Supplementary Materials: Landscape Changes in the Southern Coalfields of West Virginia: Multi-Level Intensity Analysis and Surface Mining Transitions in the Headwaters of the Coal River from 1976 to 2016 *Land* 2021, *X*, Article No.

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Supplementary Materials

Table S1. Synoptic table of remote sensing and land change studies concerning surface mining in the Central Appalachian Region.

Research	Objectives	Main area of interest	Method used	Spatial scale of analysis
(Slonecker & Berger, 2001) [1]	Review of remote sensing methods applied to MTM	Area location and extent, geomorphological aspects, land use, vegetation and reclamation, water quality	Literature review.	Appalachia, particularly WV and Kentucky.
Townsend et al. (2009) [2]	Map extents of surfaces mining and mines reclamation. Land change analysis among three classes	Remote sensing classification and watershed hydrology	Programmed decision tree in C (with ancillary data, and several spectral index like NDVI)	Eight river basins (not contiguous, two groups)
Maxwell et al. (2014) [3]	Comparison of NAIP orthophotography and RapidEye satellite imagery	Land cover classification of surface mining reclamation	Machine learning (RF, SVMs) NAIP and RapidEye data	Hobet-12 mine
Maxwell & Warner (2015) [4]	Differentiate mine-reclaimed grassland from spectrally similar land covers	Mine–reclaimed grasslands	GEOBIA and machine learning (RF, SVMs), topographic data as ancillary data	Three watersheds in southern WV
Oliphant et al. (2016) [5]	Map invasive species	Reclaimed mining areas	Machine learning (RF, SVMs) with training data	567 km2, area is inside mining permits only
Ross, McGlynn, & Bernhardt (2016) [6]	Estimation of the total volumetric and topographic disturbance associated with mining	Environmental studies, environmental impact of MTR	Elevation change using historic pre-mining DEM and post-mining DEM	~11 500 km2 area, southern coalfields of WV
Pericak et al. (2018) [7]	Land use classification on a regional scale, correlation with coal production. Technique based on open data and easily accessible technology	Evaluation and trend of surface mining extents in the Central Appalachians Region	NDVI calculation with time series and Google Earth Engine	Regional Scale, Central Appalachians,74 counties, 83000 km^2
Yang et al. (2018) [8]	How vegetation reclaimed after mining activities. The trend of vegetation recover (integrity index).	Surface mines reclamation	NDVI signatures and times series trajectories-based analyses	Two counties

Table S2. The error matrix for the classification of 1976 obtained with the Ranger package in R. Values in the cells represent the number of objects, while accuracies are reported with the percentage of land area.

		Reference							
		Barren	**Deciduous forest**	**Evergreen forest**	**Low vegetation**	**Developed areas**	**Water**	**Row tot.**	**User's accuracy % (Commission Errors)**
Classification	**Barren**	116	1	0	0	1	0	118	98.3
	Deciduous forest	13	60	0	0	0	0	73	82.2
	Evergreen forest	0	0	66	0	0	0	66	100.0
	Low Vegetation	0	2	0	57	1	0	60	95.0
	Developed areas	4	0	0	0	55	0	59	93.2
	Water	0	0	0	0	0	26	26	100.0
	Column tot	**133**	**63**	**66**	**57**	**57**	**26**	**Overall accuracy 94.5%**	
	Producer's accuracy (%) (Omission Errors)	**87.2**	**95.2**	**100.0**	**100.00**	**96.5**	**100.0**		

Table S3. The error matrix for the classification of 1996 obtained with the Ranger package in R. Values in the cells represent the number of objects, while accuracies are reported with the percentage of land area.

		Reference								
		Barren clear	Barren dark	Deciduous forest	Evergreen forest	Low vegetation	Developed areas	Water	Row tot.	User's accuracy % (Commission Errors)
Classification	Barren clear	43	0	0	0	1	10	0	54	79.6
	Barren dark	0	39	0	0	1	1	0	41	95.1
	Deciduous forest	2	0	48	6	1	1	0	58	82.8
	Evergreen forest	0	0	0	43	0	0	0	43	100.0
	Low Vegetation	0	0	2	1	47	0	0	50	94.0
	Developed areas	5	0	0	0	0	34	1	40	85.0
	Water	0	11	0	0	0	1	49	61	80.3
	Column tot.	50	50	50	50	50	47	50	Overall accuracy 87.3%	
	Producer's accuracy (%) (Omission Errors)	86.0	78.0	96.0	86.0	94.0	72.3	98.0		

Table S4. The error matrix for the classification of 2019, from Maxwell et al. (2019) [9]. Values in the cells represent the number of objects, while accuracies are reported with the percentage of land area.

	Reference							
	Barren	Forest	Low vegetation	Impervious	Mixed developed	Water	Row Total	User's Accuracy (Commission Errors)

Classification	Barren	75	4	41	59	1	5	185	37.6%
	Forest	11	20420	548	50	135	13	21177	98.0%
	Low Vegetation	63	72	2452	30	68	0	2685	94.0%
	Impervious	12	3	20	207	20	14	276	78.9%
	Mixed Developed	0	45	81	77	292	2	497	61.7%
	Water	1	17	4	1	1	154	178	96.4%
	Column Total	162	20561	3146	424	517	188	Overall Accuracy: 96.7%	
	Producer's Accuracy (%) (Omission Errors)	5.1%	99.4%	85.8%	56.8%	61.4%	97.9%		

Table S5. Number of training and validation objects for the LC classification of 1976.

Class name	number of training objects	number of validation objects
Barren	194	133
Deciduous Forest	386	63
Evergreen forest	131	66
Low Vegetation	113	57
Developed areas	122	57
Water	25	26
Total # of points	971	402

Table S6. Number of training and validation objects for the LC classification of 1996.

Class name	number of training objects	number of validation objects
Barren clear	104	50
Barren dark	62	50
Deciduous Forest	456	50
Evergreen forest	128	50
Low Vegetation	67	50
Developed areas	73	47
Water	152	50
Total # of points	1042	347

Table S7. Number of training and validation objects for the LC classification of 2016.

Class name	number of training objects	number of validation objects
Forest	13347	20561
Low Vegetation	13353	3146
Barren	1056	162
Water	1098	188
Impervious	1205	424
Mixed Developed	1022	517

Total # of points	31081	24998

Table S8. The quantities derived from the three land cover classifications used in the land-change analysis after the post-processing phase. Quantities are expressed in hectares and cells values (square meters).

Classes	1976		1996		2016	
	cells	Ha	cells	Ha	cells	Ha
Forest	485084244	48508.4	511458142	51145.8	511706592	51170.7
Low vegetation	61618287	6161.8	35552080	3555.2	42749707	4275
Barren	25324948	2532.5	22099261	2209.9	16007616	1600.8
Water	2740910	274.1	3217569	321.8	3255575	325.6
Developed areas	11842685	1184.3	14284295	1428.4	12891884	1289.2

Example of the process of establishment and abandonment of the settlement of Montcoal during the interval 1912-2016.

By way of example, the process of establishment and abandonment of the settlement of Montcoal during the interval 1912-2016 is reported in Figures S1-S2 together with some detailed images derived by the LC maps. The settlement was established with the opening of a mine in Montcoal Mountain in 1916; it was one of the leading coal towns [10] founded in the Coal River's headwaters [11]. Figures S1-S2 are exemplificative of the land-change processes; they also present the LCCs on a more detailed scale.

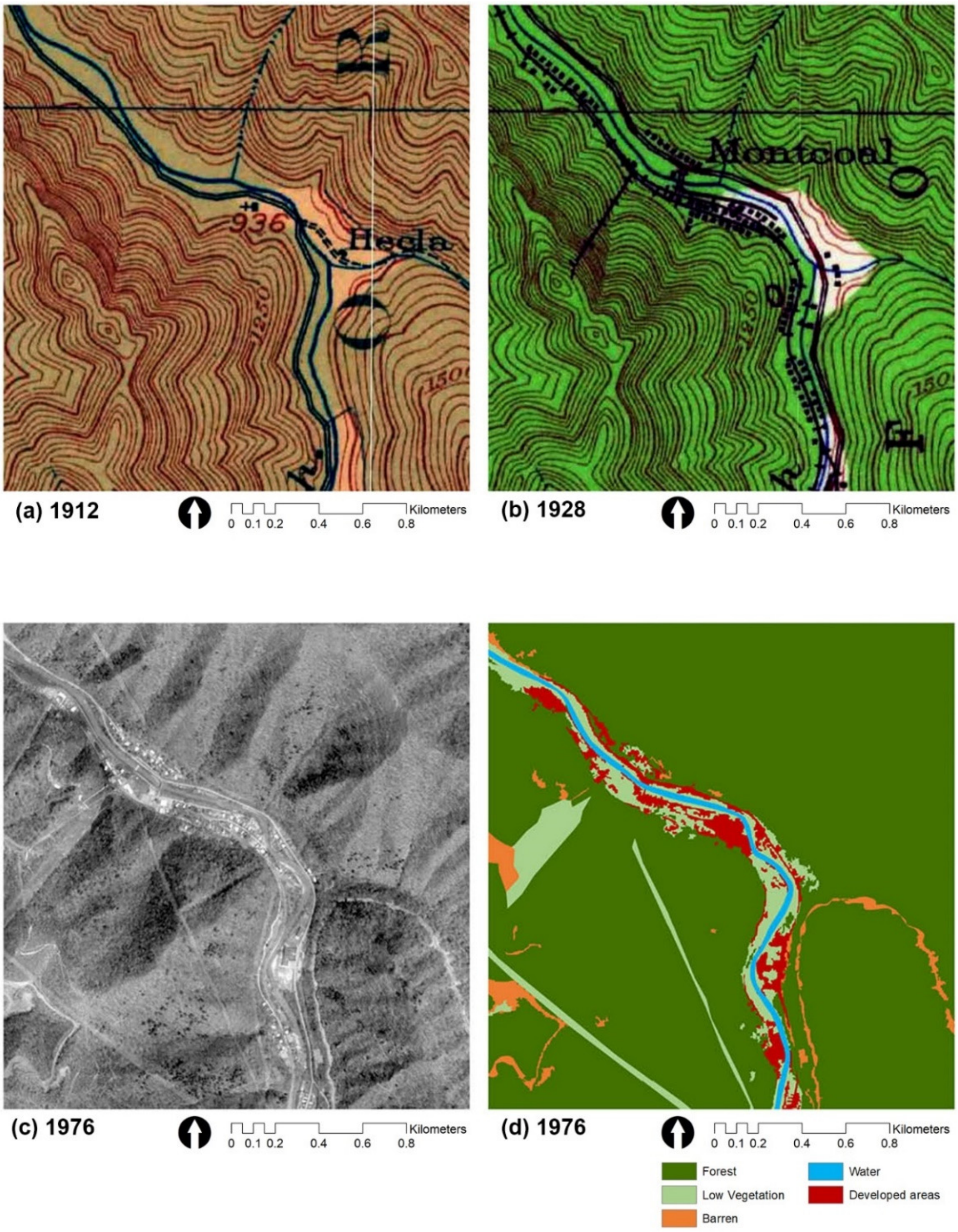

Figure S1. Comparison of historical maps, orthoimages, and LC maps. (**a**) part of the USGS 1:62500 Quadrangle for Bald Knob, WV 1912; (**b**) part of the USGS 1:62500 Quadrangle for Bald Knob, WV 1928; (**c**) part of the orthomosaic derived from 1976-1977 USGS aerial images; (**d**) a detail of the landcover produced for 1976.

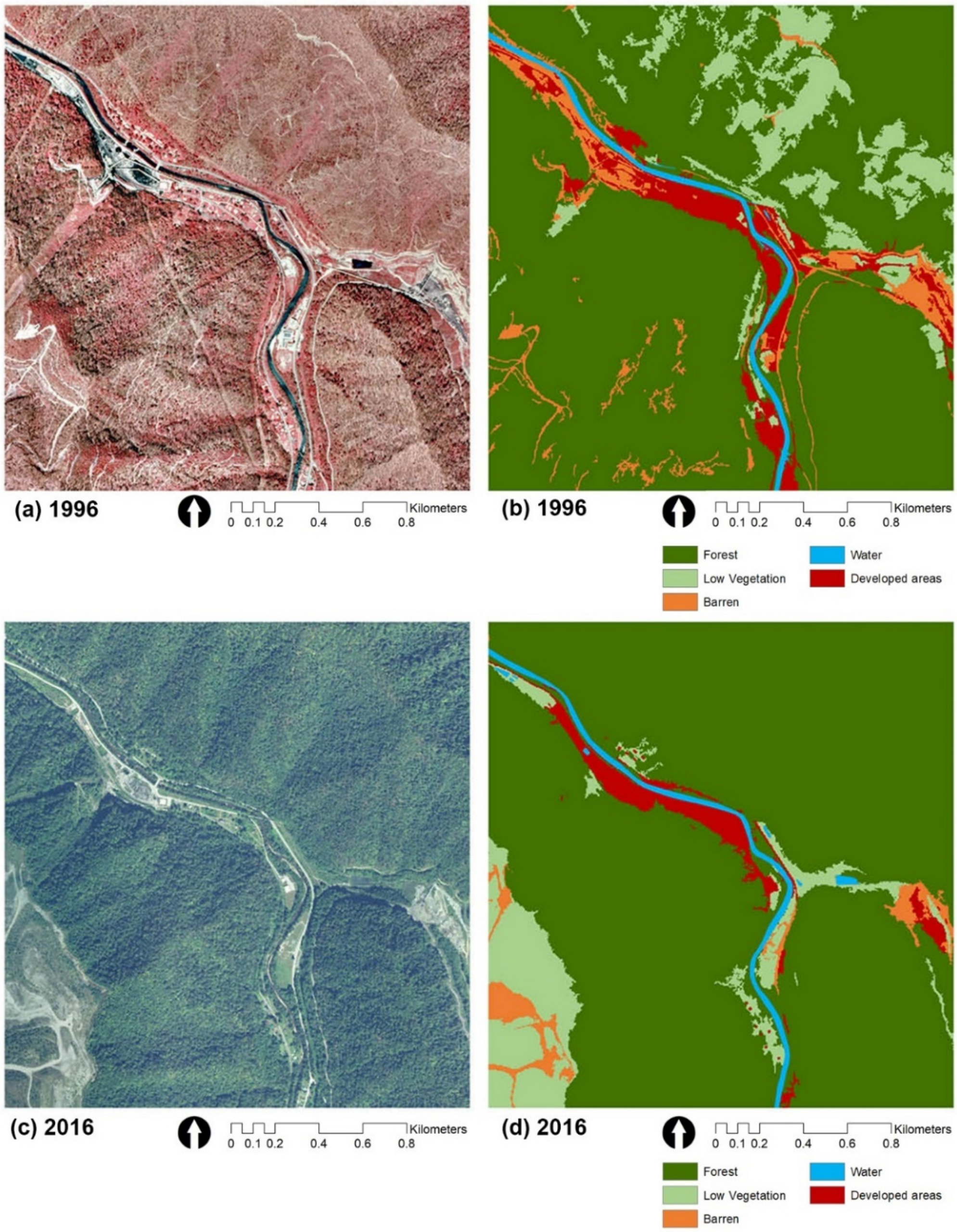
(a) 1996
0 0.1 0.2 0.4 0.6 0.8 Kilometers
(b) 1996
0 0.1 0.2 0.4 0.6 0.8 Kilometers
Forest
Low Vegetation
Barren
Water
Developed areas
(c) 2016
0 0.1 0.2 0.4 0.6 0.8 Kilometers
(d) 2016
0 0.1 0.2 0.4 0.6 0.8 Kilometers
Forest
Low Vegetation
Barren
Water
Developed areas

Figure S2. Comparison of historical maps, orthoimages, and LC maps (**a**) part of the DOQ NIR of 1996 mosaic; (**b**) part of the classification of 1996; (**c**) NAIP image of 2016; (**d**) detail of the land cover of 2016.

Comparison of surface mining extents

The following section presents a comparison of the overall estimation of surface mining areas derived from this study with the findings of Pericak et al. (2018) [7]. The surface mining areas based on the SkyTruth data were derived from the cumulative yearly dataset from 1976 to 2016 [7]. These data were combined in three time-points to allow the comparison with the data used in this study.
The surface mining areas derived from the three LCCs produced in this study were combined, adopting the following criteria. The surface mines from 1976 LCC coincided with the overall size of barren land. For the mining areas of 1996, only the barren and the low vegetation LC classes inside the mining permits were considered; the data obtained were overlaid with the barren land from 1976. For the 2016 data, barren and low vegetation classes were considered only for areas inside the mining permits. This dataset was overlaid with the cumulative set derived from 1996.
The results suggested that the SkyTruth study generally underestimated the surface mining extents derived before 1977, probably because the thin strip-minings patterns were hardly detectable by the early Landsat satellites. This hypothesis is coherent with the limitations authors declared in their findings for the data before 1985. For 1996, when excluding the amount of mining areas derived from the previous dataset of 1976, the quantities estimated in the two studies are very similar with a difference of about 26 hectares. For 2016, when excluding the amount of mining areas derived from the previous dataset of 1996, the SkyTruth is larger; it is worth mentioning that their data are not limited to mining permits. Compared with the SkyTruth data, the findings in this study reported a 39% increase of the overall disturbed land mainly derived from pre-SMCRA surface mine; it corresponds to a difference of 1708.8 hectares (Table S7, Figure S3). The region's mining history suggests that similar findings can be expected in the neighboring watersheds, specifically the WV coal counties and the central Appalachian coalfields, where MTM operations are spread out. Overall conclusions imply it should be reasonable to expect an amount of historically disturbed land in the Central Appalachia region more extensive than the one measured by Pericak et al. (2018) [7].

Table S9. Comparison of the overall surface mining areas.

Hectares of surfaces mining			
	1976	**1996**	**2016**
Current study	**2514.2**	**3689.9**	**6096.9**
SkyTruth	**154.0**	**1303.8**	**4388.1**
Difference	**2360.2**	**2386.0**	**1708.8**

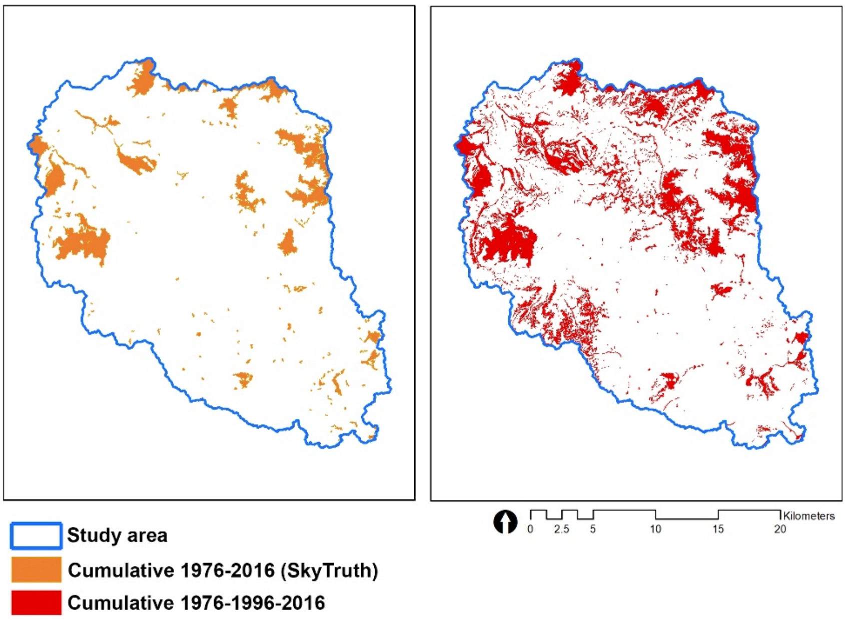

Figure S3. Comparison of the distribution of the two cumulative datasets.

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