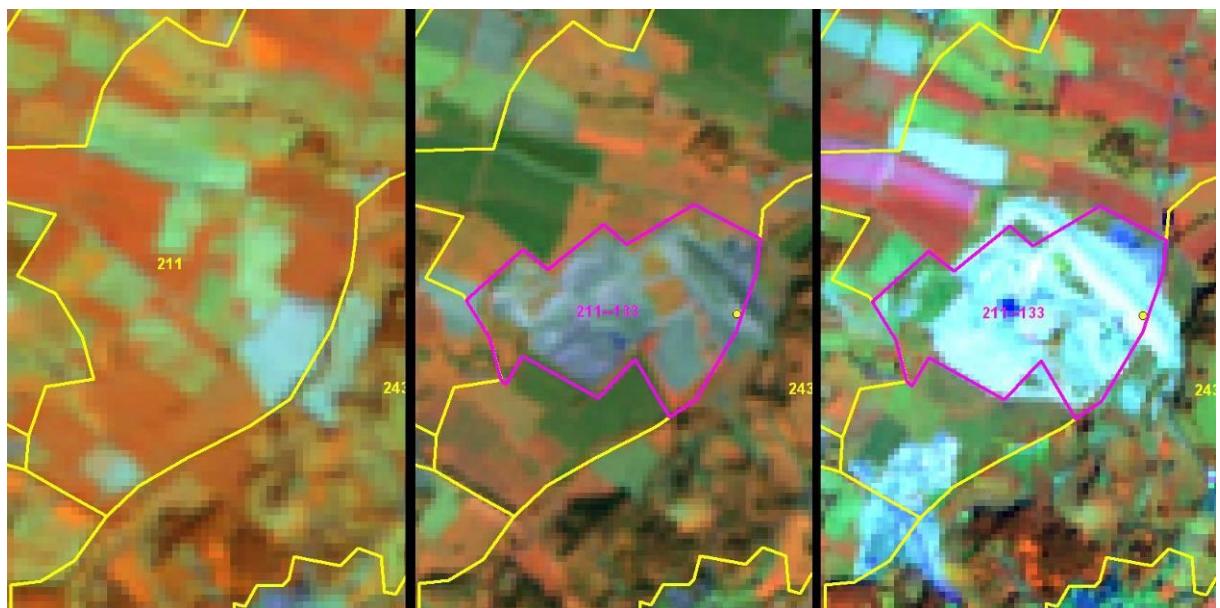


Change 211-133 means that arable land on IMAGE2000 (left side, parcels are in different status of maturity) has been turned into artificial surface. In 2006 (right), earthwork and/or construction is visible indicating the construction of a new highway. There are 3528 polygons of this type covering 1.05 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

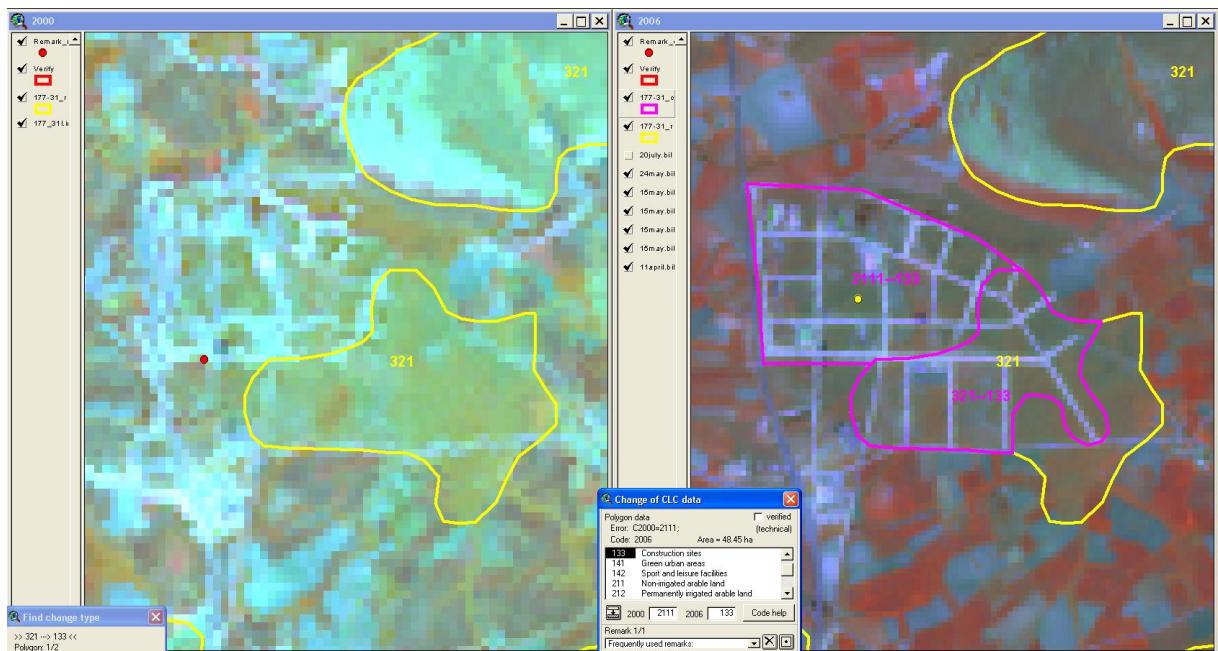
Frequent mistakes:	How to avoid the mistake
Construction on agriculture land	
Omitted mapping of a new construction site.	The entire interpreted area has to be checked at a rough scale (e.g. 1:40.000) in order to recognize any new artificial surface. However, the attribute of this new feature should be checked by in-situ data (except road / rail construction).
Width of change polygon is exaggerated (typical of road / rail constructions).	Map only the real construction area, especially concerning width of the polygon. A slight exaggeration to reach the 100 m minimum width limit is acceptable.
Wrong change code pair or missing change due to using not the latest image. Construction areas can develop quickly. If not the latest available image was used, it might result false changes or improper area coverage.	Check and use the latest available satellite image.
Bright agricultural areas are misinterpreted as construction site.	Use multi-temporal imagery to avoid interpreting temporarily non-vegetated areas as construction site.
Wrong change code pair or false change, due to not the real process being interpreted: e.g. 2xx-112 instead of 2xx-133 or 2xx-133 instead of correction of CLC2000 and no change.	Always the real process should be interpreted. Properly distinguishing construction site from completed built-up area is essential.



Mistake: missing 211-133 change. IMAGE2000 (left) shows an urban fringe zone with agricultural use. On IMAGE2006 (right) we see a large construction area not being mapped because not the latest image was interpreted. Always the latest available satellite image has to be interpreted.



Mistake in mapping construction; not the latest image was used. IMAGE2000 (left) shows an agricultural area (211 and 243). IMAGE2006 taken in July (middle) shows a large construction area, which replaced arable land. This was mapped more or less correctly, apart from a smaller omission around the yellow dot. The other IMAGE2006, taken in September (right) however indicates that the construction continued (to the north and east), and a separate construction site south-west from existing one emerged. In order to properly map construction processes the latest image should be used.

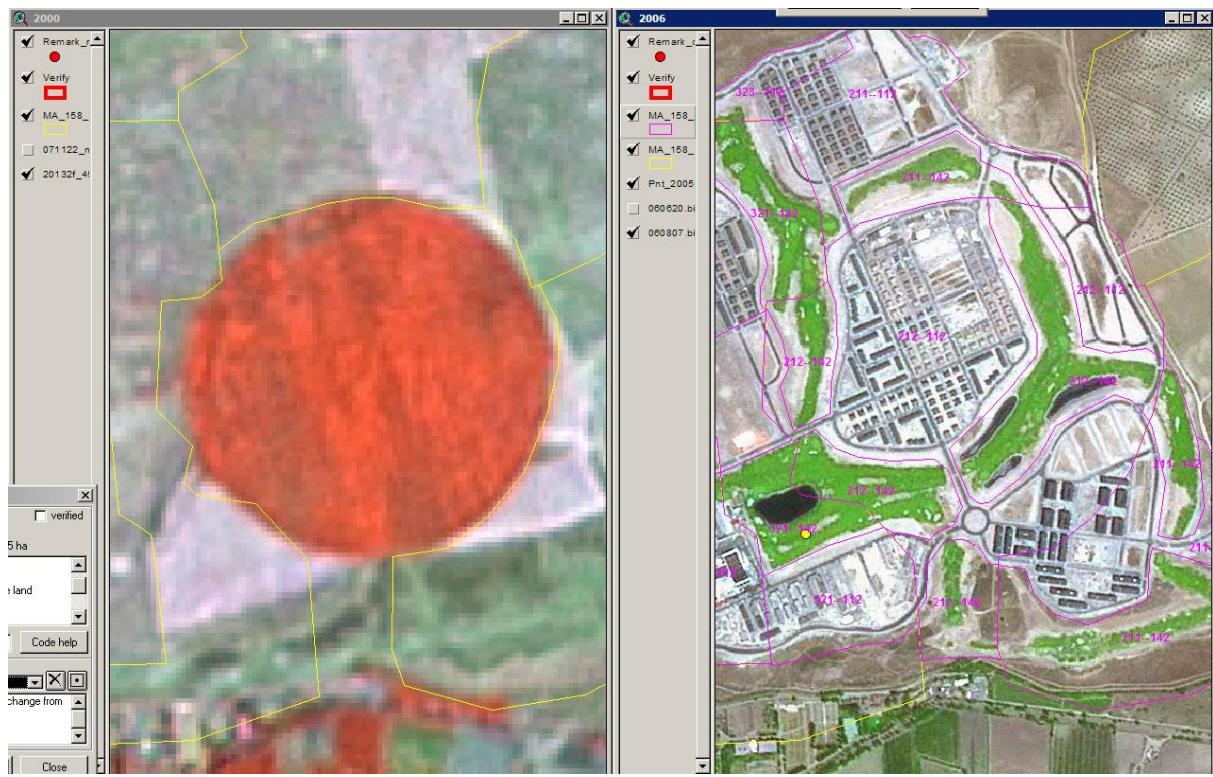


Mistake in mapping a construction process (211-133). IMAGE2000 (left) already shows a large construction area (bright linear structures). IMAGE2006 (right) shows that the construction has been extended to a former natural grassland (321-133 change is correct), and the former construction area is still not completed. IMAGE2006, due to its higher resolution shows the situation more clearly. Consequently 211-133 is not correct and correction of CLC2000 is necessary (133).

Particularity-1:

Type: Establishment of a residential area and golf course (mostly) on irrigated arable land: 212-112 and 212-142

Interpretation example (Spain):

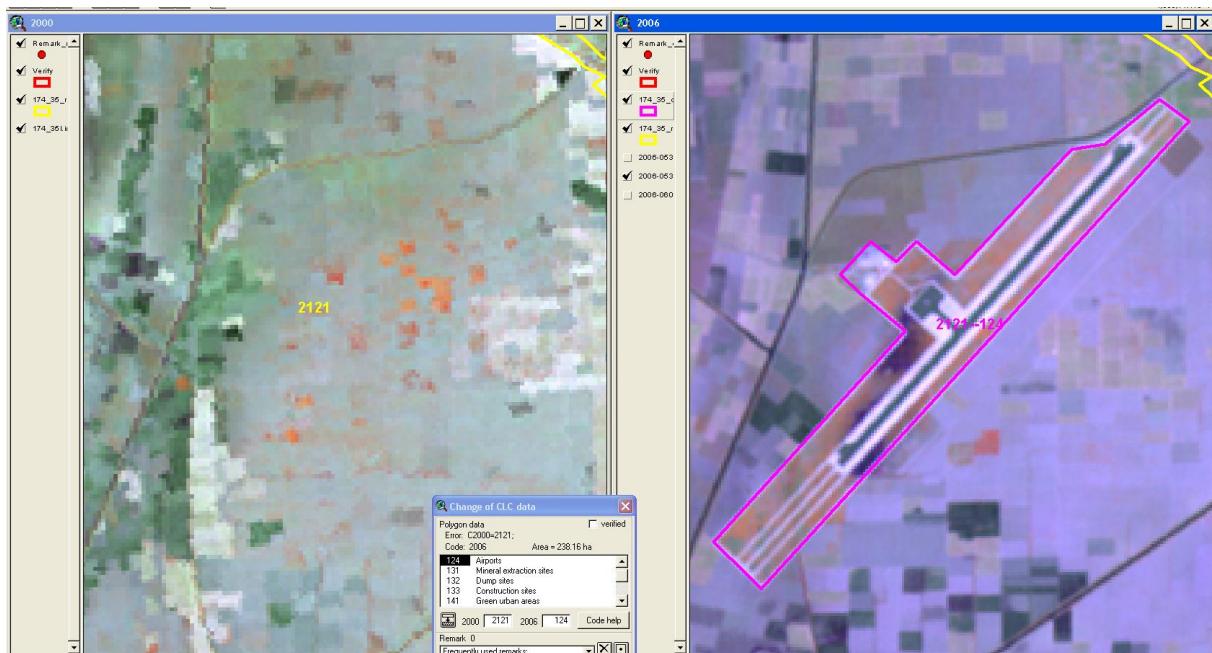


A new residential area with a surrounding golf course has been developed (right, SPOT5 image taken in 2005 with 2.5 m pixel size) and replaced mostly irrigated and some non-irrigated arable land (and also natural grassland) seen on IMAGE2000 (left). (Instead of standard IMAGE2006 Spain used SPOT-5 imagery (multispectral and PAN merge) with pixel size of 2.5 m, taken in 2005.) Mapped changes related to the loss of agricultural land are: 212-112 and 212-142. (Other changes visible on the image – 211-112/142 – are discussed earlier in this chapter.) There are 405 polygons of the 212-112 type covering 0.03 % of all changes, and 33 polygons of 212-142 type covering 0.01% of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Particularity-2:

Type: Construction of a new airport: 212-124

Interpretation example (Turkey):



A new airport has been built (IMAGE2006, right) on irrigated arable land (IMAGE2000, left). There are 6 polygons of this type covering 0.01 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

3.2 NEW MINERAL EXTRACTION AREA ON AGRICULTURE LAND

Change process: New mineral extraction area on agriculture land: 211/231-131

Overview and rationale:

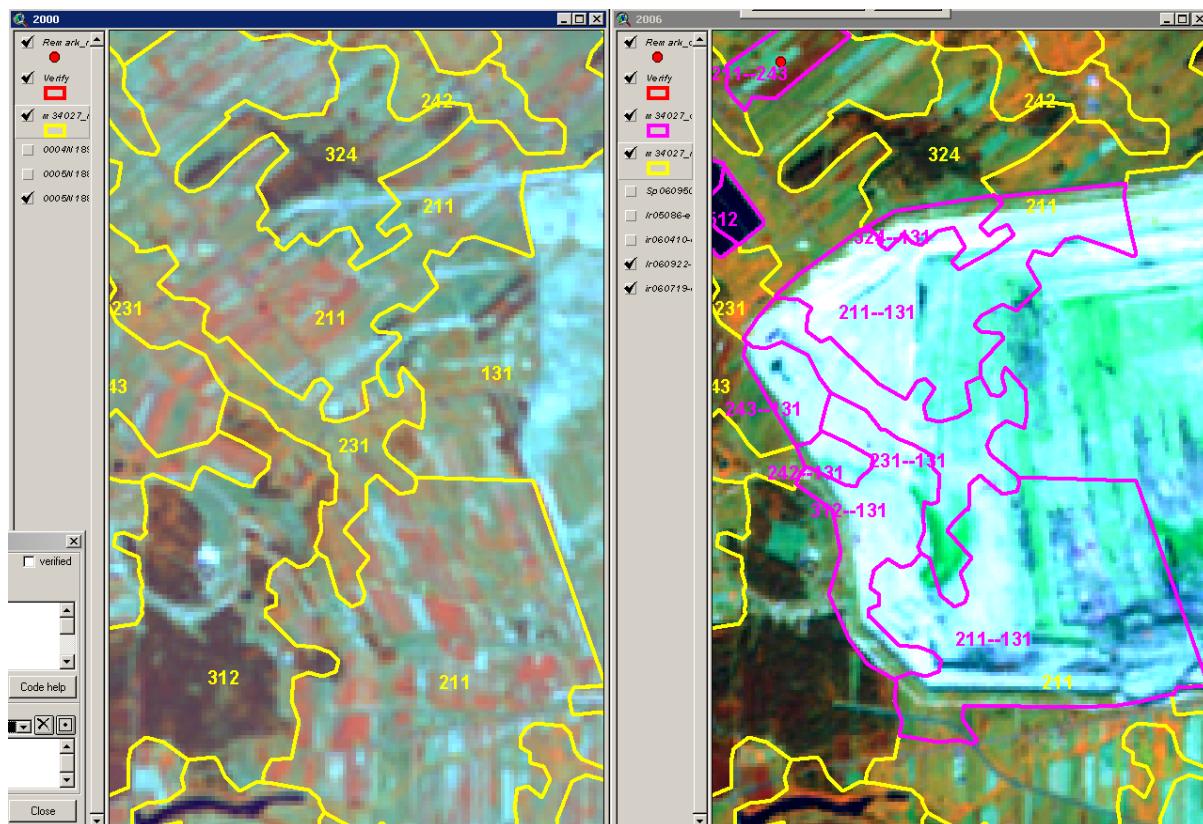
Industry requires raw materials. Establishing a new mineral extraction site usually has high priority over the current land use. Opening new mineral extraction sites means at the same time loss of agriculture land, or forests and other semi-natural areas. Mining can be started even on wetlands, water and built-up areas. Our target here is to discuss new open-pit mines on agriculture land.

Number of changes in European CLC-Change: 2592

Area of changes in European CLC-Change: 0.60%

Type: New mineral extraction area on arable land: 211-131

Interpretation examples (Poland, Hungary):



This dominantly agricultural land in Poland (IMAGE2000, left) has become mostly a mineral extraction site (IMAGE2006, right). Mapped changes related to agricultural area are 211-131 and 231-131. Looking at the 131 polygon on IMAGE2000, one sees that its west side was not yet a mine, but agriculture, similar to its neighbourhood. Probably another image, acquired a few months later in 2000 was also available for the national team, and used to map the mining activity. There are 1980 polygons of the 211-131 type covering 0.48 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database. 231-131 type changes are represented by 612 polygons covering 0.12% of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

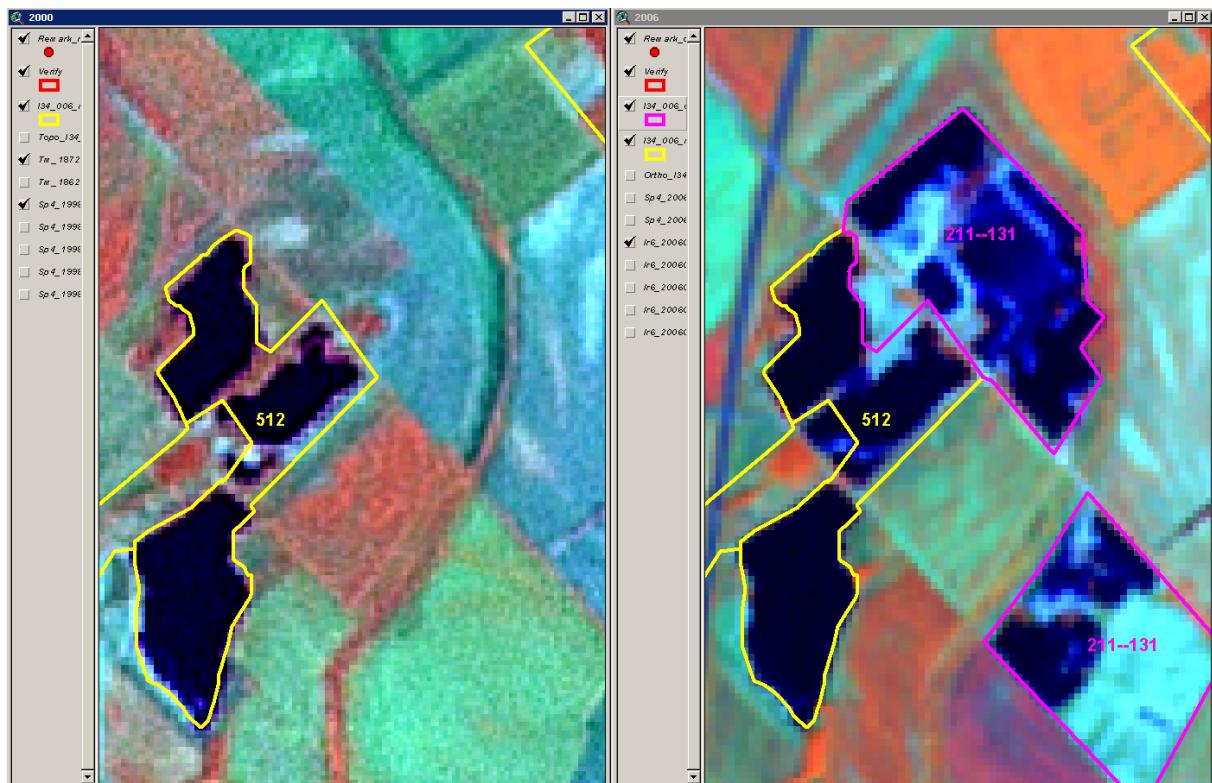
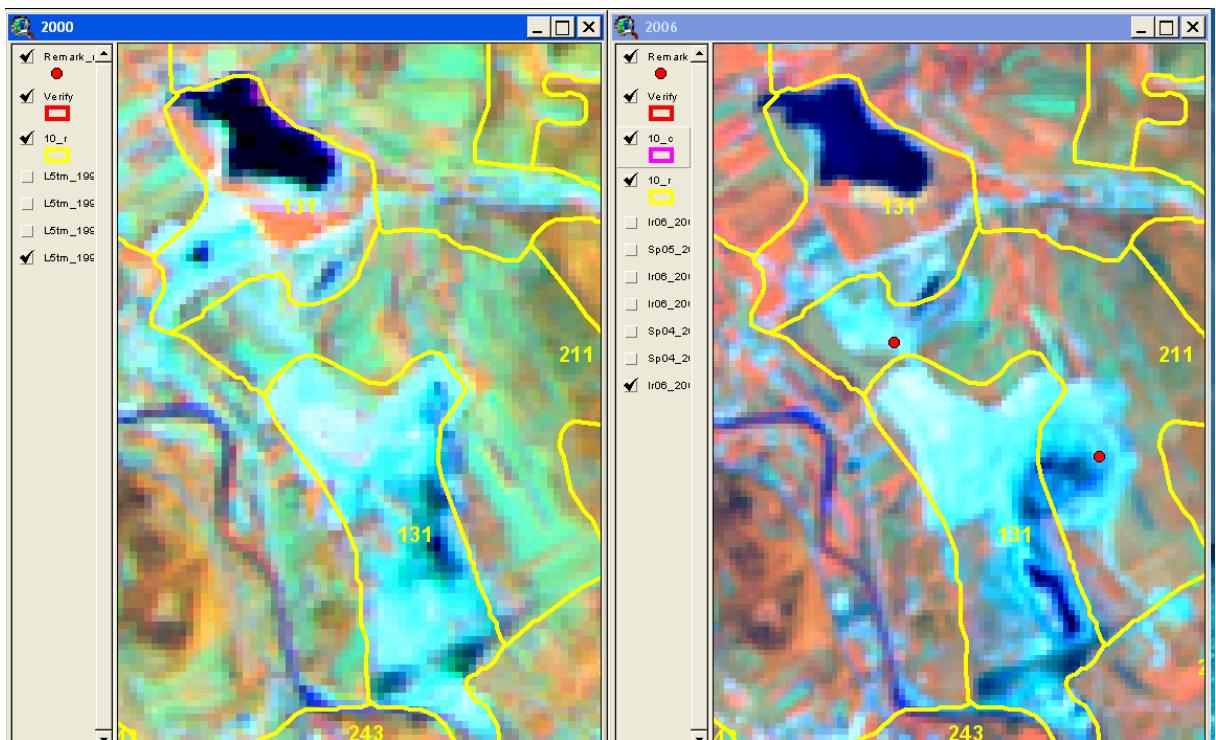


IMAGE2000 (left) shows a former gravel pit in Hungary filled with water, where mineral extraction has finished (no gravel deposits are visible), therefore it is coded as 512. IMAGE2006 (right) shows two new rectangular areas developed on arable land partly filled with water and partly showing extracted raw materials (gravel). These are new mineral extraction sites, thus the right change is 211-131. Water in the mining area is the consequence of high water table. When mineral extraction is finished, these areas usually become lakes with different use: recreation, fish pond, residential area, etc. Therefore when mining activity is finished and water is visible on its place, the right change code is 131-512. [3] There are 1980 polygons of the 211-131 type covering 0.48 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Frequent mistakes:	How to avoid the mistake
New mineral extraction area on agriculture land	
Omitted mapping of enlargement of mineral extraction sites	All 131 polygons in the parent stock layer have to be examined regarding the actual boundaries of the mineral extraction site. Frequently, new sites are opened around existing mining areas.
Omitted mapping of new mineral extraction sites	The entire interpreted area has to be checked at a rough scale (e.g. 1:40.000) in order to spot any new artificial surfaces. The attribute of this new feature should be checked by in-situ data.
Erroneous mapping of small material extraction sites with water cover (sand, gravel)	If the extracted material is visible on the site it has to be mapped as mineral extraction (131) and not water (512). Regarding mapping rules check [3].



Mistake: missing new mineral extension (211-131). The mineral extraction areas shown by IMAGE2000 (left) were extended where red dots on IMAGE2006 (right) show. Neither of the two enlargements was mapped. The enlargement on the north would join the two mining areas into a single polygon. In the northern polygon we see a reclamation process going on (size probably under the 5 ha limit).

3.3 ARABLE LAND TURNED TO SPORT AND RECREATION

Change process: Arable land turned to sport and recreation: 211-142

Overview and rationale:

As the living standard of European citizens' increases, leading to more spare time, there is a growing need for new recreation facilities. These include among others holiday settlements, cottage areas, golf courses, ski resorts in addition to new stadiums and different race courses. These new facilities are often established on agriculture land (except ski resorts), being the most frequent land cover in Europe.

Number of changes in European CLC-Change: 499 polygons

Area of changes in European CLC-Change: 0.20 % of all change areas

Type: Arable land converted to golf course: 211-142

Interpretation example (Germany):

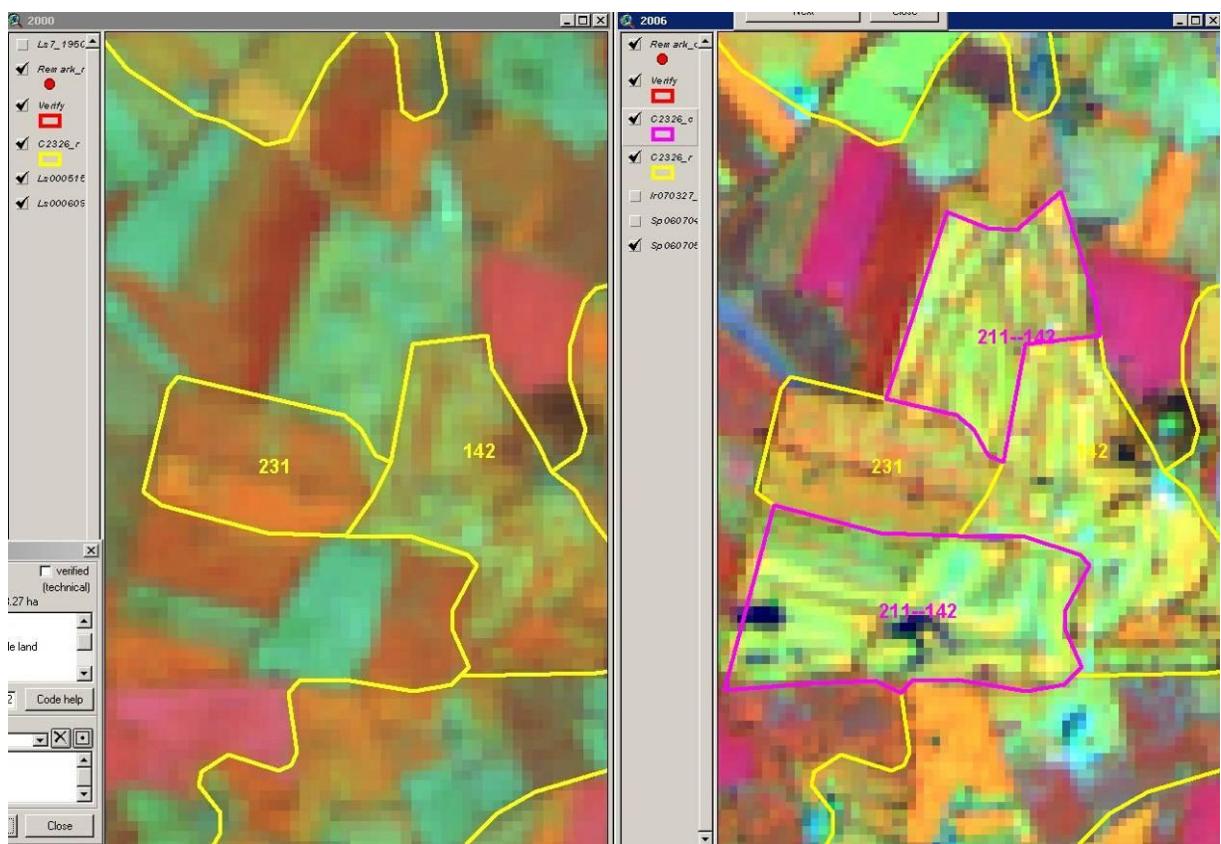
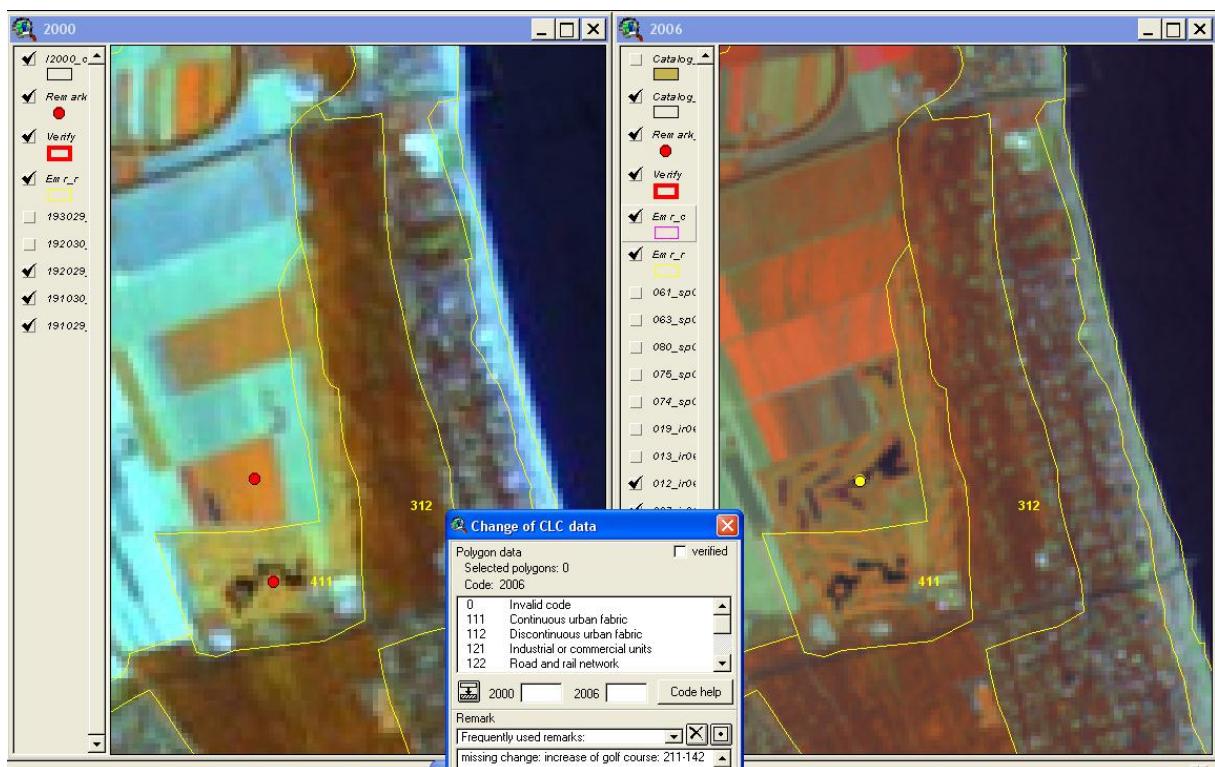


IMAGE2000 shows agriculture area (211, 231) around an existing golf course. The parcels are covered by green vegetation with different amount of biomass. On IMAGE2006 (right) we see large part of the area dominated by stripes, the typical ("spaghetti") pattern of golf courses. Due to the higher resolution of SPOT imagery (right) this pattern is more striking in 2006. The golf course has been extended to north and south resulting a loss of arable land: 211-142. There are 521 polygons of this type covering 0.21 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Associated mistakes: Arable land turned to sport and recreation	How to avoid the mistake
Omitted new golf course	Despite of its evident pattern, new golf courses (or extensions of existing ones) are sometimes not recognized. Recognition of other sport and recreation facilities (stadiums, race courses etc.) is possible from their pattern and by using VHR imagery. Check the study area at scale 1:30.000 / 40.000 and control all areas having a "spaghetti" pattern.
Erroneous mapping	All the sport and recreation facilities are artificial, therefore in a certain moment are in the status of being constructed. If construction of the site is not yet finished, 211-133 code should be applied.



Mistake: A combined mistake of CLC2000 and CLC-Changes datasets. In CLC2000 (left) a golf course (142) was miscoded as 411. On IMAGE2006 (right) the extension of the golf course on arable land was not recognized. Missing 211-142 change.

Particularity-1:

Type: Construction of ski resorts with artificial snow facility: 3xx-142

Interpretation example (not available):

In recent years many ski resorts have been equipped with facilities for producing artificial snow (snow canons). Essential part of this infrastructure is a pond providing water. Due to the artificial snow the length of the season is about doubled, lasting from November to April in e.g. Austria, therefore human impact on the environment is increased. Sometimes the slopes are also fully changed, the uneven ground is levelled, rocks are removed etc. Chemicals are also mixed into the artificial snow to assure higher melting point. For the reason of higher human impact, in such areas the surface of ski pistes is also mapped as 142. The "indicator" of these facilities (therefore the use of 142 for the pistes) is the presence of the water pond.

3.4 NON-IRRIGATED ARABLE LAND CHANGED TO IRRIGATED ARABLE LAND

Change process: Non-irrigated arable land changed to irrigated arable land: 211-212

Overview and rationale:

Major driving factors of changing non-irrigated arable land to irrigated arable land are increased food demand and higher profitability. Permanent irrigation means a significant infrastructural investment as well as high load on the environment. Environmental impacts of irrigation include changes in quantity and quality of soil and water and the ensuing effects on natural and social conditions. The impacts stem from the changed hydrological conditions owing to the establishment and operation of irrigation systems, such as reduced downstream river discharge, which in extreme cases might lead to lakes dried up. The effects on soil and water quality are indirect and complex, and include water logging and soil salinization as well as subsequent impacts on natural, ecological and socio-economic conditions, such as depletion of aquifers and competition for water.

Careful mapping of the process therefore is an important data source for environmental indicators and impact assessments.

Number of changes in European CLC-Change : 1089 polygons

Area of changes in European CLC-Change : 0.99 % of all change areas

Type: non-irrigated arable land changed to irrigated arable land: 211-212

Interpretation example (Spain):

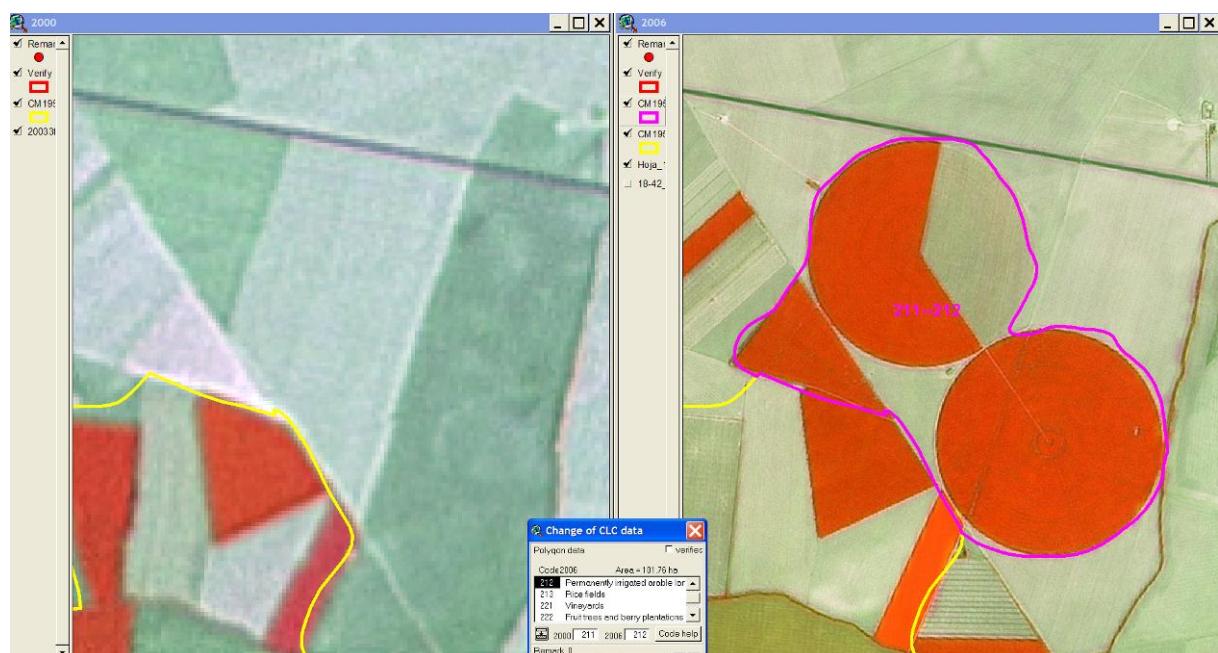
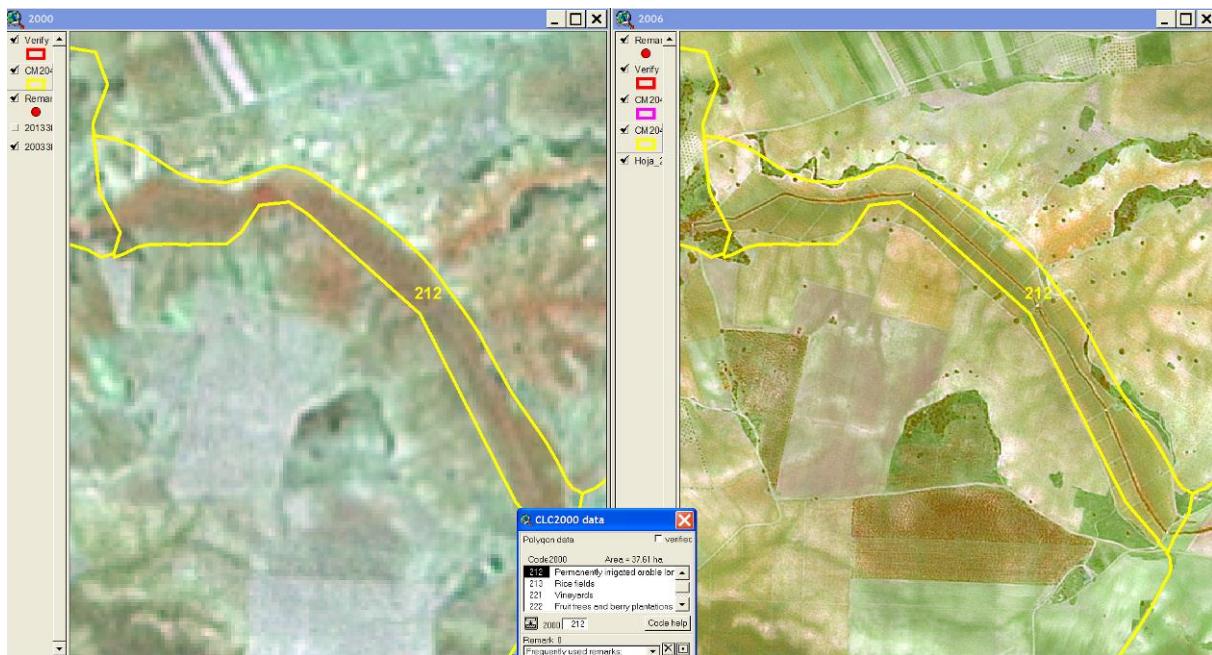
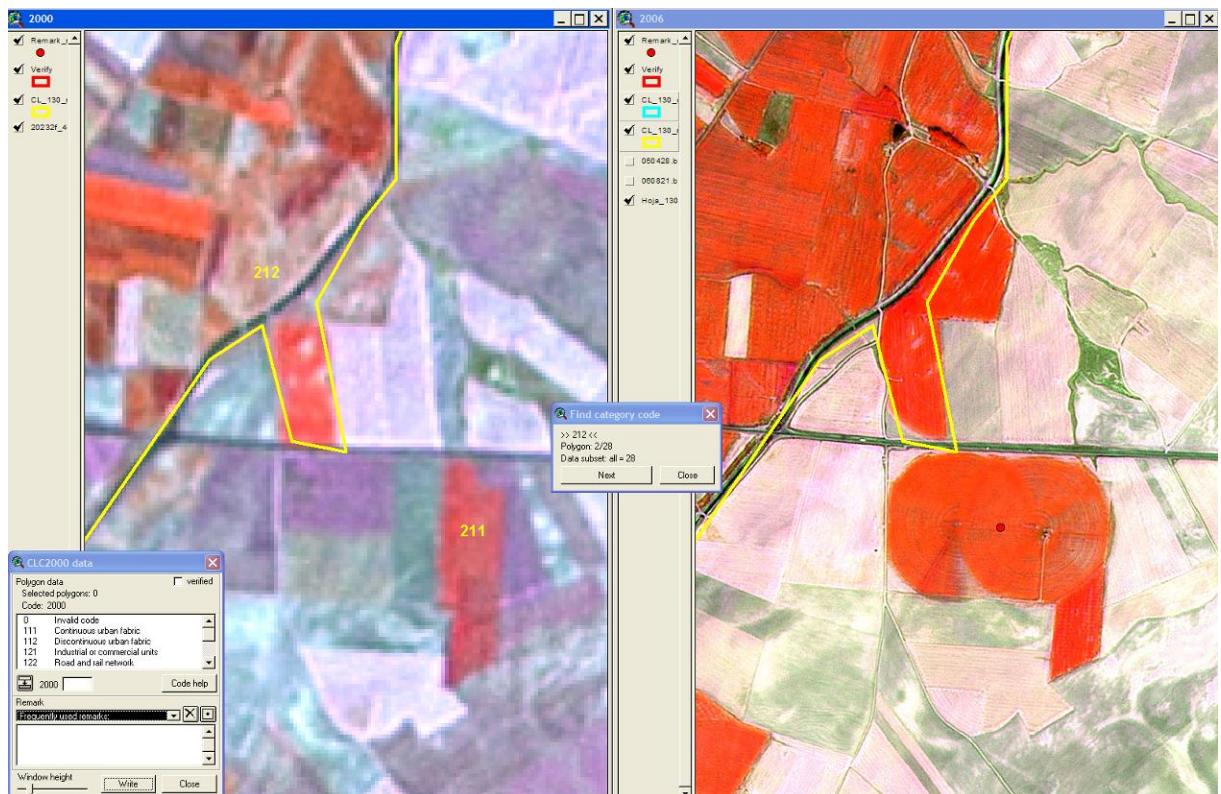


IMAGE2000 (left) shows non-irrigated arable land. On IMAGE2006 (right), a new irrigated arable land can be seen, dominated by two circular structures (providing permanent irrigation). The vivid red colour means green crops with high biomass, due to the permanent supply of water. This vivid colour (compared to surrounding agricultural landscape), together with homogeneity of parcels and the visible irrigation infrastructure are the keys of distinguishing irrigated land from non-irrigated. The example also illustrates the fact that parcels actually not covered by green crop can also belong to the irrigated arable land polygon (east part of the upper circular structure). It is therefore important to use multi-temporal imagery for identifying this kind of change. There are 1439 polygons of this type covering 0.59 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.



This example illustrates the effect of image resolution on identification of irrigated areas (not a change example). On the left we see IMAGE2000 taken by Landsat TM satellite with 30 m pixel size. The irrigated area is shown with pink shade. No infrastructure, no parcel structure is visible. On the right an image taken by the SPOT-5 satellite with 2.5 m pixels is displayed. Irrigation channels and structure of small parcels are evident, similarly some mistakes of delineation. (Instead of standard IMAGE2006 Spain used SPOT-5 imagery (multispectral and PAN merge) with pixel size of 2.5 m taken in 2005.)

Frequent mistakes: Non-irrigated arable land changed to irrigated arable land	How to avoid the mistake
Using the 212 class in a geographic area where irrigation is not a pre-requisite of arable production, but used only occasionally, to supplement water.	Permanently irrigated arable land (212) class is applicable only in regions where arable farming (or production of the specific crop) is not possible without permanent artificial water supply (i.e. the Mediterranean region). Consider the geographic context in applying 212. Similarly, if large water reservoirs or small irrigation ponds are observable in the area, interpreter should suspect irrigation.
False change caused by irrigated arable land mistaken with irrigated permanent crops (not to be mapped as 212, but as 221/222).	Use high-resolution remote sensing data to separate irrigated arable land and irrigated permanent crops (vineyards, orchards, olives).
False change or missing change due to using not the right image date. Early or late season imagery might not show any green vegetation.	Use multi-temporal imagery; avoid mapping the changes based on off-season information in either dates.
Missing or false change due to parcel pattern or irrigation infrastructure not recognized.	Use VHR imagery to map irrigated areas with small parcels along a narrow channel and identify finer structures.
Surface irrigation is mapped on slopes, where it rarely occurs.	Consider topography when deciding on using 212; irrigation is seldom used on slopes in Europe. (As an exception, in the Mediterranean irrigated vegetables grown under plastic exist on slopes, too.)



Mistake: missing 211-212. Part of the large non-irrigated arable land (211) polygon in 2000 (left) has changed to irrigated arable land (212), as indicated by the two intersecting circular irrigation structures (marked by a red dot on IMAGE2006, on the right).

3.5 VINEYARDS AND ORCHARDS REPLACING ANNUAL CROPS

Change process: Vineyards and orchards replacing annual crops: 211-221/222, 212-222

Overview and rationale:

The driving factor in exchanging arable land to plantation (fruit trees, vineyards) usually is that intensively managed plantations provide more profit to the owner than arable land. In the Mediterranean environment some of the plantations (e.g. citrus) are irrigated, which means a significant infrastructural investment as well as high load on the environment. Establishment of new plantations is very capital intensive, therefore indicates favourable financial backgrounds or significant community assistance.

Indirectly, this change has an important social impact, namely increasing the ability of rural areas to support population, by higher labour requirement (more employment) and higher income. Traditional small-scale vineyards and orchards are however gradually replaced by large-scale, industrialized plantations, reducing this positive effect.

Number of changes in European CLC-Change : 3217 polygons

Area of changes in European CLC-Change : 1.31 % of all change areas

Type: arable land changed to fruit tree plantation (orchard): 211-222

Interpretation examples (Hungary, Spain):



IMAGE2000 (left) shows large arable land fields mostly without crop. IMAGE2006 (right) shows moderate and homogeneous vegetation cover with regular structure inside. Orthophoto confirms the presence of fruit trees plantation. Existence of service roads visible inside the plantation (even with 20 m pixel size imagery) is an important key for recognition. The other key for distinguishing from arable fields (where crop rotation and development causes dynamically changing colours and structures) is the homogeneity of the plantation area (vegetation cover and field structure) over time. There are 1531 polygons of the 211-222 type covering 0.58 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

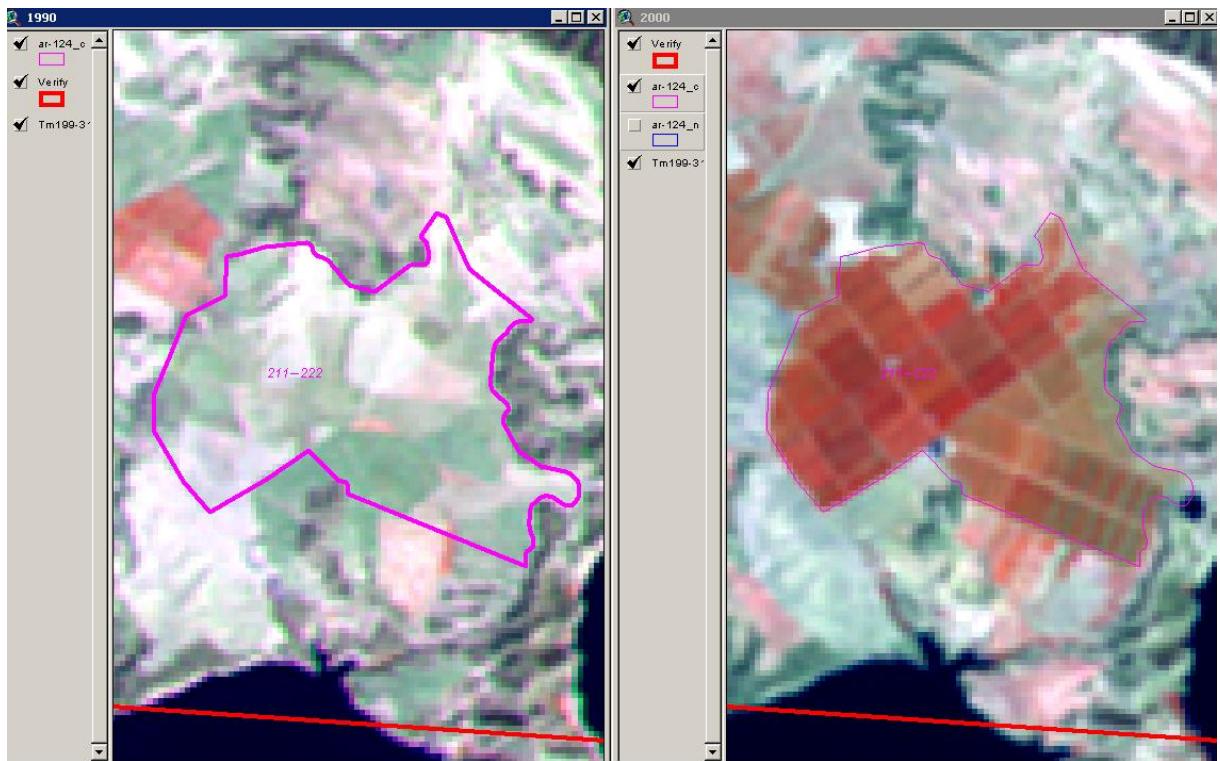


IMAGE1990 (left) shows non-irrigated arable land in the Mediterranean. IMAGE2000 (right) shows vivid red colour of significant vegetation cover in regular parcel arrangement, typical of fruit plantations. Different shades of red mean different age of trees (density of canopy). Small water basins in and around the area provide evidence of irrigation. Even though the area is irrigated this change should not be mapped as 211-212, but as 211-222. There are 1531 polygons of this type covering 0.58 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Type: arable land changed to vineyards: 211-221

Interpretation examples (Hungary):

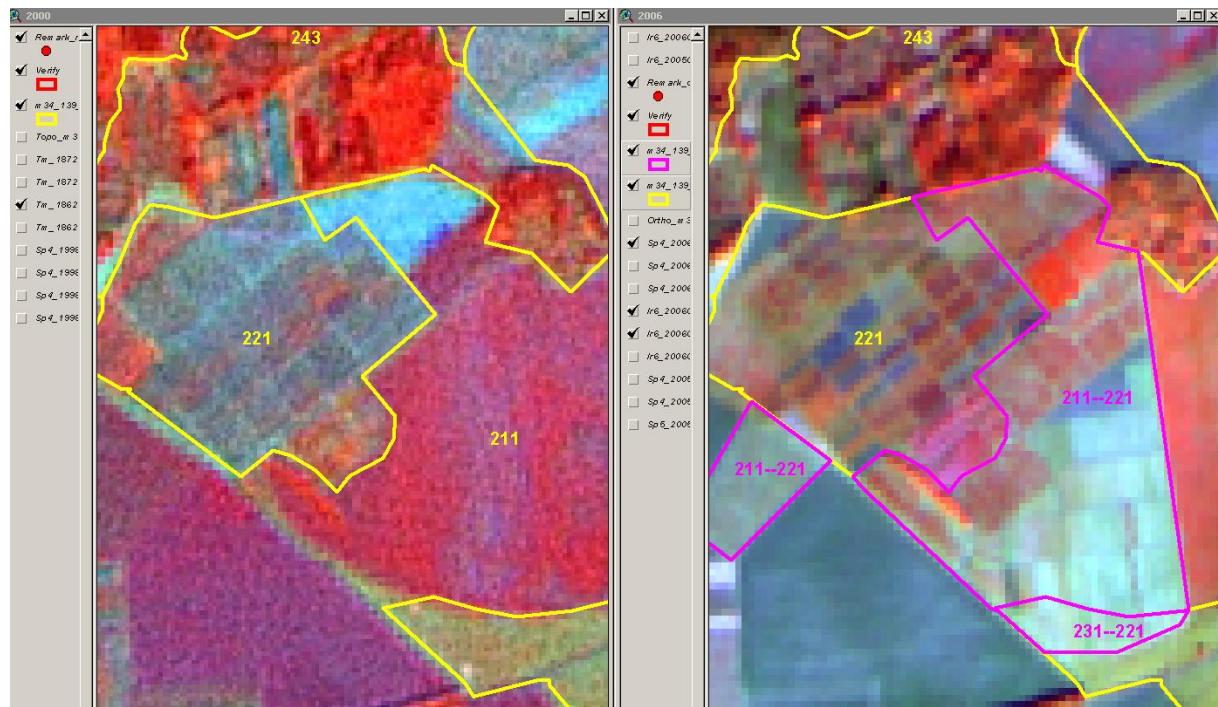
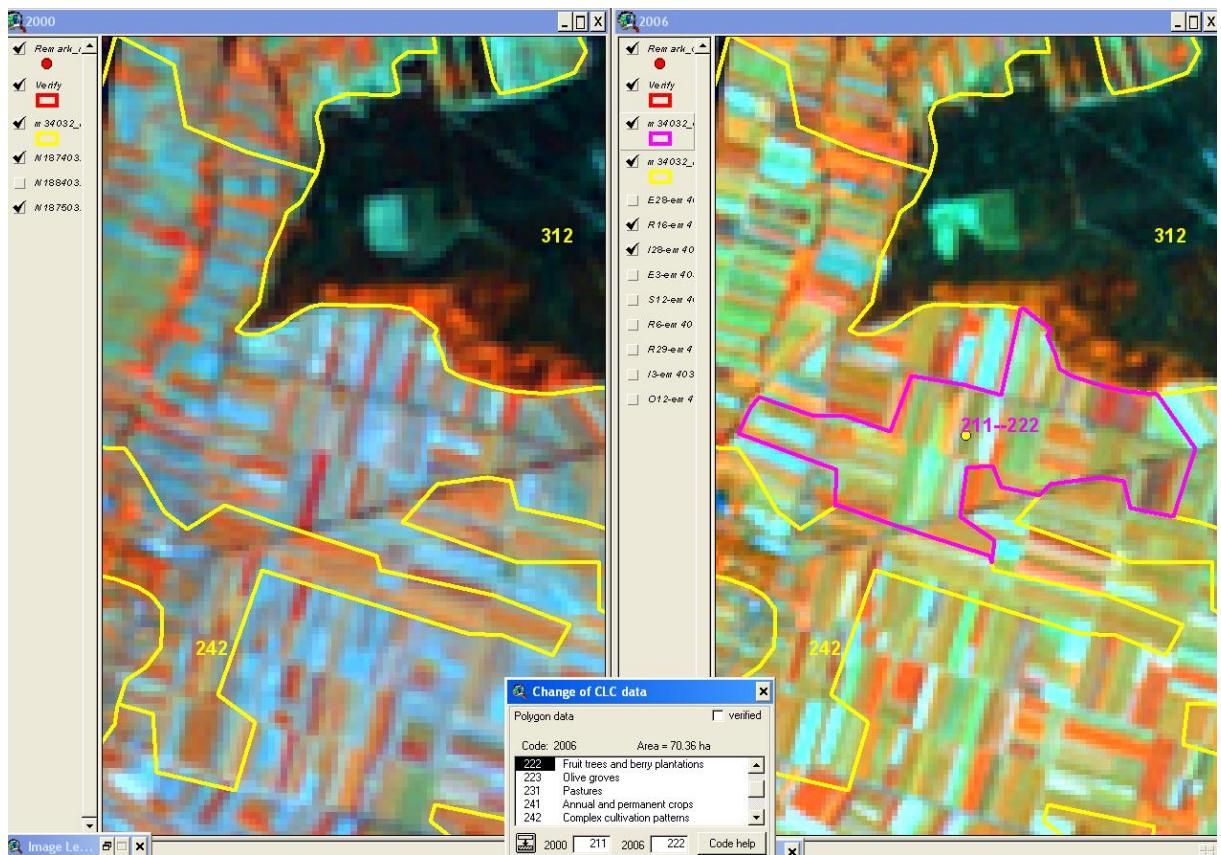
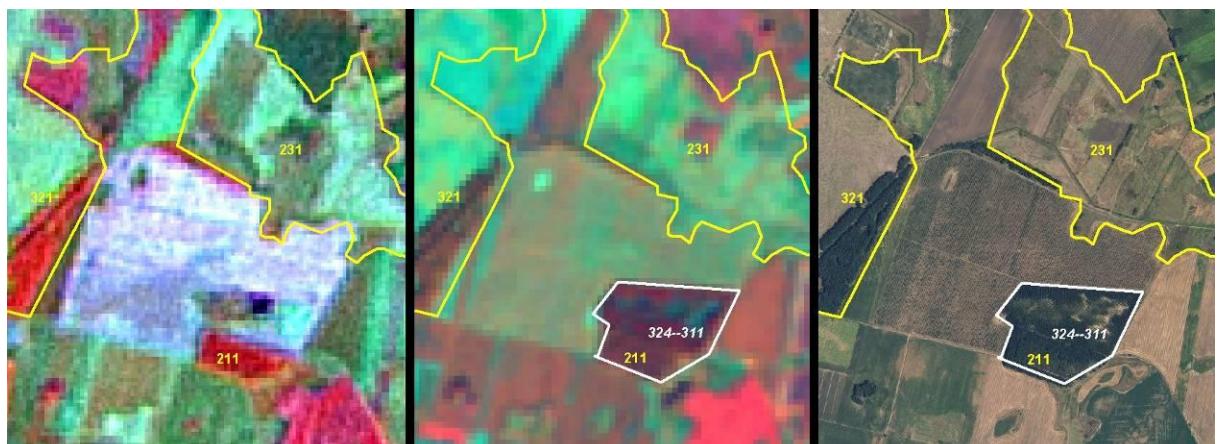


IMAGE2000 (left) shows large arable land fields and a vineyard with several smaller parcels. IMAGE2006 (right) shows that the characteristic pattern (geometry and colour) of vineyards significantly extended to the southeast (211-221). Larger part of the new vineyard is still a young plantation, as we see the special geometry, but only small biomass (red means high biomass, white means small biomass). Young plantations are often recognizable only by their structure or by using VHR imagery. There are 1439 polygons of this type covering 0.59 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Frequent mistakes:	How to avoid the mistake
Vineyards and orchards replacing annual crops	
Omitted or false changes due to not considering multi-temporal imagery in separating vineyards/orchards and arable land.	Always use multi-temporal imagery. Arable crops show more dynamics of colour on satellite imagery in the growing season, while vineyards/orchards are relatively stable concerning biomass and structure.
Missing change or wrong change code pair due to lack of VHR imagery.	VHR imagery is mandatory for recognizing new plantations, where the young plant is small and does not cover the soil. This also prevents mixing young plantations with forest plantations (324), construction sites (133) or arable land (211). VHR imagery is also useful in distinguishing 221 from 222 in some regions.
Changes might be omitted or falsely mapped in case of plantations of small field size, where the indirect evidence of permanent crops (homogeneity, service roads) is not possible to recognize.	Use higher resolution in-situ data for locating and verifying new permanent crops. Young fruit trees / vines are also plantations (and not arable land).



Questionable 211-222 change. IMAGE2000 (left) shows an agricultural area (211 and 242). On IMAGE2006 (right) 211-222 was mapped on part of the arable land area. Due to the small field size, it is hard to verify this change based only on these images. During verification it was advised to revise the area using in-situ data (orthophoto would show the rows or even individual trees).



Mistake: omitted 211-222 change. IMAGE2000 (left) shows an agricultural area with arable and pasture land. IMAGE2006 (middle) shows a similar picture, except that the large field in the middle of the image became covered by vegetation, a bit similar to neighbouring pasture. Orthophoto taken in 2005 (right) clearly indicates the presence of a fruit tree plantation in the area that looked pasture. In 2000 the area was probably just being prepared for plantation. The new plantation (211-222) was not recognized due to lack/ignorance of VHR imagery. Note that plantation could also be new forestation area. The presence of cultivation roads across the plantation (as visible here) and ancillary data help interpreter to distinguish new fruit/vineyard plantations from forest plantations.

3.6 PERMANENT CROPS TURNED TO ARABLE LAND

Change process: Permanent crops turned to arable land: 221/222-211

Overview and rationale:

Changing permanent crops to arable land is usually explained by financial drivers. The most typical causes are: (1) fruit trees get old and no resources are available for a new plantation; (2) the fruit products are not marketable.

Number of changes in European CLC-Change : 831 polygons

Area of changes in European CLC-Change : 0.32 % of all change areas

Type: fruit plantation turned to arable land: 222-211

Interpretation example (Hungary):

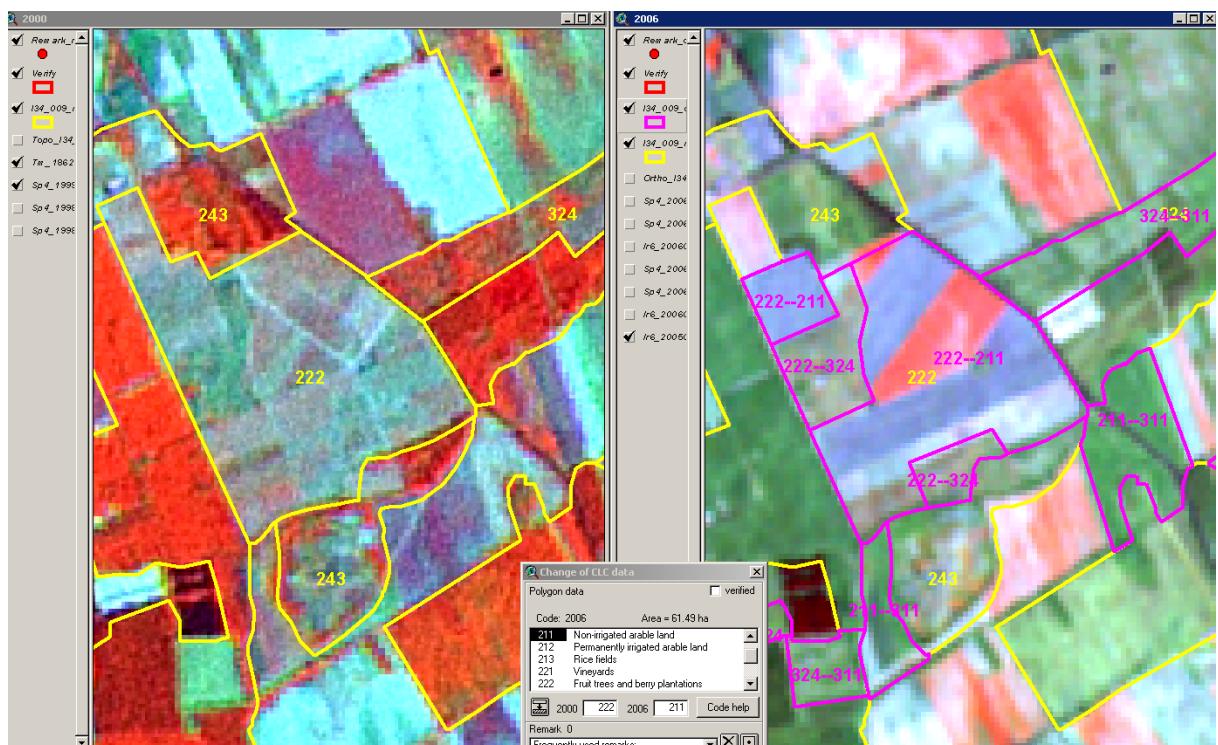
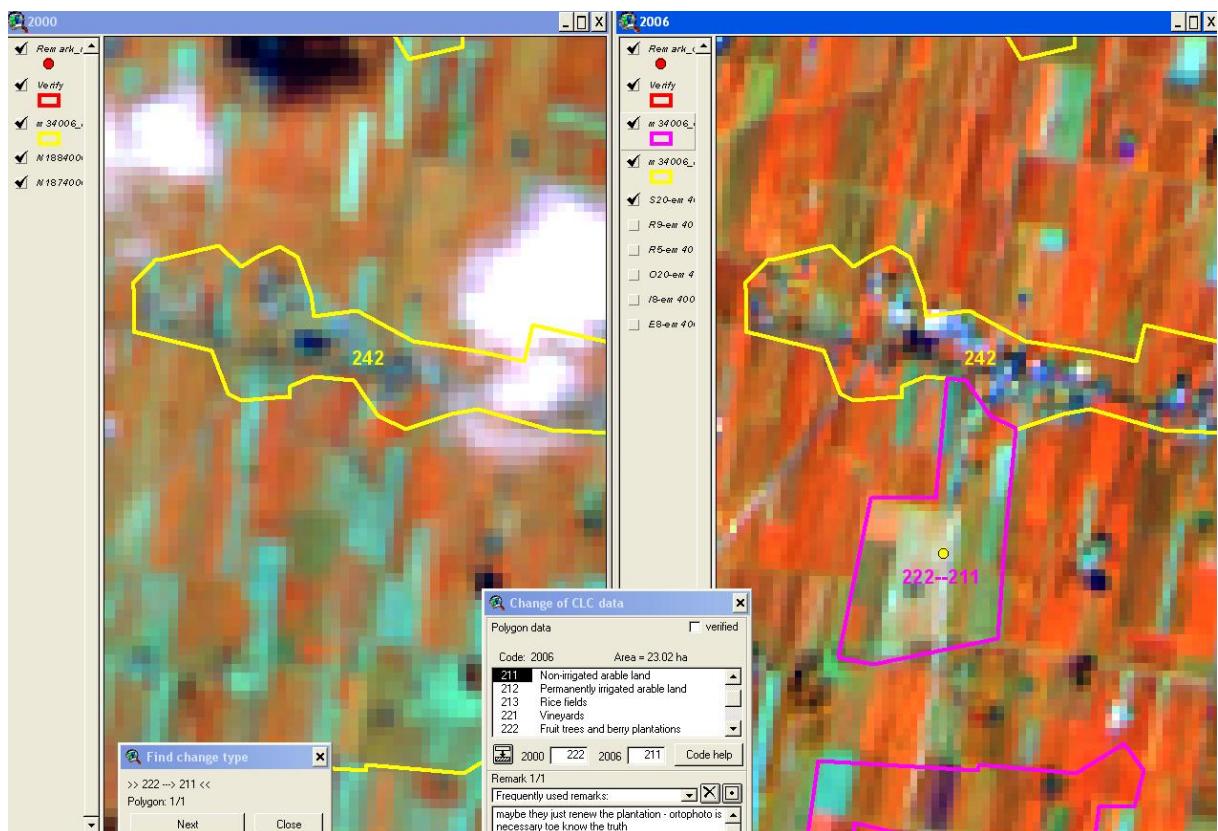
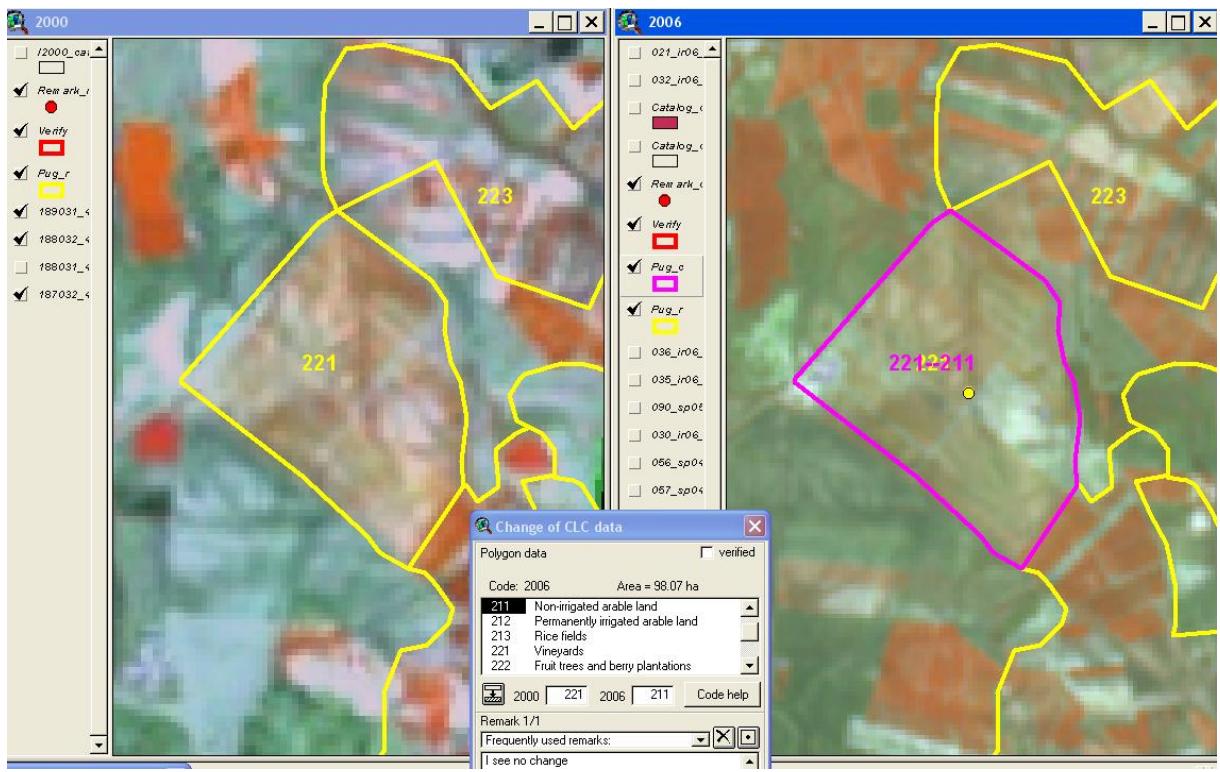


IMAGE2000 (left) taken in summer shows a fruit tree plantation. Note the service roads inside the plantation. On IMAGE2006 (right), taken in spring the area is fragmented into smaller fields with a variety of crops. Red colour means arable land with high biomass, light blue and white colour refers to bare soil (ploughed land). (Additionally, there are two parcels where fruit trees were replaced by forest plantation; confirmed by orthophoto). Note that former service roads disappeared. There are 547 polygons of the 222-211 type covering 0.21 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Frequent mistakes:	How to avoid the mistake
<p>Permanent crops turned to arable land</p> <p>Omitted changes or false changes are more often mapped in case of small field size, where disappearing plantations (in lack of characteristic structure) are difficult to recognize. Additional difficulty is that young plantation replacing old plantation looks much similar to arable land on satellite images (20 m pixels), as the first step of establishing a new plantation is also ploughing.</p>	<p>Use higher resolution in-situ data for locating and verifying disappearance of permanent crops. Note that young vineyards / fruit trees are also coded as 221 or 222 (and not arable land - 211). Multi-temporal imagery also helps distinguishing new plantation (re-plantation) from arable land (disappearing plantation).</p>



Questionable 222-211 change. IMAGE2000 (left) shows a large area with fruit tree plantation (222) with a village in the middle (112 erroneously coded as 242). On IMAGE2006 (right) 222-211 was indicated on part of the 222 area. This single image cannot provide evidence of what has happened, although some colour differences can be seen on the area compared to its surroundings. It could have happened that old fruit trees were removed and new trees were planted, meaning no CLC change. During verification it was advised to check the area with in-situ data (orthophoto showing no trees are on the parcels would indirectly prove existence of arable land). It is important to recall that delineation of 221 and 222 do not necessarily have to yield polygons with homogeneous land cover. Polygons with higher than 50% cover of vineyards or orchards should be classified as 221 or 222, respectively [3].



Mistake: IMAGE2000 (left) and IMAGE2006 (right) has totally the same texture. Slight difference in colour is explained by differences in imaging sensors, date and atmospheric conditions. 221-211 change is therefore false. No change should have been mapped. Multi-temporal imagery would show no evidence of crop rotation in 2006.

3.7 NEW OLIVE PLANTATIONS REPLACING ANNUAL CROP

Change process: New olive plantations replacing annual crops: 211/242-223

Overview and rationale:

The driving factor in exchanging arable land to olive plantation is usually the higher profitability. In some cases new plantations are irrigated, in order to increase the yield. This means a significant infrastructural investment as well as higher load on the environment. New olive plantations contribute to the ability of rural areas to support population by their higher labour requirement (more employment) and higher profitability.

Number of changes in European CLC-Change : 1725 polygons

Area of changes in European CLC-Change : 0.90 % of all change areas

Type: arable land changed to fruit trees plantation: 211-223

Interpretation example (Spain):

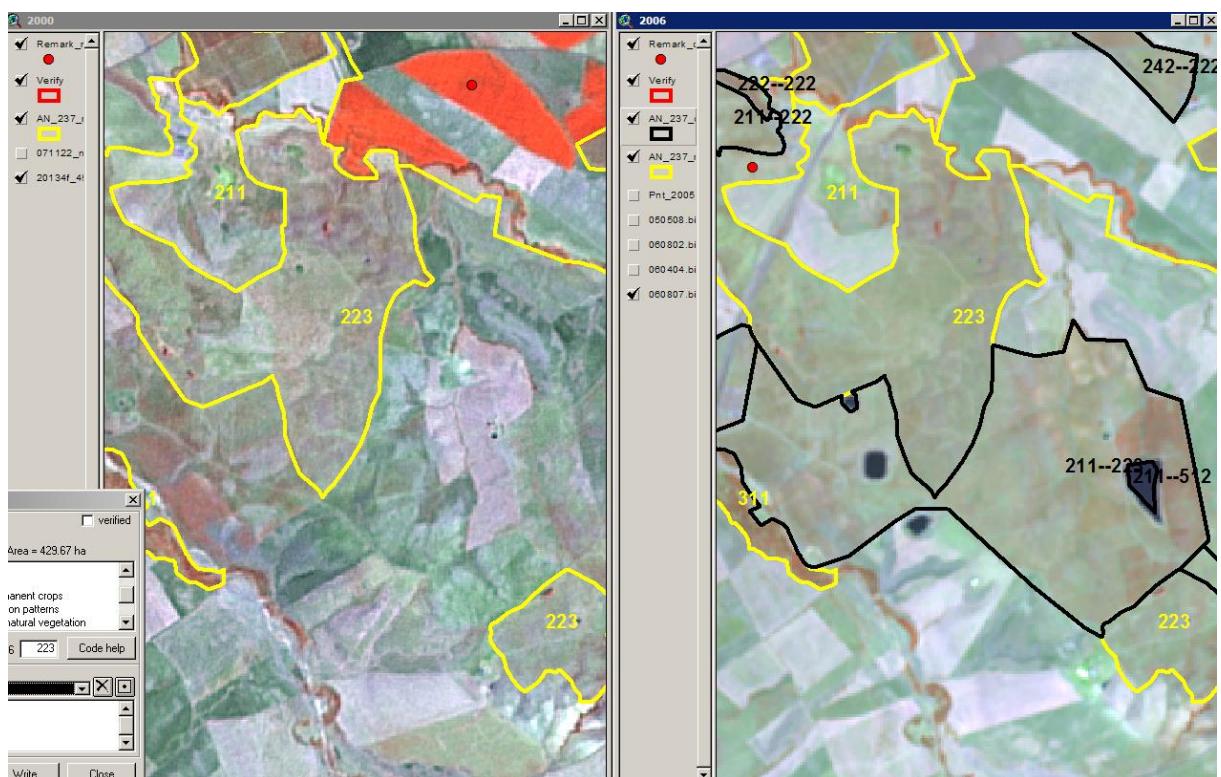
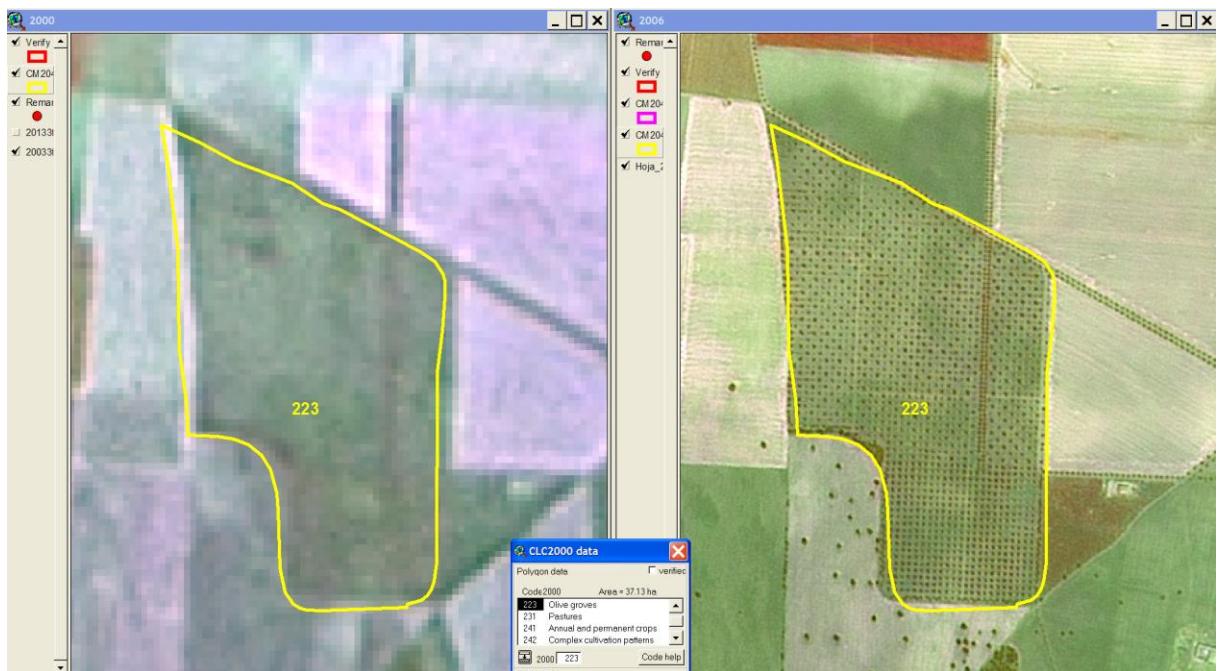
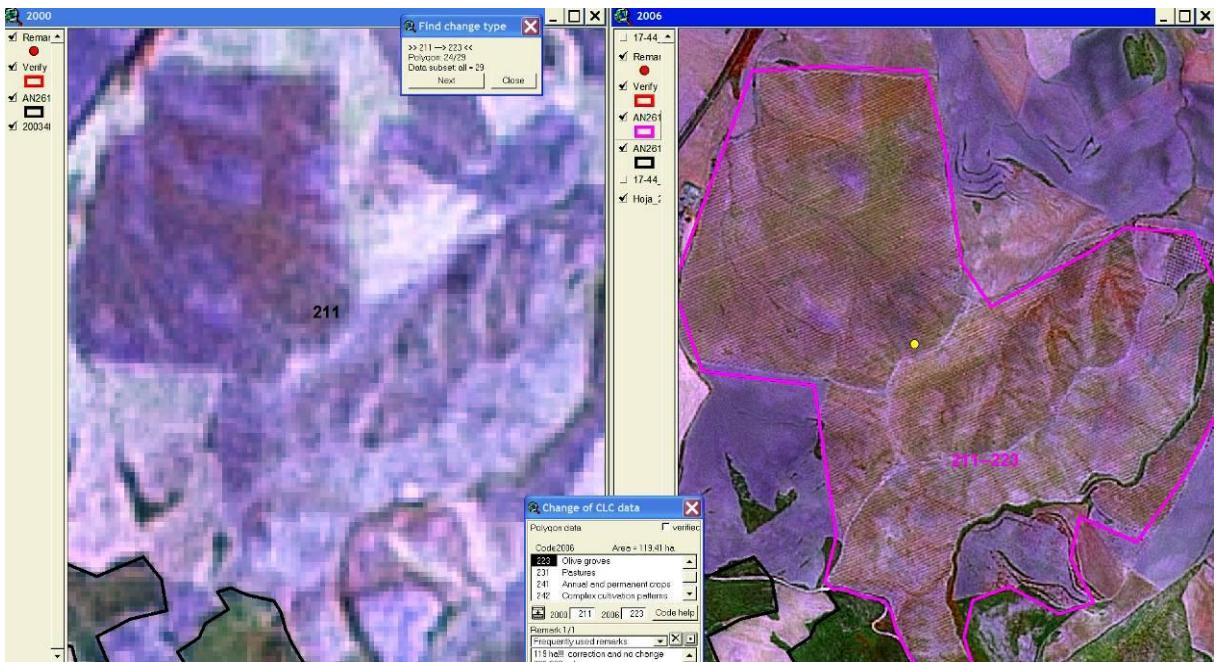


IMAGE2000 (left) shows non-irrigated arable land in the Mediterranean with patches of olive plantation with their characteristic greyish green colour. IMAGE2006 (right) shows the increase of plantations, coded as 211-223. Typical pattern of olive plantations shows practically no field structure, narrow service roads and occasionally a few irrigation ponds. (Note that even if the area is irrigated we do not map the change as 211-212, but as 211-223.) There are 1573 polygons of this type covering 0.79 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.



This example illustrates the effect of image resolution on ability of recognizing olive plantations. On the left we see IMAGE2000 taken by Landsat TM satellite with 30 m pixel size. The olive plantation is seen as an almost homogeneous parcel. On the right an image taken by the SPOT-5 satellite with 2.5 m pixels is displayed. The fine structure of the plantation is very well visible, even individual trees can be recognized. (Instead of standard IMAGE2006 Spain used SPOT-5 imagery (multispectral and PAN merge) with pixel size of 2.5 m taken in 2005.)

Frequent mistakes:	How to avoid the mistake
New olive plantations replacing annual crops	
Missing change due to lack of using VHR imagery.	Use VHR imagery if available.
False change interpreted because of existing plantation not recognized during the previous inventory due to lack of VHR imagery. Change is mapped instead of correcting parent stock layer.	Re-check the area again on the parent stock layer to find existing plantations that are not mapped. If the plantation seems mature on the new imagery, the trees presumably were already there during the previous inventory. Correct the parent stock layer, if necessary. Remember that young olives should be coded also as 223 (and not arable land - 211).
False change mapped because not examining the old satellite image. If only parent stock layer and new image is considered, many false changes are mapped instead of correcting parent stock layer.	Always both image dates should be examined when delineating changes of new plantations.



Mistake: false change (211-223) is mapped instead of correcting parent stock layer. IMAGE2000 (left) and IMAGE2006 (right) show practically identical land use, difference is only in image resolution: Landsat TM (left, 30 m pixels) and SPOT-5 (right, 2.5 m pixels). Higher resolution imagery clearly shows the geometry of olive plantation, while Landsat TM does not. Consequently, no change should be interpreted but CLC2000 has to be corrected (223).

3.8 ARABLE-LAND PASTURE ROTATION

Change process: Arable land - pasture rotation: 211-231, 231-211

Overview and rationale:

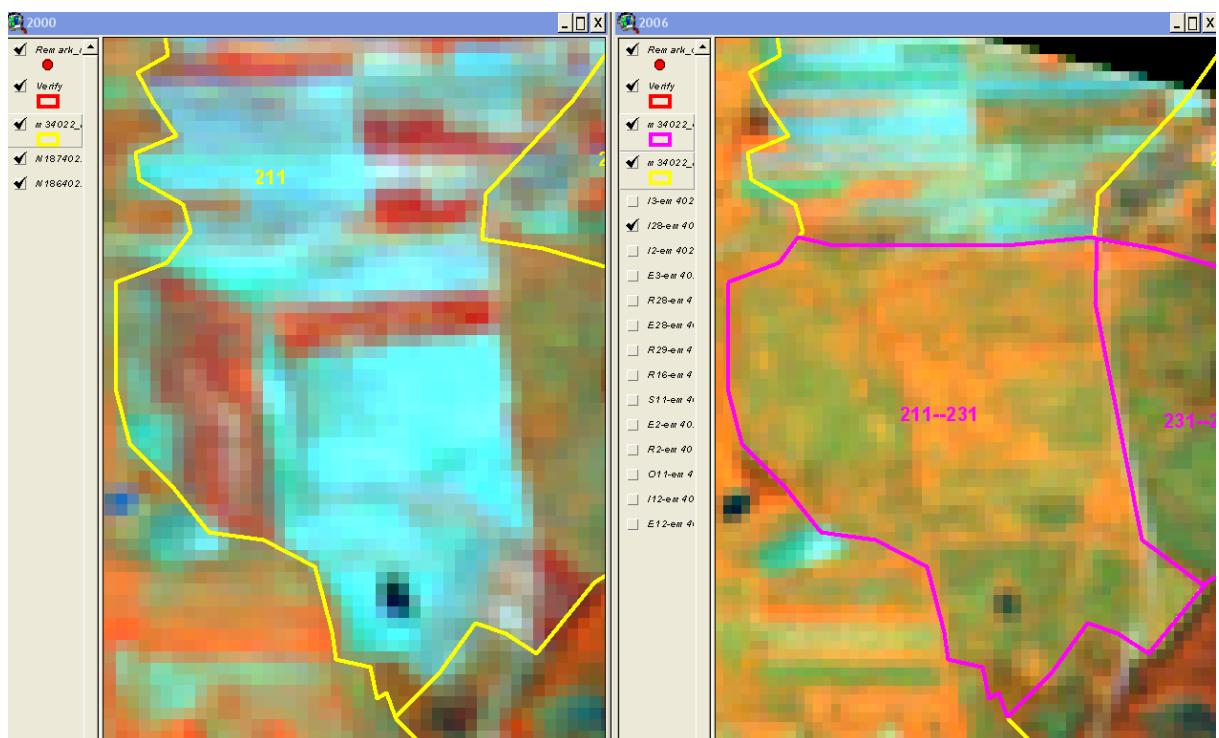
Changes between arable land and pasture / set-aside land and back are explained by agronomical and economical reasons. (Pastures and set-aside areas are treated together, because CORINE Land Cover does not distinguish one from other.) Areas used as arable land are often put set-aside after some years for agronomic reason. The set-aside land can be grazed / mowed for a couple of years, then converted back to arable land. (Alternative process can be that the area is not used agriculturally any more (no animal husbandry) thus natural succession gradually turns it first to pasture (231) then to natural grassland then shrubland and finally to forest.) The other reason for turning arable land to pasture is higher profitability of animal husbandry compared to crop production. The driving factor is usually economy (often materialized as subsidies), namely which product (arable crops or grass / animal husbandry) creates larger profit.

Number of changes in European CLC-Change : 5793 polygons

Area of changes in European CLC-Change : 2.56 % of all change areas

Type: arable land changed to pasture / set-aside land: 211-231

Interpretation example (Poland):



Arable land field structure is visible on IMAGE2000 (left). Parcels in red colour are covered by green vegetation, while parcels in light blue are recently ploughed fields. On IMAGE2006 (right) we see no parcel structure, and the two dominating colours indicate differences of grass biomass. Mapped change is 211-231. Both pattern and colour help detection of the change process. There are 2583 polygons of this type covering 1.26 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Type: pasture / set-aside land changed to arable land: 231-211
Interpretation examples (Romania, Germany):

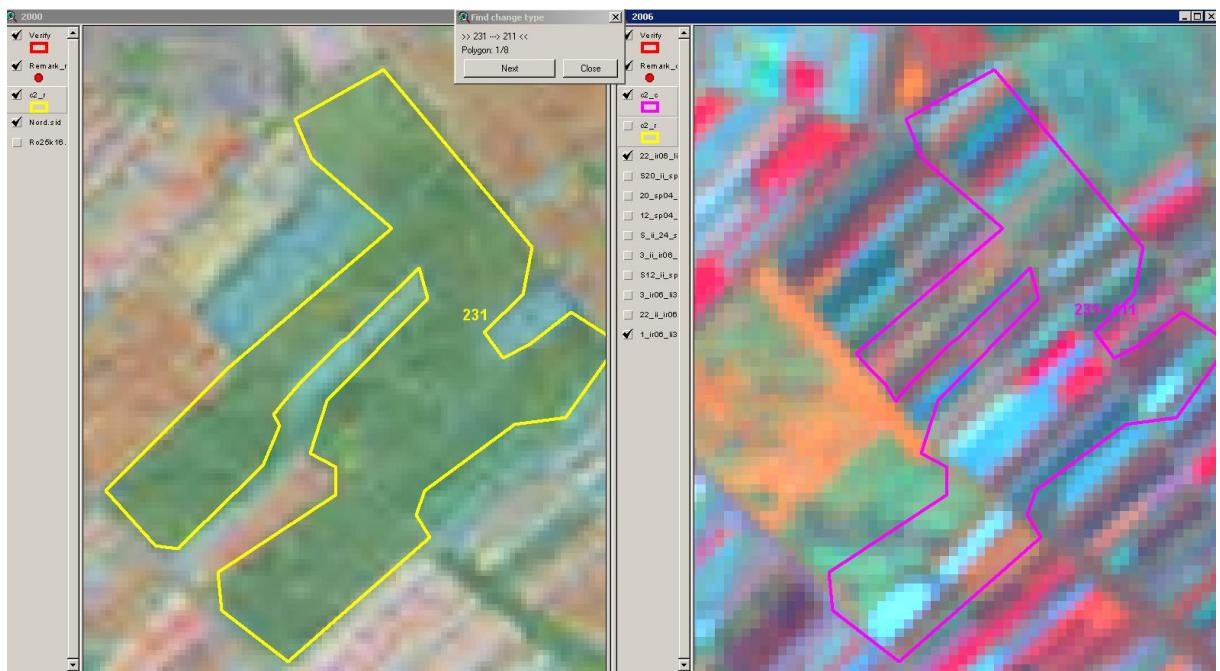


IMAGE2000 (left) shows a large, homogeneous area with colour indicating low biomass (231). By 2006 (right) area was fragmented into small parcels with different annual crops (211). Red means high biomass, green means low biomass, light blue means bare / ploughed soil. Structure (pattern) and colour together help identification of the 231-211 change. There are 3210 polygons of this type covering 1.30 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

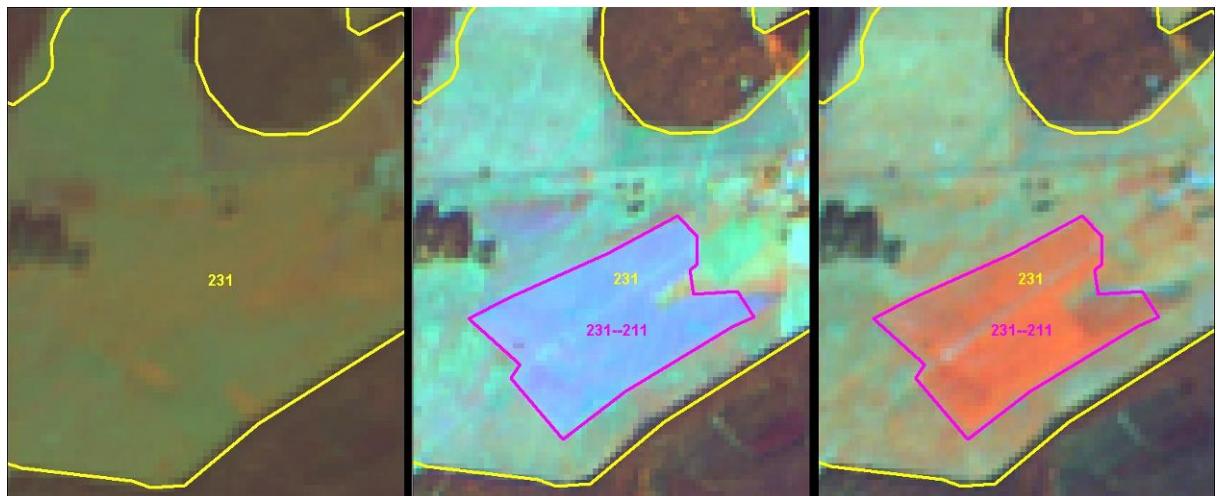
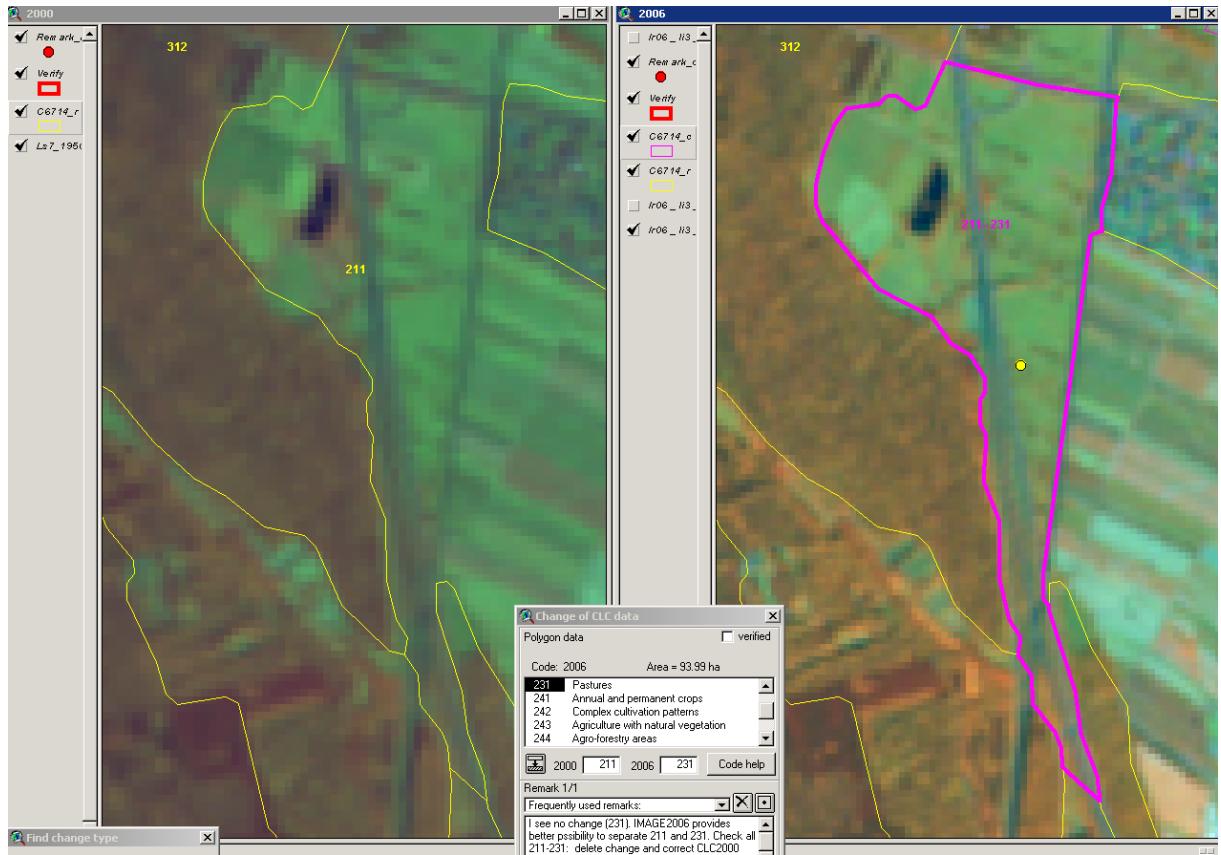
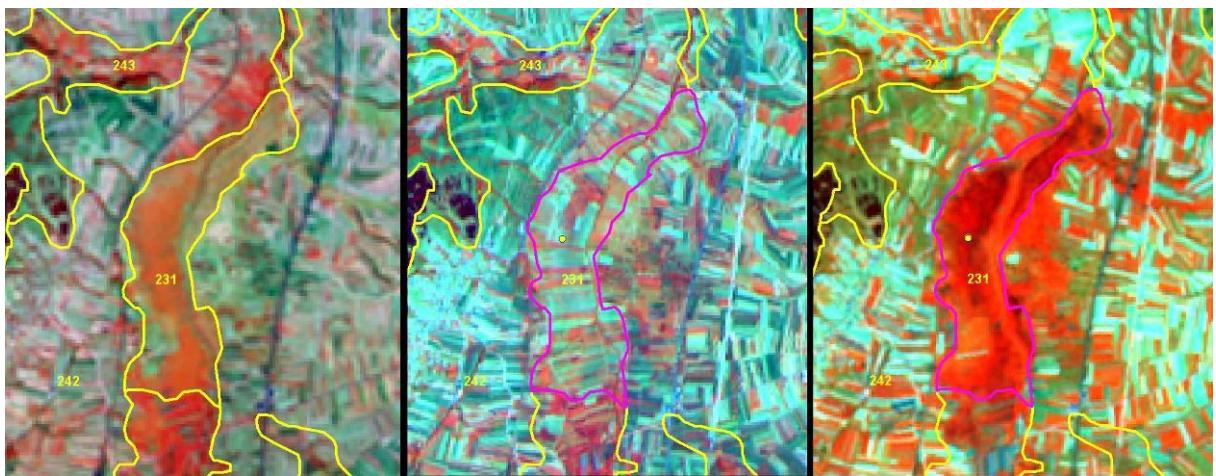


IMAGE2000 (left) indicates a pasture area. We have two IMAGE2006 pictures, the middle one taken in spring, showing ploughed land; the right one taken in summer, indicating dense green crop. The two images together provide the evidence of new arable land. Mapped change: 231-211. In this example there is no difference in pattern between pasture and arable, only the colours observable on multi-temporal imagery make possible identification of arable land. There are 3210 polygons of this type covering 1.30 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Frequent mistakes: Arable-land pasture rotation	How to avoid the mistake
<p>Omitted changes or false changes due to not considering multi-temporal information. Multi-seasonal imagery shows the crop development (ploughing, sowing, greening, yellowing) on arable parcels, while pasture shows much less colour dynamics. Other key of recognition might be the shape and texture: pastures are usually larger and more homogeneous (hay fields however can have parcel structure like arable land), while arable land area usually includes parcels with several different colours.</p>	<p>Consider all available images: multi-season from a single year or from consecutive years. Note that mown grass might also show large changes of biomass, similarly to arable land. Existence of biomass on spring and autumn images is however a rather good indicator of grass cover.</p> <p>Very-high-resolution imagery usually does not help separation of pastures from arable land.</p>
<p>False change caused by mixing pasture with fodder production (alfalfa, or annual grass as part of crop rotation). The existence of grass cover does not necessarily indicate 231. In Western and Northern Europe grass is often cultivated as annual crop, being included in the crop rotation.</p>	<p>Geographical and agricultural background knowledge is needed to identify areas where this kind of cultivation is typical. The use of multi-temporal imagery helps filtering out these false changes, too.</p>
<p>Arable/pasture rotation misinterpreted as change from/to natural grassland (321). Although 321-211 (change from semi-natural area to agriculture) is an existing phenomena (see Ch. 4.3), the opposite process (211-321) is considered to be hardly possible in CLC, because natural grassland takes much longer than 6 years period to naturally develop. The normal development line of an abandoned field is 211-231-321-324/323/322 -31x.</p>	<p>The keys of distinguishing between 321 and 231 are as follows: agricultural grasslands (231) are normally smaller, regular in shape (parcel structure), found in agriculturally favourable areas, show sign of human impact/cultivation (rows of mowing, animal path), while natural grasslands are large, irregular in shape, are often found in unfavourable (arid, sloping, rocky, remote) areas and show no signs of cultivation [3].</p>



Mistake: false 211-231 was mapped. As IMAGE2000 (left) and IMAGE2006 (right) looks exactly the same (texture and colours), we have no reason to map this change. Although in-situ data are needed to judge the right code (211 or 231), we can accept that no change occurred here.



Mistake: false change was mapped because of ignoring multi-temporal information. IMAGE2000 (left) taken in spring shows an extended pasture (231) area along a small river. The "standard" IMAGE2006 (middle) taken in July 2006 indicates a more heterogeneous pattern, including fields with green vegetation and others without green vegetation. This suggests interpreting a 231-242 change, meaning that the dominance of pasture disappeared and the area is covered by alternating small fields of pasture and arable land (242), like the neighbourhood. However, if we look at the other available IMAGE2006 (right), taken in May 2005, it is very similar to the IMAGE2000, suggesting no-change. It reveals that 231-242 is false, and on the summer image we see only the signs of hay-making. No change should be interpreted (231). Additionally, the 2006 images indicate that the area of the 231 polygon is underestimated (see south and east) and its boundaries need some modification.

3.9 DIVERSIFICATION OF AGRICULTURAL LAND USE

Change process: Diversification of agriculture land use: 211/231-242

Overview and rationale:

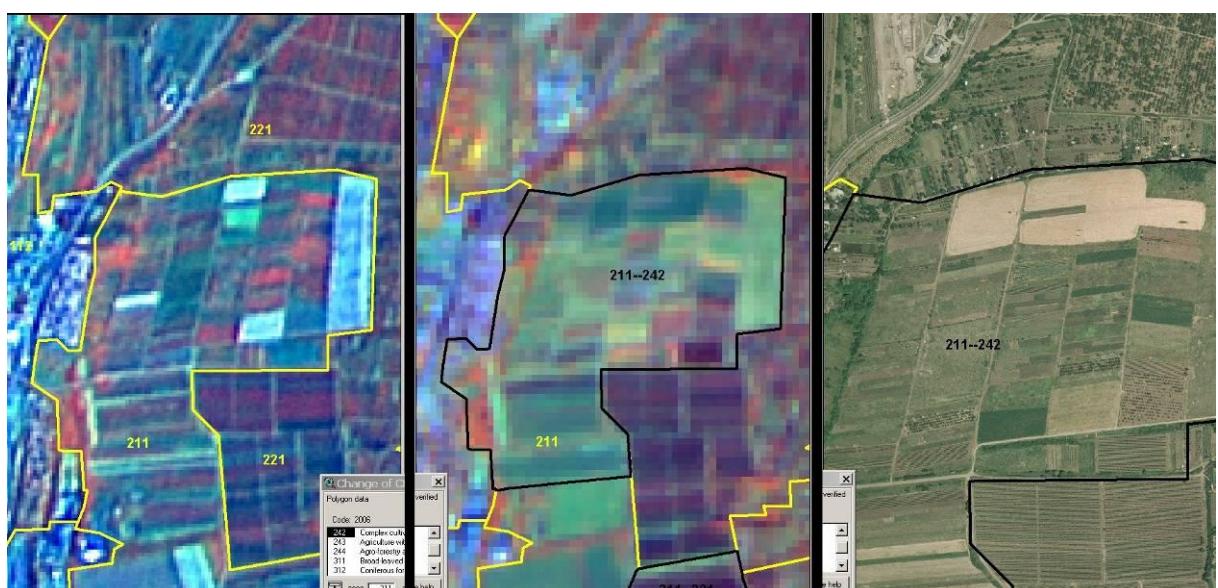
In CORINE Land Cover diversification of agricultural land use means that on a given area instead of a single crop type owners produce mixture of annual crops and / or multiyear crops and / or grass/hay. There can be different drivers: (1) socioeconomic factors: change in ownership; (2) financial factors: to produce more profitable crops, which require larger investment (e.g. orchards) or to make products that require less investment (grass, hay) and give higher profit (animal husbandry).

Number of changes in European CLC-Change: 558 polygons

Area of changes in European CLC-Change: 0.45 % of all change areas

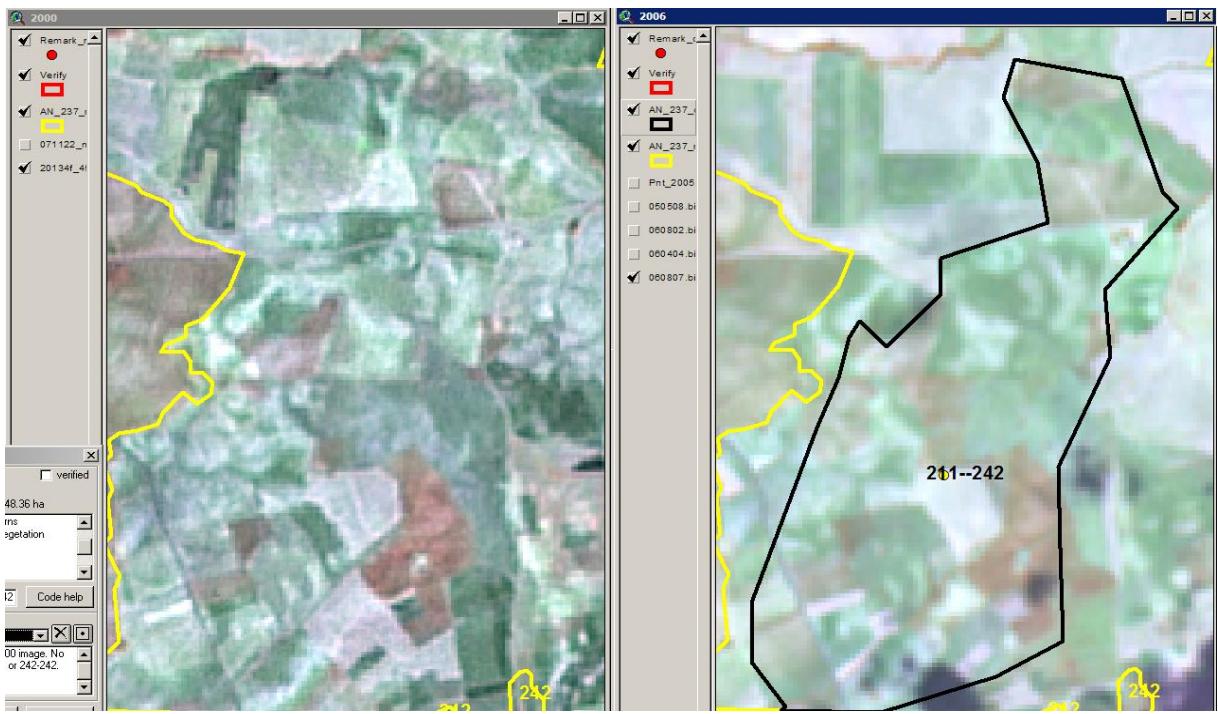
Type: Arable land changing to agricultural mosaic

Interpretation example (Hungary):

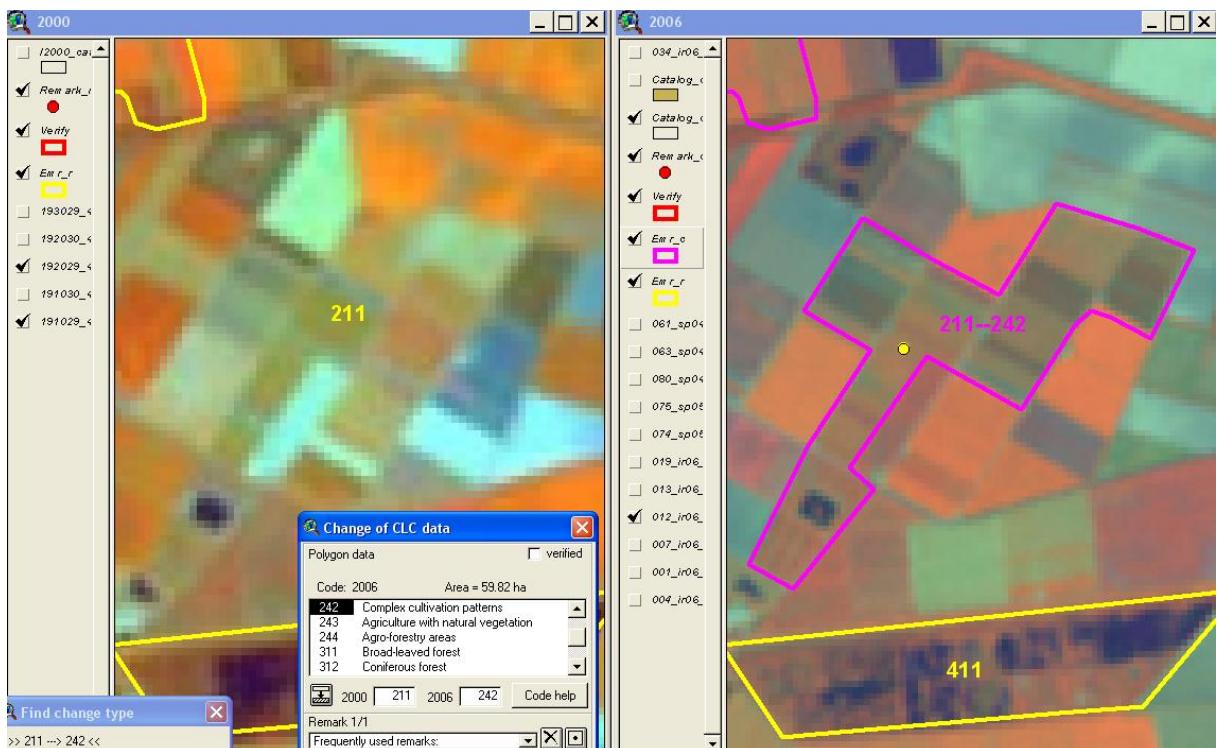


On IMAGE2000 (left) we see arable land with small parcels surrounded by vineyards (situation confirmed by topographic map at scale 1:50.000 and multi-temporal imagery). On IMAGE2006 (middle) the land cover situation seems similar at the first glance. However, taking a closer look some parcels similar in colour to the neighbour vineyards (221) can be recognized. Assumption is confirmed by the orthophoto (right image, taken in 2005). As vineyard parcels are scattered and small (<25 ha), a single 221 polygon cannot be delineated, class 242 (complex cultivation) should be applied instead. The mapped change process is 211-242. There are 292 polygons of this type covering 0.26 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

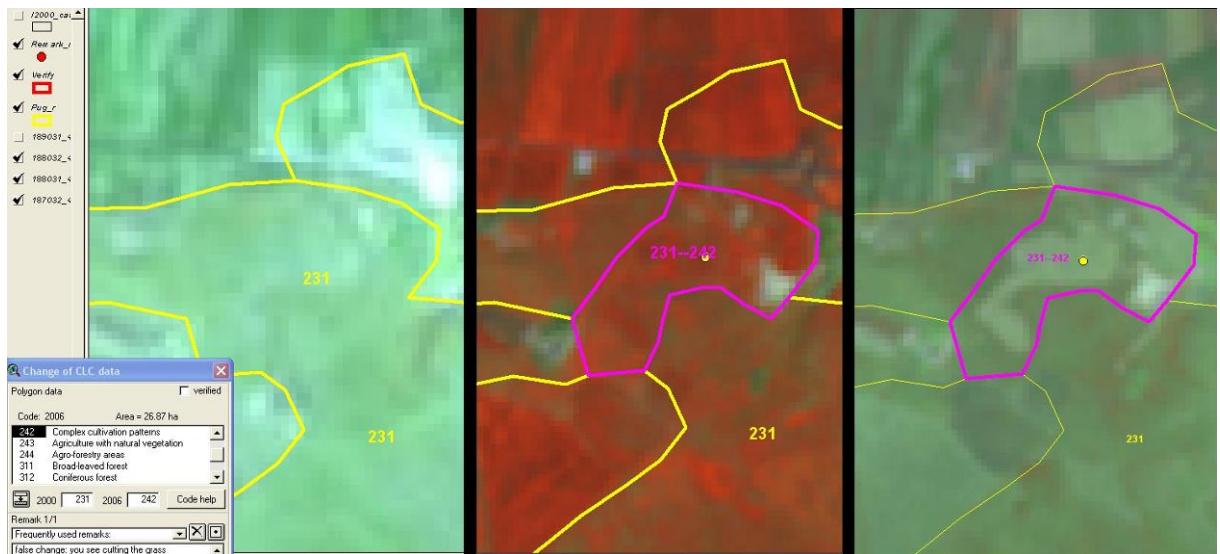
Frequent mistakes:	How to avoid the mistake
Diversification of agricultural land use	
False change due to good quality in-situ data for the new stock layer, but not for the old stock layer. The complex class is mapped in the new stock layer as a change, instead of correcting the old stock layer and mapping no change.	If "diversification of agriculture land use" is suspected, investigate carefully the old stock layer, using VHR imagery if available. If the feature existed in the previous inventory correct it, and map no change.
False changes caused by mistakes coming from not enough understanding of the 242 class. Simple colour and / or structural differences can be indications of this class, but are usually not sufficient.	Before mapping a change to 242, check the definition [3]. Try to apply VHR data or collect field information.



Mistake (Mediterranean area): In 2006 it was recognized (most likely based on VHR data) that the area is a mosaic of arable land and olives. As none of the constituents cover larger than 25 ha continuously, area was correctly classified as 242. However, if we compare IMAGE2000 (left) and IMAGE2006 (right) we cannot discover any significant structural difference: the same parcels with the same land cover already existed in 2000. Therefore the 211-242 change is false, and CLC2000 should have been corrected (242).



Mistake (continental Europe): In 2006 (right) it was probably recognized that the area is not homogeneous arable land, so it was interpreted as 242. However, the outlined polygon is not a mixture of different agricultural land uses, but a single land cover, probably fruit trees (222). Furthermore, comparing the two dates we discover the same outlines. Note the large field on the northeast part of change polygon, which was a new plantation in 2000, and grew up by 2006. Therefore the 211-242 change is false, and CLC2000 needs to be corrected (222).



Mistake: IMAGE2000 (left) was taken in May, while IMAGE2006 pictures were taken in April (central) and May (right). Colour difference indicates that grass, showing large biomass in April was cut by May, consequently mapped 231-242 is false, and no change took place. (The area is in Southern Europe.)

3.10 AFFORESTATION ON AGRICULTURE LAND

Change process: Afforestation on agriculture land: 211/231/243-324

Overview and rationale:

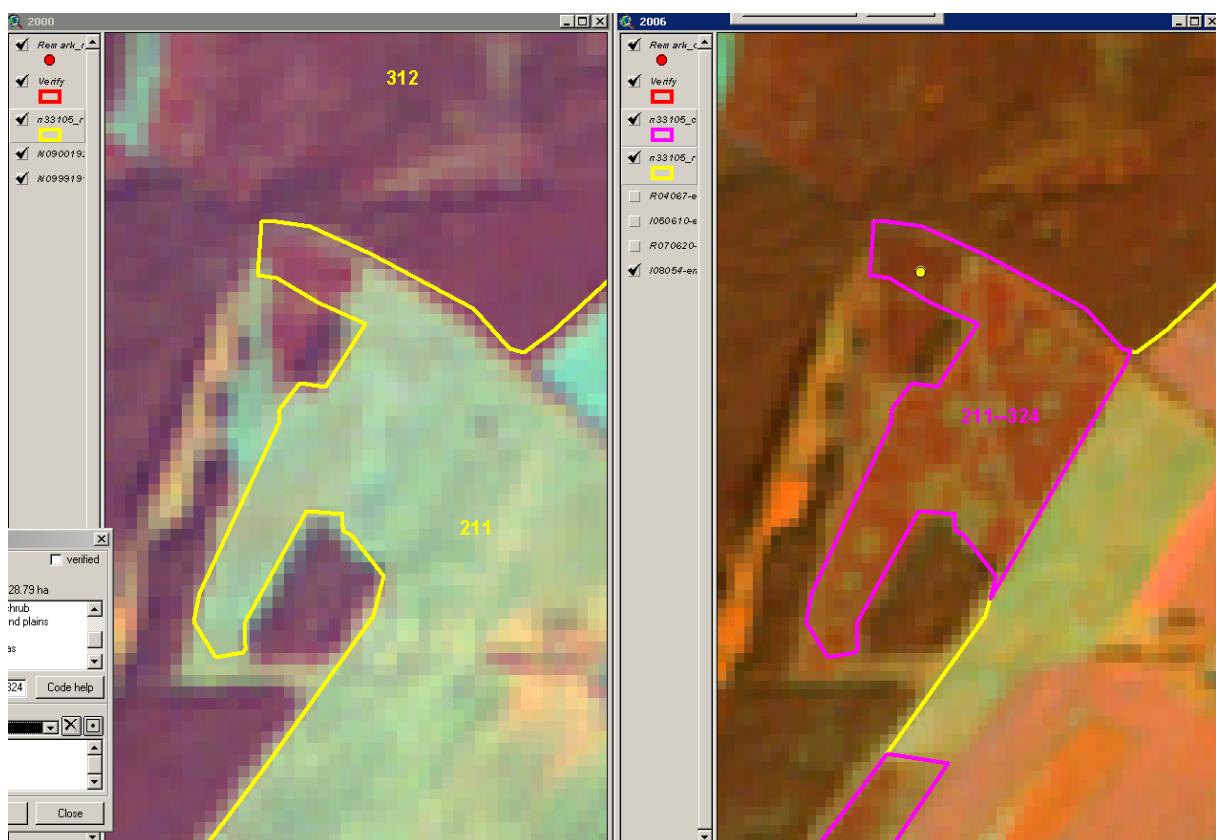
Modern, effective agricultural methods, which allow production of the same amount of crop on smaller area, the decrease of rural population and agricultural political measures are the key driving forces behind the withdrawal of farming. On the other hand, political measures on rural development are in favor of new forestation on abandoned farmland. Afforestation on former agriculture land has positive effect on biodiversity, climate and soil by increasing the forest cover (often significantly reduced in the past centuries), reduces the pressure on environment and provides important raw material for industry. An increasingly important factor behind this process is the requirement of decreasing greenhouse gas emissions. Intensive plantations (paperwood, fuel) with short cutting-cycle however might have more negative impact on environment than arable production.

Type: Arable land changed to transitional woodland: 211-324

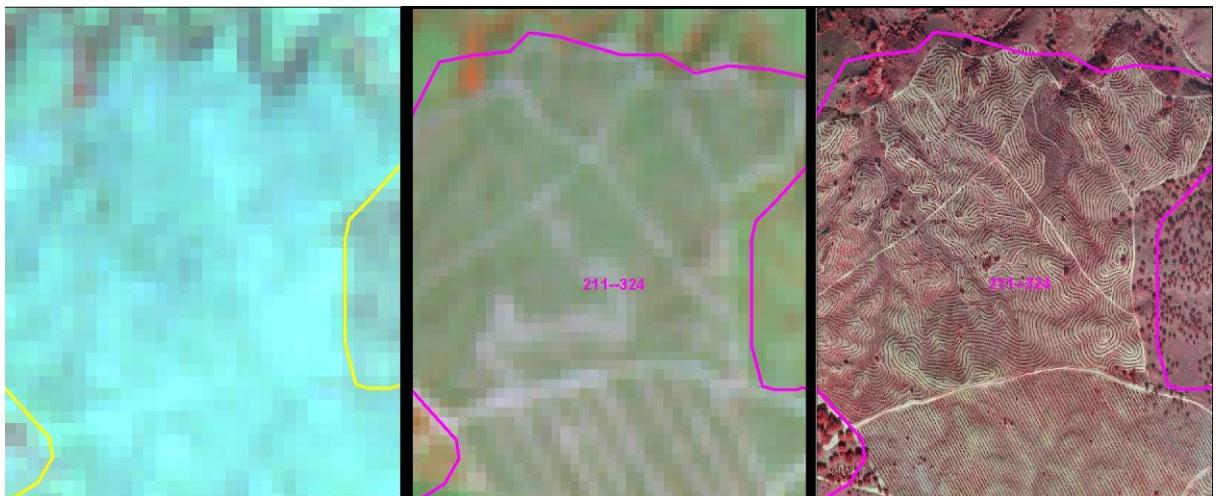
Number of changes in European CLC-Change: 5930 polygons

Area of changes in European CLC-Change: 1.93 % of all change areas

Interpretation examples (Poland, Portugal):

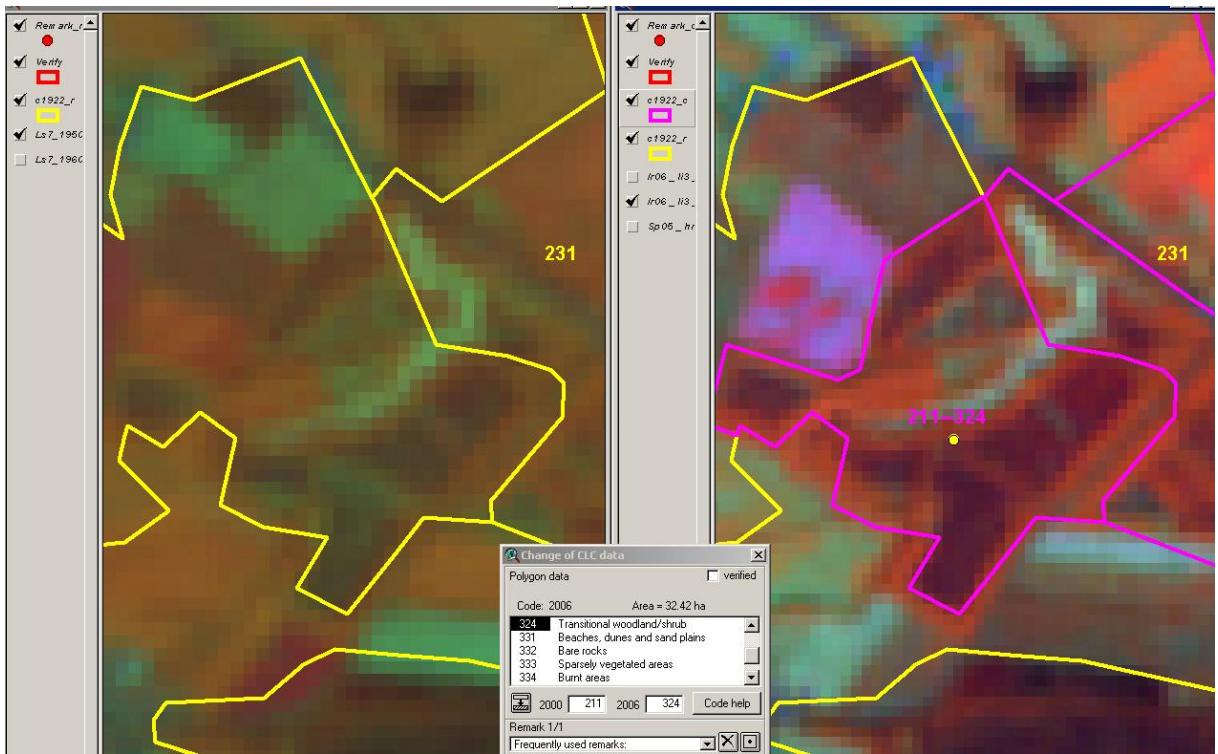


Arable land shown on IMAGE2000 (left) became afforested by 2006 (right) on this example from Poland. The new land cover is not yet considered to be forest (definition: 5-6 m height, more than 30% crown cover). On IMAGE2006 (right) the lighter colour of 211-324 polygon is different from that of the neighbouring mature forest. Another reason for using code 324 is that 6 years is usually too short period for a mature forest to develop. (The small area around the dot is a non-changed patch, and should have been separated from the 211-324 polygon if > 5 ha.) The mapped change process is 211-324. There are 3182 polygons of this type covering 1.07 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

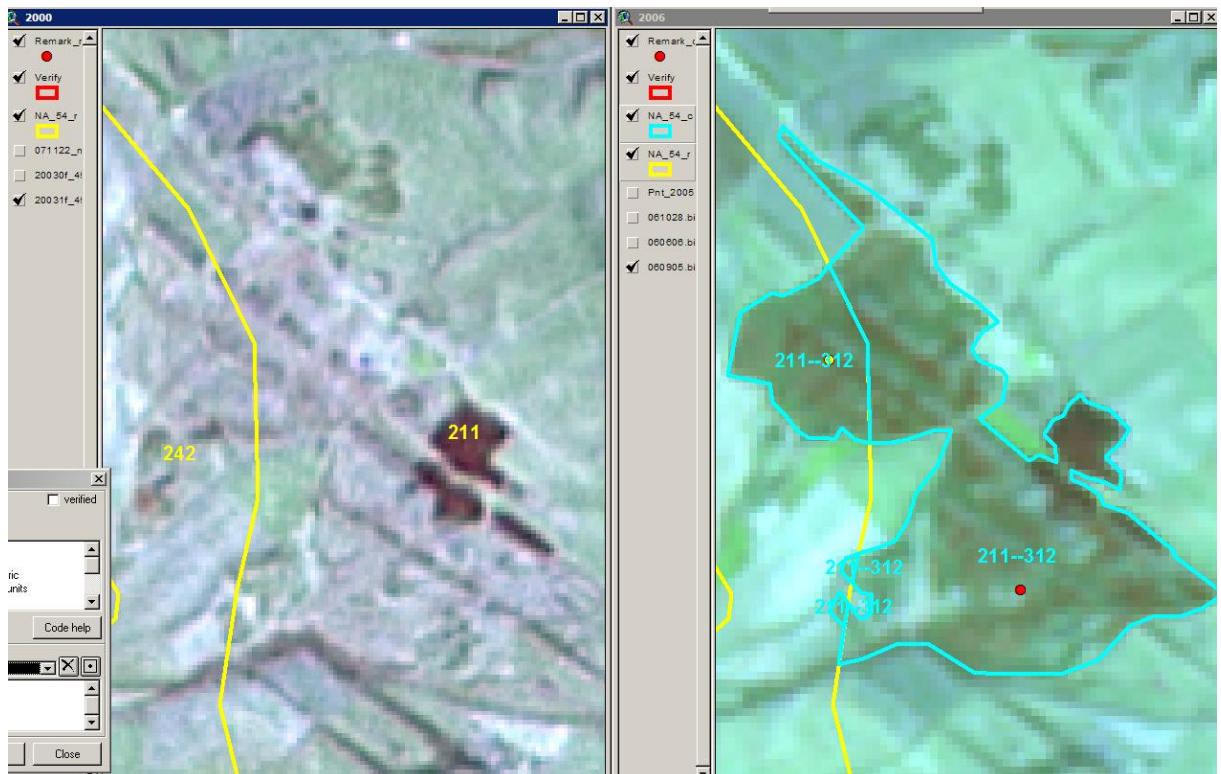


An afforestation example from Portugal. IMAGE2000 (left) shows non-irrigated arable land in summer (no green crops visible). IMAGE2006 (middle) shows a new geometric pattern, which is difficult to interpret without very-high-resolution information. A colour infrared (CIR) aerial photograph (right) is highly valuable in showing the plantation rows (along contour lines in the north part and straight in the south part). Without the VHR information this change is hardly possible to detect / interpret. There are 3182 polygons covering 1.07 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Frequent mistakes:	How to avoid the mistake
Afforestation on agriculture land Omitted changes: new plantation is not recognized	Check the area carefully at scale 1: 35-40.000. Use multi-temporal imagery. Recently established plantations should also be mapped as 324, even if almost no biomass (only the pattern) is visible on the image. VHR imagery helps much to recognize young plantations.
False changes: no change misinterpreted as change	Consider both parent images in interpreting this change. If the former image contains already 324 (and not agriculture), do not interpret a change. Recently established plantations should also be mapped as 324, even if almost no biomass only the pattern is visible on the image. VHR imagery helps much to recognize young plantations.
Wrong change code pair used: 211/231-31x interpreted instead of 211/231-324 or 324-31x	When mapping new afforestation area, use the "transitional woodland" class (= young forest, 324) instead of mature forest (311, 312, 313), because the time lapsed between two CLC inventories is usually not long enough for a mature forest to develop (except fast growing species, see Particularities). Also carefully examine old parent image as new plantation is often already visible on it. This case forest growth should be interpreted (324-31x).



Mistake: False 211-324 change. If we compare the corresponding areas on IMAGE2000 (left) and IMAGE2006 (right) it can be concluded that no CLC change took place between 2000 and 2006, and the right code is 324 in both dates. In other words a 324 polygon was omitted in CLC2000. Subtle colour differences are mostly attributed to sensor and seasonal differences.



Mistake: wrong change code pair 211-312. IMAGE2000 (left) shows an agriculture area (211, 242). IMAGE2006 (right) indicates afforestation, which was coded as 211-312. Six years however is usually too short for a mature coniferous forest to develop, therefore the right code is 211-324. (An additional technical mistake is that the code of change polygon on the west and CLC2000 code do not match; see Ch. 6.5).

Particularity-1

Type: New fast-growing deciduous forest (plantation) on arable land: 211-311

Interpretation example (Hungary):

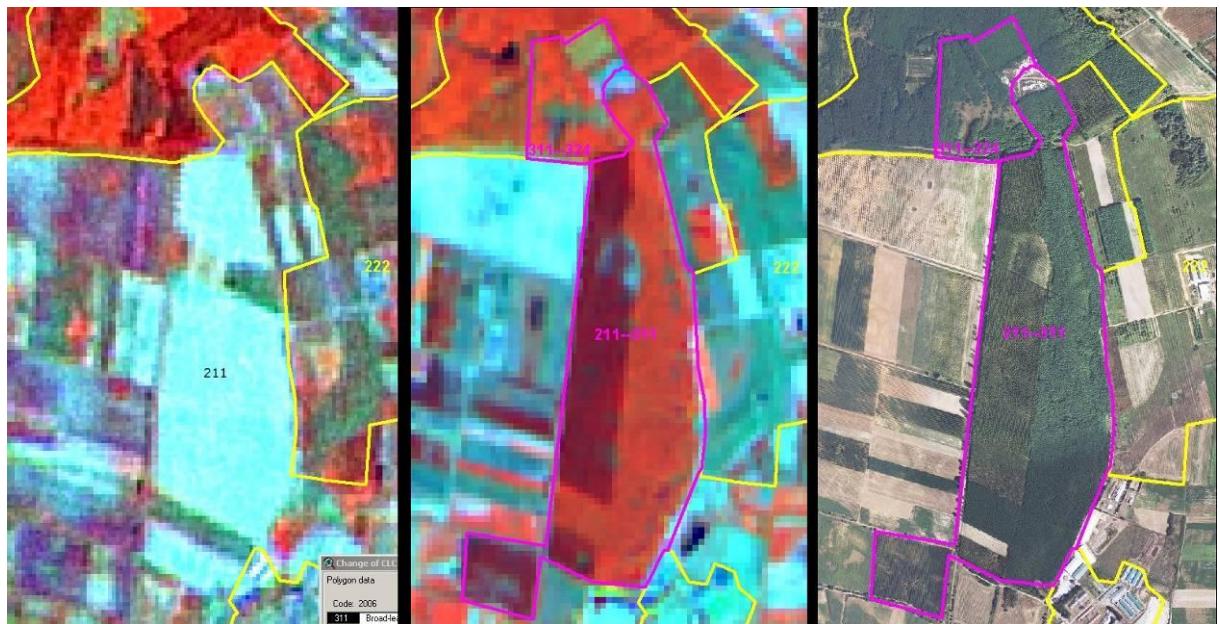


IMAGE2000 shows an area dominated by arable land. In six years on part of the arable land a mature forest developed (IMAGE2006, middle). The colour of the area coded as 211-311 is similar to the existing forest north of the polygon. The existence of forest is confirmed by orthophoto, showing rows of plantation and the forest stand with closed canopy (right). In some parts of Europe fast-growing forest species are common (e.g. poplars in Central Europe, eucalyptus in Southern Europe). In such cases 211/231/243-311 changes are allowed, otherwise 324 is recommended. There are 241 polygons of this type covering 0.06 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

3.11 ABANDONMENT OF OR AFFORESTATION ON AGROFORESTRY AREAS

Change process: Abandonment of or afforestation on agroforestry areas: 244-324

Overview and rationale:

Agroforestry areas (called 'dehesa' in Spain and 'montado' in Portugal) are important landscape types, found especially in the Iberian Peninsula. Parcels used for agriculture (especially for grazing, but sometimes for annual crops) include also scattered deciduous forestry trees (usually oak). Trees protect the soil against sunshine and their fruit (usually acorn) feeds grazing stock (usually pigs).

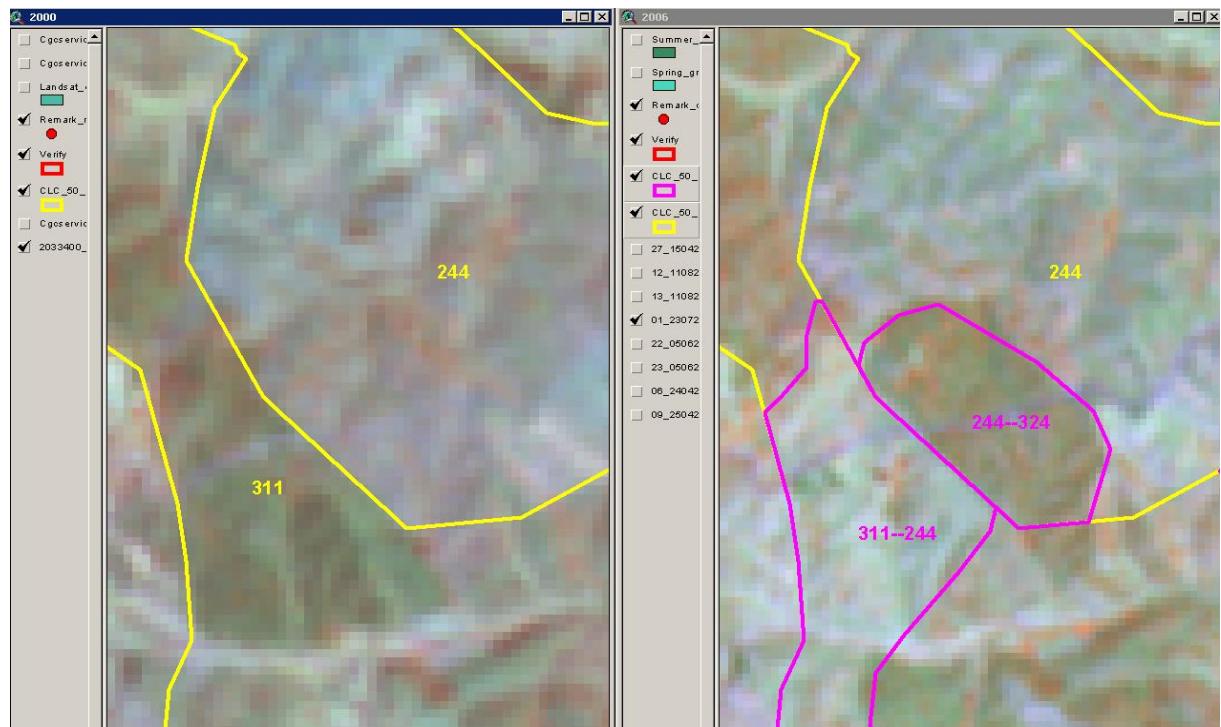
Without maintenance (cultivation) successions soon begins on agroforestry areas turning them to transitional woodland-shrub (or even forest), which is visible on satellite images. Compared to the previous process (Afforestation on agriculture land – Ch. 3.1), which is usually of anthropogenic origin, this process is usually driven by nature (however man-made afforestation also occurs). Additionally, this process is usually periodic, i.e. after certain time the area is cleared again and returns to the status of agroforestry (see Ch. 4.4). Besides being part of agricultural practice, abandonment in large scale is also an indicator of declining rural population. Rural development policies aim some measures to keep these areas in cultivation.

Type: Abandonment of or afforestation on agroforestry areas: 244-324

Number of changes in European CLC-Change: 335 polygons

Area of changes in European CLC-Change: 0.20 % of all change areas

Interpretation examples (Portugal):



This example shows the typical rotation between agroforestry areas and forests. The cycle of process is a few decades. The large agroforestry area (244) on IMAGE2000 (left) has become transitional woodland-shrub (244-324), due to grazing or arable farming being stopped. This is part of the traditional local agriculture practice. The reverse process is seen on left side of images: forest is turned to agroforestry (311-244), meaning that the area was cleaned in order to (re)start agriculture. In majority of cases VHR imagery or ancillary data is needed for identification of these processes. See details in Ch. 4.4. There are 335 polygons of the 244-324 type covering 0.2 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

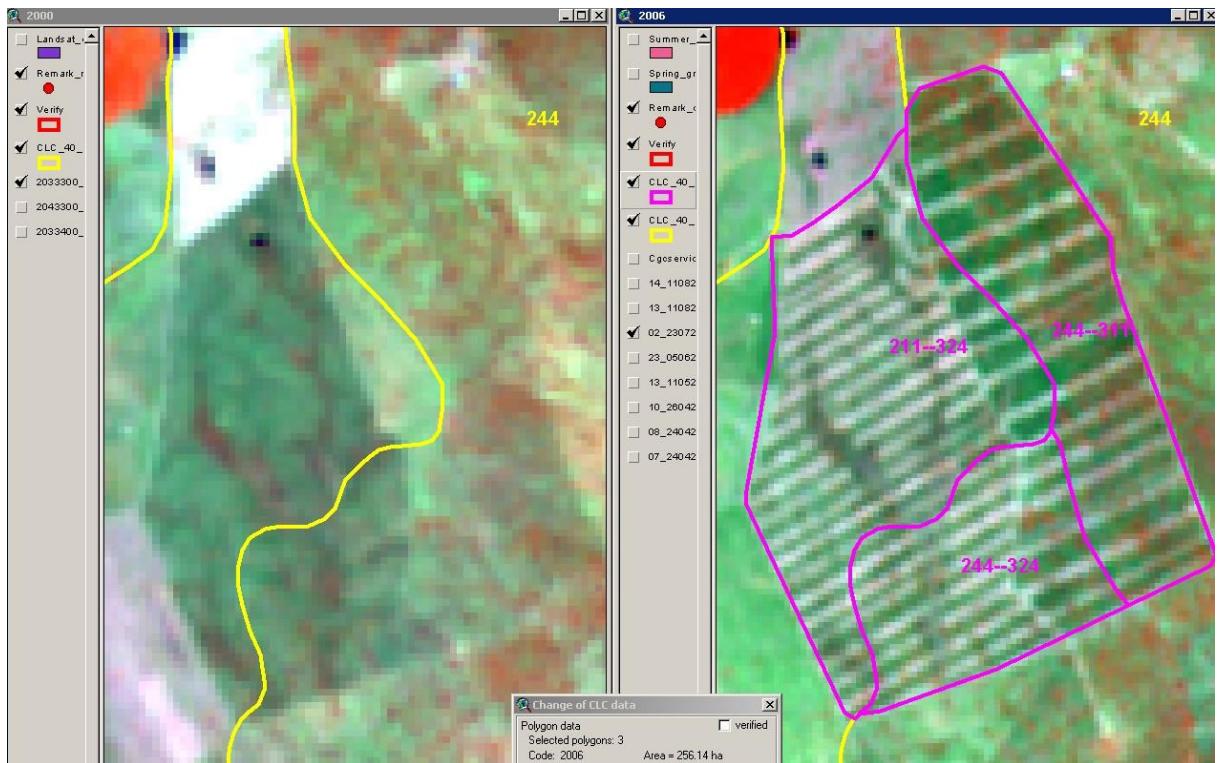
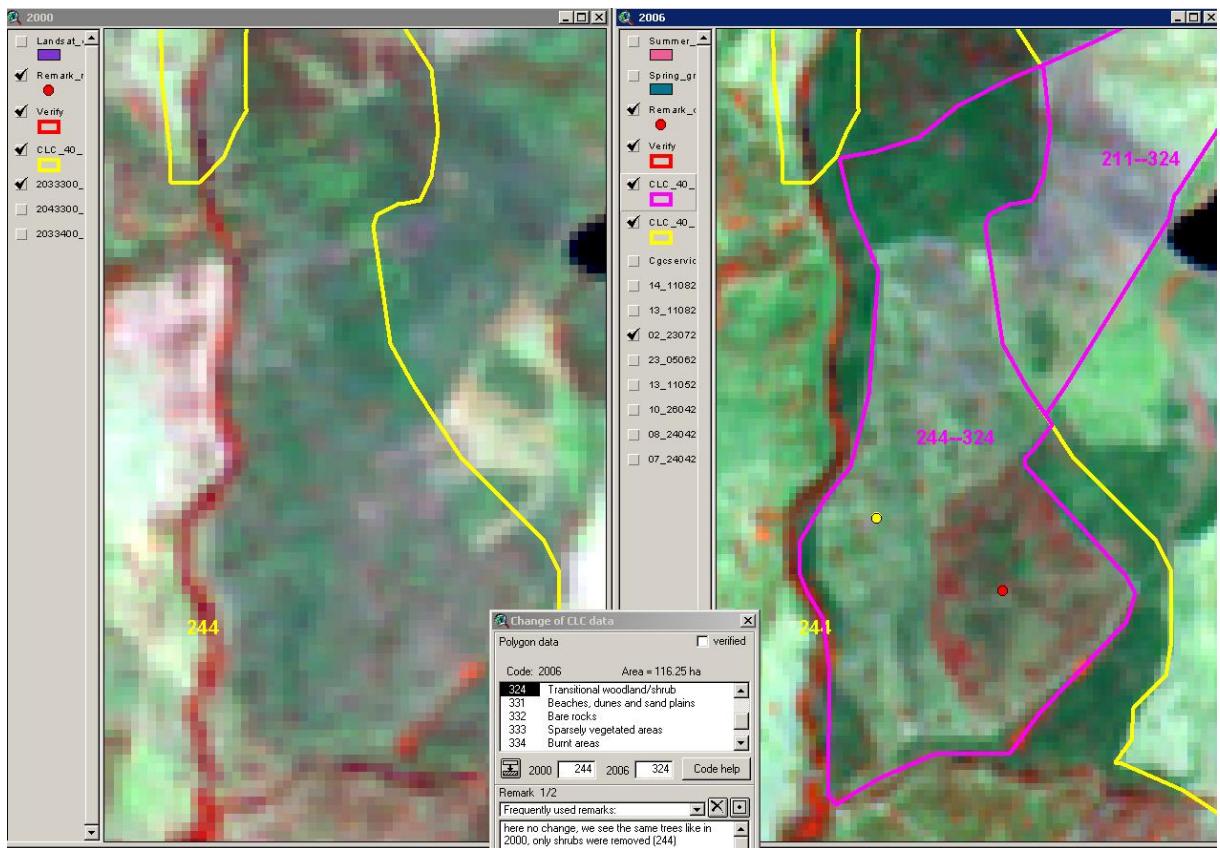


IMAGE2000 (left) shows an agricultural area including 211 and 244 patches. According to IMAGE2006 (right) afforestation was done, resulting changes 211-324 and 244-324. Note that in this example afforestation (human impact) occurred, while in the previous example natural succession is behind the emergence of class 324. There are 335 polygons of the 244-324 type covering 0.2% of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Frequent mistakes:	How to avoid the mistake
Abandonment of or afforestation on agroforestry areas	
Omitted changes due to non-availability or ignorance of very-high-resolution images	Changes are easily omitted if the parent stock layer has omitted 244 polygons. VHR imagery is necessary for recognizing agroforestry areas.
False changes	Several factors should be considered when mapping this change (244-324). In most of the cases, the 244 area becomes darker due to the emerging vegetation (will be similar to "forest"), and brighter spots of farming will disappear.



Mistake in mapping 244-324 (overestimation of change area). Around the red dot we see development of shrubs between 2000 (left) and 2006 (right), here 244-324 is correct. Around the yellow dot the pattern on the two images is the same. We suspect that either no CLC change happened or even the opposite 324-244 change occurred. The lighter colour of surface might indicate removal of shrubs, or just a sensor / seasonal difference between 2000 and 2006. Most of the polygon outlined as 244-324 change is thus false.

3.12 NEW WATER BODY ON ARABLE LAND

Change process: New water body on arable land: 211-512

Overview and rationale:

Water bodies are created for several reasons: (1) Reservoirs supporting irrigation compensating for the uneven distribution of rainfall. They are extremely important in the Mediterranean region. (2) Reservoirs created behind hydroelectric dams. (3) Reservoirs created for water retention and flood control. (4) Fishponds are constructed to breed fish. (5) Drinking water reserves are used to supply citizens. (6) Former underwater mining areas are often transformed to water bodies used as leisure facilities. (7) Formerly dried up / disappeared wetlands / lakes might be reconstructed for nature conservation purpose.

Many of the above processes affect agricultural land, including arable land.

Type: New water body on arable land: 211-512

Number of changes in European CLC-Change: 800 polygons

Area of changes in European CLC-Change: 0.20 % of all change areas

Interpretation examples (Turkey, Hungary):

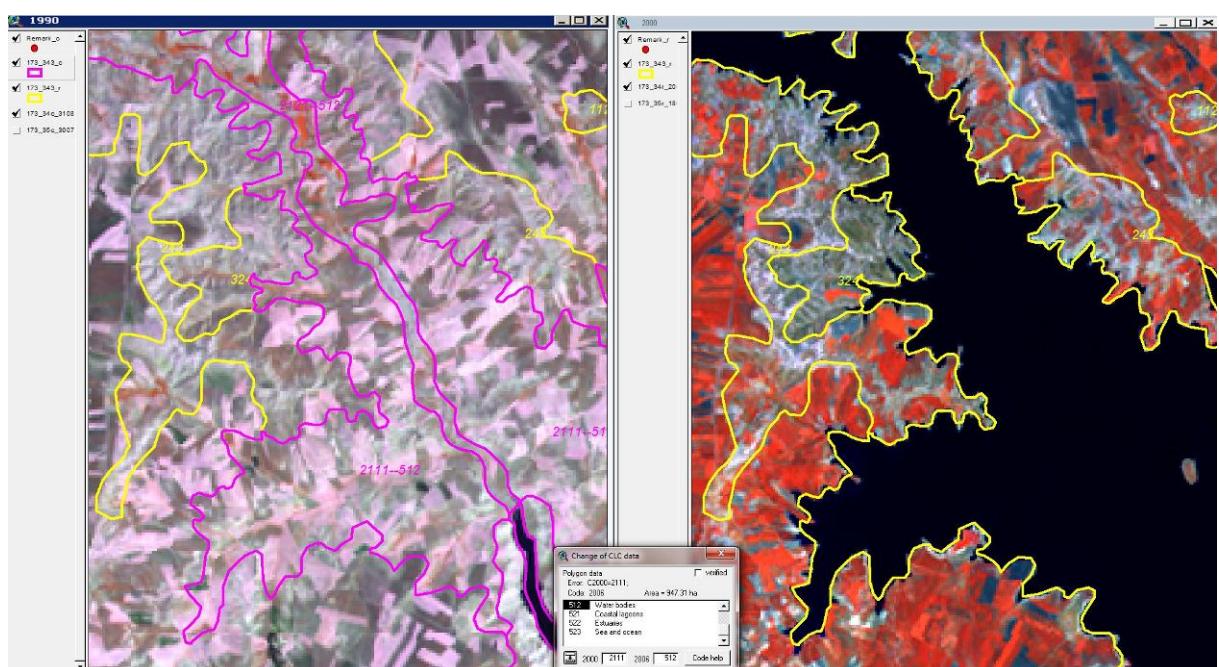
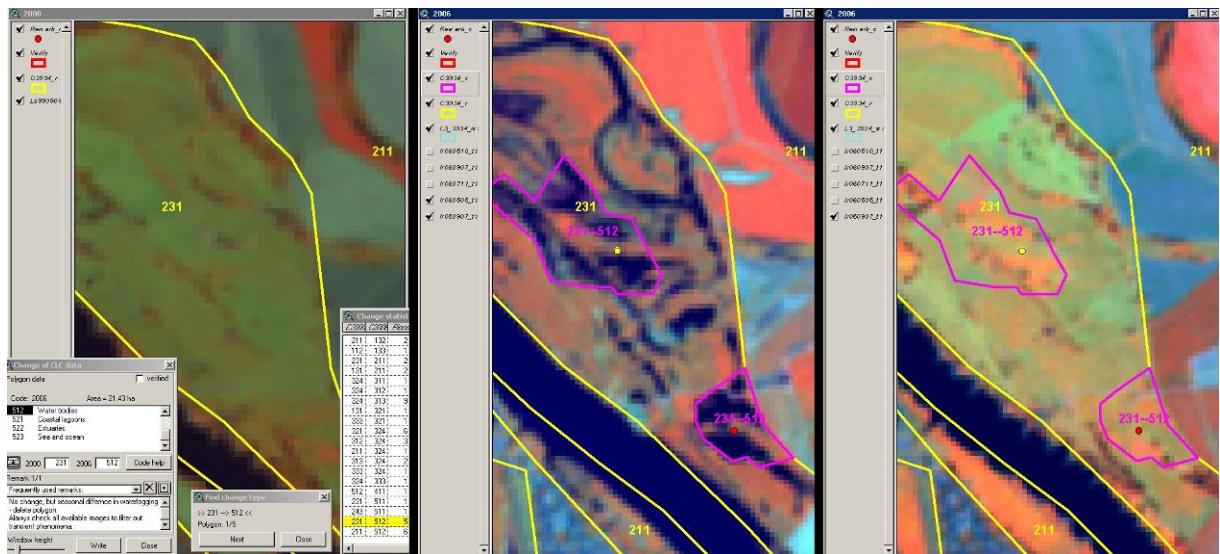


IMAGE1990 (left) shows an agricultural area along a small river. IMAGE2000 (right) shows a new water body (most probably an irrigation water reservoir) replacing the former arable land (211) and irrigated arable land (212). There are 800 polygons of this type covering 0.2 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

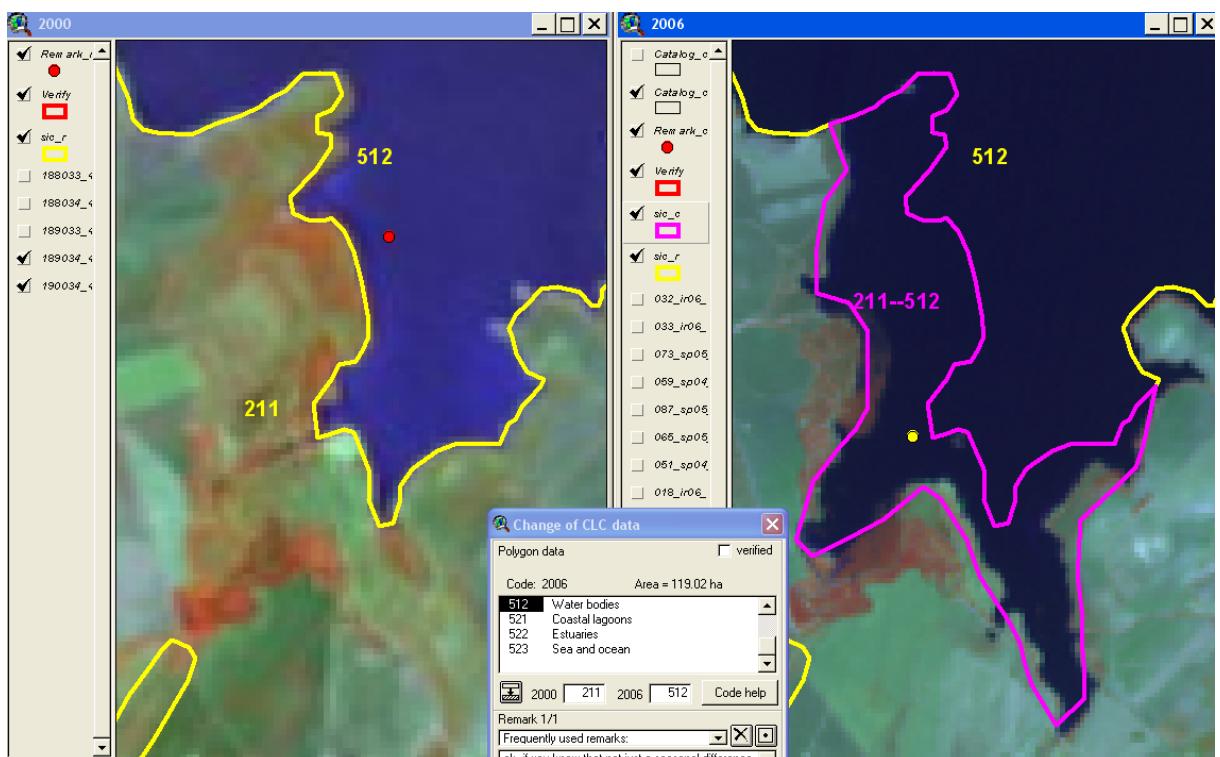


A fishpond in an arable land area (IMAGE2000, left) was enlarged by a 25 ha new pond (IMAGE2006, right). There are 800 polygons of this type covering 0.2 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

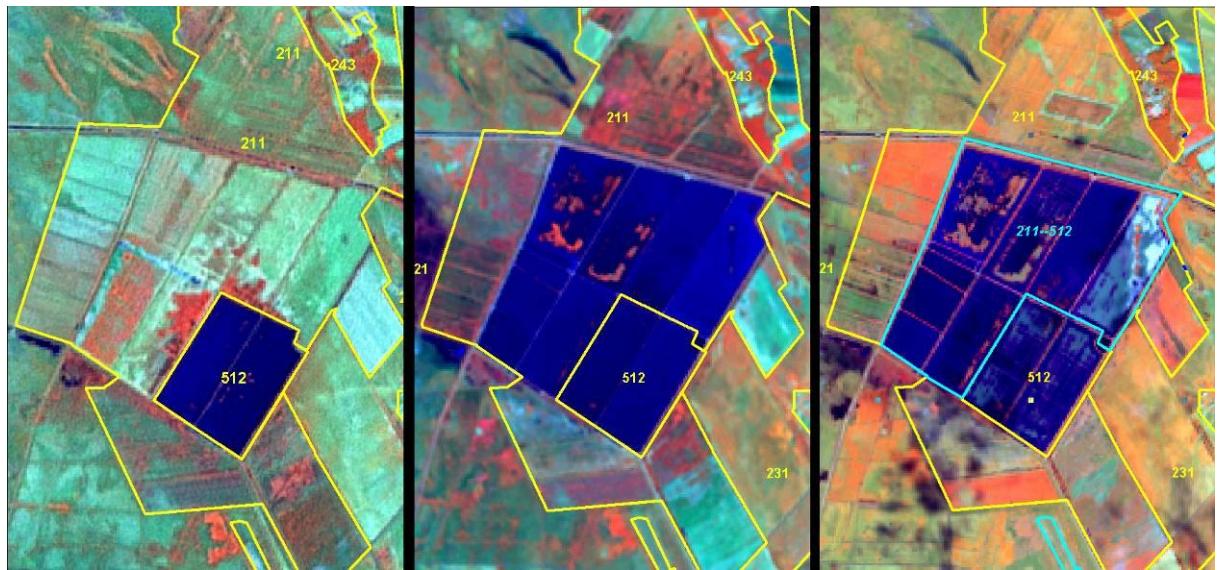
Frequent mistakes:	How to avoid the mistake
New water body on arable land	
Omitted changes	Visual recognition of water is fairly easy. After completing the work area check it again carefully at scale cca. 1: 35.000.
False changes: temporary differences interpreted as CLC change	Check all available images. Images taken in spring (or after heavy rain) may be misleading. In case of reservoirs, in-situ data should be checked to decide whether we see a real change (e.g. filling up the reservoir), or just seeing a seasonal difference (shrinking of water surface in dry summer period).
False changes: gravel/sand pits misinterpreted as water body.	Gravel extraction pits often lie in river valleys where the water table is high, so they may fill naturally with water to form ponds or lakes. Mineral extraction (131) however has a preference over water bodies (512) in mapping [3]. In case of a small (cca. 25 ha) underwater material extraction site, 131 code should be used and not 512. Lack of material deposit on the lakeshore is indication of 512.



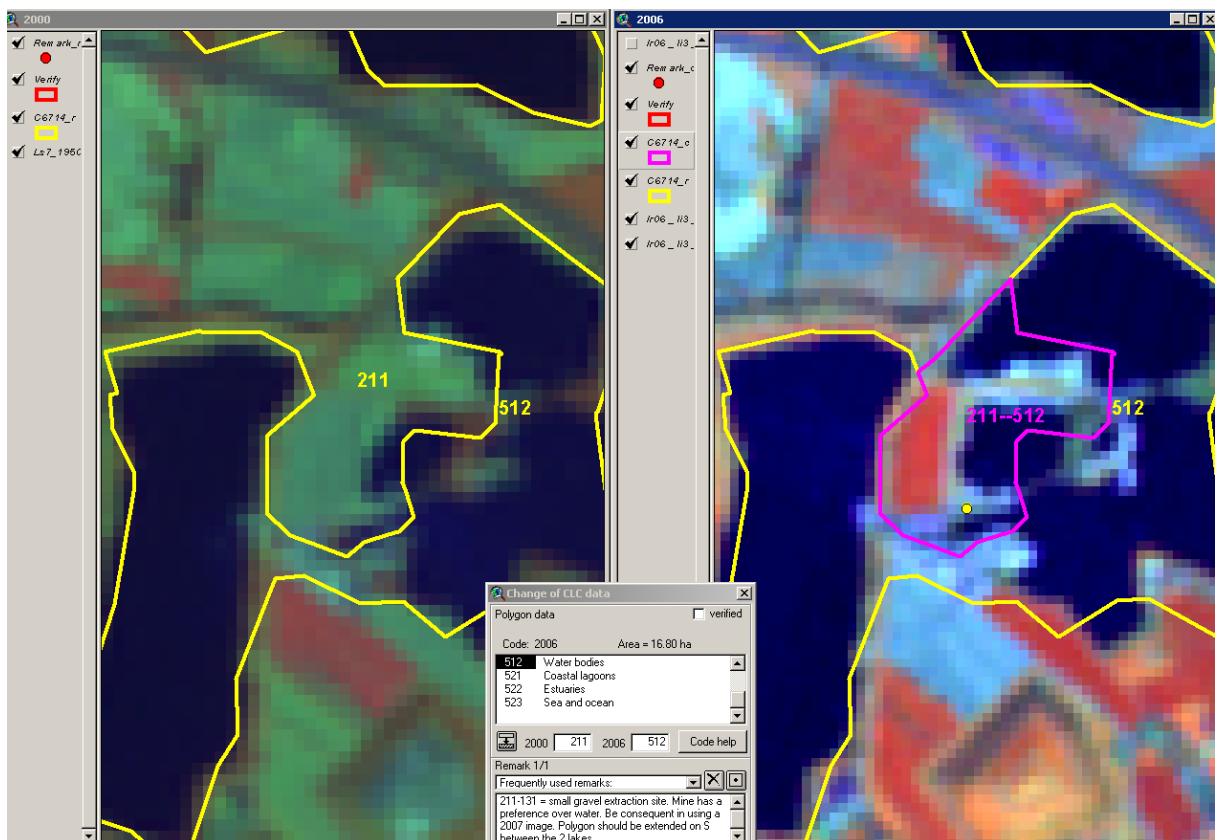
Mistake: IMAGE2000 (left) shows grassland (pasture). There are two images taken in 2006: May image shows heavy water-logging (middle), while September image (right) is without water. Consequently, 231-512 polygons are not CLC changes, but seasonal differences, thus should be deleted. Always check all available images to filter out transient phenomena.



Questionable 211-512 change: IMAGE2000 (left) shows an agriculture area with a water body. The area on the edge of the lake is not an arable land, but grassland, as we do not see any field structure (compare with areas west or south from it, where fields are clearly visible). IMAGE2006 (right) shows that water body got larger and grassland was inundated. Multi-temporal satellite imagery and / or ancillary data are needed to decide if this is a CLC change (meaning filling up the reservoir: 231-512), or just a seasonal difference in water level (no CLC change to be mapped).



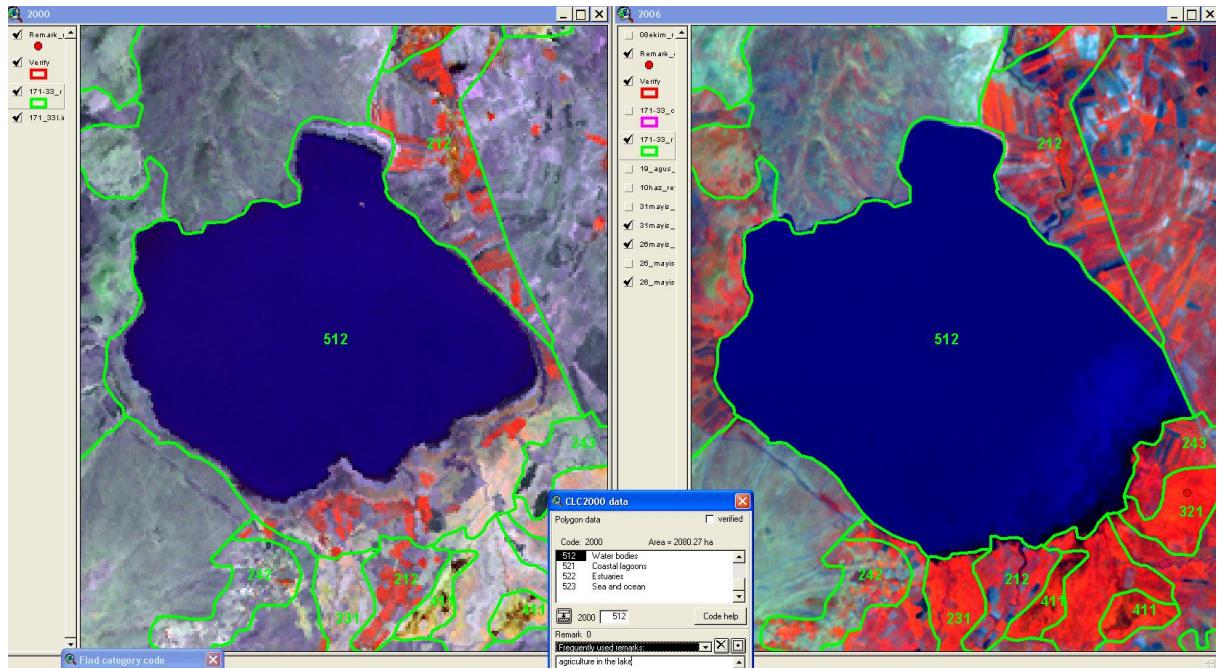
Mistake: False 211-512 change is mapped due to seasonal changes of fishpond water levels being misinterpreted. IMAGE2000 taken in August (left) was compared to IMAGE2006 taken in July (right), which led to mapping the 211-512 change. However, if the other IMAGE2000 image, taken in July (middle) is examined, we see that actually no change occurred between 2000 and 2006. Cassettes of fishponds are occasionally emptied as part of their management. These short (few-month-long) empty periods should not be considered CLC change. Here the right solution would have been to correct the polygon to 512 in CLC2000 (left).



Mistake in mapping new water bodies inside arable land. IMAGE2000 (left) shows a water body inside an agriculture area. In 2006 (right) water area slightly extended. However, we also see the typical bright signature of extracted material (see around yellow dot), which suggest that the new feature is not a water body, but a gravel pit. The right code would be 211-131. (Inclusion of the red-coloured field is a generalisation mistake.)

Particularity-1

Type: New water body on arable land (seasonal only): no CLC-Change
Interpretation example (Turkey):



Example of a lake with multiple land use. IMAGE2000 (left) was taken in September. Due to irrigation and natural evaporation the lake has shrunk by then. The south-east edge of the lake is temporarily used for agriculture. IMAGE2006 (right) was taken in May, when the water level is higher, and the area used for agriculture in late summer is under water. This alternation of water and arable land is not mapped by CORINE Land Cover, but considered as seasonal difference.

4 MOST FREQUENT CHANGES OF THE FORESTS AND SEMI-NATURAL CLASSES

4.1 FOREST OR SEMINATURAL AREA CHANGED TO MINERAL EXTRACTION SITE

Change process: Forest or semi-natural area changed to mineral extraction site: 312/324-131

Overview and rationale:

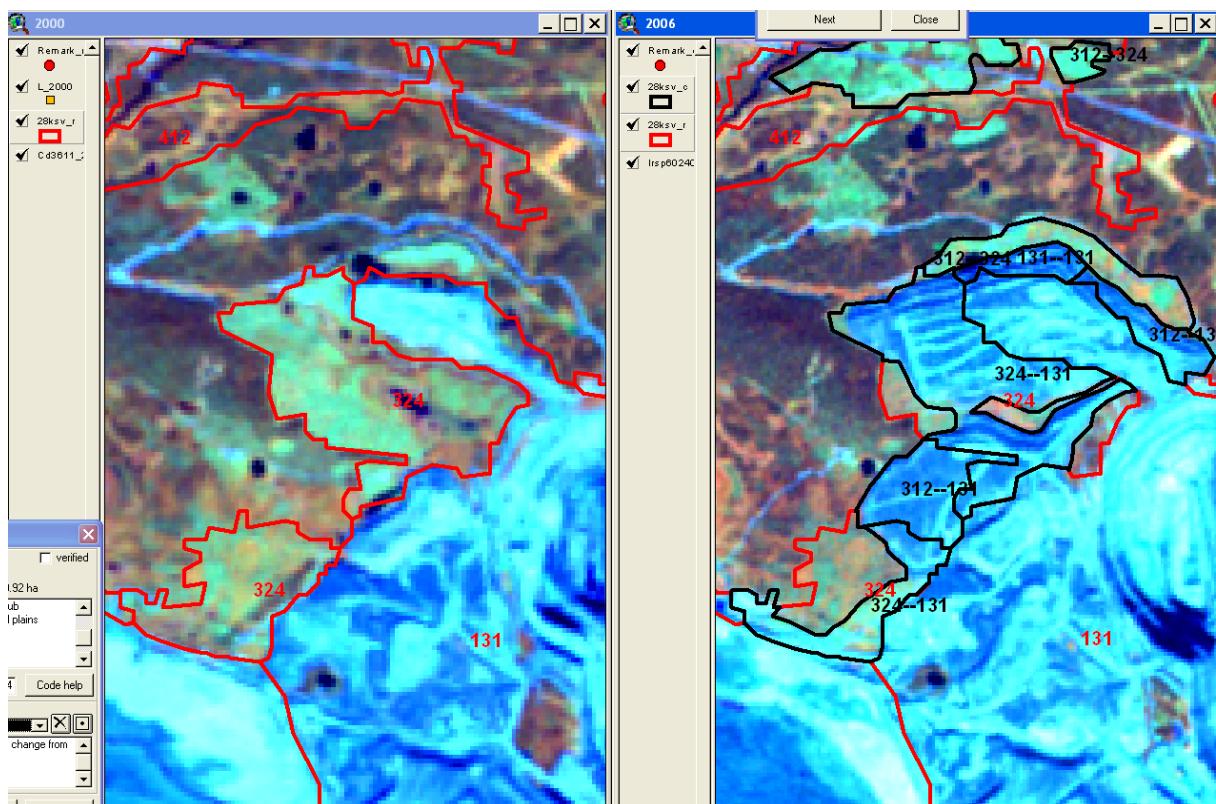
The need for raw material and energy is such strong demand that it normally overwrites any other considerations. Sometimes even residential areas are removed in order to give ground for mineral extraction. Forest and semi-natural areas most easily fall prey to mining activity, as they have relatively lower economic value, while nature conservation considerations are seldom strong enough for protection.

Number of changes in European CLC-Change: 1507 polygons

Area of changes in European CLC-Change: 0.29 %

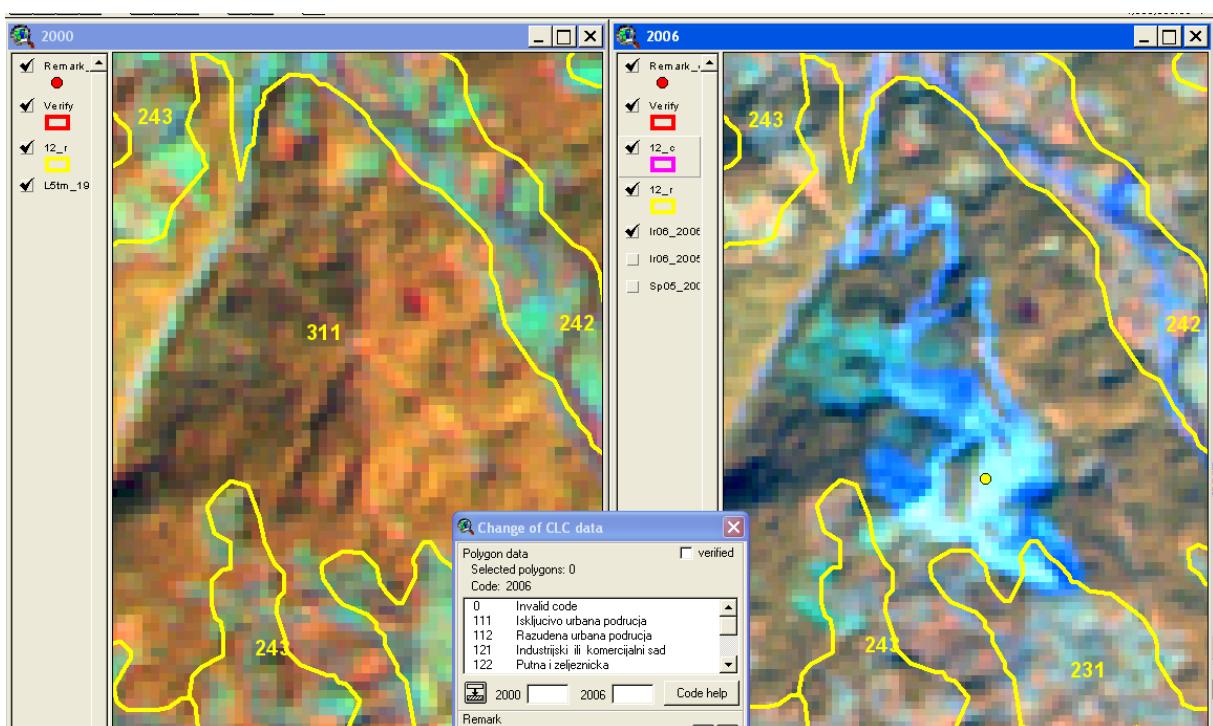
Type: Forest and transitional woodland-shrub changed to mineral extraction site: 312-131, 324-131

Interpretation example (Sweden):



Extension of mining. On IMAGE2000 (left) coniferous forest and transitional woodland-shrub became mineral extraction site, as indicated by IMAGE2006 (right). The removal of vegetation and soil is evident. There are 820 pieces of 312-131 change type covering 0.14 % of all changes and 687 pieces of 324-131 polygons covering 0.15 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Frequent mistakes:	How to avoid the mistake
Forest or semi-natural area changed to mineral extraction site	
Omitted changes	<p>Revise all 131 polygons in the parent stock layer to find mine enlargements.</p> <p>Visually scan the area in scale 1:40.000 to find new mineral extraction sites.</p> <p>As growth of open pit mines can be very fast, use of latest image is important for avoiding omissions.</p>
False change	<p>New mines might be mistaken with forest clearcut or constructions. Use multi-temporal imagery, for filtering out clearcuts by detecting vegetation development.</p>



Mistake: Missing 311-131 change. Homogeneous patch of deciduous forest (311) in 2000 (left) is partly replaced by bright blue / white bare rock surface in 2006 (right). The pattern (road, pits) suggests that the bright spot is a mineral extraction site, most likely a quarry, so the omitted change is 311-131. Missing new mineral extraction sites such as this one, most easily can be found by systematically scanning through the area visually in scale 1:40.000.

4.2 FOREST OR SEMINATURAL AREA CHANGED TO CONSTRUCTION SITE

Change process: Forest or seminatural area changed to construction site: 312/321/323-133

Overview and rationale:

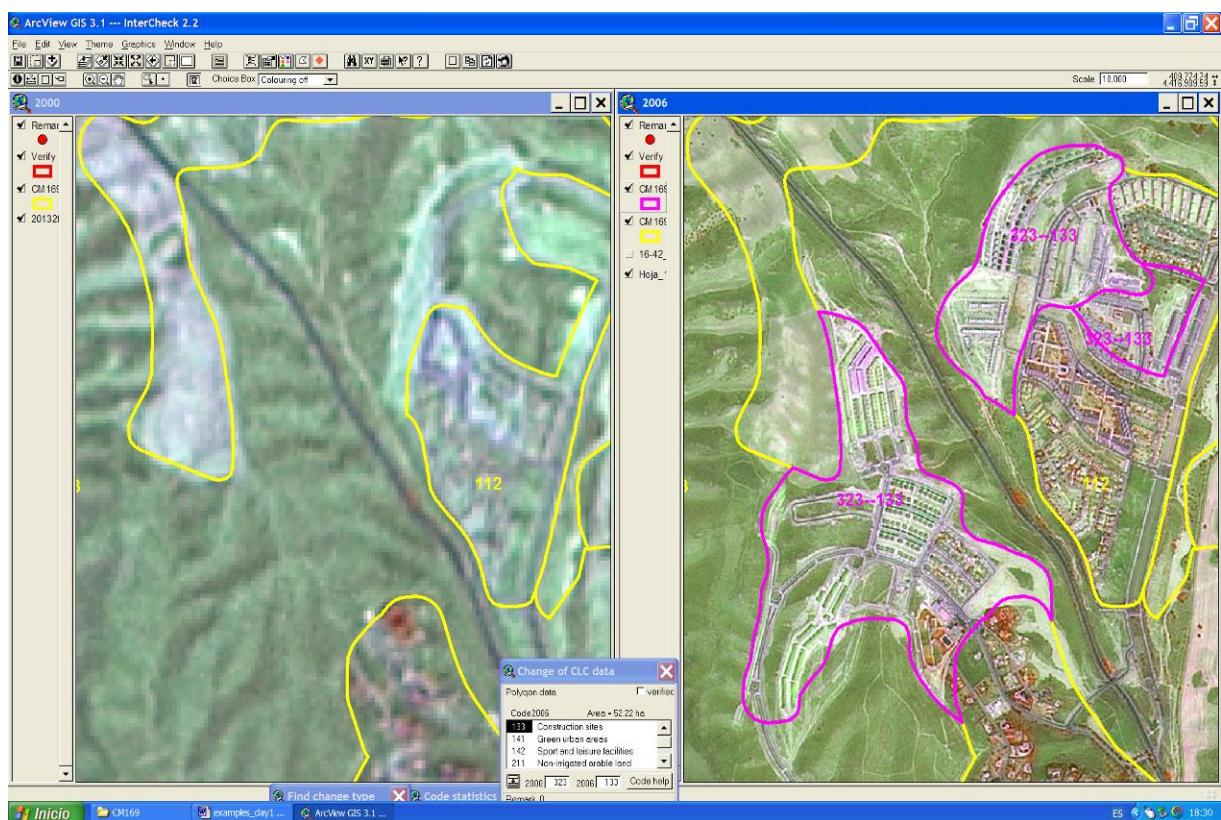
Urban sprawl, emergence of industrial sites, construction of new roads / railway, leisure facilities or water reservoirs often affect semi-natural areas in Europe. The first step of these processes is described by class construction sites (133) in CORINE Land Cover. The process often begins with removal of vegetation, and the removal of topsoil and rock by digging or blasting, creating the typical spectral signature of constructions sites. It is however the spatial pattern that allows distinguishing constructions sites from mineral extraction sites; street structure, road track or pattern of future greens on golf courses are often recognisable already during the construction. Environmental impacts include habitat loss and fragmentation, loss of soil, pollution, noise, while social impact varies depending on the type of construction: e.g. increased dependence of automobiles in case of urban sprawl; increased profitability of agriculture in case of new irrigation water reservoirs.

Number of changes in European CLC-Change: 1294 polygons

Area of changes in European CLC-Change: 0.35 % of all change areas

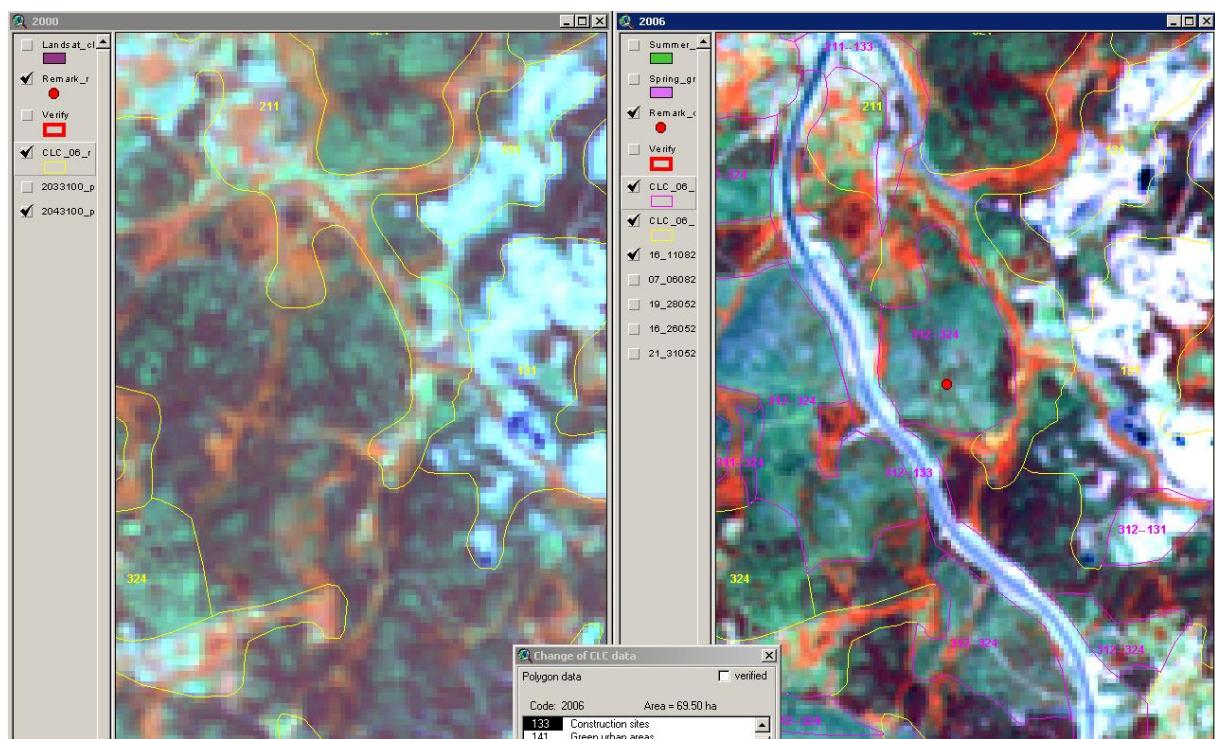
Type: Sclerophyllous vegetation changed to construction site: 323-133

Interpretation example (Spain):



The Mediterranean shrub (323) covering large part of the image was built up between 2000 (left) and 2006 (right). Note the different appearance of 133 polygons from existing 112 polygons, which is mainly due to the lack of urban green in the construction sites (133). Huge residential developments, being typical of the Iberian Peninsula between 2000 and 2006 do mostly occupy sclerophyllous shrub and other semi-natural areas. There are 386 pieces of 323-133 type covering 0.13 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

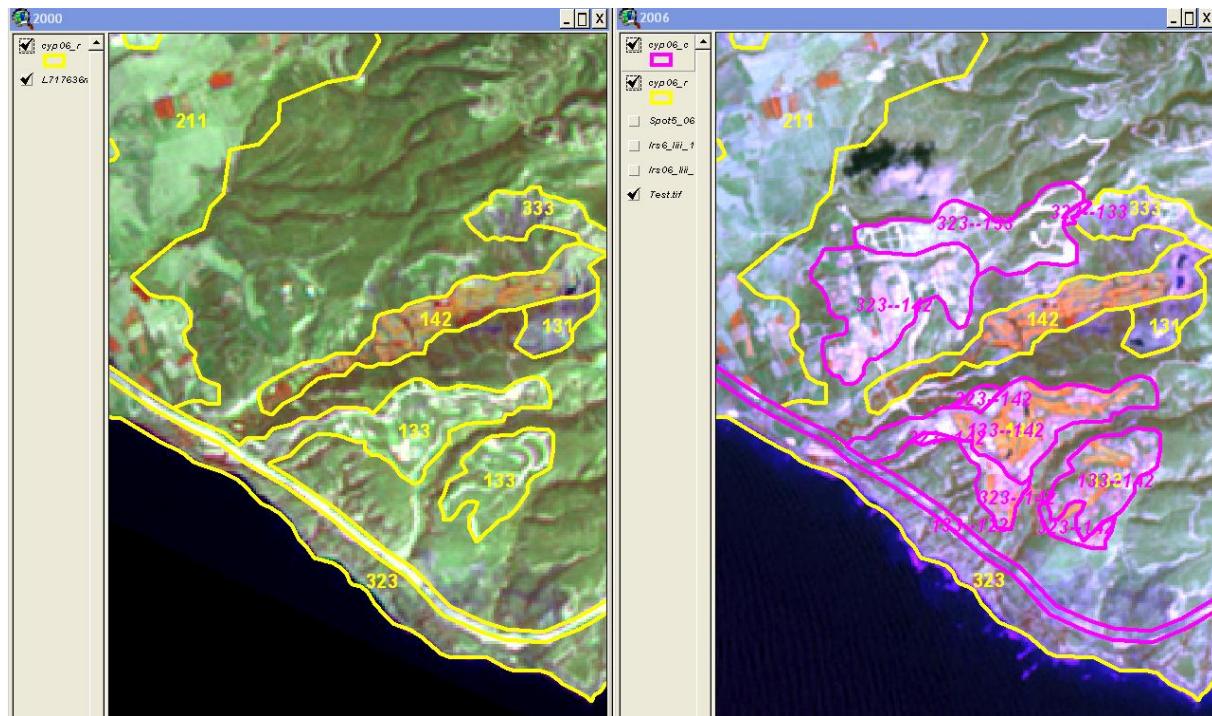
Type: Road construction in coniferous forest: 312-133
Interpretation example (Portugal):



Road construction on former natural area (mostly 312). Road construction, a particular construction type is easy to recognize. Bright colour of the disturbed rock surface / soil helps distinguishing construction from already finished road, where surrounding areas are already reclaimed and additional infrastructure finished. There are 558 polygons of this type covering 0.11 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Type: Construction of sport and recreation areas (golf courses): 323-133

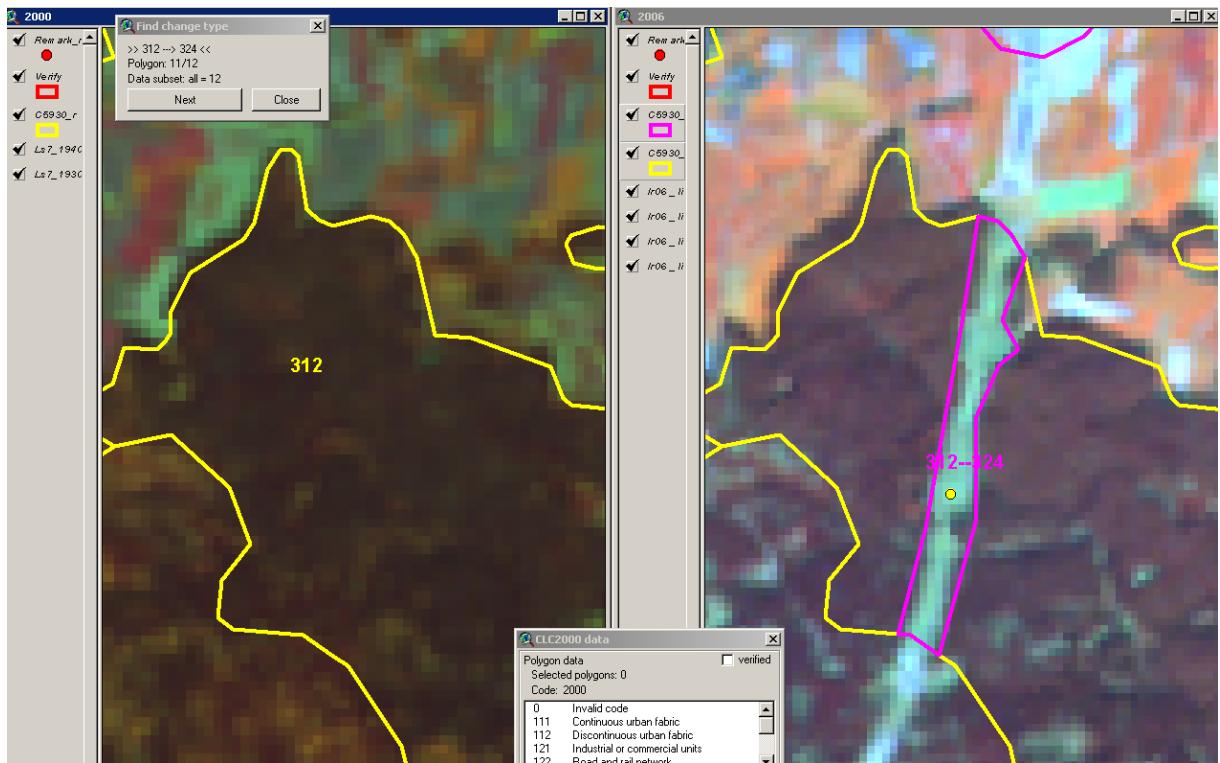
Interpretation example (Cyrus):



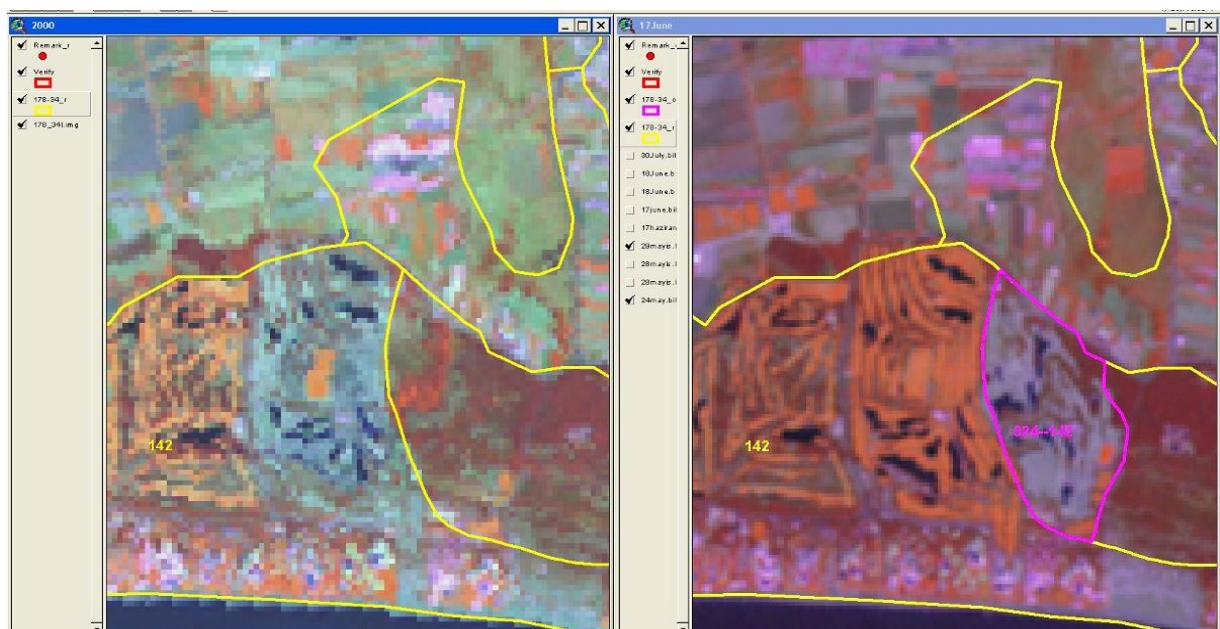
In order to serve increasing demand on behalf of tourism, a lot of new golf courses are constructed along the Mediterranean shores, especially Portugal, Spain and Cyprus. Golf course constructions are well recognizable by the 'spaghetti' pattern typical of these structures and the bright colour of irrigated vegetation on the finished parts, as visible on the 2006 image (right). The lack of vegetation is the key of distinguishing constructions from finished golf courses. There are 386 pieces of 323-133 type covering 0.13 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

New golf courses along the Mediterranean shore put heavy pressure on environment due to increased water demand in regions where water shortage is anyway an issue. Chemical pesticides and fertilizers used for maintenance, as well as the destruction of wetlands and other environmentally important areas during construction are additional negative environmental impacts.

Frequent mistakes:	How to avoid the mistake
Forest and semi-natural area changed to construction site	
Omitted new construction sites	<p>Check the surroundings of larger settlements to find urban sprawl. Scan the whole area in scale 1:40000 to find bright spots of construction sites.</p> <p>Constructions do often very dynamically grow, so use of latest image is important to avoid omissions.</p>
False change due to misinterpretation	<p>Use of multi-temporal imagery and in-situ data help distinguishing from:</p> <ul style="list-style-type: none"> - mineral extraction / dump sites (131, 132) - clearcuts (324) - arable land (211) - finished construction (new 112, 121, 142, 512)



Mistake: New construction (312-133) is misinterpreted as forest clearcut (312-324). A homogeneous forest in 2000 (left) is interrupted by a bright stripe in 2006 (right). This was interpreted as forestry use (clearcutting). It is true that the first step of construction in a forest is removing trees, but 324 should be used only if forestry use is maintained. The use of later images and examining the surrounding area (continuation of the construction track well recognizable) would have helped to avoid the mistake. The right interpretation would be 312-133.



Mistake: Golf course construction (324-133) is misinterpreted as new golf course (324-142) in the east part of the area. Typical 'spaghetti'-pattern of the golf course is already well visible in the construction phase in middle part of 2000 image (left) and eastern part of 2006 image (right), but without red colour of biomass. Note that west from the wrongly coded change there is also a missing 133-142 change – finishing of golf course development.

4.3 FOREST OR SEMI-NATURAL AREA CHANGED TO AGRICULTURE

Change process: Forest or semi-natural area changed to agriculture: 312/321/323/324-211

Overview and rationale:

In most European countries forests are protected by law in a way that re-plantation of forest is obligatory after clearcutting. There are few exceptions though, when forest might be replaced by agricultural use. One of these is when irrigated agriculture, being more profitable replaces forest. Second is the case of forest plantations (poplar, eucalyptus), where trees are planted almost like an arable crop, being part of the crop rotation. Yet another type of this process is typical in Finland, where it is a state policy to increase the area of arable land on the expense of forest area.

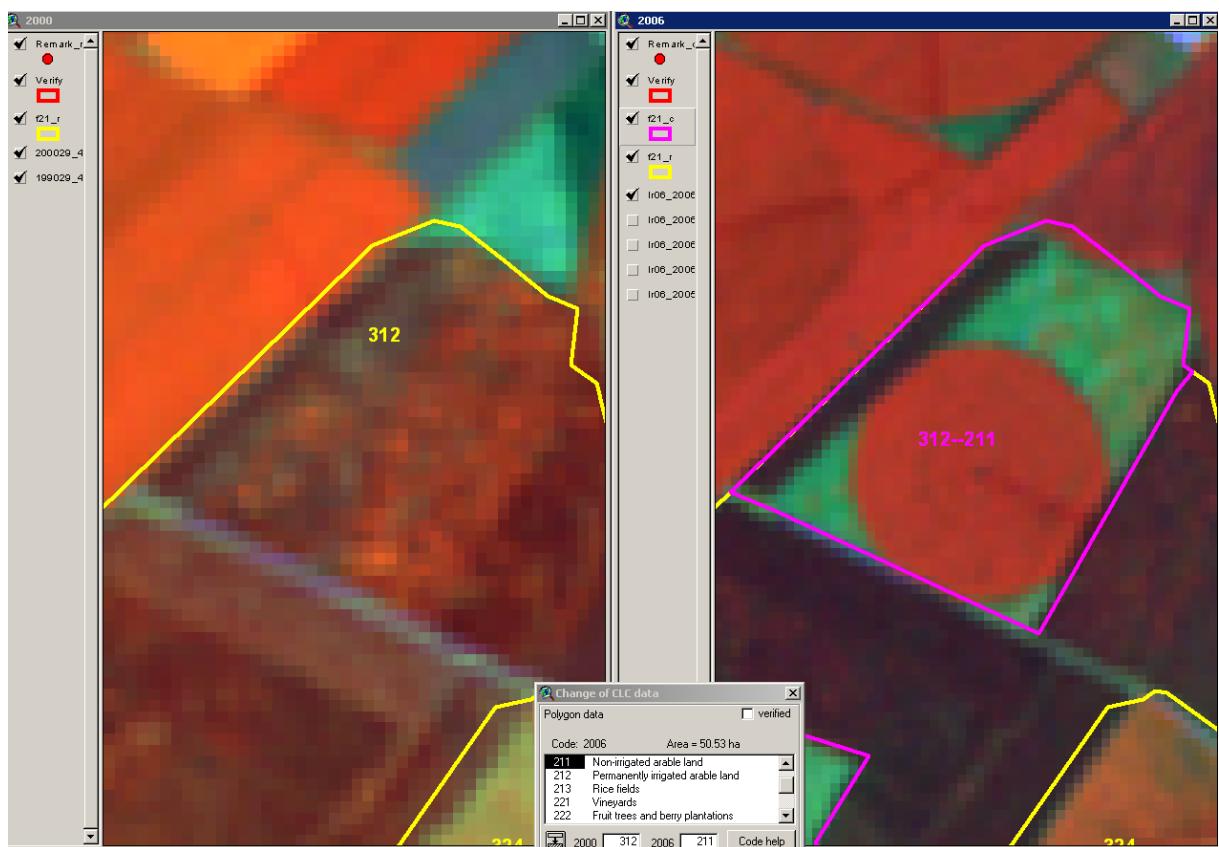
Other semi-natural areas, especially shrubs, being economically less valuable more frequently give ground to increasing need for food production and for more income. These processes often pose a threat on environment (soil erosion, increased flood risk due to reduced water retention capacity, water shortage) and nature (decreasing biodiversity due to habitat loss). This is especially true for natural grasslands lying in agriculturally favourable areas, being strong competitors for space.

Number of changes in European CLC-Change: 3375 polygons

Area of changes in European CLC-Change: 0.57 % of all change areas

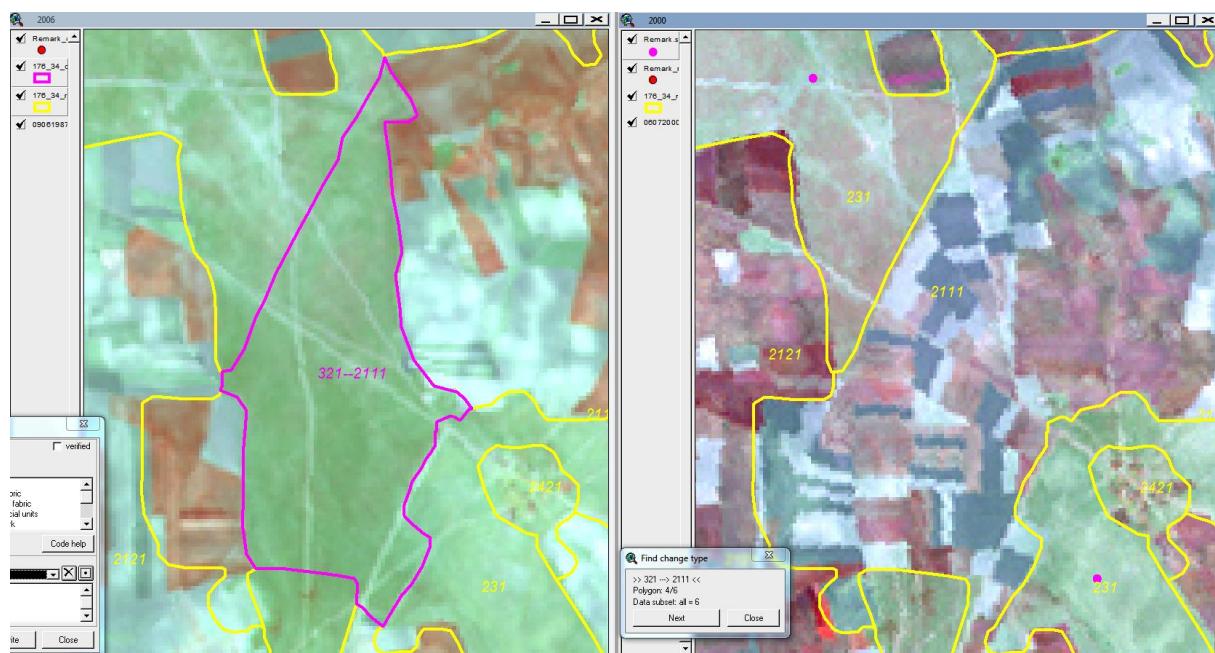
Type: Coniferous forest changed to non-irrigated arable land: 312-211

Interpretation example (France):



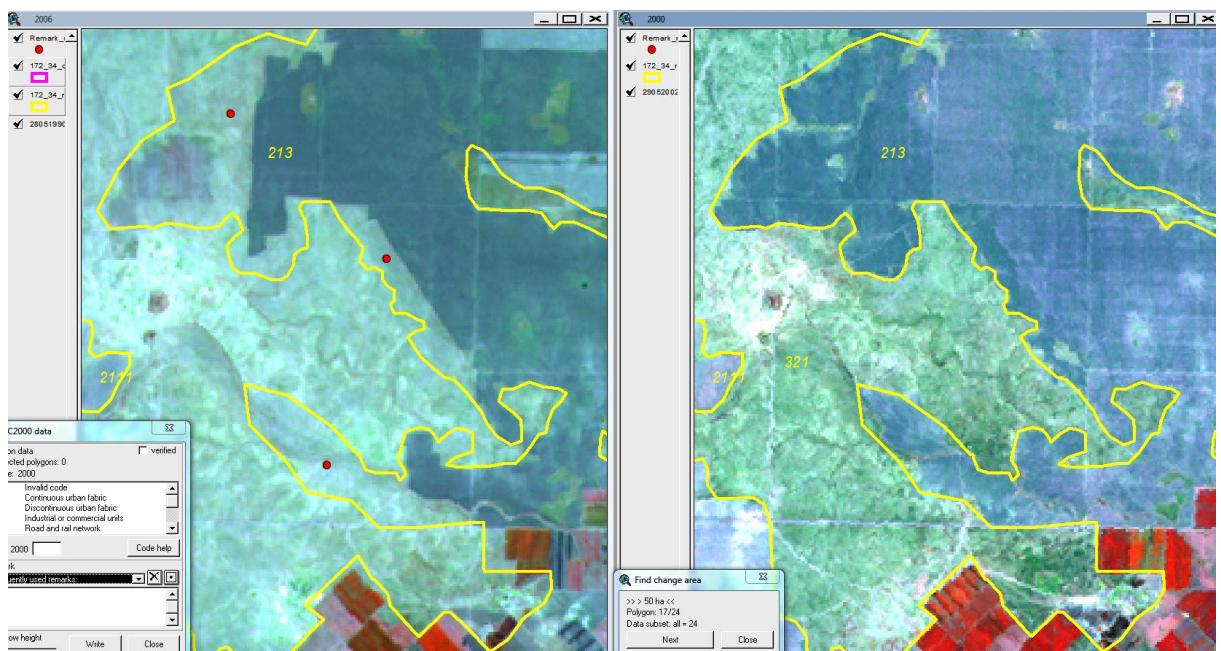
The need for more food production and higher profitability are driving forces behind replacing forest by agriculture. On this example coniferous plantations are removed to give place to arable land, characterised by bright colours on the image (left). The circular shape suggests infrastructure for temporal irrigation. There are 1027 polygons of this type covering 0.11 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Type: natural grassland changed to arable land: 321-211
Interpretation example (Turkey):



In recent European landscape natural grasslands are typically found on agriculturally less favourable areas (mountains, dry climate, poor soil) or are under nature conservation. Therefore change from natural grassland to arable land is not a frequent change in most countries. In some regions, such as Turkey, however large natural grasslands still exist in lowland areas with good agronomic conditions. These might be turned to agricultural use as seen on the example, where one can observe how irregular-shaped, more or less homogeneous grass surface in 1990 (left) is replaced by regular arable parcels of different colours representing different crops by 2000 (right). (Although change is correctly coded as 321-211, grassland is wrongly coded as 231 in parent stock layers.) There are 319 polygons of the 321-211 type covering 0.26 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Frequent mistakes: Forest or semi-natural area changed to agriculture	How to avoid the mistake
Omitted changes	Change to arable land is seldom missed in case of shrubland or natural grassland. However, in dynamic forest areas this change might be missed due to mixing with process of clearcutting.
Wrong change code pair used due to clearcutting, afforestation being misinterpreted as new agriculture	Disappearance of forest cover usually indicates normal forestry use, i.e. clear-cutting. Any other cases must be carefully proven. The keys of recognizing new agriculture replacing natural vegetation are: <ul style="list-style-type: none"> • Regular parcel structure • Colourful patches of different crops • Seasonal changes of vegetation, referring to growth and harvesting of different crops visible on multi-temporal imagery

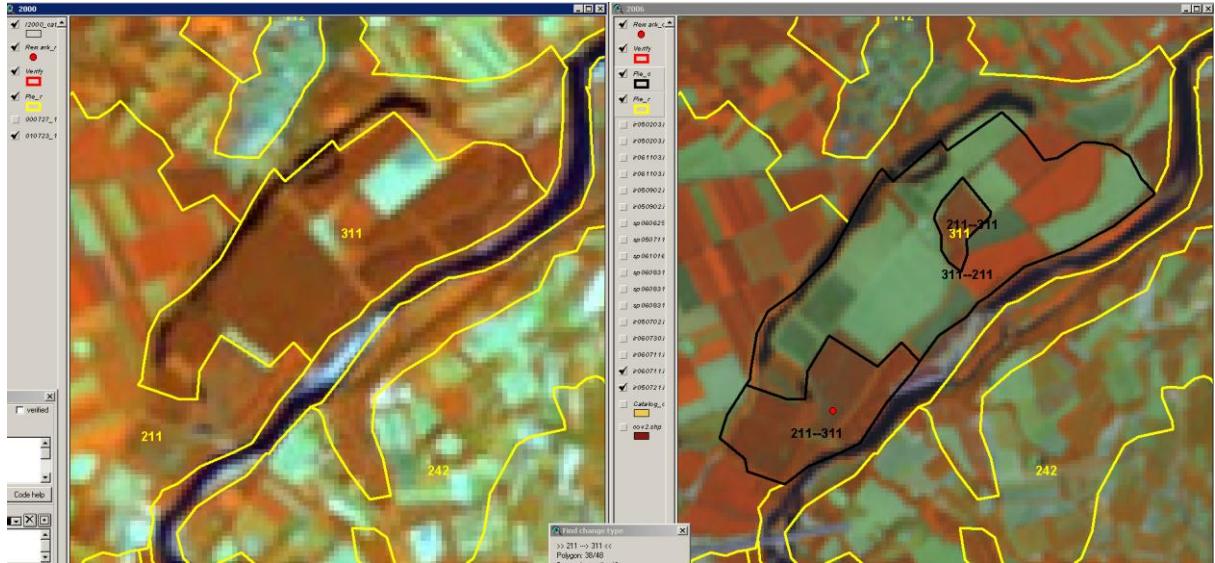


Mistake: Extension of agriculture (here wrongly interpreted as rice field instead of arable land – see around red dots) over natural grassland is missing. Arable land has homogeneous blue colour on both images. On the 1990 image (left) it is visible that natural grassland (light green colour coming from dry soil and small amount of biomass) occupied larger area than on the 2000 image (right). Rice fields are visible in southern part in very bright red.

Particularity-1

Type: Deciduous forest changed to non-irrigated arable land: 311-211

Interpretation example (Italy):

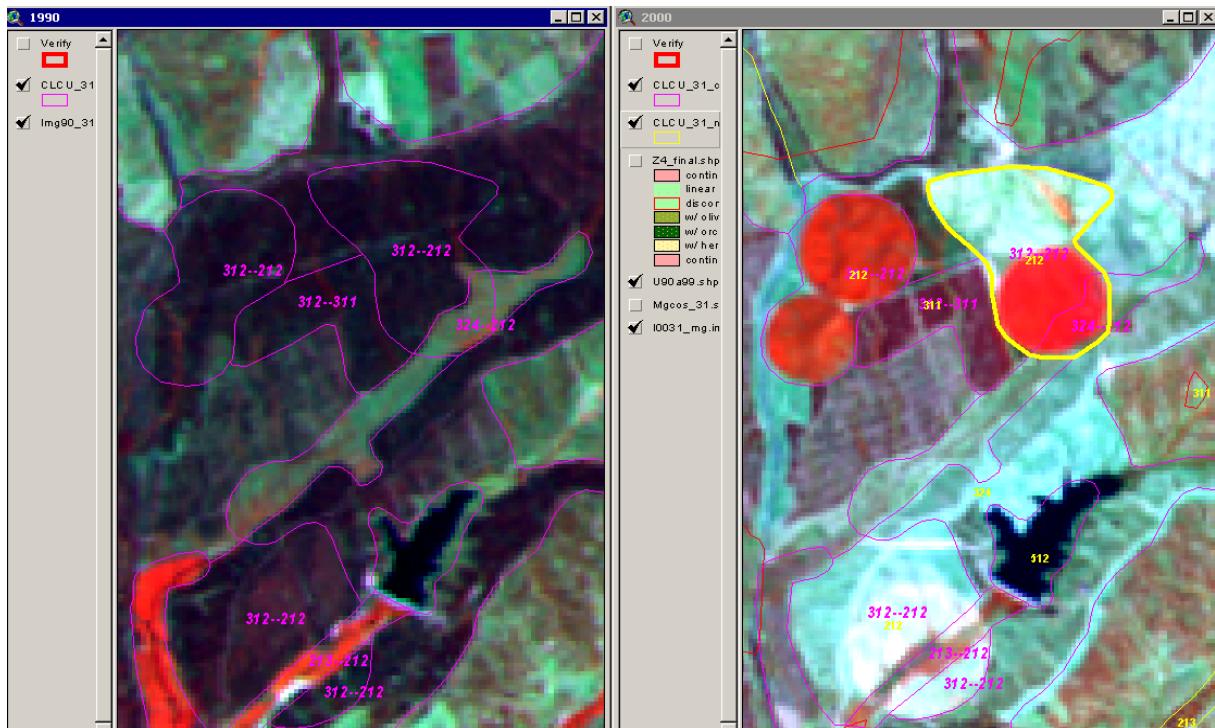


In Italy's Po valley poplar plantations are practically "part of the crop rotation", being periodically removed, replaced by agriculture (311-211), as visible on the image then re-planted again. Being very fast-growing, they can reach harvestable height within a few years, thus opposite process of 211-311 is possible here (see Ch.3.10 particularity-1). There are 344 polygons of this type covering 0.04 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Particularity-2

Type: Coniferous forest changed to irrigated arable land: 312-212

Interpretation example (Portugal):

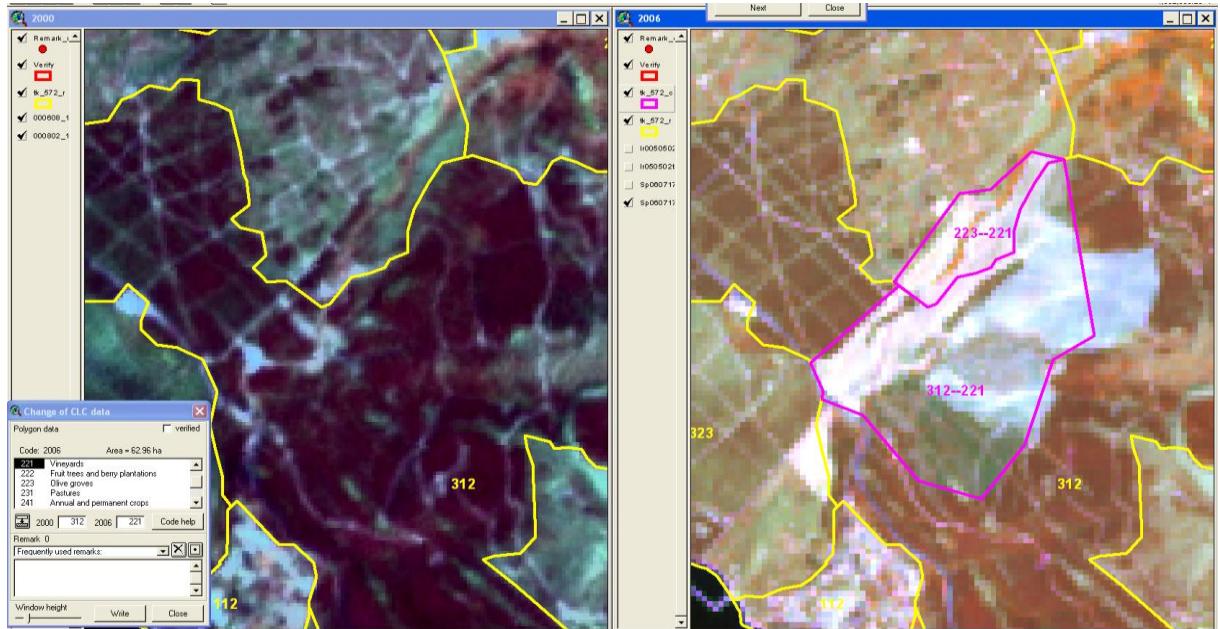


On this example coniferous plantations are removed to give place to irrigated agriculture in 2006 (right). Irrigated land is characterized by bright colours even in the dry season and by circular parcels, being consequence of the permanent irrigation installations. Note circular forms without vegetation in bottom part of image, also correctly interpreted as 212 in 2006. There are 13 polygons of this type covering 0.00 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Particularity-3

Type: Coniferous forest changed to vineyard: 312-221

Interpretation example (Croatia):

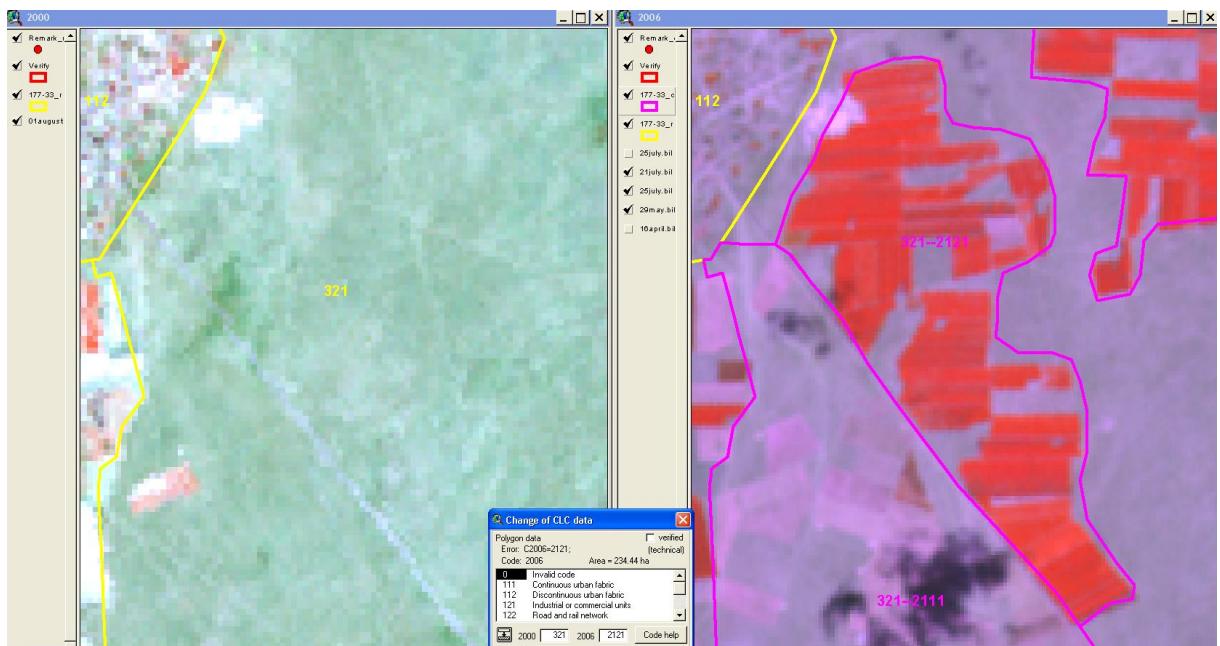


As part of national agricultural policy in Croatia, forest is replaced by vineyards in areas that are fit for wine production. Vineyards are identified by use of ancillary data (agricultural database or VHR image). Note that small part of the change is missing on the eastern part, probably being consequence of not the latest image being interpreted. There are 29 polygons of this type covering 0.00 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Particularity-4:

Type: New irrigated arable land on natural grassland: 321-212

Interpretation example (Turkey):



The need for more food is the driving force behind creating new irrigated arable land on semi-natural areas as well. IMAGE2000 (left) shows light green of dry natural grassland (321), while IMAGE2006 (right) shows several large fields of irrigated arable land in bright red (and non-irrigated arable land in lilac). The interpreted change is 321-212. There are 60 polygons of this type covering 0.05 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Particularity-5:

Type: New irrigated arable land on sparsely vegetated area: 333-212

Interpretation examples (Spain):

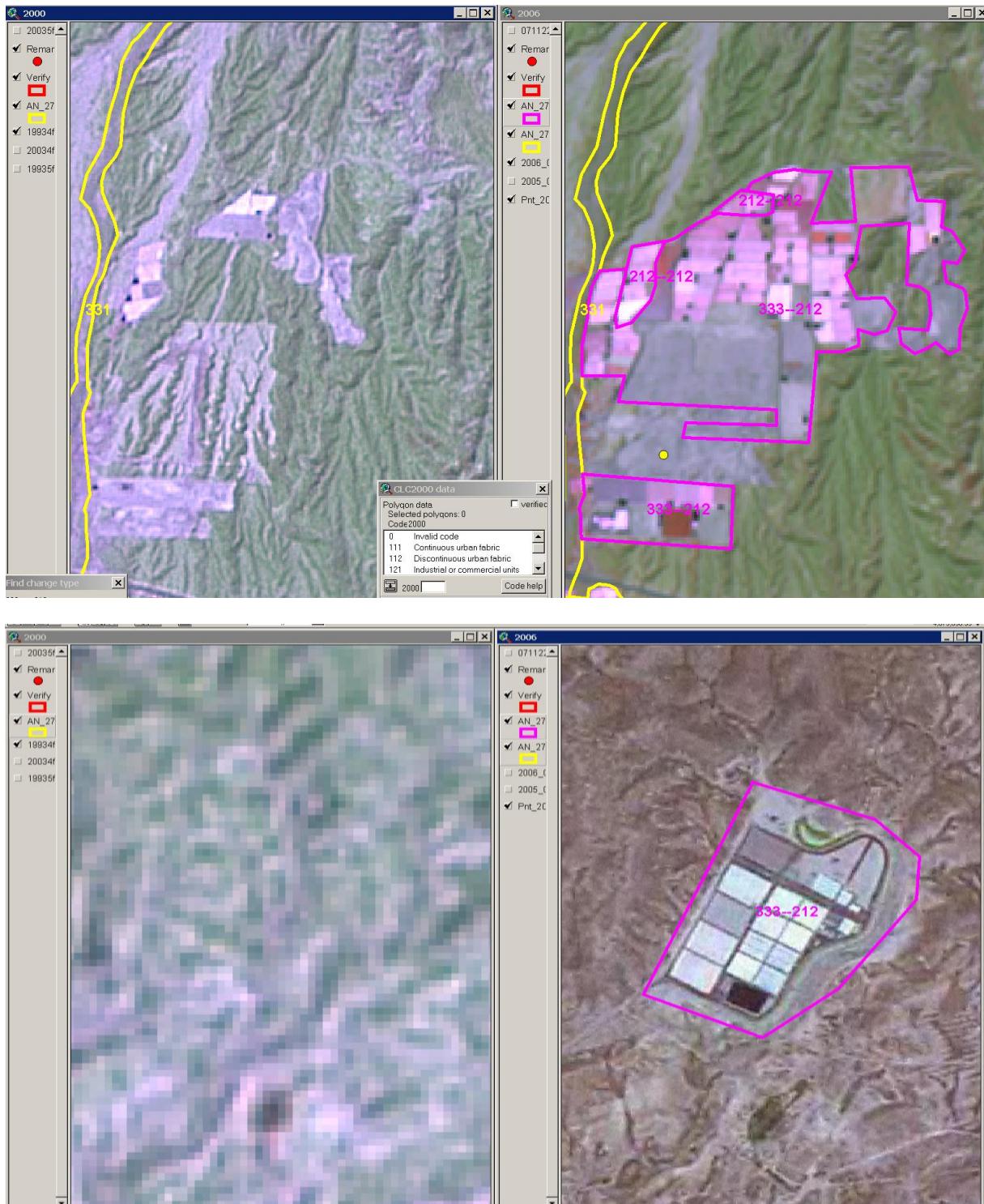


IMAGE2000 (left) shows a sparsely vegetated area (333) in a semi-arid region of Southern Europe. IMAGE2006 (right) shows patches of irrigated arable land area, the soil partly being covered by plastic, which is seen in magenta colour. Ponds providing water for irrigation are clearly visible as small dark spots. More detailed structure of one such area is shown in the bottom image. The interpreted changes are: 333-212. There are 118 polygons of this type covering 0.05 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

4.4 FOREST OR SEMINATURAL AREA CHANGED TO AGROFORESTRY

Change process: Forest or seminatural area changed to agroforestry: 311/324-244

Overview and rationale:

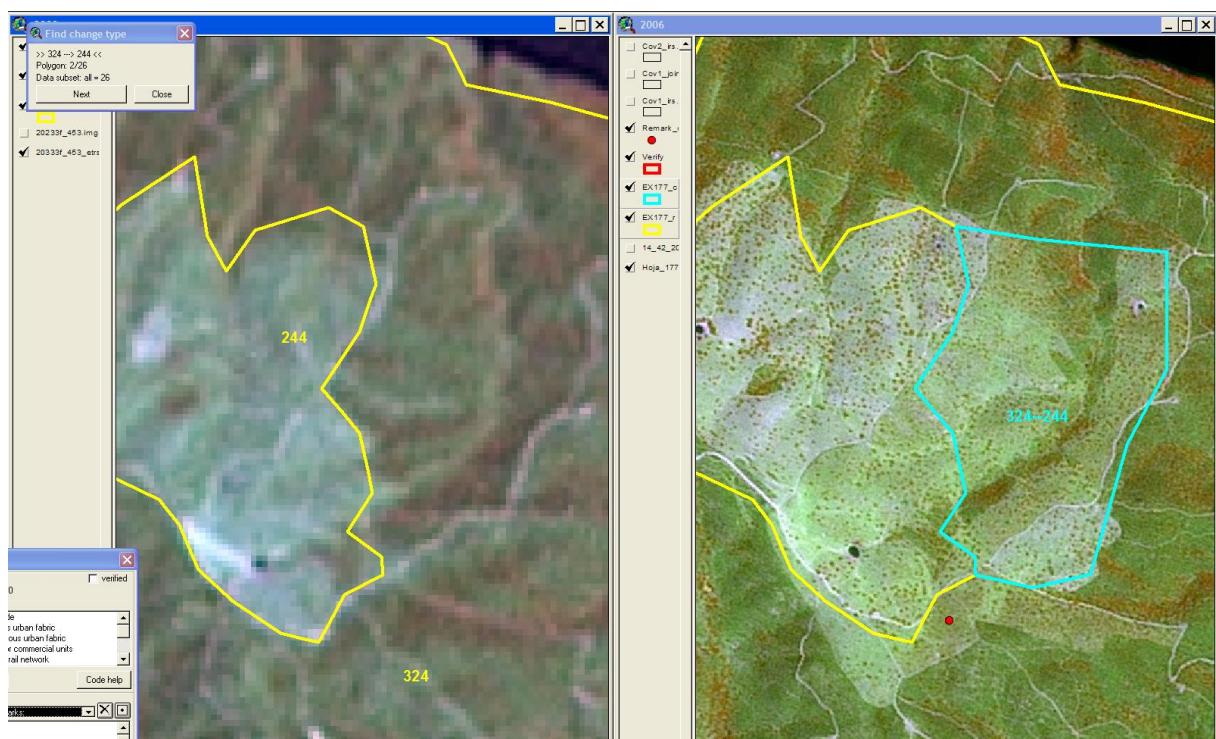
'Dehesa' (ES) or 'montado' (PT) is an ancient agricultural practice, where dispersed forestry trees (usually oak) are combined with agricultural use, usually grazing (pasture), less frequently arable land. Trees give shadow thus helping to protect water in the soil and provide fodder (acorn) for the free-running animals (pigs). "Dehesa/montado" might be periodically abandoned, letting shrubs overtaking agricultural ground among the trees (Ch. 3.11). When the area is taken to cultivation again, shrub is removed and grazing/arable cultivation starts, being the topic of this chapter. The "dehesa/montado" system (agroforestry) has great economic and social importance on the Iberian Peninsula because of both the large amount of land involved and its importance in maintaining the rural population levels. The "dehesa/montado" system has reduced the flow of emigration and its consequences (aging, increased mortality rates, lower birth rates, abandonment of farms, etc.). The exploitation of the "dehesa/montado" usually coincides with areas that could be termed "marginal" because of both their limited agricultural potential (due to the poor quality of the soil) and the lack of an industrial fabric, which boils down to isolated agro-industries and very small capitalization. Extension of this type of land use (mostly on areas from which it withdrew from in the near past) is therefore has great social significance [9, 10].

Number of changes in European CLC-Change: 673 polygons

Area of changes in European CLC-Change: 0.49 % of all change areas

Type: Transitional woodland-shrub changed to agroforestry: 324-244

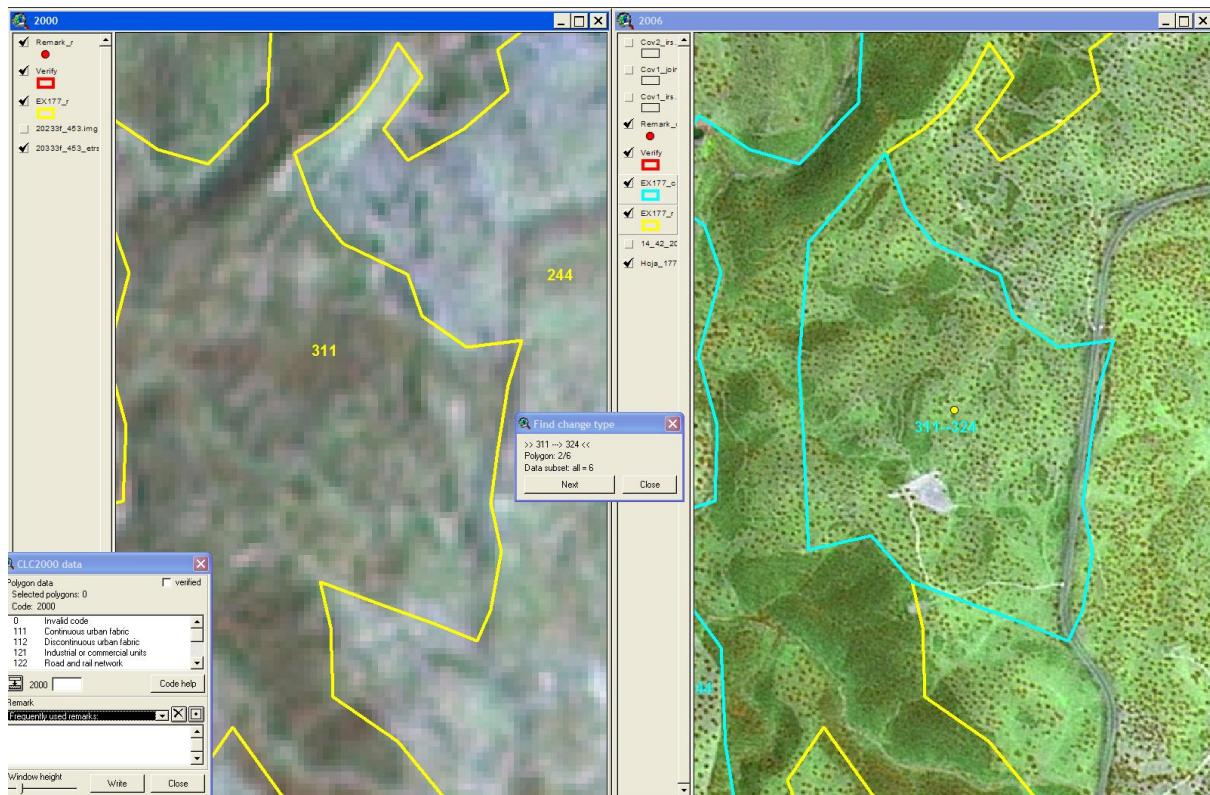
Interpretation example (Spain):



Transitional woodland-shrub is turned into dehesa (244, agroforestry). This is a process typical of the Iberian Peninsula's "dehesa/montado" type cultivation. Left side: standard IMAGE2000, right side: SPOT-5 image. Note that HR imagery allows recognition of alone-standing trees of 244. There are 428 polygons of this type covering 0.33 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database. (Instead of standard IMAGE2006 Spain used SPOT-5 imagery (multispectral and PAN merge) with pixel size of 2.5 m taken in 2005.)

Frequent mistakes:	How to avoid the mistake
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Forest or seminatural area changed to agroforestry	
Omitted changes	Revising questionable patches on HR/VHR imagery is the tool of avoiding this mistake.
False change – new agroforestry not recognized, but interpreted as clearcutting	The use of local knowledge and HR/VHR images helps avoiding misinterpretations.



Mistake: omission (misinterpretation) of 311-244 change. On satellite imagery decreasing crown cover is visible (left: IMAGE2000/Landsat TM, right: 2005/SPOT-5). On high-resolution SPOT-5 image the spots of dispersed trees are also recognizable, referring to agroforestry land use (244). If tree cover in a dehesa is dense enough, after abandonment we can interpret the area as forest (311). In order to re-start agroforestry, shrubs and some trees are cleared, the process being 311-244. Here the process was not recognized, thus interpreter misinterpreted the process as forest clearcutting (311-324).

4.5 CLEARCUTTING OR DAMAGE OF FORESTS

Change process: Clearcutting or damage of forests: 311/312/313-324

Overview and rationale:

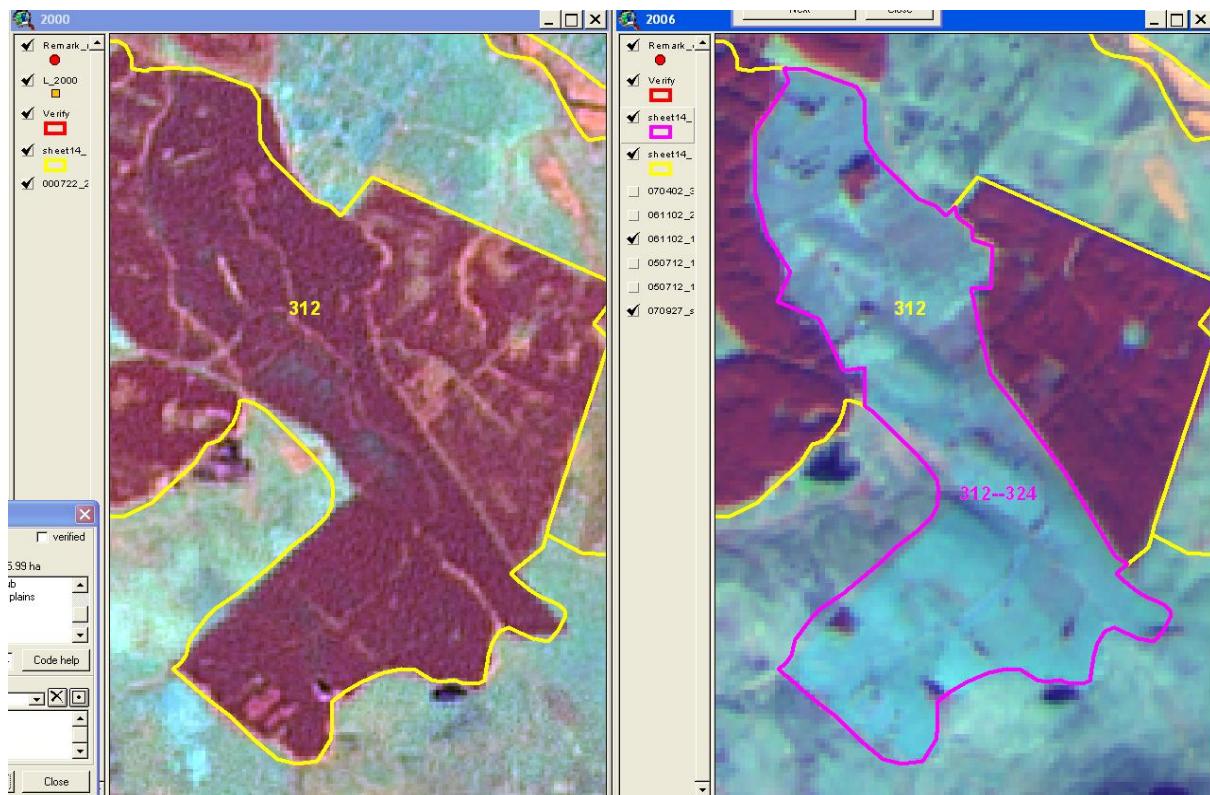
These are the most widespread changes in Europe concerning both area and frequency. Clearcutting, or clearfelling, is a controversial forestry/logging practice in which most or all trees in an area are uniformly cut down. Clearcutting, along with shelterwood and seed tree harvests, is used by foresters to create certain types of forest ecosystems and to promote select species that require an abundance of sunlight or grow in large, even-age stands. Logging companies and forest-worker unions in some countries support the practice for scientific, safety, and economic reasons. Detractors see clearcutting as synonymous with deforestation, destroying natural habitats and contributing to climate change [11].

Number of changes in European CLC-Change: 192 854 polygons

Area of changes in European CLC-Change: 47.19 % of all change areas

Type: Clearcutting of coniferous forests: 312-324

Interpretation example (Ireland):



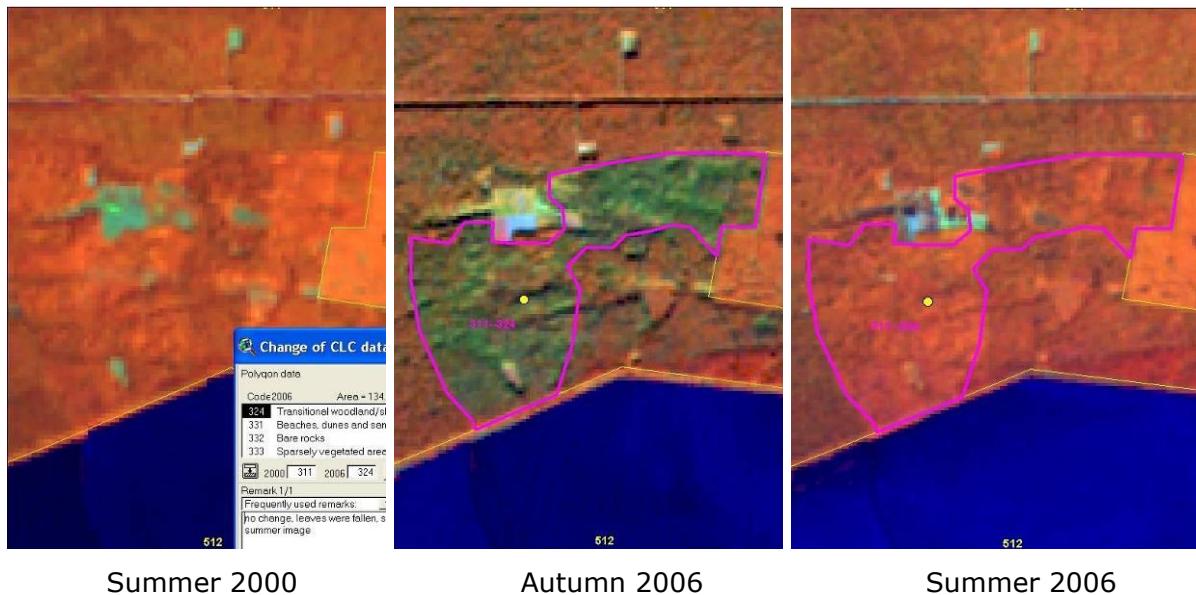
Coniferous forest in 2000 (left) is clearcut by 2006. "Loss" of forest cover is characterised by light colour of the ground (right) becoming visible due to disappearance of crown cover. In most European countries forestry regulation protects forest cover in a way that after harvesting the forest must be replanted. This means that the loss of crown cover is temporary, transitional woodland area will sooner or later be replaced by forest. Thus when observing the loss of crown cover on the images, we should assume that forest has changed to transitional woodland and shrub (324). 312-324 change is the most widespread change type in Europe. There are 146 596 polygons of this type covering 34.66 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Type: Clearcutting of deciduous forests: 311-324
Interpretation example (Hungary):

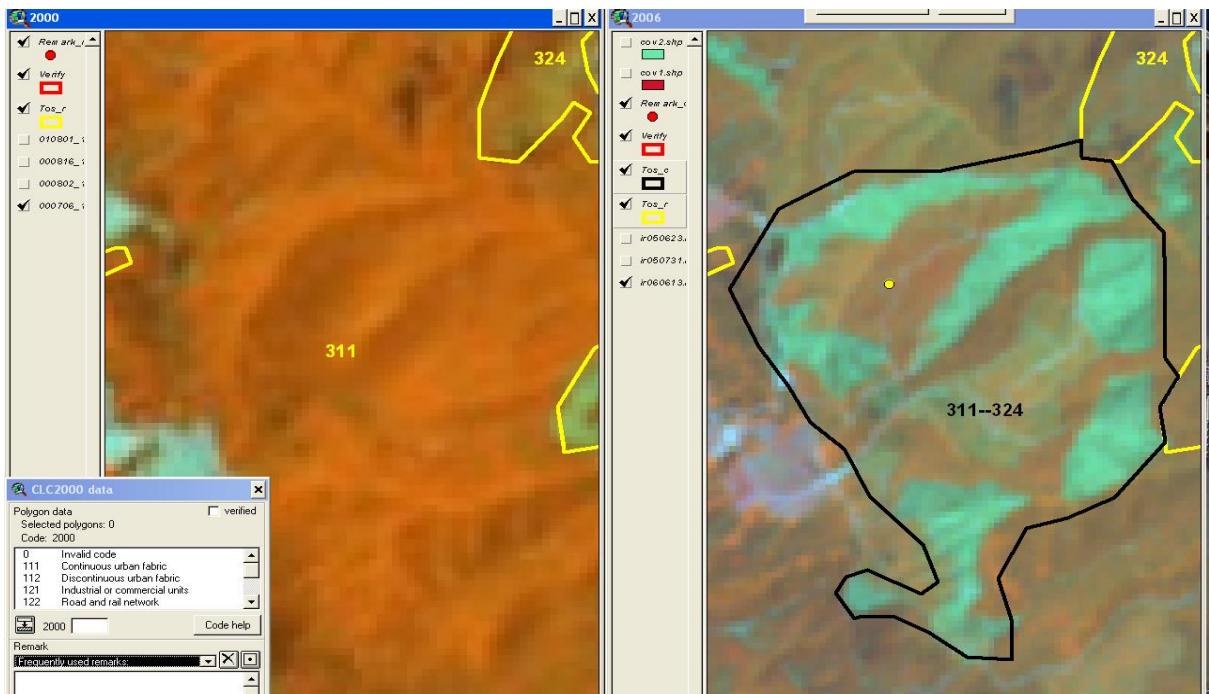


In a dense lowland deciduous forest (left) new patches of clearcut occur by 2006 (right). The spectral signature of green clearcut patches comes from the mixture of bare soil and herbaceous species / young trees emerging in competition for light. Also note brown-reddish colour of developing new forest in patches of earlier clearcuts, already visible on the 2000 image (left). In many European countries the maximum size of clearcuts is regulated by forest law in order to prevent soil erosion and habitat fragmentation, so size of clearcuts is often small. There are 24 633 polygons of this type covering 8.09 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

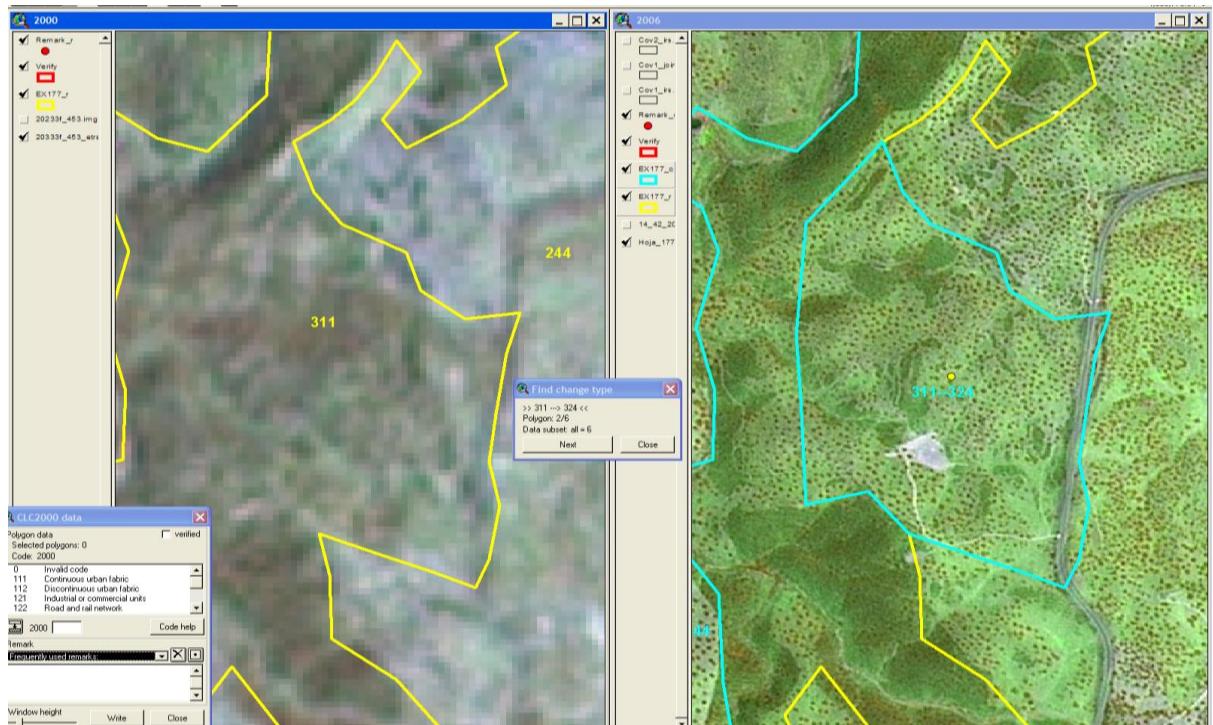
Frequent mistakes:	How to avoid the mistake
Clearcutting or damage of forests	
Omitted changes	Forest clearcutting is often a very dynamic process. All available images should be checked in order to map the latest status.
False change due to seasonal differences interpreted as CLC change	Out of the vegetation season, the leafless status of deciduous trees shows a spectral pattern very close to that of a clearcut / damaged forest. Clearcuts mapped on out-of-season images therefore must be always confirmed by in-season (summer) imagery. Note that some species (e.g. black locust – Robinia pseudoacacia) are leafless until late spring (May), while others (Poplars) might have their leaves lost already in late summer.
Non-changed (non-clearcut) patches > 5 ha are not separated from the change polygon	A very common mistake in interpreting forestry changes, causing an overestimation of decrease of forest cover. All non-changed (forest-covered in new date) patches within a 31x-324 polygon must be separated.
Clearcut is mapped as forest-agriculture change due to misinterpreting the bright colour as arable land	Forest-to-agriculture changes are rare in most European countries. When interpreter sees forest “disappearing”, the first interpretation option should be 31x-324. Any other solutions must be soundly proven by ancillary data.
Clearcut is mapped as 31x-321	321 normally cannot develop naturally in 6 years. Even though very often some natural herbaceous vegetation (e.g. grass) covers recent clearcuts making young trees hardly visible, the area’s primary land use is still forestry (324).



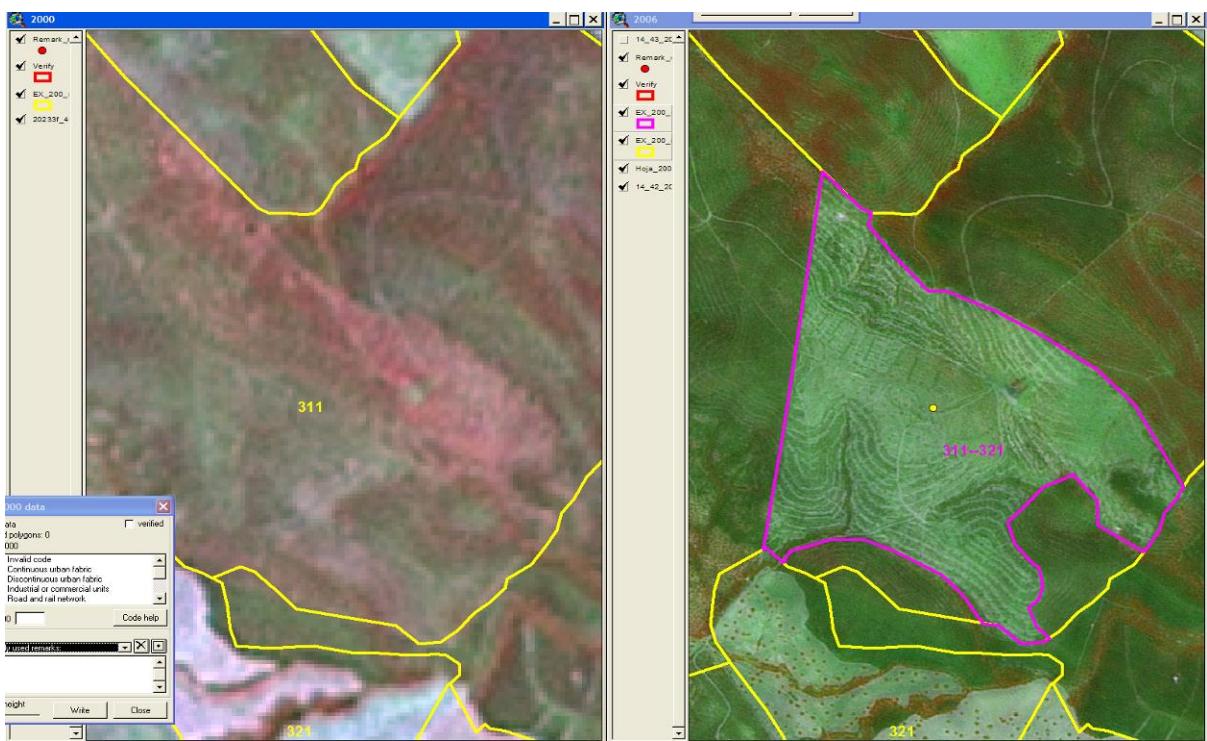
Mistake: seasonal/temporal change (leafless status of deciduous species) in forest, mapped erroneously as CLC change. The summer 2000 (left) / autumn 2006 (middle) comparison suggests that crown cover density has significantly decreased, which is mapped as CLC change (311-324). Examining summer 2006 (right) shows that crown cover is still dense, so no change should be interpreted (311 in both dates).



Mistake: Non-changed parts not separated within a large 311-324 polygon, causing a heavy overestimation of forest cover decrease. From a deciduous forest visible in 2000 (left), large patches have been felled by 2006 (right) appearing in greenish colour. Most of the area mapped as 311-324 has really changed, however some large patches are still covered by forest in 2006. If being >5 ha (which is the case here), these should have been separated and deleted from the change polygon.



Mistake: change code 311-324 wrongly used. Compared to the 2000 image (Landsat TM, left), the change area shows obvious decrease of biomass by 2005 (SPOT-5, right), which is interpreted as forest clearcutting (311-324). The HR image (2.5 m pixels) however shows that area has actually changed to agroforestry ("dehesa / montado") by clearing the shrubs (see Ch. 4.4). The right change code pair therefore would have been 311-244.

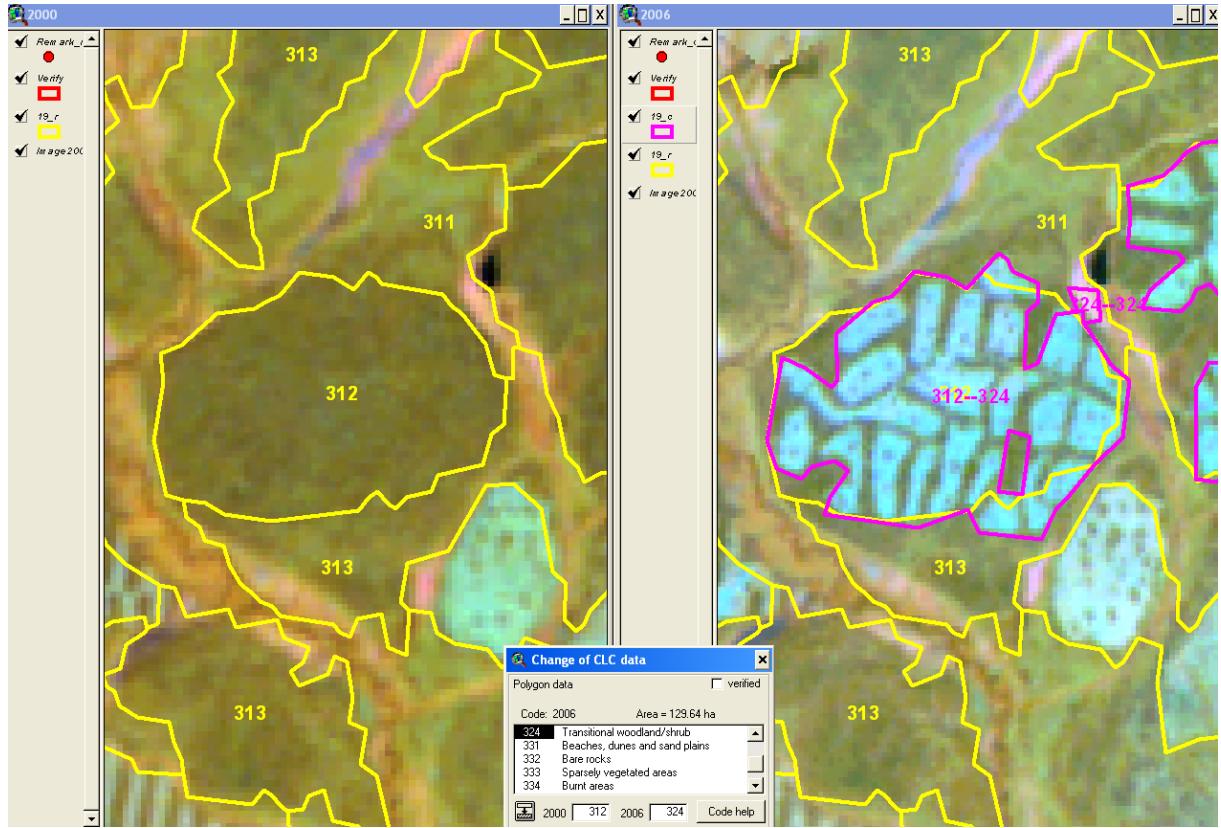


Mistake: clearcutting misinterpreted as 311-321. Sparse deciduous forest visible in 2000 (left) has "disappeared" by 2006 (right), the process wrongly being interpreted as permanent loss of forest area. Natural grassland (321) vegetation usually takes long time to develop. In case forest cover is seen to "disappear" from the image, in most of the cases 324 is the right code, even if the surface is mostly covered by grass among the young trees. Here rows of young trees are well visible on the SPOT-5 image (2.5 m pixels) as stripes along contour lines, so the right change code would be 311-324.

Particularity-1:

Type: Patch clearcutting of coniferous forests: 312-324

Interpretation example (Finland):



A coniferous forest area in 2000 (left) has been clearcut by 2006 (right). The “fish-bone” structure is explained by environmental and ecological considerations. Due to resolution constraints of CLC (100 m width, 25 ha MMU) here it is not possible to separate clearcut and non-clearcut areas. (Non-cut patches within the change are < 5 ha, therefore do not have to be separated.) If clearcut cover “significant” (> 70%) inside a patch, the entire area should be considered clearcut. (According to [3] > 30% crown cover should be interpreted as forest.)

4.6 FOREST GROWTH

Change process: Forest growth: 324-311/312/313

Overview and rationale:

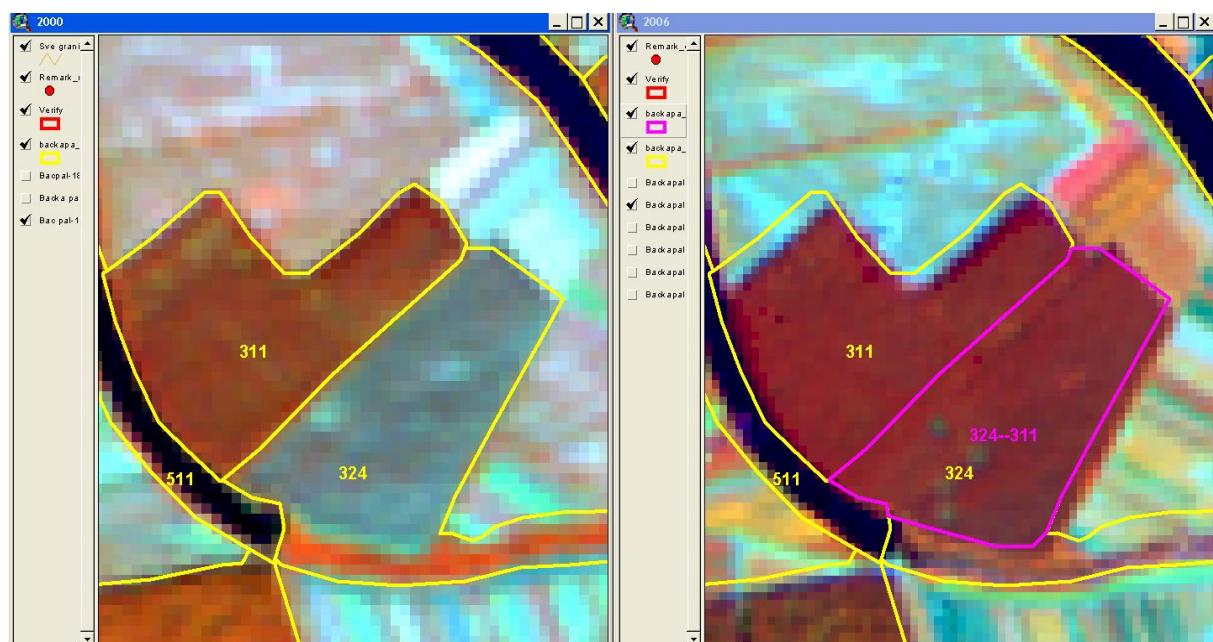
Reforestation (referred to as forest growth in CLC terminology) is the restocking of existing forests and woodlands which have been depleted (clearcut). In CLC terms forest growth is mapped when young forest reaches the status of mature forest (5 m height, 30% crown cover density). This process, being the counterpart of clearcutting or deforestation, makes up the second largest area of CLC changes in Europe. Reforestation competes with other land uses such as food production, livestock grazing, and living space for further economic growth. In order to prevent forest loss, forestry legislation in majority of countries therefore prescribes replanting of clearfelled forests either by treeplanting or by natural regeneration using seedstock from seed-trees. Reforestation, if several native species are used, can provide other benefits in addition to financial returns, including restoration of the soil, rejuvenation of local flora and fauna, and the capturing and sequestering carbon dioxide. Forest growth, due to happening gradually and often slowly is a change much more difficult to detect than the abrupt change of clearcutting. [12].

Number of changes in European CLC-Change: 66 537 polygons

Area of changes in European CLC-Change: 17.47 % of all change areas

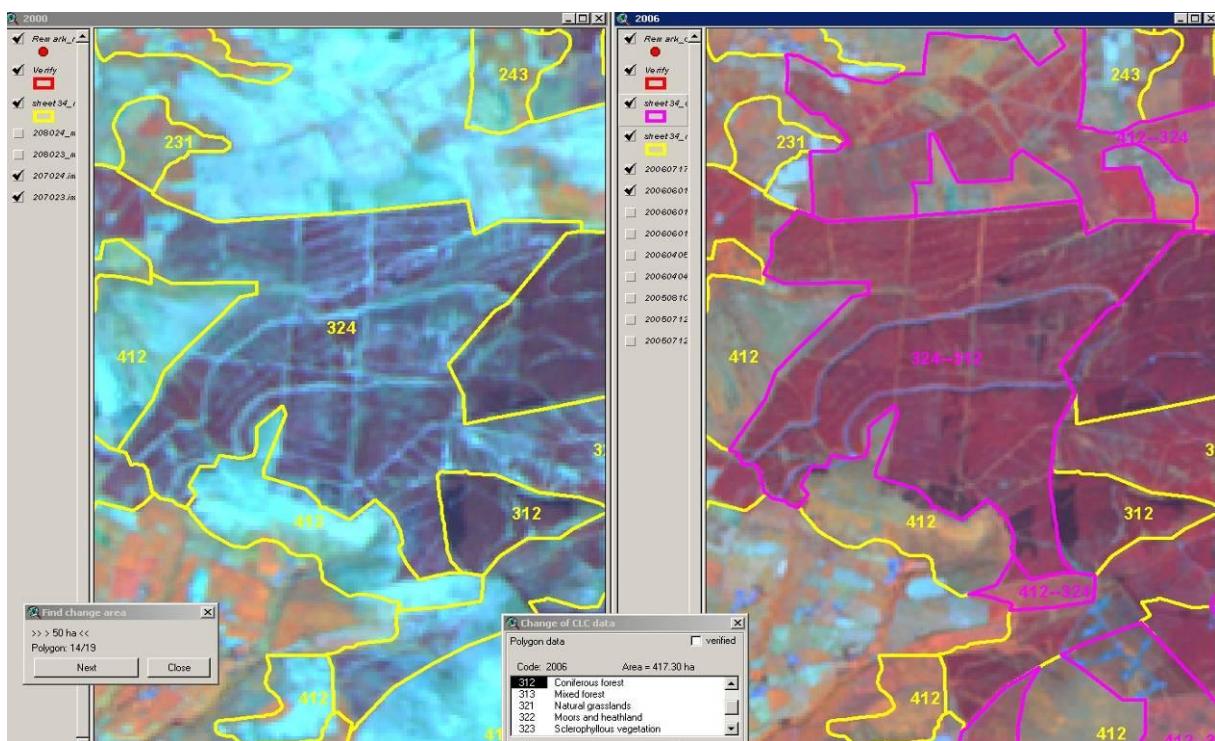
Type: Growth of deciduous forests: 324-311

Interpretation example (Serbia):



The young forest (324) in 2000 (left) has become mature deciduous forest by 2006 (right). The mapped process is: 324-311. The process is confirmed by comparison with the neighbouring forest, which has the same colour and texture in 2006. Comparison with neighbouring mature forest is a good method for finding the 324-31x change plots. The example shows a fast-growing species (most probably poplar), which can exceed the 5 m height limit in even 6-7 years. Slower-growing species might take decades to exceed the 5 m height limit, thus even though forest growth of some extent is visible, the young forest might fall in the 324 category for more change mapping periods. There are 12 327 polygons of this type covering 4.49 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

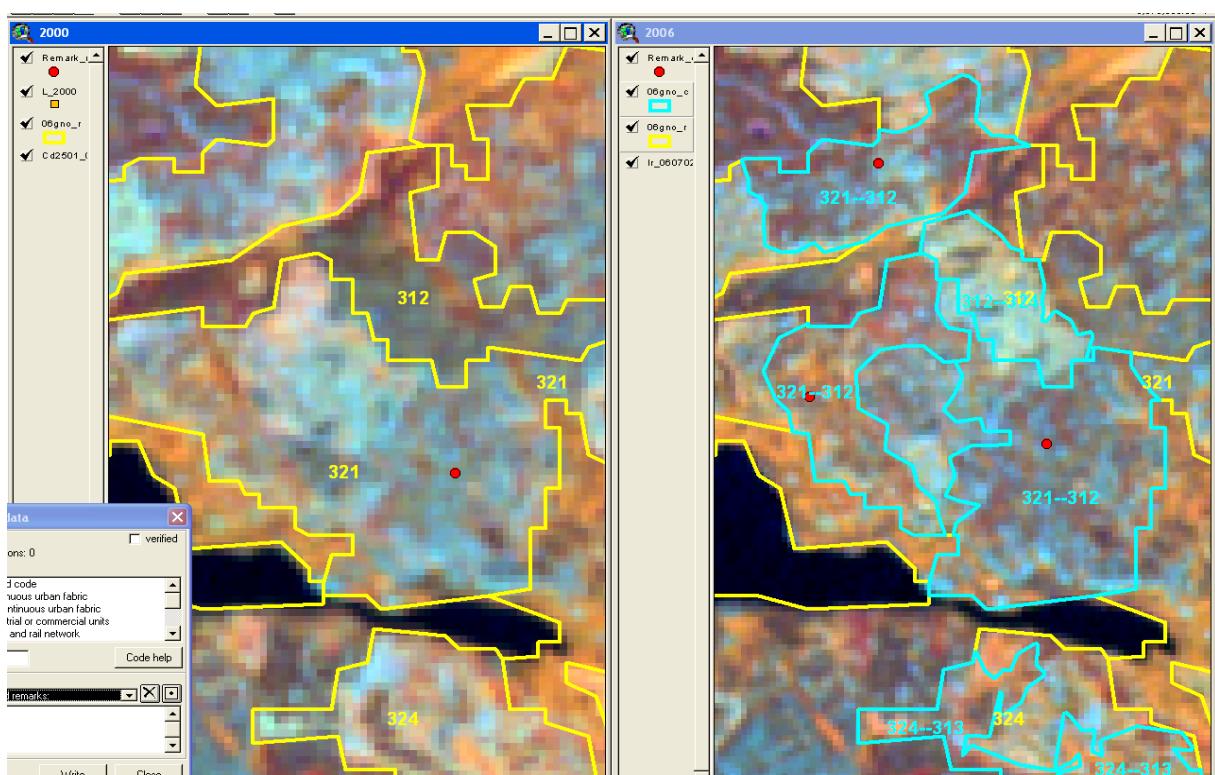
Type: Growth of coniferous forests: 324-312
Interpretation example (Ireland):



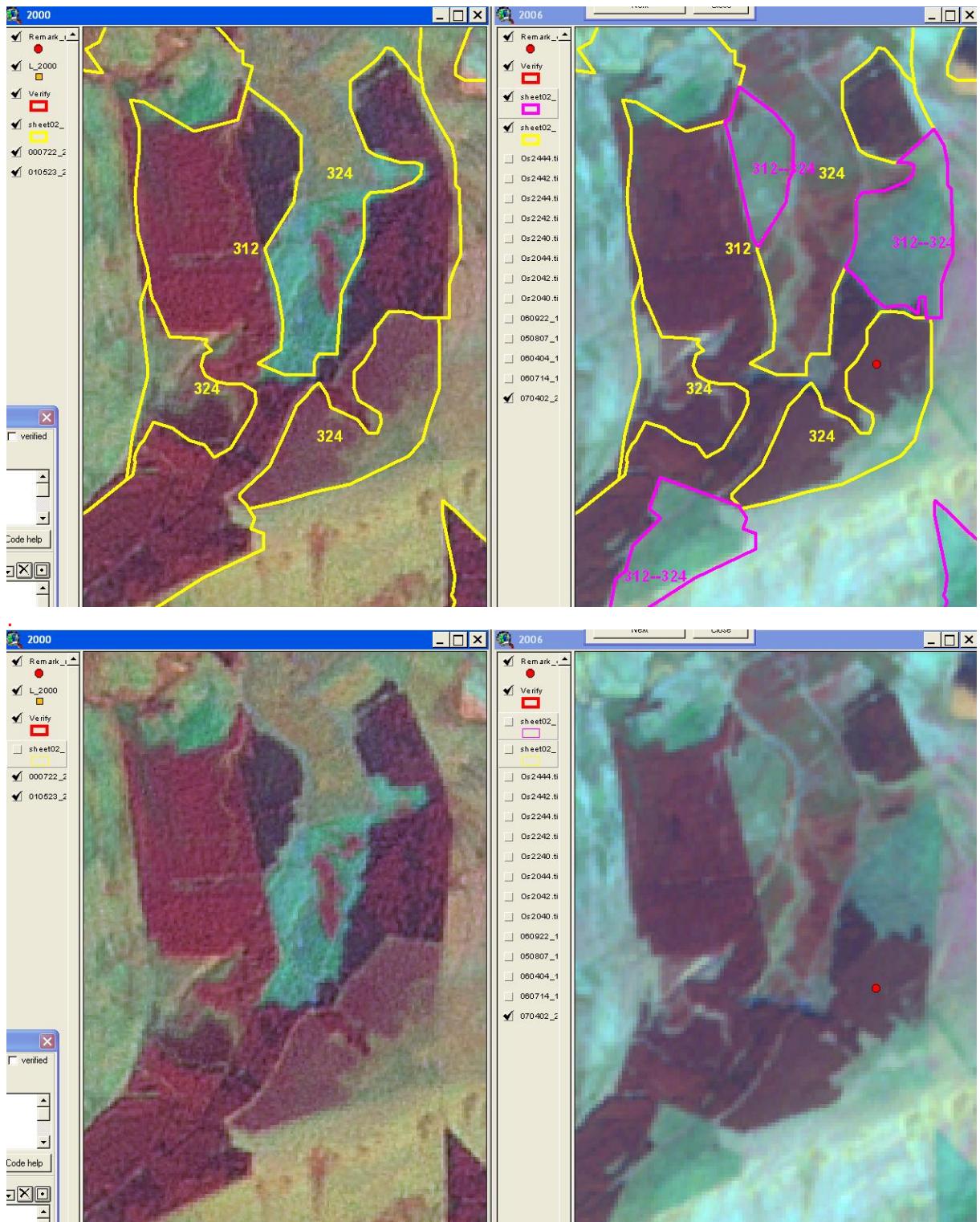
Forest growth in coniferous plantation. On IMAGE2000 (left) a huge coniferous plantation is visible. Part of it is not fully grown up, which is indicated by lighter colour compared to neighbours (consequence of spectral response of the soil / undergrowth). This patch is correctly mapped as 324 in 2000. By 2006 (right) colour of the patch is similar to neighbouring grown-up forest areas, 324-312 change being correctly mapped. There are 34 719 polygons of this type covering 8.91 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Frequent mistakes:	How to avoid the mistake
Forest growth	
Omitted changes	In most of the countries loss and growth of forest cover is balanced, thus we must assume that the same area is covered by this change than with clearcutting. This is the change type where there is the most ground for using semi-automated methods for detection of changes / potential change areas.
False change due to seasonal differences mapped as change	Seasonal differences of foliage of deciduous trees are not real CLC changes. Being aware of image dates (month, but at least season) and biological characteristics of the most common forest tree species helps avoiding this mistake.
False change mapped due to overestimation of change extent	Trees do continuously grow, which is often well visible on images. However, not all growth is a change from CLC point of view. Only if forest has presumably reached the 5 m height limit, can we talk about 324-31x change. Until then the area remains to be 324 even for decades (this is often the case in less favourable climatic/soil growing conditions and with certain slower-growing species, e.g. oaks).
Forest growth (324-31x) misinterpreted as new forestation area (2xx-31x)	As a base rule, new forest (31x) is always preceded by transitional woodland, i.e. young forest plantation (324). As 6 years is (with very few exceptions) too

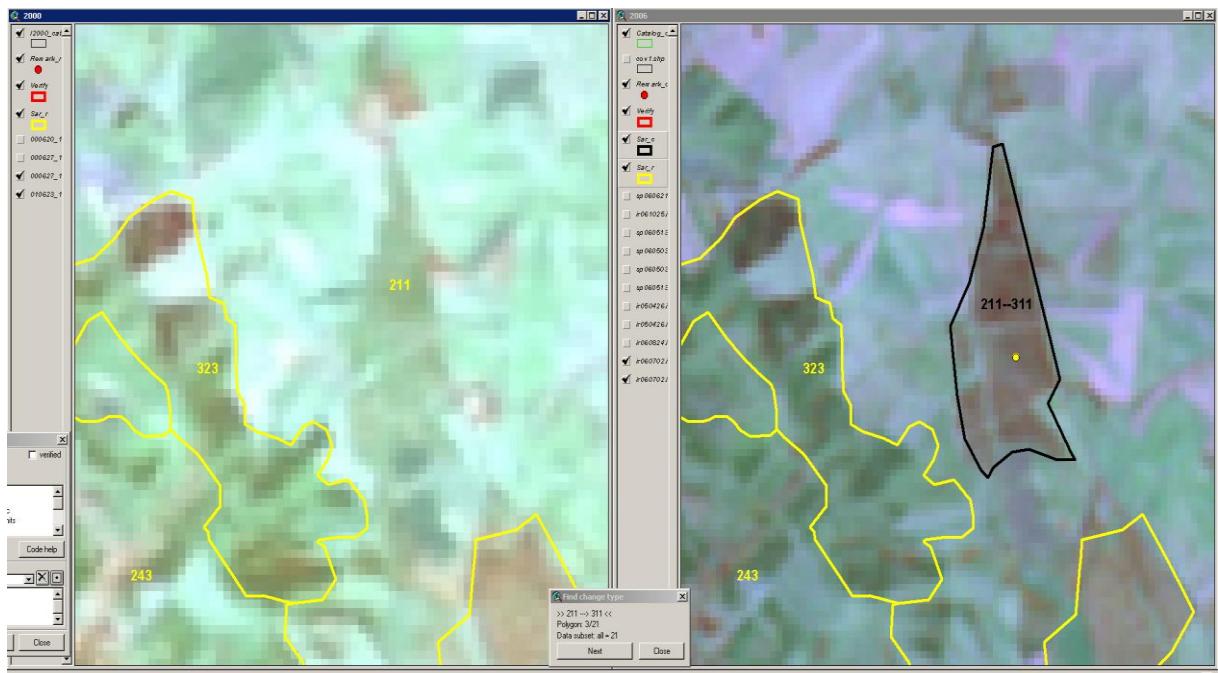
	short for a new forest to fully develop from "nothing" to above height limit, we must assume that a forest discovered on the new image was already there as young plantation on the old image, even if it was not well visible. In such cases the right solution is correcting the old database into 324 and mapping the change as 324-31x. HR/VHR imagery often helps identifying the young plantation on the old image. If no sign of plantation is visible on the old image, the right interpretation is often 2xx-324.
Regeneration after fire misinterpreted as forest growth	Black or dark green colour on satellite image usually indicates recent fire damage. Regeneration of forest after burn should be mapped as 334-31x or 334-324. See Ch. 4.8.



Mistake: forest growth misinterpreted as new forestation area (321-31x). In 2000 (left) a shrub-covered area (324) is visible in the middle, being misinterpreted as natural grassland (321). Although some growth in biomass is visible on the 2006 image (right), the area still cannot be considered fully-grown forest (compare with neighbours). On the other hand, 6 years is too short for a new forest to fully develop. The process normally happens in two steps, first 321-324 then 324-313. The right solution would be correcting the code to 324 and mapping no change.



Mistake: typical case of overestimating forest loss by omitting forest growth (324-312, see red dot). (Clearcuts are properly interpreted as 312-324.) In 2000 (left) a mosaic of forests in different stages of development is visible (312 and 324). On 2006 image (right) patches where young forest has reached the full-grown height of minimum 5 m were not mapped as change. Switching off polygon outlines (see bottom image) helps the identification of such cases; note how the patch differs from its surroundings on the 2000 image and how similar is to the neighbouring grown-up forest on the 2006 image.



Mistake: forest growth misinterpreted as new forestation, because of a missing 324 in CLC2000. Although patch of forestation was already visible on the 2000 image (left), forest growth was misinterpreted as afforestation on arable land. The patch can be mapped as 311 based on 2006 image (right), and some increase in biomass is also visible, but 211-311 change is not correct. The right solution would be either mapping forest growth (324-311) or correction of parent stock layer using technical change (324-324).

4.7 DEGRADATION OF FORESTS AND SHRUBS BY FIRE

Change process: Degradation of forests and shrubs by fire: 311/312/313/323/324-334, 312/324-323

Overview and rationale:

Wildfires in Europe typically (but not exclusively) occur in the Mediterranean areas, appearing in the news day by day in the dry summer season. Fire is the most important natural threat to forests and wooded areas of the Mediterranean basin. According to FAO Forest Fire assessment, 600.000 hectares are affected by fires annually in this region, with the frequency of fires continuously growing since the 1970's. Although natural causes (such as lightning) contribute to ignition of wildfires, in the Mediterranean basin major cause is human carelessness, such as discarded cigarettes, arson, sparks from equipment, fires left unattended. Prescribed fire ignited to prevent increased destruction by future fires is the third major cause. Wildfires, natural or anthropogenic have:

- ecological effect (destruction, changes of plant associations)
- economic effect (loss of timber and crops, damage to human property, negative effect on tourism and aviation, cost of detection and fire fighting)
- health effect (air pollution, casualties)
- climatic effect (greenhouse gases).

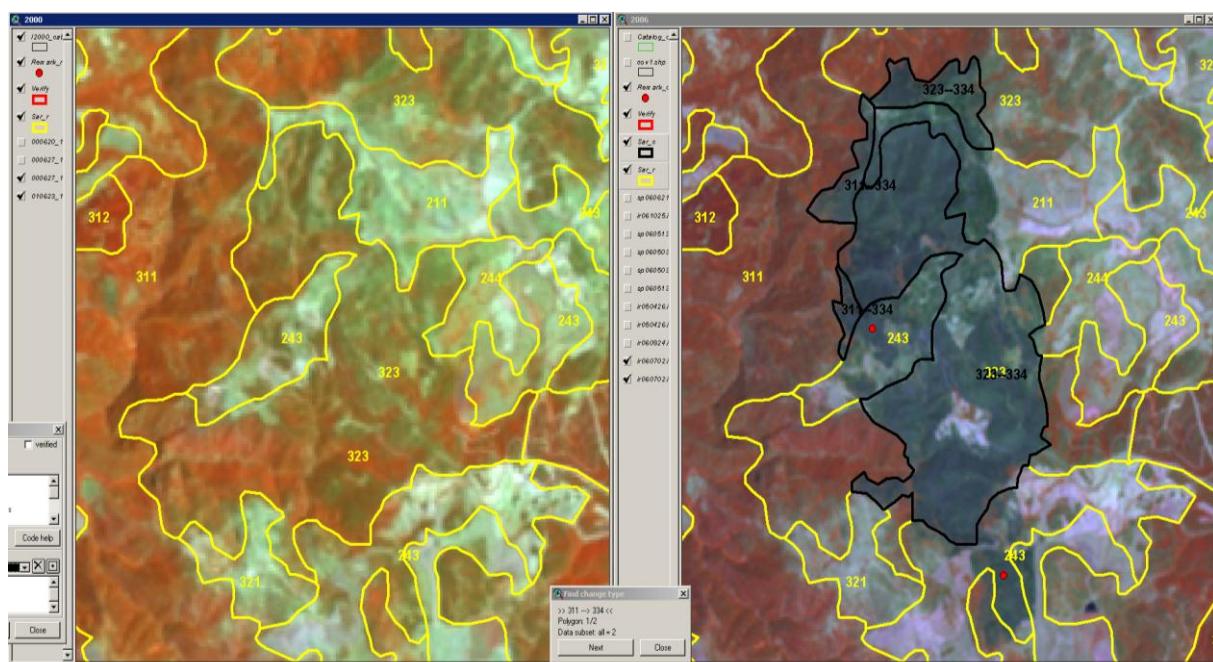
Wildfires in Scandinavia are mostly caused by natural phenomena. Peat fires do also have serious economic effect, but they are not detectable by remote sensing, which is otherwise the most important method of detection and damage assessment of surface fires. In CLC mapping only fires affecting forest and shrub are mapped, burnt grassland and agricultural crops are not coded as 334.

Number of changes in European CLC-Change: 1473 polygons

Area of changes in European CLC-Change: 1.72 %

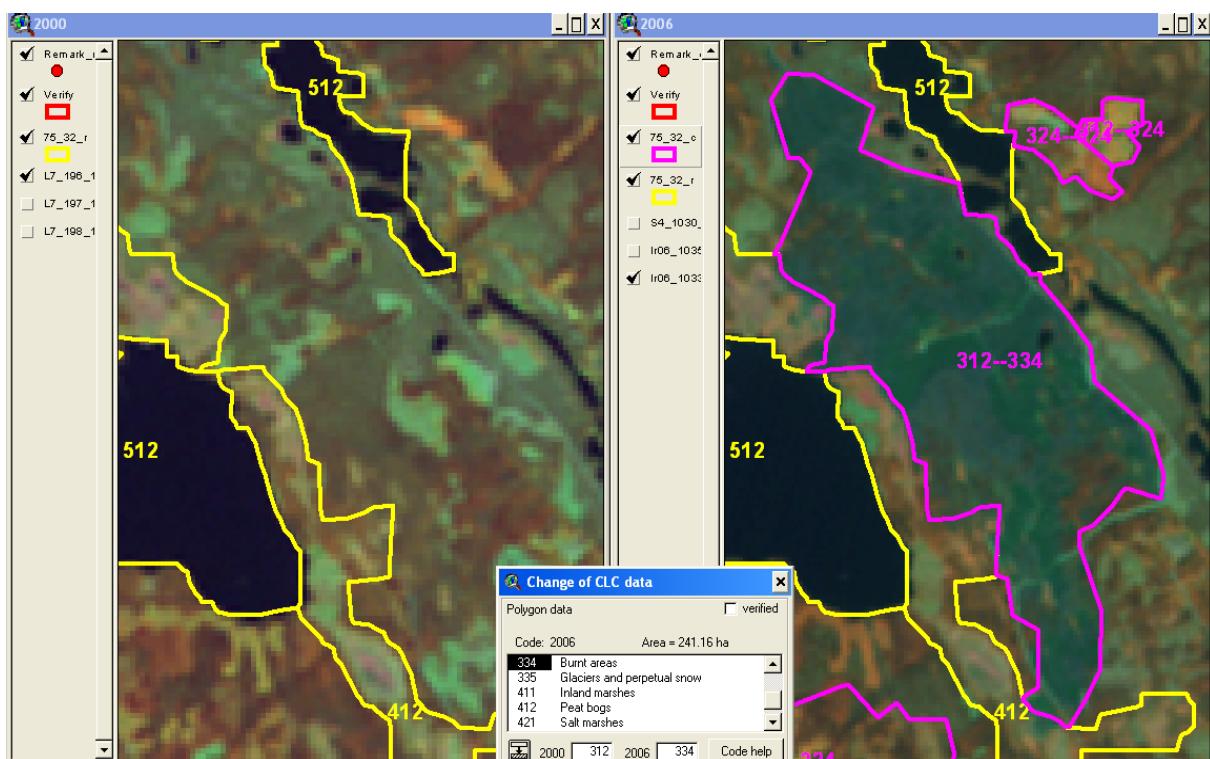
Type: Wildfire in the Mediterranean area: 311-334 and 323-334

Interpretation example (Italy):



Nicely mapped forest fire (311-334 and 323-334) in the Mediterranean area. Code 334 should be used until the black (dark green) colour, characteristic of freshly burnt areas, is visible (as on 2006 image - right). Note that burnt agricultural areas (211, 243) are – correctly – not mapped as 334. 334 code should be used only for burnt forest (311, 312, 313) and shrubs (322, 323, 324, 333). There are 205 pieces of 311-334 polygons covering 0.18 % of all changes; and there are 148 pieces of 323-334 polygons covering 0.25% of changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

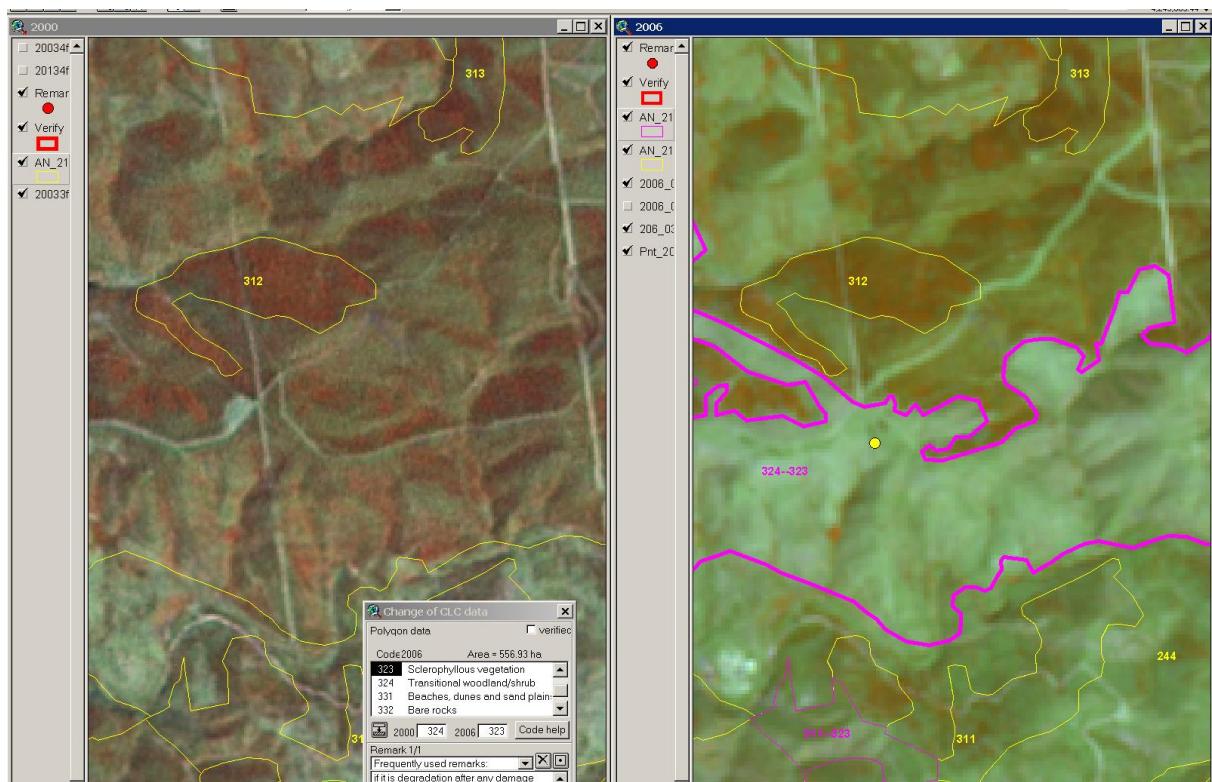
Type: Burnt coniferous forest (in temperate climate): 312-334
Interpretation example (Norway):



Forest fires occur also in Central Europe and in the Scandinavian areas, this being an example of the latter. A heterogeneous 312 area (left) became a homogeneous dark green patch by 2006 (right). The characteristic dark green colour is a mixture of spectral response from ashes and underlying rock / soil. Dark colour is often more difficult to recognize in such areas as the images are generally dominated by dark colours anyway. There are 321 polygons of 312-334 change covering 0.48 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

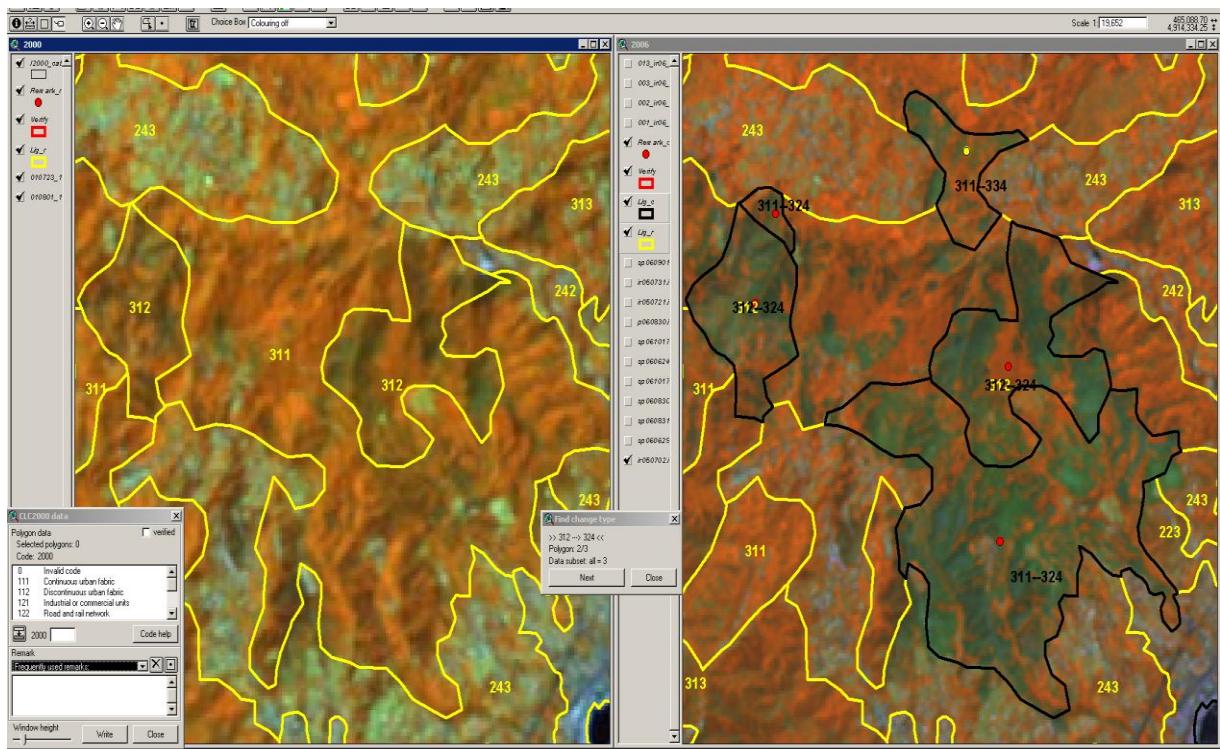
Type: Transitional woodland-shrub changed to sclerophyllous vegetation as result of former wildfire: 324-323

Interpretation example (Spain):

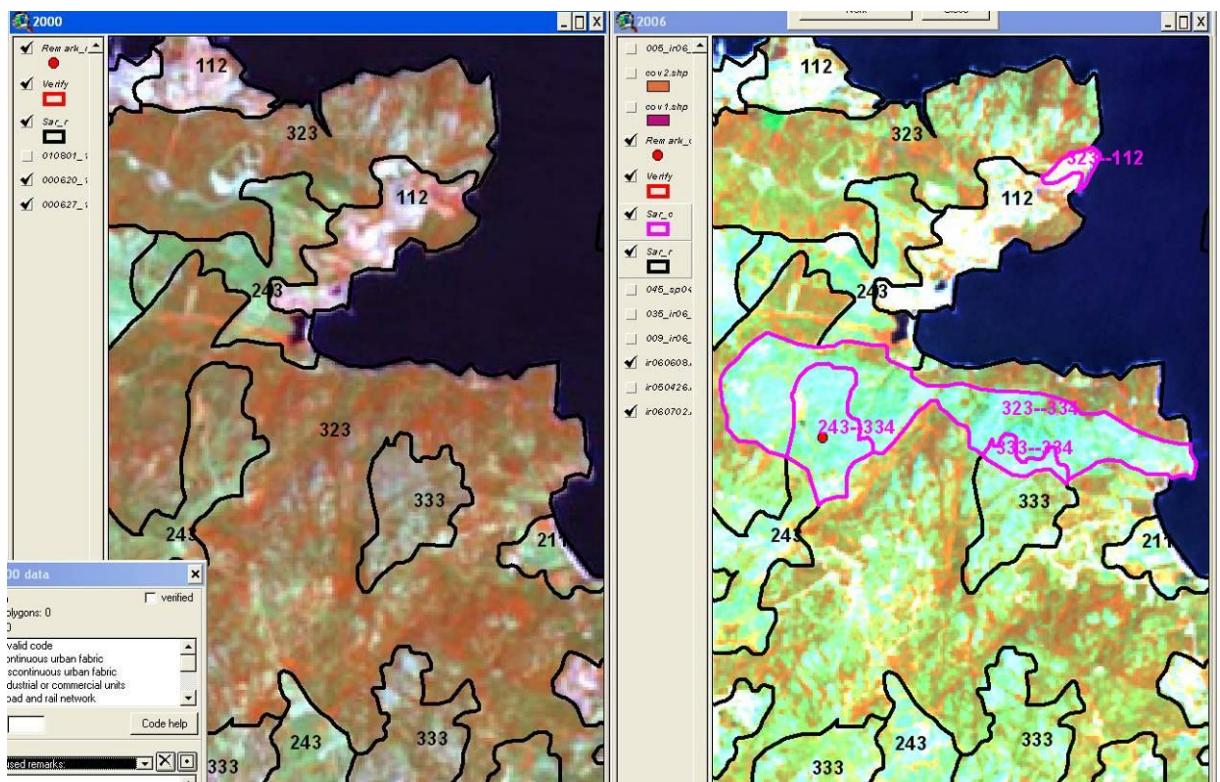


Transitional woodland (forest plantation, 324) has become sclerophyllous vegetation, most likely because of earlier fire damage (324-323). A decrease in the biomass is visible comparing the satellite images. When examining the area using in-situ data, we learn that in 2000 (left) the area was a forestation area with fairly young trees (rows of plantation visible). By 2006 (right) much of the biomass disappeared and the lines of plantation are no longer visible. Forest plantation (324) has been destroyed by wildfire then natural vegetation (323) occupied its place during the regeneration process. There are 65 polygons of this change type covering 0.13 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

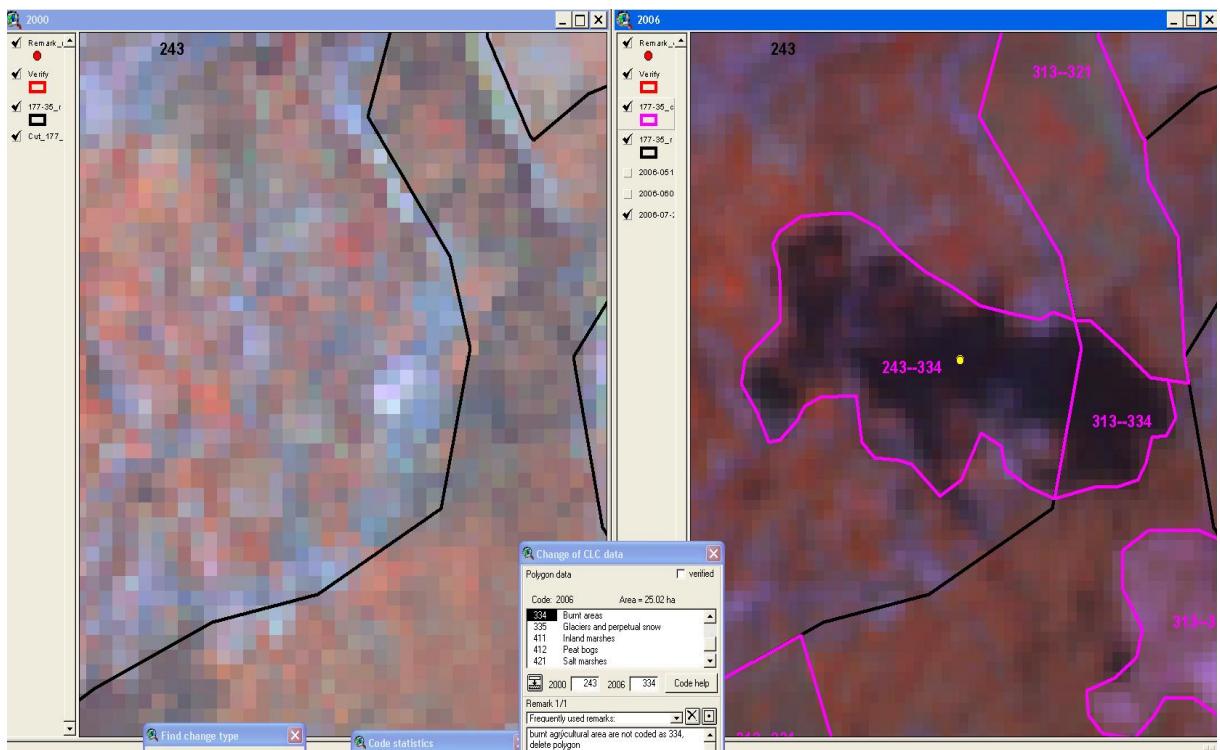
Frequent mistakes:	How to avoid the mistake
Degradation of forests and shrubs by fire	Characteristic black / dark green colour of freshly burnt vegetation is very easy to recognize. Revising the interpretation area in scale 1:40.000 is good way of finding these patches. By checking the code statistics we can find out whether forest fires are typical of the given area; if 334 code occurs in the parent stock layer, we can expect this process to be present in the area.
Omitted changes	Characteristic black / dark green colour of freshly burnt vegetation is very easy to recognize. Revising the interpretation area in scale 1:40.000 is good way of finding these patches. By checking the code statistics we can find out whether forest fires are typical of the given area; if 334 code occurs in the parent stock layer, we can expect this process to be present in the area.
False change due to burnt area not recognized, forest burn is misinterpreted as clearcutting	Beside colour (black/dark green), shape of forest loss might help to identify forest fires. Fire scars have irregular shape, while forest clearcuts are often regular, with defined boundaries.
Old fire scars misinterpreted as 334	Code 334 should be used only until dark colour is visible. After that the next step of regeneration process (e.g. 333, 321, 323, 324) should be mapped. For more explanation see table at Ch.4.8.



Mistake: forest burn misinterpreted as clearcut. Loss of forest is normally assumed to be of human origin, i.e. clearcutting. Here interpreter failed to recognize the characteristic dark green colour of burnt forest in 2006 (right) and misinterpreted the area as transitional woodland and shrub (324). The right process is 311-334 and not 311-324.



Mistake in mapping burnt sclerophyllous vegetation. 334 should be used until dark colour is visible. Here we see light colour of the ground in 2006 (right), which is the consequence of soil erosion after fire removed protective vegetation cover (323). Thus the process to be mapped is Mediterranean shrub changed to sparsely vegetated area (323-333) and not shrub being burnt (323-334).



Mistake: burnt agricultural area erroneously mapped as 334. On the 2000 image (left) a heterogeneous agricultural area is visible, correctly mapped as 243. Black patches on 2006 image (right) indicate fire scars. The fire affected both the agricultural area and the neighbouring forest (313). Burnt forest is correctly mapped as 313-334, but following the rules described in the nomenclature, burnt agriculture polygon (243-334) should have been deleted. 334 class should be used only for fire-affected natural vegetation (forest, shrub, sparse vegetation). These changes are very easy to find during control process by revising all 2xx-334 changes from the change code statistics.

Particularity-1:

Type: Active forest fire: 312-334, 324-334

Interpretation example (Portugal):

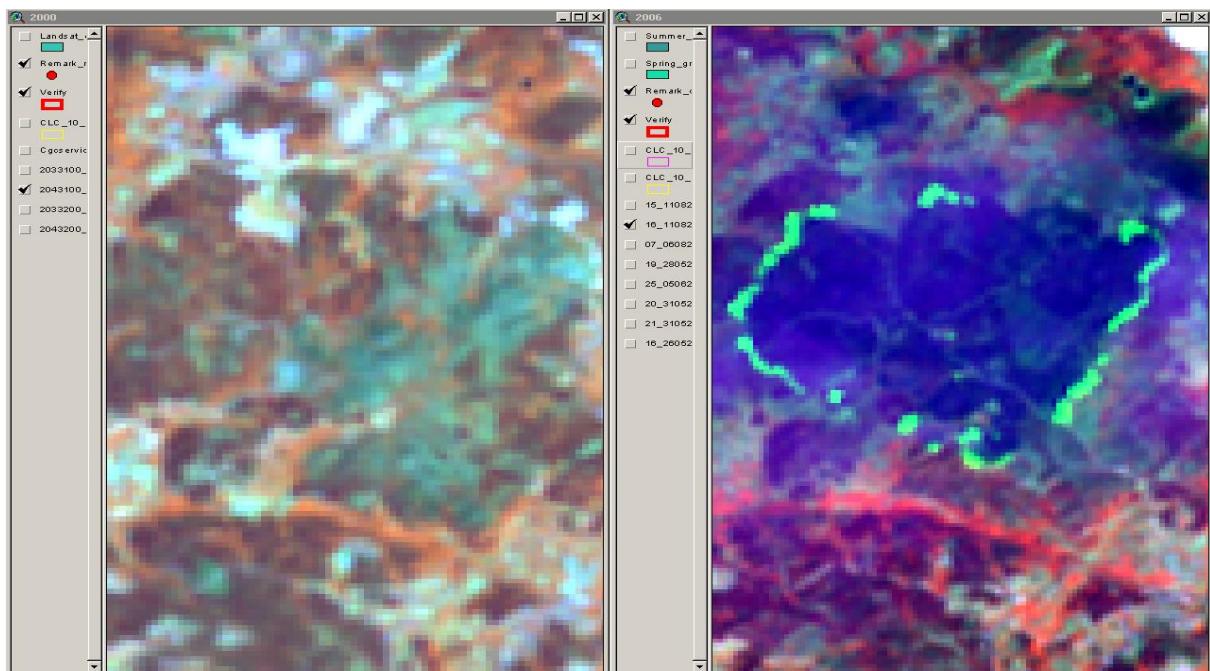


IMAGE2006 (right) shows a just burnt area (334) with active fire on the edges (light green). The fire progressed radially outward. The corresponding area on IMAGE2000 includes coniferous forest (312, brown colour) and transitional woodland-shrub (324, light-green) which can be forest damaged by previous fire or young forest. Mapped processes are: 312-334 and 324-334.

4.8 AFFORESTATION, REGENERATION AFTER DAMAGE, NATURAL SUCCESSION

Change process: Afforestation, regeneration after damage, natural succession:
321/322/323/333/334-324, 334-323

Overview and rationale:

This group includes anthropogenic and natural processes that result emergence of transitional woodland and shrub areas. Afforestation is the process of establishing a forest on previously unforested land, for reasons of timber harvesting, conservation of biodiversity, or soil decontamination, among many. Regeneration after (fire) damage and natural succession are both natural processes aiming to reach the climax-stage vegetation type (forest or shrub) on areas that became unforested due to fire or specific land use practices (e.g. grazing / mowing). While due to its human origin the process of afforestation is often easy to detect (signs of soil preparation, rows of young trees) on remote sensing data, the second two processes are more difficult to capture, due to their gradual development.

Number of changes in European CLC-Change: 2575 polygons

Area of changes in European CLC-Change: 3.40 % of all change areas

Type: Regeneration of forest/shrub after fire: 334-324

Interpretation example (Kosovo under the UN Security Council Resolution 1244/99):

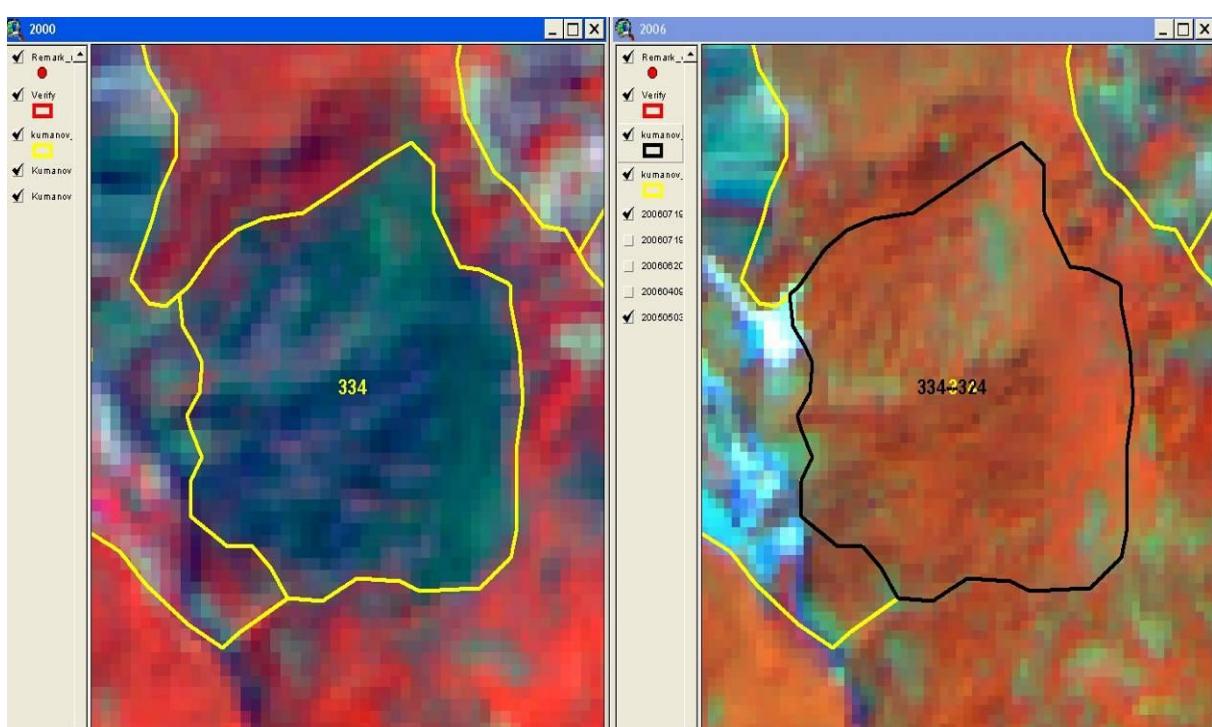


IMAGE2000 (left) shows a burnt area (334), indicated by the black / gray colour. By 2006 (right) regeneration of forest started and transitional woodland-shrub class (324) had to be mapped. In a few more years the 324 will most likely grow up to forest. There are 630 polygons of this type covering 1.44 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Certain vegetation types, such as sclerophyllous shrubs (323) are more frequently affected by wildfires. This vegetation type has therefore "developed" the ability of quick regeneration. If fire was not very fierce, shrubs might start sprouting weeks after the fire (see photo below), replacing the original 323 vegetation in a few years. This might apply to moors and heathland (322), too. However, if fire was too strong, shrubs might die out, leaving the ground to herbaceous vegetation (321) (see photo below). On rocky and sloping grounds, where soil is shallow, disappearing vegetation lets soil erosion take

away the thin soil layer, leaving the area sparsely vegetated (333) or even without vegetation (332). Burnt forests take longer time to regenerate. This process is characterised by 334-324 change type, regardless whether natural or human induced (re-plantation). The rules in the table below do also apply to heavily damaged forests.

The following table gives an overview of which processes are possible during regeneration after fire [7].

	321	322	323	324	333
322	Possible but rare	possible	impossible	only with human intervention	Possible but rare
323	Possible but rare	impossible	possible	only with human intervention	Possible but rare
324	Possible but rare	possible only if 324 was of human origin (plantation)	possible only if 324 was of human origin (plantation)	Possible, often with human intervention	Possible but rare
31x	Possible but rare	impossible	impossible	Possible, often with human intervention	Possible but rare

As we see from the table, regeneration process depends on the original vegetation. It is therefore good to know what the vegetation was before the fire.

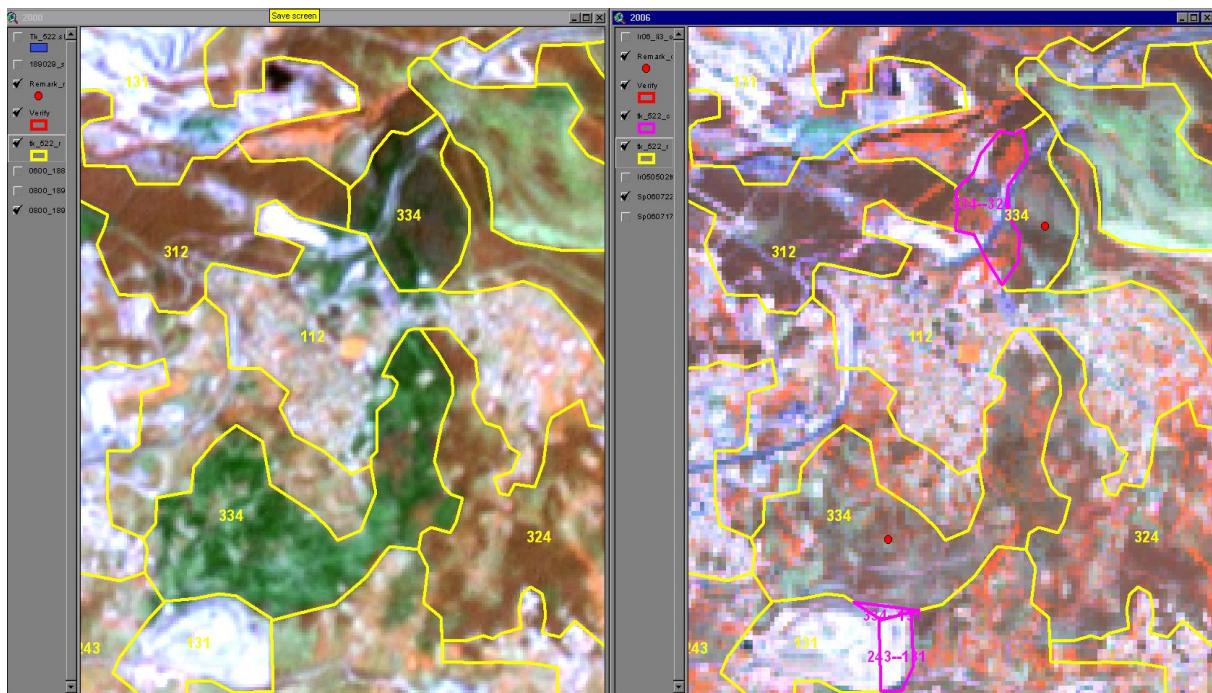


If fire was not very fierce, surviving shrub starts sprouting short after the fire, as visible on this image. Sclerophyllous shrub might fully regenerate within a few years.

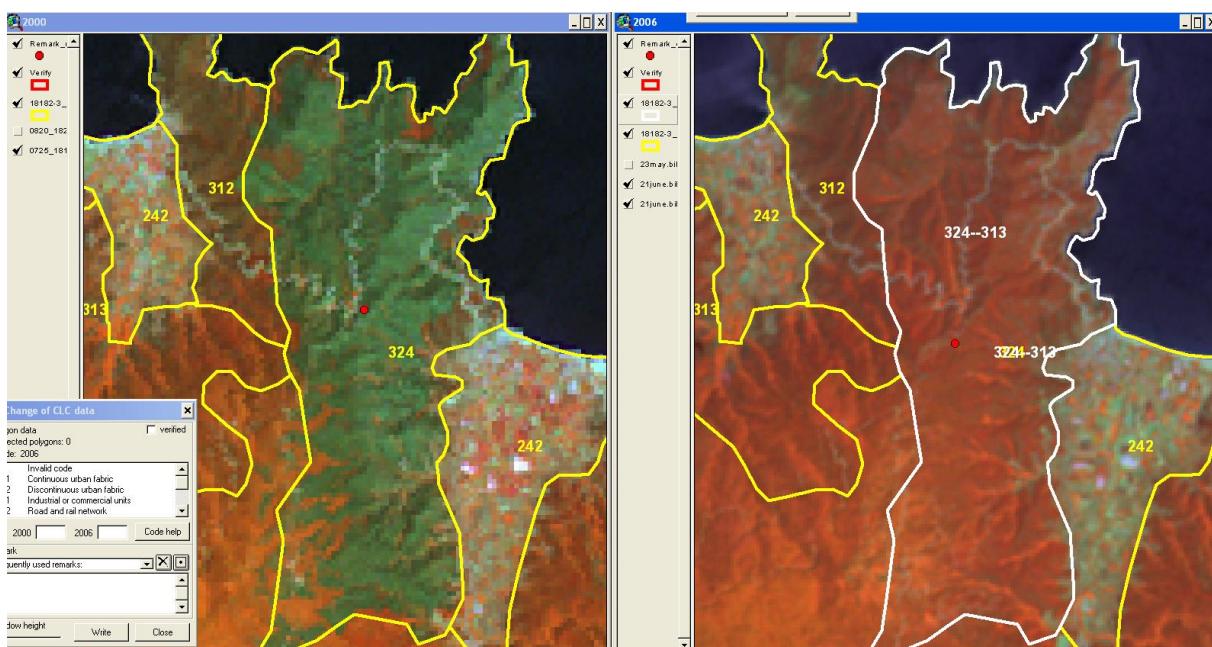


Shrubby/forest vegetation after heavy fire damage might completely die out, so that regeneration does not start for years. In such cases the area might be occupied by herbaceous vegetation, like on this image (321) or on a rocky surface erosion might destroy thin soil, leaving the ground bare or sparsely vegetated (333).

Frequent mistakes: Regeneration of forest/shrub after fire	How to avoid the mistake
Omitted changes	Black colour of the burnt area always disappears in a few years. Therefore, 334 patches must change in 6 years, either because of natural regeneration (321, 322, 323, 324), or forest re-plantation (324) or erosion (333). Check all 334 polygons in the stock layer in order to find missing changes.
False change because of 334 not recognized in the old database, misinterpreted as 324-31x	Characteristic colour helps identifying fires scars.

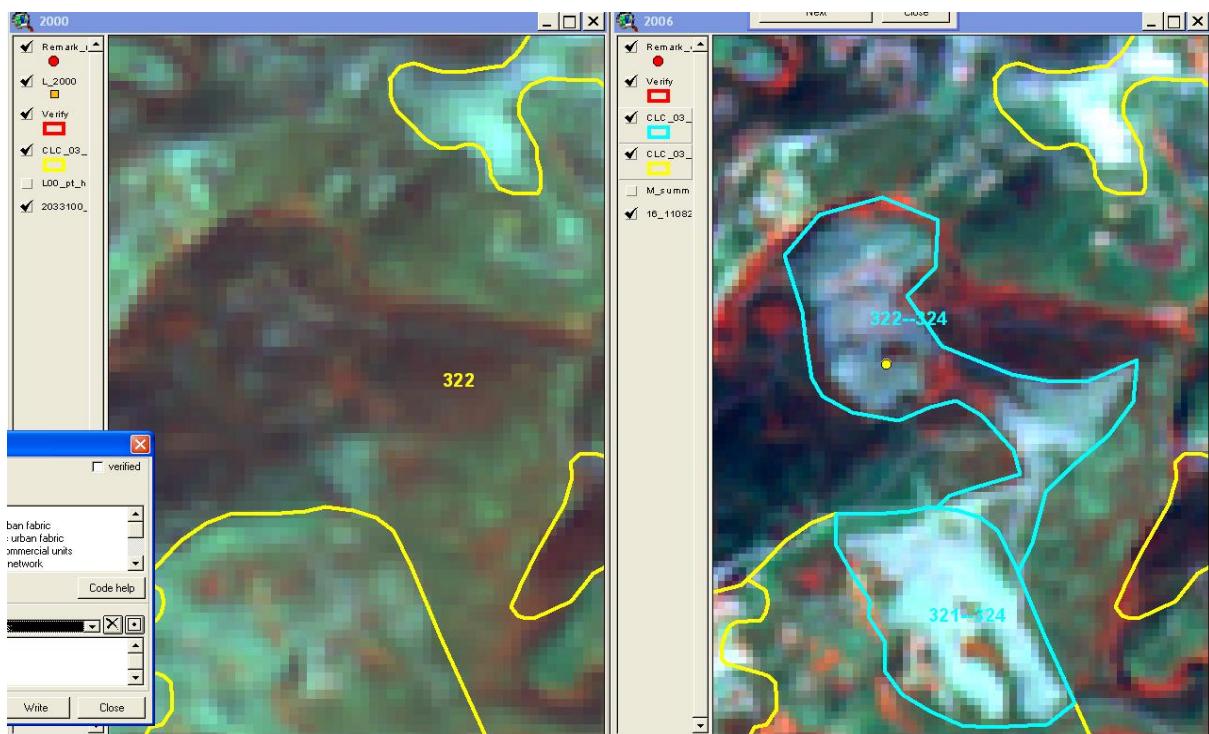


Mistake: Regeneration after fire not mapped (see red dots). It is well visible how dark green colour of the fire scar was replaced by brown-red colour of upcoming vegetation (323 or 324). Missing change: 334-323 or 334-324 (in-situ information is needed to decide on 323 or 324).



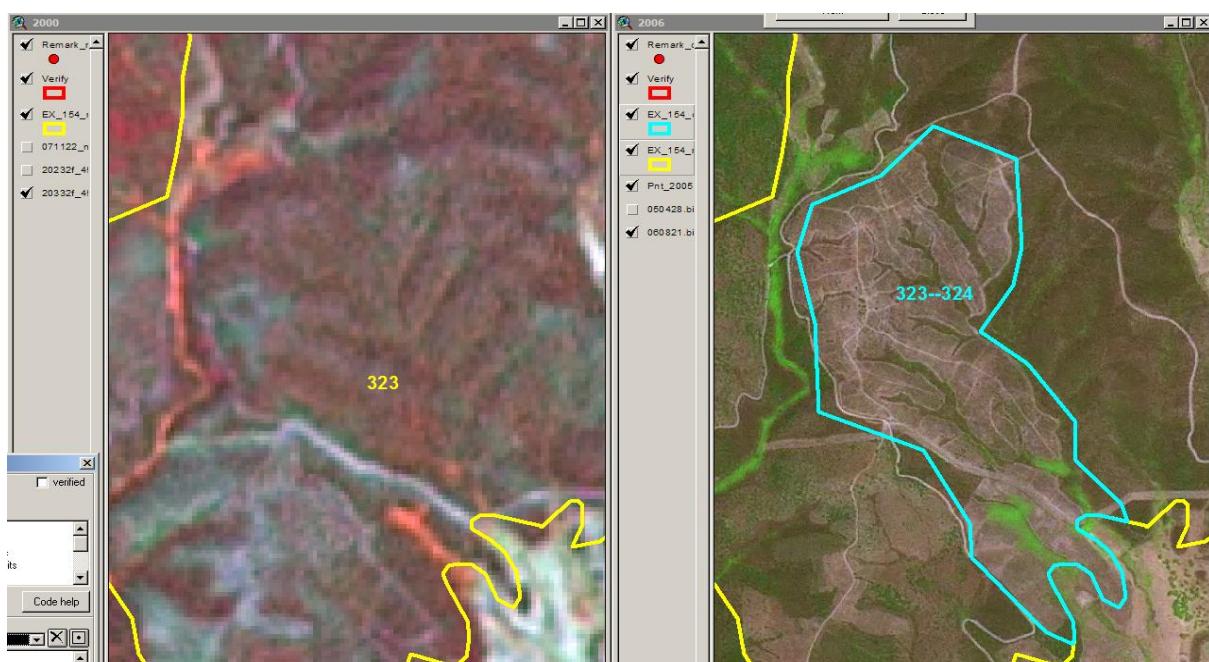
Mistake: 334-313 miscoded as 324-313. IMAGE2000 (left) shows low biomass over most of the outlined polygon, while IMAGE2006 indicates a "normal" forest. The colour visible in 2000 suggests a burnt area, consequently instead of 324-313 the correct change would be 334-313. As the regeneration was completed in 6 years, the fire must not have been very destructive.

Type: Afforestation replacing moors and heathland: 322-324
Interpretation example (Portugal):



Natural vegetation, atlantic shrub visible in 2000 (left) is replaced by forestry (322-324). Note that as first stage of forestation the original vegetation was removed and soil is disturbed, being recognizable as bright patches on the 2006 image (right). There are 369 polygons of this type covering 0.16 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

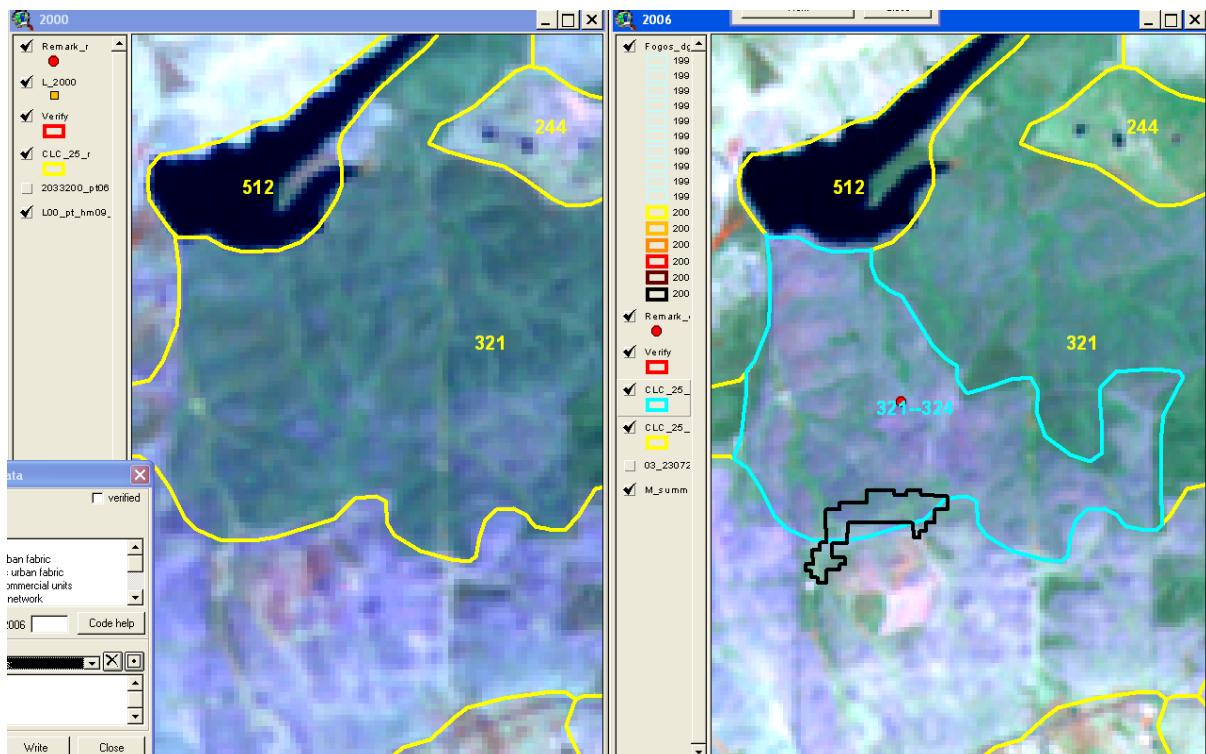
Type: Afforestation replacing sclerophyllous vegetation: 323-324
Interpretation example (Spain):



Mediterranean shrub (323, IMAGE2000 left side) is replaced by forest plantation (324, SPOT-5, right side). Signs of afforestation are often visible only on HR imagery. Use of ancillary data is therefore necessary for identifying this change. There are 693 polygons of this type covering 0.80 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database. (Instead of standard IMAGE2006 Spain used SPOT-5 imagery (multispectral and PAN merge) with pixel size of 2.5 m taken in 2005.)

322 and 323 are climax vegetation types, meaning that these form the final stages of natural succession in the given area. They can be replaced by forest only by strong human impact (soil preparation, selection of tree species that are often foreign to the area). 322/323-324 change therefore does not occur naturally, only by human intervention. Interpreter must look for signs of this human impact, often visible only on HR/VHR imagery.

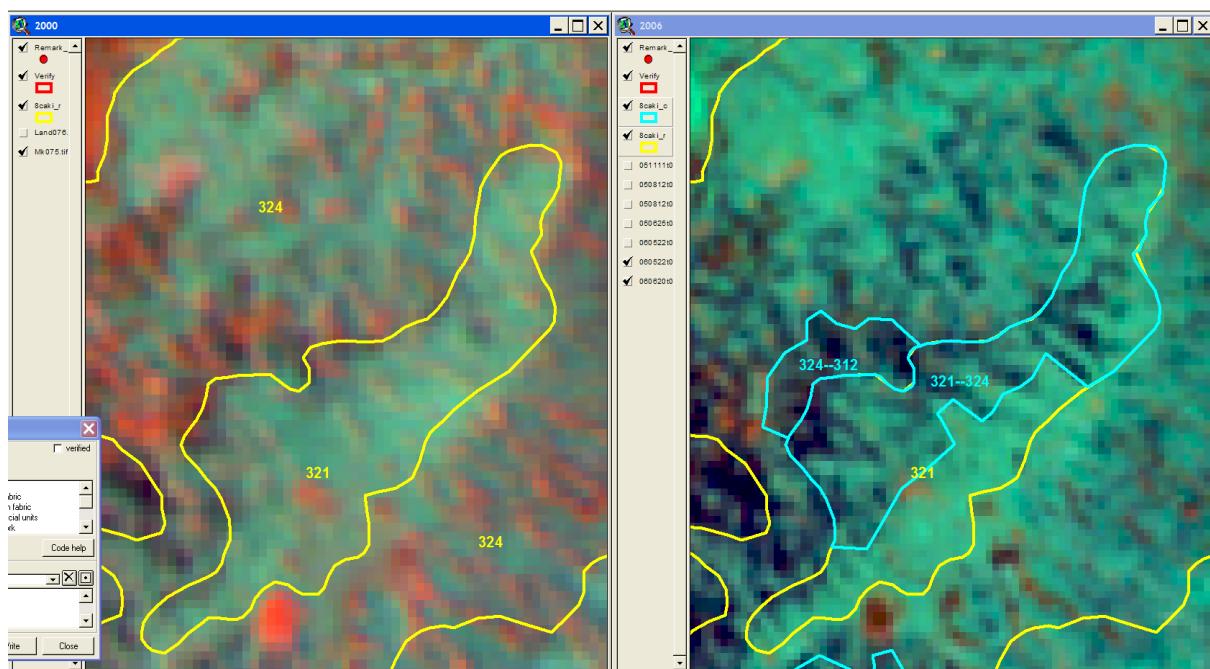
Type: Afforestation on natural grassland: 321-324
Interpretation example (Portugal):



New forestation area on former natural grassland. Natural grass area (321) visible in 2000 (left) in green colour, was replaced by a disturbed soil surface by 2006 (right), correctly mapped as 321-324. Note that first step of forest plantation shows reduced biomass (opposite to what would be expected). Use of HR/VHR imagery or ancillary (forestry) data is necessary for identification of this process. There are 652 polygons of this type covering 0.46 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Type: Natural succession: 321-324

Interpretation example (FYR Macedonia):



First step of natural forest succession on natural grassland, correctly interpreted as 321-324. Forest succession is indicated by increasing number and density of forest patches in 2006 (right) compared the 2000 (left) status, where green colour of grassland dominates. Note that opposite to the previous, human-induced change, biomass shows continuous increase here. There are 652 such polygons covering 0.46 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Frequent mistakes:	How to avoid the mistake
Afforestation on natural areas False changes due to seasonal differences in vegetation being misinterpreted as real change	Seasonal differences of foliage of deciduous shrubs and differences coming from lifecycle of herbaceous species (fresh green in spring, burnt out by sun in summer) are not CLC changes. Being aware of image dates (month, but at least season) and biological characteristics of the most common vegetation types help avoiding these mistakes.
Afforestation misinterpreted as vegetation loss	While in case of natural succession biomass gradually increases in the area, human-induced afforestation often starts with a temporary decrease of biomass. Often strong human impact (removal of natural vegetation cover, soil preparation, selection of tree species that are often foreign to the area) is required for replacing natural climax-stage vegetation (e.g. 321, 322, 323) with forestry species. The use of background knowledge and VHR imagery help identification of young forest plantations.

4.9 MELTING OF GLACIERS

Change process: Melting of glaciers: 335-332

Overview and rationale:

The retreat of glaciers (observed since cca. 1850) affects the availability of fresh water for irrigation and domestic use, mountain recreation, animals and plants that depend on glacier-melt, and in the longer term, the level of the oceans. Studied by glaciologists, the temporal coincidence of glacier retreat with the measured increase of atmospheric greenhouse gases is often cited as an evidentiary underpinning of global warming. Mid-latitude mountain ranges such as the Alps are showing some of the largest proportion of glacial loss. Though the glaciers of the Alps have received more attention from glaciologists than in other areas of Europe, research indicates that throughout most of Europe, glaciers are rapidly retreating [13].

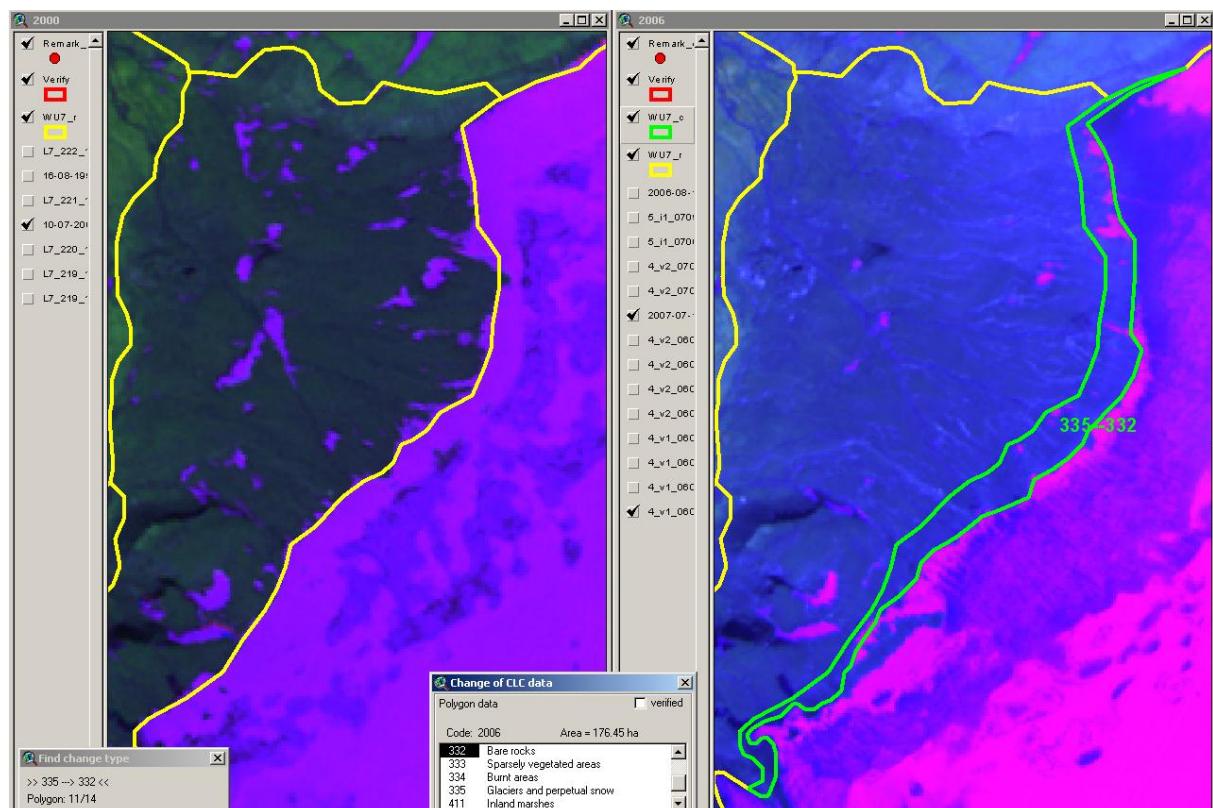
Being a sensitive ecological, political and social issue, monitoring of glaciers' retreat deserves special attention therefore must be carried out especially carefully.

Number of changes in European CLC-Change: 589 polygons

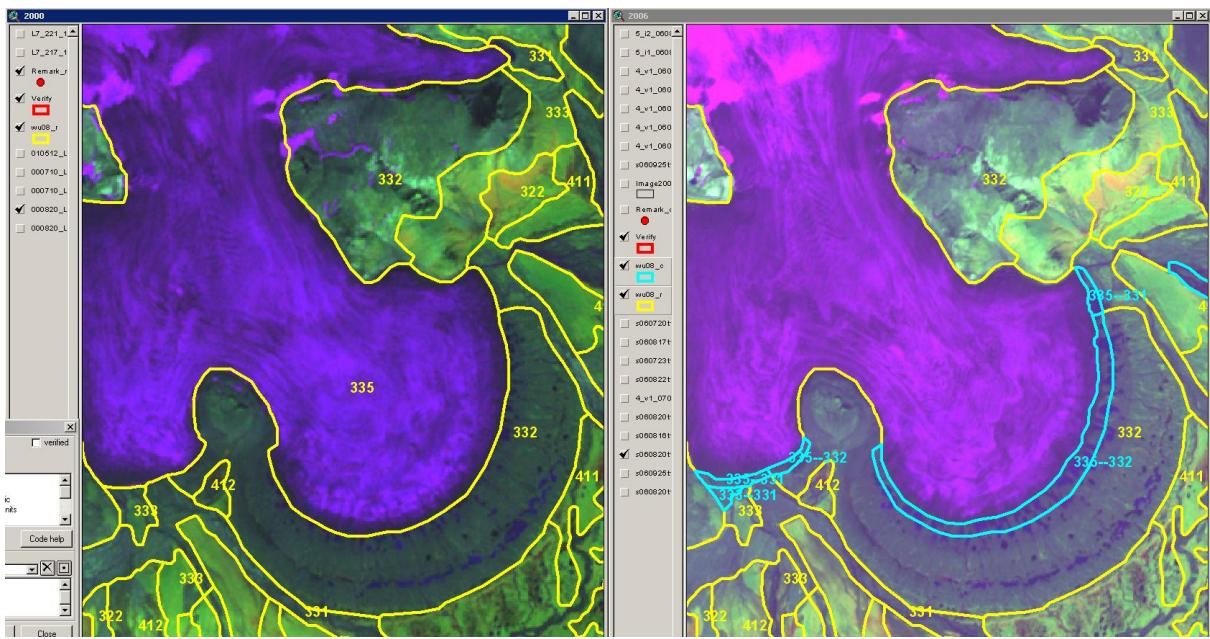
Area of changes in European CLC-Change: 0.33 % of all change areas

Type: Melting of glaciers: 335-332

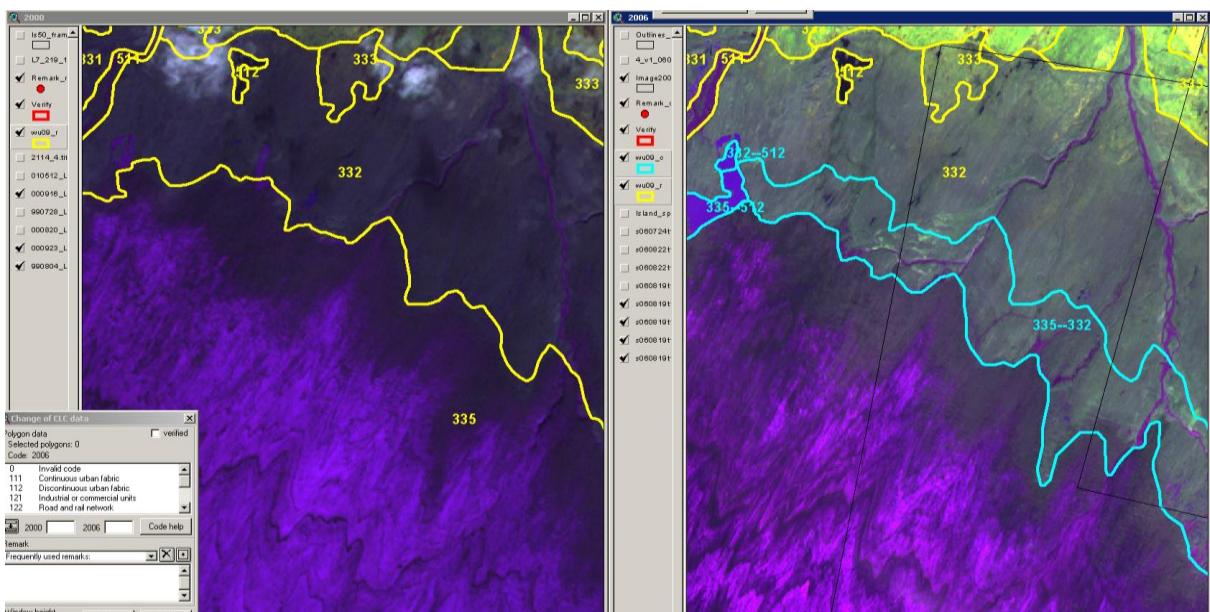
Interpretation example (Iceland):



Magenta colour means snow or ice. The large snow surface on the right of each image is a glacier, partly covered by annual snow (dispersed magenta patches). Black on IMAGE2000 (left) and blue on IMAGE2006 (right) indicates bare rock. The elongated change polygon (335-332) shows an area on the edge of the glacier, from where the permanent ice cover disappeared, i.e. glacier retreated. Retreating ice gives place to advancing moraine, consisting of large boulders and finer sediments, to be interpreted as 332. There are 589 polygons of this type covering 0.33 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

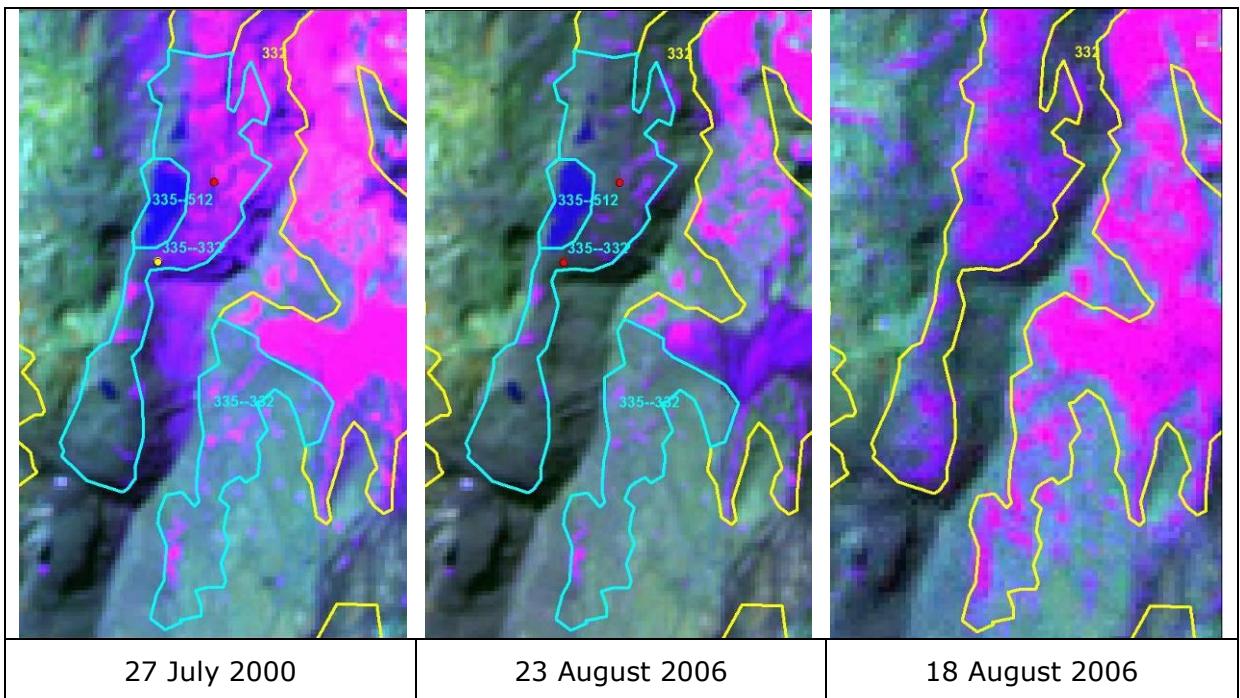


Retreat normally can be observed on the glacier's front, usually having an elongated shape. Be careful to keep the 100 m width limit of the change polygons.



Europe's largest ice cap, Vatnajökull (Iceland) also shows significant retreat.

Frequent mistakes:	How to avoid the mistake
Melting of glaciers	
Omitted changes	Systematically examining glacier fronts being much aware of image dates is the right way of avoiding omissions.
False changes due to using not the right image date	As glacier retreat is a hot and politically sensitive issue, you must make sure that real extent of change is mapped. Only images from exactly the same season are comparable. Even a few days/weeks difference between dates of image acquisition means large difference in snow/ice extent. Interpreters have to rely on images from end of August/early September, when extent of annual ice/snow is the smallest within the year. By this time previous winter's snow cover has shrunk to a minimum extent, while new snowfall of next winter has not occurred yet.

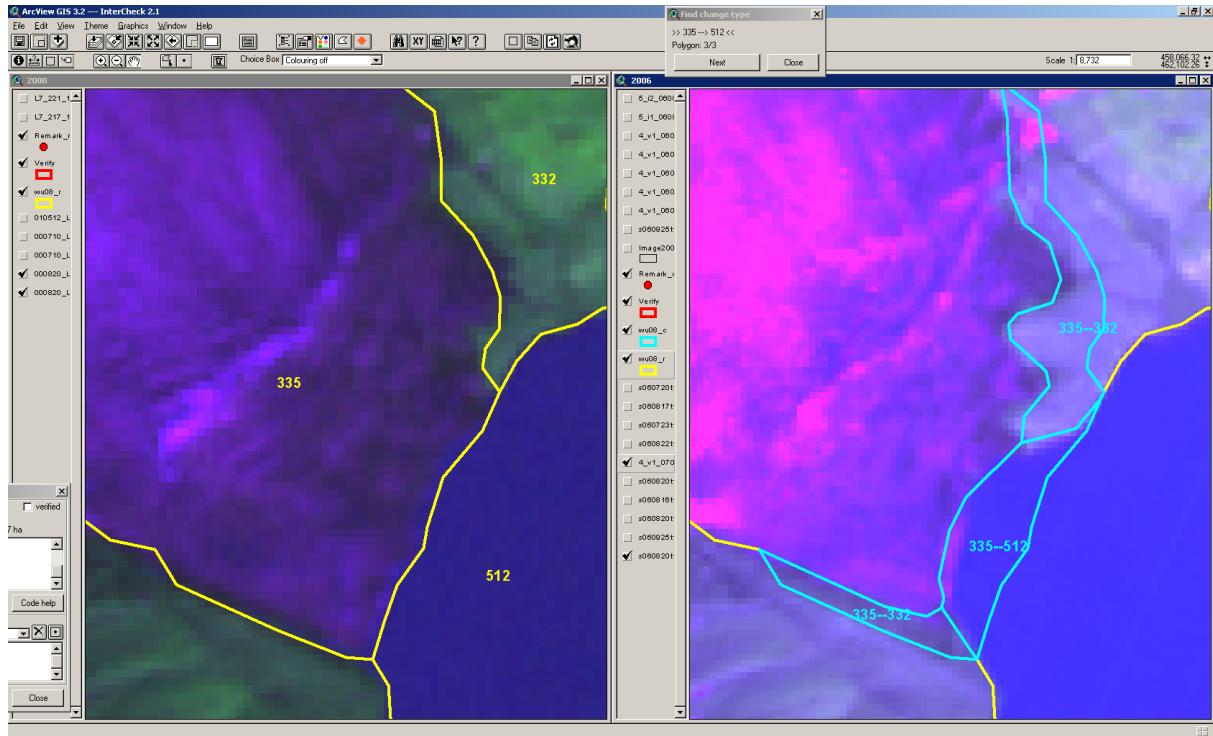


Mistake: Seasonal difference falsely mapped as glacier retreat change. When mapping glacier retreat, using the right image dates is of utmost importance. On the example end of July 2000 image (left) was compared to end of August 2006 image (middle). As a result false changes were drawn where differences in snow cover (indicated by red dots) were visible. When checking the same area on a bit earlier (only 5 days difference!) mid-August 2006 image (right), one can see that ice extent is almost as large as in July 2000, therefore no change should be mapped, but most likely parent stock layer has to be corrected to 332 at these points. Images from a few weeks difference within the season are already not comparable!

Particularity-1

Type: Retreating glacier changing to water surface: 335-512

Interpretation example (Iceland):



Retreating glacier might give area to the growing moraine lake, like on this image pair. Magenta colour indicates ice in both images (2000: left) part of which has melted into the moraine lake at the end of the ice tongue by 2006 (right). There are 21 polygons of this type covering 0.01 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

4.10 GRAVEL, SAND CHANGING TO (FREE-FLOWING) RIVER

Change process: Gravel, sand changing to (free-flowing) river: 331-511
Overview and rationale:

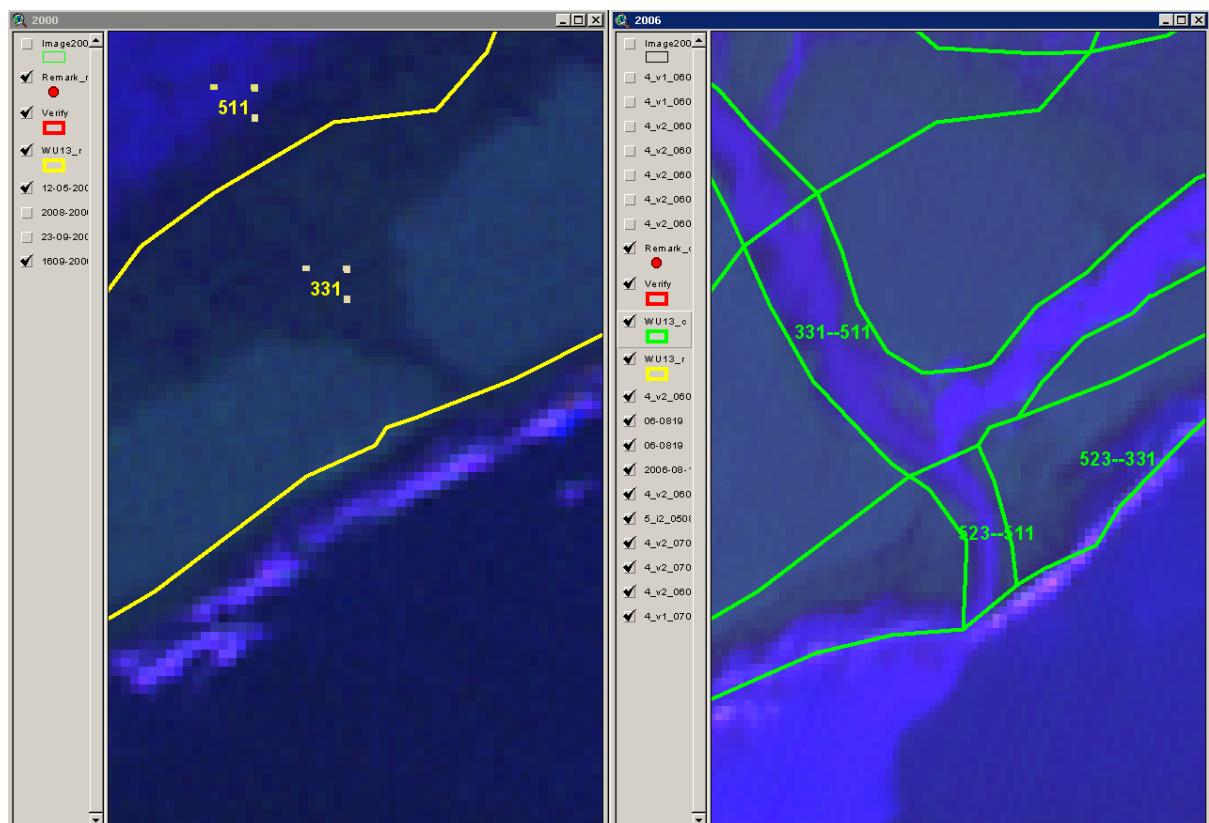
Changes from river sediments to water and back are characteristics of meandering free-flowing (i.e. its channel nor confined to dikes) rivers. The phenomena occurs on lower reaches of the river, where shallow gradient allows the meandering process, causing sedimentation in inner edge of curves, while erosion in the outer edge, which results a constant change of the river's course. Glacial or alpine rivers often have wide gravel beds, within which they constantly change their course by rearranging the deposited material during each flooding (high-water period). The existence of such changes is an important indicator of the natural (good ecological) status of rivers.

Number of changes in European CLC-Change: 118 polygons

Area of changes in European CLC-Change: 0.22 % of all change areas

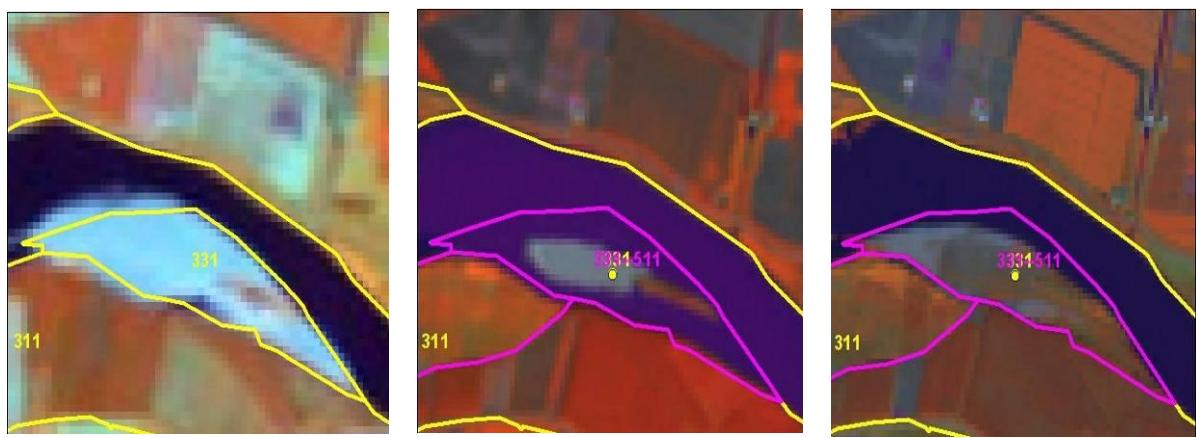
Type: Gravel, sand changing to river: 331-511

Interpretation example (Iceland):



Colours on these images: dark blue is water (river and ocean), gray is wet volcanic (dark) sand, light shades on the coast are ocean waves. The river seen on the top of IMAGE2000 (left) broke through a sand bank to flow into the ocean by 2006 (right). This 331-511 process is possible because the river flows freely and its flow is not confined between embankments (dikes, levees). (Additional associated process is 523-331, the enlargement of the land area due to sedimentation.) There are 118 polygons of the 331-511 type covering 0.22 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Frequent mistakes: Gravel, sand changing to river	How to avoid the mistake
Omitted changes	Examine imagery along the course of rivers where this process is suspected (e.g. glacial, alpine rivers and their estuaries)
False change, temporary change	Seasonal water level differences are not to be mistaken with permanent changes of the river course. Interpreter must always be aware of geographical/climatic characteristics of the region (to know when flooding is expected) and the image dates.

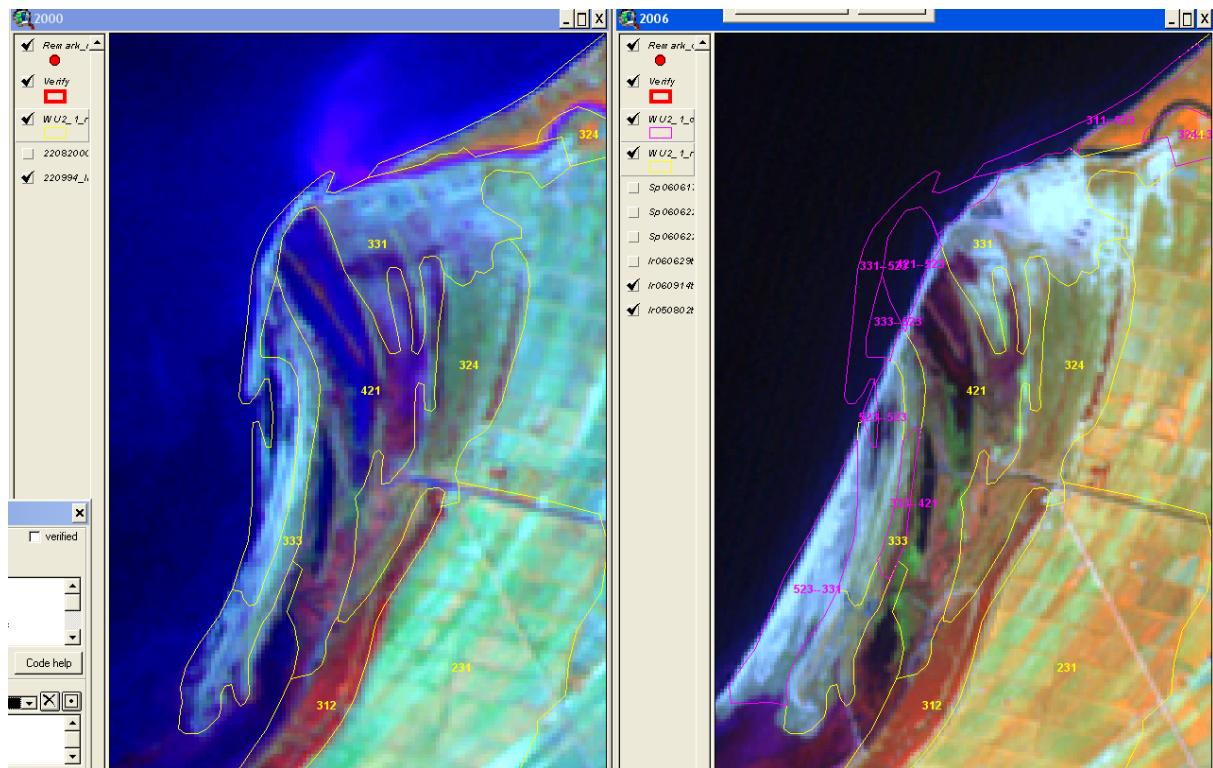


Mistake: Temporary change interpreted as CLC change. August 2000 image (left) compared with April 2006 image (middle) shows a change of the sand bank (being flooded). August 2006 image (right) however reveals the transient character of flooding, which means that no CLC change should have been mapped.

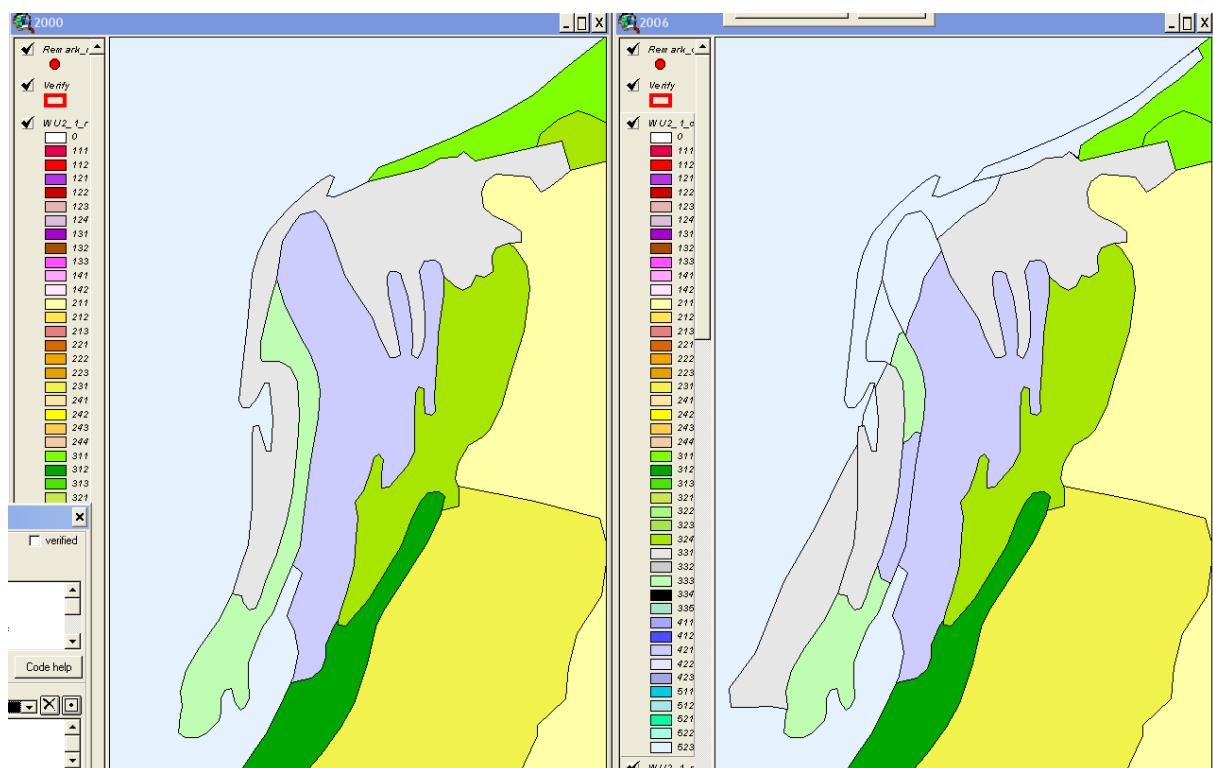
Particularity-1

Type: Sea shoreline change at free-flowing river's mouth: 331-523

Interpretation example (Albania):



Mouth of a free-flowing river dynamically forms the shoreline, too (left: IMAGE2000, right: IMAGE2006). This is possible only in areas not occupied by tourism and being non-built-up. On the example currents by incoming river south from here (out of image view here) swept away sediment (sand) previously accumulated by the river in the north. The change is correctly interpreted as 331-523. Colouring with CLC legend below helps illustrating the process. There are 19 polygons of this type covering 0.01 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.



5 MOST FREQUENT CHANGES IN WETLANDS AND WATER CLASSES

5.1 PEATLAND CONVERTED TO ARABLE LAND

Change process: Peatland converted to arable land: 412-211

Overview and rationale:

In historical times conversion of peat areas for agricultural use was the major cause of loss of peat areas. Today, conversion for arable use is usually observable on exploited peat (cutaway peatland), as a type of reclamation after stopping peat extraction. The process is most widespread in Finland, where peatland is one of the largest coverage types compared to country area.

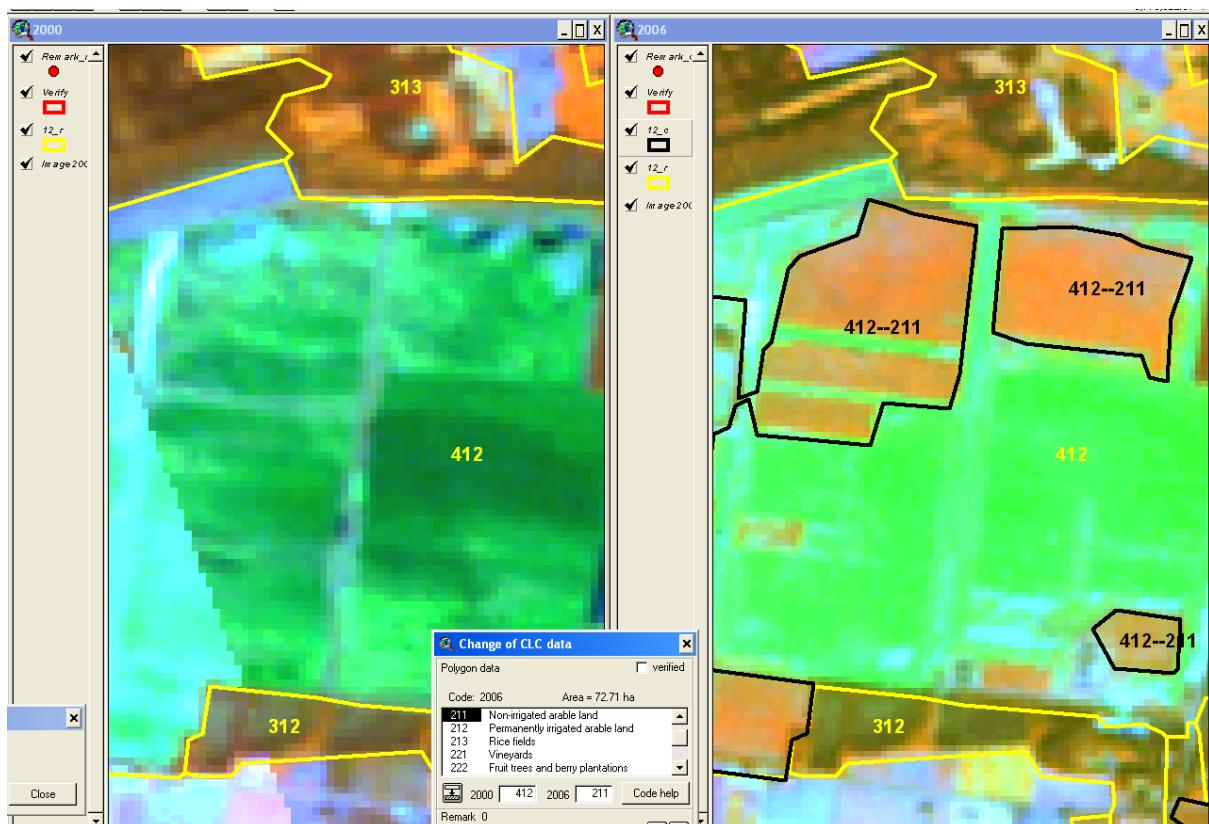
Note that in CLC both natural peat areas (raised bogs, blanket bogs, mires) and exploited peatland (turf-cutting areas) are interpreted as 412 [3].

Number of changes in European CLC-Change: 949 polygons

Area of changes in European CLC-Change: 0.29 % of all change areas

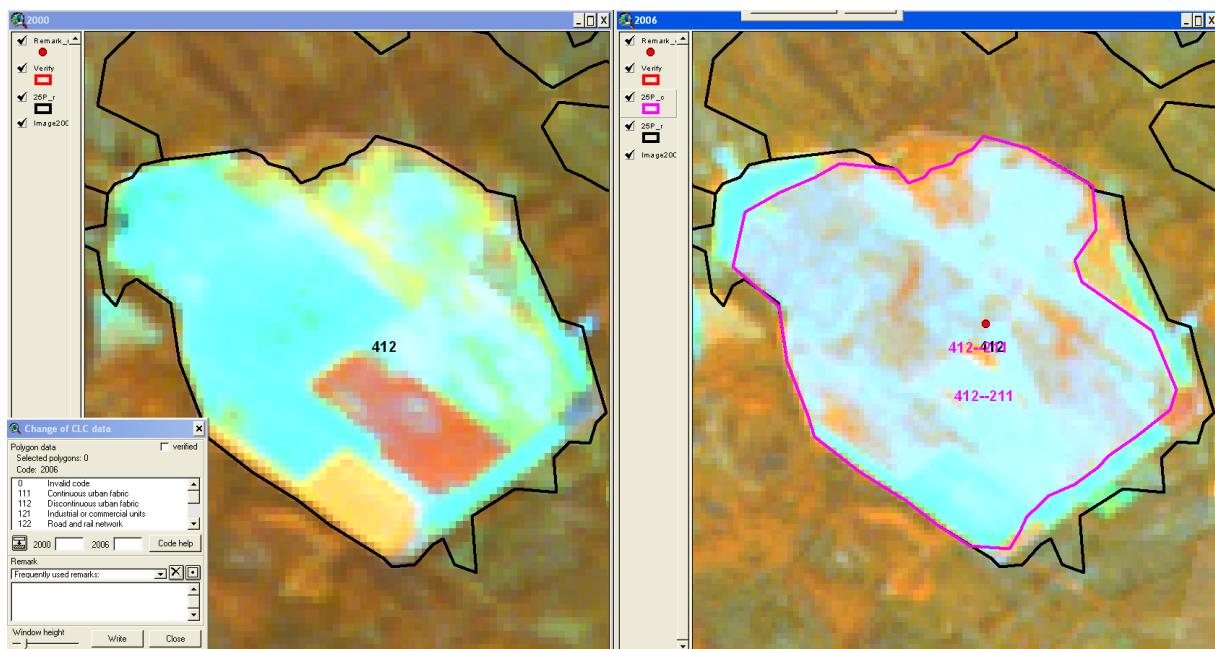
Type: Peatland converted to arable land: 412-211

Interpretation example (Finland):



Parts of a large exploited peatland (412) on IMAGE2000 (left) were transformed to arable land on IMAGE2006 (right). IMAGE2000 (left) shows that the peatland was not in natural condition, but under excavation (bright green and turquoise colour of disturbed peat indicates this). (The line on the left side of IMAGE2000 is a separation of two different IMAGE2000 scenes.) There are 949 polygons of this type covering 0.29 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Frequent mistakes:	How to avoid the mistake
Peatland converted to arable land	
Omitted changes	All 412 polygons (especially those under cultivation) situated in a region where arable farming is important have to be examined. Multi-seasonal imagery is useful because it shows well the crop development.
False change due to missing correction of parent stock layer	Parent stock layer must be checked in order to avoid mapping already existing arable parcels as new.



Mistake: Overestimation of new arable land replacing peatland (412-211). Interpretation failed to notice that part of the polygon had been used for agriculture already in 2000 (note colourful parcels on left image). Bright colour of exploited peat is often difficult to distinguish from arable land. Use of ancillary data is advisable for identification.

5.2 AFFORESTATION ON PEATLAND

Change process: Afforestation on peatland: 412-324

Overview and rationale:

Plantation of forest on nutrient-poor blanket bogs and abandoned peat extraction sites is a process that requires significant human intervention. Soil preparation, including fertilization and drainage ditches fundamentally changes habitat conditions so that natural peatland plants, which have adapted to growing in nutrient poor conditions die out quickly and are replaced by more vigorous species. Subsequently the peatland vegetation is replaced by dense stands of conifers with few other plants. Beside turf cutting forestation is the main threat to blanket bogs.

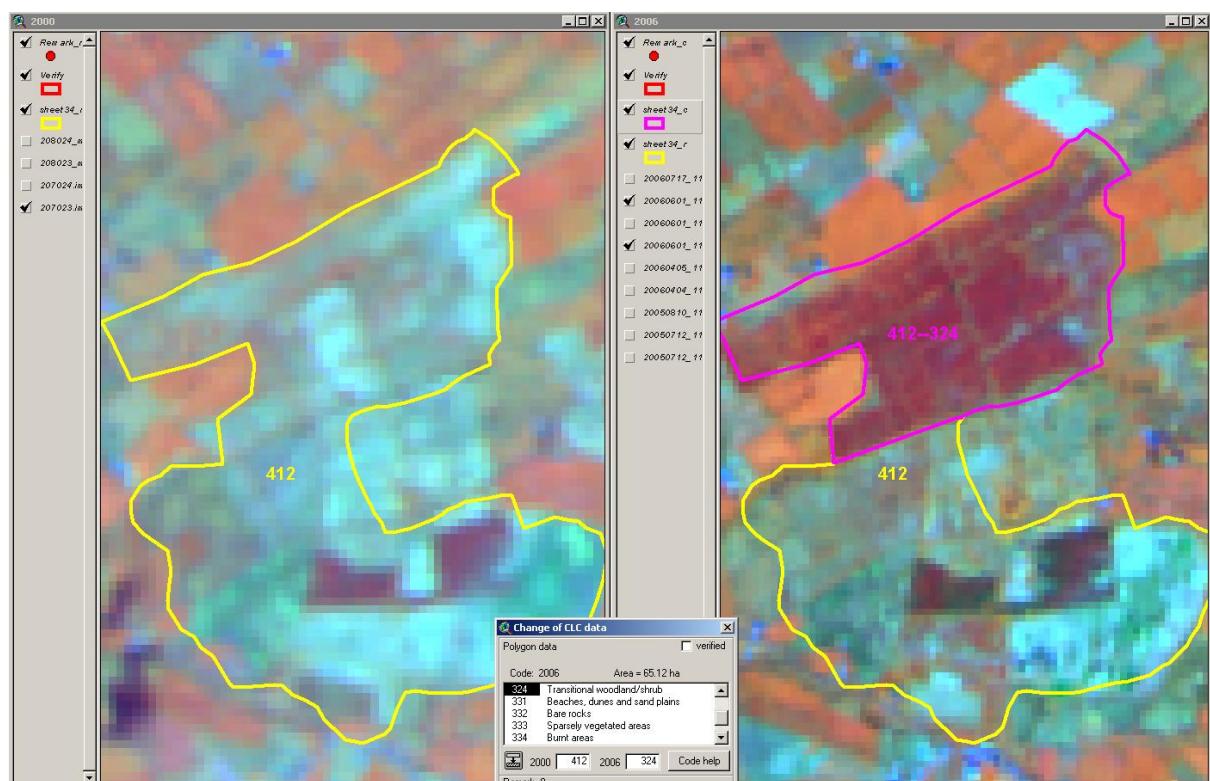
The process is most significant on the British Islands. Main driving force behind afforestation of peatbogs/blanket bogs is the wish to increase forest cover / timber production. This has been part of national land use policy in the British Islands since the 1920's when radical decrease of forest cover (to the lowest percentages within Europe) was recognized. Afforestation's harmful effects such as loss of biodiversity, nutrient leakage and loss of carbon stores have been recently realized. This led to a change in policy from forest expansion to "increasing ecosystem services".

Number of changes in European CLC-Change: 1017 polygons

Area of changes in European CLC-Change: 0.44 % of all change areas

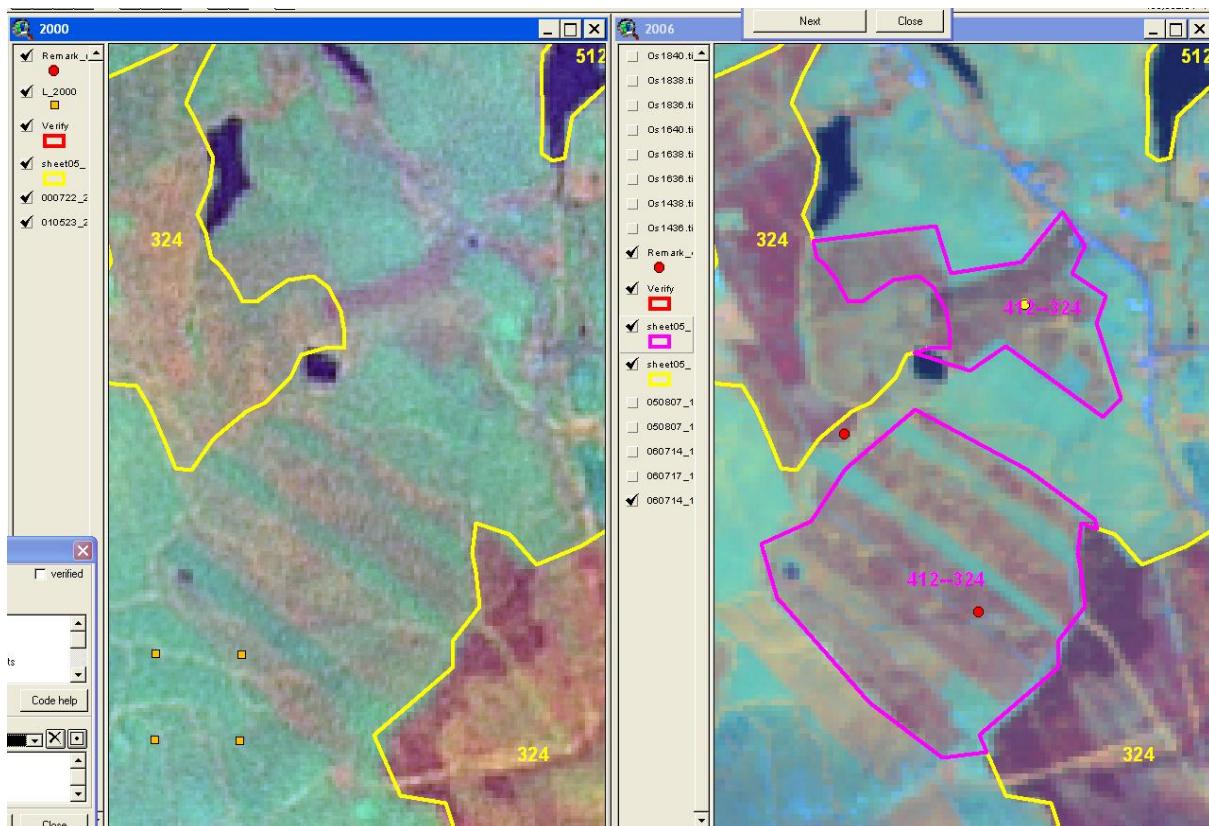
Type: peatland changed to transitional woodland-shrub: 412-324

Interpretation example (Ireland):

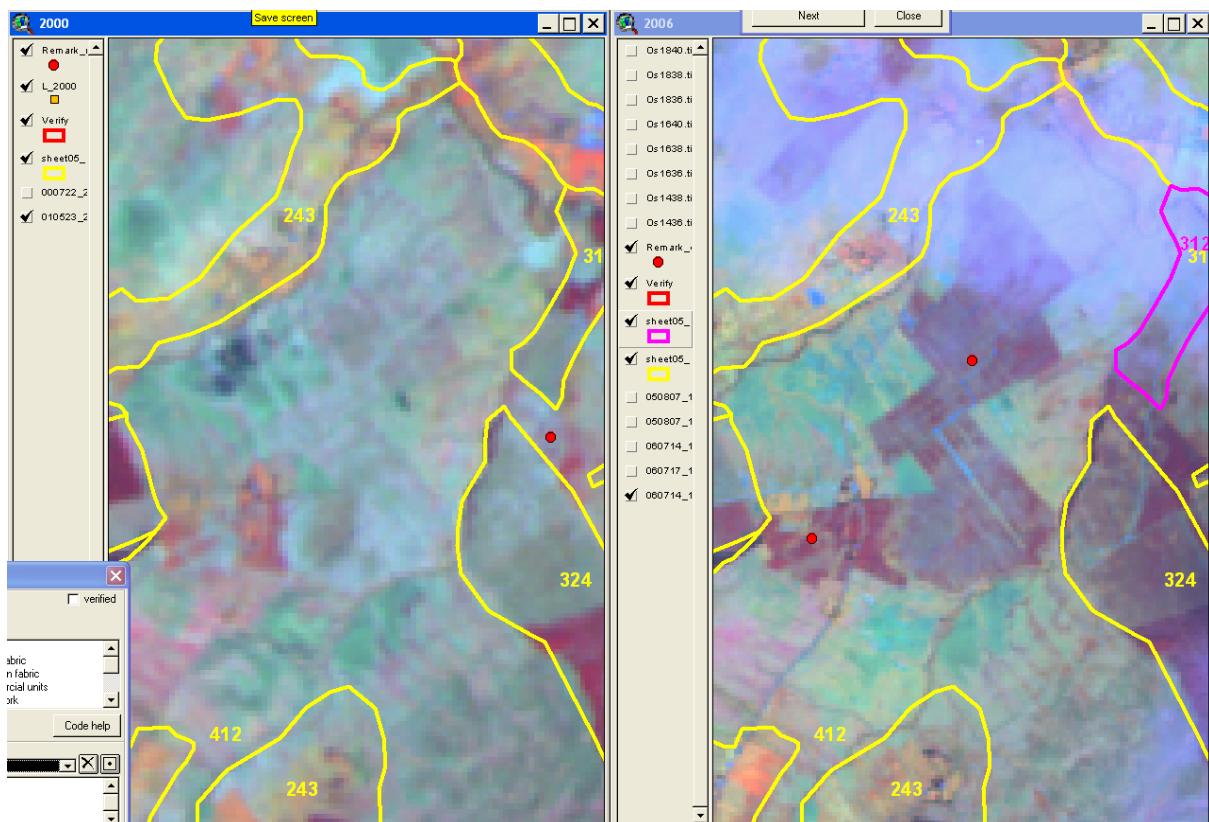


A peatland area shown by IMAGE2000 (left) has been afforested as indicated by IMAGE2006 (right). The emerging young (coniferous) forest is indicated by its characteristic colour, different from neighbour pastures (orange) and peatland (light green/brown). Afforestation might occur both on natural peat areas and exploited peatbogs. There are 1017 polygons of the 412-324 type covering 0.44 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Frequent mistakes:	How to avoid the mistake
Peatland changed to transitional woodland-shrub	
Omitted changes	All 412 polygons have to be examined in regions where afforestation on peatland is characteristic (e.g. Ireland, Scotland, parts of Norway).
False change	No-change areas are often interpreted as change, because young forest was not recognized/hardly recognizable on the parent imagery. More careful investigation of parent image (and consequent correction) is needed for avoiding this mistake.



Mistake: false change 412-324. Forestation already started in 2000 as shown by the light reddish stripes on IMAGE2000 (left). The same stripes got more pronounced and reddish in 2006 (right) due to forest growth. The polygons should be interpreted as correction of CLC2000 (324) and no change. The same is true for the smaller change polygon in the north. Young plantation is often hard to recognize, interpreter has to look not only for reddish colour of young trees, but also for bright white colour of soil preparation.



Omitted new coniferous plantation on peatland. Although some signs of preparation for planting are already visible on the 2000 image (left), 412-324 could be an acceptable code pair to depict the process at the northern red dot. At the other dot to the south forestation was already well visible in 2000 (omitted correction of parent stock layer), so the process to be mapped is 324-312.

5.3 RIVER (FREE FLOWING) CHANGING TO GRAVEL, SAND

Change process: River (free flowing) changing to gravel, sand: 511-331
Overview and rationale:

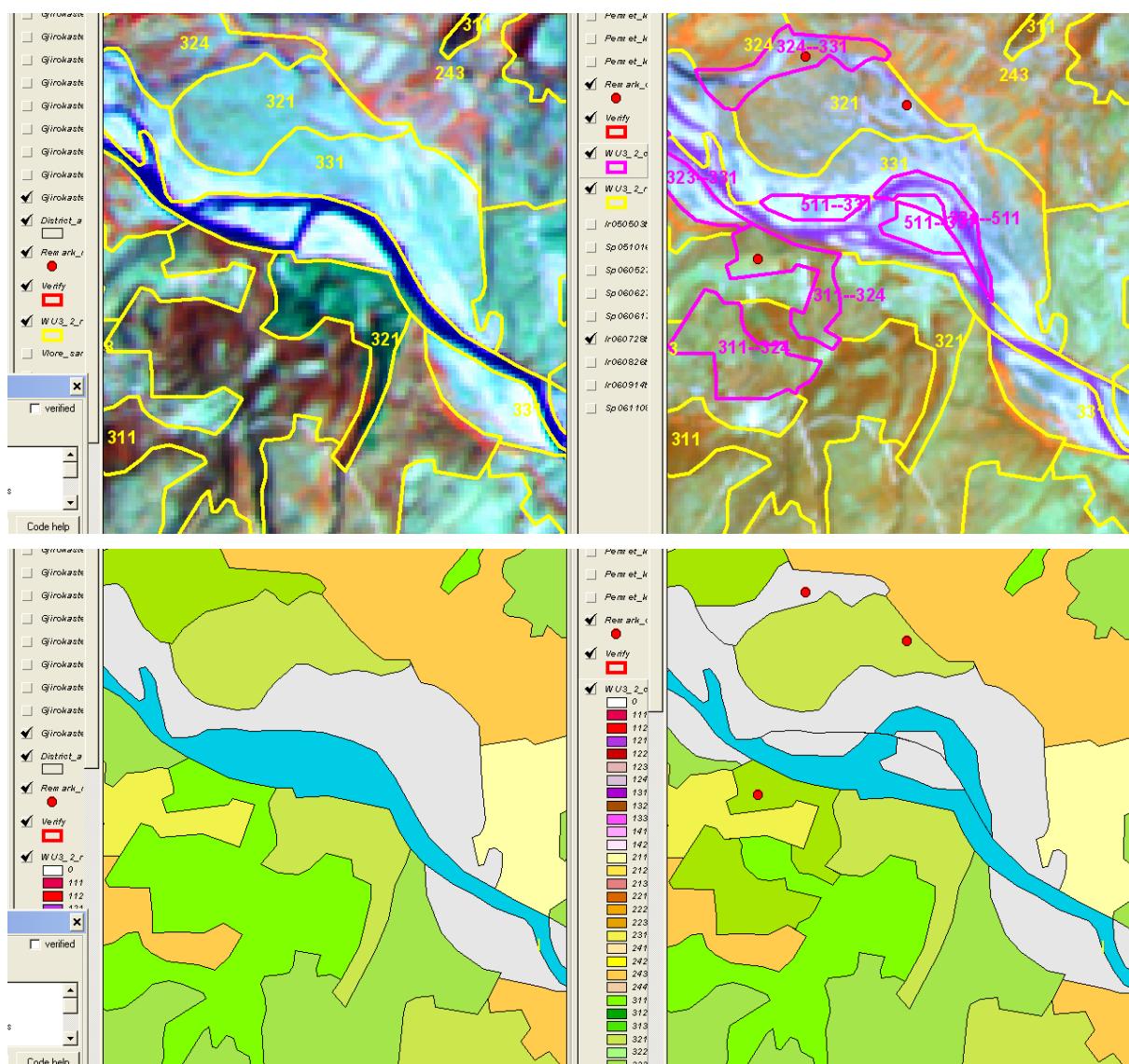
This process is counterpart of 331-511 (see Ch. 4.10), typical of freely flowing (alpine, glacial) rivers that constantly sweep away then accumulate sediment. Occurrence of these two processes is good indicator of "natural/wild rivers" (vs. "artificial" or channel-like water courses).

Number of changes in European CLC-Change: 175 polygons

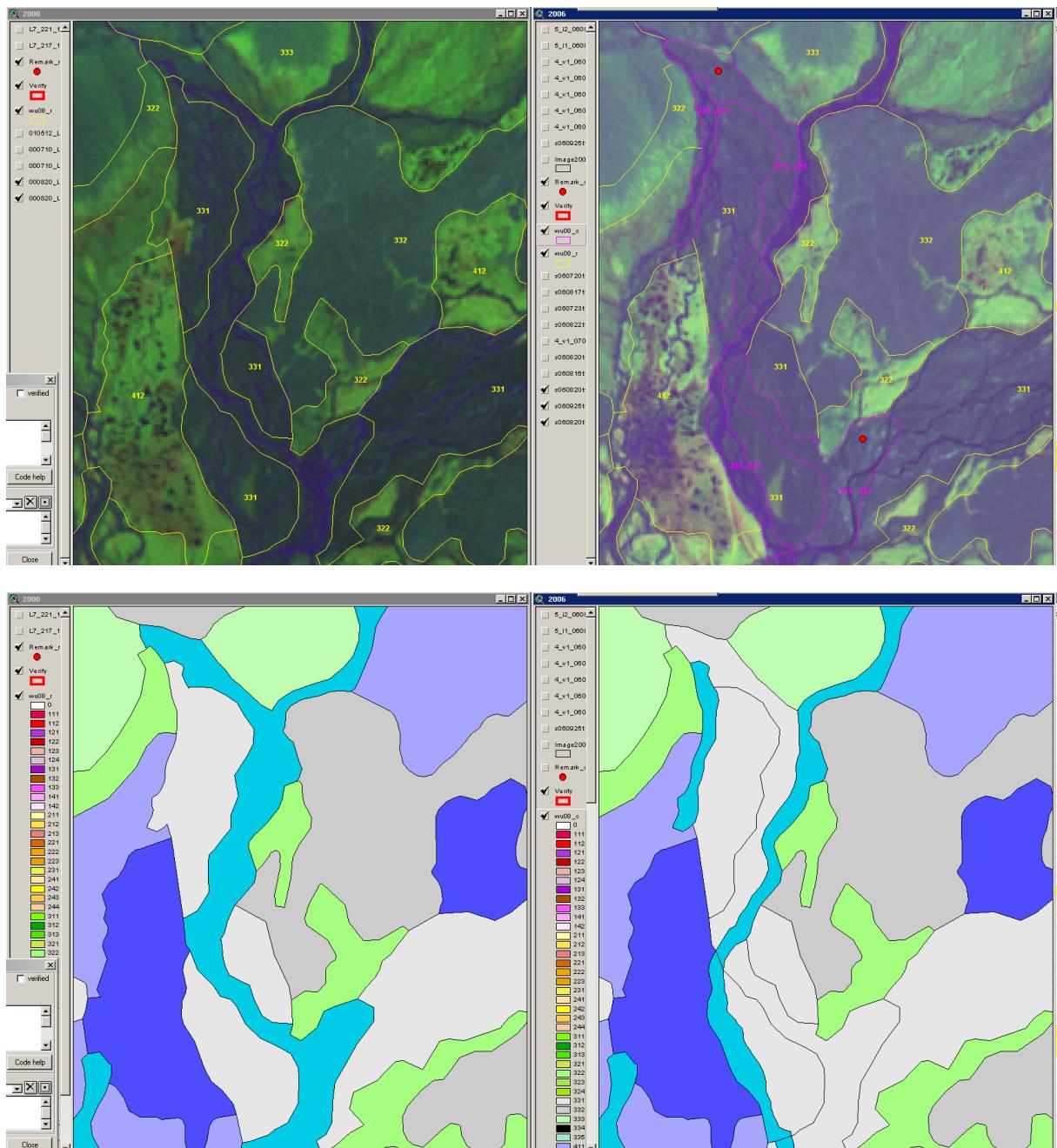
Area of changes in European CLC-Change: 0.21 % of all change areas

Type: River (free flowing) changing to gravel, sand: 511-331

Interpretation examples (Albania, Iceland):

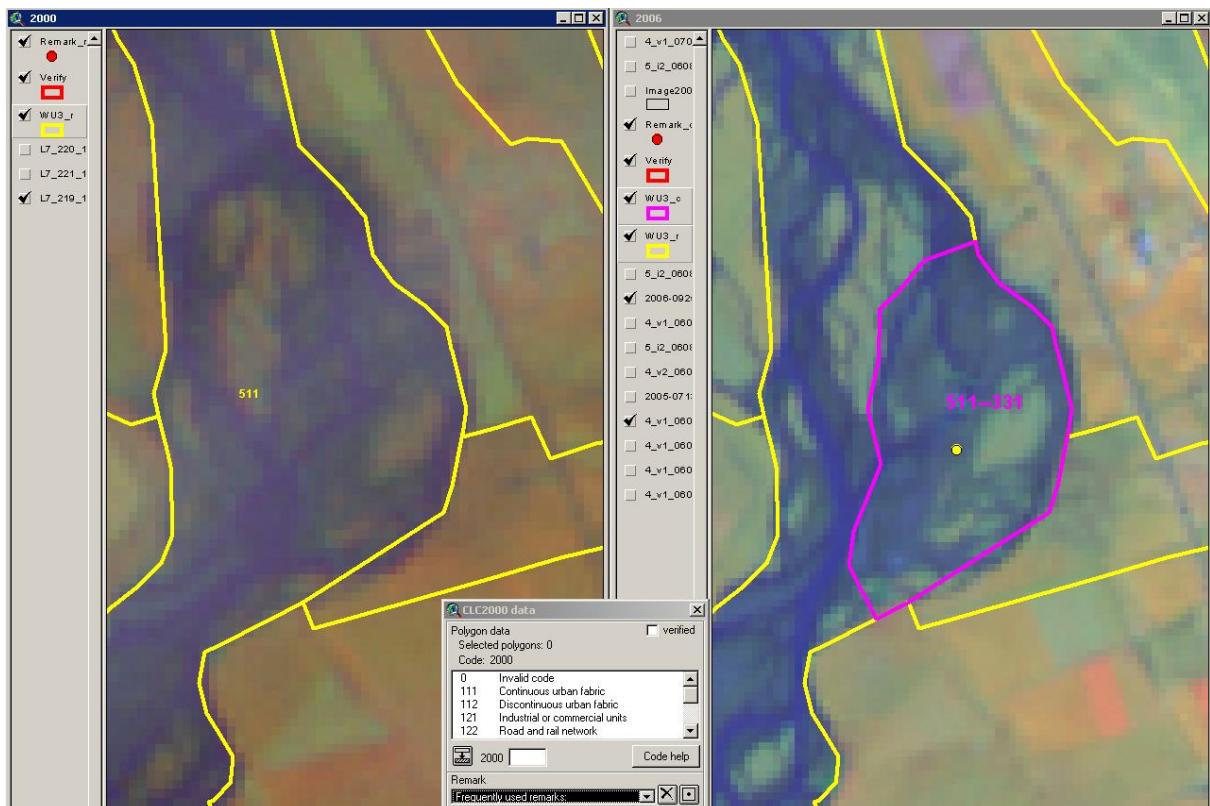


A mountain river in Albania reaching lowlands slows down, starts meandering, accumulating gravel banks, then during next spring floods washing them away, changing its course. The processes of 511-331 and 331-511 (Ch. 4.10) are counterparts; they usually do not occur without each other. Bright white colour indicates gravel/sand banks. Note how branches of the river are generalized on the 2000 interpretation (left) in order to keep the 100 m width limit. Bottom image shows the same site with CLC colouring. There are 175 polygons of this type covering 0.21 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.



A free-flowing glacial river (seen in dark purple) in Iceland is constantly changing its course in a wide gravel-covered valley. The dark colour of sand and gravel (dark green) on the example is due to volcanic rocks. Note that interpretation of such rivers occupying wide gravel bed requires considerable generalization, as seen on the 2000 status, where numerous narrow branches are generalized into a wider river polygon. Bottom image shows the same site with CLC colouring for better visualization. There are 175 polygons of this type covering 0.21 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

Frequent mistakes:	How to avoid the mistake
River (free flowing) changing to gravel, sand	
Omitted changes	In case of larger free-flowing (especially alpine and glacial) rivers check along their course to find missing changes.
False changes due to seasonal or sensor differences interpreted as CLC change	Seasonal water level differences are not to be mistaken with permanent changes of river course. Interpreter must always be aware of geographical / climatic characteristics of the region (to know when flooding is expected) and the image dates.

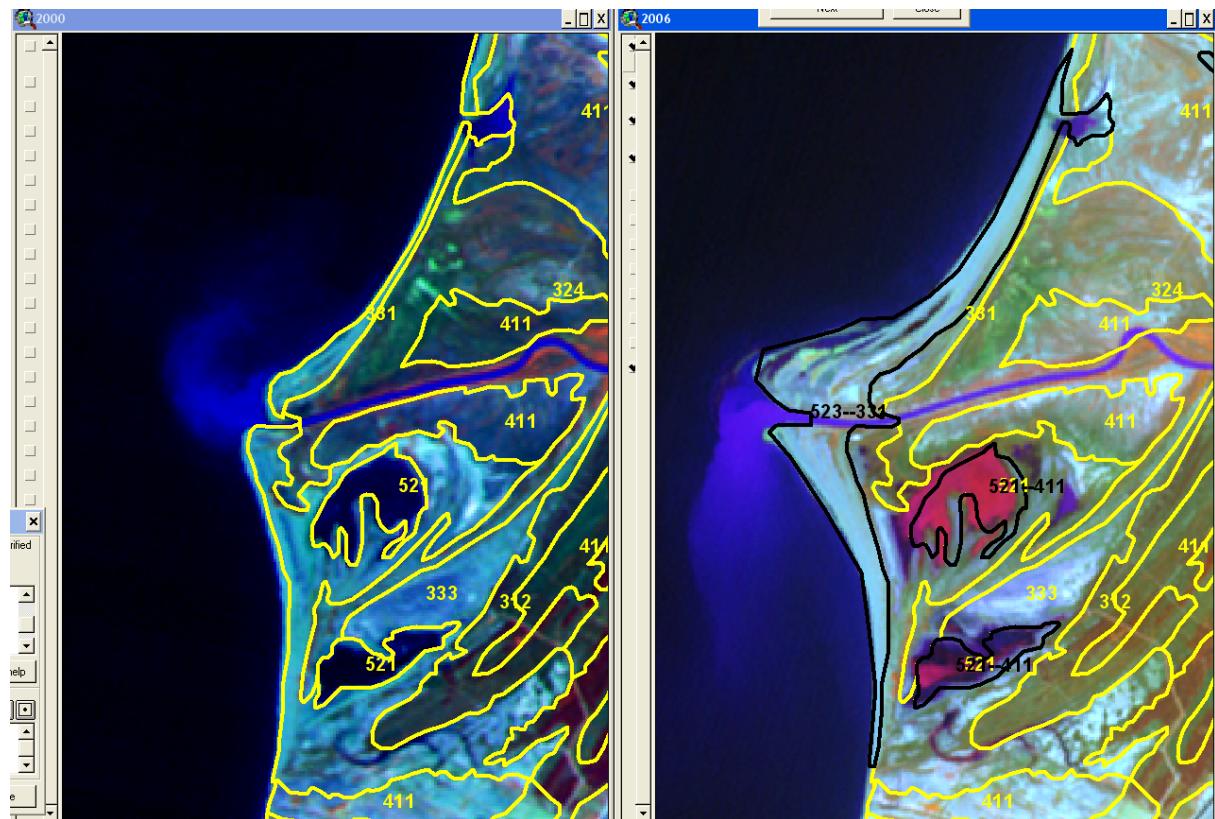


Mistake: sensor differences misinterpreted as 511-331 change in the river's course. Glacial river (purple colour) meanders within its wide gravel bed (gravel/sand: greenish colour). The change mapped (magenta outlines on right image) does not show any real permanent change, only a colour difference coming from either different sensors or different seasons. Note that the proportion of water and gravel/sand is much the same in the patch on both images. A simple rule of interpretation is that if the given patch is dominated by water, it should be coded as 511, while it should be mapped as 331 if dominated by sediments.

Particularity-1:

Type: Changing shoreline due to inflowing river: 523-331

Interpretation example (Albania):



Changes of sea shoreline at mouth of a river, correctly mapped as 523-331. Mouth of a river and connected shoreline is continuously being formed by deposited sediment. This might happen only on non-built-up shores untouched by mass tourism. Note the pattern of floating sediment in the sea (lighter blue colour) and the way its flow is redirected by changed shape of the shore. There are 47 polygons of this type covering 0.02 % of all changes in CLC-Change₂₀₀₀₋₂₀₀₆ Europe database.

6 TECHNICAL ISSUES

This chapter includes examples that are not associated to a specific change process or change type, but considered being of general importance.

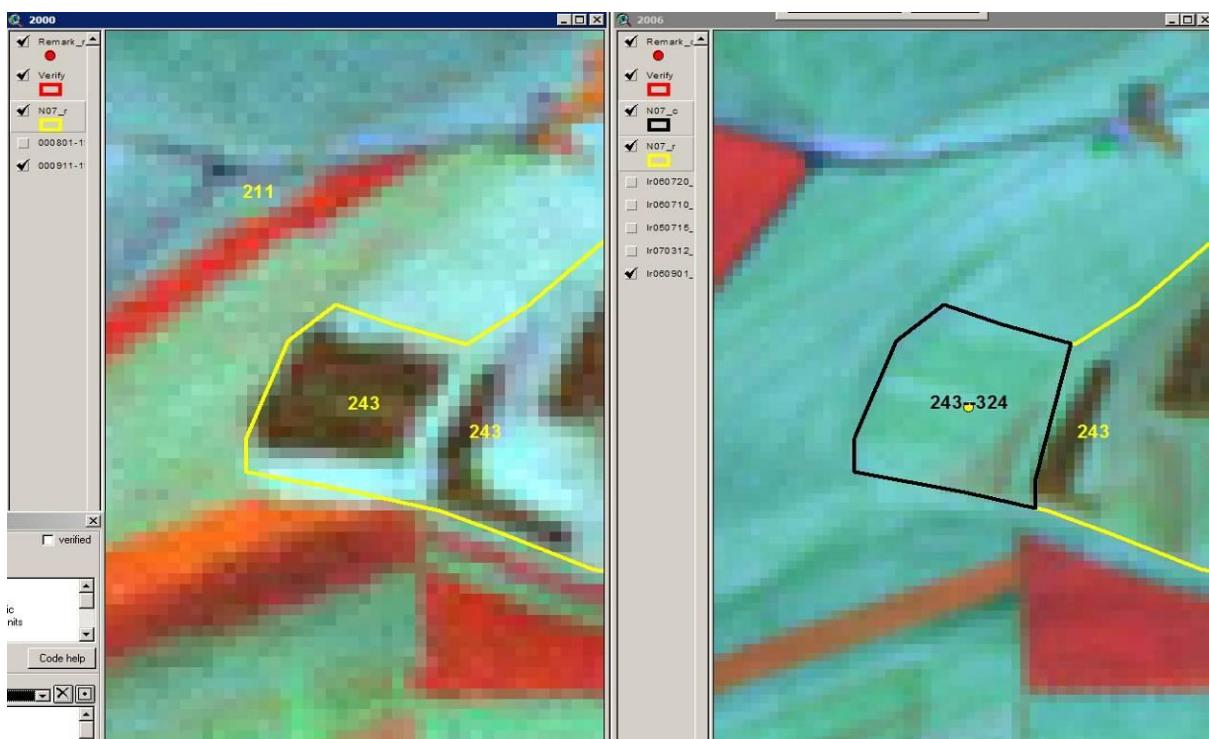
6.1 CHANGES WITHIN COMPLEX AGRICULTURAL CLASSES

Overview:

CLC nomenclature includes some classes that are complex 'by definition'. The existence of these classes is explained by the size of minimum mapping unit (25 ha), which does not allow mapping of small features that would be of importance. The most characteristic complex classes are:

- 242: meaning spatial mix of annual and permanent crops and pastures, none of them covering ≥ 25 ha contiguous area
- 243: meaning spatial mix of agriculture areas with significant patches of natural formations (e.g. forests, shrubs, natural grassland, water), none of the elements covering ≥ 25 ha contiguous area

Frequent mistakes:	How to avoid the mistake
Change of complex classes Wrong change type	Always the real process has to be mapped, shown by satellite images. Check which constituent of the complex class has changed. Keep in mind that change mapping has better resolution than CLC mapping.



Mistake: Not the real change was mapped. IMAGE2000 (left) shows an agriculture area including part of a 243 polygon with a small forest, which has been clearcut (IMAGE2006, right). The right process is not 243-324 (which actually means afforestation), but 312-324 (clearcutting), which specifies the process properly.

6.2 IMPOSSIBLE, RARE AND FORBIDDEN CHANGES

Overview:

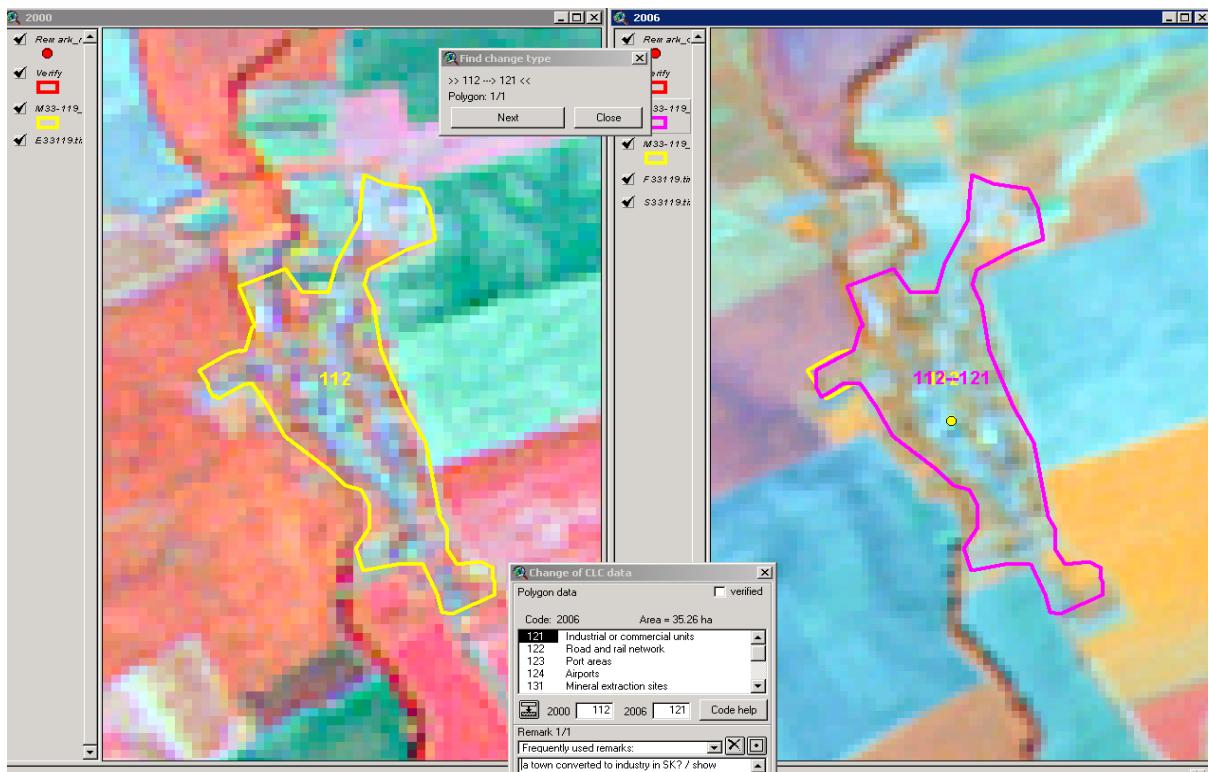
In some of the 1892 theoretically possible CLC change types there are ones that are impossible or at least rare to happen. The list of impossible changes varies from country to country. Checking CLC-Change statistics it is relatively easy to find these impossible changes during the interpretation or control phase. Some examples:

- The occurrence of some CLC classes has geographical limitations (e.g. no vineyards in Iceland, no glaciers in Portugal, no marine wetlands far from sea).
- Residential areas do rarely disappear in Europe.
- The complex agricultural classes (241, 242, 243, 244) are usually stable over time and rarely change to each other.
- The two climax-stage shrub types (i.e. 322 - Atlantic and 323 - Mediterranean) cannot change one to other due to climatic conditions.
- Bare rock cannot become burnt.
- Wetland types (411, 412, 421) rarely change to each other.

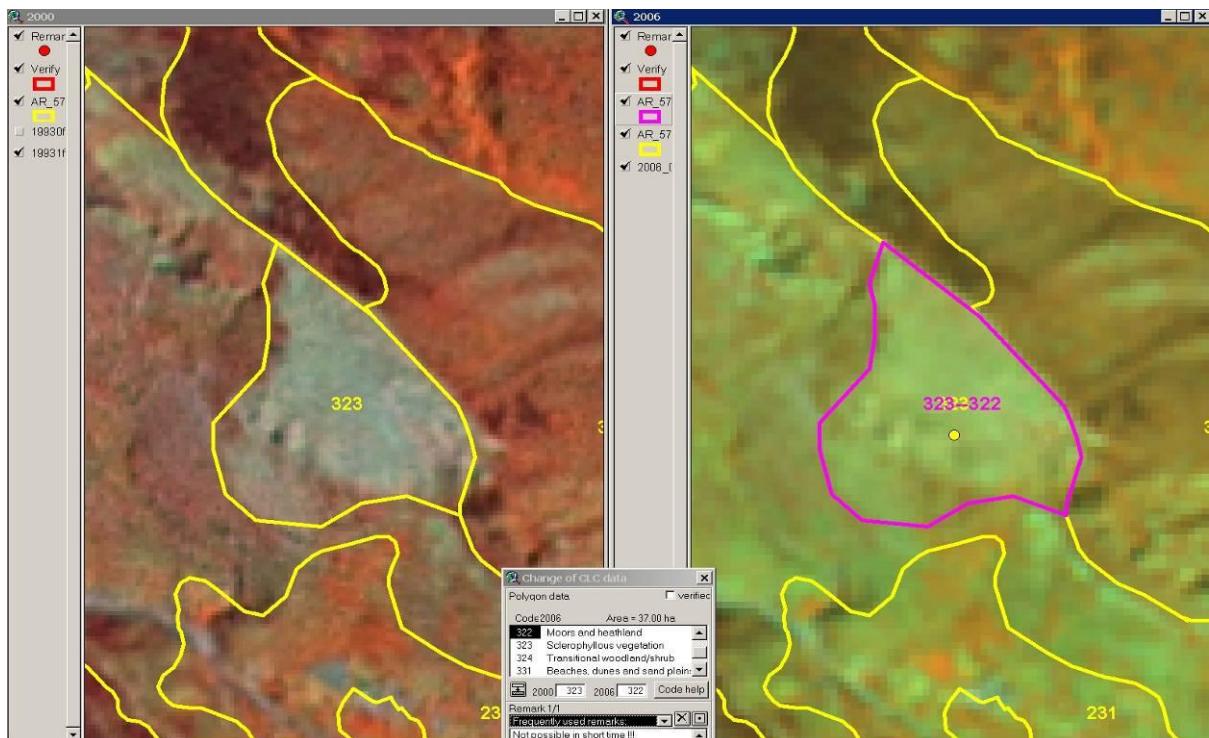
On the other hand, CLC nomenclature [3] includes some definitions / explanations implying that some changes are forbidden. These are:

- Burnt vegetation class (334) should not be applied for agriculture classes. The only exception is that forest patches as part of complex agriculture classes (242, 243, 244) can be classified as burnt. In such cases 31x-324 has to be mapped. Similarly, 321-334 change is forbidden, because natural grassland quickly regenerates.
- Urban green area (141) is never created outside built-up area as by definition it should be surrounded by built-up.

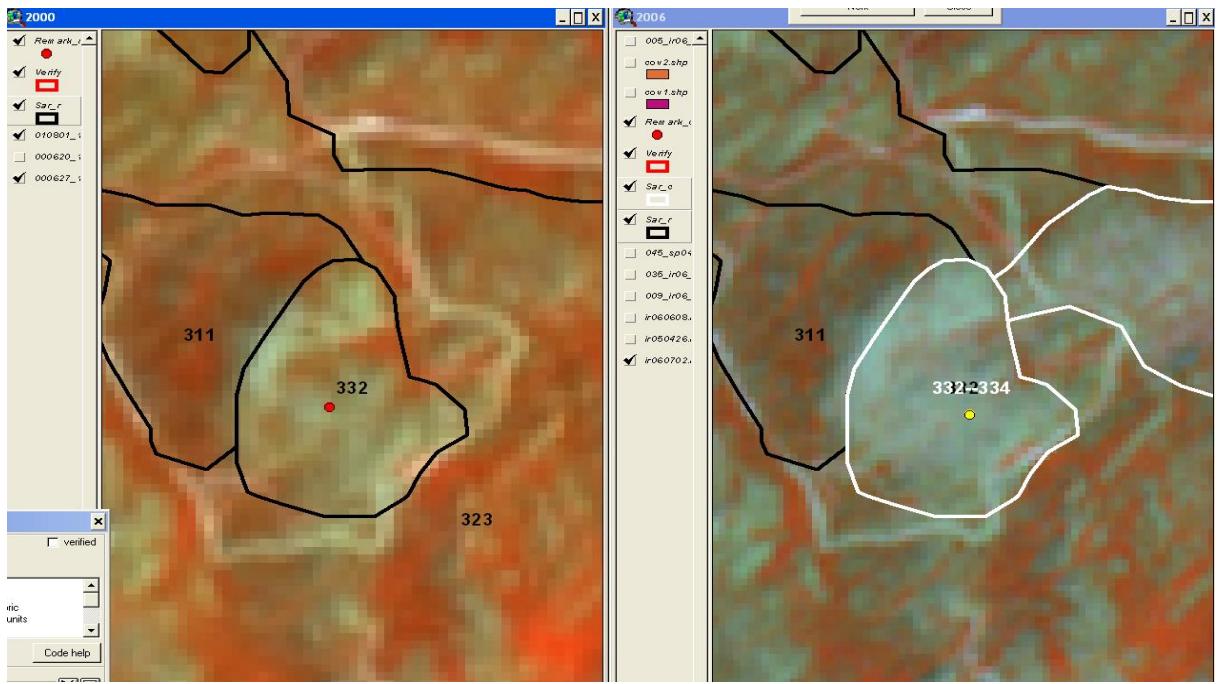
Frequent mistakes:	How to avoid the mistake
Impossible and rare changes	
Impossible and rare changes mapped	Interpreter should always ask: is this change possible in a given geographic environment and in the time lapsed between the two CLC inventories (or is it allowed by nomenclature)? Check all satellite images and HR/VHR imagery if needed.



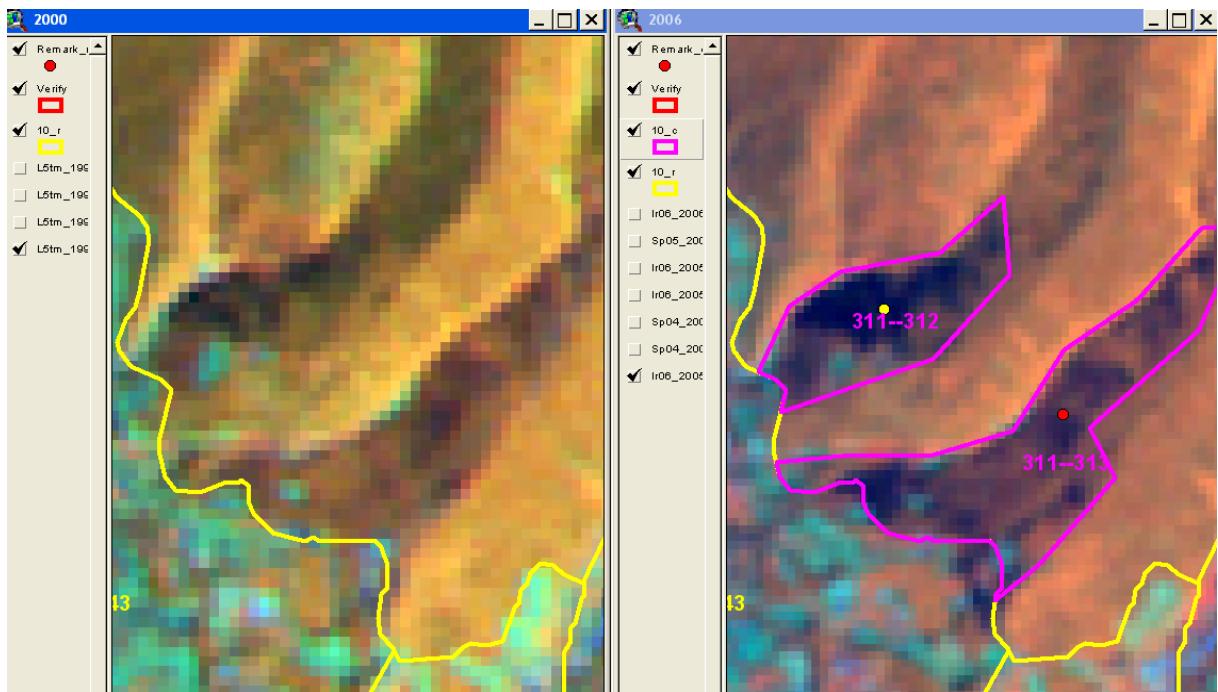
Mistake: mapping 112-121 (meaning that residential area has changed to industry). If we look at the satellite images (left: IMAGE2000; right: IMAGE2006) we do not see any differences either in pattern or in colour of the "change" polygon. The right solution is not to modify the CLC2000 code (112) and map no-change.



Mistake: mapping 323-322. CLC2000 (left) shows a 323 polygon (sclerophyllous vegetation), which was mapped as changed (323-322) on IMAGE2006 (right). This is an impossible process, as 322 and 323 means different shrub types. 322 is found in areas with high precipitation (Atlantic/mountain areas), while 323 is typically found under low precipitation and high temperature (Mediterranean). The change between these two classes would need a change in climatic conditions, which is not possible in short term. No change should be mapped.



Mistake: mapping 332-334 (meaning that bare rock was burnt). CLC2000 (left) shows a 332 polygon (bare rock), which is a mistake, because we see some vegetation. 333 (spare vegetation) would be the right code. IMAGE2006 (right) shows a burnt area (334) that affected the "332" polygon, too. The correct change is 333-334 (meaning: burnt sparse vegetation). This is an example of the need to correct (revise) the parent stock layer (here CLC2000) before mapping the change.

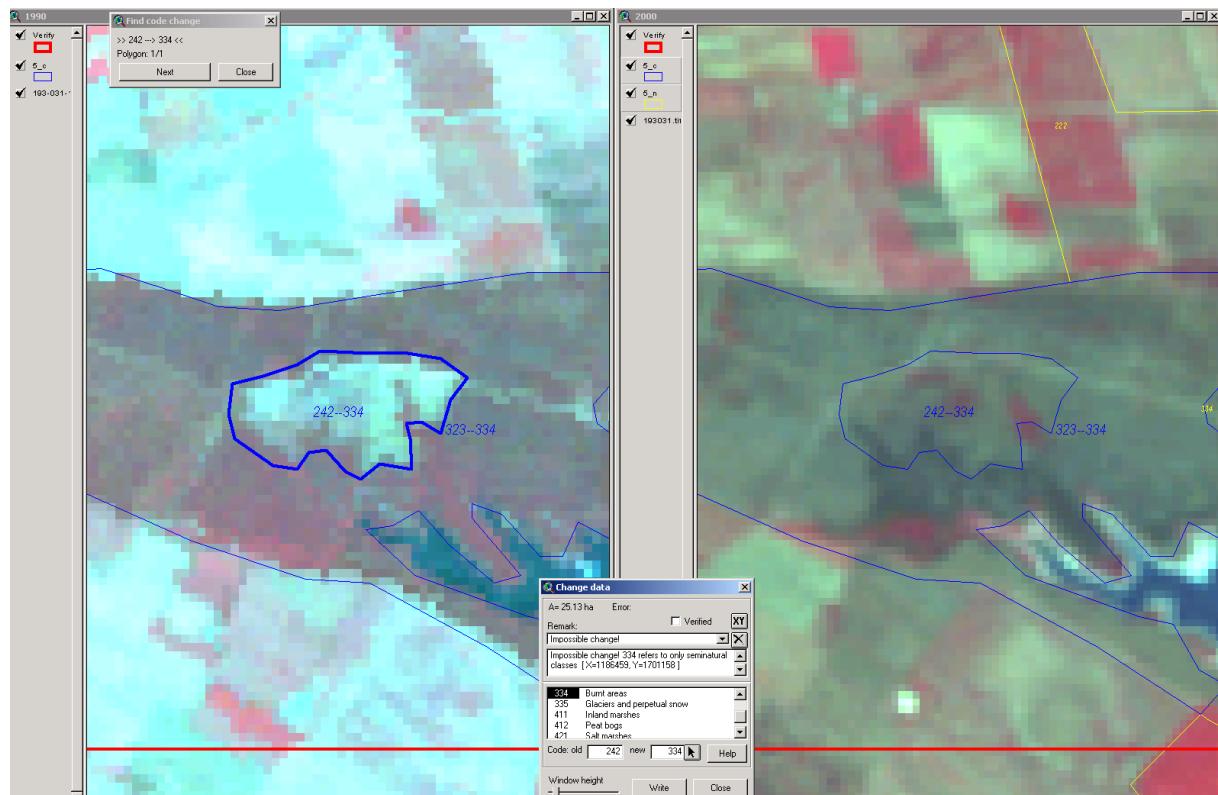


Mistake in mapping changes between forest types (311-312, 311-313). Forest types seldom change from one to other between two CLC inventories. What we see here is a seasonal difference, due to different Sun incidence angles. IMAGE2006 shows a forest area on a hilly terrain with image taken in summer. CLC2000 shows the same area in early autumn. Shadowed areas got darker because of the lower Sun angle, and not because of increased density of coniferous trees. The mapped changes are false and have to be deleted.

Note that other changes from one forest type to another might still occur, although seldom only. It is for example possible that from a mixed forest stand (313) deciduous trees are selectively felled at a certain age of development so the stand changes from mixed to pure coniferous (313-312).

Another example is when coniferous stand (312) is clearcut then re-planted with fast-growing species (e.g. eucalyptus), which can reach the 5 m height in a few years, the process being correctly mapped as 312-311. These changes however, are rare and /or geographically limited in occurrence. Such changes therefore should be mapped only if ancillary data or local knowledge confirms them.

Occasional mistakes:	How to avoid the mistake
Forbidden changes	
Changes forbidden by the nomenclature are applied	Think about, especially in case of burnt area, if the intended change is supported by the nomenclature.

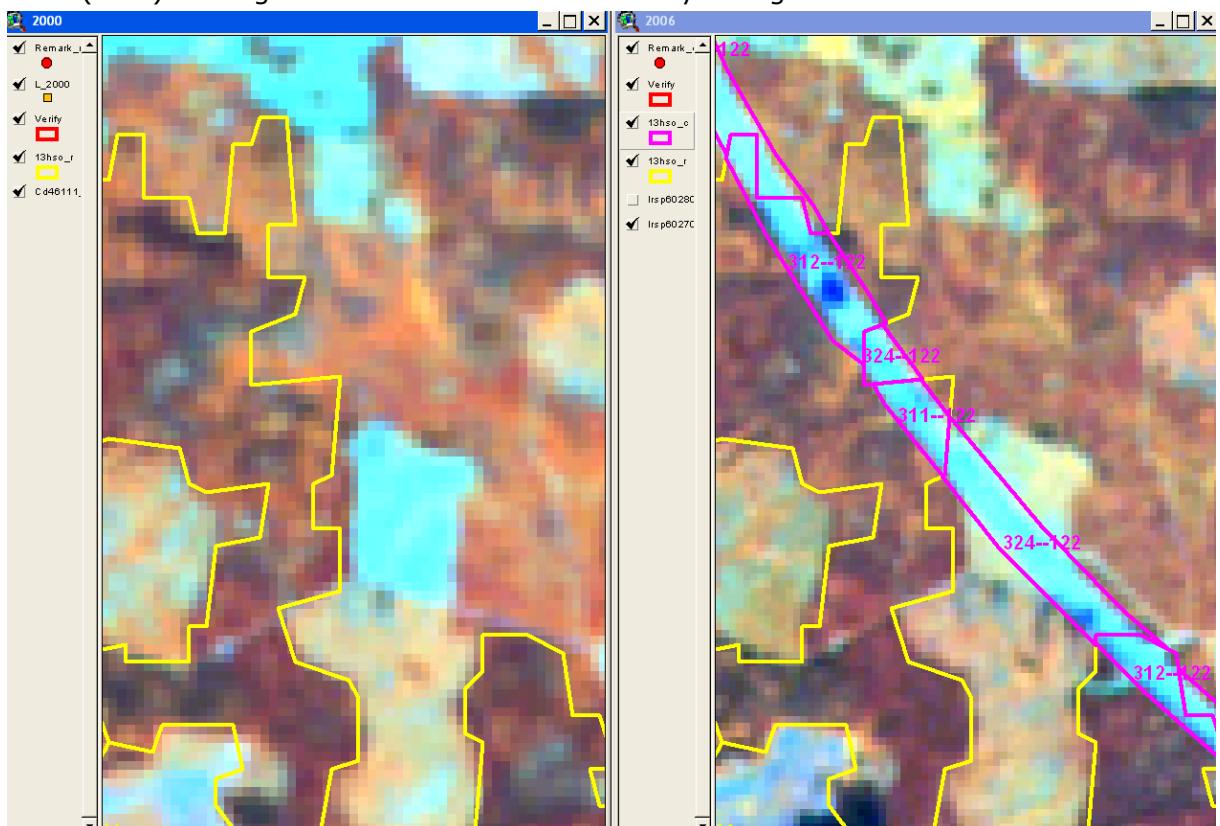


Mistake by mapping burnt agricultural area. IMAGE1990 (left) shows a patch of agriculture mosaic (242) inside sclerophyllous vegetation (323). IMAGE2000 (right) shows that the whole area was burnt, including the agriculture. Burnt sclerophyllous vegetation is correctly mapped as 323-334 on one hand. On the other hand 242-334 is not a valid change, as burnt vegetation class (334) should be used only if semi-natural vegetation with shrubs and trees (except natural grassland) is affected by fire.

6.3 LINEAR FEATURES AND COMPLEX CHANGES

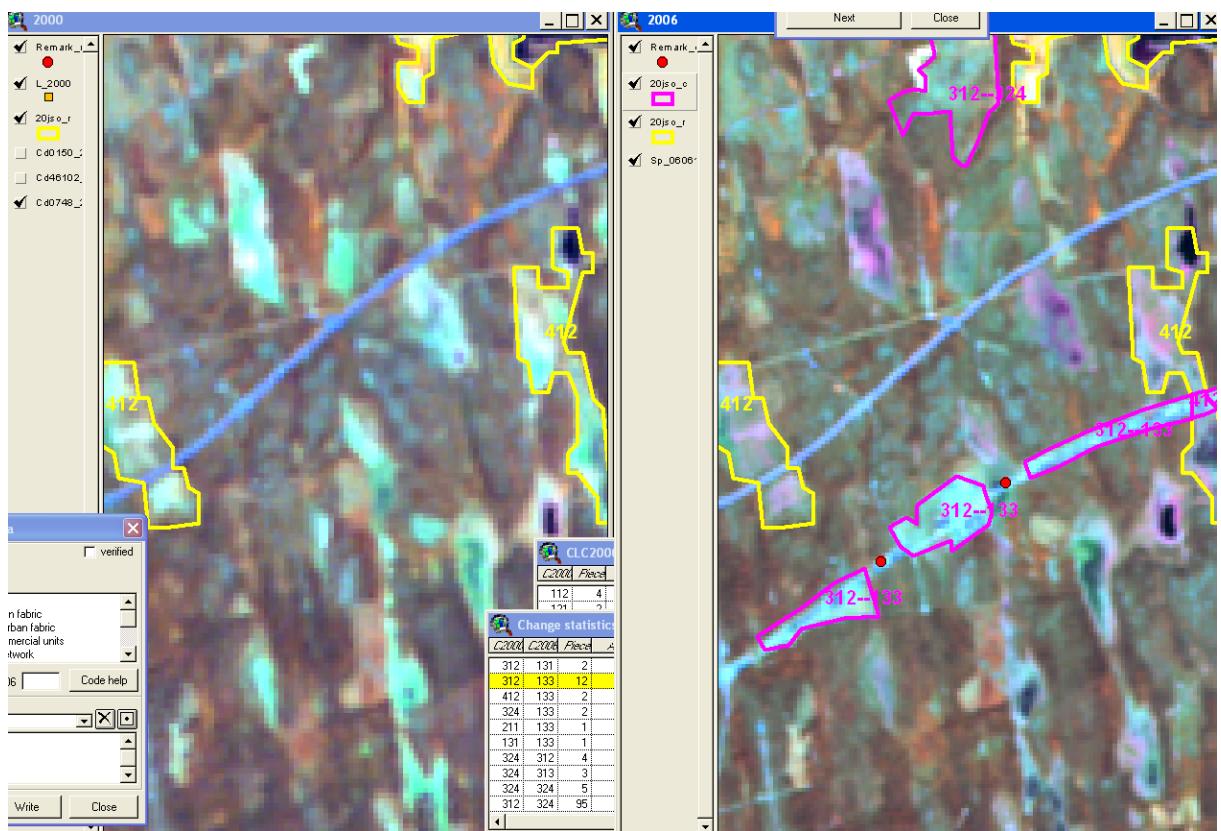
Overview:

Linear change features are mostly associated to roads (railways) and their construction and are important elements of the environment. Mapping them in CLC is often problematic, because they frequently have width below the 100 meter limit of CORINE Land Cover (see Ch. 2.1, 3.1 and 4.2). A linear change is often mapped as complex change, meaning a connected set of different changes, having either of the two attributes identical. Any of the elementary changes of the complex change can have area below the MMU (5 ha) as long as the total area of elementary changes reaches the 5 ha size.

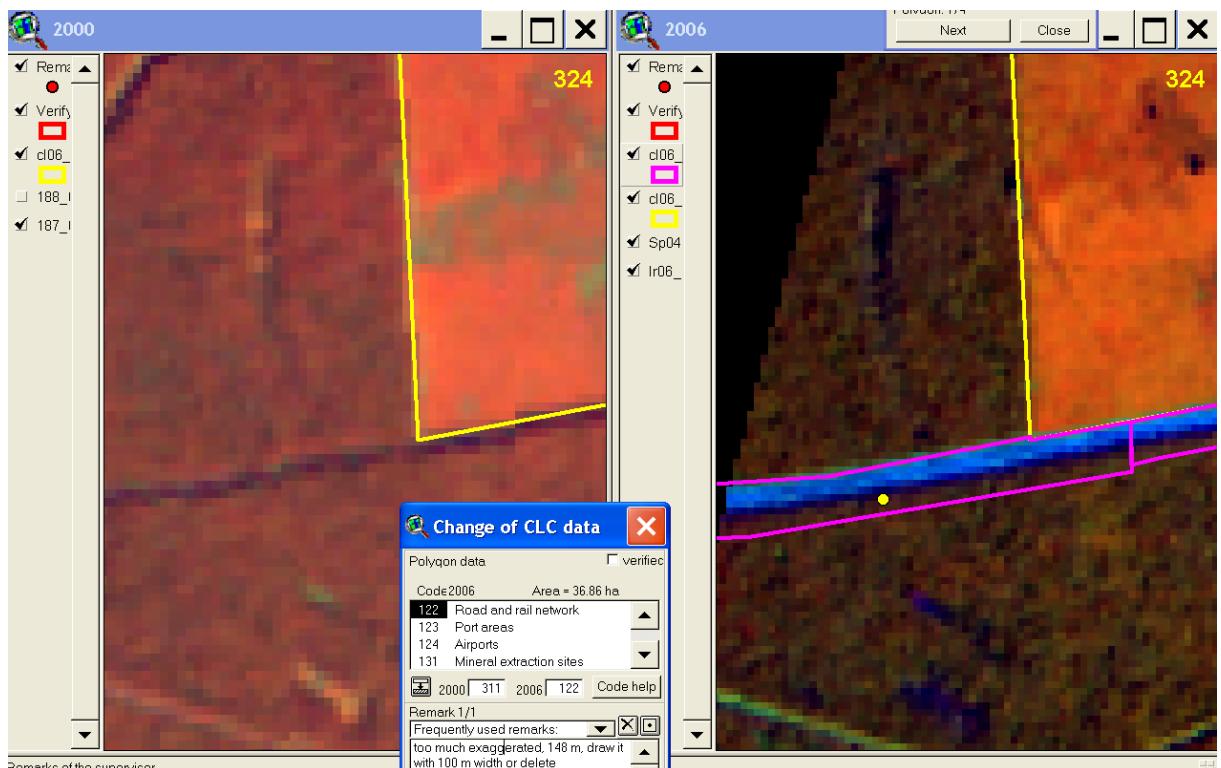


New highway was constructed in Sweden. On IMAGE2000 (left) patches of forest and transitional woodland (clearcut and young forest) are visible. In CLC2006 (right) we have a complex change forming a linear feature, with all elementary change polygons having 122 code (road and rail network) as second attribute. In complex change it is allowed to have polygons below the 5 ha limit, in order to keep the continuity of the feature. The width of the new linear feature exceeds 100 m, as probably it includes "associated areas" as well. E.g. service roads, residual construction areas, etc.

Frequent mistakes: Linear features and complex change	How to avoid the mistake
Change area is not continuous	It is better to draw a continuous change area, even if its width is a bit below the 100 meter in short sections.
Exaggerated change area	Do not overestimate the width of the new linear feature. However, slight exaggeration is allowed in order to keep continuity.



Mistake in mapping road / highway construction. Although the road construction area has width below 100 meter in some sections (see red dots) it is recommended to map a continuous construction area, by applying generalization.



Mistake in mapping road / highway construction. Here, width of the change polygon is 148 metres, but includes more forest than road (right), meaning that actual road width is well below 100 m. In such a case generalization / exaggeration is not recommended and it is better not to map the new road in order to respect the 100 m width rule.

6.4 AUTOMATIC USE OF IN-SITU INFORMATION

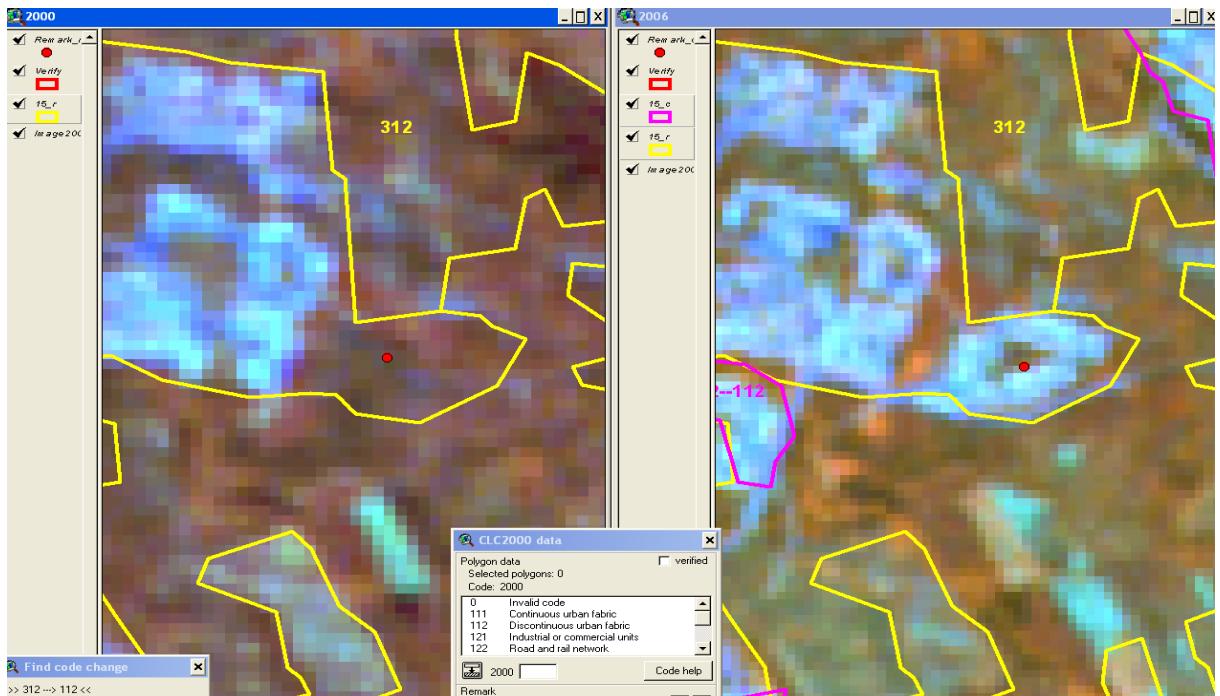
Overview:

In some countries application of automated solutions replaced to smaller or larger extent the traditional photointerpretation in change mapping. The main aim of (semi-) automatized solutions is to provide reproducible, better quality results with less workload. This can be achieved by applying one or more of the following methods:

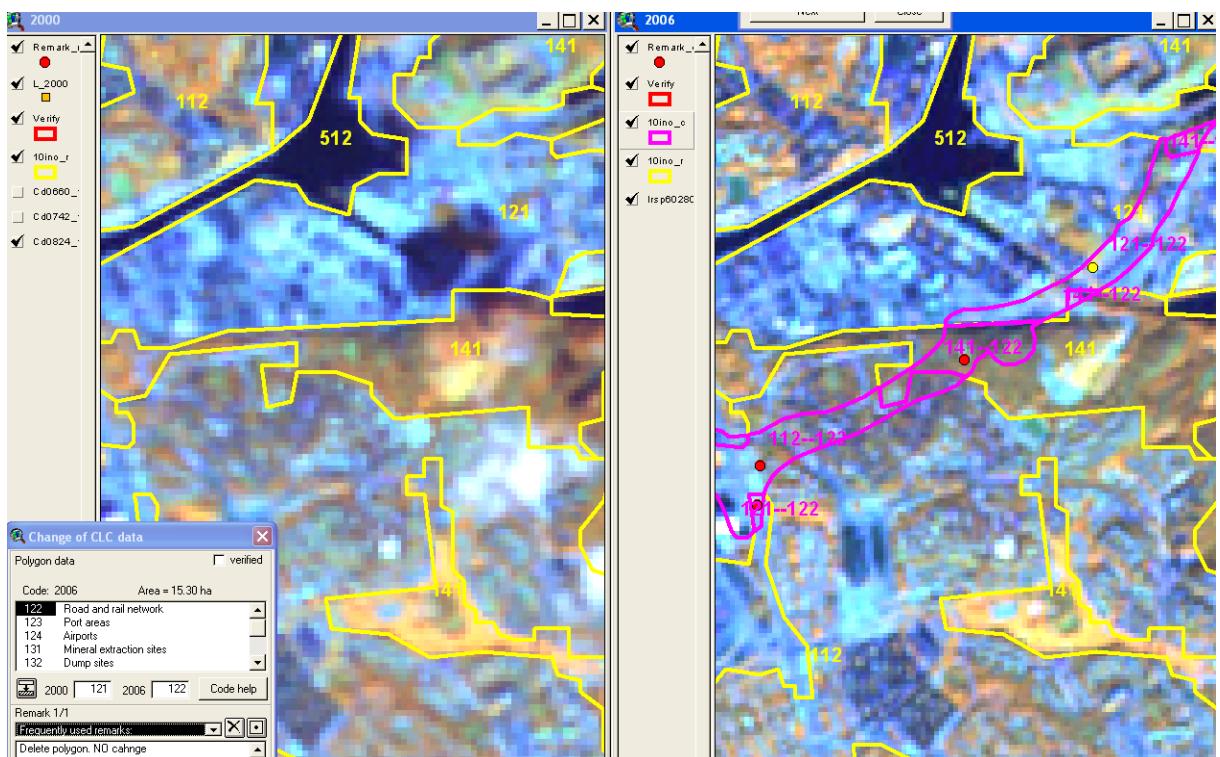
- Image processing technology to derive CLC classes by digital classification
- Modelling technology: estimation of continuous variables and derivation CLC classes (e.g. forest model)
- Use of national inventories, thematic layers, databases, including topographic datasets (collectively called in-situ data)
- GIS techniques to generalize high-resolution national databases to lower resolution European databases.

Besides the advantages of applying these methods, there are certain drawbacks that imply occurrence of specific mistakes.

Frequent mistakes: Automatic use of in-situ information	How to avoid the mistake
False changes	Changes derived by automated way (e.g. differencing topographic datasets) should be checked by asking "is this change possible in a given geographic environment and short time between the two CLC inventories?" Consistent metadata and being aware of source layer's metadata are elementary conditions of using such information. Interpreter (GIS expert) must be able to differentiate between "change data" that come from real changes and ones that are false changes i.e. are consequences of difference between databases. Another elementary information needed is the age of source data. Ignoring data age might lead to e.g. mapping features that do actually not exist at the time of inventory (they are only planned or built after).
Missing changes	The age of source data might also lead to omission of changes. Data in national inventories do not always have a correct time attribute. Data always must be validated by means of e.g. remote sensing.



Mistake: missing change due to "future" outline provided by in-situ data. IMAGE2000 (left) shows a built-up area surrounded by forest. IMAGE2006 (right) indicates an increased built-up area. Comparing the two images there is a clear change between 2000 and 2006: 312-112, which is not derived. The explanation is that the outline of the built-up area was fore-dated in CLC2000, not matching the actual situation shown by IMAGE2000. Consequently, change was omitted.



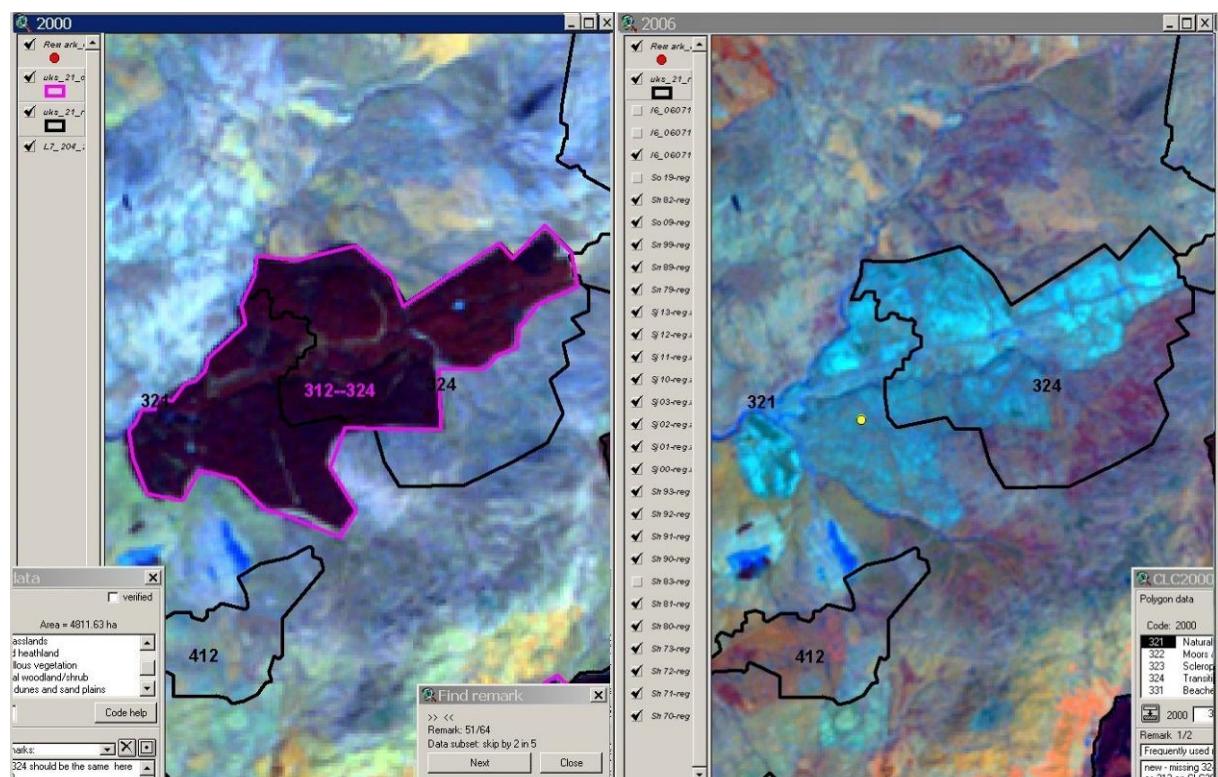
Mistake: wrong change due to improper use of cartographic database. IMAGE2000 (left) and IMAGE2006 (right) show a large urban area. We do not see any difference on the images (except the small cloud and shadow on IMAGE2000), while a new road (112/141-122) was mapped. Changes were derived by comparing the topographic databases of 2000 and 2006. Analysing the situation revealed that a tunnel has been constructed between the two dates, which naturally has no visible consequence on the surface. All derived change polygons are false and have to be deleted. Changes derived from differencing in-situ data should be checked by an expert.

6.5 RELATION BETWEEN CHANGE AND STOCK LAYER POLYGONS

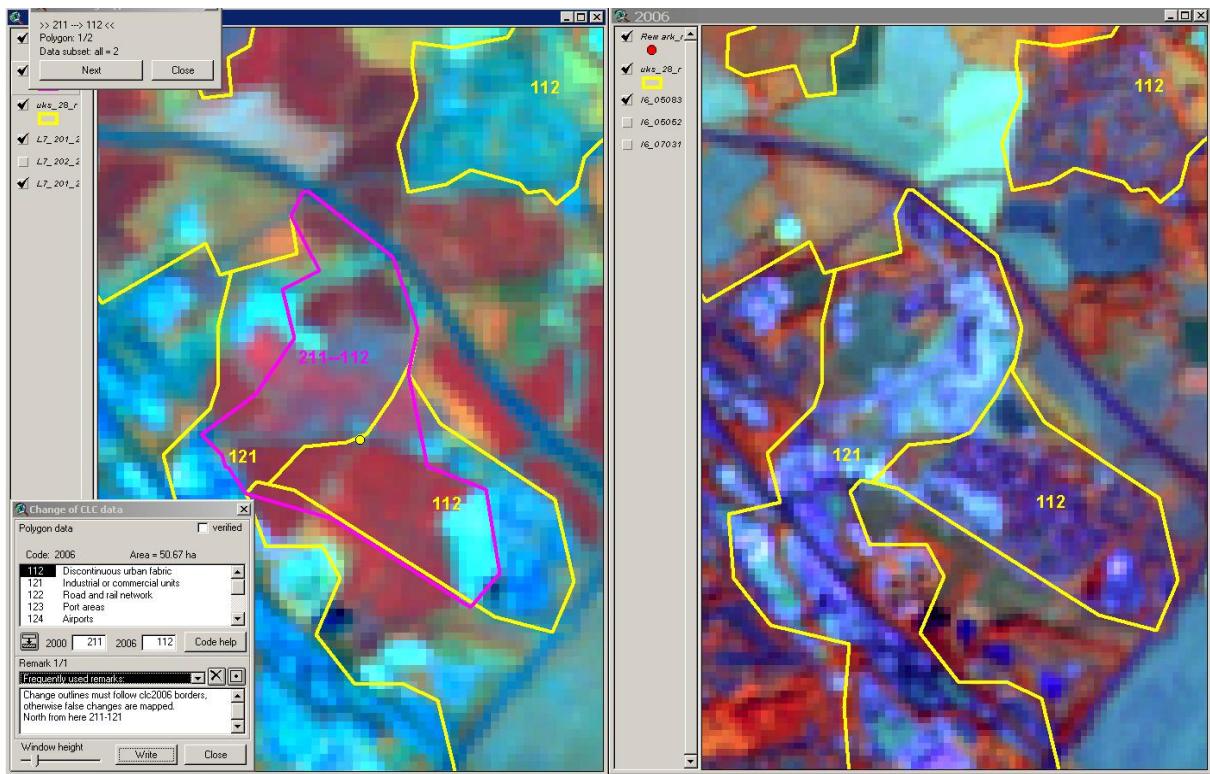
Overview:

CLC and CLC-Change data should fulfil certain technical requirements, summarized in [4]. As CLC stock layers and CLC-Change layers are logically interrelated, their geometries are not independent from each other. Actually, outlines of CLC-Change polygons should match polygons of parent CLC stock layer.

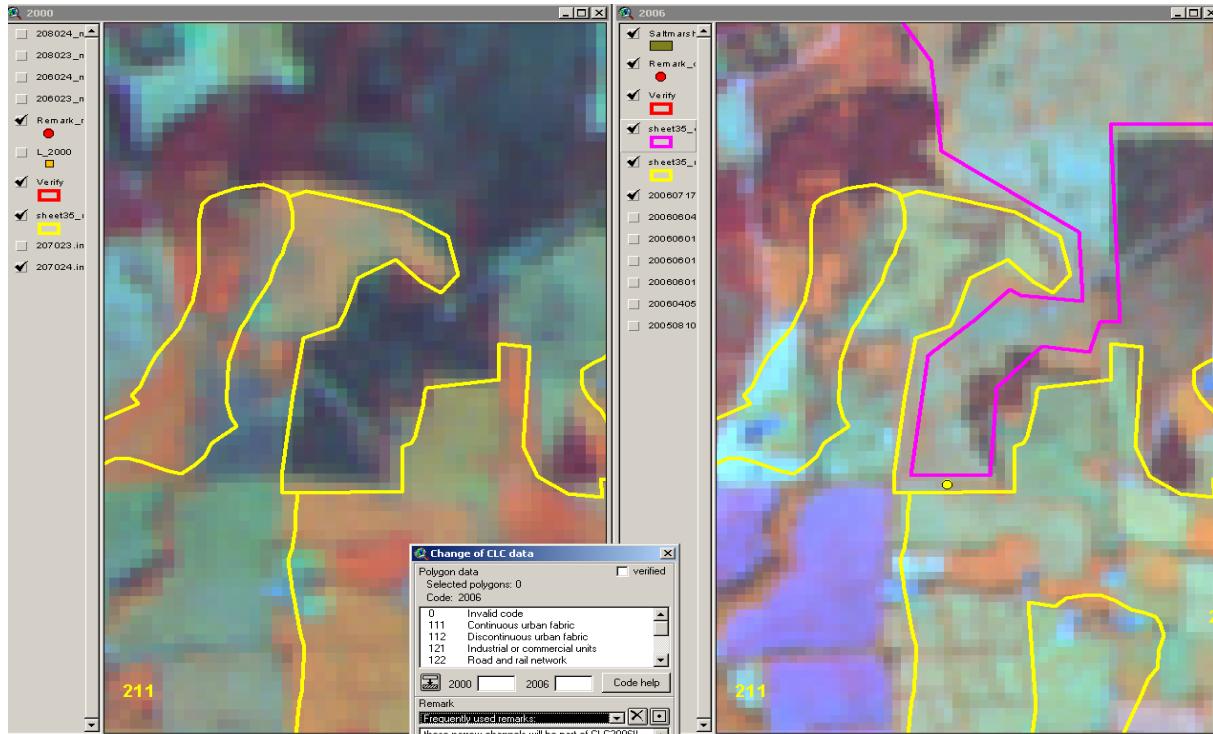
Frequent mistakes:	How to avoid the mistake
Relation between Change and Stock layer polygons	
CLC and CLC-Change outlines do not match, which results false CLC and / or false changes	CLC and CLC-Changes have to be produced in an interrelated process, and not independently. Outlines in CLC and CLC-Change should be harmonized as much as possible
There is a corridor between CLC and CLC-Change, resulting disconnected ("lost") features and / or loss of changes below 25 ha in the new stock layer.	Changes must be drawn so that features' continuity is kept in updated CLC (derived from parent layer and Change layer).



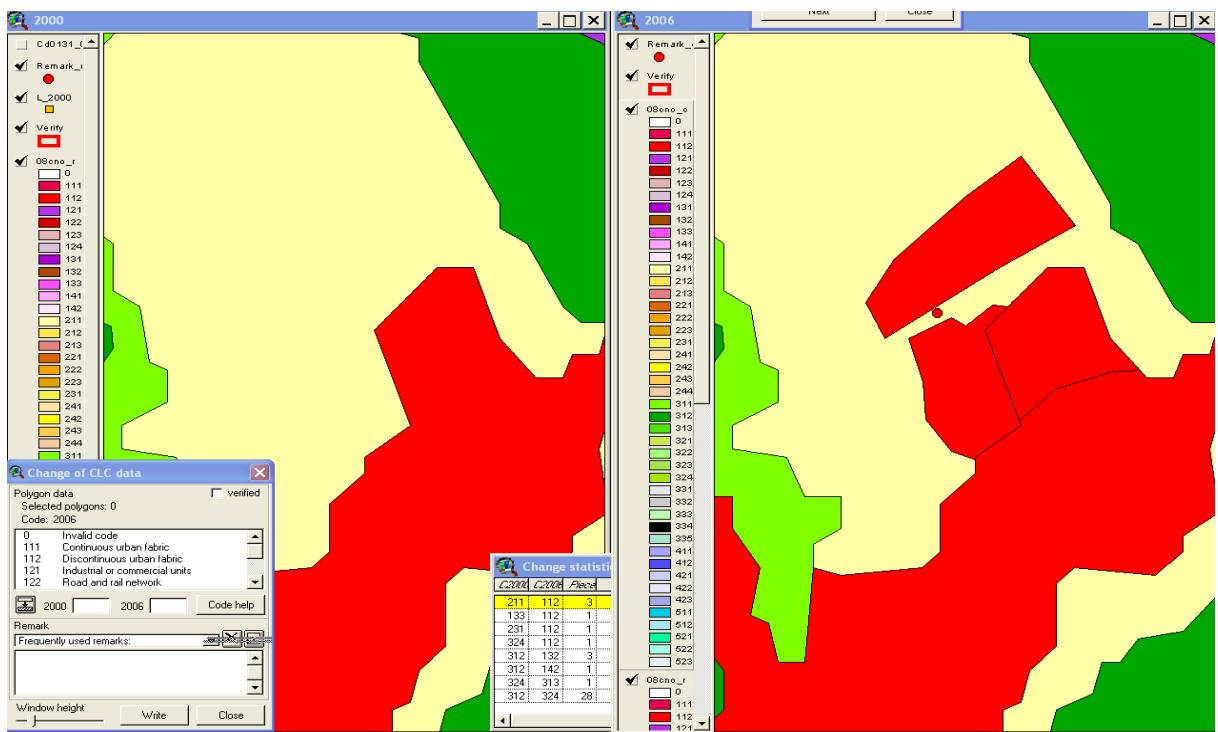
Mistake: CLC2006 and CLC-Change outlines do not match. IMAGE2000 (left) indicates a coniferous forest, which was cut by 2006 (right). Mapped change is correct (312-324), but CLC2006 is not correct: outlines of the 324 polygon in 2006 should be adjusted to the shape of the 312-324 change polygon. In this case CLC-Change and CLC2006 were produced in practically independent processes, which solution is strongly not recommended.



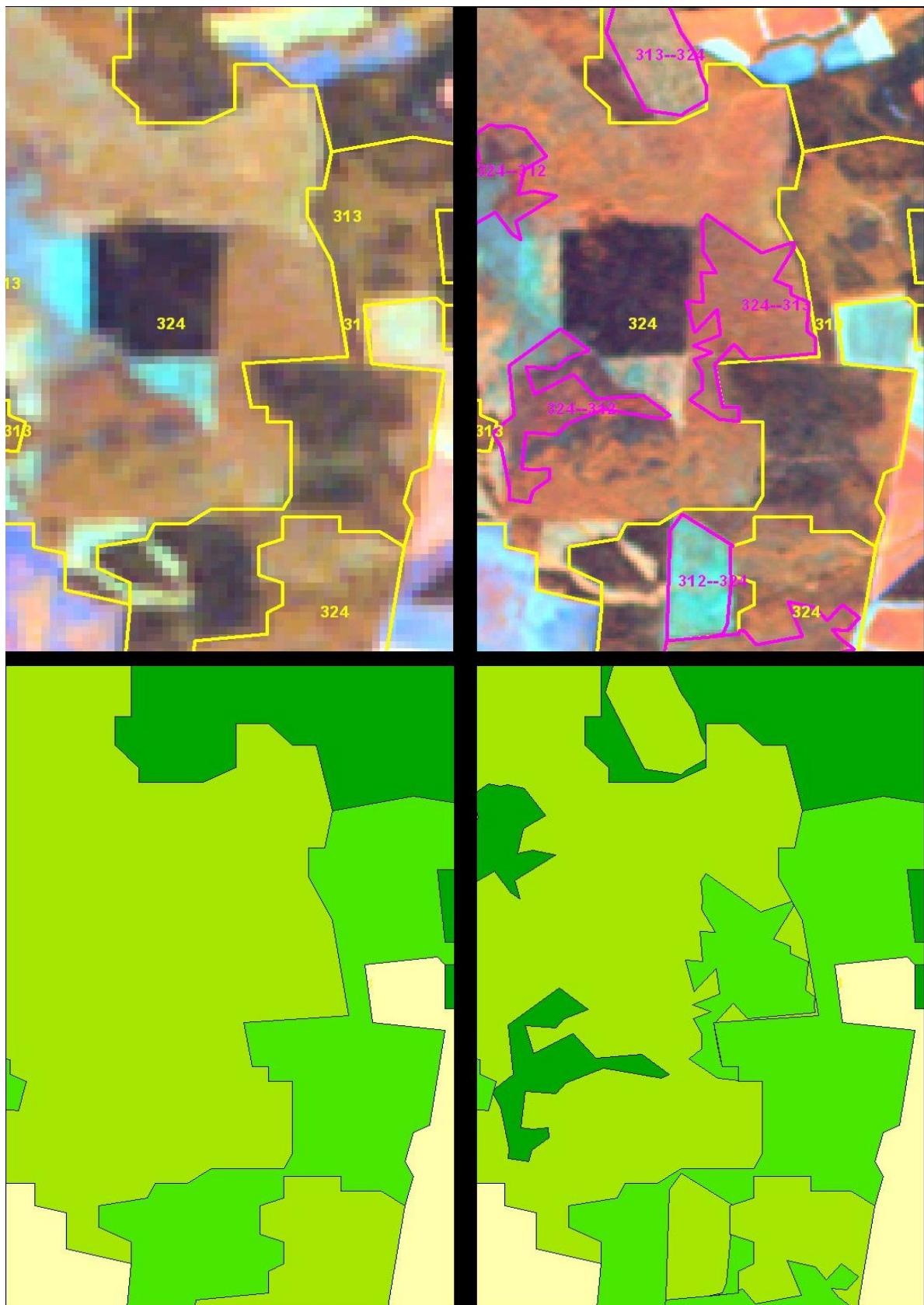
Mistake: CLC2006 and CLC-Change outlines do not match. IMAGE2000 (left) shows an agricultural area, which was built up by 2006 (right). Part of it became industry (121), southern part became residential area (112) – see correct CLC2006 (right). Northwest part of the change polygon is therefore wrongly coded as 211-112 instead of 211-121. In this case CLC-Change and CLC2006 were produced in practically independent processes, which solution is strongly not recommended.



Mistake: CLC-Change (magenta line, right) intentionally drawn (for unknown reason) in a distance from CLC2000 outlines leaving a narrow corridor un-changed. This is a mistake. Changes should be attached to existing CLC2000 polygons. Note that corridor area (marked by a yellow dot) has also been clearcut, not just the area inside the magenta line.



Mistake: One of the two change polygons (211-112) is drawn in a way that changed patch is disconnected from existing patch in the updated stock layer. CLC2000 (left) and CLC2006 (right) are shown in thematic colours: yellow is agriculture, green is forest, red is built-up. There are two changes in built-up class; one associated to the existing built-up, while the other (north) is separated from it. If the separated change is < 25 ha, it will be not represented in CLC2006 (will be generalized into agriculture). If it is > 25 ha, it will be separated from the large built-up area by a narrow channel. It is better to connect changes to existing features if distance between them is below or close to 100 meter.



Mistake: automatically derived CLC-Change produced narrow corridors in CLC2006. Upper images: IMAGE2000 with CLC2000 lines in yellow (left), IMAGE2006 (right) with changes (magenta). Lower images: IMAGE2000 and IMAGE2006 in thematic colours. If changes are not attached to existing CLC2000 polygons, narrow features will be produced in CLC2006 and <25 ha changes will not be represented in the new stock layer.

6.6 TECHNICAL CHANGE

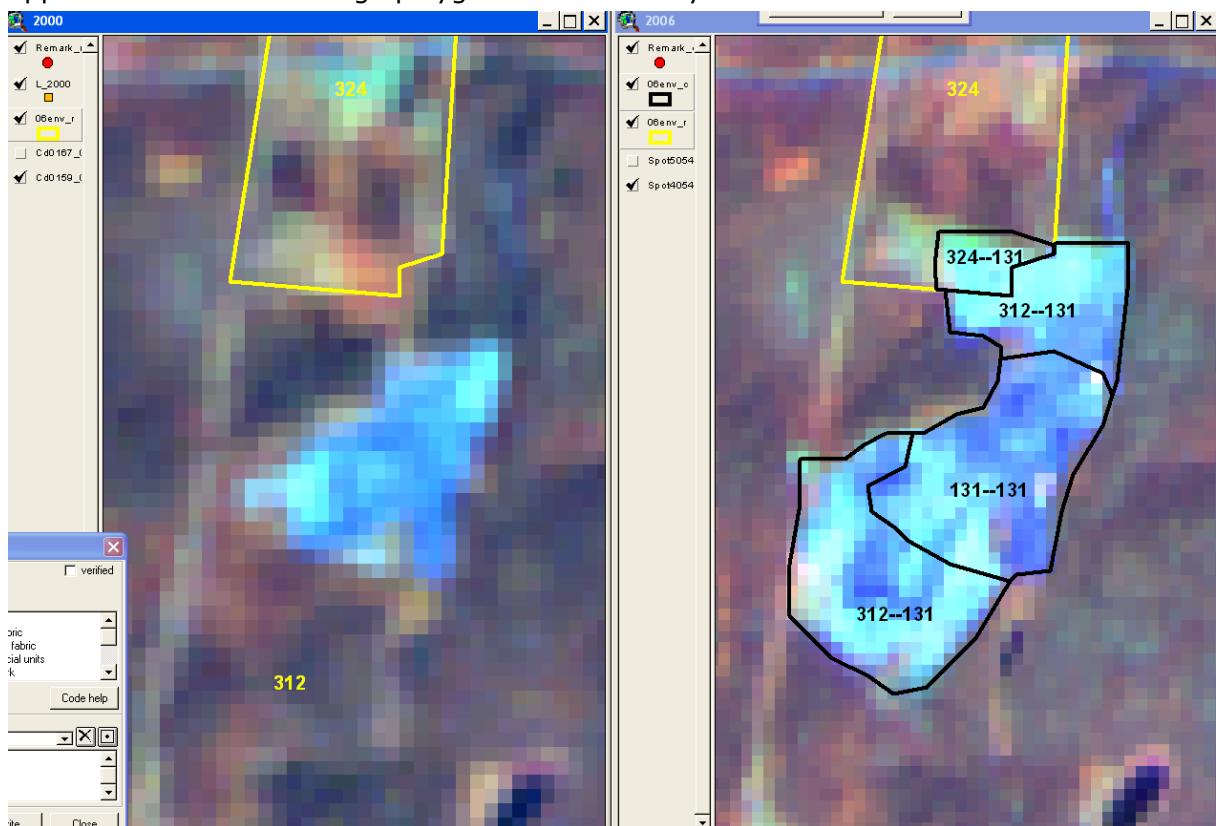
Overview:

Technical change was introduced to help mapping real CLC changes with 5 ha MMU, while keeping also the 25 ha MMU in CLC stock layer [1]. Technical change polygons do not represent a change of land cover in reality, but are used for avoiding inaccuracies of the new stock layer and the change layer. In this sense technical change is typically used to map a feature (land cover patch) that:

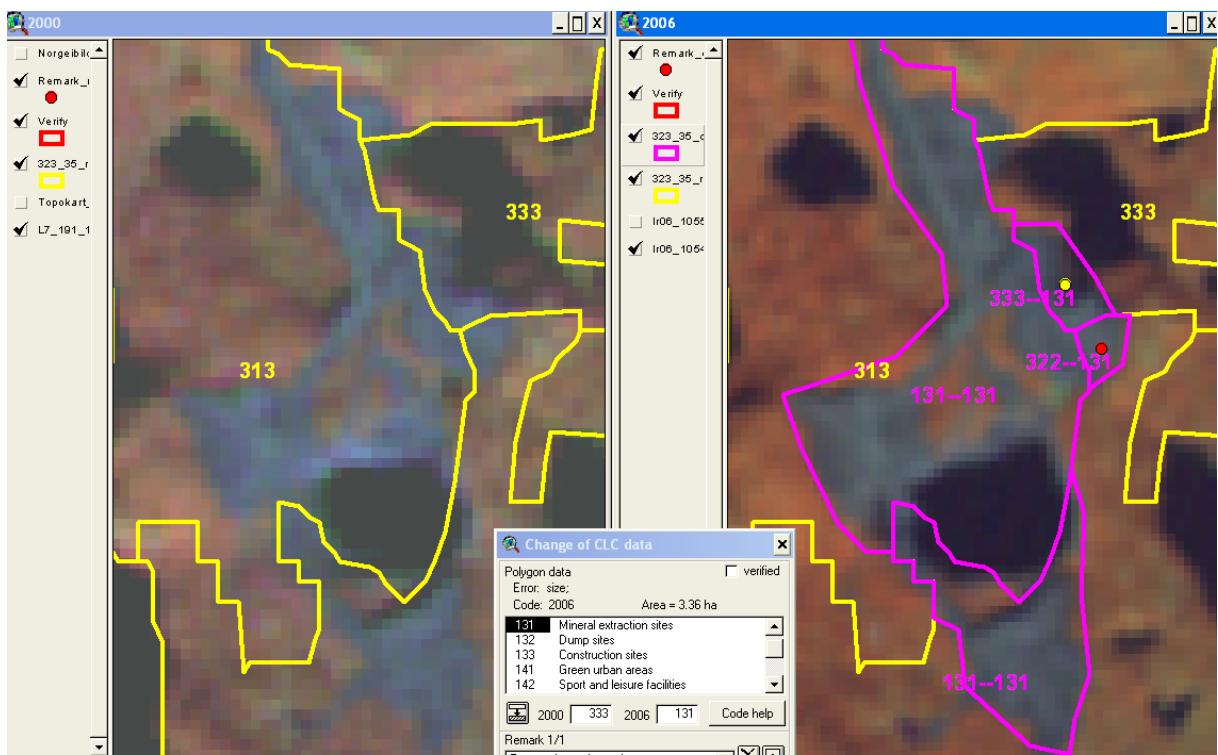
- already existed at time of previous inventory, but its area was below 25 ha, thus was not mapped as CLC polygon; and
- has increased by the new inventory because of a real change, its area thus exceeding 25 ha.

Technical changes, having two identical CLC codes and area below 25 ha, allow mapping new features with their real area in the new inventory, as well as to map changes with real area.

Another application of technical change emerged during the implementation of CLC2006; it is used for mapping mistakes (usually omissions) in the parent stock layer in countries where parent stock layer was decided not to be directly corrected / modified. In this application technical change polygons can have any size.

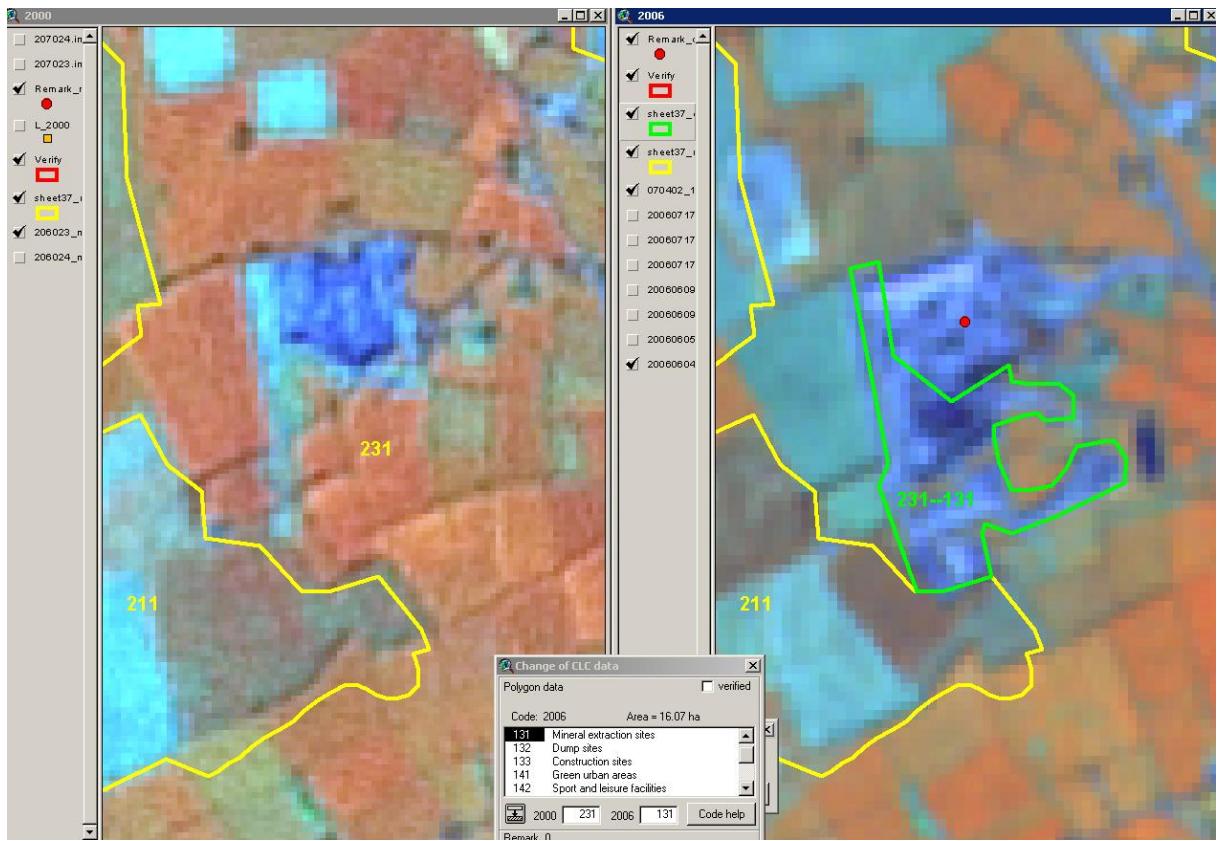


Nice example of application of technical change (Sweden). IMAGE2000 (left) shows a mineral extraction site inside a forest. As the mine was below the 25 ha MMU, it was not mapped in CLC2000. IMAGE2006 (right) shows that in six years the mine significantly extended to the north as well as to the south. The middle part of the mine is mapped as a technical change: 131-131 (meaning it was mine in 2000 as well as in 2006). The other three polygons document the increase of mine: 312-131, 324-131). The four polygons form a complex change in CLC-Change and a >25 ha polygon in CLC2006. Without the technical change the mine would have been "lost" (generalized into neighbours) in CLC2006 as the changed patches are not contiguous and are below 25 ha. Without technical change we could map either the real changes, but not the right status in 2006, or exaggerated (false) changes and the true status in 2006, both of which would be mistakes.

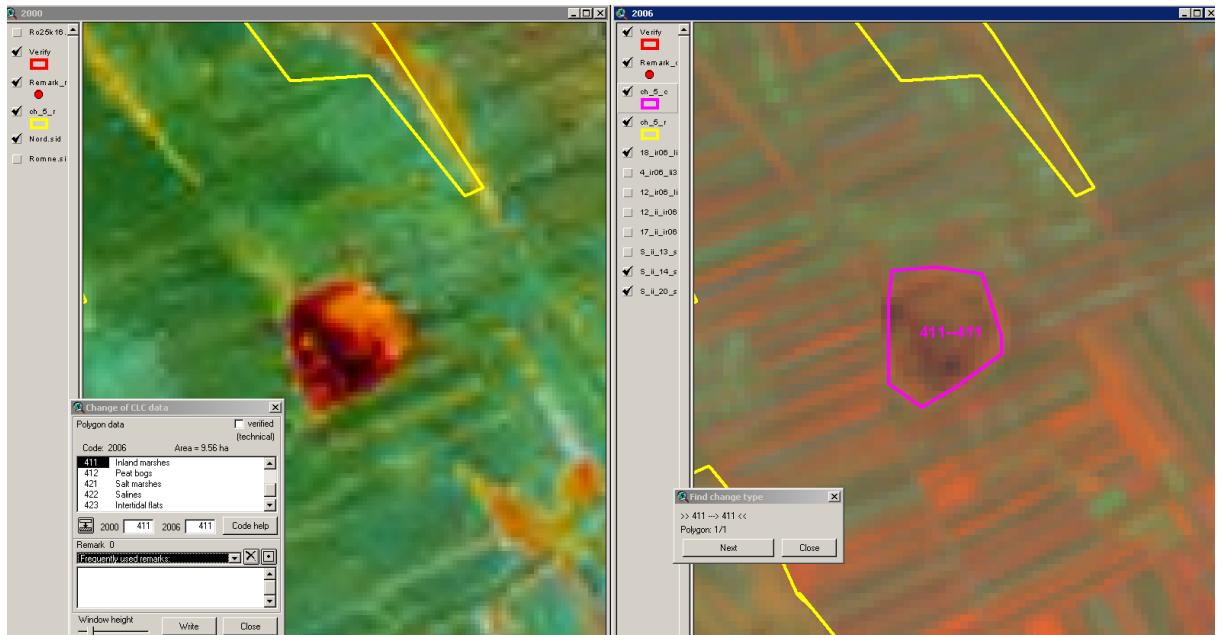


The example shows the application of technical change for correcting the parent stock layer (Norway). Norway used national databases for producing CLC2000. Some of these registers were not fully up-to-date; consequently some features were missing in CLC2000. Technical changes were used during CLC2006 project to map these missing features, such as this mineral extraction site. IMAGE2000 (left) shows a large, not mapped mineral extraction area in a forest. IMAGE2006 (right) shows no significant change in six years. Several technical change polygons were drawn (following outlines of CLC2000 polygons). Code 131-131 means that the area was a mine in 2000, as well as in 2006. Technical change polygons do not contribute to CLC-Change layer, but will help producing the correct CLC2006 stock layer. If needed, technical changes can also be used to produce a revised CLC2000 database.

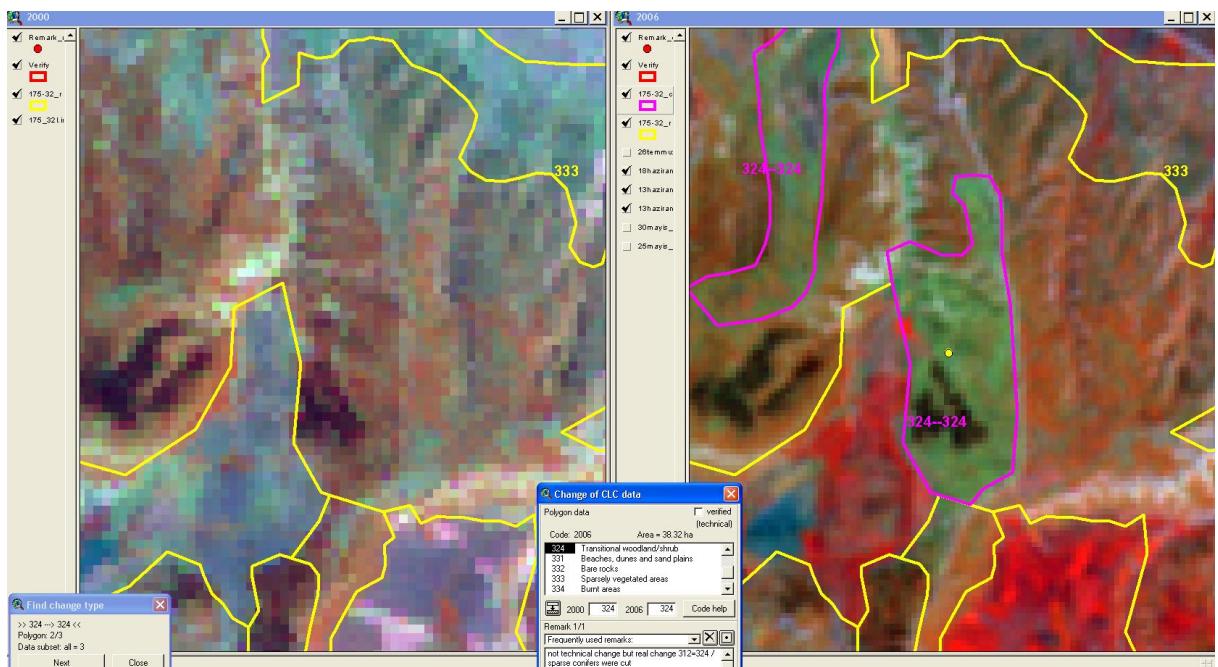
Frequent mistakes:	How to avoid the mistake
Technical change	
Incorrect CLC or CLC-Change polygon because of missing technical change	Apply technical change
Incorrect application of technical change, including use of technical change instead of a real change	Understand better the definition and application of technical change [1].



Mistake: missing technical change. CLC2000 (left) shows an agriculture area with a small (<25 ha) mineral extraction site. CLC2006 (right) indicates a significant enlargement (16 ha) of the mining area. While the 231-131 change is correct, there is a missing technical change (131-131) around the red dot. Without technical change CLC2006 will not include the mine, as the changed area is < 25 ha, therefore it will be generalized into surrounding polygons. Assuming that technical change area is at least 7 ha, they would together make up a valid (>25 ha) mine polygon in CLC2006.



Mistake: useless technical change. Both images show an agriculture area with a small (<25 ha) wetland. In CLC2006 this area has been delineated, and classified as technical change (411-411). However, this technical change is of no use in CLC, because it does not have any neighbouring change with 411 attribute. This kind of polygon does not cause any mistake; it is simply unnecessary and should be deleted.



Mistake: using technical change instead of real change. CLC2000 (left) shows a forest polygon. On IMAGE2006 (right) forest cover disappeared (or degraded) on two polygons, which were erroneously coded as 324-324. In these cases we have real changes, most probably 312-324 or 311-334. With the mapped technical changes CLC2006 will be correct, but CLC-Change will not be correct.

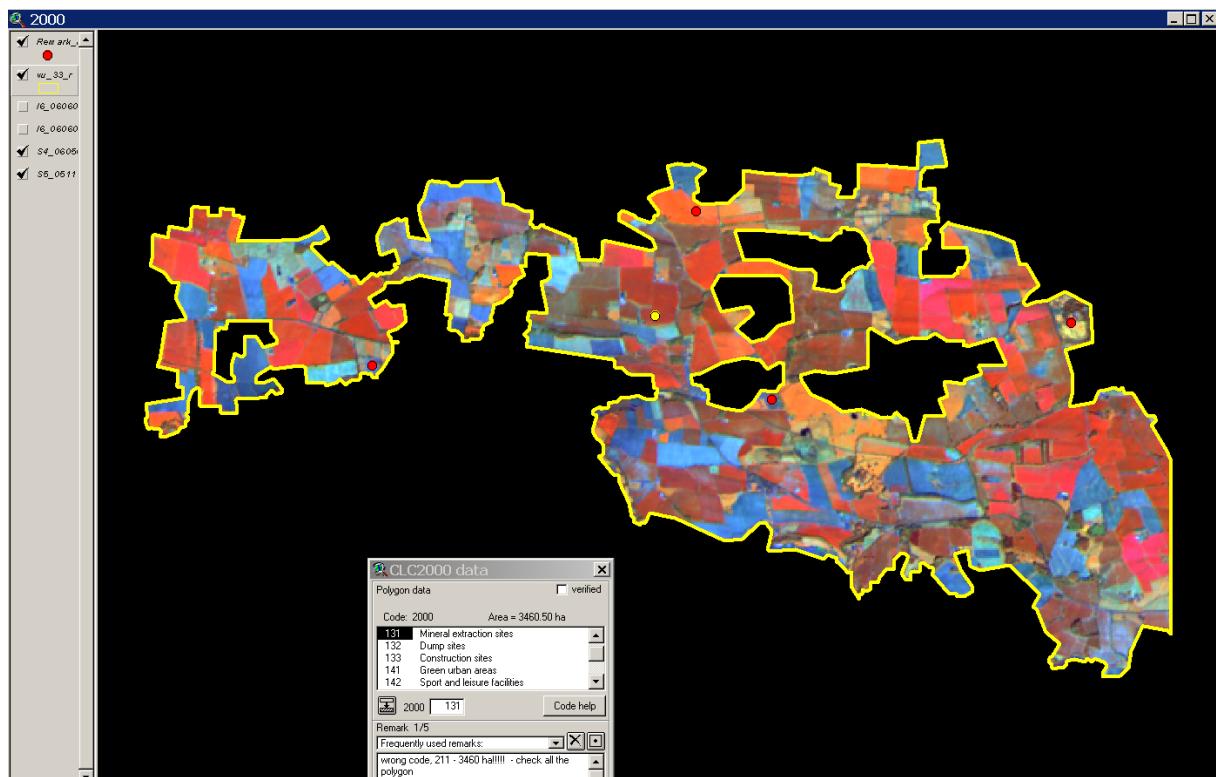
6.7 TYPING ERRORS

Overview:

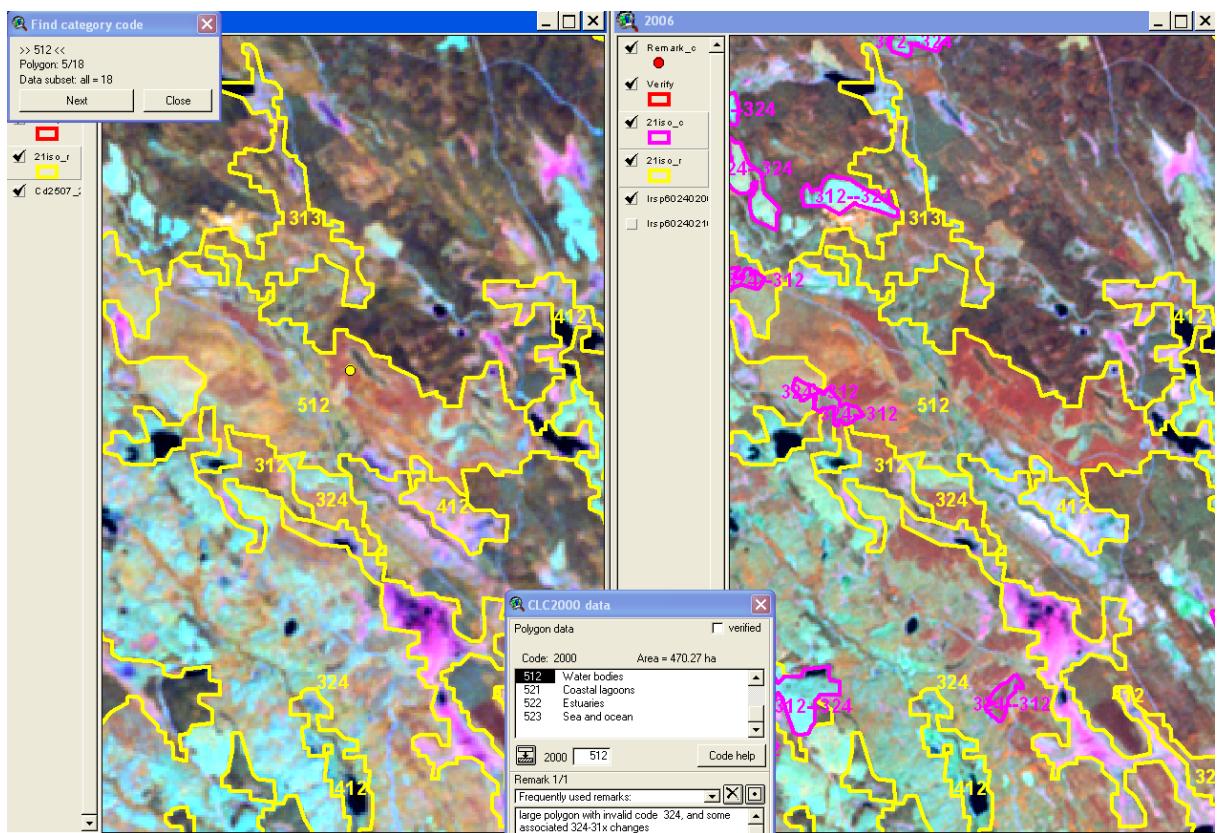
As CLC changes cover usually only few percent of the country area, the new CLC inventory relies mostly on the previous inventory. Consequently mistakes (geometric and thematic) are inherited by new inventory from the previous inventory. Typing (coding) mistakes, where the CLC code is badly erroneous usually occur randomly. These mistakes are sporadic, but if not found and corrected, they are inherited by consecutive stock layers. Typing mistakes can be avoided by not applying manual typing during interpretation, but selecting codes from a list where class names are also visualized.

In addition to the stock layer, CLC-Change layer also can include such typing errors. If not found (and if larger than 25 ha), these mistakes are inherited by consecutive stock layers.

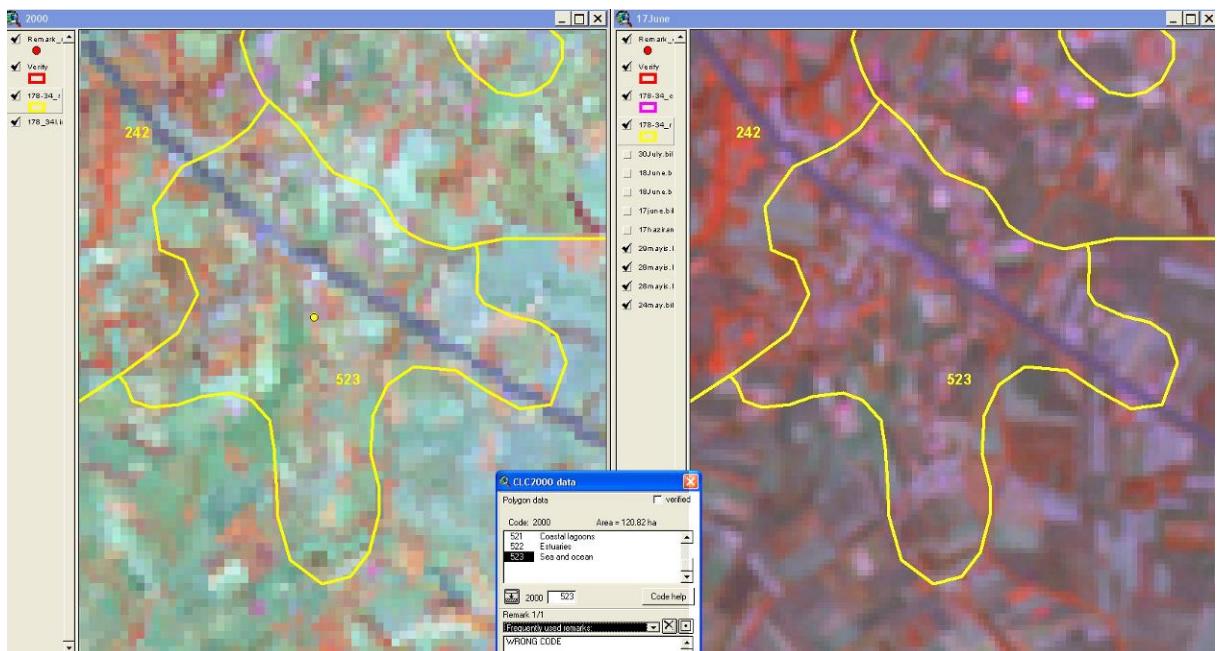
Mistakes:	How to avoid the mistake
Typing errors	
Typing errors in CLC stock layer	Check the entire working unit carefully at scale cca. 1:35.000. Additionally, average polygon size can help to filter out large miscoded areas. Locally impossible CLC codes can be found based on CLC code statistics. Viewing the stock layer using CLC thematic colouring might also help to filter out bad mistakes (e.g. large sea (523) patch inland).
Typing errors in CLC change layer	Check CLC-Change: all (if there are few only) or by sampling (if there are many). Check all "rare" changes (see Ch. 6.2).



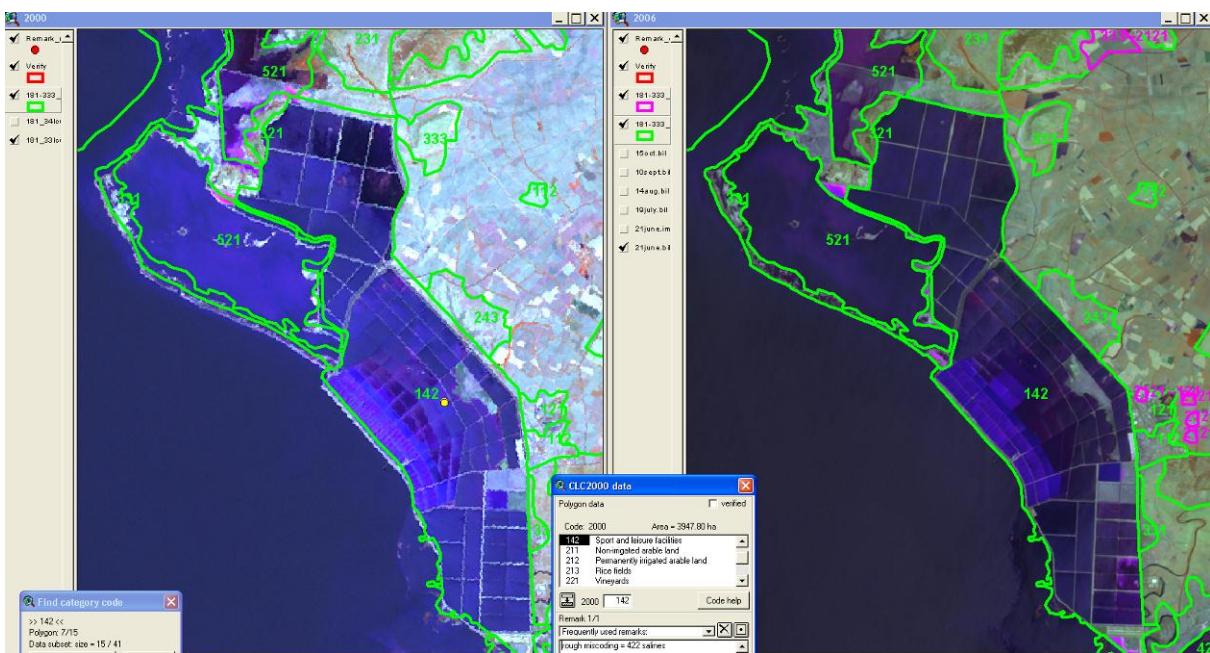
Mistake: typing error in CLC stock layer. 3460 ha agriculture land (dominantly arable land) is miscoded as mineral extraction site (131). If not found, this mistake is inherited by all consecutive stock layers. Average polygon size computed for CLC classes in the working unit could help finding in such cases, as mineral extraction sites usually have much smaller area.



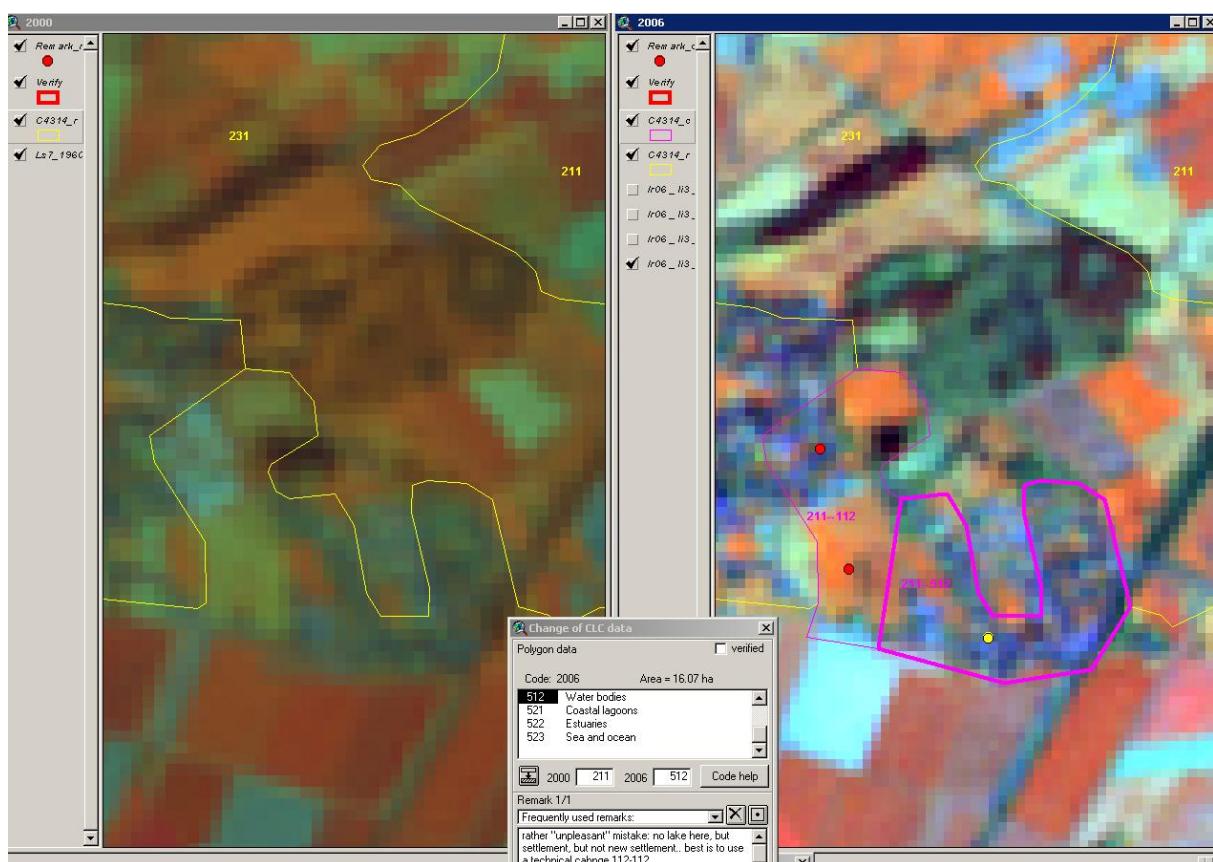
Mistake: typing error in CLC stock layer. 470 ha forested area was miscoded as water body (512). If not found, this mistake is inherited by all consecutive stock layers.



Mistake: typing error in CLC stock layer. 120 ha agricultural area is miscoded as 523 (sea and ocean). Explanation might be that code 223 (olives) was mistyped as 523. This mistake could have been found by checking CLC code statistics supposing that the working unit was situated inland. If not found, this mistake is inherited to all consecutive stock layers.



Mistake: typing error in CLC stock layer. 3948 ha saline (422) was miscoded as 142 (sport and recreation). Explanation can be bad mistyping. This kind of typing mistake is easy to find by checking "rare" codes, as 142 code usually is not too frequent. If not found, this mistake is inherited by all consecutive stock layers.



Mistake: typing error in CLC-Change layer. A new urban area is miscoded as 211-512, which is a common change. The right change can be 133-112, meaning that in 2000 (left) the area was under construction, while in 2006 (right) it was already residential area. Code 112 was mistyped as 512. If not found (and if larger than 25 ha), this mistake is inherited to all consecutive stock layers.

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8 ANNEX 1: IMPLEMENTING ORGANISATIONS

country	implementing organisation	technical project manager
Albania	Centre of Agricultural Technology Transfer, Albania GeoVille Austria	Vango Kovaci Nina Schuldner
Austria	Umweltbundesamt (Enviroment Agency Austria)	Gebhard Banko
Belgium	IGN Belgium	Yvan Van der Vennet
Bosnia and Herzegovina	University of Sarajevo	Hamid Čustović
Bulgaria	Geomatics Department, Bulgaria Academy of Sciences	Anton Stoimenov
Croatia	GISDATA d.o.o. OIKON	Ivana Lampek Vladimir Kušan
Cyprus	MANRE, Environment Service	Nicos Siamarias
Czech Republic	Help Service – Remote Sensing spol. s.r.o.	Stanislav Holý
Denmark	National Environmental Research Institute (NERI)	Michael Stjernholm
Estonia	Regio AS	Helle Koppa
Finland	Finnish Environment Institute (SYKE)	Pekka Härmä
France	Systèmes d'Information à Référence Spatiale (SIRS)	Lionel Mequignon
Germany	Deutsches Zentrum für Luft- und Raumfahrt (DLR)	Manfred Keil
Hungary	Inst. Geodesy, Cartography and Remote Sensing (FÖMI)	Gergely Maucha
Iceland	National Land Survey of Iceland (LMI)	Kolbeinn Árnason
Ireland	ERA Maptec Ltd.	Martin Critchley
Italy	Università degli Studi del Molise	Gherardo Chirici
Kosovo	EvroGeomatika (Serbia)	Ivan Nestorov
Latvia	Envirotech	Harijs Baranovs
Liechtenstein	Umweltbundesamt (Enviroment Agency Austria)	Gebhard Banko
Lithuania	Institute of Ecology of Vilnius University	Daiva Vaitkuvienė
Luxemburg	GeoVille Luxemburg	Stefan Kleeschulte
Macedonia	GOVe d.o.o.	Zoran Velickov
Malta	Malta Environment and Planning Authority (MEPA)	Saviour Formosa
Montenegro	Geological Survey of Montenegro	Slobodan Radusinovic
The Netherlands	Alterra, Wageningen University and Research Centre	Gerard Hazeu
Norway	Norwegian Forest and Landscape Institute	Linda Aune-Lundberg
Poland	Institute Geodezji i Kartografii (IGiK)	Elzbieta Bielecka
Portugal	Instituto Geográfico Português (IGP)	Mário Caeteno
Romania	Danube Delta National Institute (DDNI)	Jenica Hanganu
Serbia	EvroGeomatika	Ivan Nestorov
Slovak Republic	Slovak Environmental Agency (SAŽP)	Nada Machova
Slovenia	GISDATA d.o.o.	Sandra Radi Goljak
Spain	IGN Spain	Antonio Arozarena
Sweden	METRIA, National Land Survey of Sweden	Jan-Peter Mäki
Switzerland	Bundesamt für Umwelt (BAFU)	Tom Klingl
Turkey	Ministry of Forest and Environment	Ahmet Çivi
United Kingdom	Centre for Ecology and Hydrology (CEH)	Ian Simson

9 ANNEX 2: CORINE LAND COVER NOMENCLATURE

LEVEL 1	LEVEL 2	LEVEL 3
1. ARTIFICIAL SURFACES	1.1. Urban fabric 1.2. Industrial, commercial and transport units 1.3. Mine, dump and construction sites 1.4. Artificial, non-agri-cultural vegetated areas	1.1.1. Continuous urban fabric 1.1.2. Discontinuous urban fabric 1.2.1. Industrial or commercial units 1.2.2. Road and rail networks and associated land 1.2.3. Port areas 1.2.4. Airports 1.3.1. Mineral extraction sites 1.3.2. Dump sites 1.3.3. Construction sites 1.4.1. Green urban areas 1.4.2. Sport and leisure facilities
2. AGRICULTURAL AREAS	2.1. Arable land 2.2. Permanent crops 2.3. Pastures 2.4. Heterogeneous agricultural areas	2.1.1. Non-irrigated arable land 2.1.2. Permanently irrigated land 2.1.3. Rice fields 2.2.1. Vineyards 2.2.2. Fruit trees and berry plantations 2.2.3. Olive groves 2.3.1. Pastures 2.4.1. Annual crops associated with permanent crops 2.4.2. Complex cultivation patterns 2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation 2.4.4. Agro-forestry areas
3. FOREST AND SEMI-NATURAL AREAS	3.1. Forests 3.2. Scrub and/or herbaceous associations 3.3. Open spaces with little or no vegetation	3.1.1. Broad-leaved forest 3.1.2. Coniferous forest 3.1.3. Mixed forest 3.2.1. Natural grassland 3.2.2. Moors and heathland 3.2.3. Sclerophyllous vegetation 3.2.4. Transitional woodland-scrub 3.3.1. Beaches, dunes, sands 3.3.2. Bare rocks 3.3.3. Sparsely vegetated areas 3.3.4. Burnt areas 3.3.5. Glaciers and perpetual snow
4. WETLANDS	4.1. Inland wetlands 4.2. Marine wetlands	4.1.1. Inland marshes 4.1.2. Peat bogs 4.2.1. Salt marshes 4.2.2. Salines 4.2.3. Intertidal flats
5. WATER BODIES	5.1. Inland waters 5.2. Marine waters	5.1.1. Water courses 5.1.2. Water bodies 5.2.1. Coastal lagoons 5.2.2. Estuaries 5.2.3. Sea and ocean