remote sensing

MDPI

Supplementary Materials

Over 150 years of change: Object oriented analysis of historical land cover in the Main river catchment, Bavaria/Germany

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Figure S1. Numbers and years of selected position sheets from 19th century Bavaria. Quality of tiles randomly selected (marked with *) for manual classification was a) very good, b) good or c) poor. Position sheets in group a) are 52, 53, 80, 105, 130; in group b) 51, 78, 79, 102, 103, 129, 157, 159, 185; and in group c) 76, 77, 104, 106, 128, 131, 132, 156, 158, 183, 184, 186.

Figure S2. Land cover of 1850 and of 2015 as basis for change analysis. The water bodies on the historical map are taken from the current map assuming that their extent did not change.

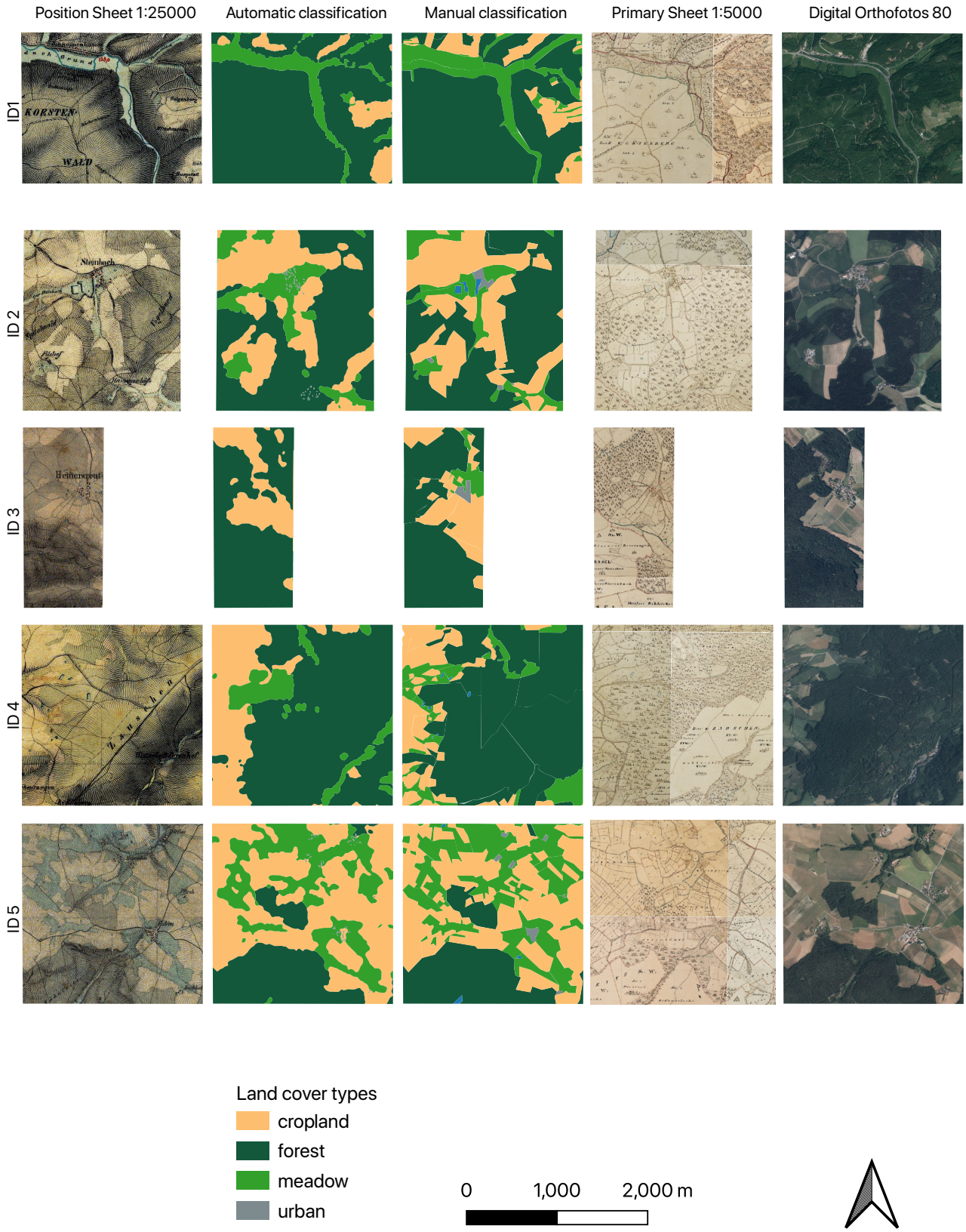

Figure S3. continued

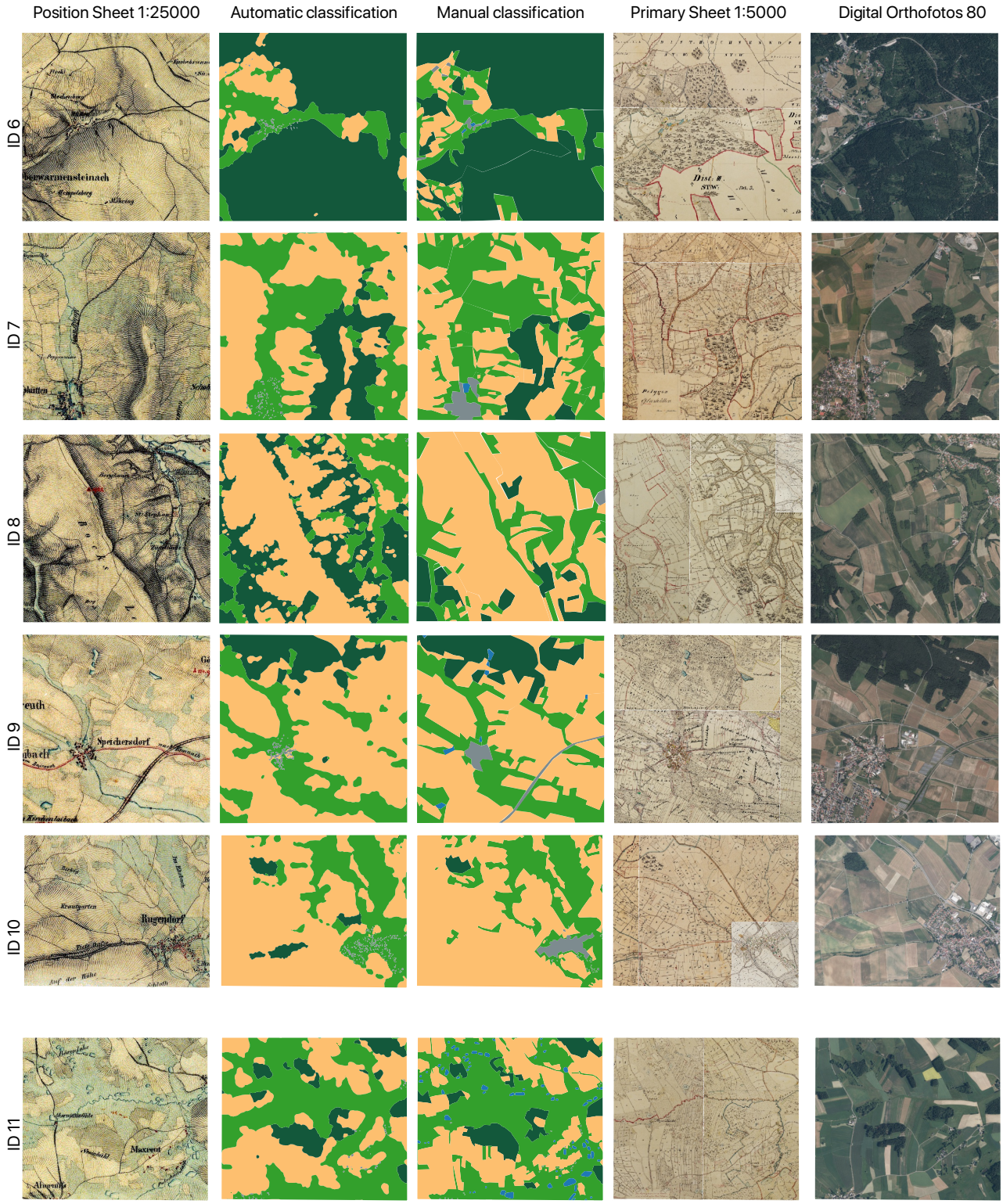

Figure S3. continued

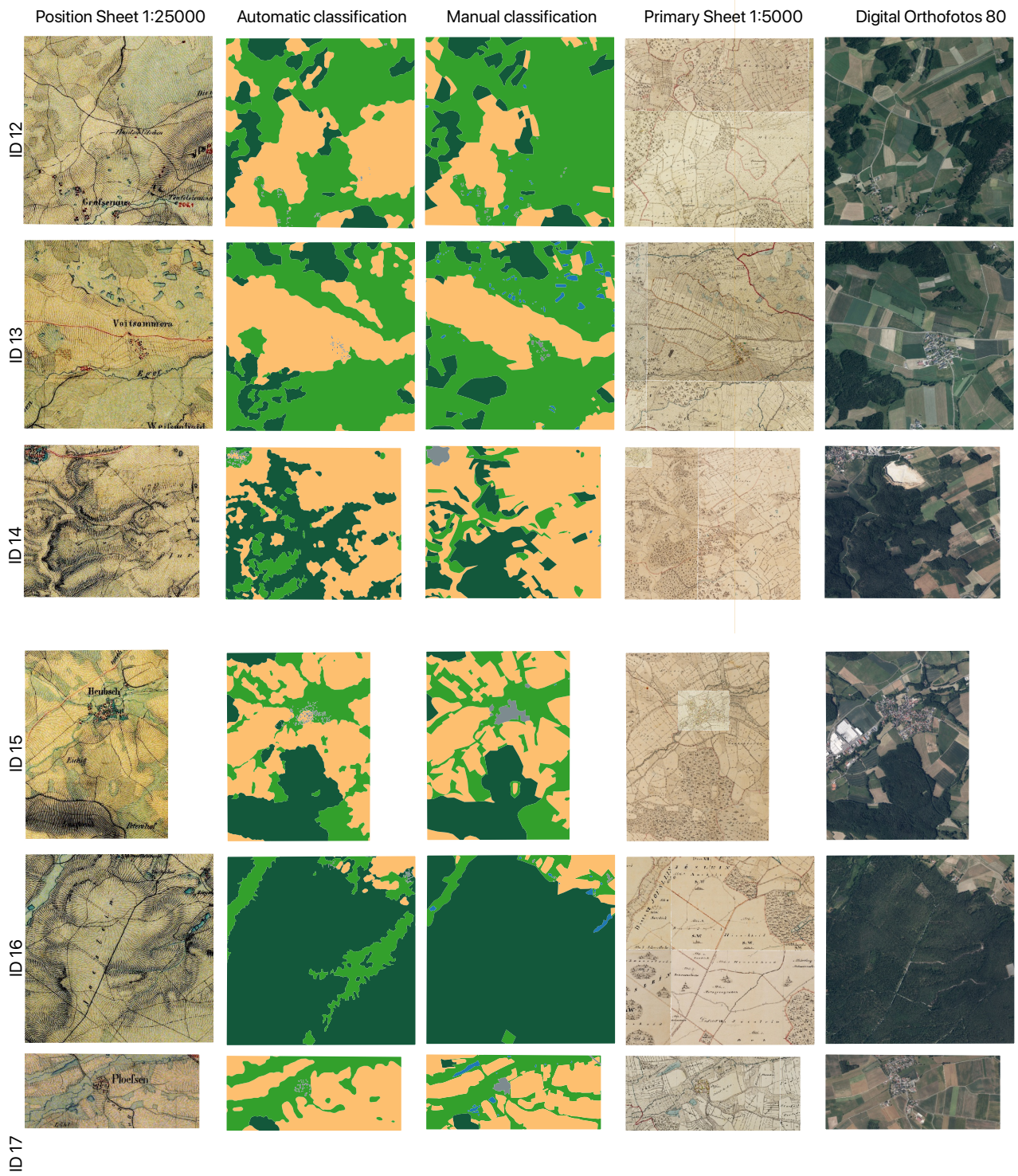

Figure S3. Comparison of automatic classification with manual classification for 17 randomly selected quadrants (see Fig. SI1 and 1b for location). For better assessment also the primary sheets (scale 1:5000 from 1847-1864) as well as the digital orthophotos (80 cm) from 2017 are shown. (Note: some quadrants are not rectangular, because of edge effects). Source of historical maps and orthofotos was the Bavarian State Office for Digitisation, High-Speed Internet and Surveying (LDBV).

Table S1. Comparison of automatic classification with manual classification.

		Ground truth (manual classification)						User accuracy
	ClassValue	**Cropland**	**Forest**	**Meadow**	**Urban**	**Water**	**Total**	
ID 1 / Map Sheet 52 / Quality a*)								
Classified (eCognition)	Cropland	10209	943	1140	0	0	12292	0.83
	Forest	6222	103981	11107	0	0	121310	0.86
	Meadow	893	3813	13234	0	0	17940	0.74
	Urban	0	0	0	0	0	0	NA
	Water	0	0	0	0	0	0	NA
	Total	17324	108737	25481	0	0	151542	
Producer accuracy		0.59	0.96	0.52	NA	NA		0.84
Kappa								0.60
ID 2 / Map Sheet 79 / Quality b								
Classified (eCognition)	Cropland	48307	2441	920	5	0	51673	0.93
	Forest	3558	76976	1570	162	0	82266	0.94
	Meadow	4090	1451	16118	1066	730	23455	0.69
	Urban	24	68	71	263	21	447	0.59
	Water	0	0	0	0	0	0	0.00
	Total	55979	80936	18679	1496	751	157841	
Producer accuracy		0.86	0.95	0.86	0.18	0.00		0.90
Kappa								0.83
ID 3 / Map Sheet 103 / Quality b								
Classified (eCognition)	Cropland	14660	4933	625	466	0	20684	0.71
	Forest	6294	48774	3350	657	0	59075	0.83
	Meadow	0	0	0	0	0	0	0.00
	Urban	2	0	0	0	0	2	0.00
	Water	0	0	0	0	0	0	NA
	Total	20956	53707	3975	1123	0	79761	
Producer accuracy		0.70	0.91	0.00	0.00	NA		0.80
Kappa								0.53
ID 4 / Map Sheet 105 / Quality a								
Classified (eCognition)	Cropland	25468	6048	8782	0	19	40317	0.63
	Forest	3253	112399	7157	0	24	122833	0.92
	Meadow	687	13107	4265	0	257	18316	0.23
	Urban	0	0	0	0	0	0	
	Water	0	0	0	0	0	0	0.00
	Total	29408	131554	20204	0	300	181466	
Producer accuracy		0.87	0.85	0.21		0.00		0.78
Kappa								0.53
ID 5 / Map Sheet 130 / Quality a								
Clas sifie	Cropland	78221	1860	9476	555	7	90119	0.87

	Forest	328	41593	1281	10	79	43291	0.96
	Meadow	1480	222	44887	563	261	47413	0.95
	Urban	1	0	132	259	0	392	0.66
	Water	0	0	0	0	0	0	0.00
	Total	80030	43675	55776	1387	347	181215	
Producer accuracy		0.98	0.95	0.80	0.19	0.00		0.91
Kappa								0.86
ID 6 / Map Sheet 132 / Quality c								
	ClassValue	**Cropland**	**Forest**	**Meadow**	**Urban**	**Water**	**Total**	
Classified (eCognition)	Cropland	10721	4090	4638	147	0	19596	0.55
	Forest	4994	125257	7710	3	0	137964	0.91
	Meadow	2266	3501	16774	698	184	23423	0.72
	Urban	51	23	191	132	4	401	0.33
	Water	0	0	0	0	0	0	0.00
	Total	18032	132871	29313	980	188	181384	
Producer accuracy		0.59	0.94	0.57	0.13	0.00		0.84
Kappa								0.62
ID 7 / Map Sheet 156 / Quality c								
Classified (eCognition)	Cropland	65596	1063	21807	50	0	88516	0.74
	Forest	7598	15637	4719	0	0	27954	0.56
	Meadow	3283	227	56234	3633	285	63662	0.88
	Urban	3	0	32	519	0	554	0.94
	Water	0	0	0	0	0	0	0.00
	Total	76480	16927	82792	4202	285	180686	
Producer accuracy		0.86	0.92	0.68	0.12	0.00		0.76
Kappa								0.62
ID 8 / Map Sheet 158 / Quality c								
Classified (eCognition)	Cropland	80312	962	8608	212	0	90094	0.89
	Forest	30008	10728	13728	79	0	54543	0.20
	Meadow	4101	4738	25962	287	0	35088	0.74
	Urban	0	0	23	6	0	29	0.21
	Water	0	0	0	0	0	0	
	Total	114421	16428	48321	584	0	179754	
Producer accuracy		0.70	0.65	0.54	0.01			0.65
Kappa								0.42
ID 9 / Map Sheet 159 / Quality b								
Classified (eCognition)	Cropland	98396	3621	7579	1374	37	111007	0.89
	Forest	1304	21070	786	0	30	23190	0.91
	Meadow	4347	274	38070	1903	1265	45859	0.83
	Urban	3	0	65	766	3	837	0.92
	Water	0	0	0	0	0	0	0.00

	Total	104050	24965	46500	4043	1335	180893	0.00
Producer accuracy		0.95	0.84	0.82	0.19	0.00		0.88
Kappa								0.78
ID 10 / Map Sheet 51 / Quality b								
Classified (eCognition)	Cropland	96421	132	4489	0	0	101042	0.95
	Forest	3216	1493	386	0	0	5095	0.29
	Meadow	2836	0	36377	2894	0	42107	0.86
	Urban	16	0	145	830	0	991	0.84
	Water	0	0	0	0	0	0	NA
	Total	102489	1625	41397	3724	0	149235	
Producer accuracy		0.94	0.92	0.88	0.22	NA		0.91
Kappa								0.79
ID 11 / Map Sheet 53 / Quality a								
Classified (eCognition)	Cropland	50597	2453	8844	5	0	61899	0.82
	Forest	572	14580	2710	1	6	17869	0.82
	Meadow	1959	321	72580	37	4043	78940	0.92
	Urban	20	0	185	179	5	389	0.46
	Water	0	0	0	0	0	0	0.00
	Total	53148	17354	84319	222	4054	159097	
Producer accuracy		0.95	0.84	0.86	0.81	0.00		0.87
Kappa								0.78
ID 12 / Map Sheet 80 / Quality a								
Classified (eCognition)	Cropland	36735	2283	35132	48	4	74202	0.50
	Forest	515	21973	2070	2	0	24560	0.89
	Meadow	2044	931	79183	154	391	82703	0.96
	Urban	12	6	136	277	5	436	0.64
	Water	0	0	0	0	0	0	0.00
	Total	39306	25193	116521	481	400	181901	0.00
Producer accuracy		0.93	0.87	0.68	0.58	0.00		0.76
Kappa								0.60
ID 13 / Map Sheet 106 / Quality c								
Classified (eCognition)	Cropland	44599	551	19167	241	28	64586	0.69
	Forest	571	17539	6181	0	14	24305	0.72
	Meadow	775	5387	83734	1	3354	93251	0.90
	Urban	2	0	22	163	0	187	0.87
	Water	0	0	0	0	0	0	0.00
	Total	45947	23477	109104	405	3396	182329	0.00
Producer accuracy		0.97	0.75	0.77	0.40	0.00		0.80
Kappa								0.66
ID 14 / Map Sheet 128 / Quality a								
Clas sifie	Cropland	75575	1511	3276	329	0	80691	0.94

	Forest	22463	30561	11130	257	13	64424	0.47
	Meadow	1496	7981	2375	1009	23	12884	0.18
	Urban	4	0	23	456	0	483	0.94
	Water	0	0	0	0	0	0	0.00
	Total	99538	40053	16804	2051	36	158482	
Producer accuracy		0.76	0.76	0.14	0.22	0.00		0.69
Kappa								0.45
ID 15 / Map Sheet 102 / Quality b								
Classified (eCognition)	Cropland	56756	59	8540	568	0	65923	0.86
	Forest	4602	31107	2006	1	0	37716	0.82
	Meadow	1338	111	31331	1210	13	34003	0.92
	Urban	15	0	47	684	0	746	0.92
	Water	0	0	0	0	0	0	0.00
	Total	62711	31277	41924	2463	13	138388	
Producer accuracy		0.91	0.99	0.75	0.28	0.00		0.87
Kappa								0.79
ID 16 / Map Sheet 129 / Quality b								
Classified (eCognition)	Cropland	6265	87	196	0	1	6549	0.96
	Forest	3226	147855	1474	42	15	152612	0.97
	Meadow	513	13122	8458	67	783	22943	0.37
	Urban	30	14	118	62	0	224	0.28
	Water	0	0	0	0	0	0	0.00
	Total	10034	161078	10246	171	799	182328	
Producer accuracy		0.62	0.92	0.83	0.36	0.00		0.89
Kappa								0.57
ID 17 / Map Sheet 186 / Quality c								
Classified (eCognition)	Cropland	40607	196	6464	0	0	47267	0.86
	Forest	208	1732	76	0	0	2016	0.86
	Meadow	1501	565	24933	928	1111	29038	0.86
	Urban	0	0	3	276	0	279	0.99
	Water	0	0	0	0	0	0	0.00
	Total	42316	2493	31476	1204	1111	78600	
Producer accuracy		0.96	0.69	0.79	0.23	0.00		0.86
Kappa								0.73

*) a: very good, b: good, c: poor

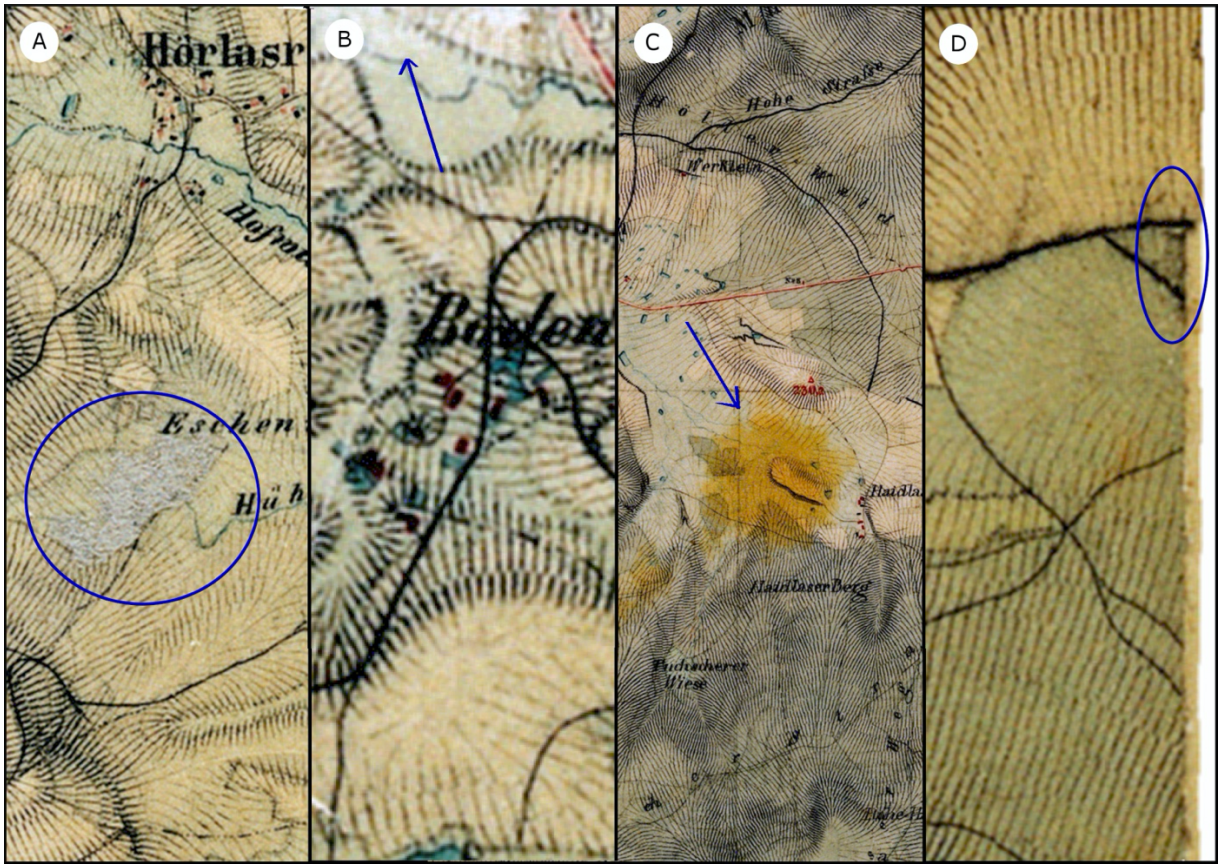

Figure S4. Physical damage examples of historical maps (**A**) scratches, (**B**) colours fading or missing, (**C**) stains and (**D**) incomplete features at borders.

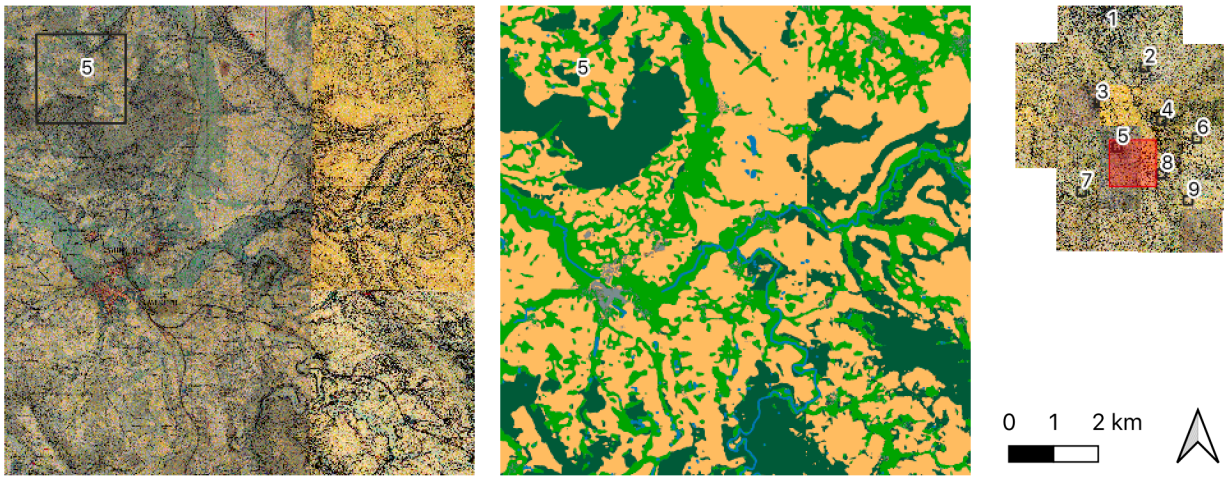

Figure S5. Edge effects due to differently coloured maps.

Table S2. eCognition features used in classification specified for each of the map tiles. (With feature white: Brightness >= 254, Brightness = 0 and Distance to scene border = 0 Pxl).

Tile	Letters and Lines	Cropland	Meadow	Forest	Urban
PB051	- Maximal difference >=1 - Mean blueHist <= 111	- Mean redHist > =231 - Hue (R=green. G=red. B=blue) >=0.78	- Unclassified left objects assigned to Meadow	- Maximal difference < 0.09 - Mean redHist <= 195 - Hue(R='redHist'.G='red'.B='green') <=0.33 - Saturation(R='blueHist'.G='redLinear'.B='red') <=0.085	- First classify as L&L - Mean redHist=27. 80 - Shape index <=1.29 - Area <=10 Pxl - Length/Width <1.8
PB052	- Maximal difference >=1.2 - Mean blueHist <= 111	- Mean redHist > =222 - Hue (R=green. G=red. B=blue) >=0.78	- Intensity(R=blueNormalized.G=redLinear.B=red) >= 0.8	- Maximal difference < 0.09 - Mean redHist <= 44 - Hue(R='redHist'.G='red'.B='green') <=0.33 - Saturation(R='blueHist'.G='redLinear'.B='red') <=0.085	- First classify as L&L - Rectangular Fit >0.71 - Elliptic Fit > 0.5
PB053	- Maximal difference >0.5 - Mean blueHist <= 60	- Hue(R='blueHist',G='redHist',B='red') < 0.59 - Mean redHist > 190	- Hue(R='redHist',G='red',B='green') > 0.52 - Hue(R='blueLinear',G='redLinear',B='greenLinear') > 0.51	- Hue(R='redHist',G='red',B='green') < 0.51 - Hue(R='redHist',G='red',B='green') > 0.46 - Hue(R='blueLinear',G='redLinear',B='greenLinear') > 0.47 - Hue(R='blueLinear',G='redLinear',B='greenLinear') < 0.58	- Hue(R='blueLinear',G='redLinear',B='greenLinear') > 0.33 - Hue(R='blueLinear',G='redLinear',B='greenLinear') < 0.4 - Normalized brightness <= 0.8 - Mean blue > 55 - Area >= 70 Pxl - Asymmetry >= 0.8 - Shape index > 1.6 - Elliptic Fit < 0.5
PB076	- Maximal difference >0.4 - Mean blue <= 60	- Mean redLinear >=216 - Mean redHist > =223 - Hue (R=redHist. G=red. B=green) <= 0.15	- Unclassified left objects assigned to Meadow	- Maximal difference <= 0.16 - Mean redHist <= 150	- First classify as L&L - Area <= 90 Pxl - Asymmetry <= 0.8 - Normalized Brightness >= 0.7 - Elliptic Fit > 0.3
PB077	- Maximal difference >0.5 - Mean blue <= 60	- Mean redLinear >=200 - Mean redHist > =200 - Hue (R=redHist. G=red. B=green) <= 0.3	- Mean greenLinear >= 132	- Normalized Brightness >= 0.39 - Hue(R='redHist'.G='red'.B='green') >=0.514 - Normalized Brightness [0.37; 0.61]	- First classify as L&L - Area <= 100 Pxl - Asymmetry <= 0.8 - Normalized Brightness >= 0.7 - Elliptic Fit > 0.3
PB078	- Maximal difference >=1.2 - Mean blueHist <= 111	- Mean redHist > =231 - Hue (R=green. G=red. B=blue) >=0.79	- Unclassified left objects assigned to Meadow	- Maximal difference < 0.09 - Mean redHist <= 44 - Hue(R='redHist'.G='red'.B='green') <=0.33 - Saturation(R='blueHist'.G='redLinear'.B='red') <=0.085	- First classify as L&L - Rectangular Fit >0.71 - Elliptic Fit > 0.5
PB079	- Maximal difference >0.4 - Mean blueHist <= 54	- Hue(R='blueHist',G='redHist',B='red') < 0.59 - Hue(R='redHist',G='red',B='green') < 0.37	- Intensity(R=greenLinear,G=greenHist,B=blueHist) > 0.69 - Intensity(R=greenHist,G=blueHist,B=redHist) > 0.58	- Intensity(R=greenHist,G=blueHist,B=redHist) < 0.55 - Hue(R='redHist',G='red',B='green') < 0.5 and HSI Transformation - Hue(R='redHist',G='red',B='green') > 0.42	- Hue(R='blueLinear',G='redLinear',B='greenLinear') > 0.31 and HSI Transformation - Hue(R='blueLinear',G='redLinear',B='greenLinear') < 0.36 - Normalized brightness <= 0.8 - Mean blue > 34 - Area >= 70 Pxl

					- Shape index > 1.6 - Elliptic Fit < 0.5
PB080	- Maximal difference >0.6 - Mean blueHist <= 60	- Hue(R='blueHist',G='redHist',B='red') < 0.61 and HSI Transformation - Hue(R='blueHist',G='redHist',B='red') > 0.16 - Hue(R='redHist',G='red',B='green') < 0.19	- Hue(R='blueLinear',G='redLinear',B='greenLinear') > 0.51 - Intensity(R=greenHist,G=blueHist,B=redHist) > 0.67	- Intensity(R=greenHist,G=blueHist,B=redHist) < 0.69 - Hue(R='redHist',G='red',B='green') < 0.45	- Hue(R='blueLinear',G='redLinear',B='greenLinear') > 0.31 and HSI Transformation - Hue(R='blueLinear',G='redLinear',B='greenLinear') < 0.36 - Normalized brightness <= 0.86 - Mean blue > 28 - Area >= 70 Pxl - Shape index > 1.6 - Elliptic Fit < 0.5
PB102	- Maximal difference >1 - Mean blue <= 58	- Mean redLinear >210 - Mean redHist > 179 - Hue (R=redHist. G=red. B=green) <= 0.3	- Hue(R='redHist'.G='red'.B='green') > 0.5 - Hue(R='blueLinear'.G='redLinear'.B='greenLinear') > 0.48 - Hue(R='redLinear'.G='greenLinear'.B='greenHist') [0.15 ; 0.45]	- Hue(R='greenLinear'.G='greenHist'.B='blueHist') > 0.83 - Hue(R='redHist'.G='red'.B='green') [0.41; 0.49]	- First classify as L&L - Normalized Brightness >= 0.7 - Mean blue < 55 - Area <= 70 Pxl - Asymmetry <= 0.8 - Shape index < 1.9 - Elliptic Fit > 0.3
PB103	- Maximal difference >0.5 - Mean blue > 0.57	- Hue(R='blueHist',G='redHist',B='red') < 0.63 and HSI Transformation - Hue(R='blueHist',G='redHist',B='red')>0.13 - Hue(R='blueHist',G='redHist',B='red')<0.63 - Hue(R='blueLinear',G='redLinear',B='greenLinear') > 0.44	- Hue(R='redHist',G='red',B='green') < 0.31 - Hue(R='redLinear',G='greenLinear',B='greenHist') < 0.75 and HSI Transformation - Hue(R='redLinear',G='greenLinear',B='greenHist') > 0.28 - Hue(R='blueLinear',G='redLinear',B='greenLinear') > 0.47	- Mean greenHist < 146	- Hue(R='blueLinear',G='redLinear',B='greenLinear') < 0.389 and HSI Transformation - Hue(R='blueLinear',G='redLinear',B='greenLinear') > 0.343 - Normalized brightness < 0.73 - Mean blue > 55 - Asymmetry > 0.79 - Shape index > 1.8 - Elliptic Fit < 0.4
PB104	- normalized brightness > 0.61	- Hue(R='blueHist',G='redHist',B='red') < 0.64	- Hue(R='blueHist',G='redHist',B='red') < 0.62 and HSI Transformation - Hue(R='blueHist',G='redHist',B='red') > 0.5 - Normalized brightness < 0.35 - Normalized brightness > 0.22	- Hue(R='redLinear',G='greenLinear',B='greenHist') > 0.13 - Hue(R='blueHist',G='redHist',B='red') > 0.73	- Hue(R='blueLinear',G='redLinear',B='greenLinear') < 0.41 - Normalized brightness < 0.8 - Mean blue > 55 - Asymmetry > 0.79 - Shape index > 1.8 - Elliptic Fit < 0.4
PB105	- normalized brightness > 0.61	- Hue(R='redHist',G='red',B='green') < 0.43	- Hue(R='blueHist',G='redHist',B='red') < 0.59 - Hue(R='blueLinear',G='redLinear',B='greenLinear') > 0.53 - Normalized brightness < 0.43	- Hue(R='blueHist',G='redHist',B='red') > 0.65 - Hue(R='blueLinear',G='redLinear',B='greenLinear') > 0.45 and HSI Transformation - Hue(R='blueLinear',G='redLinear',B='greenLinear') < 0.5	- Hue(R='blueLinear',G='redLinear',B='greenLinear') < 0.4 - Normalized brightness < 0.8 - Mean blue > 55 - Asymmetry > 0.83 - Shape index > 1.8 - Elliptic Fit < 0.4
PB106	- Maximal difference >0.7 - Mean blueHist <= 85	- Mean redLinear >200 - Mean redHist >239 - Hue(R='blueLinear'.G='redLinear'.B='greenLinear') < 0.459	- Normalized Brightness < 0.41 - Hue(R='redHist'.G='red'.B='green') < 0.05	- Hue(R='greenLinear'.G='greenHist'.B='blueHist') > 0.67 - Hue(R='redHist'.G='red'.B='green') < 0.5 - Hue(R='blueLinear'.G='redLinear'.B='greenLinear') > 0.47	- First classify as L&L - Normalized Brightness >= 0.7 - Mean blue < 55 - Area <= 70 Pxl - Asymmetry <= 0.8 - Shape index < 1.6 - Elliptic Fit > 0.5

PB128	- Maximal difference >0.7 - Mean blueHist <= 55	- Mean redLinear >193 - Mean redHist >135	- Hue(R='blueLinear'. G='redLinear'.B='green Linear') > 0.5 - Hue(R='redHist'.G='r ed'.B='green') > 0.49	- - Hue(R='greenLinear'. G='greenHist'.B='blue Hist') > 0.88- Hue(R='redHist'.G='re d'.B='green') < 0.5	- First classify as L&L - Normalized Brightness >= 0.7 - Mean blue < 55 - Area <= 70 Pxl - Asymmetry <= 0.8 - Shape index < 1.6 - Elliptic Fit > 0.5
PB129	- Maximal difference >0.7 - Mean blueHist <= 65	- Mean redLinear >195 - Hue (R=redHist. G=red. B=green) <= 0.14	Hue(R='redHist'.G='re d'.B='green') > 0.51 - Hue(R='blueLinear'. G='redLinear'.B='green Linear') < 0.56	- Hue(R='greenLinear'. G='greenHist'.B='blue Hist') < 0.18 - Hue(R='redHist'.G=' red'.B='green') > 0.17	- First classify as L&L - Normalized Brightness >= 0.7 - Mean blue < 55 - Area <= 70 Pxl - Asymmetry <= 0.8 - Shape index < 1.6 - Elliptic Fit > 0.5
PB130	- normalized brightness > 0.65	- Intensity(R=redHist, G=red,B=green) > 0.68 - Hue(R='redHist',G='r ed',B='green') < 0.4	- Hue(R='blueLinear', G='redLinear',B='green Linear') > 0.62 - Hue(R='redHist',G='r ed',B='green') > 0.54 Hue(R='redLinear',G=' greenLinear',B='green Hist') > 0.52	- - Hue(R='redLinear',G=' greenLinear',B='green Hist') < 0.8	- Hue(R='blueLinear', G='redLinear',B='green Linear') < 0.39 - Normalized brightness < 0.8 - Mean blue > 55 - Asymmetry > 0.79 - Shape index > 1.8 - Elliptic Fit < 0.4
PB131	- normalized brightness > 0.61	- Hue(R='blueHist',G=' redHist',B='red') < 0.52 and HSI Transformation - Hue(R='blueHist',G=' redHist',B='red') > 0.27	- Hue(R='blueHist',G=' redHist',B='red') < 0.59 - Hue(R='blueLinear', G='redLinear',B='green Linear') > 0.53 - Normalized brightness < 0.43	- Hue(R='greenLinear', G='greenHist',B='blue Hist') > 0.66 - Hue(R='blueHist',G=' redHist',B='red') > 0.65 - Hue(R='blueLinear', G='redLinear',B='green Linear') > 0.45 and HSI Transformation - Hue(R='blueLinear', G='redLinear',B='green Linear') < 0.5	- Hue(R='blueLinear', G='redLinear',B='green Linear') < 0.4 - Normalized brightness < 0.8 - Mean blue > 55 - Asymmetry > 0.83 - Shape index > 1.8 - Elliptic Fit < 0.4
PB132	- Maximal difference >0.5 Mean blueHist <= 100	- Hue(R='greenLinear' ,G='greenHist',B='blue Hist') < 0.49 and HSI Transformation - Hue(R='greenLinear' ,G='greenHist',B='blue Hist') > 0.24	- Hue(R='blueLinear', G='redLinear',B='green Linear') > 0.51 - Intensity(R=greenHis t,G=blueHist,B=redHis t) > 0.67	- Intensity(R=greenHis t,G=blueHist,B=redHis t) < 0.69 - Hue(R='redHist',G='r ed',B='green') < 0.45	- Hue(R='blueLinear', G='redLinear',B='green Linear') > 0.36 and HSI Transformation - Hue(R='blueLinear', G='redLinear',B='green Linear') < 0.4 - Normalized brightness < 0.84 - Mean blue > 12 - Asymmetry > 0.8 - Shape index > 1.6 - Elliptic Fit < 0.5
PB156	- Maximal difference >1 - Mean blueHist <20	- Hue(R='blueHist',G=' redHist',B='red') > 0.36 and HSI Transformation - Hue(R='blueHist',G=' redHist',B='red') < 0.59 - Hue(R='redHist',G='r ed',B='green') > 0.06 and HSI Transformation - Hue(R='redHist',G='r ed',B='green') < 0.1	- Hue(R='blueLinear', G='redLinear',B='green Linear') > 0.49 - Intensity(R=greenHis t,G=blueHist,B=redHis t) > 0.83	- Intensity(R=greenHis t,G=blueHist,B=redHis t) > 0.59 - Hue(R='redHist',G='r ed',B='green') > 0.43	- Hue(R='blueLinear', G='redLinear',B='green Linear') < 0.39 and HSI Transformation - Hue(R='blueLinear', G='redLinear',B='green Linear') > 0.22 - Normalized brightness < 0.86 - Mean blue > 19 - Asymmetry > 0.8 - Shape index > 1.6 - Elliptic Fit < 0.5

PB157	- - Normalized brightness > 0.61	- Intensity(R=redHist, G=red,B=green) > 0.04 and HSI Transformation - Hue(R='redHist',G='red',B='green') < 0.17 - Hue(R='blueHist',G='redHist',B='red') < 0.39 and HSI Transformation - Hue(R='blueHist',G='redHist',B='red') > 0.14	- Hue(R='blueLinear', G='redLinear',B='green Linear') > 0.51 - Hue(R='redHist',G='red',B='green') > 0.5 - Hue(R='redHist',G='red',B='green') < 0.03	- Hue(R='redHist',G='red',B='green') > 0.12 and HSI Transformation - Hue(R='redHist',G='red',B='green') < 0.5	- Hue(R='blueLinear', G='redLinear',B='green Linear') < 0.39 - Normalized brightness < 0.8 - Mean blue > 55 - Area >= 100 Pxl - Asymmetry > 0.79 - Shape index > 1.8 - -Elliptic Fit < 0.4
PB158	- Maximal difference >0.7 - Mean blueHist <= 85	- Mean redLinear >210 - Mean redHist > 210 - Hue (R=redHist. G=red. B=green) <0.35	Hue(R='redHist'.G='red'.B='green') > 0.52 - Hue(R='blueLinear'. G='redLinear'.B='green Linear') > 0.48	- Hue(R='greenLinear'. G='greenHist'.B='blue Hist') < 0.2 - Hue(R='redHist'.G='red'.B='green') > 0.49 - Hue(R='blueLinear'. G='redLinear'.B='green Linear') < 0.5	- First classify as L&L - Normalized Brightness >= 0.85 - Mean blue < 55 - Area <= 70 Pxl - Asymmetry <= 0.8 - Shape index < 1.6 - Elliptic Fit > 0.5
PB159	- Maximal difference> 0.5 - Normalized brightness > 0.43	- Hue(R='blueHist',G='redHist',B='red') < 0.62 - Hue(R='redHist',G='red',B='green') < 0.44	- Hue(R='blueLinear', G='redLinear',B='green Linear') > 0.52 - Hue(R='greenLinear', G='greenHist',B='blue Hist') > 0.28 and HSI Transformation - Hue(R='greenLinear', G='greenHist',B='blue Hist') < 0.84 Hue(R='blueLinear',G='redLinear',B='greenLinear') > 0.47	- Intensity(R=greenHist,G=blueHist,B=redHist) < 0.68 - Hue(R='redHist',G='red',B='green') > 0.39	- Hue(R='blueLinear', G='redLinear',B='green Linear') < 0.4 and HSI Transformation - Hue(R='blueLinear', G='redLinear',B='green Linear') > 0.35 - Normalized brightness < 0.79 - Mean blue > 52 - Area >= 100 Pxl - Asymmetry > 0.79 - Shape index > 1.8 - Elliptic Fit < 0.4
PB183	- Maximal difference >0.7 - Mean blueHist <= 75	- Mean redLinear >201 - Hue (R=redHist. G=red. B=green) <0.28	- Hue(R='redHist'.G='red'.B='green') > 0.52 - Hue(R='blueLinear'. G='redLinear'.B='green Linear') > 0.49	- Hue(R='greenLinear'. G='greenHist'.B='blue Hist') < 0.2 - Hue(R='redHist'.G='red'.B='green') > 0.49 - Hue(R='blueLinear'. G='redLinear'.B='green Linear') < 0.5	- First classify as L&L - Normalized Brightness >= 0.80 - Mean blue < 55 - Area <= 70 Pxl - Asymmetry <= 0.8 - Shape index < 1.6 - Elliptic Fit > 0.5
PB184	- Maximal difference >0.7 - Mean blueHist <= 55	- Hue(R='blueHist',G='redHist',B='red') < 0.54 - Mean redHist > 185	- Hue(R='redHist',G='red',B='green') > 0.48 - Hue(R='blueLinear', G='redLinear',B='green Linear') > 0.47	- Hue(R='greenLinear', G='greenHist',B='blue Hist') < 0.72 - Hue(R='redHist',G='red',B='green') < 0.46	- Normalized brightness <= 0.8 - Mean blue > 55 - Area >= 70 Pxl - Asymmetry >= 0.8 - Shape index > 1.6 - Elliptic Fit < 0.5
PB185	- Maximal difference >0.5 - Mean blueHist <= 55	- Hue(R='blueHist',G='redHist',B='red') < 0.57 - Mean redHist > 200	- Hue(R='redHist',G='red',B='green') > 0.51 - Hue(R='blueLinear', G='redLinear',B='green Linear') > 0.5	- Hue(R='redHist',G='red',B='green') < 0.5 and HSI Transformation - Hue(R='redHist',G='red',B='green') > 0.31	- Normalized brightness <= 0.8 - Mean blue > 55 - Area >= 70 Pxl - Asymmetry >= 0.8 - Shape index > 1.6 - Elliptic Fit < 0.5
PB186	- - Normalized brightness > 0.61	- Intensity(R=redHist, G=red,B=green)>0.8 - Hue(R='redHist',G='red',B='green')<0.14	- Hue(R='blueLinear', G='redLinear',B='green Linear') > 0.48 - Hue(R='redHist',G='red',B='green') > 0.5 - Hue(R='blueHist',G='redHist',B='red') < 0.47 - Normalized brightness < 0.45	- - Intensity(R=redHist,G=red,B=green) < 0.65	- Hue(R='blueLinear', G='redLinear',B='green Linear') < 0.39 - Normalized brightness < 0.8 - Mean blue > 55 - Area >= 100 Pxl - Asymmetry > 0.79 - Shape index > 1.8

	- Hue(R='blueLinear', G='redLinear',B='green Linear') > 0.46 - Hue(R='blueLinear', G='redLinear',B='green Linear') > 0.45	- Elliptic Fit < 0.4