

## Supplementary Material, Figure S1.

### Google Earth Engine code used to extract total pixel count for each land cover/land use type

```
Google Earth Engine Search places and datasets...

Final Project/MapBIOMAS - SP Annual Land Cover Get Link Save Run Reset Apps

1 //Create feature for Sao Paulo Boundary
2 var Admins = ee.FeatureCollection("FAO/GAUL/2015/level1");
3 var SaoPaulo = Admins.filter(ee.Filter.eq('ADM1_NAME', 'Sao Paulo'));
4 // print(SaoPaulo);
5 //Map.addLayer(SaoPaulo, {}, 'Sao Paulo');
6 Map.centerObject(SaoPaulo, 6);
7
8 // import images from Mapbiomas project
9 var MapBiomas = ee.Image('projects/mapbiomas-workspace/public/collection5/mapbiomas_collection50_integration_v1');
10
11 // return number of pixels for each classification type for full Mapbiomas project (1985-2019)
12 var frequency = MapBiomas.reduceRegion({
13   reducer: ee.Reducer.frequencyHistogram(),
14   geometry: SaoPaulo,
15   scale: 300,
16   maxPixels: 104744501200
17 });
18 print(frequency); // select data from relevant years only (2002-2017)
19
20 // Rename objects to reflect Mapbiomas classes
21 // Lookup table based on https://mapbiomas-br-site.s3.amazonaws.com/_EN_C%3%B3digos_da_legenda_Cole%C3%A7%C3%A3o_5__1_.pdf
22 // "0": "Not Observed"
23 // "1": "Forest"
24 // "2": "Natural Formation",
25 // "3": "Forest Formation",
26 // "4": "Savanna Formation",
27 // "5": "Mangrove",
28 // "9": "Forest Plantation",
29 // "10": "Non Forest Natural Formaton",
30 // "11": "Wetland",
31 // "12": "Grassland Formation",
32 // "32": "Salt Flat",
33 // "29": "Rocky Outcrop",
34 // "13": "Other non Forest Formaton",
35 // "14": "Farming",
36 // "15": "Pasture",
37 // "18": "Agriculture",
38 // "19": "Temporary Crop",
39 // "39": "Soybean",
40 // "20": "Sugar Cane",
41 // "41": "Other Temporary Crops",
42 // "36": "Perennial Crop",
43 // "21": "Mosaic of Agriculture and Pasture",
44 // "22": "Non vegetated area",
45 // "23": "Beach and Dune",
46 // "24": "Urban Infrastructure",
47 // "30": "Mining",
48 // "25": "Other non Vegetated Areas",
49 // "26": "Water",
50 // "33": "River, Lake and Ocean",
51 // "31": "Aquaculture"
52
53 // import project palette
54 var palettes = require('users/mapbiomas/modules/Palettes.js');
55
56 // select year(s) to visualize
57 var startYear = 2002;
58 var midYear = 2010;
59 var endYear = 2017;
60
61 // Each classification year is a band
62 // Apply palette to each selected band year
63 var vis1 = {
64   'bands': ['classification_' + String(startYear)],
65   'min': 0,
66   'max': 34,
67   'palette': palettes.get('classification2')
68 };
69
70 var vis2 = {
71   'bands': ['classification_' + String(midYear)],
72   'min': 0,
73   'max': 34,
74   'palette': palettes.get('classification2')
75 };
76
77 var vis3 = {
78   'bands': ['classification_' + String(endYear)],
79   'min': 0,
80   'max': 34,
81   'palette': palettes.get('classification2')
82 };
83
84 Map.addLayer(MapBiomas.clip(SaoPaulo), vis1, 'Land use for ' + startYear.toString(), true);
85 Map.addLayer(MapBiomas.clip(SaoPaulo), vis2, 'Land use for ' + midYear.toString(), true);
86 Map.addLayer(MapBiomas.clip(SaoPaulo), vis3, 'Land use for ' + endYear.toString(), true);
87
```

## Supplementary Material, Figure S2.

Google Earth Engine code used to create yearly burned area mask to calculate total number of pixel for each land cover/land use type in an area with a MODIS detected fire event

```
Google Earth Engine Search places and datasets...

Sao Paulo/MODIS monthly burned areas Get Link Save Run Reset Apps

1 // Study period 2002 - 2017
2 // Select year here to choose corresponding MODIS data and Mapbiomas classification image
3 var year = 2002;
4
5 var Admins = ee.FeatureCollection("FAO/GAUL/2015/level1");
6 var SaoPaulo = Admins.filter(ee.Filter.eq('ADM1_NAME', 'Sao Paulo'));
7 //print(SaoPaulo);
8
9 // MODIS available dates 2000-02-18T00:00:00 - PRESENT
10 var dataset = ee.ImageCollection('MODIS/006/MCD64A1')
11   .filter(ee.Filter.date(year+'-01-01', year+'-12-31'))
12   .map(function(image){return image.clip(SaoPaulo)});
13
14 // Reduce image collection to a single image per year
15 var annualFires = dataset.reduce(ee.Reducer.median());
16 var firemask = annualFires.select('BurnDate_median');
17 //print(firemask);
18
19 var MapBiomas = ee.Image('projects/mapbiomas-workspace/public/collection5/mapbiomas_collection50_integration_v1')
20   .select('classification_'+year);
21 //print(MapBiomas);
22
23 var firemasked = MapBiomas.updateMask(firemask);
24
25 // Print out the number of burned pixels for each cover type.
26 // Applies the burn mask to all the MapBiomas images
27 // frequency counts will only be correct for the band (year) that corresponds with the MODIS filter year
28
29 var frequency = firemasked.reduceRegion({
30   reducer: ee.Reducer.frequencyHistogram(),
31   geometry: SaoPaulo,
32   scale: 300
33 });
34 //print(String(year) + ' - Aggregate MODIS Monthly Fire ', frequency);
35
36 var dict = ee.Dictionary(frequency.get('classification_' + String(year)));
37 var new_dict = dict.map(function(k,v){
38   return ee.Number(v);
39 });
40
41 // Rename objects to reflect MapBIOMAS classes
42 // Names retrieved from able based on https://mapbiomas-br-site.s3.amazonaws.com/_EN_C%C3%B3digos_da_legenda_Cole%C3%A7%C3%A3o_5_1_.pdf
43 // Comment out types when not included in annual classification
44
45
46 var landcover = ee.Dictionary({
47   //1: "Forest", //2: "Natural Formation",
48   "3": "Forest Formation",
49   "4": "Savanna Formation",
50   //5: "Mangrove",
51   "9": "Forest Plantation",
52   //10: "Non Forest Natural Formaton",
53   "11": "Wetland",
54   "12": "Grassland Formation",
55   //13: "Salt Flat",
56   "29": "Rocky Outcrop",
57   "13": "Other non Forest Formations",
58   //14: "Farming",
59   "15": "Pasture",
60   //18: "Agriculture", //19: "Temporary Crop",
61   "39": "Soybean",
62   "20": "Sugar Cane",
63   "41": "Other Temporary Crops",
64   "36": "Perennial Crop",
65   "21": "Mosaic of Agriculture and Pasture",
66   //22: "Non vegetated area", //23: "Beach and Dune",
67   "24": "Urban Infrastructure",
68   "30": "Mining",
69   "25": "Other non Vegetated Areas",
70   //26: "Water",
71   "33": "River, Lake and Ocean",
72   //31: "Aquaculture", //0: "Not Observed",
73 });
74
75 print(String(year) + ' - Aggregate MODIS Monthly Fire ', new_dict.rename({
76   from: landcover.keys(),
77   to: landcover.values()
78 }));
79
80 // color only outline of SP, no fill color
81 var empty = ee.Image().byte();
82 var outline = empty.paint({
83   featureCollection: SaoPaulo,
84   color: 1,
85   width: 3
86 });
87 Map.addLayer(outline, {palette: 'black'}, 'Sao Paulo State');
88 Map.addLayer(firemasked, {palette: 'red'}, 'Fire Events');
```

**Supplementary Material, Table S1.**

**Sum totals of the gross added value of agriculture, gross added value across all sectors, gross domestic product (GDP), annual inflation rate for Brazil, and inflation corrected GDP**

<b>Year</b>	<b>Sum of gross added value of agriculture</b>	<b>Sum of total gross added value</b>	<b>Sum of gross Domestic Product</b>	<b>Inflation rate</b>	<b>Corrected GDP</b>
<b>2002</b>	\$ 14,112,139.40	\$ 430,781,193.23	\$ 518,878,815.17	8.45%	\$ 475,033,555.29
<b>2003</b>	\$ 15,683,499.10	\$ 492,825,390.86	\$ 591,454,031.64	14.71%	\$ 504,451,143.58
<b>2004</b>	\$ 14,796,608.49	\$ 539,425,320.93	\$ 652,955,557.52	6.60%	\$ 609,860,490.72
<b>2005</b>	\$ 15,586,855.31	\$ 619,285,178.45	\$ 743,042,944.44	6.87%	\$ 691,995,894.16
<b>2006</b>	\$ 19,562,571.87	\$ 686,836,869.88	\$ 824,529,299.05	4.18%	\$ 790,063,974.35
<b>2007</b>	\$ 21,201,862.17	\$ 782,245,713.72	\$ 935,653,179.99	3.64%	\$ 901,595,404.24
<b>2008</b>	\$ 18,004,557.76	\$ 854,006,280.55	\$ 1,042,510,167.95	5.68%	\$ 983,295,590.41
<b>2009</b>	\$ 23,610,343.42	\$ 939,371,647.05	\$ 1,127,093,826.12	4.89%	\$ 1,071,978,938.02
<b>2010</b>	\$ 22,631,448.90	\$ 1,071,840,401.68	\$ 1,294,695,988.45	5.04%	\$ 1,229,443,310.63
<b>2011</b>	\$ 23,370,861.71	\$ 1,184,832,820.72	\$ 1,436,672,709.02	6.64%	\$ 1,341,277,641.14
<b>2012</b>	\$ 23,809,337.25	\$ 1,286,699,000.77	\$ 1,559,033,443.70	5.54%	\$ 1,472,662,990.92
<b>2013</b>	\$ 26,457,535.09	\$ 1,419,426,222.29	\$ 1,715,238,416.57	6.20%	\$ 1,608,893,634.74
<b>2014</b>	\$ 27,335,095.71	\$ 1,552,872,896.86	\$ 1,858,196,055.49	6.33%	\$ 1,740,572,245.18
<b>2015</b>	\$ 26,323,233.63	\$ 1,626,004,207.51	\$ 1,939,901,907.12	9.03%	\$ 1,764,728,764.91
<b>2016</b>	\$ 35,827,656.85	\$ 1,725,307,449.73	\$ 2,038,757,381.63	8.74%	\$ 1,860,569,986.48
<b>2017</b>	\$ 36,514,604.66	\$ 1,785,834,012.07	\$ 2,119,854,035.00	3.45%	\$ 2,046,719,070.79

Annual inflation rate from:

<https://www-statista-com.proxy.wexler.hunter.cuny.edu/statistics/270812/inflation-rate-in-brazil/>

**Supplementary Material, Table S2.**

**Yearly total number of by land use/land cover type**

<b>Year</b>	<b>Wetland</b>	<b>Grassland Formation</b>	<b>Other non Forest Formations</b>	<b>Pasture</b>	<b>Sugar Cane</b>	<b>Mosaic of Agriculture and Pasture</b>	<b>Urban Infrastructure</b>	<b>Other non Vegetated Areas</b>
<b>2002</b>	4163	14333	725	1236347	335314	464572	75118	1827
<b>2003</b>	4007	14132	687	1189085	352904	489076	76264	1476
<b>2004</b>	4227	14753	779	1154094	378336	489581	76836	1794
<b>2005</b>	4378	15416	805	1112608	397721	502164	77478	1954
<b>2006</b>	4517	15566	819	1056135	424991	519214	78045	1904
<b>2007</b>	4621	17108	768	988632	488025	515703	80059	2084
<b>2008</b>	4627	17135	713	928460	580322	493335	80120	2043
<b>2009</b>	4680	16596	752	889415	630219	476959	82651	1700
<b>2010</b>	4828	16821	763	849239	644487	491907	84036	1735
<b>2011</b>	4896	16803	766	810603	656298	507049	85208	1272
<b>2012</b>	5154	15696	777	760162	686928	516637	86446	1464
<b>2013</b>	5495	15267	775	723140	708498	522678	88290	1596
<b>2014</b>	5431	15108	740	698922	741991	504466	89807	1561
<b>2015</b>	5231	15070	683	684119	751562	492634	91319	1567
<b>2016</b>	5335	14782	753	675938	755625	486701	92374	1505
<b>2017</b>	5425	14641	717	656637	763347	480566	92579	1601

NOTE: Classification types listed as beach and dune; mining; aquaculture; rocky outcrop; salt flat; and not observed were not transcribed to this table, as combined they represented less than 0.02% of the total land cover per year (fewer than 500 pixels each year, cumulatively) Values were rounded up to the nearest whole number.

**Supplementary Material, Table S2 (continued).**

**Yearly total number of by land use/land cover type**

<b>Year</b>	<b>Forest Formation</b>	<b>River, Lake and Ocean</b>	<b>Perennial Crop</b>	<b>Soybean</b>	<b>Savanna Formation</b>	<b>Other Temporary Crops</b>	<b>Mangrove</b>	<b>Forest Plantation</b>
<b>2002</b>	577303	67814	254	42743	19605	78355	1751	70807
<b>2003</b>	579432	67903	178	46400	20665	75083	1740	72000
<b>2004</b>	580919	68108	186	48921	20219	76354	1736	74198
<b>2005</b>	582524	68195	245	53014	20725	74615	1779	77430
<b>2006</b>	585001	68287	450	51717	20123	81964	1816	80493
<b>2007</b>	589182	68342	544	45327	19736	83984	1832	85093
<b>2008</b>	592598	68304	606	37842	19370	72823	1818	90935
<b>2009</b>	597563	68395	779	43398	18948	61004	1819	96160
<b>2010</b>	598297	68570	1502	49443	18734	57366	1809	101483
<b>2011</b>	598819	68651	2818	55061	19350	54558	1785	107068
<b>2012</b>	599147	68547	4030	55956	18143	58665	1774	111442
<b>2013</b>	598206	68586	5942	56405	17730	61766	1769	114824
<b>2014</b>	598657	68318	8284	69389	16971	52236	1799	117255
<b>2015</b>	604765	67838	11156	79473	17235	47707	1824	118728
<b>2016</b>	606097	68521	14162	82687	17001	46001	1816	121590
<b>2017</b>	605377	68621	17542	89306	16433	52803	1705	123587

NOTE: Classification types listed as beach and dune; mining; aquaculture; rocky outcrop; salt flat; and not observed were not transcribed to this table, as combined they represented less than 0.02% of the total land cover per year (fewer than 500 pixels each year, cumulatively) Values were rounded up to the nearest whole number.

**Supplementary Material, Table S3.**

**Overall relative change and absolute change for land use/land cover types between 2002 and 2017**

Land Cover/Land Use Type	2002-2017 Percent (Relative) Change	2002-2017 Absolute Change in Pixel Number
<b>Wetland</b>	30.32%	1262
<b>Grassland Formation</b>	2.15%	308
<b>Other non Forest Formations</b>	-1.11%	-8
<b>Pasture</b>	-46.89%	-579709
<b>Sugar Cane</b>	127.65%	428033
<b>Mosaic of Agriculture and Pasture</b>	3.44%	15994
<b>Urban Infrastructure</b>	23.24%	17461
<b>Other non Vegetated Areas</b>	-12.41%	-227
<b>Forest Formation</b>	4.86%	28075
<b>River, Lake and Ocean</b>	1.19%	807
<b>Perennial Crop</b>	6806.17%	17288
<b>Soybean</b>	108.94%	46564
<b>Savanna Formation</b>	-16.18%	-3172
<b>Other Temporary Crops</b>	-32.61%	-25552
<b>Mangrove</b>	-2.63%	-46
<b>Forest Plantation</b>	74.54%	52780

**Supplementary Material, Table S4.**

**Yearly total number of burned area pixels by land use/land cover type**

<b>Year</b>	<b>Wetland</b>	<b>Grassland Formation</b>	<b>Other non Forest Formations</b>	<b>Pasture</b>	<b>Sugar Cane</b>	<b>Mosaic of Agriculture and Pasture</b>	<b>Urban Infrastructure</b>	<b>Other non Vegetated Areas</b>
<b>2002</b>	38	273	12	9657	52192	10331	206	32
<b>2003</b>	161	431	6	10552	57034	11159	93	29
<b>2004</b>	177	330	13	7665	55331	9215	68	32
<b>2005</b>	59	333	9	8737	62273	11650	180	36
<b>2006</b>	140	474	20	11867	78249	16276	162	42
<b>2007</b>	210	570	11	14248	88817	17392	117	64
<b>2008</b>	177	334	9	11942	74426	13665	89	37
<b>2009</b>	72	248	17	6897	55641	7693	32	15
<b>2010</b>	306	518	19	16275	103494	16644	121	28
<b>2011</b>	249	331	20	8564	69125	10325	67	22
<b>2012</b>	87	187	6	3809	41222	5090	46	13
<b>2013</b>	125	105	9	2303	25315	4033	24	13
<b>2014</b>	89	194	5	3053	36448	4699	108	16
<b>2015</b>	14	130		1500	17137	1796	10	5
<b>2016</b>	192	130		2123	21883	2681	58	7
<b>2017</b>	429	159	3	2204	30825	3613	36	8

NOTE: Classification types listed as beach and dune; mining; aquaculture; rocky outcrop; salt flat; mangrove; and not observed were not transcribed to this table, as they showed fewer than 10 burned pixels per year

**Supplementary Material, Table S4 (continued).**

**Yearly total number of burned area pixels by land use/land cover type**

<b>Year</b>	<b>Forest Formation</b>	<b>River, Lake and Ocean</b>	<b>Perennial Crop</b>	<b>Soybean</b>	<b>Savanna Formation</b>	<b>Other Temporary Crops</b>	<b>Forest Plantation</b>
<b>2002</b>	4830	227	4	710	438	2883	422
<b>2003</b>	4972	334	2	952	424	2969	417
<b>2004</b>	3844	240		729	428	2487	334
<b>2005</b>	4010	227	2	897	340	2484	261
<b>2006</b>	5360	357	5	998	513	3104	413
<b>2007</b>	6578	437	17	875	660	3350	361
<b>2008</b>	4993	341	14	683	473	1865	323
<b>2009</b>	2998	212	4	1082	271	1049	224
<b>2010</b>	7490	565	11	1729	486	1563	560
<b>2011</b>	4391	419	6	2187	376	1279	437
<b>2012</b>	2439	193	10	710	121	827	361
<b>2013</b>	1583	103	7	227	117	650	190
<b>2014</b>	3532	175	33	665	228	601	480
<b>2015</b>	1034	77	22	263	112	230	172
<b>2016</b>	1204	94	42	317	158	386	199
<b>2017</b>	2631	218	35	703	201	640	405

NOTE: Classification types listed as beach and dune; mining; aquaculture; rocky outcrop; salt flat; mangrove; and not observed were not transcribed to this table, as they showed fewer than 10 burned pixels per year. Values were rounded up to the nearest whole number.



**Supplementary Material, Table S5.**

**Overall percent change and absolute change in burn frequency for each LULC type between 2002 and 2017**

Land Cover/Land Use Type	2002-2017 Percent (Relative) Change	2002-2017 Absolute Change in Pixel Number
<b>Wetland</b>	1028.95%	391
<b>Grassland Formation</b>	-41.76%	-114
<b>Other non Forest Formations</b>	-75.00%	-9
<b>Pasture</b>	-77.18%	-7452.968627
<b>Sugar Cane</b>	-40.94%	-21367.42745
<b>Mosaic of Agriculture and Pasture</b>	-65.03%	-6718.117647
<b>Urban Infrastructure</b>	-82.52%	-170
<b>Other non Vegetated Areas</b>	-75.00%	-24
<b>Forest Formation</b>	-45.53%	-2199.34902
<b>River, Lake and Ocean</b>	-4.34%	-9.878431373
<b>Perennial Crop</b>	775.00%	31
<b>Soybean</b>	-0.99%	-7
<b>Savanna Formation</b>	-54.00%	-236.5215686
<b>Other Temporary Crops</b>	-77.80%	-2242.956863
<b>Forest Plantation</b>	-4.03%	-17

**Supplementary Material, Table S6.**

**Total monthly number of MODIS detected burned area pixels**

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>Jan</b>	315	41	82	78	249	217	106	115	89		185	63	206	34	106	6
<b>Feb</b>	70	211	148	238	187	353	118	236	341	83	211	55	136		122	74
<b>Mar</b>	177	181	88	209	323	305	202	872	421	161	214	111	93	2	180	39
<b>Apr</b>	896	989	358	2033	2116	2200	684	2973	2377	803	295	569	268	52	1020	100
<b>May</b>	2549	3539	1338	4382	7313	3927	2622	3778	4011	3797	669	974	1050	124	291	213
<b>Jun</b>	4150	5971	2317	3784	5579	6611	3973	2950	5674	2984	838	351	1363	308	729	564
<b>Jul</b>	5263	4806	4849	6408	8399	5476	6225	4293	7053	5092	2865	1881	2397	1304	2221	1753
<b>Aug</b>	5114	5926	6612	6724	7101	8881	7063	4858	14238	10036	5407	3682	3892	2997	2671	4499
<b>Sep</b>	3373	5657	6646	4454	4559	9653	9685	2059	12634	7949	4952	2493	4552	1467	1556	4964
<b>Oct</b>	5292	2192	2075	1253	1798	6038	1333	2582	1636	1556	1565	661	2811	904	756	1272
<b>Nov</b>	322	568	1854	1136	1898	1234	3424	584	1770	371	990	507	193	288	163	300
<b>Dec</b>	308	74	808	167	191	402	1458	511	478	182	301	284	73	49	124	353