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# **Deforestations in Switzerland as reported under the Kyoto Protocol Art. 3.3**

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Reference: J344-1715

## **1 Introduction**

In its National Inventory Report 1990-2008 (FOEN 2010), Switzerland reported for the first time CO<sub>2</sub> removals and emissions from activities under the Kyoto Protocol Article 3.3 (Afforestation and Deforestation) and Article 3.4 (Forest Management). For reporting Deforestations under Article 3.3 of the Kyoto Protocol ("Kyoto Deforestations"), activity data for Deforestations were derived from the Swiss Statistics of Deforestation (see FOEN 2009i). This database contains detailed information about all deforestations approved by the authority as it is prescribed by the Forest Act (Swiss Confederation 1992).

For reporting CO<sub>2</sub> eq removals and emissions from the LULUCF sector (Chapter 7 in FOEN 2010), activity data were retrieved from the Swiss Land Use Statistics AREA (SFSO 2009). The land-transition matrix (Table 7-9 in FOEN 2010) shows the mean annual rates of land-use change for a specific year. It includes conversion areas from forest combination categories to any other combination category. However, these changes in accordance with the forest definition are mainly due to changes in tree cover and do not necessarily fulfil the definition of Deforestation as it is defined under the Kyoto Protocol Article 3.3.

In this paper, land-use changes from forest combination categories to non-forest combination categories as derived from AREA (SFSO 2009) have been identified and screened in order to determine which conversions to non-forest combination categories are really in accordance with the definition of Deforestation according to paragraph 1(d) in the Annex to decision 16/CMP.1. Based on this screening, a robust methodology for retrieving "Kyoto Deforestations" from the AREA dataset has been developed. These AREA-based "Kyoto Deforestations" have been compared with the Swiss Statistics of Deforestation (see FOEN 2009i). Finally, the estimation of CO<sub>2</sub> emissions from AREA-based Deforestations has been updated.

For illustrative purposes, some examples of AREA conversions of forest combination categories classified as Kyoto Deforestations and of AREA conversions of forest combination categories not classified as Kyoto Deforestations are shown in the Annexes.

## **2 Swiss Land Use Statistics AREA**

### **2.1 AREA inventory database**

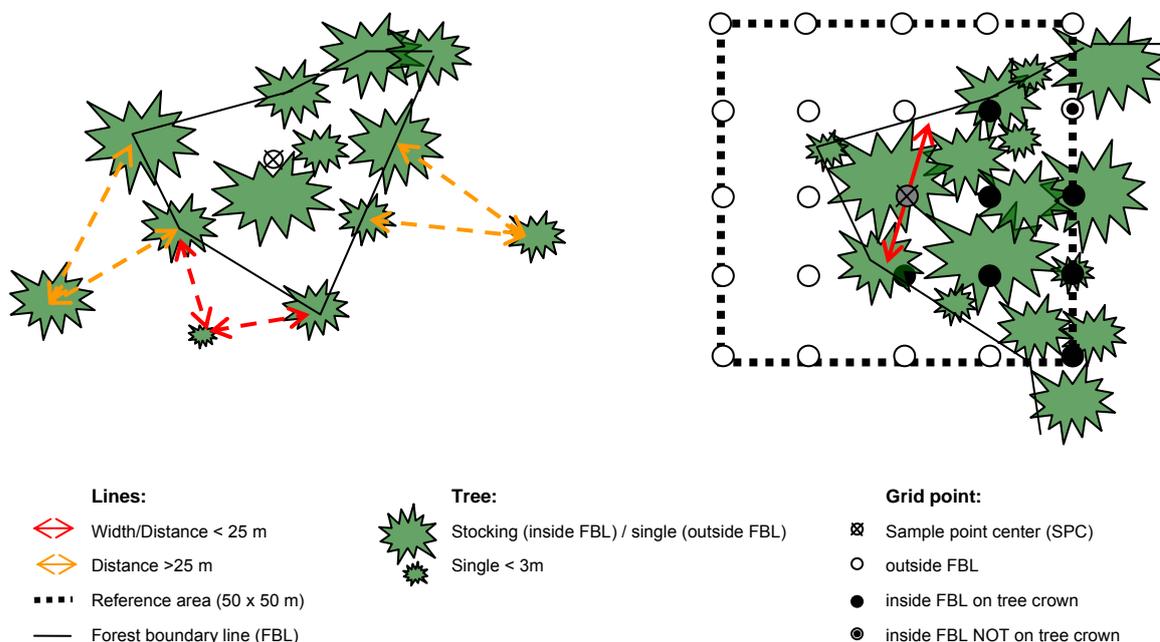
Activity data for reporting the LULUCF sector in Switzerland's National Inventory Report (FOEN 2010) are retrieved from the Swiss Land Use Statistics AREA (SFSO 2009). Land information is gained by means of stereographic interpretation of aerial photos. The inter-survey period amounts to on average approximately 12 years. The sample plots are located on the intersection of the 100-metre coordinates that cover the entire territory of Switzerland. For each point a land-use (LU) and a land-cover (LC) category is assigned. This classification is done by interpreting the land characteristic at the sample

point, and in cases of tree cover, by interpreting its surrounding area (reference area of 50 x 50 m with the midpoint located on the sample point). To assign a specific LC category for tree or shrub vegetation, crown cover percent, width or area of forest stand and height of the dominant trees have to be determined (SFSO 2006a). These parameters, also determining the Swiss definitions of Forest and Deforestation (FOEN 2006h), are measured within the reference area with the same methods used for the interpretation of aerial photos during the first phase of the National Forest Inventory (NFI; WSL 2001).

The forest boundary line (FBL) within the reference area is determined by connecting all vegetation elements (i.e. trees and shrubs of at least 3 m height) less than 25 m apart (Fig. 1 left). The width of the forest stand is then determined by measuring the shortest distance between the FBLs, with the distance line passing through the sample point center (red line in Fig. 1 right). Tree crown cover percent is measured by means of 25 grid points regularly distributed within the reference area (every 12.5 m) with the midpoint located at the sample point. Tree crown cover percentage is calculated based on the proportion of dot grid points covering tree vegetation within the FBL.

### Identification forest boundary line (FBL)

### Calculation crown cover percent



**Figure 1:** Determination of forest boundary lines (FBL, on the left), width of forest stand and crown cover percentage (on the right) for tree or brush vegetation at the sample point. The forest stand in the right panel is classified as “forest edges” (AREA code LC42) because tree cover percentage is 89 % (8 of 9 grid points within the FBL are covered by tree crowns) and the forest width is less than 25 m.

## 2.2 Combination categories

For LULUCF reporting purposes under the Convention combination categories (CC) have been defined on the basis of the AREA land-use and land cover categories (see Table 7-2 in FOEN 2010). The 6 main categories introduced by the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and by the 2003 IPCC Good Practice Guidance for LULUCF have been extended to 18 combination categories by means of aggregation of all possible combinations between the 46 land-use categories and 27 land-cover categories of AREA. This combination matrix, shown in Table 1, is also used in the analysis for identification of “Kyoto Deforestations”.

### 2.3 Extrapolation

The third AREA-survey (AREA 3) is still ongoing and by June 2010 about 59% of the Swiss territory has been interpreted (SFSO 2010). For this reason a spatial extrapolation of the presently available AREA data to the entire Swiss territory has been performed. Updated activity data will be implemented annually in future NIR submissions. For this study the dataset of June 2010 has been used.

### 3 Land-Use Changes from forest land to non-forest land

In order to identify the areas that changed from a forest combination category (afforestation CC11, productive forest CC12 and unproductive forest CC13 in Table 1) to a non-forest category, the AREA surveys AREA2 (1992/97) and AREA3 (2004/09) have been compared. Not all changes from a forest combination category to a non-forest combination category have to be accounted for as Deforestation according to the Kyoto Protocol Art. 3.3 (see Annex 1 and Annex 2 for illustrative examples). In fact, in some cases these conversions do not meet the definition of Deforestation as it is defined under the Kyoto Protocol and in Switzerland's Initial Report (FOEN 2006h). The definition of Deforestation is related to the definition of forest, which is based on tree coverage, minimum area and minimum width. A change from a forest combination category to a non-forest combination category does not necessarily mean a land-use change as it has to be according to the definition of deforestation. Hence, conversions not fulfilling the definition of Deforestation are not classified as Kyoto Deforestations.

The excluded areas and the characteristics for identification by means of AREA are listed in Table 2. The criteria affect mainly forest combination categories converted to grassland, whereas no criteria apply to conversions to settlements and urban areas (CC51-54 or LU1xx). These conversions are not excluded, but considered as Kyoto Deforestation. This is in accordance with the agreement of not classifying the following areas as forests: orchards, parks, camping grounds, open tree formations in settlements, gardens, cemeteries, sports or parking fields (FOEN 2006h).

Switzerland's definitions of Deforestation and Forest chosen for activities under Article 3.3 and 3.4 of the Kyoto Protocol are defined in Switzerland's Initial Report (FOEN 2006h):

- **Deforestation** is the permanent conversion of areas fulfilling the definition of forest in terms of minimum forest area to areas not fulfilling the definition of forest as a consequence of direct human influence.
- **Forest** is a minimum area of land of 0.0625 ha with a minimum width of 25 m and a crown cover of at least 20%. The minimum height of the dominant trees must be 3 m or have the potential to reach 3 m at maturity in situ.



**Table 2:** Criteria identifying conversions from a forest combination category to a non-forest combination category, which are not classified as Deforestations under the Kyoto Protocol Art. 3.3. The criteria do not apply to conversions to settlements. The classification is based on changes in land use (LU) and land cover (LC) information (Table 1). See Annex 2 for illustrative examples. The area excluded by the criteria is given for the period AREA2-AREA3.

Criteria	Criterion's number and explanation	Identification of affected areas	Area [ha/yr]
Non-permanent conversions due to forest management practices, natural dynamics or hazards	1.1 Tree loss temporally limited: conversion into temporally non-forested area whose land use can not be identified. As is common practice in Switzerland, natural regeneration is expected, but could not yet be recognized	AREA3: unused land (LU421)	209
	1.2 Tree loss spatially limited: conversion is caused by an alteration of the surrounding stand, but the change does not affect the tree cover at the sample point	AREA3: linear woods (LC46), cluster of trees (LC47) not in settlements or urban areas (i.e. only in LU2xx, LU4xx)	111
Conversions of combination categories not meeting the definition of Deforestation	2.1 Before conversion: areas which do not reach the minimum area of forest definition (<625 m <sup>2</sup> )	AREA2: forest edges (LC42)	30
	2.2 After conversion: areas still fulfilling the Kyoto definition of Forest, i.e. having the potential to reach 3 m at maturity in situ	AREA3: shrubs (LC31) not in settlements or urban areas (i.e. only in LU2xx, LU4xx)	69
No change in land-use	3. Reduction of tree cover without land-use change; former land use was mainly alpine pasture	AREA2/3: same land-use category (LUxyz / LUxyz)	306
Tree loss not human-induced	4. Conversion due to natural hazards and dynamics	AREA3: unused or along streams located bare land LU421 or 402 / LC 51 or 52 or 53	80

The process flow how “Kyoto Deforestations” are derived from the AREA data set by excluding the conversions from forest land to non-forest land fulfilling the criteria listed in Table 2 is shown in Figure 2. Since more than one criterion can be applicable to a certain conversion the total area that can be excluded does not equal to the sum of all single values showed in the right column of Table 2 ( $\Sigma=805$ ), rather it is 616 ha/y.

From 946 ha/yr (Fig. 2) of forest combination categories that changed to a non-forest combination category between AREA2 and AREA3, only 330 ha/yr (Tab. 3) are classified as “Kyoto Deforestations”. The characteristics of the Kyoto Deforested areas (combination categories before and after Deforestation) are presented in Table 3. Most of the “Kyoto Deforestations” occurred on productive forest converted into settlements (46%) or grasslands (36%).

**Table 3:** Kyoto Deforestations between AREA2 and AREA3 specified for combination category (CC). Values are rounded and extrapolated to the total Swiss territory.

ha/yr in CH from CC AREA2	to CC AREA3					Total
	Cropland	Grassland	Wetlands	Settlements	Other Land	
Afforestation		1		3		4
Prod. Forest	1	119	18	153	10	302
Unprod. Forest		19		4	1	24
Total	1	139	18	160	11	330

#### 4 Comparison of “Kyoto Deforestations” with the Swiss Forest Statistics of Deforestation

In Switzerland changes in forest areas through clearing is fundamentally prohibited by law and subject to approval by the authorities. If permitted, a like-for-like compensation is required on the same site (temporary clearing) or within the same area (permanent clearing; Swiss Confederation 1991). The records of the authorized deforestation are stored in Swiss Forest Statistics of Deforestation (contained in FOEN 2009i).

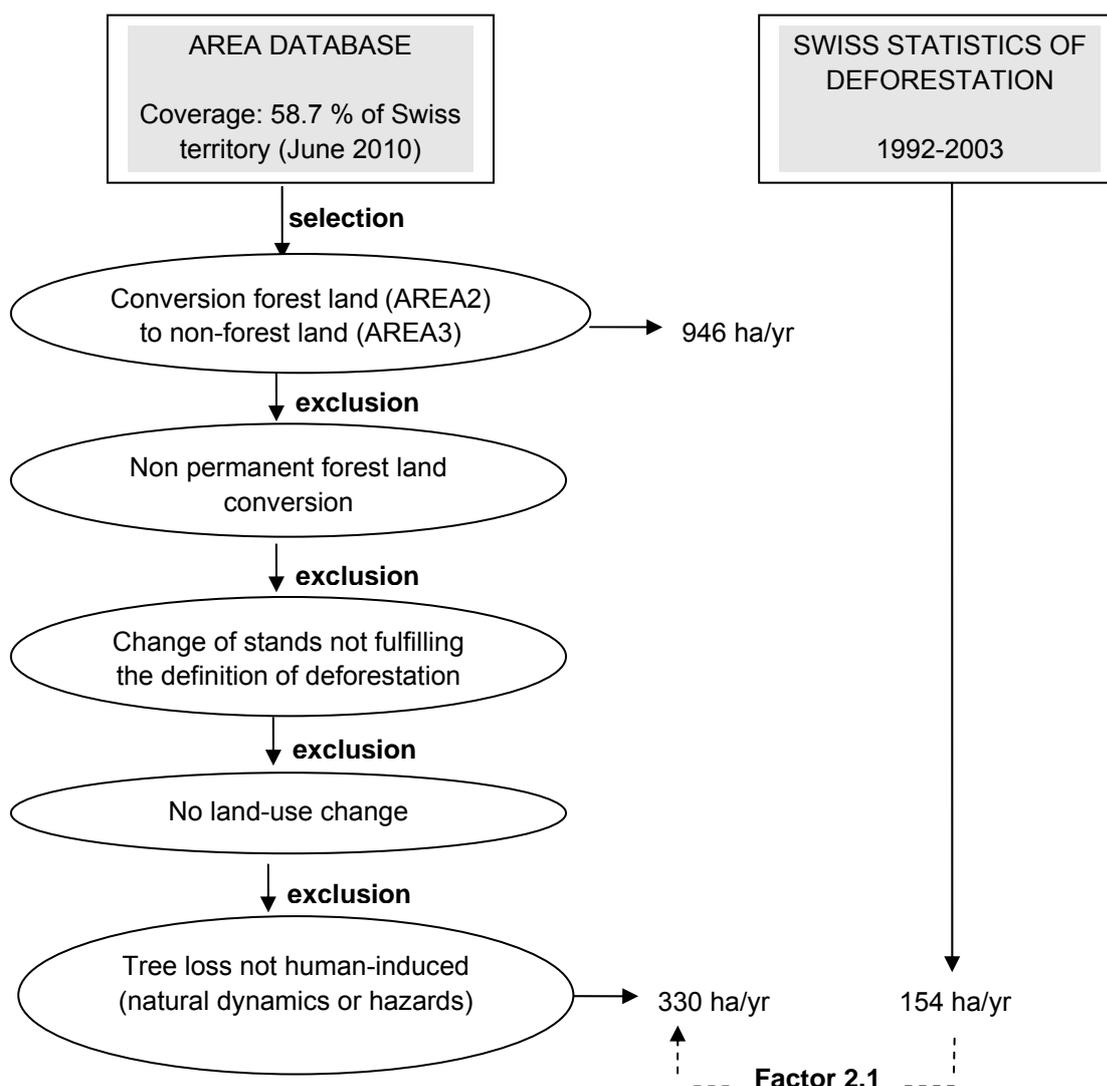
In Figure 2 the area of “Kyoto Deforestations” is compared with the Swiss Forest Statistics of Deforestation (see FOEN 2009i). It is 2.1 times larger than the area provided by the Forest Statistics of Deforestation (154 ha/yr). The differences are mainly due to the fact that different definitions of deforestations are applied. “Kyoto Deforestations” fulfill the definition of Deforestation as defined under the Kyoto Protocol. Deforestations according to the Swiss Forest Law (Swiss Confederation 1991) and listed in the Swiss Statistics of Deforestation are conversions to non-forest land, where the “legal definition of forest” is no longer fulfilled. This “legal definition” is not a distinct definition, but rather a flexible one. The Swiss Confederation only prescribes ranges for defining forest (like minimum forest area and width thresholds). Within these ranges each of the 26 Swiss Cantons can choose its own forest definition. Another important difference is that in contrast to the Kyoto definition of forests, the Swiss law also includes a time span of 10-20 years before natural regeneration can be considered as forest. Furthermore, on farmland dynamic processes occur: sometimes trees established by natural regeneration are cut after becoming forest without being legally classified as forests.

#### 5 Revised estimate of CO<sub>2</sub> emissions from “Kyoto Deforestations”

In Switzerland’s National Inventory Report 1990-2008 (FOEN 2010) activity data for Deforestations reported under Article 3.3 of the Kyoto Protocol were derived from the Swiss Statistics of Deforestation (see FOEN 2009i). However, as shown in Figure 2, the area of “Kyoto Deforestations” is 2.1 times higher than the area provided by the Forest Statistics of Deforestation. Using the AREA dataset would thus mean that the CO<sub>2</sub> emissions due to deforestations would be approximately 2.1 times higher, assuming a similar geographical distribution of the deforestations which are contained in the Swiss Statistics of Deforestation.

As an example, the respective data for the year 2008 are:

- Estimate of CO<sub>2</sub> emissions from Deforestation with activity data from Forest Statistics of Deforestation (see Table 11-4 in FOEN 2010) 82.18 Gg CO<sub>2</sub>
- Revised estimate of CO<sub>2</sub> emissions from “Kyoto Deforestations” 172.59 Gg CO<sub>2</sub>



**Figure 2:** Flow chart of the identification process of “Kyoto Deforestations” based on AREA data. The data are extrapolated for the total Swiss territory and calculated per year. The criteria applied for excluding certain areas are also listed in Table 2. AREA values are compared with the yearly deforested areas retrieved from the Swiss Statistics of Deforestation (FOEN 2009i).

## 6 Conclusion

The AREA-survey regularly monitors the entire Swiss territory and offers a highly-detailed differentiation of land-use and land-cover type. In the future, activity data for “Kyoto Deforestations” will be provided from the Swiss Land Use Statistics AREA. This has inter alia the following advantages:

- Using the AREA survey for determining “Kyoto Deforestations” improves the consistency in methodology: activity data of the whole LULUCF sector and for all activities reported under the Convention and under the Kyoto Protocol are based on one single comprehensive database.
- Conversions from a forest combination category to another combination category not matching the deforestation definition can be clearly marked. Those points not matching the definition of deforestation are marked and will be tracked to assess any change in land use and land cover.
- The information on land use and land cover allows identifying and tracking in detail what happens with the sample plots in the future. As soon as data from the next AREA will be available, this data will be used for monitoring future changes of all sample plots and for assigning potential land-use changes.

Further, in this paper it was shown that the area of “Kyoto Deforestations” is approximately 2.1 times higher than the area reported in the Swiss Statistics of Deforestation. Using the AREA survey as the future basis for identification of Deforestations would mean that CO<sub>2</sub> emissions from Kyoto Deforestations would also be approximately 2.1 times higher. This figure incorporates the current stage of the 3<sup>rd</sup> AREA survey (coverage of 59% of Swiss territory by June 2010).

The determination of the activity data from the AREA database will be automatized in autumn 2010, taking into account the geographical distribution (altitudinal level and NFI production region) of these Kyoto Deforestations. Estimations of CO<sub>2</sub> emissions from Deforestations will be updated in future submissions according to the then extended coverage of the AREA survey (complete coverage will be reached by the end of the first KP commitment period).

## 7 References

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## **8 Annexes**

In Annex 1 (Forest Land conversions classified as Deforestation according to Kyoto Protocol 3.3) and Annex 2 (Forest Land conversions NOT classified as Deforestation according to Kyoto Protocol 3.3) examples of series of aerial photos from the AREA surveys 1, 2 and 3 are shown. The average inter-survey period amounts to 12 years. The photos (copyright by swisstopo) serve as basis for the identification of the land-use and land-cover categories by the interpreters at the Swiss Federal Office of Statistics. In this study they have been used for the establishment of criteria to identify which types of forest conversion have to be reported as Deforestation according to the Kyoto Protocol.

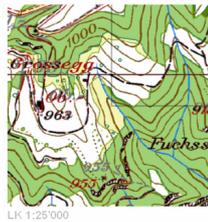
# Annex 1

## Forest CC conversions classified as Deforestation according to Kyoto Protocol 3.3



### Example 1

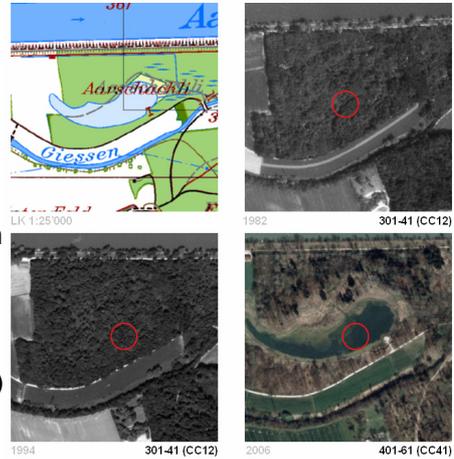
- **Reason**  
Forest CC conversions fulfill the definition of deforestation
- **Explanation**  
human induced conversion to grassland (farm pastures)
- **AREA example**  
A1: prod. forest (CC12)  
A2,3: permanent grassland (CC31)





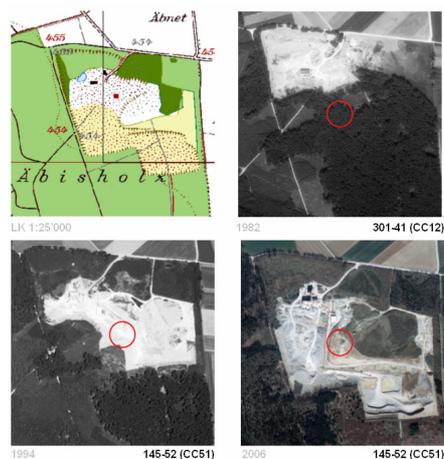
## Example 2

- **Reason**  
Forest CC conversions fulfill the definition of deforestation
- **Explanation**  
human induced conversion to wetlands (lake)
- **AREA example**  
A1,2: prod. forest (CC12)  
A3: surface waters (CC41)



## Example 3

- **Reason**  
Forest CC conversions fulfill the definition of deforestation
- **Explanation**  
human induced conversion to settlements (mines)
- **AREA example**  
A1: prod. forest (CC12)  
A2,3: building and constructions (CC51)





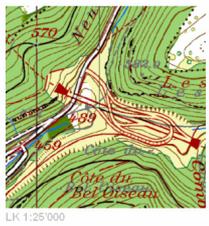
## Example 4

- **Reason**  
Forest CC conversions fulfill the definition of deforestation
- **Explanation**  
human induced conversion to settlements (residential areas, family house)
- **AREA example**  
A1,2: prod. forest (CC12)  
A3: herbaceous biomass in settlements (CC52)



## Example 5

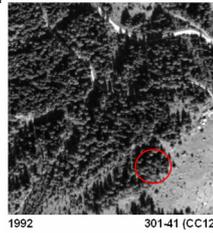
- **Reason**  
Forest CC conversions fulfill the definition of deforestation
- **Explanation**  
human induced conversion to settlements (motorways)
- **AREA example**  
A1: prod. forest (CC12)  
A2,3: buildings and construction (CC51)





## Example 6

- **Reason**  
Forest CC conversions fulfill the definition of deforestation
- **Explanation**  
human induced conversion to other land (avalanche protection structures)
- **AREA example**  
A1,2: prod. forest (CC12)  
A3: other land (CC61)



# Annex 2

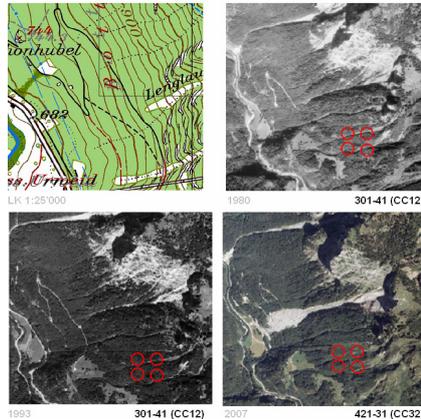
## Forest CC conversions NOT classified as Deforestation according to Kyoto Protocol 3.3

The criterion's number refers to the number presented in Table 2.



## Criterion 1.1

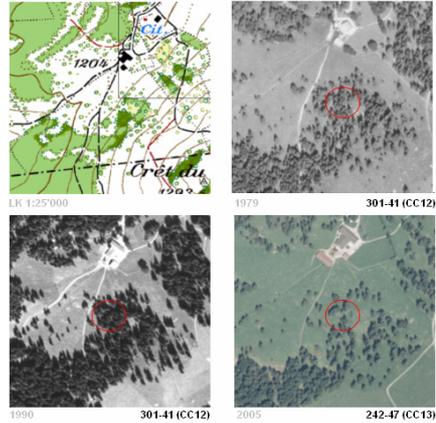
- **Reason**  
NON-permanent forest CC conversions (due to forest management practices or natural dynamics or hazards)
- **Explanation**  
the former stands are converted into temporarily non-forested area whose land-use can not be identified yet. As is common practice in Switzerland, natural regeneration is expected, but could not yet be recognized (tree loss temporarily limited)
- **AREA example**  
A1,2: forest (CC12)  
A3: shrub vegetation (CC32) with unused land (LU421)





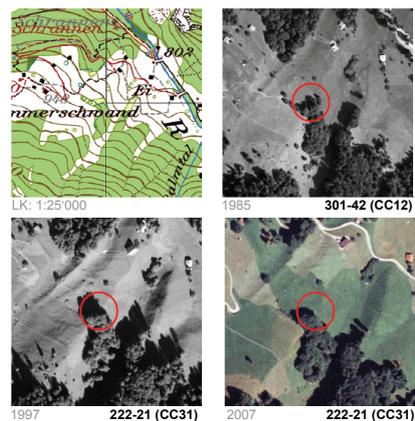
## Criterion 1.2

- **Reason**  
NON-permanent forest CC conversions (due to forest management practices or natural dynamics or hazards)
- **Explanation**  
the conversion is caused by an alteration of the surrounding stand, but the change does not affect the tree cover at the sample point (tree loss spatially limited)
- **AREA example**  
A1,2: closed forest (LC41)  
A3: clusters of trees (LC47)



## Criterion 2.1

- **Reason**  
Forest CC conversions do NOT fulfill the definition of deforestation
- **Explanation**  
the converted forest areas in itself did NOT fulfill the definition of forest (<625 m<sup>2</sup>)
- **AREA example**  
A1: forest (CC12) in a forest edge (LC42)  
A2,3: permanent grassland (CC31) with grass and herb vegetation (LC21)





## Criterion 2.2

- **Reason**

Forest CC conversions do NOT fulfill the definition of deforestation

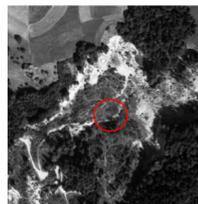
- **Explanation**

the areas still fulfill the definition of forest after the conversion (have the potential to reach 3 m at maturity in situ)

- **AREA example**

A1,3: forest (CC12)

A2: shrub vegetation (CC32) with shrubs (LC31)



## Criterion 3

- **Reason**

NO land-use change

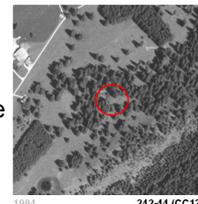
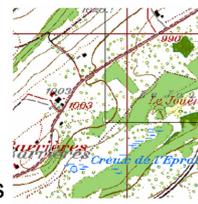
- **Explanation**

a reduction of tree cover occurred, but not a land-use change (former land use was mainly alpine pasture)

- **AREA example**

A1,2: forest (CC12) on an alpine pasture (LU421)

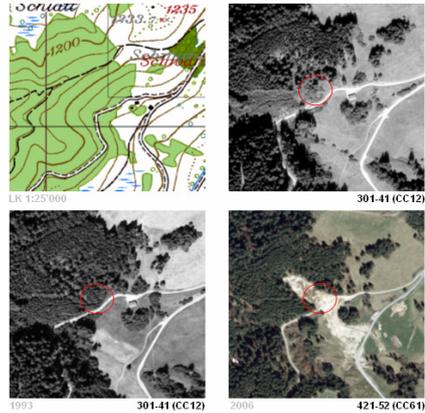
A3: permanent grassland (CC31) on an alpine pasture (LU421)





## Criterion 4 (example 1)

- **Reason**  
tree loss is NOT human induced
- **Explanation**  
the conversions are due to natural hazards (e.g. landslide)
- **AREA example**  
A1,2: forest (CC12)  
A3: other land (CC61)  
with granular soil (LC52)  
on unused land (LU421)



## Criterion 4 (example 2)

- **Reason**  
tree loss is NOT human induced
- **Explanation**  
the conversions are due to natural dynamics (e.g. flood)
- **AREA example**  
A1,2: forest (CC12)  
A3: other land (CC61) with  
granular soil (LC52)  
along river (LU402)

