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SUPPLEMENTARY INFORMATION

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Moment of truth for the Cerrado Hotspot

I. Supplementary Methods

1. Data sources and methods

1.1. Land use data

Current and future land-use maps and future greenhouse gases emissions due to land-use change presented in the main text were obtained from the OTIMIZAGRO land-use model[7].

OTIMIZAGRO, an upgraded version of SimAmazonia/SimBrasil, is a nationwide, spatially-explicit model that simulates land use, land-use change, forestry, deforestation, regrowth, and associated carbon emissions under various scenarios of agricultural land demand and deforestation policies for Brazil. OTIMIZAGRO simulates nine annual crops (i.e. soy, sugarcane, corn, cotton, wheat, beans, rice, manioc, and tobacco), including single and double cropping; five perennial crops (i.e. Arabica coffee, Robusta coffee, oranges, bananas, and cocoa); and plantation forests.

The starting map (year 2012) used is closer to the TERRACLASS map and native pasturelands are still classified as native vegetation. In this sense, all our main estimates are conservative, assuming that species remain in disturbed native vegetation.

Another set of current and future land-use maps were obtained from the GLOBIOM-Brazil land-use model, and used for calculations presented in Supplementary Table 2.

GLOBIOM[15] is a partial-equilibrium model for agriculture, forestry and bioenergy. It solves an optimization problem every ten years, maximizing the sum of the consumers' and the producers' surpluses in the landscape. Prices are computed endogenously. Land-use changes are driven exogenously by demand projections for the period. The regional version of the model for Brazil[8] aims to have a better-detailed representation of the country's landscapes by including data on conservation units, legal reserves deficits and small farms amnesty from the new Forest Code, forest regrowth, harvested areas per year and pasture productivity from IBGE, livestock numbers from the agricultural census of 2006, internal transportation costs, the Atlantic Rainforest law, along with a few modifications in the equations and assumptions.

Validation was performed for the 2000-2010 period. The authors report that starting from the year 2000, the model predicts a deforestation of 16.9 mi ha in the amazon by 2010, against the observed 16.5 mi ha from PRODES/INPE. They also report that the model's projections for crop area differs from IBGE/PAM data by less than 5% for that same period.

The starting map (year 2010) used by this model only consider as Cerrado remnants those areas without direct use anthropogenic use (approx. 26% of the biome). For 2050 this model suggests only 15% of such remnants would remain. Calculations based on this model are presented in Supplementary Table 3.

1.2. Species distribution data

Species range data for threatened endemic plants were obtained from[16]. Data is provided by the National Centre for the Conservation of Flora (CNCFlora), a department of the Research Institute of the Botanical Garden of Rio de Janeiro. The CNCFlora is the Red List Authority for plants in Brazil and adopts the standards and procedures recommended by the International Union for the Conservation of Nature – IUCN. The Centre is responsible for assessing the conservation status of species of the Brazilian flora and elaborate red lists of threatened species, supporting the government on the issuance of Official Red Lists. The data used was systematically checked and validated by a network of 542 botanical specialists who worked in collaboration with the Centre to assess the extinction risk in the last four years and all species used in our analysis are enlisted in the Official Threatened Flora Species List. Therefore, this is the most updated and reliable data on the distribution of threatened plants available in Brazil.

1.3. Pasture productivity data

Current and potential pasture productivity data were obtained from[1].

1.4. Crop suitability data

Soybean and sugarcane crop suitability was obtained from GAEZ[17].

1.5. Extinction estimates

The estimate for extinctions followed two methods, both based on the species-area relationship:

1.5.1. An aggregate model for all species combined

We used the species-area relationship to estimate aggregate extinctions based on loss of natural vegetation loss across the entire biome up to 2012 and then up to 2050, based on two different projections of land-use change (point 1 above). We used three different slopes (z values of 0.15, 0.25 and 0.35) and applied the relationship to 4600 endemic plant species. Steeper slopes yield higher projected extinctions. Results are presented in Supplementary Table 2 (for the OTIMIZAGRO land-use data) and Supplementary Table 3 (for the GLOBIOM-Brazil land-use data).

1.5.2. A continuous model for extinction risk of each species individually

We estimated the extinction risk facing individual plant species using a rearrangement of the species area curve[9,18]:

$$E = 1 - (A_t/A_{t0})^z$$

where E is the individual species' extinction risk, A_t is the area of Cerrado vegetation that overlaps with the species' range in year t, and A_{t0} is the original range of that species. For original range, we used the extent of occurrence maps from the recent Brazilian Red List of Threatened Flora[12] for the 397 endemic plant species currently classified as threatened. For the area of Cerrado vegetation in years 2012 and 2050 we used data from OTIMIZAGRO model[7]. In this sense, as the true original range of the species is likely much larger, our results area a conservative underestimation of each species' extinction risk. Individual species extinction probabilities were then mapped to their extent of occurrences ranges. Finally, for each cell, we summed up all species extinctions probabilities whose ranges overlap with that cell (Figure 1E).

We applied this model for the BAU scenario and the Greener Cerrado scenario (Supplementary Table 4).

1.6. The Greener Cerrado scenario

The "Greener Cerrado" scenario land-use allocation was obtained following (*2*). The area of sugarcane (1.9 mi ha) and soybean (13.4 mi ha) expansions projected by OTIMIZAGRO in the Business-as-usual (BAU) scenario were allocated to suitable pasturelands in municipalities with the highest current production of that crop. After this, 6,38 million hectares of restoration, equivalent to the forest code deficit for this biome, were allocated to those cells that would yield the highest benefits in terms of avoided extinctions (using the continuous for extinction risk, of each species individually, described above). As in (*2*), this scenario is meant to be illustrative of a possible future involving zero deforestation and restoration, but not predictive.

Supplementary Table 1 – Key ongoing policy developments that will influence the future of the Cerrado

Policy instrument	Current situation	Improvement/Desired
Soybean Moratorium	Applies only to Amazon biome; 88.4% of the remaining Cerrado is biophysically suitable for soybean expansion	**Expansion of the soybean moratorium to the Cerrado.** It is possible to do so without compromising the projected soybean expansion, as there is much more suitable land for soybean in current pasturelands (72.3 mi ha) than the projected soybean expansion (13.4 mi ha)
Climate and International Cooperation Finance	Even though Cerrado deforestation contributed to over one quarter of Brazil´s emissions, Brazil's main climate change mitigation fund, the Amazon Fund, restricts funding in other biomes to monitoring activities. A possible expansion of Amazon Fund geographic scope to include the Cerrado, in particular the areas inside the Legal Amazon region, is currently under discussion. The current international cooperation projects coordinated by the Ministry of the Environment (MMA) sum up approx. US$ 100 million in the Cerrado	**Expand climate finance to the Cerrado.** In particular, the Amazon Fund is currently considering this option, and the new Green Climate Fund should have an appropriate focus on the Cerrado. Avoiding 2012-2050 projected deforestation in Cerrado would mitigate 8.5 Pg CO_2eq
Beef Supply Chains	Lagging behind soybean and sugarcane; No market pressure for banning beef production from newly deforested areas; International supply chains bans on products associated with direct deforestation planned for 2030 might come too late	**Anticipate bans on direct conversion**. Huge yield gap in current pastureland is enough to fulfil all sectoral targets and by going from 35% to 61% of potential carrying capacity of pasturelands over 38 years would be enough for increased beef production by 49% and potential land sparing for all projected agricultural expansion and restoration of 6,38 million hectares
Protected Areas	Only 7.5% of the biome area is currently protected	**Expand public conservation areas to at least the nation-wide Aichi target 11 level (17%)**. Using systematic conservation planning, species persistence could be maximized. Impacts of climate change and actual conversion threat should be taken into consideration
Forest Code	Currently allows for legal deforestation in part of the private properties (20% in the Amazon, 65% in the Amazonian Cerrado and 80% in the majority of the Cerrado and in the rest of the country). As a consequence, at least 40% of the remaining Cerrado (cf 6% of the Amazon) can be legally deforested. Ongoing regulation of crucial aspects can weaken or strengthen it	**Enforce the law, in particular the requirements to recuperate native vegetation in areas currently below the legal minimum**. Accelerate the implementation of rulings and state and county regulations to correct pending issues with the Forest Code based on scientific knowledge and with wider citizen participation. Commitment of the private sector is crucial
Forest Code Offset market (Tradable Environmental	Strategic spatial planning for conservation and restoration are under discussion but not developed yet	**Accelerate implementation, regulation and enforcement, including the expansion of CRA scope to consider also conservation and**

Reserve Certificates - CRA)		**environmental services, and not only an area-based compensation of legal reserve deficits.** Accelerate spatial planning for conservation (threatened species, climate refugia) and restoration (threatened species, climate refugia and landscape connectivity)
Policies for Endangered Species	Action plans under development for endangered species, but fewer than 10% of Brazilian plant species have been assessed for threat level	**Accelerate species assessments and development of territorial action plans** (with a focus on plants) to make the most of the Forest Code offset market (CRA) and Protected Areas expansion plans
Genetic Patrimony	Recently approved landmark law that envisions funds for conservation and benefit sharing. Still lacking crucial regulations and action plan	**Accelerate the law implementation process**. Leverage the potential for conservation funding; 628 plant species are currently threatened and over 4208 of endemic plants are at risk
Restoration	National restoration plan ongoing and international agreements signed, but few real on-the-ground actions have been executed so far	**Accelerate the creation and implementation of a national restoration plan (PLANAVEG)**. Improve regulations and incentives for the restoration supply chain (seed and seedling producers, project planners, companies and co-operatives that undertake plantings, etc.)
Cerrado Deforestation Monitoring	Monitoring of habitat loss was interrupted in 2011	**Accelerate the implementation of the Brazilian Biomes Environmental Monitoring Program** (MMA Ruling nº 365, from November 27th, 2015). It includes annual/biannual monitoring of early detection deforestation, deforestation rate, land use, native vegetation recovery, fire occurrence and burned area
Action Plan for the Prevention and Control of Deforestation and Forest Fires in the Cerrado biome PPCerrado	Evaluation of second phase (2014-15) and preparation of the third phase (2016-2020)	**Accelerate the implementation of the third phase of Action Plan** (2016-2020) and strengthen the institutional governance to approach and orientate new actions
National REDD+ Strategy (ENREDD+ Portuguese acronym)	Established in Dec/2015: still in its initial steps towards implementing its governance structure and guidance documents to deliver transparency and a consistent national strategy. Still weak integration and consistency between Federal and states strategies.	**Accelerate the submission of the Cerrado Forest Reference Emissions Level and Technical Annex to UNFCCC** to stimulate and facilitate the flow of resources for Cerrado conservation and sustainable use policies implementation (restoration, protected areas, public and private preservation, monitoring and the Forest Code). Accelerate the implementation of a convergent strategy to integrate on-going subnational and national level initiatives. Conclude initial guidance documents on safeguards and resource fundraising and distribution, to bring transparency and legal certainty for private and public future initiatives in the short and long term. **Implement biodiversity safeguards and provide incentives for biodiversity co-benefits,**

		in particular for actions that would reduce extinction risks.

Supplementary Table 2. Projected extinctions of threatened endemic Cerrado plant species based on original vegetation cover and the OTIMIZAGRO model.

	z = 0.15	z = 0.25	z = 0.35
2012 (54% of the biome remaining with native vegetation cover)	406	657	892
2050 (32% of the biome remaining with native vegetation cover)	723	1140	1513

Supplementary Table 3. Projected extinctions of threatened endemic Cerrado plant species based on undisturbed habitat only and the GLOBIOM-Brazil model.

	z = 0.15	z = 0.25	z = 0.35
2012 (26% of the biome remaining as undisturbed habitat)	842	1315	1729
2050 (15% of the biome remaining as undisturbed habitat)	1139	1737	2232

Supplementary Table 4. Projected extinctions for the 397 threatened endemic plant species

	BAU Scenario	Greener Cerrado Scenario
Projected extinctions (z=0.25)	75	13

Supplementary References

15. Havlik, P. U. A. *et al.* Energy Policy **39,** 5690– 5702 (2011).

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18. Thomas, C. D. *et al.*, Extinction risk from climate change. *Nature* **427**, 145-148 (2004).