

GOZDARSKI INŠTITUT SLOVENIJE
SLOVENIAN FORESTRY INSTITUTE

SLOVENIA'S LAND USE CHANGE MATRIX

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JRC Technical workshop on reporting LULUCF
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GOZDARSKI INŠTITUT SLOVENIJE
SLOVENIAN FORESTRY INSTITUTE

SLOVENIA



20,273 km²

2,027,300 ha



AVAILABLE DATA

- **Cadaster** (national, land use, but not up to date)
- **CORINE land cover** (EEA, land cover, coarse resolution, last in 2006)
- **StatGIS** (National Statistical office, Landsat images, land cover, coarse resolution, last in 2005)
- **Survey of SFI for 1986 – 2005** (national, sampling, ortophoto images, land use, aggregated categories)
- **Agricultural land use map (ALUM)** (national, Ministry of agriculture and environment, whole county, vector data, ortophoto images, field visits, land use, continuously from 2002)



AGRICULTURAL LAND USE MAP

- Ministry of Agriculture and Environment
- Actual land use
- Continuously from 2002 ->
- Ortophoto images, other national data, field visits
- Publicly available
- <http://rkg.gov.si/GERK/WebViewer/>



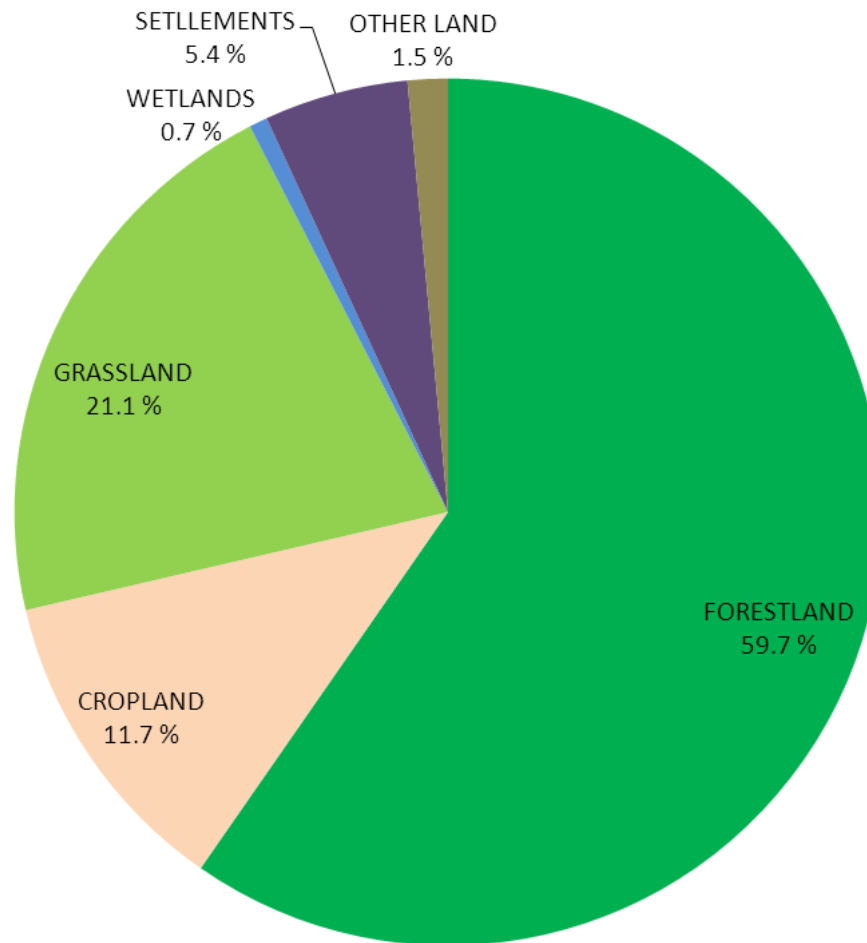
ALUM CATEGORIES

National class ID	Category description
1100	Arable land
1130	Temporary meadows
1160	Hop fields
1180	Other permanent crops on arable land
1190	Green houses
1211	Vineyards
1212	Nursery
1221	Intensive orchards
1222	Extensive orchards
1230	Olive groves
1240	Other permanent crops
1300	Meadows and pastures
1321	Swampy meadows and pastures
1330	Alpine meadows
1410	Overgrown areas
1420	Forest plantation
1500	Mixed land use (arable land and forest, small areas)
1600	Uncultivated agriculture land
1800	Forest trees on agricultural land
2000	Forest
3000	Built-up areas and related surfaces
4100	Swamps
4210	Reeds
4220	Other marshy areas
5000	Dried open areas with special vegetation
6000	Open areas with little or no vegetation
7000	Waters (inland water bodies)

LULUCF category	LULUCF sub-category	National class ID	Category description
FOREST LAND	FL	2000	Forest
CROPLAND	CL_a	1100	Arable land
	CL_a	1130	Temporary meadows
	CL_a	1160	Hop fields
	CL_a	1190	Green houses
	CL_w	1180	Other permanent crops on arable land
	CL_w	1211	Vineyards
	CL_w	1212	Nursery
	CL_w	1221	Intensive orchards
	CL_w	1222	Extensive orchards
	CL_w	1230	Olive groves
	CL_w	1240	Other permanent crops
	CL_w	1420	Forest plantation
GRASSLAND	GL_a	1300	Meadows and pastures
	GL_a	1321	Swampy meadows and pastures
	GL_a	1330	Alpine meadows
	GL_a	1600	Uncultivated agriculture land
	GL_w	1410	Overgrown areas
	GL_w	1500	Mixed land use (arable land and forest, small areas)
	GL_w	1800	Forest trees on agricultural land
WETLANDS	WL	4100	Swamps
	WL	4210	Reeds
	WL	4220	Other marshy areas
	WL	7000	Waters (inland water bodies)
SETTLEMENTS	SL	3000	Built-up areas and related surfaces
OTHER LAND	OL	5000	Dried open areas with special vegetation
	OL	6000	Open areas with little or no vegetation



LAND USE DISTRIBUTION



ALUM, 2012



LAND USE CHANGE MATRIX

- ALUM (Agricultural land use map)
- Vector data (.shp format) is available for years
2002, 2005, 2009 and 2012
- Accuracy assessment was done for ALUM 2002
- Not for newer editions (€)
- We took the vector data for 2002 and 2012
- Vector to raster
- Reclassification
- Cross-tabulation



VECTOR TO RASTER

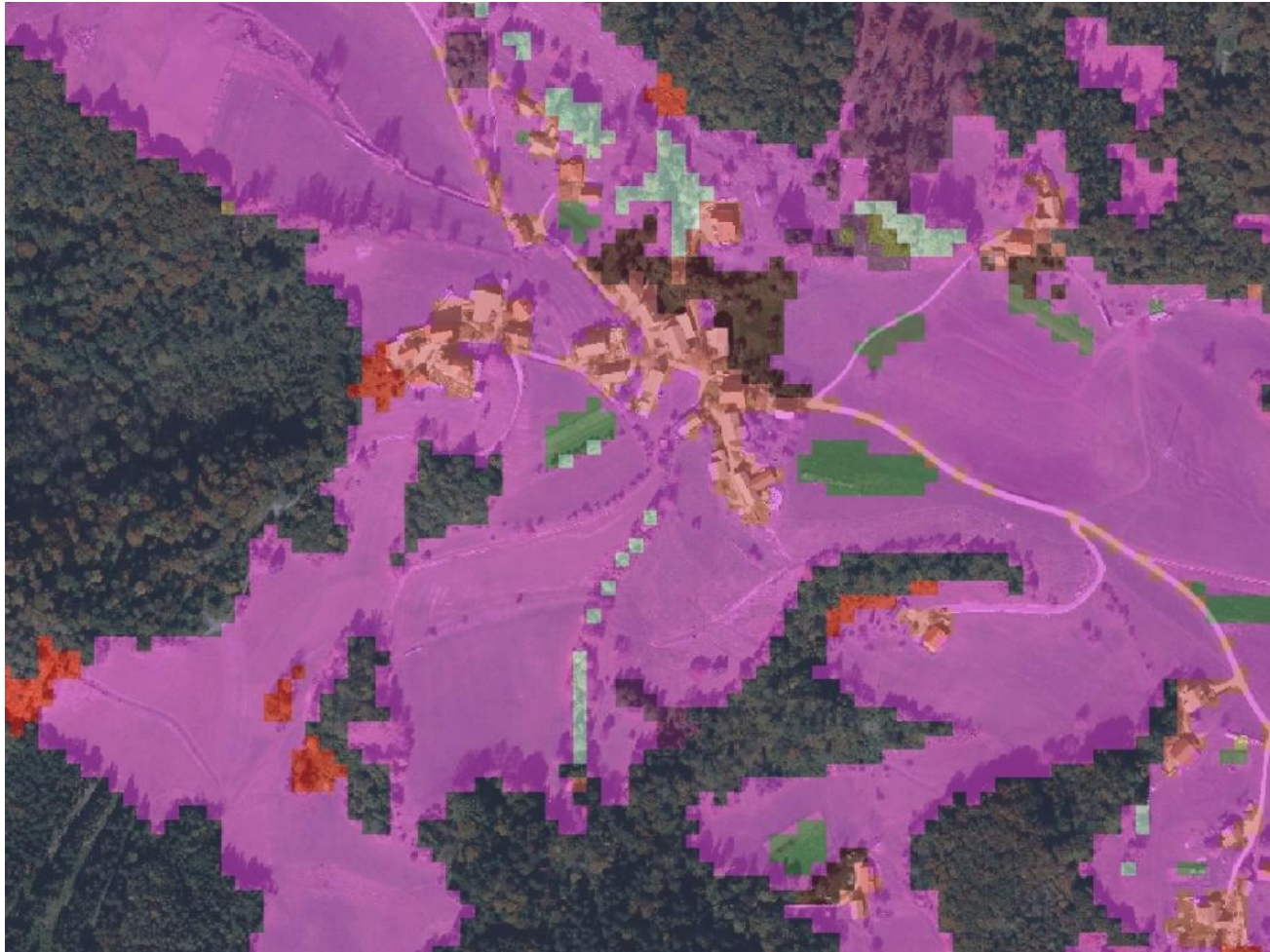
- We transformed vector data (.shp) to raster data (.adf)
- In ArcMap (ArcInfo, ESRI)
- ArcToolbox > Conversion tools >
To Raster > Polygon to Raster
- Pixel size: 10 x 10 m



VECTOR ...



... TO RASTER



RECLASSIFICATION

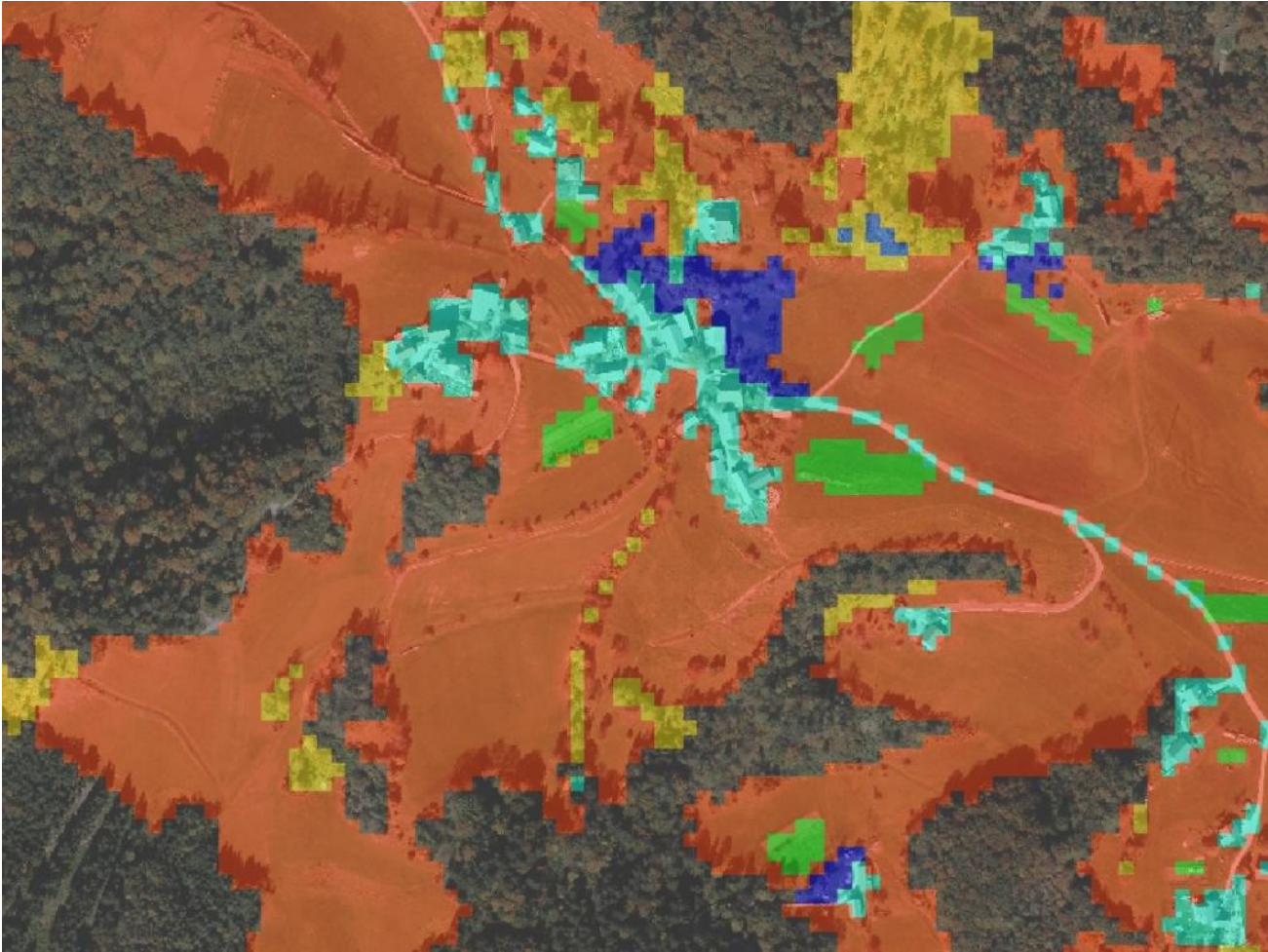
- ArcToolbox > Spatial Analyst Tools >
Reclass > Reclassify
- 27 national classes to 6 main LULUCF categories
- We divided CROPLAND further to
 - cropland annual
 - cropland woodyand GRASSLAND to
 - grassland annual
 - grassland woody
- We established 8 LULUCF (sub)categories



LULUCF category	LULUCF sub-category	National class ID	Category description
FOREST LAND	FL	2000	Forest
CROPLAND	CL_a	1100	Arable land
	CL_a	1130	Temporary meadows
	CL_a	1160	Hop fields
	CL_a	1190	Green houses
	CL_w	1180	Other permanent crops on arable land
	CL_w	1211	Vineyards
	CL_w	1212	Nursery
	CL_w	1221	Intensive orchards
	CL_w	1222	Extensive orchards
	CL_w	1230	Olive groves
	CL_w	1240	Other permanent crops
	CL_w	1420	Forest plantation
GRASSLAND	GL_a	1300	Meadows and pastures
	GL_a	1321	Swampy meadows and pastures
	GL_a	1330	Alpine meadows
	GL_a	1600	Uncultivated agriculture land
	GL_w	1410	Overgrown areas
	GL_w	1500	Mixed land use (arable land and forest, small areas)
	GL_w	1800	Forest trees on agricultural land
WETLANDS	WL	4100	Swamps
	WL	4210	Reeds
	WL	4220	Other marshy areas
	WL	7000	Waters (inland water bodies)
SETTLEMENTS	SL	3000	Built-up areas and related surfaces
OTHER LAND	OL	5000	Dried open areas with special vegetation
	OL	6000	Open areas with little or no vegetation



RECLASSIFICATION



CROSS TABULATION

- ArcToolbox > Spatial Analyst Tools >

Zonal > Tabulate Area

- matrix

		to								
	2002-2012	FL	CL_a	CL_w	GL_a	GL_w	WL	SL	OL	total [ha]
from	FL									
	CL_a									
	CL_w									
	GL_a									
	GL_w									
	WL									
	SL									
	OL									
	total [ha]									



LAND USE CHANGE MATRIX 2002-2012

		to								
	2002-2012	FL	CL_a	CL_w	GL_a	GL_w	WL	SL	OL	total [ha]
from	FL		714	1550	17852	9424	578	5841	2152	38111
	CL_a	1286		2899	46268	2587	229	4238	1	57508
	CL_w	1317	1915		11431	1791	23	2080	0	18558
	GL_a	19296	21891	8825		22426	750	7930	101	81219
	GL_w	18857	574	1217	8900		607	1451	241	31847
	WL	545	143	12	2167	834		719	192	4613
	SL	2470	1122	5160	14295	1399	217		46	24708
	OL	2792	6	9	5966	1495	118	107		10493
	total [ha]	46563	26365	19673	106878	39956	2523	22368	2732	267057 ha in 10 years

Land use change matrix in period
2002 – 2012, [ha], whole country, ALUM

13.2 % of the
country area

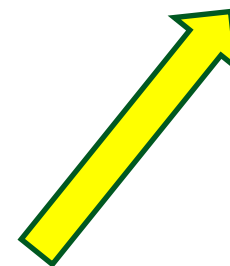


LAND USE CHANGE MATRIX 2002-2012

		to								
	2002-2012	FL	CL_a	CL_w	GL_a	GL_w	WL	SL	OL	total [ha]
from	FL		71	155	1785	942	58	584	215	3811
	CL_a	129		290	4627	259	23	424	0	5751
	CL_w	132	192		1143	179	2	208	0	1856
	GL_a	1930	2189	883		2243	75	793	10	8122
	GL_w	1886	57	122	890		61	145	24	3185
	WL	55	14	1	217	83		72	19	461
	SL	247	112	516	1429	140	22		5	2471
	OL	279	1	1	597	149	12	11		1049
	total [ha]	4656	2636	1967	10688	3996	252	2237	273	26706 ha / year

Average annual changes, [ha/year],
2002-2012, whole country, ALUM

1.3 % of the
country area



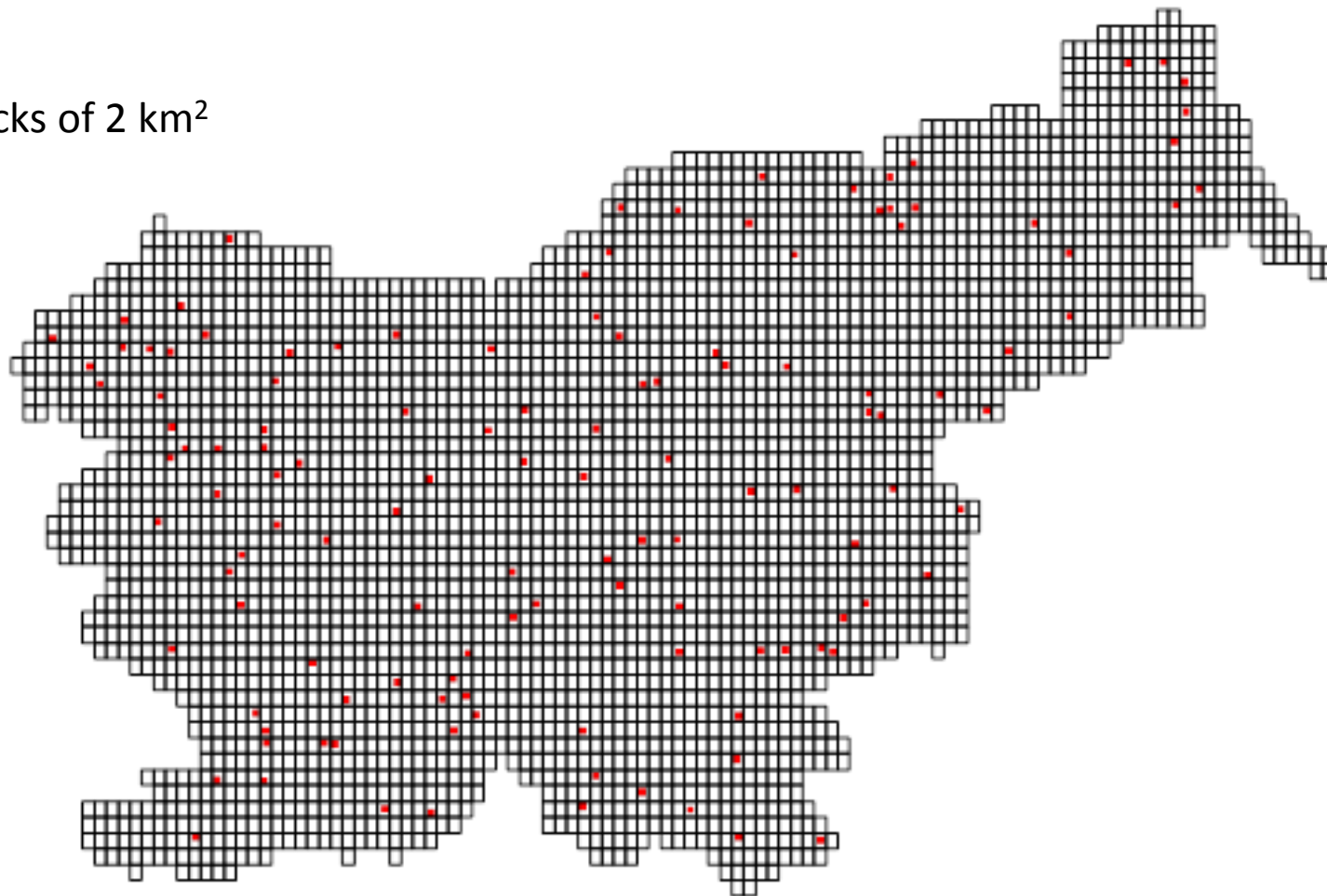
BEFORE 2002 ?

- Survey done at Slovenian Forestry Institute in 2006,
published in 2008 (Kobler et al.)
- „Downdating“ to 1995 and 1986
- 1986 is the base year for Slovenia
- They took the newest available ALUM data (.shp) at that time (2005)
- Then compared ortophoto images from that time
(1986 and 1995) and marked changed polygons
- Survey was done on a sample of randomly chosen
128 blocks of 200 ha
- 25,600 ha = 1.3 % of country area



BEFORE 2002 ?

128 blocks of 2 km²



BEFORE 2002 ?

- Agregated categories – reasons:

- difficulties distinguishing cropland and grassland on old ortophoto images,
- not able to check in field the actual land use,
- budget limitations,
- focusing more on FL (more important in emissions/removals contribution) and less on not-so-important land uses in terms of biomass present (SL, WL, OL)

forest land	FL
agricultural land	CL_a + CL_w + GL_a
abandoned agricultural land	GL_w
land without vegetation	WL + SL + OL



1986 - 1995

SAMPLE		forest land	agricultural land	abandoned agricultural land	land without vegetation	total
	1986-1995	FL	CL_a + CL_w + GL_a	GL_w	WL + SL + OL	[ha]
forest land	FL	15286	31	10	17	15345
agricultural land	CL_a + CL_w + GL_a	26	7302	210	32	7570
abandoned agricultural land	GL_w	458	12	476	1	946
land without vegetation	WL + SL + OL	1	3	13	1706	1723
total	[ha]	15771	7347	708	1756	25583



1986 - 1995

	SAMPLE		forest land	agricultural land	abandoned agricultural land	land without vegetation	total
		1986-1995	FL	CL_a + CL_w + GL_a	GL_w	WL + SL + OL	[%]
from	forest land	FL	59,75	0,12	0,04	0,07	59,98
	agricultural land	CL_a + CL_w + GL_a	0,10	28,54	0,82	0,12	29,59
	abandoned agricultural land	GL_w	1,79	0,05	1,86	0,00	3,70
	land without vegetation	WL + SL + OL	0,00	0,01	0,05	6,67	6,73
	total	[%]	61,65	28,72	2,77	6,86	100,00

SAMPLE		forest land	agricultural land	abandoned agricultural land	land without vegetation	total
	1986-1995	FL	CL_a + CL_w + GL_a	GL_w	WL + SL + OL	[ha/year]
forest land	FL		3	1	2	6
agricultural land	CL_a + CL_w + GL_a	3		23	4	30
abandoned agricultural land	GL_w	51	1		0	52
land without vegetation	WL + SL + OL	0	0	1		2
total	[ha/year]	54	5	26	6	90



1986 - 1995

		to				
SAMPLE		forest land	agricultural land	abandoned agricultural land	land without vegetation	total
1986-1995		FL	CL_a + CL_w + GL_a	GL_w	WL + SL + OL	[%]
from	FL		0,01	0,00	0,01	0,03
	CL_a + CL_w + GL_a	0,01		0,09	0,01	0,12
	GL_w	0,20	0,01		0,00	0,20
	WL + SL + OL	0,00	0,00	0,01		0,01
total [%]		0,21	0,02	0,10	0,02	0,35

Average of 0.4 % of sampling area changed in a year



1995 - 2002

1995-2002	FL	CL_a	CL_w	GL_a	GL_w	WL	SL	OL	total [ha]
FL	15430	8	6	112	163	2	12	39	15771
CL_a + CL_w + GL_a	98	2085	574	4283	192	11	96	8	7347
GL_w	299	4	9	152	181	3	1	61	708
WL + SL + OL	29	12	17	25	11	99	903	658	1756
total [ha]	15856	2109	606	4572	547	114	1013	766	25583

1995-2002	FL	CL_a	CL_w	GL_a	GL_w	WL	SL	OL	total [ha/year]
FL	2204	1	1	16	23	0	2	6	2253
CL_a + CL_w + GL_a	14	298	82	612	27	2	14	1	1050
GL_w	43	1	1	22	26	0	0	9	101
WL + SL + OL	4	2	2	4	2	14	129	94	251
total [ha/year]	2265	301	87	653	78	16	145	109	3655



1995 - 2002

1995-2002	FL	CL_a	CL_w	GL_a	GL_w	WL	SL	OL	total [ha/year]
FL	60,3	0,0	0,0	0,4	0,6	0,0	0,0	0,2	61,6
CL_a + CL_w + GL_a	0,4	8,1	2,2	16,7	0,7	0,0	0,4	0,0	28,7
GL_w	1,2	0,0	0,0	0,6	0,7	0,0	0,0	0,2	2,8
WL + SL + OL	0,1	0,0	0,1	0,1	0,0	0,4	3,5	2,6	6,9
total [ha/year]	62,0	8,2	2,4	17,9	2,1	0,4	4,0	3,0	100,0

1995-2002	FL	CL_a	CL_w	GL_a	GL_w	WL	SL	OL	total [%]
FL		0,0	0,0	0,1	0,1	0,0	0,0	0,0	0,2
CL_a + CL_w + GL_a	0,1				0,1	0,0	0,1	0,0	0,2
GL_w	0,2	0,0	0,0	0,1		0,0	0,0	0,0	0,3
WL + SL + OL	0,0	0,0	0,0	0,0	0,0				0,1
total [%]	0,2	0,0	0,0	0,2	0,2	0,0	0,1	0,1	0,8

Average of 0.8 % of sampling area changed in a year



1986-2012

		1986	1995
aggregated categories		[%]	[%]
forest land	FL	58,61	59,99
agricultural land	CL_a + CL_w + GL_a	32,00	30,96
abandoned agricultural land	GL_w	2,04	1,56
land without vegetation	WL + SL + OL	7,35	7,49
	total	100,00	100,00

Survey SFI, 2008, Kobler et al.



1986-2012

- With auxiliary data (Statistical Office of RS)
- We were able to calculate distribution (%) of all land uses for 1986, 1995, 2002 and 2012

	[%]			
LULUCF category	1986	1995	2002	2012
FL	58,6	60,0	59,3	59,7
CL_a	8,0	8,3	10,7	9,1
CL_w	2,2	2,2	2,6	2,6
GL_a	21,8	20,4	17,3	18,4
GL_w	2,0	1,6	2,2	2,7
WL	0,8	0,8	0,8	0,7
SL	5,1	5,2	5,3	5,4
OL	1,5	1,5	1,9	1,5
total [%]	100,0	100,0	100,0	100,0

 Netto changes



DEFORESTATION

		to								
	2002-2012	FL	CL_a	CL_w	GL_a	GL_w	WL	SL	OL	total [ha]
	FL		714	1550	17852	9424	578	5841	2152	38111
from	CL_a	1286		2899	46268	2587	229	4238	1	57508
	CL_w	1317	1915		11431	1791	23	2080	0	18558
	GL_a	19296	21891	8825		22426	750	7930	101	81219
	GL_w	18857	574	1217	8900		607	1451	241	31847
	WL	545	143	12	2167	834		719	192	4613
	SL	2470	1122	5160	14295	1399	217		46	24708
	OL	2792	6	9	5966	1495	118	107		10493
	total [ha]	46563	26365	19673	106878	39956	2523	22368	2732	267057

38 kha in 10 years ?!? (1.9 % of country area, 3.2 % of Slovenian forests)



DEFORESTATION

- Land use change matrix from ALUM in time period 2002 – 2012 (38,111 ha, 1.9 % of the country area), average 3,811 ha per year
- For every change of forest to any land use, the owner must get a permit from Slovenia Forest Service
- Official data from Slovenia Forest Service in time period 2002 – 2011 (4,418 ha, 0.2 % of country area), average 491 ha per year
- The difference is almost 10x !



DEFORESTATION

- We took vector data on forest (category 2000 in ALUM)
- Polygons – where forest was in 2002, but isn't in 2012 (app. 38 kha)
- By legislation, difference of 15 m between ALUM and management plans is allowed
- Buffer of 15 m was eliminated (remaining deforestation area was 12kha, 0.6 % of country area)



DEFORESTATION

- On remaining area, app. 1200 polygons was checked on ortophoto images for both years
- 50 polygons per category, 100 polygons in larger categories
- After visual check of real changes of forest on ortophoto images, the assessment of actual deforestation was 5,491 ha (0.3 % of country area), average 549 ha per year
 - Comparison: official data – average 491 ha
LUC matrix – average 3,811 ha

CONCLUSION

- We have all this data available...
- How to implement it in CRF and NIR?
- if we use LUC matrix 2002-2012 for whole time period – we come to some absurd situations / numbers (i.e. GL_woody area, deforestation – emissions of 1,600 GgCO₂ etc.)
- If and how to report emissions/removals by aggregated categories?



Thank you for your attention!

