Harmonizing activity data from the Swiss land use statistics (AREA) with the Kyoto Protocol guidelines

Revision based on complete AREA data 2004/2009 –

LULUCF, QA/QC: Revision of CC 13 with new AREA AD. (IDP 2012; Item 24)

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Introduction

This document addresses the revision of the definition of the area of unproductive forest (CC13). It was based on the initial analysis by Esther Thürig from 30. May 2007 (Ref # G223-0767) and followed the methodology presented there. This revision relied on the complete country-wide coverage from the third survey of the Swiss land use statistic 2004/2009 (compared to ca. 21.5% coverage in 2007). In the following, firstly, the purpose, method and results are briefly presented; secondly, implications for the definition of CC13 are discussed.

Purpose

For reporting on LULUCF activities under the Kyoto Protocol (KP), Switzerland uses spatial data from the Swiss land use statistics (AREA) compiled by the Swiss Federal Statistical Office. Requirements for KP reporting include the use of single, minimum parameter values for defining a forest. According to the IPCC Good Practice Guidance for LULUCF (chapter 4 in IPCC 2003), a forest must be defined by a minimum area (0.05-1 ha), a minimum crown closure at maturity (10-30%), and a minimum tree height at maturity (2-5 m). The definition for land use 'forest' used in AREA is not conform with the KP requirements and the chosen forest definition by Switzerland for activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol (KP-forest), i.e., a minimum area of land of 0.0625 ha with crown closure of at least 20 % and a minimum width of 25 m and the minimum height of the dominant trees must be 3 m or have the potential to reach 3 m at maturity in situ (FOEN 2007). Instead, in AREA a forest is defined based on multiple values for parameters, i.e., either ≥50 m width and ≥20% crown closure or 25 m ≤ width < 50 m and ≥60% crown closure (AREA-forest, Fig. 1). Thürig (2007) identified and discussed an approach to apply a revised forest definition to the AREA data that is in agreement with KP requirements and the chosen forest definition by Switzerland.

The recommendation by Thürig (2007) followed a conservative approach that was in line with the IPCC Good Practice Guidance. It was based on extending the default AREA forest definition (area shaded in dark-grey in Fig. 1) to a minimum width of 25 m and a minimum crown closure of 20%. The revised forest definition can be applied to the AREA data and plots can be identified that meet the criteria of the additional area (i.e., 25 m ≤ width < 50 m and crown closure ≥20% (area shaded in light-grey in Fig. 1); henceforth 'forest gap';). The corresponding land area can be estimated and applicable land cover and land use (LCLU) types in AREA can then be assigned to the combination category (CC) unproductive forest (CC13); see Appendix I for the complete combination matrix.
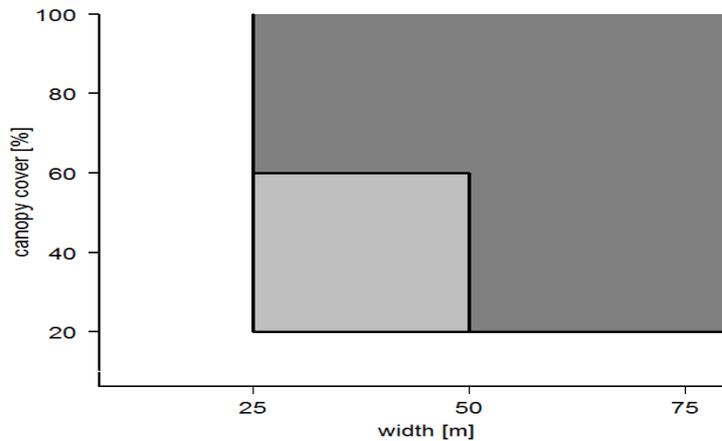
Figure 1. Forest definitions used a) by Switzerland for activities under KP (i.e., width ≥25 m and crown closure ≥20%; shaded area) and b) in AREA (i.e., either width ≥50 m and crown closure ≥20% or 25 m ≤ width < 50 m and crown closure ≥60%; shaded in dark-grey). To harmonize the definitions, the AREA forest definitions can be extended to include land areas with a tree cover of 25 m ≤ width < 50 m and crown closure ≥60%; shaded in light-grey).

Methods

AREA data for all 4,128,498 plots on the 100 by 100 m grid covering the whole of Switzerland were provided by L. Mathys, Sigmaplan, Bern. The data were based on the 2004/2009 survey campaign under the administration of the Swiss Federal Statistical Office. In the AREA database plot-specific information including forest width and crown closure were not kept alongside the categorical LCLU data. To complement AREA with data on forest width and crown closure, information from aerial photography were used, which were collected between 2004 and 2006 in the frame of the third NFI. The NFI data were based on a 500 by 500 m grid and provided information pertaining to forests for 165,153 plots across Switzerland.

The AREA data were overlaid with NFI data to obtain a common dataset. For 6 plots along the national borders no common information existed in AREA and in NFI. Thus after the overlay 165,147 plots remained with available data from AREA on LCLU and from NFI on forest width and crown closure. From the combined dataset plots were identified that a) were not classified as forest (i.e., CC ≠ 11, 12, 13), b) met the revised forest definition (i.e., width ≥25 m and crown closure ≥20%), c) were classified as forest after NFI (i.e., either regular forest [*Normalwald*] or shrub-forest [*Gebüschwald*]) and d) had an applicable LCLU type (Tab. 1). With this information

3

the number of plots could be derived that additionally needed to be classified as forest to fill the forest-gap, whereby it was assumed that a plot is representative for a defined land area.

Table 1. Land use and land cover types in AREA and respective combination categories (CC information as of 30.05.2007; cf. Tab. A-1) that may be classified as forest. Note that land cover 47 on land use 242 was assigned to forest (CC13) after the analysis by Thürig (2007).

Land cover	221 Arable land, in general	222 Semi-natural grassland, in general	223 Farm pastures, in general	241 Alpine meadows, in general	242 Alpine pastures, in general	243 Alpine sheep grazing pastures, in general	401 Lakes	402 Streams, rivers	403 Flood protection structures	421 Unused	422 Avalanche and rockfall protection structures	423 Alpine sports facilities	424 Landscape intervention
46 Linear woods	34	34	34	34	34	34	34	34	34	34	34	34	34
47 Clusters of trees	34	34	34	34	13	34	34	34	34	34	34	34	34

Applicable LCLU types were derived by a) possible land use / land cover combinations identified in the AREA definitions (*Standardnomenklatur*[1] used by the Swiss Federal Statistical Office) and b) expert judgment to further filter the possible land use / land cover from AREA. The latter was necessary since it was not possible to revise LCLU type for individual plots but for an entire LCLU type only. This limitation was due to the fact that AREA plots have no associated forest width and crown closure information. Since entire LCLU types needed to be re-classified, plots would be included that do not meet the criteria for a forest. Expert judgment was used to exclude unsuitable LCLU types from the analysis such as CC 'Trees in settlements'. Based on the number of plots in applicable LCLU types (Tab. 1), it was then possible to re-classify the equivalent of the forest-gap.

[1] More information available at:
http://www.bfs.admin.ch/bfs/portal/de/index/dienstleistungen/geostat/datenbeschreibung/arealstatistik_noas04.html

An implication of combining AREA data with a 100 m resolution and NFI data with a 500 m resolution was a loss of information since only a subset of the AREA data remained after the overlay (Fig. 2). For the further analysis it was assumed that the LCLU types in the subset of the AREA data occurred approximately proportional to the full AREA data.
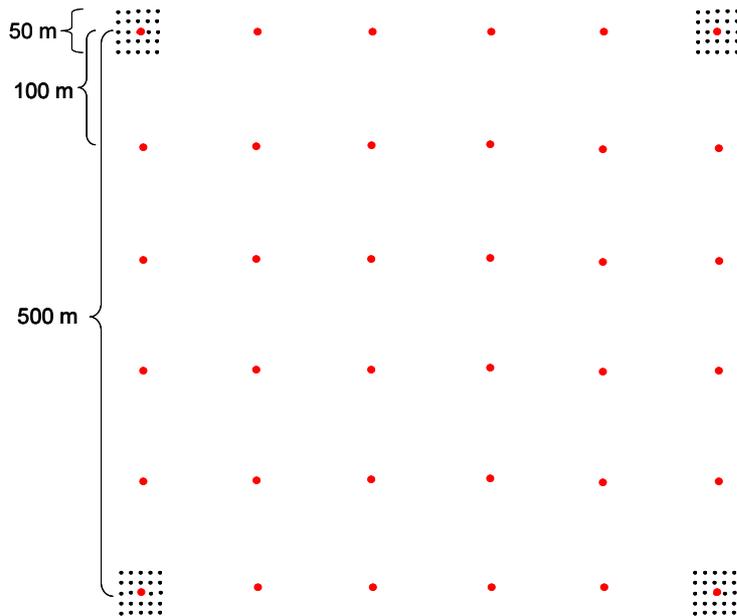
Figure 2. Overlay of AREA plot data (red) with a 100 m grid resolution and NFI aerial photography data (black) with a 500 m grid resolution. 4% of the AREA data are retained in the overlay (from Thürig 2007).

Further information on the methodology is available in the report by Thürig (2007).

Results and Discussion

A comparison of the occurrence of LCLU types in the full AREA dataset (i.e., 100 m grid resolution) and in the subset overlaid with NFI data (i.e., 500 m grid resolution) did not show a significant difference. Only five LCLU types had an occurrence of > 5% (Tab. 2). Hence, the assumption was justified that the 4% of the AREA plots were representative of the LCLU distribution of the complete data set.

Table 2. Land cover – land use combinations (LCLU type) with >5% occurrence in the full AREA dataset (n=4,128,498) and in the combined AREA-NFI dataset (n=165,147).

	Full AREA dataset	Combined AREA-NFI dataset
LCLU type	Occurrence [%]	
Closed forest- Forest	22.69	22.78
Grass and herb vegetation - Arable land, in general	9.86	9.86
Grass and herb vegetation - Alpine pastures, in general	8.22	8.18
Grass and herb vegetation - Semi-natural grassland, in general	8.19	8.23
Granular soil – Unused	6.31	6.37

From the combined dataset of AREA and NFI data with a total of 165,147 plots (Tab. 3), 51,498 plots or ca. 31% met the KP-forest criteria, i.e. they were a) covered by forest ≥25 m width and ≥20% crown closure and b) classified as forest in the NFI (they may temporally have no cover). The forest definitions in NFI and AREA are more strict than in KP and, hence fewer plots were classified as forest in NFI and AREA, respectively: 50,828 plots (98.7% of the KP-forest plots) were classified as forest in the NFI (Tab. 3, sum of plots in regular forest and shrub-forest) and 49,029 plots (95.2% of the KP-forest plots) were classified as forest in AREA (Tab. 3, sum of plots in CCs 11, 12 and 13).

Of the 50,828 plots that were classified as forest in the NFI, 92.0% or 46,783 plots were also classified as forest in AREA. The difference between the number of plots classified as forest in the NFI and in AREA was to a large degree due to a different classification of CC32 (1415 plots or ca. 35%), CC34 (840 plots or ca. 21%), CC31 (568, 14%), CC61 (346, 9%) and CC51 (275, 7%; Tab. 3). In AREA they typically belonged to either agricultural or urban land uses but were classified as forest in the NFI. These results were similar to the results from 2007. As stated in Thürig 2007, these deviations were likely due to differences in the dates of observation between the land use statistics and the forest inventory.

Of the 51,498 plots that met the KP-forest criteria, 959 belonged to an applicable LCLU type (cf. Tab. 1) and were not already classified as forest in AREA (i.e., CCs 11, 12 and 13). Among the 49,029 plots that belonged to either CC11, CC12 or CC13 in AREA were also 858 plots with land cover 47 'Clusters of trees' on land use 242 'Alpine pastures, in general' that were assigned

to CC13 after the analysis by Thürig (2007); ca. 50% or 433 of these plots met the KP-forest criteria. For completeness, these 433 plots were considered in the estimate of the area required to close the forest-gap, which was thus represented by a total of 1392 plots, i.e. the sum of 959 plots that belonged to an applicable LCLU type but were not in CCs11, 12 and 13 and 433 plots classified as CC13 after the analysis by Thürig (2007). The 1322 plots were distributed unevenly over the two relevant land cover types (203 in LC 46, Tab. 4 and 1189 in LC47, Tab. 5). The selection of the number of plots equivalent to the forest-gap had to be based on a complete LCLU type rather than on individual plots (cf. Methods). Hence, the 1392 plots needed to be matched against the totals for land use types in Tables 4 and 5.

Table 3. Number of plots by AREA combination categories and NFI forest classification: Unforested (*Nicht-Wald*), regular forest (*Normalwald*), shrub-forest (*Gebüschwald*) and no decision possible (*Waldentscheid nicht möglich*).

AREA Combination Category	NFI forest classification				Total
	Unforested	regular forest	shrub-forest	no decision possible	
11	13	23	1	1	38
12	1143	43757	119	317	45336
13	637	1305	1578	135	3655
21	16322	21	0	6	16349
31	36576	497	71	45	37189
32	4490	692	723	102	6007
33	1008	11	0	0	1019
34	2577	805	35	33	3450
35	39	0	0	0	39
36	5714	103	84	79	5980
37	2448	92	20	28	2588
41	6061	74	11	329	6475
42	948	62	1	2	1013
51	7715	272	3	6	7996
52	3258	38	0	3	3299
53	136	18	2	1	157
54	815	64	0	2	881
61	22978	240	106	352	23676
Total	112878	48074	2754	1441	165147

Table 4. Plots classified as land cover type 46 'Linear woods' in AREA stratified by applicable land use type (cf. Tab. 1) including a) the number of plots classified as forest or not-forest after the chosen forest definition by Switzerland for activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol (KP-forest), b) the totals for each land use type, c) the percentage of plots classified as forest after KP of the total number of plots for each land use type and d) the number of plots classified as forest after NFI (regular forest and shrub-forest). Note, plots classified as forest after NFI area a subset of the plots classified as forest after KP.

		Land use type													Total
		221	222	223	241	242	243	401	402	403	421	422	423	424	
A	KP – Forest	2	40	41	2	35	0	0	43	2	38	0	0	0	203
	Not KP-forest	41	264	195	13	125	0	13	235	7	68	0	0	1	962
B	Total – Land use type	**43**	**304**	**236**	**15**	**160**	**0**	**13**	**278**	**9**	**106**	**0**	**0**	**1**	**1165**
C	*Percent (%) KP – Forest*	*5*	*13*	*17*	*13*	*22*	*0*	*0*	*15*	*22*	*36*	*0*	*0*	*0*	*17*
D	NFI – Forest	2	36	35	2	25	0	0	37	2	30	0	0	0	169

Table 5. Plots classified as land cover type 47 'Clusters of trees' in AREA stratified by applicable land use type (cf. Tab. 1) including a) the number of plots classified as forest or not-forest after the chosen forest definition by Switzerland for activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol (KP-forest), b) the totals for each land use type, c) the percentage of plots classified as forest after KP of the total number of plots for each land use type and d) the number of plots classified as forest after NFI (regular forest and shrub-forest). Note, plots classified as forest after NFI area a subset of the plots classified as forest after KP.

		Land use type													Total
		221	222	223	241	242	243	401	402	403	421	422	423	424	
A	KP – Forest	0	56	106	22	433	12	1	5	1	551	2	0	0	1189
	Not KP-forest	7	186	239	28	425	12	1	12	1	270	0	0	1	1182
B	Total – Land use type	**7**	**242**	**345**	**50**	**858**	**24**	**2**	**17**	**2**	**821**	**2**	**0**	**1**	**2371**
C	*Percent (%) KP – Forest*	*0*	*23*	*31*	*44*	*50*	*50*	*50*	*29*	*50*	*67*	*100*	*0*	*0*	*50*
D	NFI – Forest	0	44	90	21	350	9	1	5	1	495	2	0	0	1018

Implications

To fill the forest-gap of 1392 plots (203 plus 1189 KP forest plots in Tabs. 4 and 5), an equivalent number was selected from the total number of plots in applicable land use and land cover types (Tabs. 4 and 5). For this selection it was reasoned that it is preferable to select land use types with higher proportions of plots classified as KP-forest (cf. Tabs. 4 and 5). The preference for land use types with higher proportions of plots classified as KP-forest was based on the objective to minimize the number of plots that were re-classified to forest but did not meet the KP-forest criteria. This is desirable because on forest lands parameters such as increment and growing stock need to be estimated, which is only possible for plots with relevant information.

Since it cannot be expected that the AREA forest definition will be revised to meet the KP-forest criteria, a re-analysis of the forest-gap will be required after the completion of the Swiss land use statistic 2013/2018. In order to minimize the need for major re-classifications, those land use types from the applicable types were preferred that had experienced the smallest change between the surveys 1979/1985, 1992/1997 and 2004/2009. Following this reasoning, the optimal solution would to re-classify land use types 222 'Semi-natural grassland, in general', 223 'Farm pastures, in general' and 421 'Unused' with land cover type 47 'Clusters of trees' from CC34 to CC13. This would result in the best agreement between the number of re-classified plots and the number of plots needed to fill the forest gap:

Forest gap:	**1392**
LC47/LU222:	242
LC47/LU223:	345
LC47/LU421:	821
Total:	**1408**
Difference	16

This approach would require reversing the decision from 2007 to re-classify land use type 242 with land cover type 47. In order to maintain consistency and transparency of combination categories, this may not be desirable.

> Thus, it is **recommended** to re-classify land use types 222 and 223 with land cover 47 from CC34 to CC13 and to maintain the status quo for land use type 242 with land cover type 47 (i.e., CC13).

It is assumed that the gain in transparency that the recommended approach provides offsets a) the slightly higher difference between the number of plots needed to fill the forest-gap and the

number of reclassified plots, i.e., 53 instead of 16 and b) the smaller proportion of plots that do not meet the definition for KP-forest (i.e.,50% for LU242 and 67% for LU421, Tab. 5):

Forest gap:	**1392**
LC47/LU222:	242
LC47/LU223:	345
LC47/LU242:	858
Total:	**1445**
Difference	53

So far in AREA no records are kept on quantitative information on forest conditions on a plot, including width and crown closure. Hence, alternative approaches to fill the forest gap are only possible in combination with NFI data. In order to be able to identify the forest area that is conform to KP requirements from AREA data alone, it would be necessary that records of forest width and crown closure are kept alongside the categorical information on whether or not a plot is forested.

References

FOEN. 2007. Switzerland's Initial Report under Article 7, paragraph 4 of the Kyoto Protocol. Update following the UNFCCC review. From Federal Office for the Environment (FOEN), Bern.

IPCC. 2003. Good Practice Guidance for Land Use, Land-Use Change and Forestry IPCC/IGES [Penman, J., Gytarsky, M., Hiraishi, T., Krug, T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. and Wagner, F. eds.)]. Intergovernmental Panel on Climate Change (IPCC), Hayama, Japan.

Thürig, E. 2007. Anpassung der CH Daten an die Vorgaben der Walddefinition vom KP. Internal Report #G223-0767. Federal Office for the Environment, Bern.

Appendix I: Combination Matrix

Tab A-1. Combination matrix: combination categories (CC, codes description on the matrix bottom) are assigned to each possible combination of the 46 AREA land-use categories (LU, description in the upper row) and 27 AREA land-cover categories (LC, description in the left column). From Federal Office for the Environment (FOEN) 2007. Definition der Kombinationskategorien (CC) für die LULUCF-Berichterstattung auf derBasis der AREA-Landnutzungs- und Landbedeckungskategorien. Internes Dokument, Version 2 vom 30.05.2007. [Definition of combination categories (CC) for LULUCF reporting based on AREA land-use/land-cover categories. Internal document, version 2 as of 30.05.2007.] Federal Office for the Environment, Bern.