

Supplementary information for

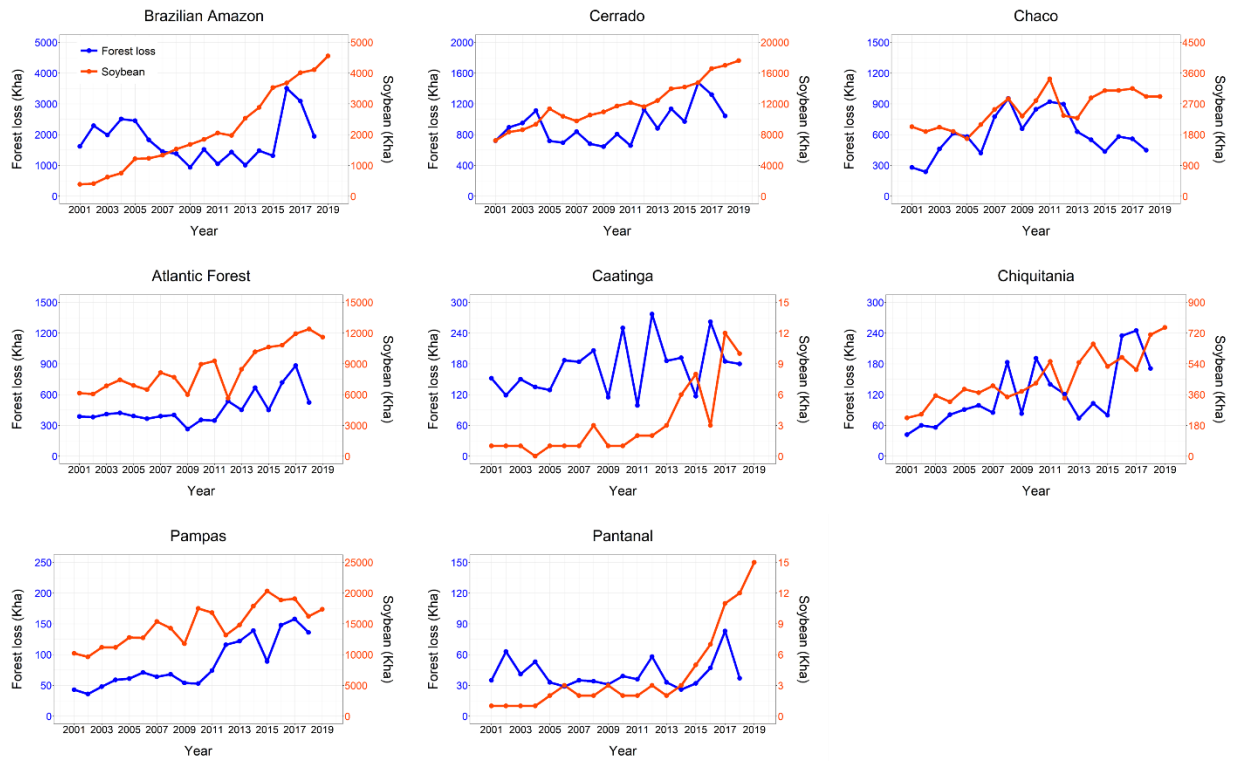
**Massive soybean expansion in South America since 2000 and implications for conservation**

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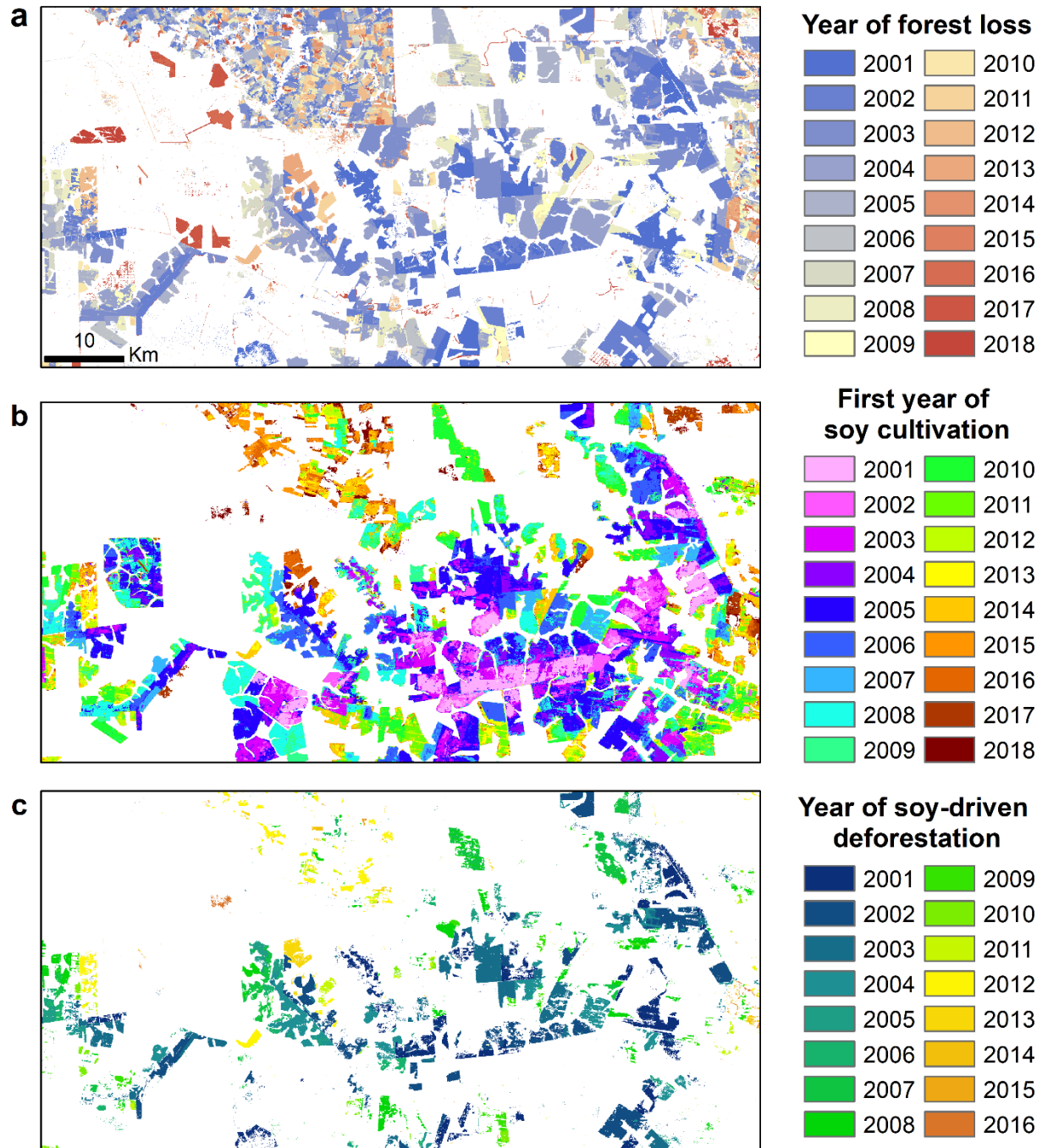
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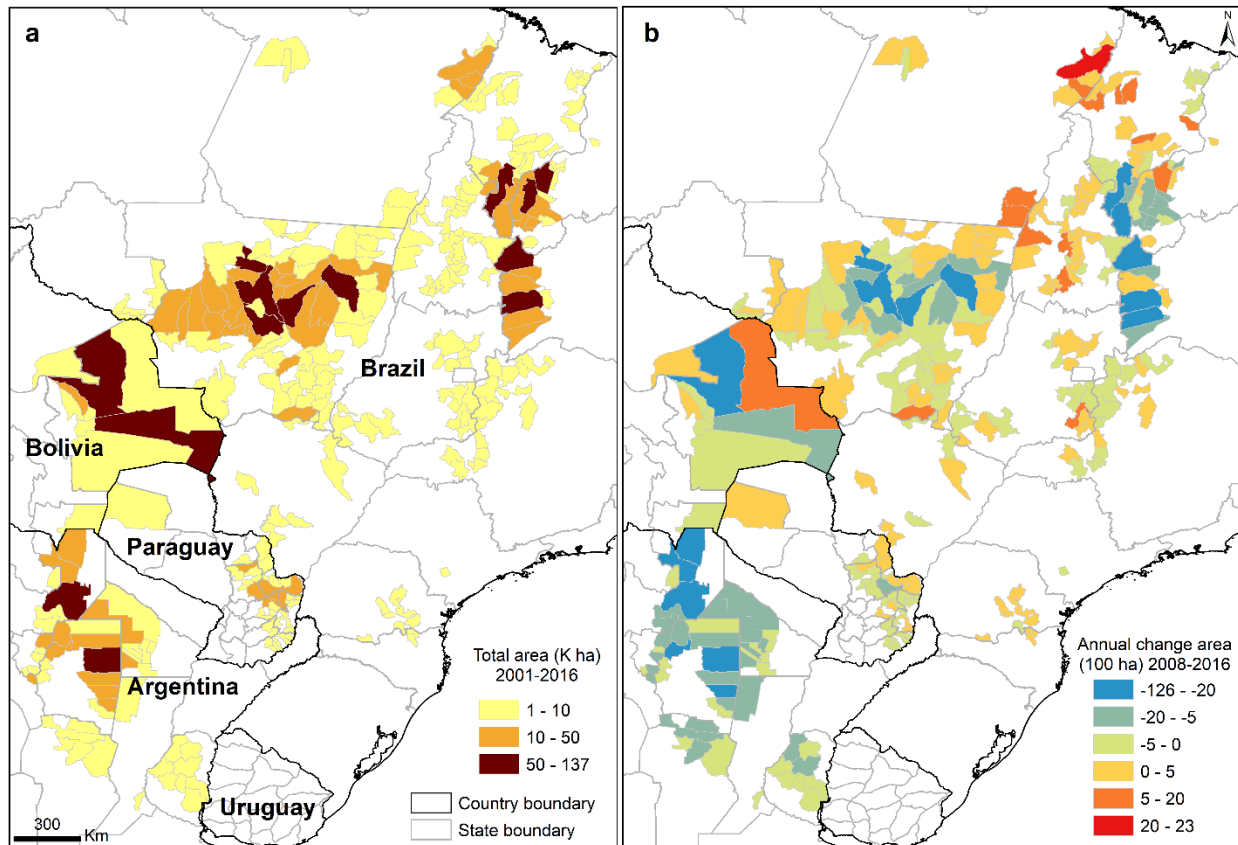
- Supplementary Figures 1-8
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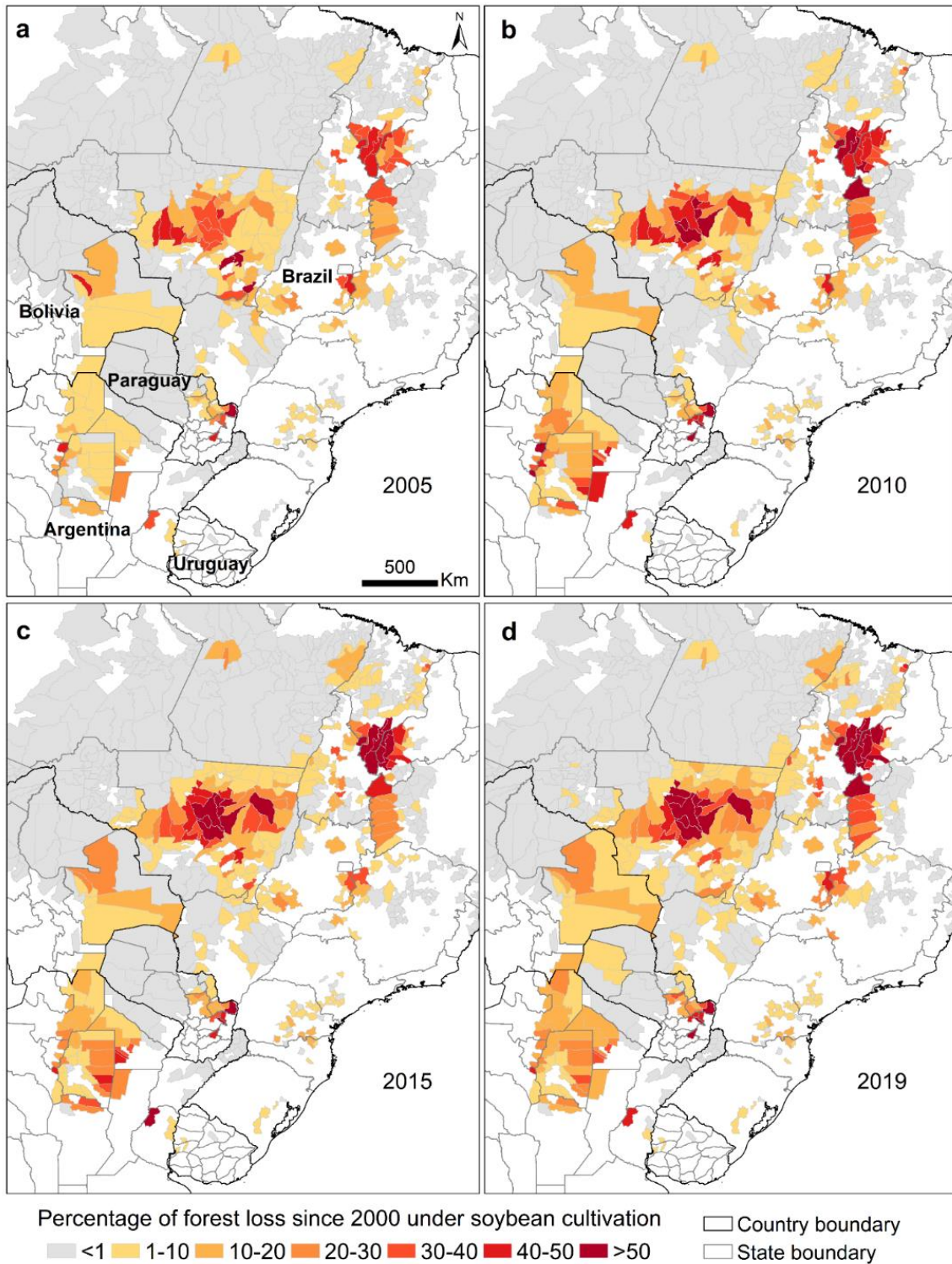
**Supplementary Fig. 1.** Annual forest loss and soybean cultivated area in major biomes in South America.



**Supplementary Fig. 2.** Combining annual forest loss data (a) and new soybean cultivation data (b) to map soybean-driven deforestation (c).

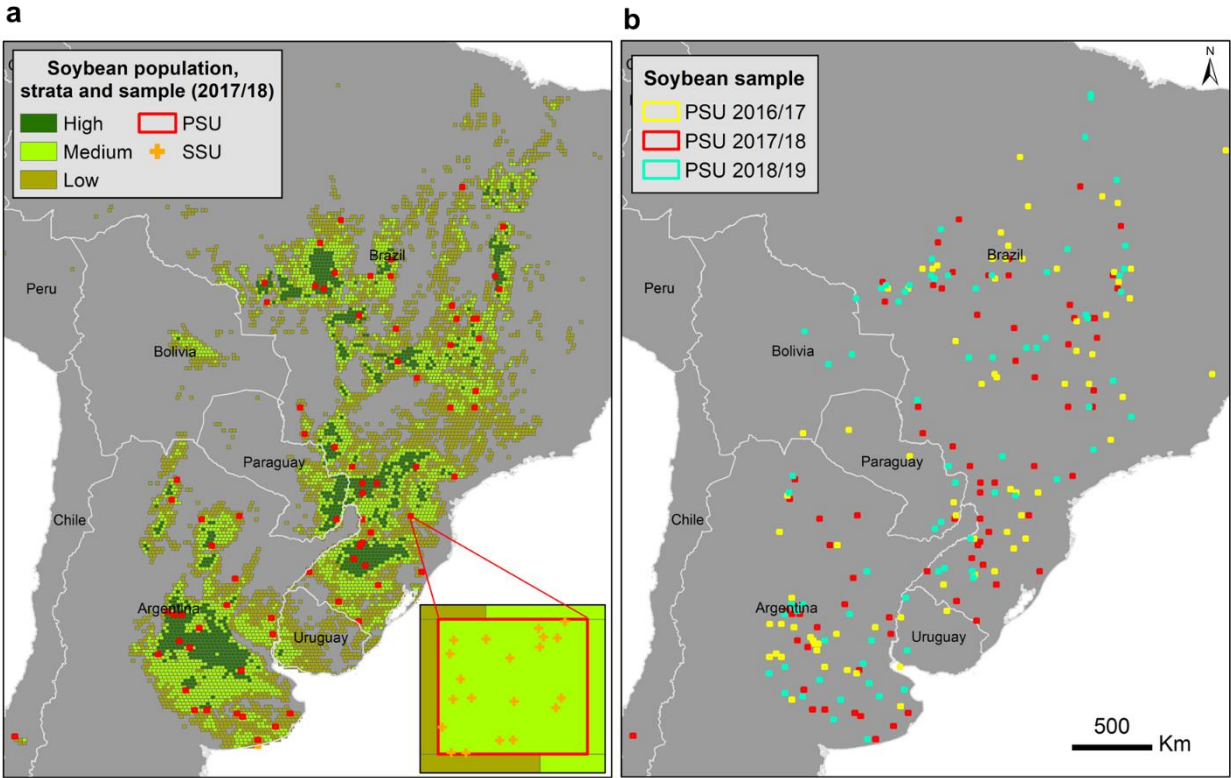


**Supplementary Fig. 3.** Municipality/county-level soybean-driven deforestation. **a.** Total area between 2001 and 2016. Municipalities with total soybean-driven deforestation  $\geq 1$  K ha are shown. **b.** Change in annual area from 2006 to 2016.

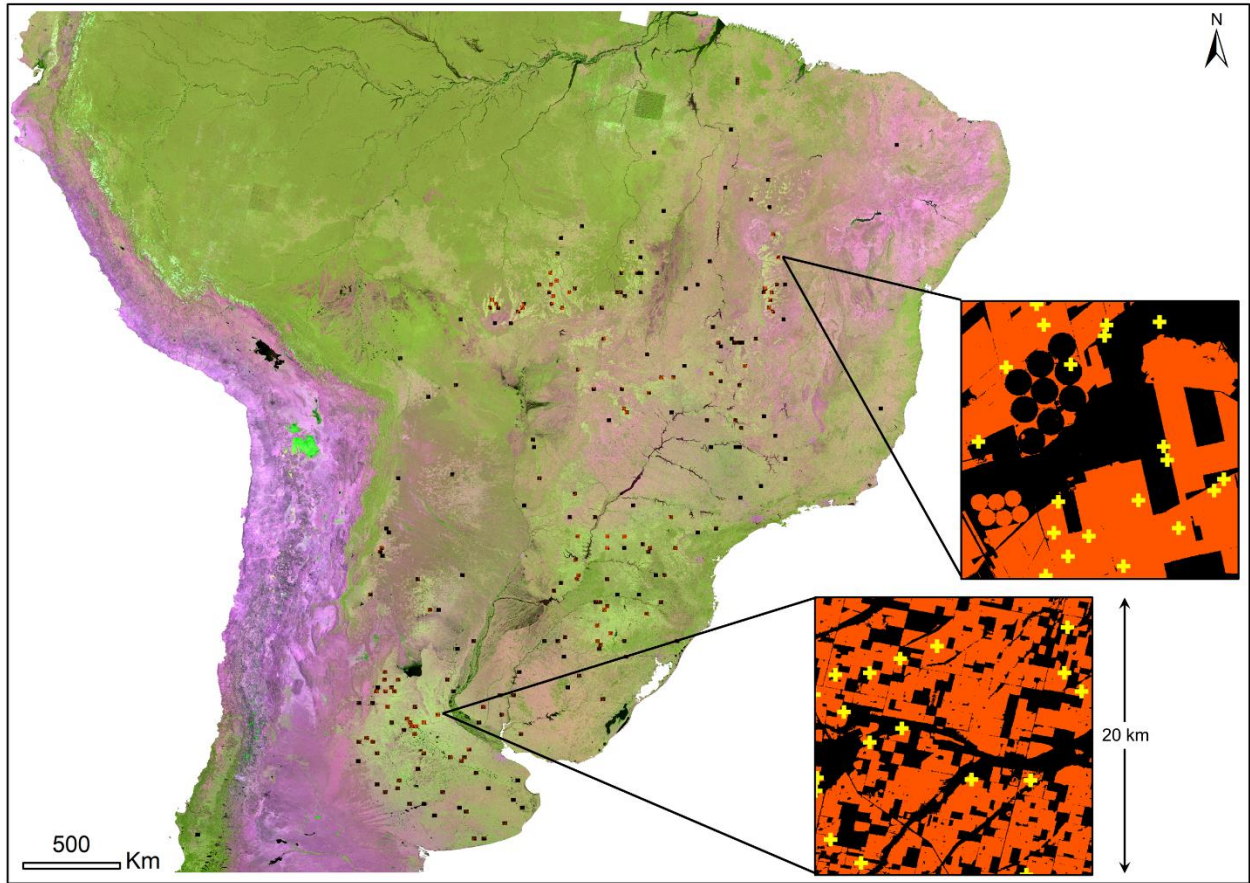


**Supplementary Fig. 4.** Percentage of forest loss since 2000 under soybean cultivation at municipal scale in 2005 (a), 2010 (b), 2015 (c) and 2019 (d).

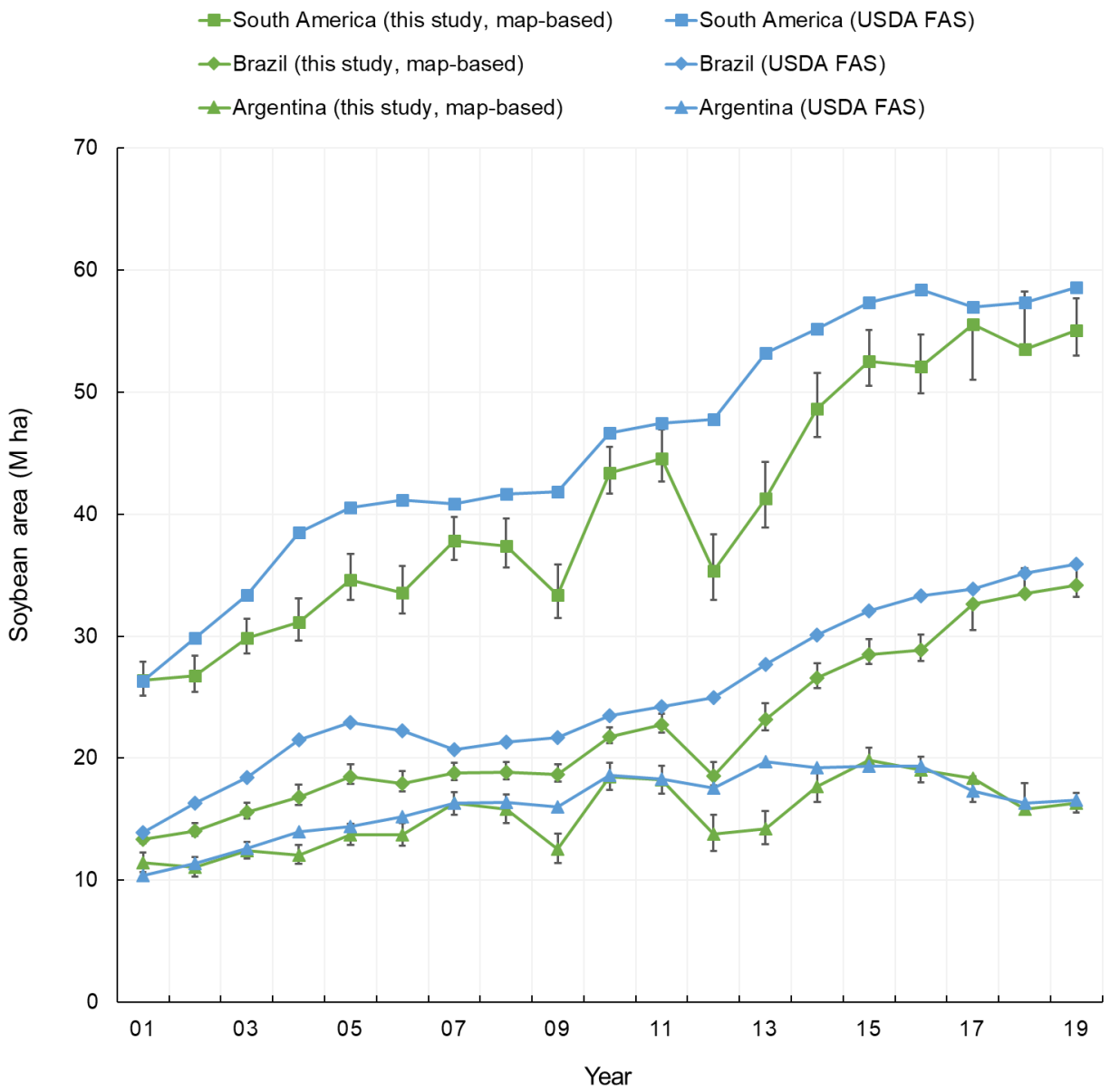




**Supplementary Fig. 5.** Sampling design for estimating soybean cultivated area in South America. A two-stage stratified random sampling is implemented. **a:** stratification, primary sampling units (PSU) and secondary sampling unit (SSU) for cropping year 2017/18. The PSUs are 20 km × 20 km equal-area blocks, and the SSUs are 30 m × 30 m pixels. **b:** PSUs for cropping year 2016/17, 2017/18 and 2018/19. These PSUs represent the locations where ground data have been collected.

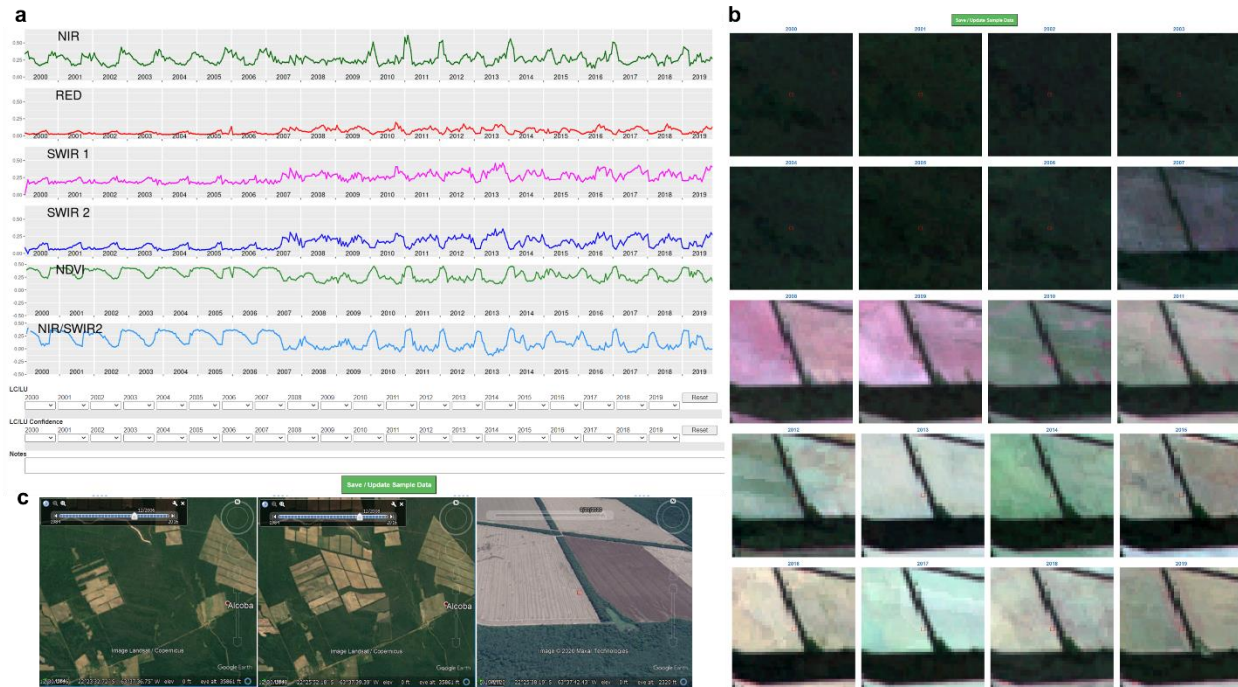


**Supplementary Fig. 6.** Classified primary sample units (PSUs) overlaid on Landsat image composites. The two insets on the right show examples from the total of 225 sampled 20 km × 20 km equal-area PSUs that were classified to soybean (orange) and non-soybean (black) at 30 m spatial resolution. Yellow crosses denote secondary sample units (SSU). The band combination of the Landsat composites is: R: mean value of minimum and 25<sup>th</sup> percentile of shortwave-infrared surface reflectance (1.6 μm), G: mean value of maximum and 75<sup>th</sup> percentile of near-infrared surface reflectance, B: mean value of minimum and 25<sup>th</sup> percentile of shortwave-infrared surface reflectance (2.2 μm).



**Supplementary Fig. 7.** Comparison of map-based annual soybean area estimates derived from this study to official soybean harvest area statistics reported by the United States Department of Agriculture Foreign Agricultural Service (USDA FAS). Error bars represent lower and upper bounds for areas based on applying different probability thresholds in the decision tree model (see details in Methods).





**Supplementary Fig. 8.** Interpreting multiple sources of remote sensing data over an example sample location for uncertainty analysis. **a.** Time-series of MODIS 16-day NIR, red, SWIR1, SWIR2 reflectance and NDVI and NDWI over the selected sample location from 2000 to 2019. **b.** Annual cloud-free Landsat composites in NIR-SWIR1-SWIR2 band combination from 2000 to 2019. The red box in the center of the Landsat images indicates the sample location. **c.** Selected high-resolution images in Google Earth over the sample location. In this example, the deforestation event occurred in year 2007, clearly visible from both Landsat data and MODIS NDVI time series. Cropland is identified based on recent high-resolution Google Earth images, and first crop cultivation appeared in year 2009, interpreted from the MODIS NIR and NDVI curves.

**Supplementary Table 1.** 2001 land-cover area per biome (unit: Kha)

<b>Biome</b>	<b>Primary forest</b>	<b>Non-primary forest</b>	<b>Cropland</b>	<b>Other land</b>	<b>Water</b>
Brazilian Amazon*	277191	42415	885	31298	6777
Atlantic Forest	7632	49716	13370	49452	1476
Caatinga	358	27462	1299	52916	602
Cerrado	9926	76956	15528	102060	866
Chaco	5106	58111	3661	40132	808
Chiquitania	9942	4252	454	1702	27
Pampas	0	9103	20321	75306	1229
Pantanal	2619	7902	50	7704	248

\*Brazilian Amazon covers the Southern Hemisphere portion of the Amazon in this study.

**Supplementary Table 2.** Accuracy of 2017, 2018 and 2019 soybean maps validated using a probability field sample to obtain the reference class data. PA: Producer’s accuracy (%); UA: User’s accuracy (%). Bold numbers at the bottom right corner represent overall accuracy (%). Cell entries of the error matrix represent proportion of area.

2017					
		Reference			
		Soy	Nonsoy	Total	UA
Map	Soy	0.15	0.02	0.16	90
	Nonsoy	0.02	0.82	0.84	97
	Total	0.17	0.83	1.00	
	PA	86	98		<b>96</b>
2018					
		Reference			
		Soy	Nonsoy	Total	UA
Map	Soy	0.16	0.03	0.19	86
	Nonsoy	0.03	0.78	0.81	96
	Total	0.19	0.81	1.00	
	PA	85	97		<b>94</b>
2019					
		Reference			
		Soy	Nonsoy	Total	UA
Map	Soy	0.15	0.01	0.16	92
	Nonsoy	0.03	0.81	0.84	97
	Total	0.18	0.82	1.00	
	PA	83	98		<b>96</b>