

Forest Research and Management Institute Romania



Legal and Illegal Forest Clear Cutting Detection Using Landsat Imagery. A Case Study in Romania



Dr.ing. Vladimir Gancz

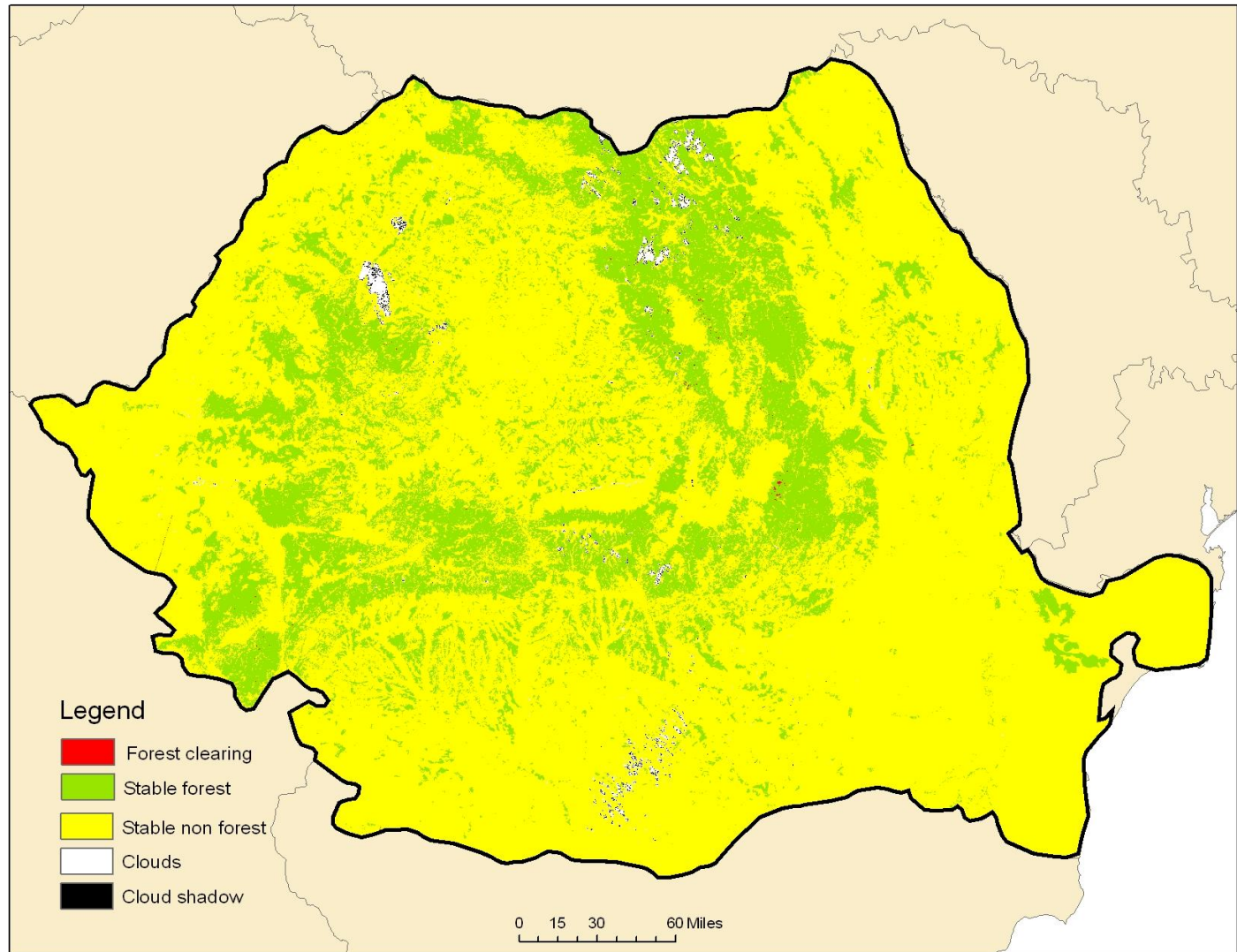
1990-2000



**Boston
University,
Department of
Geography**
Directed by Prof.
Curtis Woodcock

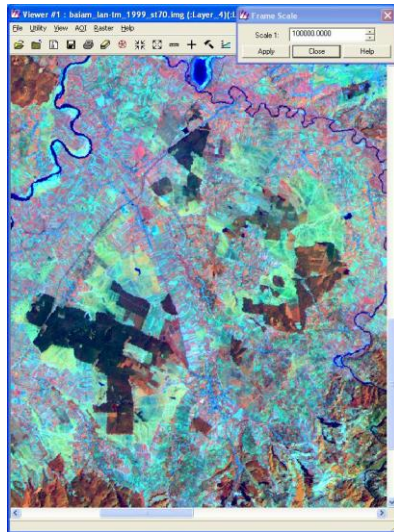


Financed by NASA

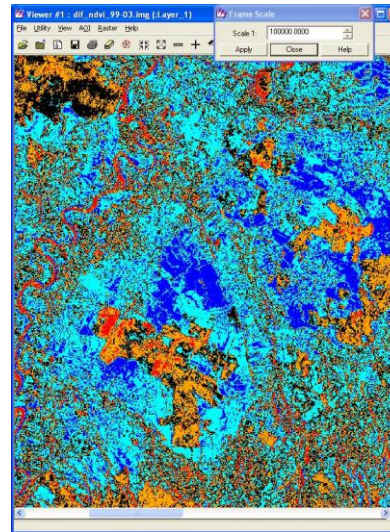


2.4 percent of what was forest in 1990 changed to non forest. (No evidence of land use change from forest to other uses.)

After 2000 we see continuous increasing of clear cutting areas, many times on large areas

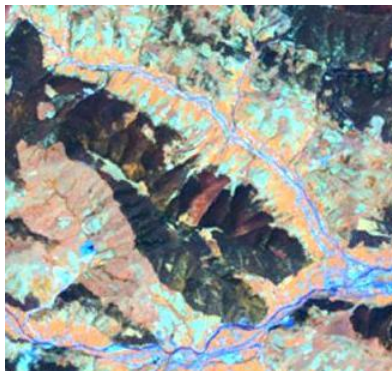


1999

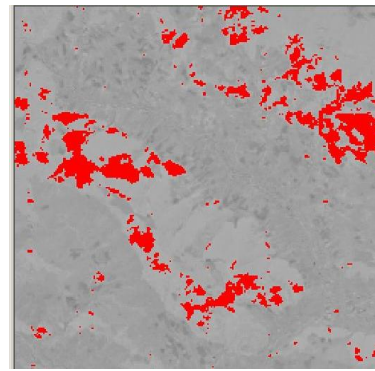


2003

Maramures county (N of Roamnia)

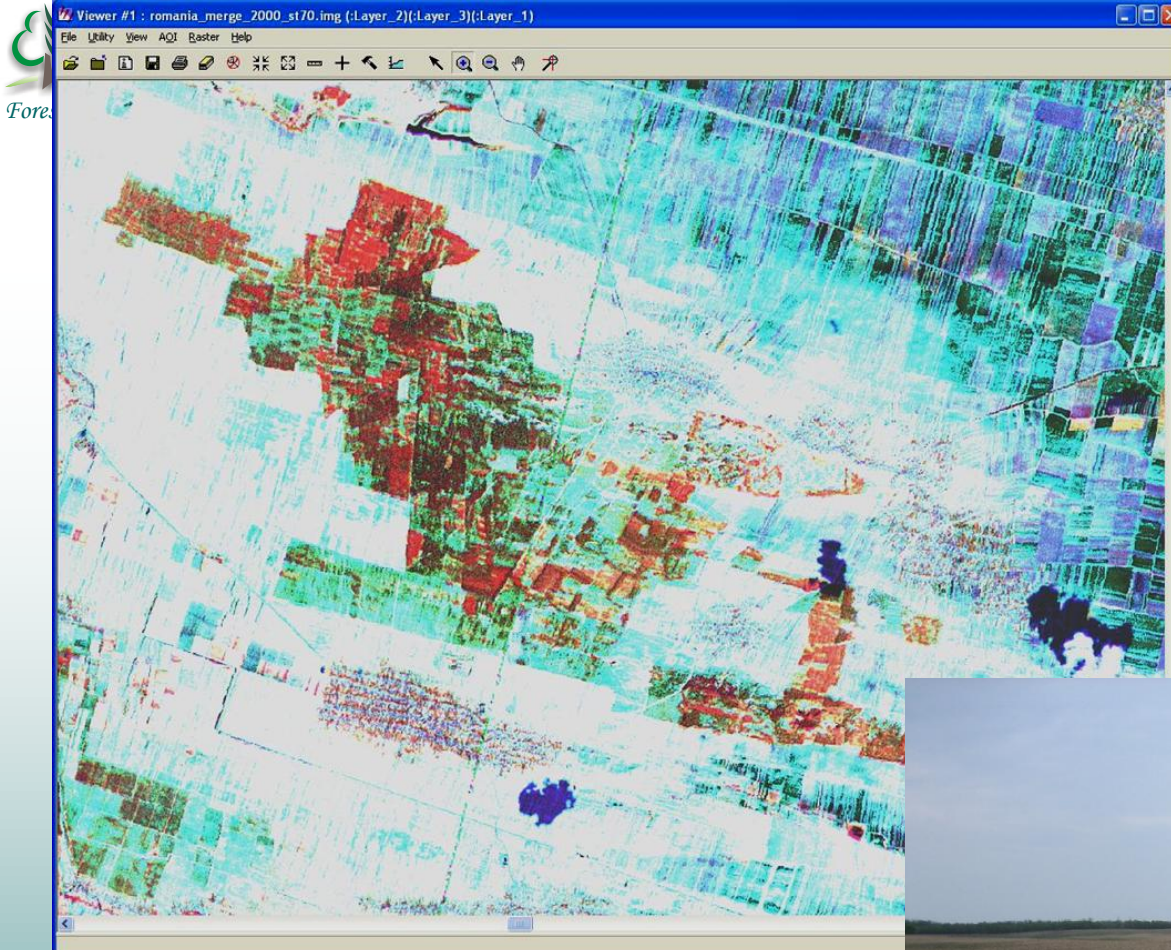


2001



2002

Suceava county (NE of Romania)



Soil protection forest (sandy area)

Dolj county (SW of Romania)





Chaotic urban development
put pressure on forest cover

New changes
North of Bucharest city

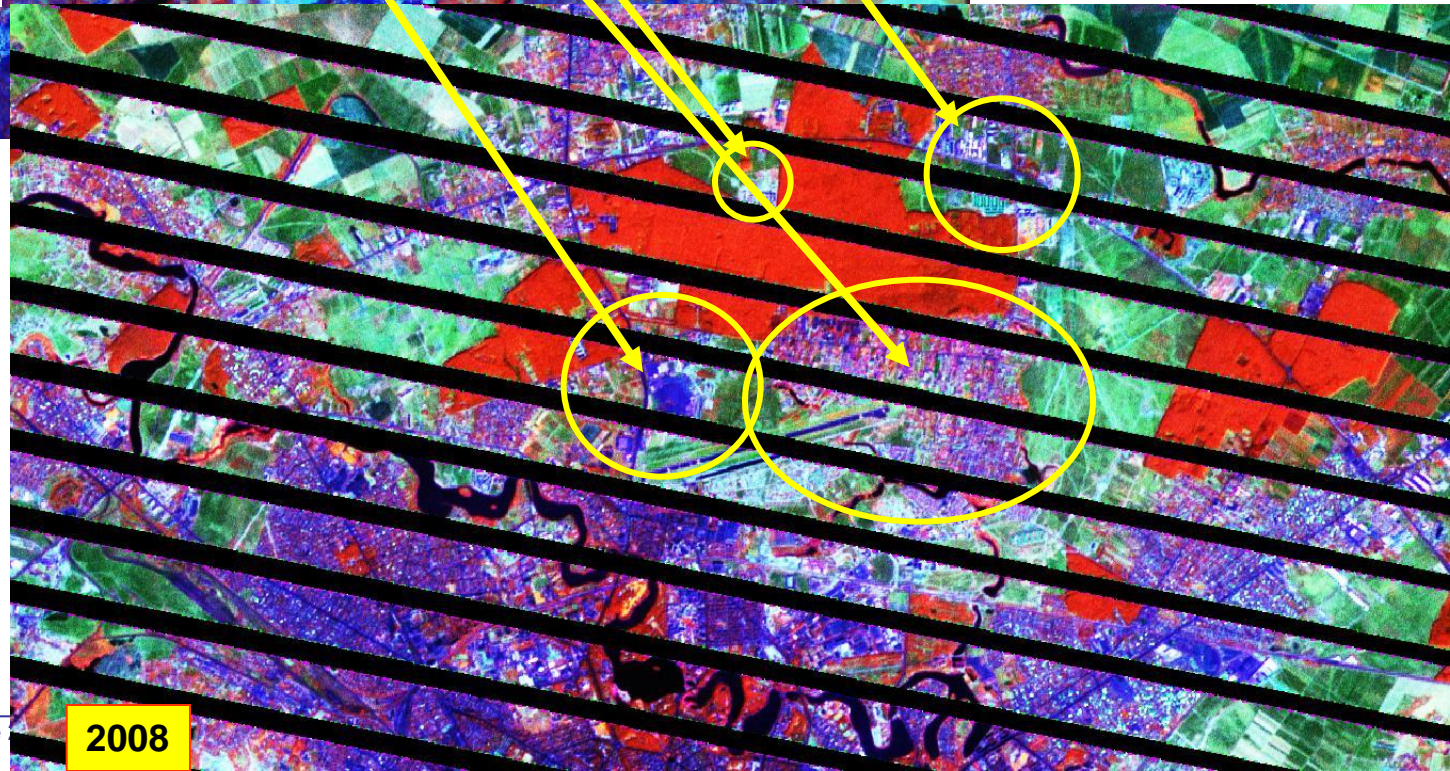
Bucharest

Baneasa Forest

Airport

1988

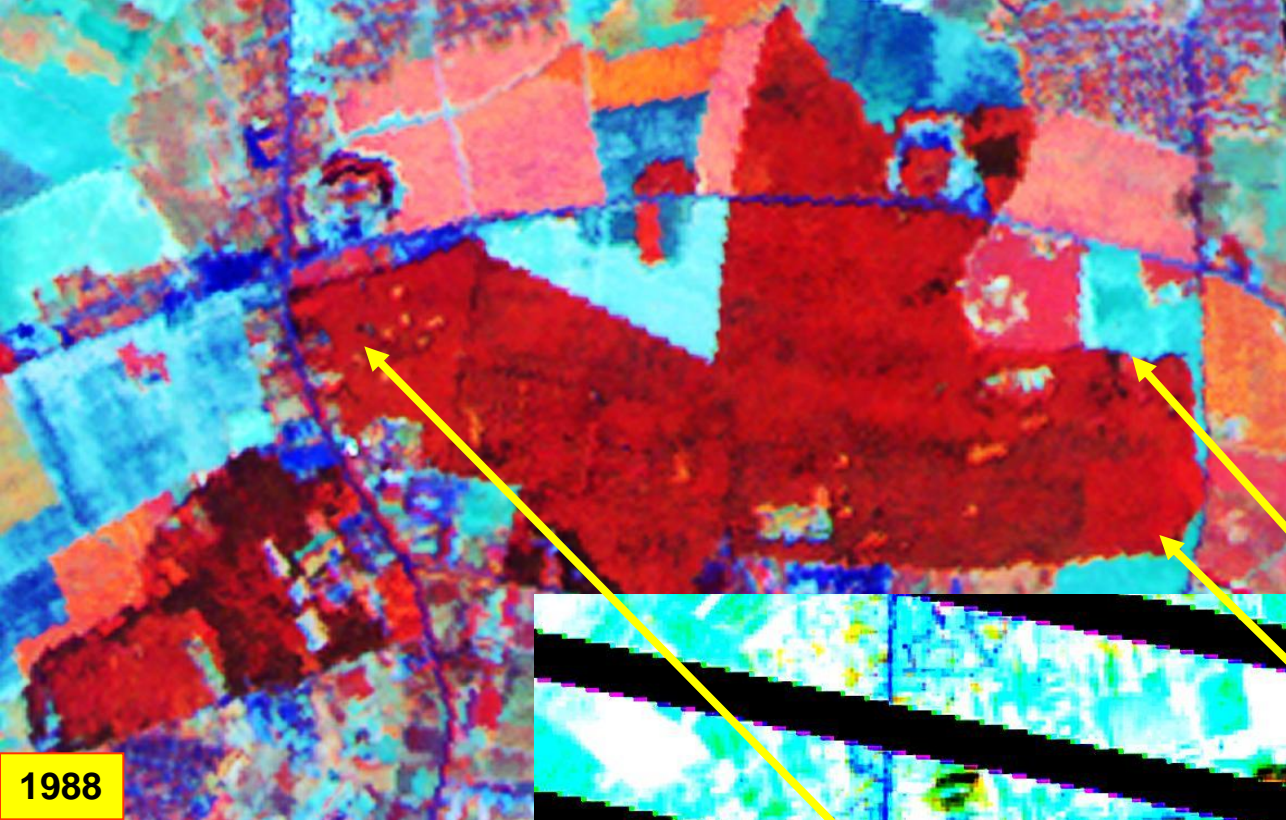
Ilfov County



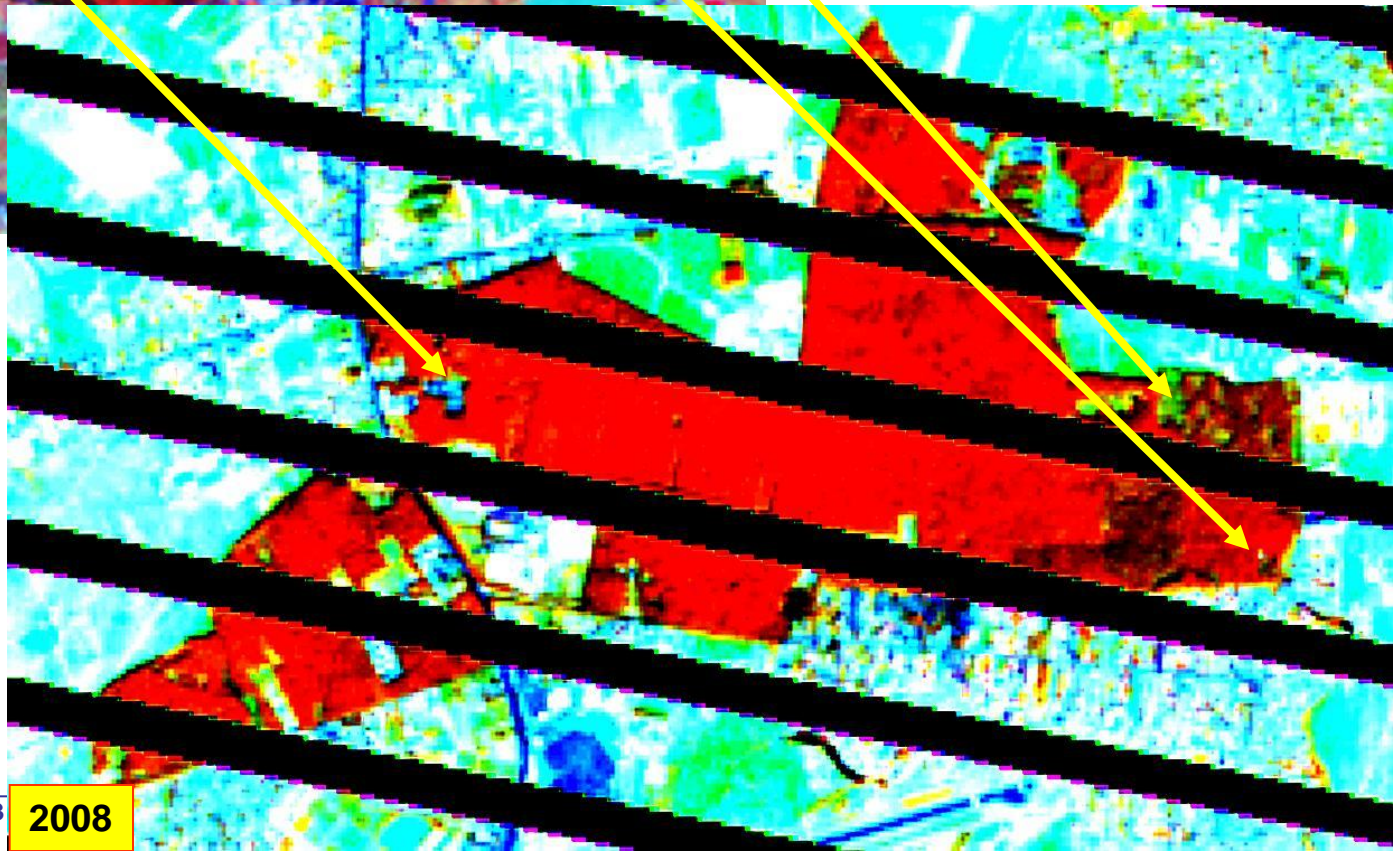
SCERIN-1 Meeting, 17-19 June

2008

Baneasa forest,
N of Bucharest City

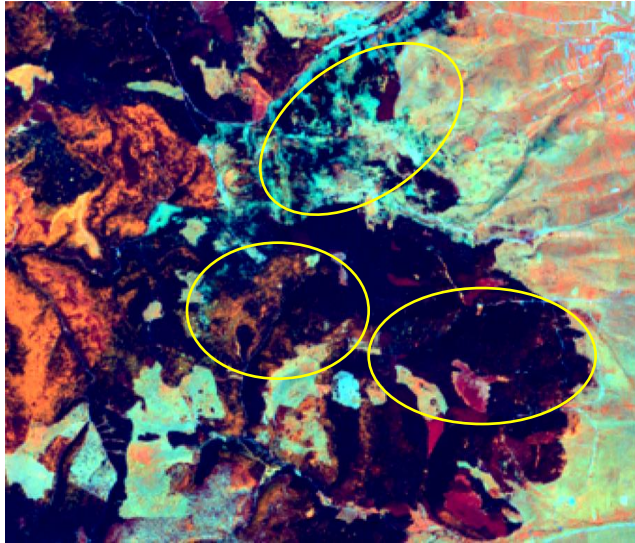


1988

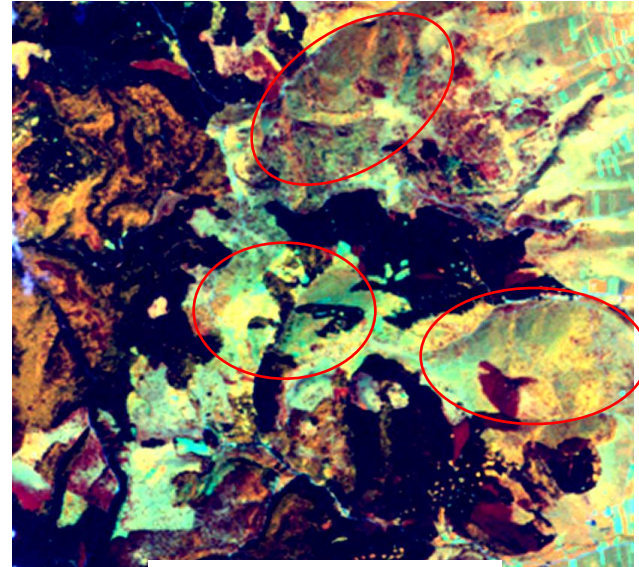


Illegal cuttings of the forest
to make room for buildings

2008



2000



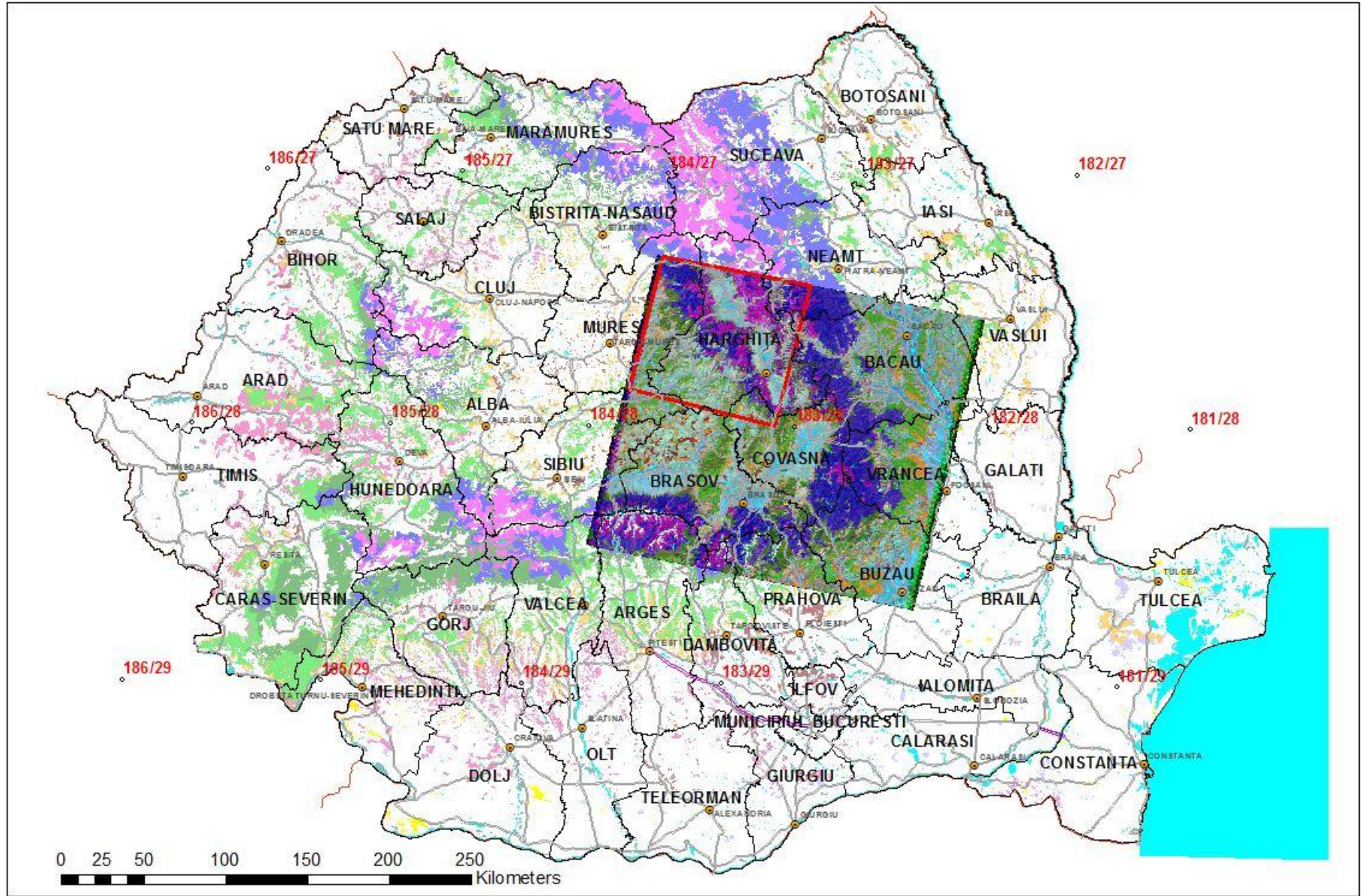
2010

Harghita county

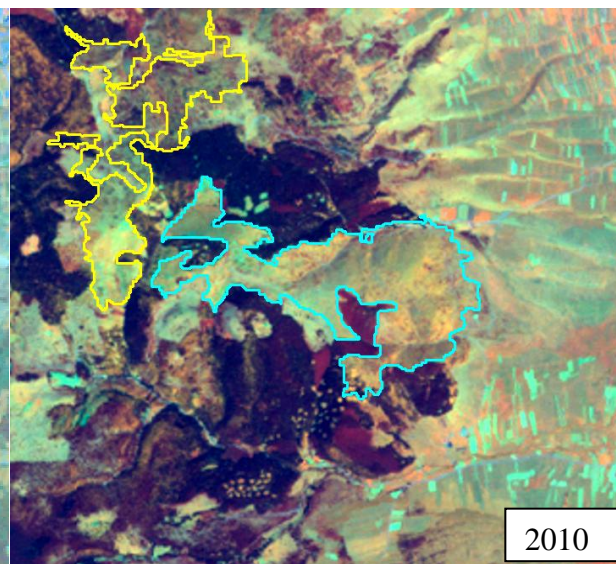
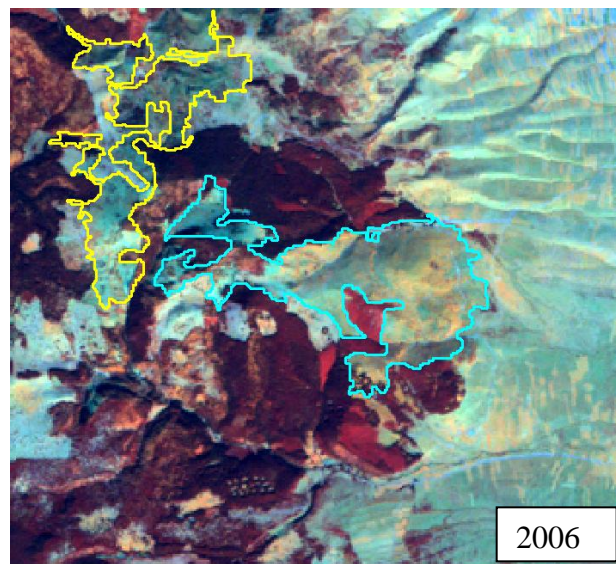
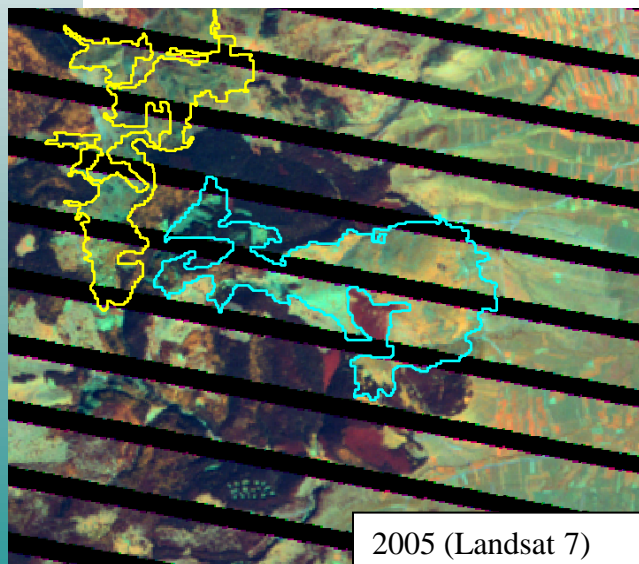
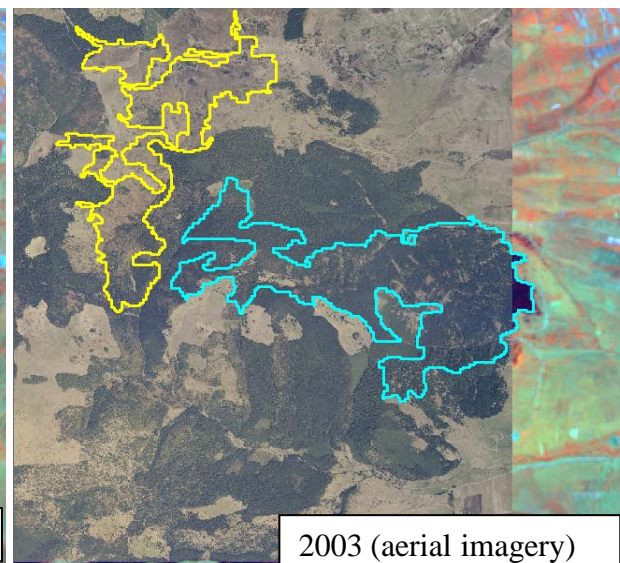
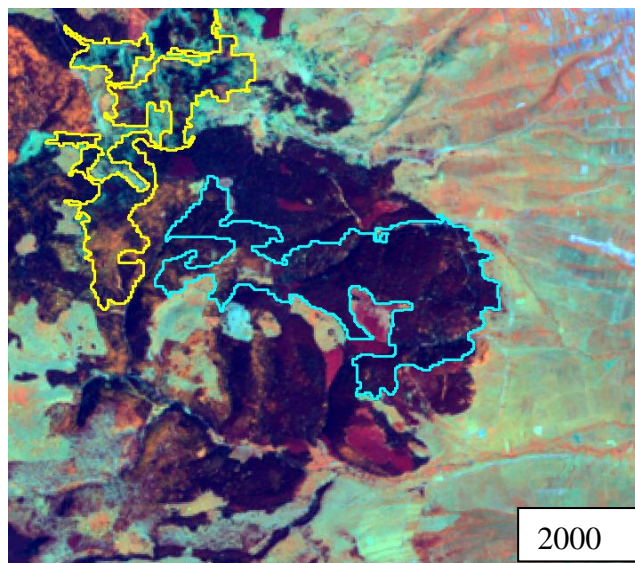
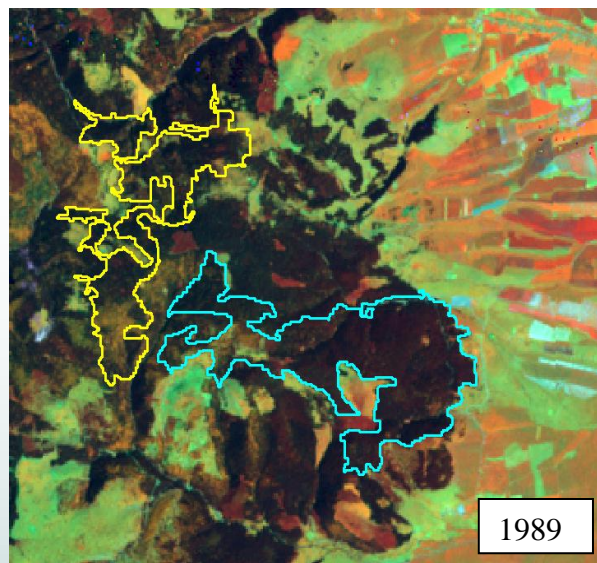
This case we have been studying more carefully

Test area: Almost a quarter of 183/28 frame, over Harghita judet (county)

(~ 835,000 ha from which ~325,000 ha forest)



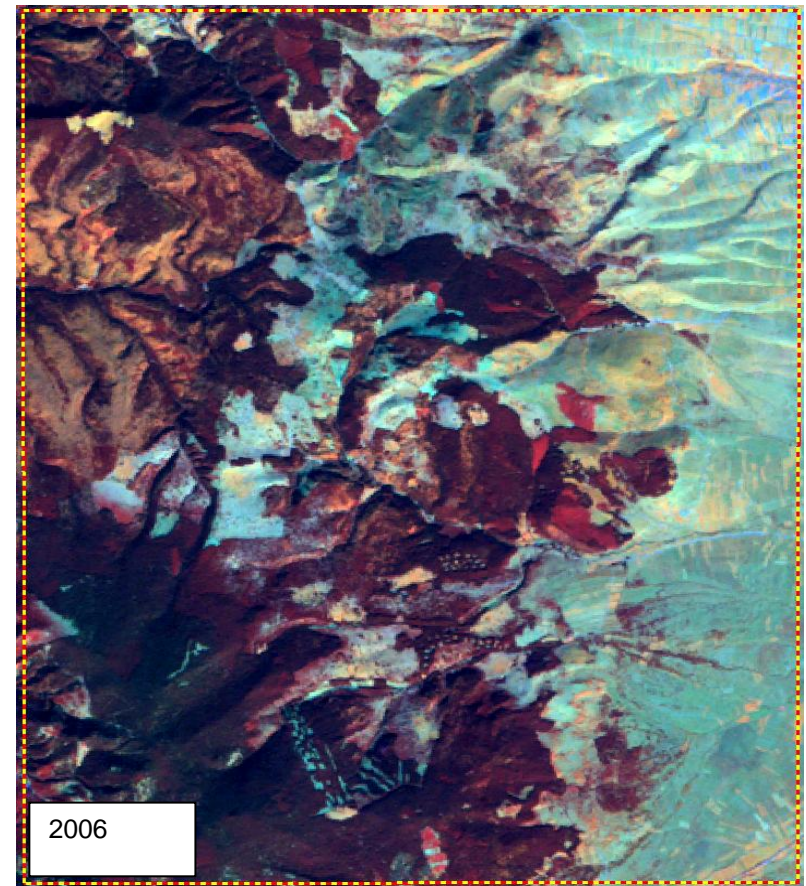
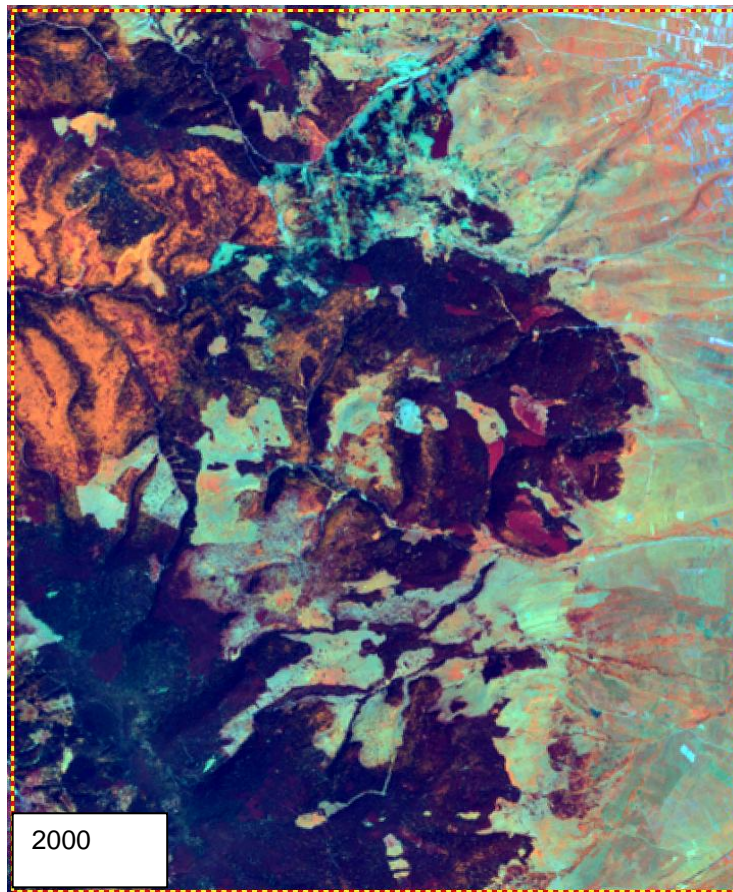
Investigating the history

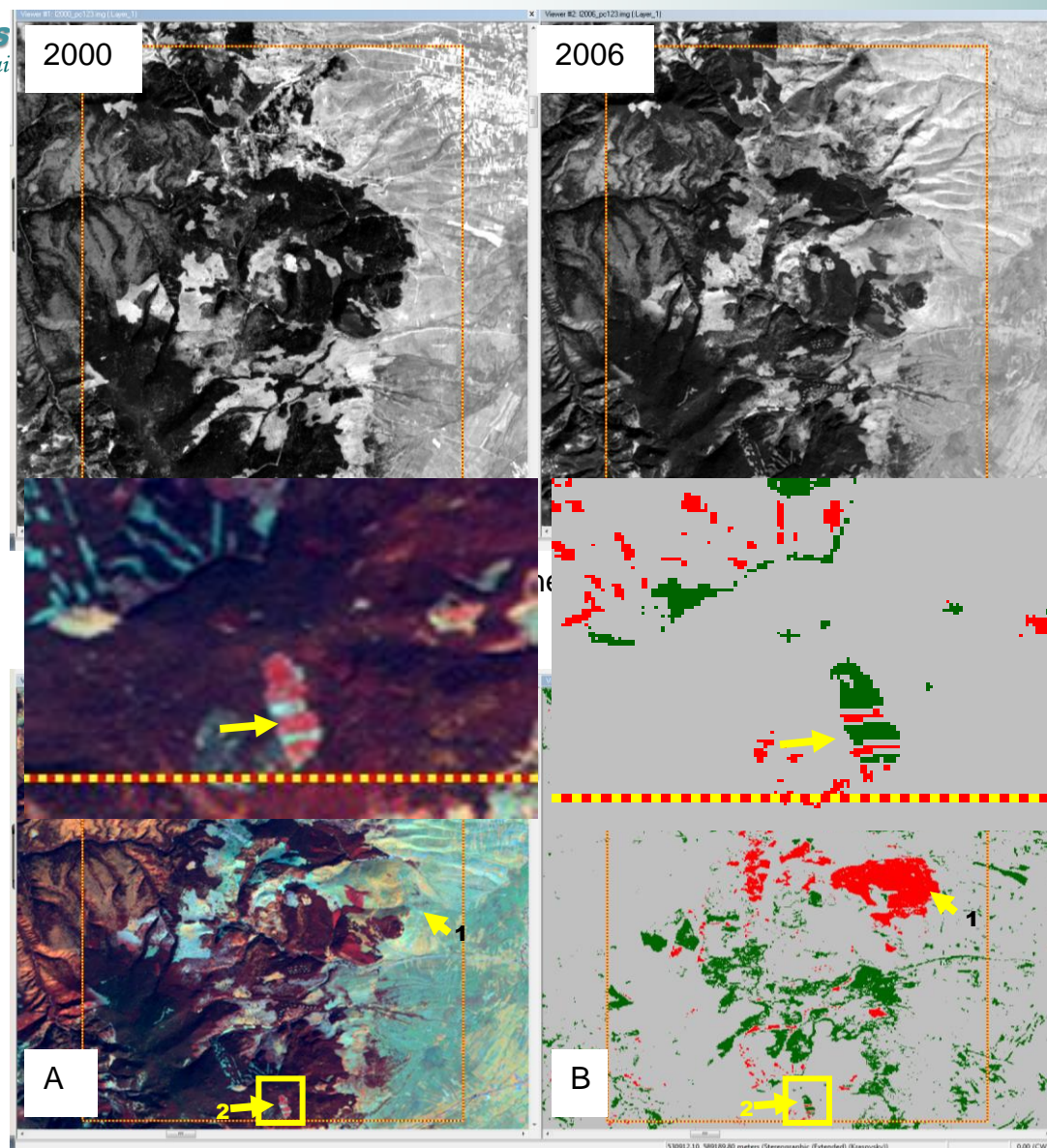


Method: using change detection tool from ERDAS 9.x

Between two pairs of Landsat images from **5 June 2000** and **4 October 2006**:

1. **Band 5**
2. **NDVI**
3. **PC1**





Raster Attribute Editor - I2000-I2006_dif.img(Layer_1)

File Edit Help

Layer Number: 1

Row	Value	Histogram	Color	Opacity
86	83.6719	394200	Green	1
87	81.6797	483075	Green	1
88	79.6875	598500	Green	1
89	77.6953	731925	Green	1
90	75.7031	861750	Green	1
91	73.7109	1063375	Green	1
92	71.7188	1272150	Green	1
93	69.7266	1570725	Green	1
94	67.7344	1797300	Green	1
95	65.7422	2113200	Green	1
96	63.75	2532600	Green	1
97	61.7578	2938050	Green	1
98	59.7656	3476250	Green	1
99	57.7734	4066225	Green	1
100	55.7813	4740975	Green	1
101	53.7891	5489100	Green	1
102	51.7969	6106950	Green	1
103	49.8047	6769375	Green	1
104	47.8125	7244650	Green	1
105	45.8203	7637250	Green	1
106	43.8281	7955325	Green	1
107	41.8359	8183925	Green	1
108	39.8438	8222625	Green	1
109	37.8516	8026650	Green	1
110	35.8594	7681275	Green	1
111	33.8672	7364700	Green	1
112	31.875	6764850	Green	1
113	29.8828	6294600	Green	1
114	27.8906	5751675	Green	1
115	25.8984	5269275	Green	1
116	23.9063	4705650	Green	1
117	21.9141	4009500	Green	1
118	19.9219	3000600	Green	1
119	17.9297	2058750	Green	1
120	15.9375	1306350	Green	1
121	13.9453	890650	Green	1
122	11.9531	643050	Green	1
123	9.96094	466200	Green	1
124	7.96875	396900	Green	1
125	5.97656	391725	Green	1
126	3.98438	337275	Green	1
127	1.99219	125325	Green	1
128	0	87940525	Green	1
129	1.99219	176525	Red	1
130	3.98438	147600	Red	1
131	5.97656	92425	Red	1
132	7.96875	93150	Red	1
133	9.96094	85725	Red	1
134	11.9531	68175	Red	1
135	13.9453	61875	Red	1
136	15.9375	61875	Red	1
137	17.9297	47325	Red	1
138	19.9219	52875	Red	1
139	21.9141	48375	Red	1

Forest occurrence (1);

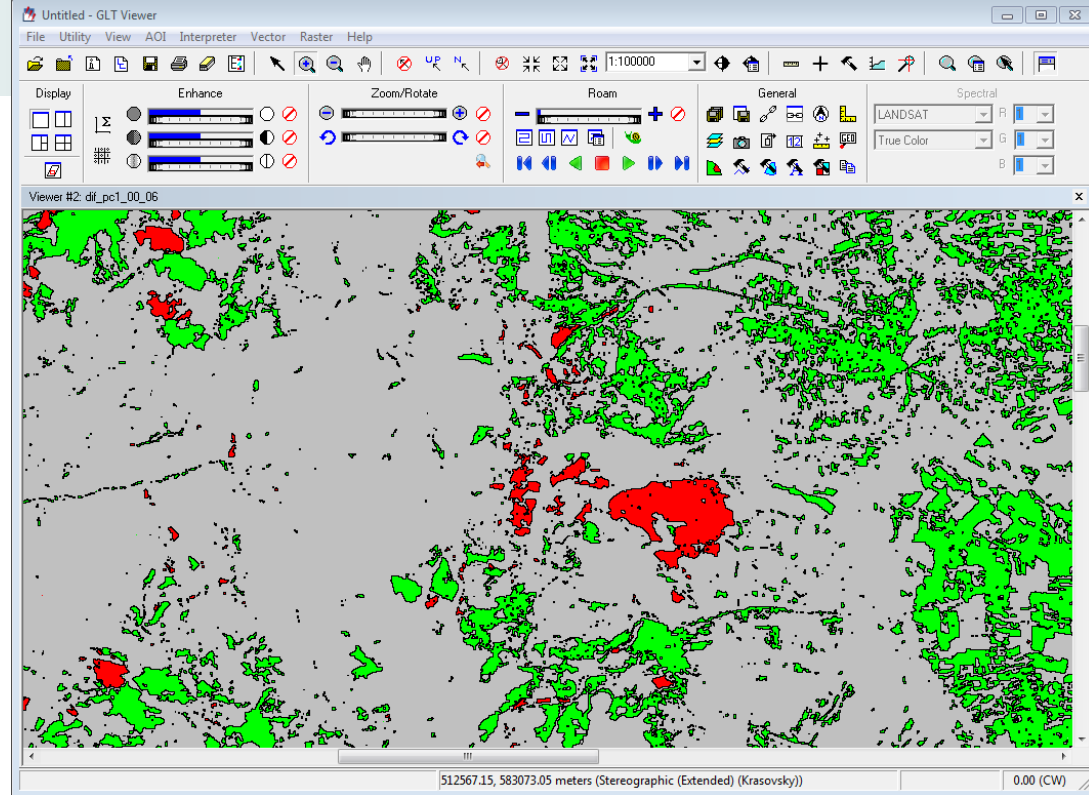
Unchanged (2)

Forest disappear (3).

Manual density slicing

False color combination (7,5,3) from 2006 (A) and difference between PC1 from 2000 and 2006 (B).

Work flow



ERDAS Imagine

Classification into 3 classes
Forest occurrence (1);
Unchanged (2)
Forest disappear (3).

Conversion raster to vector
and GDB building in ArcGIS

Separation of class 3 (forest vegetation disappear)

Results analyses

Accuracy assessment

Affected areas estimation and legal/illegal classification

Slope estimation and legal/illegal classification

Type of forest vegetation affected (species/groups of species)

ArcGIS

Method: checking every case (pan to) and mark as True or False
Where False also record the cause.
(5214 issues)

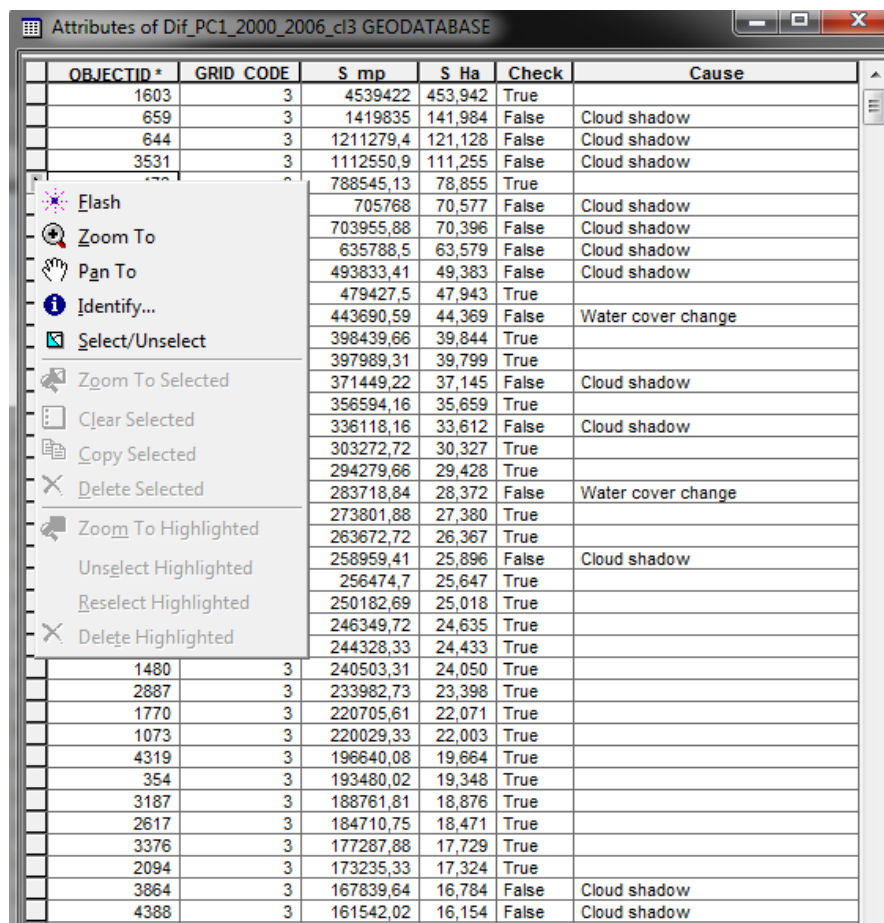
Results:

4508 areas = true

Accuracy 86.5% (Error 13.5%)

Errors causes:

- Illumination difference – 5.6%
- Misregistration – 2.4%
- Cloud shadows – 1.8 %
- Agriculture changes – 1.7 %
- Water areas changes – 0.9 %
- Seasonal change – 0.6%



OBJECTID*	GRID CODE	S mp	S Ha	Check	Cause
1603	3	4539422	453,942	True	
659	3	1419835	141,984	False	Cloud shadow
644	3	1211279,4	121,128	False	Cloud shadow
3531	3	1112550,9	111,255	False	Cloud shadow
		788545,13	78,855	True	
		705768	70,577	False	Cloud shadow
		703955,88	70,396	False	Cloud shadow
		635788,5	63,579	False	Cloud shadow
		493833,41	49,383	False	Cloud shadow
		479427,5	47,943	True	
		443690,59	44,369	False	Water cover change
		398439,66	39,844	True	
		397989,31	39,799	True	
		371449,22	37,145	False	Cloud shadow
		356594,16	35,659	True	
		336118,16	33,612	False	Cloud shadow
		303272,72	30,327	True	
		294279,66	29,428	True	
		283718,84	28,372	False	Water cover change
		273801,88	27,380	True	
		263672,72	26,367	True	
		258959,41	25,896	False	Cloud shadow
		256474,7	25,647	True	
		250182,69	25,018	True	
		246349,72	24,635	True	
		244328,33	24,433	True	
1480	3	240503,31	24,050	True	
2887	3	233982,73	23,398	True	
1770	3	220705,61	22,071	True	
1073	3	220029,33	22,003	True	
4319	3	196640,08	19,664	True	
354	3	193480,02	19,348	True	
3187	3	188761,81	18,876	True	
2617	3	184710,75	18,471	True	
3376	3	177287,88	17,729	True	
2094	3	173235,33	17,324	True	
3864	3	167839,64	16,784	False	Cloud shadow
4388	3	161542,02	16,154	False	Cloud shadow

To improve the accuracy:

- To find images close as year season
- To apply mask for clouds/clouds shadows
- To apply a mask for forest cover

Method:

1. Spatial join of B5 with PC1 stratum. Result:

2716 areas overlap with PC1 stratum from 2829-only 113 are different (<6 ha totally)

2. Spatial join of PC1 with B5. Result:

2071 areas don't overlap with B5 stratum (small areas, totally 215.2 ha, the biggest one=3.20

Results

in terms of confusions with other areas:

Accuracy 88% (Error 12%)

**In terms of missing changed areas
(comparing with PC1 method):**

Accuracy 58% (Error 42%)

Errors causes:

Illumination difference – 2.4%

Misregistration – 0.4%

Cloud shadows – 2.7 %

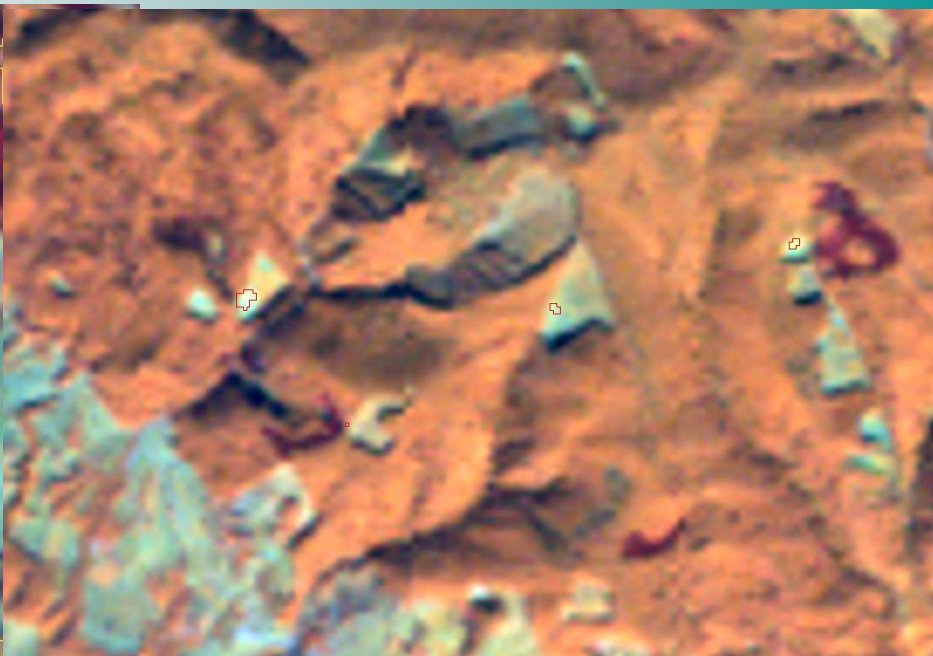
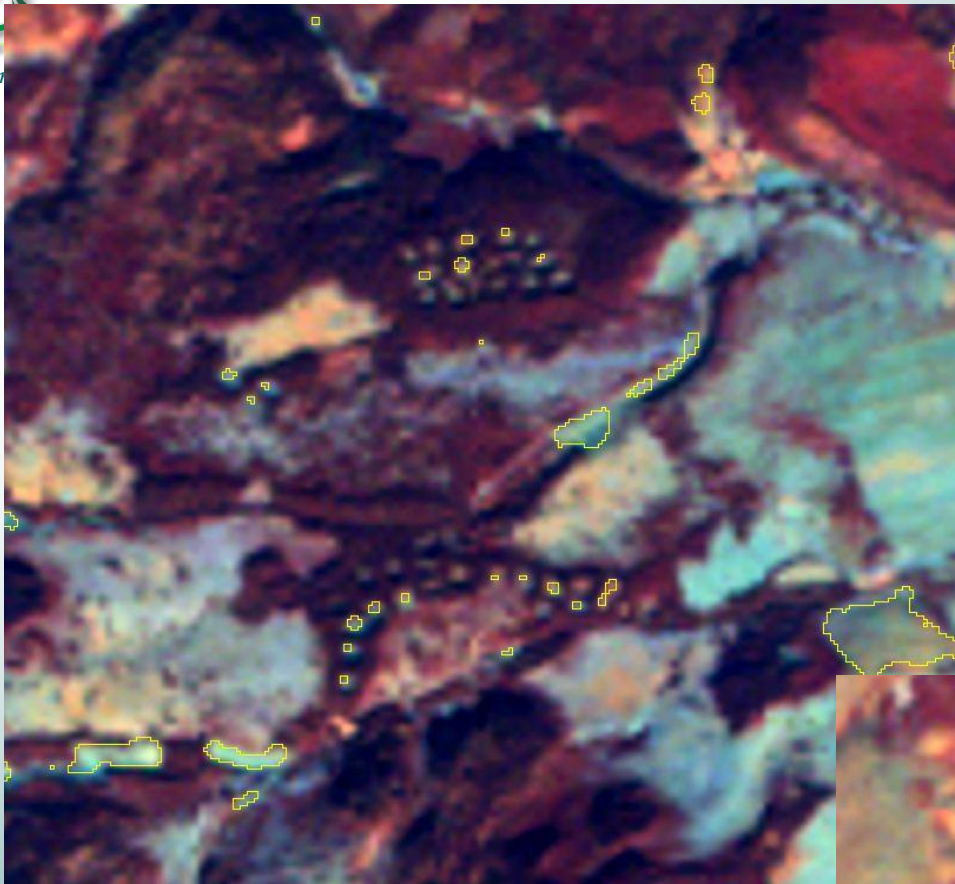
Agriculture – 1.5 %

Water areas changes – 0.6 %

Seasonal change – 0.3%

Unknown – 4.5%

Final conclusion: PC1 method is the best. Even so, it underestimates the areas.



Difference on PC1 detect small areas of changes but is rather underestimating

Affected areas estimation

PC1 – 4508 areas (true) = 4296.42 ha

≤ 1ha – 3762 areas = 826.36 ha

≤ 0.09 ha – 1650 areas = 83.47 ha

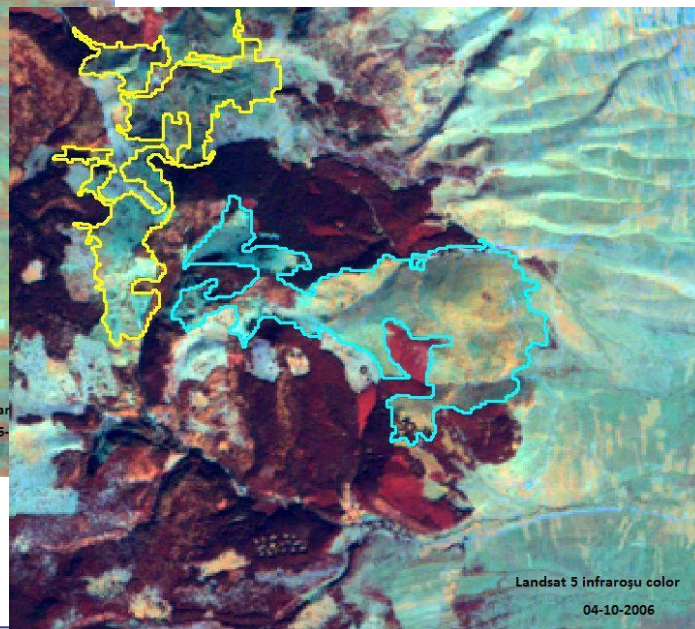
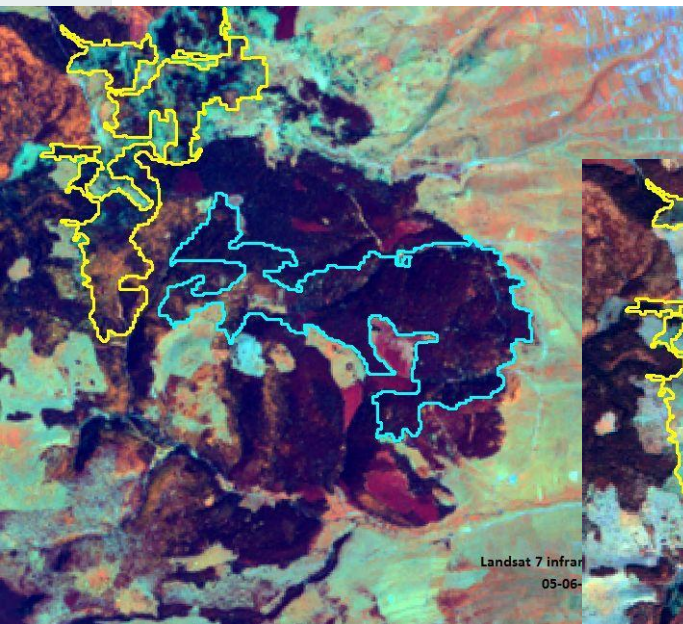
≤ 3 ha – 246 areas = 2458.53 ha

12 areas >25 ha

25 ha ≥ 38 areas >10 ha

10 ha ≤ 196 areas ≥ 3 ha

**Notice: it is forbidden
to clear cut
areas over 3 ha
(according with law)**



OBJECTID*	S mp	S Ha	Check
1392	4539422	453,94	True
437	788545	78,85	True
626	479428	47,94	True
1465	398440	39,84	True
1348	397989	39,80	True
1688	356594	35,66	True
1307	303273	30,33	True
2884	294280	29,43	True
1872	273802	27,38	True
285	263673	26,37	True
653	256475	25,65	True
2873	250183	25,02	True
360	246350	24,63	True
1455	244328	24,43	True
1277	240503	24,05	True
2527	233983	23,40	True
1557	220706	22,07	True
923	220029	22,00	True
3763	196640	19,66	True
316	193480	19,35	True
2769	188762	18,88	True
2334	184711	18,47	True
2950	177288	17,73	True
1875	173235	17,32	True
140	160858	16,09	True
1169	159061	15,91	True
256	157709	15,77	True
668	150735	15,07	True
4028	149169	14,92	True
1539	145787	14,58	True
1439	143312	14,33	True
1389	140162	14,02	True
405	138136	13,81	True
4407	133196	13,32	True
84	133186	13,32	True
238	129361	12,94	True
155	126662	12,67	True
1981	124865	12,49	True
859	121938	12,19	True
2372	121491	12,15	True
1923	119465	11,95	True
4329	115421	11,54	True
3703	113619	11,36	True
2022	107316	10,73	True
3950	103495	10,35	True
3722	103495	10,35	True
49	103264	10,33	True
1469	101691	10,17	True
127	101689	10,17	True
1700	101010	10,10	True

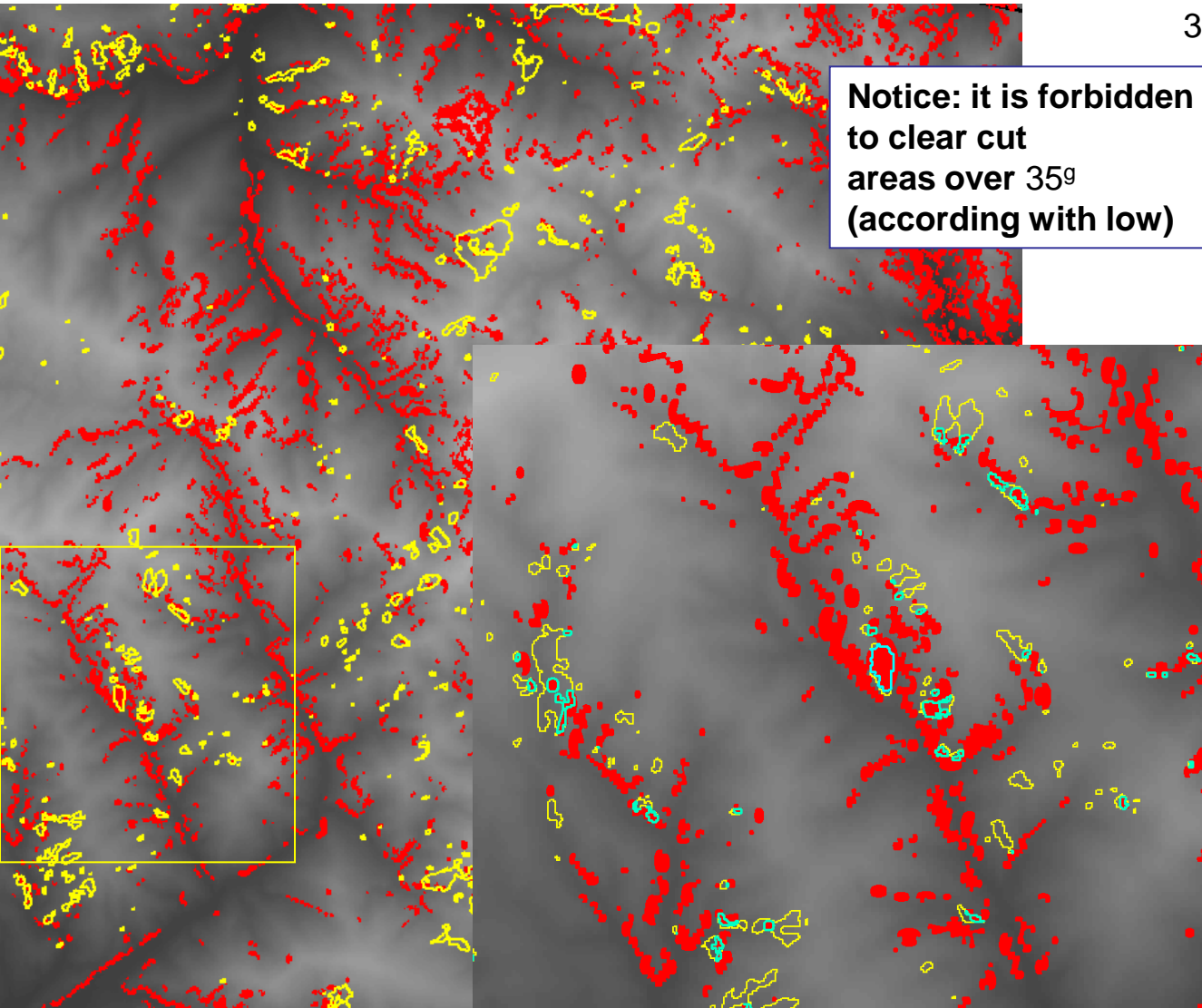
Slope analysis

Red areas: slope over 35° (~ 32.5°)

Geospatial analyse:
Intersect clear cutting areas
with slope over 35°

Result: 1263 areas (~335 ha)
From this 665 ≥ 0.1 ha (~314 ha)
196 areas ≥ 0.5 ha (~207 ha)
78 areas ≥ 1 ha (~124 ha)
16 areas ≥ 2 ha (~42 ha)
3 areas > 3 ha (~11 ha)

DEM SPOT 30m spatial resolution



Notice: it is forbidden to clear cut areas over 35° (according with law)

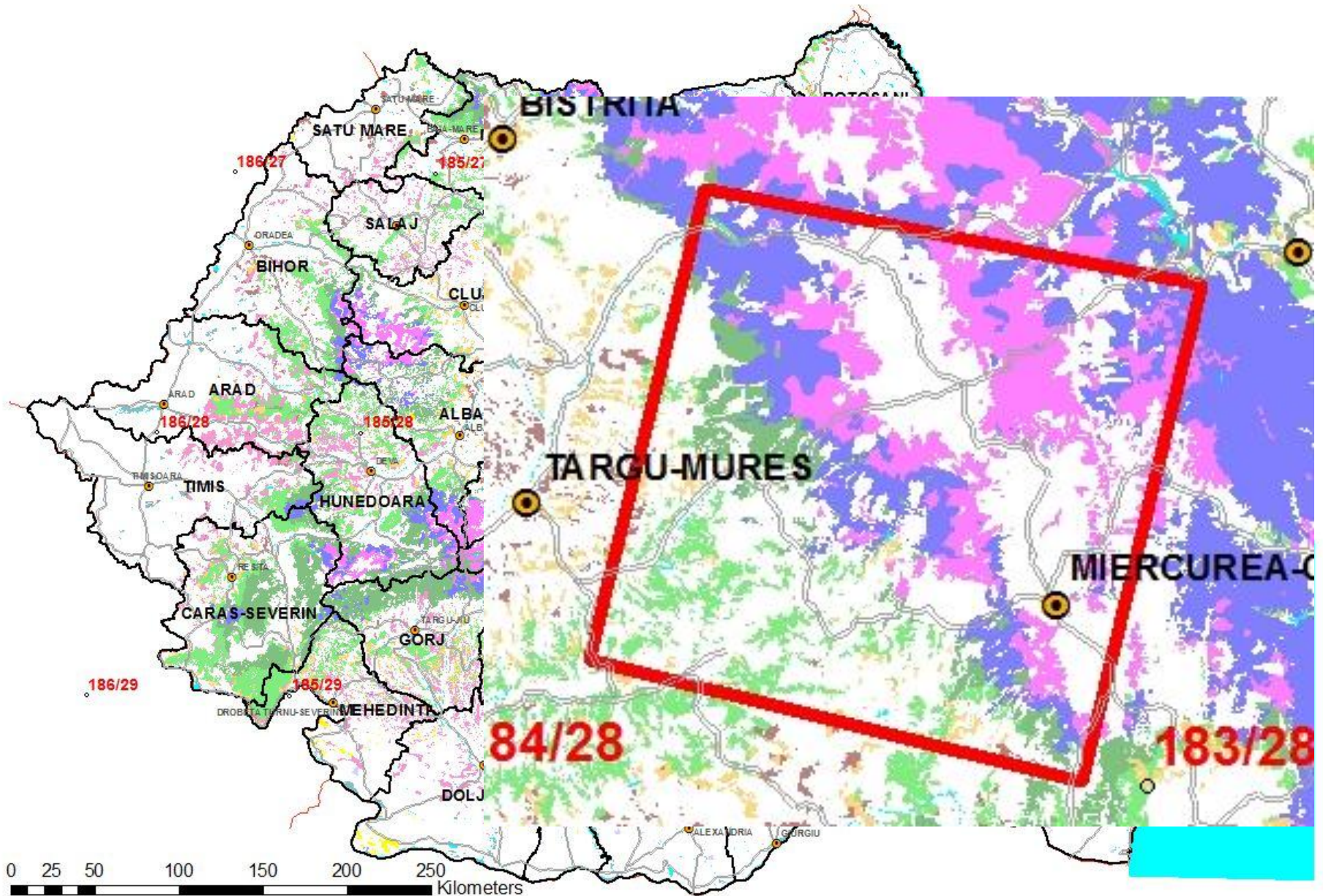
Attributes of Pante_pest31g...

OBJECTID*	Join Count	Supr ha
466	2	4.67
663	5	3.41
52	6	3.36
1015	3	2.95
122	8	2.90
330	3	2.65
524	3	2.51
685	2	2.50
678	2	2.41
692	4	2.38
352	6	2.20
279	7	2.09
384	6	2.05
826	2	2.03
985	3	2.03
496	2	2.00
372	2	1.99
912	3	1.95
146	5	1.92
265	2	1.90
578	9	1.90
239	2	1.80
457	4	1.74
925	2	1.56
559	4	1.55
1056	2	1.53
491	4	1.52
382	6	1.48
749	4	1.48
1174	2	1.46
619	3	1.45
291	3	1.45
1093	4	1.44
297	3	1.43
1201	2	1.42
190	4	1.40
390	2	1.40
44	4	1.39
140	3	1.38
278	7	1.36
336	4	1.36
1090	2	1.34
581	9	1.32
1106	2	1.31
644	2	1.29
808	2	1.28
969	2	1.26
498	5	1.25
71	2	1.24

Record: 1 Show: 1

Type of forest vegetation affected (species/groups of species)

Using ecosystems types map



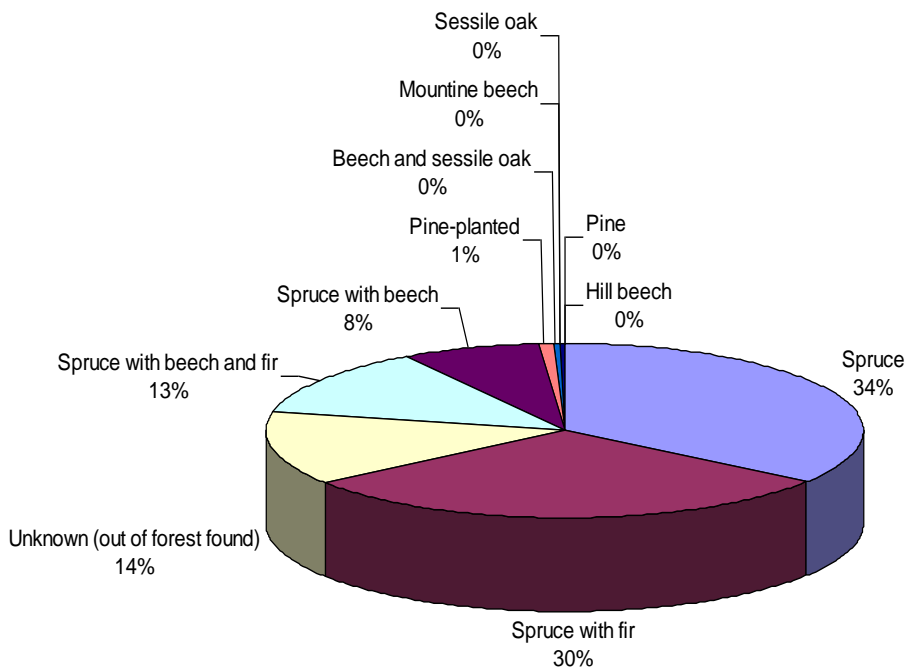
Spatial join tool

Attributes of Dif_PC1_2000_2006_cl3_join_ecosys

OBJECTID *	GRID CODE	S mp	S Ha	Check	COD	COD 1	DENUMIRE	Type
4780	3	22724,08	2,27	True	12	1	Molidisuri cu Hylocomium	Spruce
2662	3	22723,25	2,27	True	11	1	Molidisuri cu Oxalis	Spruce
2056	3	22723,07	2,27	True				<Null>
790	3	22722,78	2,27	True	17	1	Molidisuri cu brad, slab acidofile	Spruce with fir
5208	3	22499,68	2,25	True	PP	P		<Null>
4507	3	22498,96	2,25	True	18	1	Molidisuri cu brad, acidofile	Spruce with fir
4470	3	22498,94	2,25	True	18	1	Molidisuri cu brad, acidofile	Spruce with fir
400	3	22497,68	2,25	True				<Null>
3779	3	22273,59	2,23	True	21	2	Molidisuri cu fag slab acidofile	Spruce with beech
2629	3	22273,28	2,23	True				<Null>
1880	3	22273,06	2,23	True	21	2	Molidisuri cu fag slab acidofile	Spruce with beech
763	3	22272,82	2,23	True	17	1	Molidisuri cu brad, slab acidofile	Spruce with fir
2882	3	22048,36	2,20	True	31	3	Fagete montane neutrofile dacice	Mountine beech
1284	3	22047,97	2,20	True	12	1	Molidisuri cu Hylocomium	Spruce
4677	3	21824,08	2,18	True	PP	P		<Null>
4066	3	21823,74	2,18	True	12	1	Molidisuri cu Hylocomium	Spruce
3433	3	21823,51	2,18	True	11	1	Molidisuri cu Oxalis	Spruce
3261	3	21823,48	2,18	True	17	1	Molidisuri cu brad, slab acidofile	Spruce with fir
2571	3	21823,30	2,18	True	11	1	Molidisuri cu Oxalis	Spruce
1225	3	21822,98	2,18	True	12	1	Molidisuri cu Hylocomium	Spruce
493	3	21822,78	2,18	True	17	1	Molidisuri cu brad, slab acidofile	Spruce with fir
460	3	21822,77	2,18	True	23	2	Molideto-fageto-bradete slab acidofile	Spruce with beech and fir
488	3	21822,78	2,18	True				<Null>
430	3	21822,77	2,18	True	17	1	Molidisuri cu brad, slab acidofile	Spruce with fir
3794	3	21598,64	2,16	True	PP	P		<Null>
3542	3	21598,56	2,16	True	12	1	Molidisuri cu Hylocomium	Spruce
1635	3	21598,08	2,16	True	24	2	Molideto-fageteo-bradete acidofile	Spruce with beech and fir
928	3	21597,93	2,16	False				<Null>
841	3	21597,91	2,16	True	23	2	Molideto-fageto-bradete slab acidofile	Spruce with beech and fir
699	3	21597,86	2,16	True	23	2	Molideto-fageto-bradete slab acidofile	Spruce with beech and fir
3752	3	21148,65	2,11	True	21	2	Molidisuri cu fag slab acidofile	Spruce with beech
3633	3	21148,62	2,11	True	PP	P		<Null>
3281	3	21148,53	2,11	True	27	2	Bradete slab acidofile	Mountine beech
3297	3	21148,53	2,11	True	14	1	Molidisuri cu Vaccinium	Spruce
3060	3	21148,48	2,11	True	12	1	Molidisuri cu Hylocomium	Spruce
2190	3	21148,23	2,11	True				<Null>
1881	3	21148,15	2,11	True	23	2	Molideto-fageto-bradete slab acidofile	Spruce with beech and fir
1028	3	21148,00	2,11	True	11	1	Molidisuri cu Oxalis	Spruce
878	3	21147,96	2,11	True	23	2	Molideto-fageto-bradete slab acidofile	Spruce with beech and fir

Type	Area (ha)
Spruce	1482,57
Spruce with fir	1250,38
Unknown (out of forest found)	575,61
Spruce with beech and fir	542,06
Spruce with beech	321,84
Pine-planted	33,83
Beech and sessile oak	9,58
Mountine beech	4,97
Sessile oak	4,07
Pine	2,13
Hill beech	1,84

Group of species	Area (ha)	%
Resinous	2768,91	75,79
Broad leaved	20,46	0,56
Mixed	863,9	23,65
Total	3653,27	



What's next:

- To improve the accuracy by use of masks (forest and cloud/cloud shadow)
- To extend the study area to a county (judet) level and than to country level
- To estimate the accuracy of class 1 – forest growing

Some preliminary conclusions:

- The method is simple and robust, even sometime under estimating clear cutting areas;
- Disadvantage of method: is rather slow and required some efforts;

- There are problems within test areas concerning illegal clear cutting.

Wandering: what the real situation is on whole Romanian forest ?

Thank you for your attention

