Supplementary information 1 - tables and figures

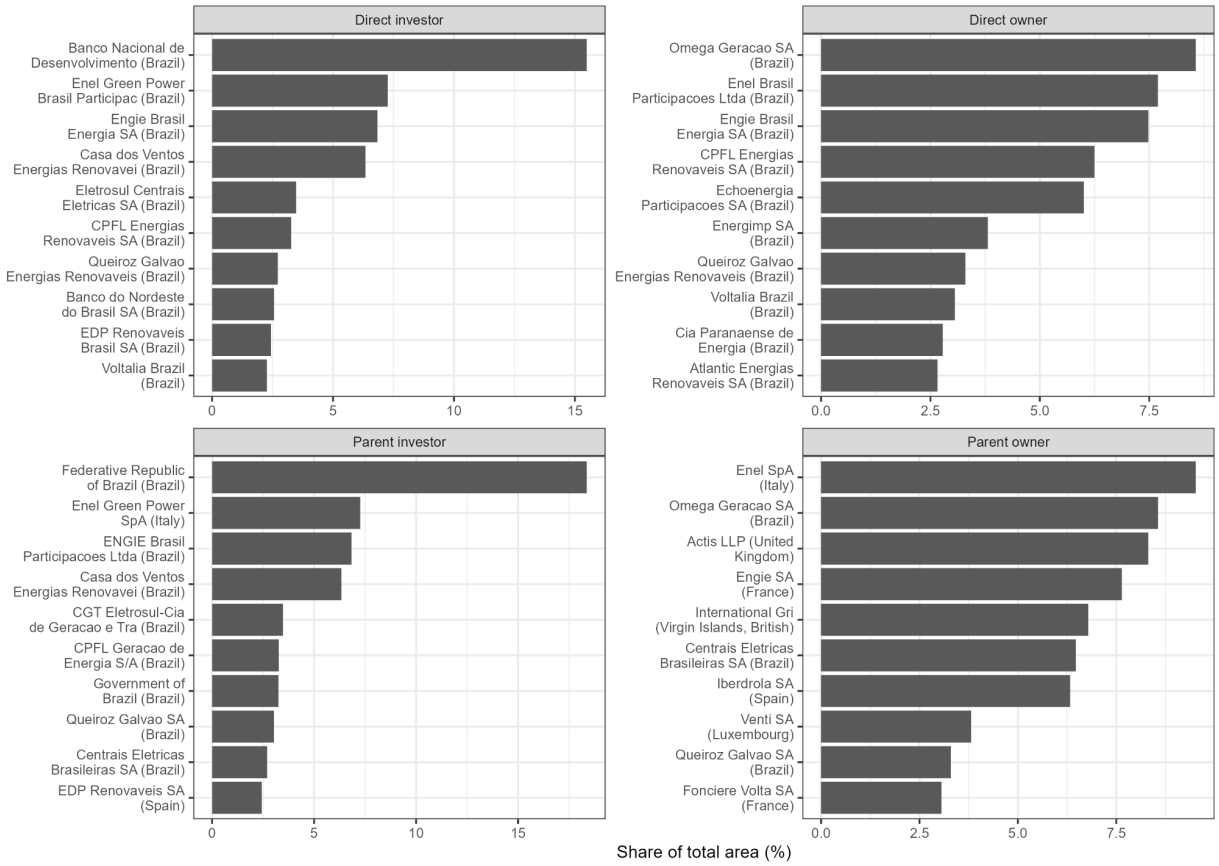
Supplementary Table 1. Dataset of the digital land tenure system

Core land tenure-regime	Land tenure category and description	Source	Date of acquisition	Period covered
Private land	Licit private property titles: Privately owned properties are registered in the Sistema de Gestão Fundiária (SIGEF) or Sistema Nacional de Certificação de Imóveis (SNCI). The certification of the georeferencing of rural property ownership, created by Law 10.267 of 2001, is carried out exclusively by Incra, and guarantees that the georeferencing complies with legal technical standards and specifications. We considered the names and boundaries of the rural properties as well as the date of submission and/or approval.	SIGEF and SNCI-INCRA	12-01-2022	> 2022
	CAR titles: According to Brazilian Forest Code (Law 12,651/2012), geo-referenced private rural property information must be submitted to the public electronic registry Sistema Nacional de Cadastro Ambiental Rural (SICAR). We only considered property boundaries and submission dates.	SICAR-MMA	12-01-2022	2022
Public land	Indigenous lands: Legally defined area owned by the Union, aimed at preserving indigenous communities.	FUNAI	12-10-2021	> 2021
	Quilombola areas: Rural properties occupied by Afro-Brazilian communities of descendants of fugitive slaves from the colonial period.	INCRA	12-01-2022	> 2022
	Rural settlement areas: Agrarian reform areas composed of small-scale agricultural plots.	INCRA	12-01-2022	> 2022
	Conservation units: Differentiation according to ecological protection status – i) Integral Protected Areas (strict protection); ii) Protected Areas for Sustainable Use (with options for anthropogenic land use).	ISA	03-03-2021	> 2021
Undesignated public land	Vacant lands (known as *terras devolutas*): Undesignated or untitled public lands owned by	Estimated result	n/a	2022

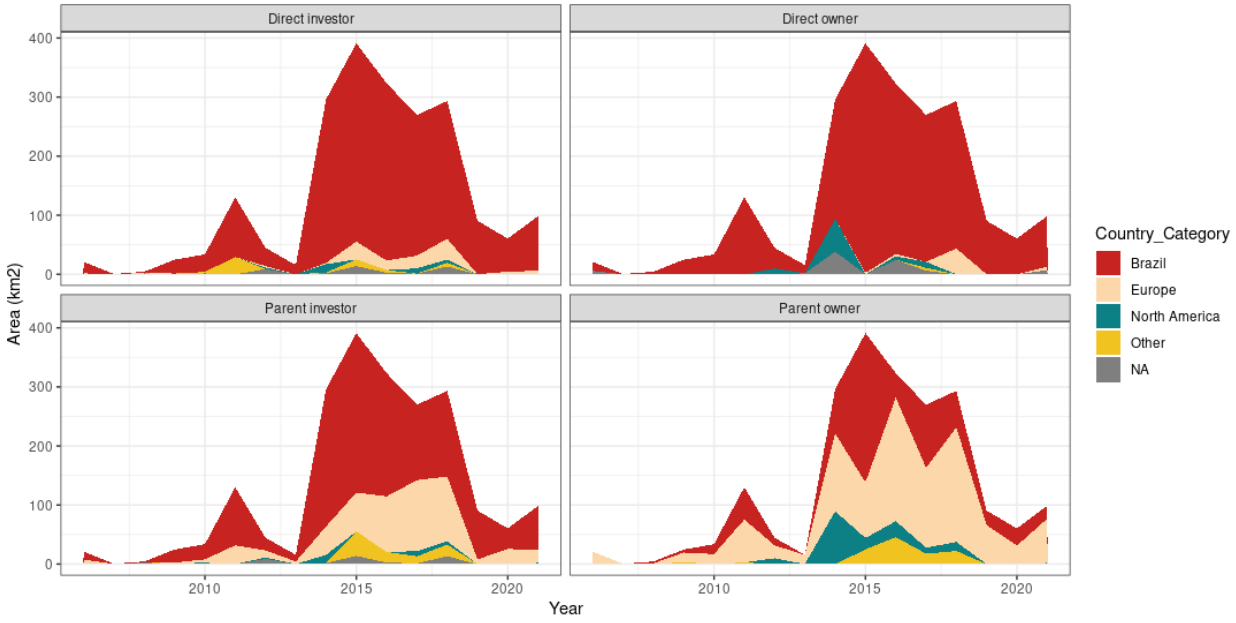
	the Union or States, but often historically occupied and used by traditional communities, as well as affected by land grabbing and resource extraction.	based on the spatial analysis		
Administrative	Municipality borders	IBGE	18-01-2021	2020
	State boundaries	IBGE	18-01-2021	2020

Supplementary Table 2: Countries in regional groups

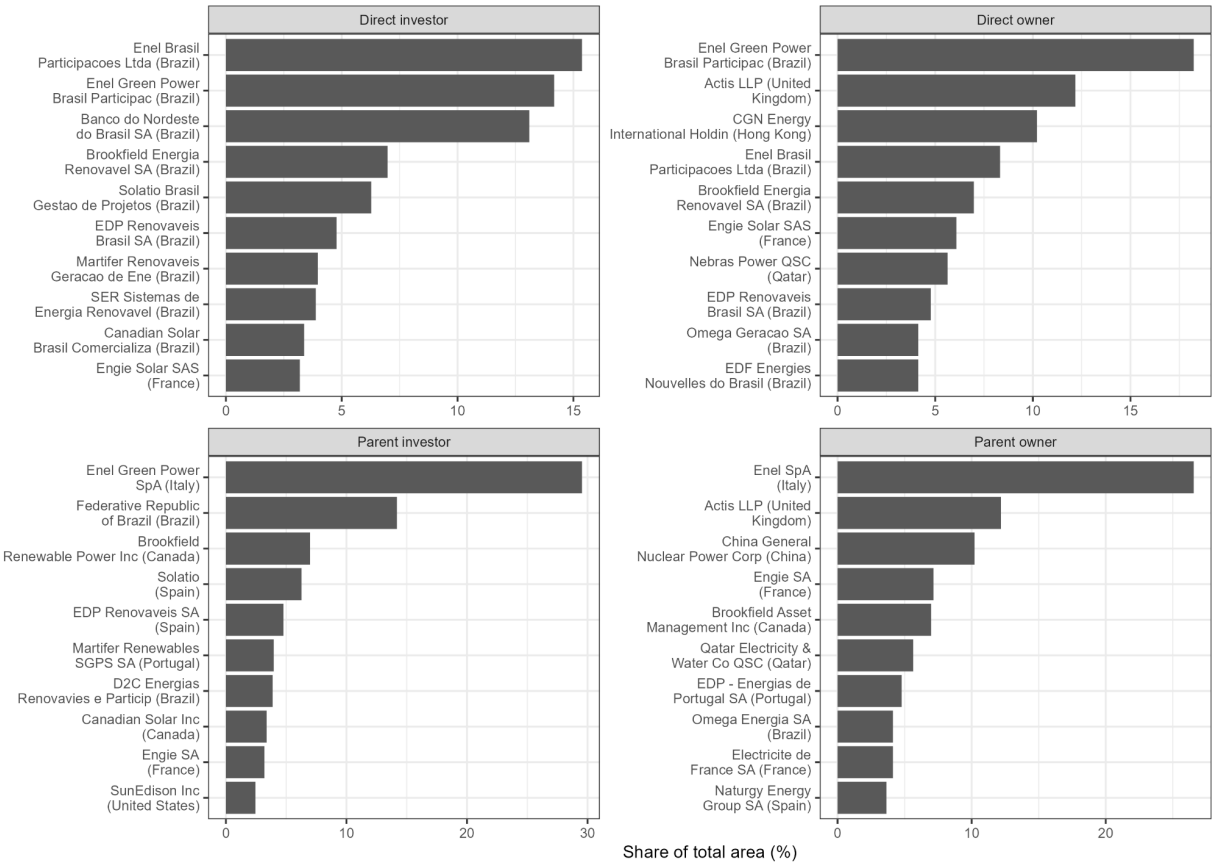
Technology	**Region**	**Included countries**
Wind	Brazil	Brazil
	North America	United States, Canada
	Europe	British Virgin Islands, Denmark, France, Germany, Isle of Man, Italy, Luxembourg, Portugal, Spain, Sweden, United Kingdom
	Other	Argentina, Australia, Bahrain, China, Colombia, Hong Kong
Solar PV	Brazil	Brazil
	North America	Canada, United States
	Europe	British Virgin Islands, Denmark, Germany, Hong Kong, Isle of Man, Italy, Luxembourg, Portugal, Spain, Sweden, United Kingdom
	Other	Argentina, Australia, Bahrain, China, Colombia, Hong Kong, Qatar



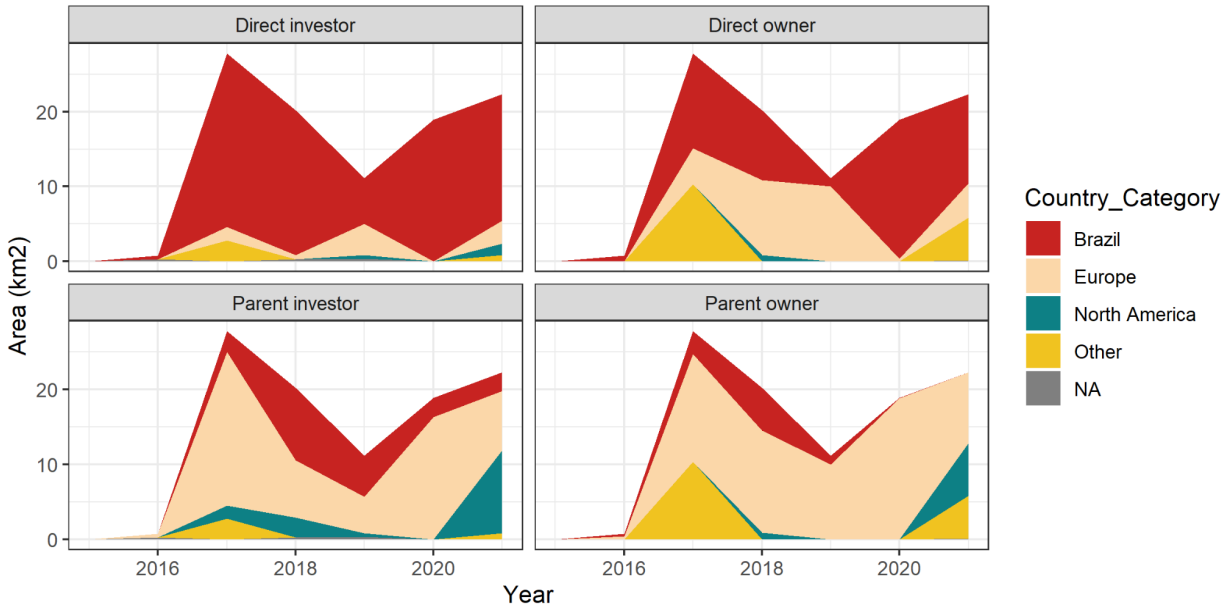
Supplementary Figure 1: Share of total land area occupied by wind parks per company



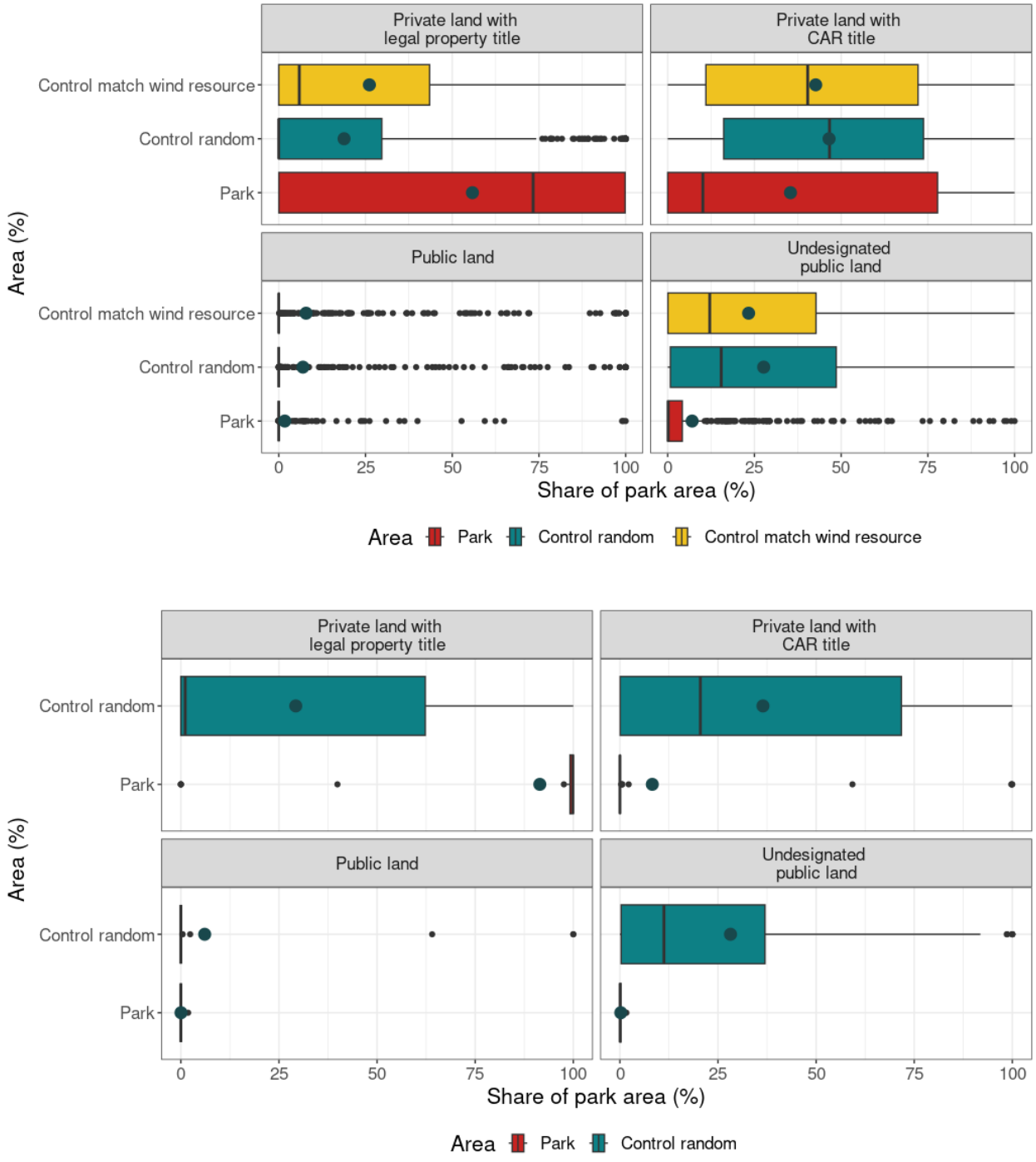
Supplementary Figure 2: Land area occupied by wind parks per investment and ownership country. Year indicates the start of park operation. Countries included in regions can be found in Supplementary Table 2.



Supplementary Figure 3: Share of total land area occupied by solar PV parks per company



Supplementary Figure 4: Land area occupied by solar PV parks per investment and ownership country. Year indicates the start of park operation. Countries included in regions can be found in Supplementary Table 2.



Supplementary Figure 5. Boxplots wind and solar PV park areas related to land tenure categories

Supplementary Table 3. Means and standard deviations of land tenure categories for park and control areas.

Area type	Land tenure	Mean of area (km2)	Standard deviation of area (km2)
Wind power (n=574)			
Control match wind resource	Private land with legal property title	0.579	1.22
Control match wind resource	Private land with CAR title	0.264	0.731
Control match wind resource	Public land	0.805	1.39
Control match wind resource	Undesignated public land	0.276	1.14
Control random	Private land with legal property title	0.557	0.977
Control random	Private land with CAR title	0.297	0.922
Control random	Public land	0.976	1.75
Control random	Undesignated public land	0.322	1.22
Park	Private land with legal property title	0.833	1.93
Park	Private land with CAR title	0.32	0.878
Park	Public land	0.266	0.944
Park	Undesignated public land	0.104	0.758
Solar PV (n=44)			
Control random	Private land with legal property title	0.881	1.44
Control random	Private land with CAR title	0.276	0.478
Control random	Public land	1.64	4.26
Control random	Undesignated public land	0.24	0.618
Park	Private land with legal property title	1.14	1.96
Park	Private land with CAR title	0.106	0.304
Park	Public land	0.00805	0.0114
Park	Undesignated public land	0.00411	0.00985

Supplementary Table 4. Results of t-tests

Land tenure	Group 1	Group 2	Type	Value
Wind power (n=574)				
Private land with legal property title	Park	Control match wind resource	p value	0
Private land with CAR title	Park	Control match wind resource	p value	8,00E-04
Public land	Park	Control match wind resource	p value	0
Undesignated public land	Park	Control match wind resource	p value	0
Private land with legal property title	Park	Control random	p value	0
Private land with CAR title	Park	Control random	p value	0
Public land	Park	Control random	p value	0
Undesignated public land	Park	Control random	p value	0
Private land with legal property title	Control match wind resource	Control random	p value	1,00E-04
Private land with CAR title	Control match wind resource	Control random	p value	0.0469
Public land	Control match wind resource	Control random	p value	0.481
Undesignated public land	Control match wind resource	Control random	p value	0.0097
Private land with legal property title	Park	Control match wind resource	t statistic	12.8405
Private land with CAR title	Park	Control match wind resource	t statistic	-3.3628

Public land	Park	Control match wind resource	t statistic	-6.1169
Undesignated public land	Park	Control match wind resource	t statistic	-12.278
Private land with legal property title	Park	Control random	t statistic	16.667
Private land with CAR title	Park	Control random	t statistic	-5.1548
Public land	Park	Control random	t statistic	-5.3299
Undesignated public land	Park	Control random	t statistic	-14.486
Private land with legal property title	Control match wind resource	Control random	t statistic	-3.8492
Private land with CAR title	Control match wind resource	Control random	t statistic	1.9893
Public land	Control match wind resource	Control random	t statistic	-0.705
Undesignated public land	Control match wind resource	Control random	t statistic	2.5903
Solar PV (n=44)				
Private land with legal property title	Park	Control random	p value	0
Private land with CAR title	Park	Control random	p value	1,00E-04
Public land	Park	Control random	p value	0.0874
Undesignated public land	Park	Control random	p value	0
Private land with legal property title	Park	Control random	t statistic	8.8903
Private land with CAR title	Park	Control random	t statistic	-4.0618
Public land	Park	Control random	t statistic	-1.7494
Undesignated public land	Park	Control random	t statistic	-5.1108

Supplementary Figure 6: Example random sampling procedure for wind park Guirapa in the municipality Guanambi. The red shape is the original wind park. The green shapes are other wind or solar PV parks in the municipality. The points are 100 randomly chosen locations. the shapes surrounding the points are rotated and shifted shapes of the original wind parks on those points. Shapes which intersect with existing parks or which are not spatially fully contained in the municipality are removed. From the remaining shapes, a random shape is chosen (in orange) for the group of *Control random* areas. For the group *Control match wind resource* the shape is chosen, where the absolute difference between the mean wind power density of the original wind park in red and the mean power density of the shape is minimized.

Supplementary information 2 - Cleaning GIS data

Land tenure data

We follow the methods introduced by ATLAS[55] to clean the GIS data, and inform here in detail about the performed steps. QGIS 3.28 and Python 3.9.13 with Geopandas were used to clean the GIS data. Although the data cleaning processes for CAR and SIGEF/SNCI data are very similar, the data quality of SIGEF and SNCI Data is by far better. Due to overlaps and erroneous geometries more than 50% of CAR area is lost during data cleaning, while the SIGEF/SNCI data set loses less than 5% of area.

CAR data

The Rural Environmental Registry CAR dataset was downloaded from the official Brazilian website at the end of 2022. As the dataset has to be downloaded for each district individually, only those from districts intersecting with the solar and wind plants were used (i.e. 132 municipalities). To clean the data, the 132 CAR shapefiles were merged to one large Geodatabase. The polygons that intersect with wind and solar parks were selected with *select by location* and duplicate geometry was removed. Furthermore, duplicates in the column COD_IMOVEL, i.e. the CAR registration code, were removed, prioritizing larger areas over smaller ones. To remove polygons with unnatural shapes, the CI (circularity index) was calculated according to the following formula: $CI = \frac{2\sqrt{\pi A}}{P}$, A being the area and P the perimeter. Polygons with CI smaller than 0.12 and polygons with a CI bigger than 0.98 were removed. This rule does not affect final outcomes significantly. Furthermore, polygons that contain more than 5 Polygons within their boundaries were removed. The total CAR area resulting from our analysis is in particular sensitive to this rule, as very large CAR titles are removed from the data set and total CAR area therefore is reduced.

The CAR dataset was divided into poor and premium quality: premium polygons have less than 5% overlap with other CAR polygons and are therefore more trustworthy. Polygons with poor quality have more than 5% overlap with other CAR titles and therefore possibly lose a significant amount of area in the following cleaning process. If there are overlaps, premium CAR titles are prioritized over poor CAR titles. Within the two categories, overlaps were removed randomly. At the end polygons smaller than 1 ha were removed. Note, as we do not use CAR title specific meta-information, the order of prioritization of CAR titles does not affect our results - they are therefore insensitive to the particular choices made in these final steps.

SIGEF/SNCI data

SIGEF and SNCI polygons are both representing rural properties in Brazil. Therefore they were merged, keeping the certification date. Duplicate geometry was removed. Again, shapes with unnatural CI (see above) were removed. Overlapping geometry was also removed, prioritizing titles with the most recent certification date.

Wind park data

Wind park data was of high quality in general, but a minor share of wind parks showed overlaps. We removed them, prioritizing the area of the wind park with the most recent operating date.