



Supplement of

Refined burned-area mapping protocol using Sentinel-2 data increases estimate of 2019 Indonesian burning

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Supplementary Tables.

Table S1. Landcover types associated with the training sites one year before fire (2018) based on the ESA CCI global land cover maps described here (<http://maps.elie.ucl.ac.be/CCI/viewer/index.php>). The training sites were associated with 15 landcover types.

CCI 2018 Land Cover	Unburned	Burned
Cropland, rainfed	54	33
Herbaceous cover	58	44
Tree or shrub cover	29	6
Cropland, irrigated or post-flooding	6	0
Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover)	93	52
Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland	40	28
Tree cover, broadleaved, evergreen, closed to open (>15%)	132	47
Mosaic tree and shrub (>50%) / herbaceous cover (<50%)	0	5
Mosaic herbaceous cover (>50%) / tree and shrub (<50%)	2	12
Shrubland	9	0
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	31	39
Tree cover, flooded, fresh or brakish water	57	33
Tree cover, flooded, saline water	18	0
Urban areas	136	18
Water bodies	6	0
Total number of training sites	671	317

Table S2. Density of sites of the reference dataset. One site is an area of 20 m x 20 m. The total combined burned areas of all three datasets in the seven provinces is 2.745 Mha. It presents a high density of sites (> 150 sites/Mha), while the density of sites is lower in the area classified as unburned by all three datasets (10.36 sites/Mha). The row with ‘Yes Yes Yes’ represents the area (0.529 Mha) where all three datasets were classified as burned. The other rows indicate all other possible combinations after intersection of all three burned area datasets.

<i>Sentinel</i>	<i>Official</i>	<i>MCD64A1</i>	<i>Area (Ha)</i>	<i>No of reference sites</i>	<i>Density of samples (Sites/Mha)</i>
No	Yes	Yes	0.146	22	150.25
No	Yes	No	0.201	31	154.15
No	No	Yes	0.561	86	153.16
Yes	Yes	Yes	0.529	81	153.05
Yes	Yes	No	0.318	48	150.98
Yes	No	Yes	0.346	53	152.97
Yes	No	No	0.643	98	152.47
Total			2.745	419	
No	No	No	84.857	879	10.36

Table S3. Estimation of the expected sample size in the areas classified as unburned in the dataset that was being evaluated but burned in the other datasets.

	<i>Burned area (B) dataset i (Mha)</i>	<i>Unburned area (U') detected as burned in datasets $\neq i$ (Mha)</i>	<i>Expected sample size in U'</i>	<i>Subsample size (B + U + U')</i>
<i>Sentinel</i>	1.836	0.909	9	280 + 879 + 9
<i>Official</i>	1.195	1.551	16	182 + 879 + 16
<i>MCD64A1</i>	1.584	1.162	12	242 + 879 + 12

Table S4. Landcover types associated with the reference sites one year before fire (2018) based on the ESA CCI global land cover maps described here (<http://maps.elie.ucl.ac.be/CCI/viewer/index.php>).

CCI 2018 Land Cover	Unburned	Burned
Cropland, rainfed	16	13
Herbaceous cover	16	3
Tree or shrub cover	23	6
Cropland, irrigated or post-flooding	1	0
Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover)	127	101
Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland	150	73
Tree cover, broadleaved, evergreen, closed to open (>15%)	467	63
Mosaic tree and shrub (>50%) / herbaceous cover (<50%)	5	6
Mosaic herbaceous cover (>50%) / tree and shrub (<50%)	7	20
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	16	33
Tree cover, flooded, fresh or brakish water	94	31
Tree cover, flooded, saline water	19	4
Urban areas	1	0
Water bodies	3	0
Total number of reference sites	945	353

Table S5. Confusion matrix. A_m = Area mapped (the area classified as class i by the Random Forest; the sum of this column equals to the total area of study). W_h = Proportion of area mapped (the proportion of area classified as class i ; the sum of this column equals to 1)

<i>SENTINEL</i>		<i>Reference</i>			A_m [ha]	W_h
		<i>Burned</i>	<i>Unburned</i>	<i>Total</i>		
<i>Map</i>	<i>Burned</i>	274	6	280	1,836,396	0.021
	<i>Unburned</i>	6	882	888	85,766,079	0.979
	<i>Total</i>	280	888	1,166	87,602,475	1

<i>OFFICIAL</i>		<i>Reference</i>			A_m [ha]	W_h
		<i>Burned</i>	<i>Unburned</i>	<i>Total</i>		
<i>Map</i>	<i>Burned</i>	173	9	182	1,194,705	0.014
	<i>Unburned</i>	12	883	895	86,407,770	0.986
	<i>Total</i>	185	892	1,077	87,602,475	1

<i>MCD64A1</i>		<i>Reference</i>			A_m [ha]	W_h
		<i>Burned</i>	<i>Unburned</i>	<i>Total</i>		
<i>Map</i>	<i>Burned</i>	184	58	242	1,583,643	0.018
	<i>Unburned</i>	11	880	881	86,018,832	0.982
	<i>Total</i>	195	938	1,133	87,602,475	1

Supplementary Figures.

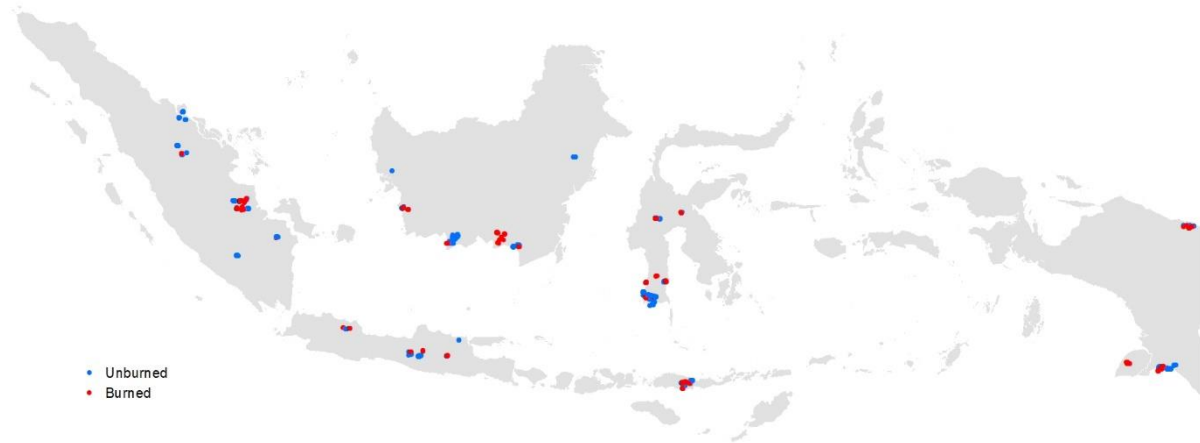


Figure S1. Location of 988 training pixels (317 'burned' and 671 'unburned') used to train our supervised classification model (Random Forest) across Indonesia (grey area).

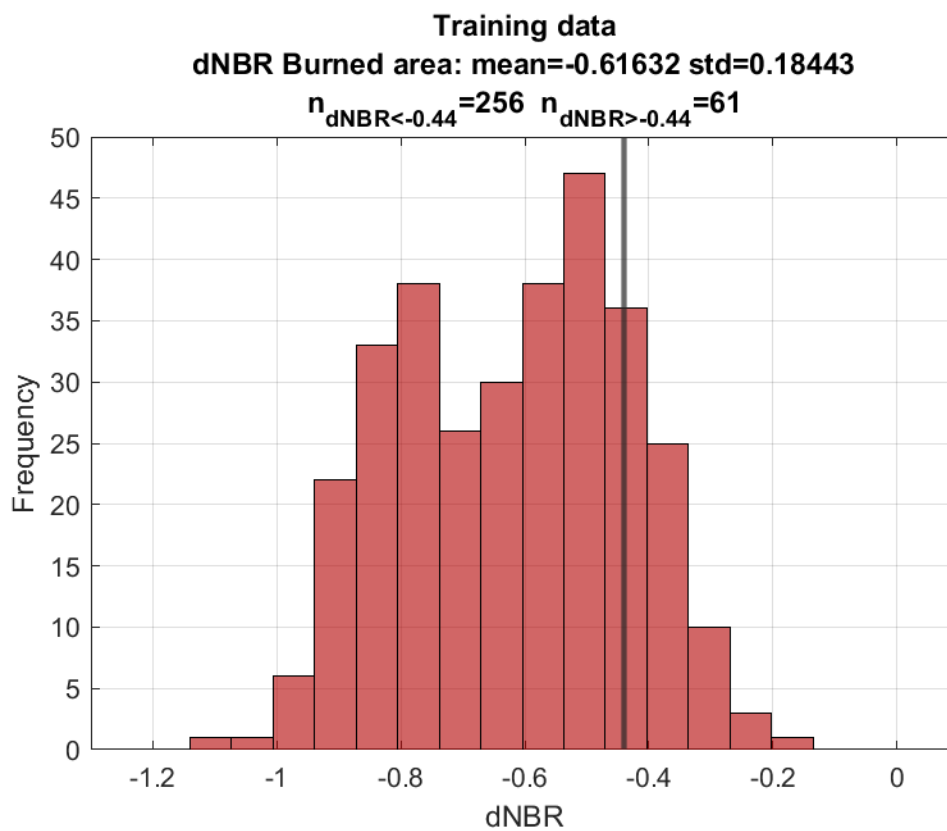


Figure S2. Histogram of dNBR ($NBR_{\text{postfire}} - NBR_{\text{prefire}}$) for the 317 training points labelled 'burned'.

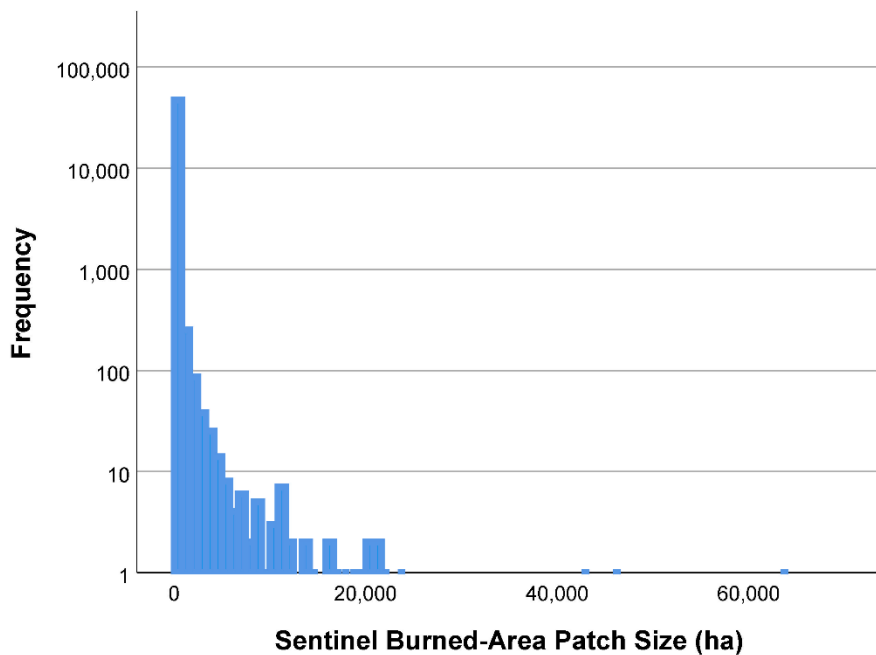
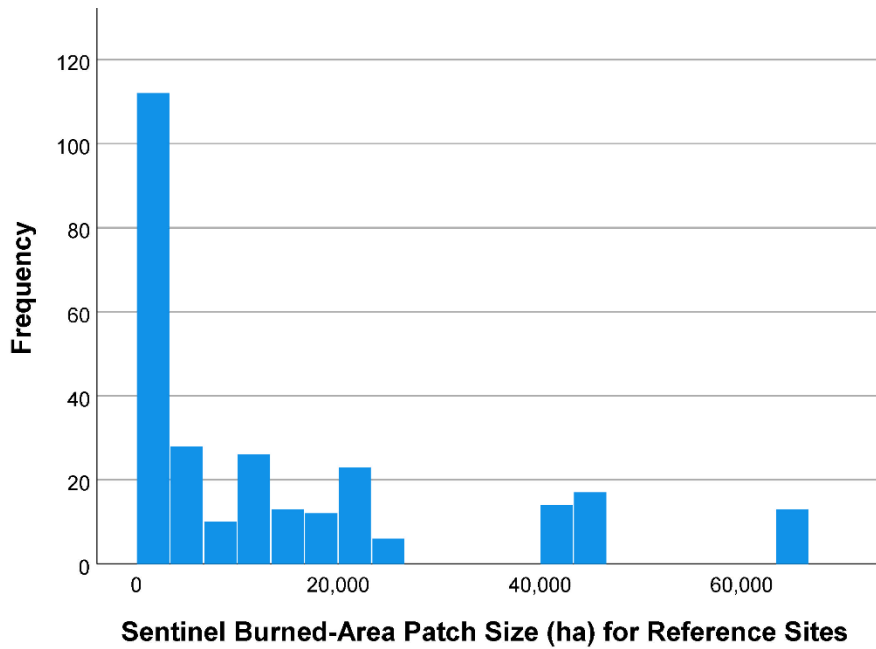


Figure S3. Frequency distributions of burn scar sizes of the Sentinel-2 burned-area map, for select spatially coincident reference sites used to validate the Sentinel burned-area map (top), and for all of Indonesia (bottom). Note: Bin widths are not consistent between upper and lower panels. In the lower panel, note the logarithmic scale of the y-axis and the presence of rare patches above 40,000 ha. Patches <6.25 ha are excluded. Reference sites (top) are those 274 sites deemed ‘burned’ by visual inspections (labelled as ‘truth’) and coincident with Sentinel-2 burn scars.

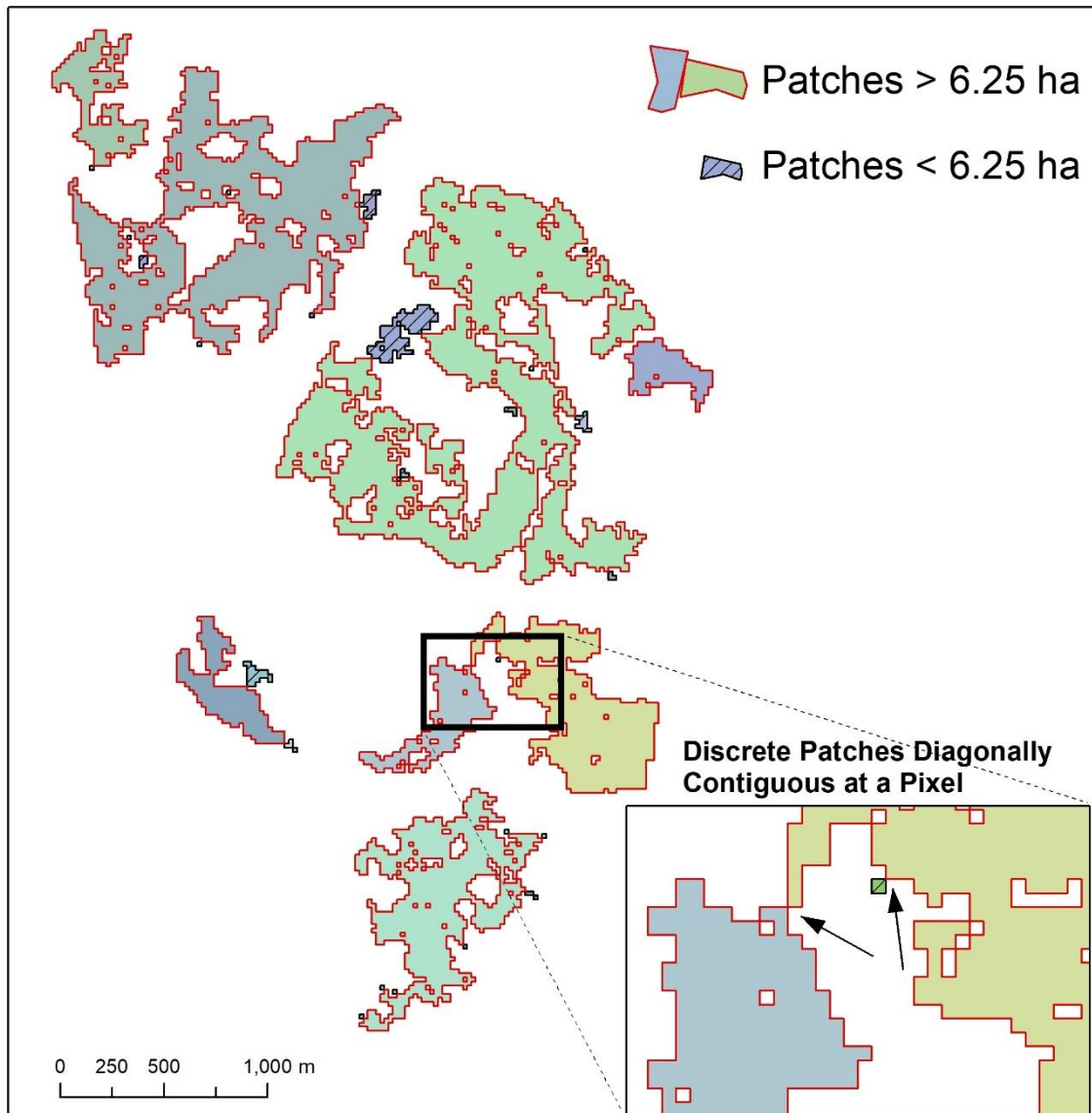


Figure S4. Discrete burned-area patches according to Sentinel data.

Notes: Discrete patches are denoted by unique shading. Patches that are contiguous diagonally at a given pixel are deemed to be discrete burned areas. Patches < 6.25 ha are excluded from analysis in the main text.

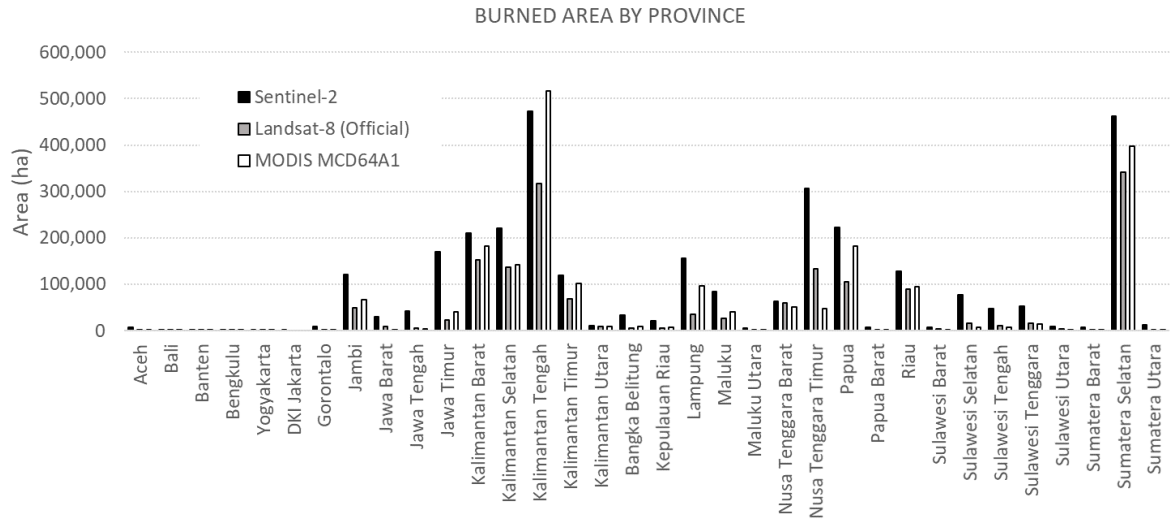


Figure S5. Estimated area of land that burned in 2019 in Indonesia’s 34 provinces, based on the analyses of Sentinel-2 imagery, Official and MODIS MCD64A1

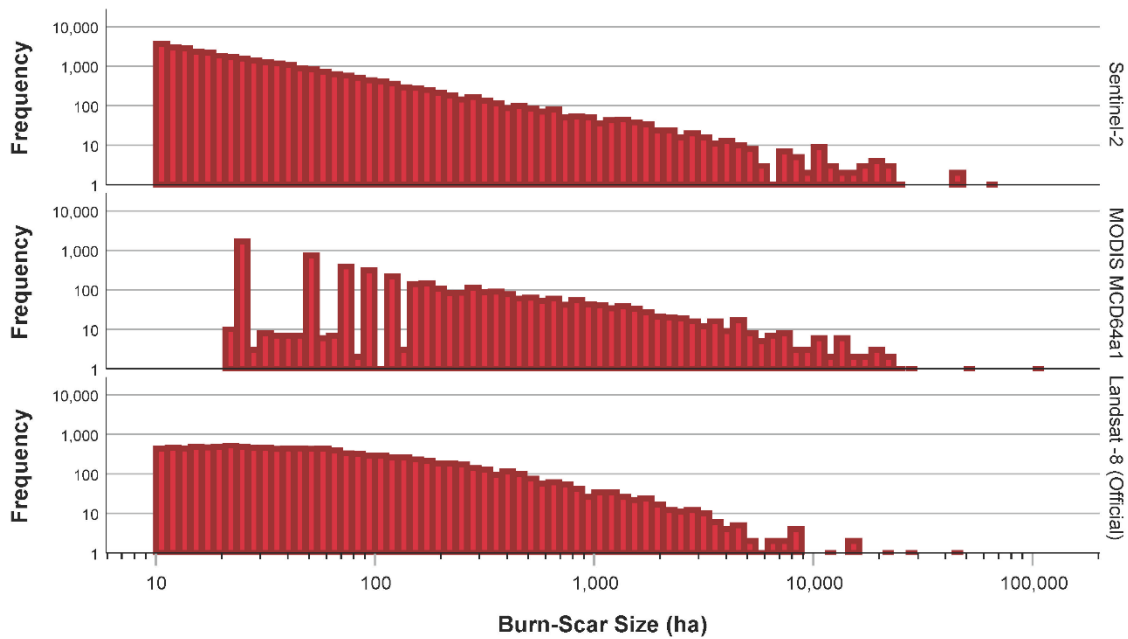


Figure S6. Histogram of burn-scar size (ha) for Sentinel, MODIS MCD64A1, and MOEF burned area products. Notes: Note the logarithmic axes.