ENVIRONMENT AND DEVELOPMENT

Brazil's Soy Moratorium

Supply-chain governance is needed to avoid deforestation

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POLICY

Brazil's Soy Moratorium (SoyM) was the first voluntary zero-deforestation agreement implemented in the tropics and set the stage for supply-chain governance of other commodities, such as beef and palm oil [supplementary material (SM)]. In response to pressure from retailers and nongovernmental organizations (NGOs), major soybean traders signed the SoyM, agreeing not to purchase soy grown on lands deforested after July 2006 in the Brazilian Amazon. The soy industry recently extended the SoyM to May 2016, by which time they assert that Brazil's environmental governance, such as the increased enforcement and national implementation of the Rural Environmental Registry of private properties (Portuguese acronym CAR) mandated by the Forest Code (FC) (*1*), will be robust enough to justify ending the agreement (*2*). We argue that a longer-term commitment is needed to help maintain deforestation-free soy supply chains, as full compliance and enforcement of these regulations is likely years away. Ending the SoyM prematurely would risk a return to deforestation for soy expansion at a time when companies are committing to zero-deforestation supply chains (*3*).

Between 2001 and 2006, soybean fields expanded by one million hectares (Mha) in the Amazon biome, and direct conversion of forests for soy production contributed to record deforestation rates (*4–6*). Farms violating the SoyM were identified using a satellite and airborne monitoring system—developed by industry, NGOs, and government partners—and were blocked from selling to SoyM signatories. Monitoring data confirm high compliance with the SoyM (*6*).

ESTIMATING IMPACTS. In the 2 years preceding the agreement, nearly 30% of soy expansion occurred through deforestation rather than by replacement of pasture or other previously cleared lands. After the SoyM, deforestation for soy dramatically decreased, falling to only ~1% of expansion in the Amazon biome by 2014 (see the chart) (SM, table S1) (*6*). Soy increased by 1.3 Mha in the Amazon biome during this period (*5*).

In the Cerrado biome, where the SoyM does not apply, the annual rate of soy expansion into native vegetation remained sizable, ranging from 11 to 23% during 2007–2013 (SM, table S2). In Brazil's newest agricultural hotspot—the eastern Cerrado region in the states of Maranhão, Piauí, Tocantins, and Bahia (Mapitoba)—nearly 40% of total soy expansion (2007–2013) occurred at the expense of native vegetation (table S3). About half of the Cerrado biome has been converted for agricultural production in recent decades, and these woodlands and savannas have less protection than Amazon forests under environmental laws (*7*). Further study is needed to assess potential leakage into the Cerrado and other countries and to quantify the avoided deforestation from the SoyM.

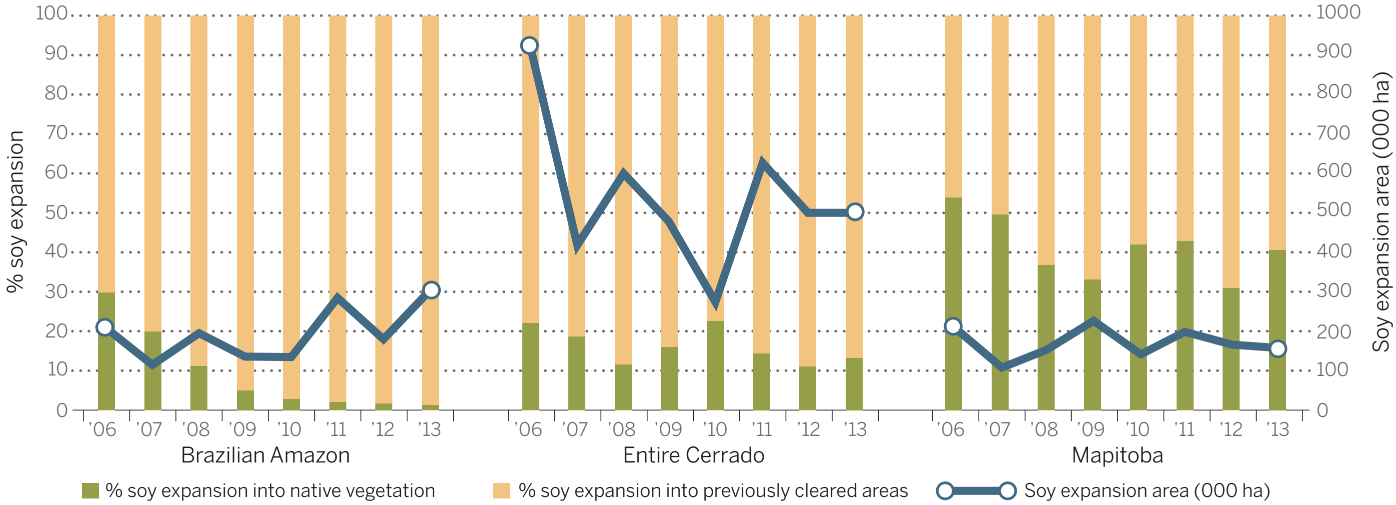
PROPERTY REGISTRATION. The CAR provides the first transparent mechanism to evaluate compliance with the FC and other regulations by linking a responsible landholder to land use on a particular property. All rural properties across Brazil are required to obtain the CAR by May 2016, although delays are expected, given the formidable task of demarcating more than 5 million properties. In Pará and Mato Grosso, the two states with the highest CAR participation, more than 65% and 48% of the agricultural land, respectively, is registered (SM).

Property registration alone, however, does not safeguard forests (*8*, *9*). In 2014, for example, nearly 25% of Amazon deforestation in Mato Grosso and 32% in Pará occurred within registered properties (*10*) (SM). In both states, nearly half of this clearing occurred in the Legal Reserve (LR) areas designated as set-asides required by the FC. Most of this clearing was illegal; few registered properties with deforestation in Mato Grosso (9%) or Pará (4%) had the ≥80% forest cover mandated by the FC (SM).

Comparing property-level compliance with the SoyM and the FC illustrates the relative response by soy farmers. In Mato Grosso, which accounts for 85% of the soy produced

Annual soy cultivation expansion by region

Annual soy expansion and land sources after the 2006 SoyM. Note that the Mapitoba area is included in the Cerrado (see SM).



in the Amazon biome, mapped farms with ≥25 ha of soy violated the FC, even while complying with the SoyM (table S4). Only 2% of mapped soy farms in Mato Grosso had sufficient LRs, making almost all deforestation illegal (table S5). At least 627 soy properties in Mato Grosso violated the FC and cleared forest illegally during the SoyM. Yet only 115 properties were excluded by soy traders for SoyM violations (*2*). This discrepancy can occur because the SoyM regulates only the portion of the property where soy is grown—not the entire property. The larger number of FC violations suggests that producers are more likely to comply with the SoyM.

LIMITED FEDERAL ENFORCEMENT. Without the SoyM, federal enforcement mechanisms would be the primary intervention against deforestation in the soy supply chain. Brazil's environmental protection agency, IBAMA, uses satellite data and field visits to issue fines and embargo economic activities on rural properties with illegal deforestation. The number of properties listed as embargoed more than tripled in the last 5 years (SM). However, thousands of deforestation events occur in the Brazilian Amazon each year across an area spanning 550 Mha, which makes it difficult to achieve enforcement (*11*). As of May 2014, roughly half of the registered properties with deforestation ≥25 ha, 2009–2013, were not embargoed (tables S6 and S7). Most of this deforestation was illegal. Government monitoring of embargoed properties is limited; in the embargoed list, for more than half of registered properties with embargoes, producer identification was inconsistent with the CAR system. Production could continue in embargoed areas and be transferred to another nonembargoed property or farmer for sale ("laundering"). Producer information was inconsistent between the embargoed list and the CAR system for more than half of the registered properties with embargoes. Soy traders and others use the CAR to check for embargoes; inconsistent information makes it difficult to avoid transactions with embargoed properties (SM).

Federal enforcement mechanisms are unlikely to be an effective substitute for the SoyM in the near term, because there is no simple way to identify properties that are in compliance with the FC. Recent changes to the FC have created the forest certificate (Portuguese acronym, CRA)–trading schemes, which allow landholders to purchase CRA from other properties and compensate for LR deficits accrued from illegal deforestation before 2008 (*1*). A system is not yet in place to monitor this off-property LR compensation. Enforcement is more straightforward under the SoyM, because all clearing for soy is prohibited. Of the existing policy and enforcement regimes, only the SoyM allows buyers to ensure deforestation-free supply chains over the next several years. Over the long term, elements of the SoyM and FC monitoring systems could be combined to satisfy market demands for information. However, even with eventual full compliance under the FC, legal deforestation could enter the soy supply chain without the SoyM (*1*).

"Federal enforcement mechanisms are unlikely to be an effective substitute for the Soy Moratorium ..."

VULNERABLE CERRADO. In the Amazon biome, there are an estimated 14.2 Mha of unprotected tropical forest considered suitable for soy production, and up to 2 Mha of this forest could be cleared legally under the FC (SM and fig S3). These forests would be vulnerable to soy expansion without the SoyM. However, the bank of eligible, previously cleared land suitable for soy production is more than six times the area planted in 2014 indicating the expansion is possible under the SoyM (table S8) (*12*).

More than 20 Mha of natural vegetation in the Cerrado are considered suitable for soy expansion, and up to 11 Mha of these lands could be legally converted under the FC. Large areas of cleared lands suitable for soy (42.5 Mha) also exist in the Cerrado, enough to triple current soy production, but these lands are not located in the regions with the most rapid recent expansion of soy into native vegetation. In the Mapitoba region, for example, there are fewer than 2 Mha of cleared lands considered suitable for soy production (fig. S3). If large-scale soy expansion continues in Mapitoba, remaining natural vegetation could be highly susceptible to soy conversion without additional safeguards. Expanding the SoyM could reduce the ongoing direct conversion of cerrado vegetation to soy.

By prohibiting new deforestation, the SoyM incentivizes soy expansion into already-cleared areas, which may displace pastures and could indirectly lead to more deforestation. Zero-deforestation agreements in the cattle sector, together with national and municipal policies, may partially mitigate the risk of this indirect deforestation (*11*). Ongoing efforts to increase production on existing pasturelands could free additional areas for production (*13*).

CONCLUSIONS. Since the SoyM's inception in 2006, only a small area of soy expansion in the Brazilian Amazon occurred in newly deforested areas. Soy farmers are about five times as likely to have violated the FC as the SoyM (115 versus 627 violations) (SM). The success of the SoyM is due to an array of factors, including (i) a limited number of soy buyers that exert considerable control over soy purchase and finance; (ii) simple requirements for compliance; (iii) streamlined and transparent monitoring and enforcement systems; (iv) simultaneous efforts by the Brazilian government to reduce deforestation; and (v) active participation by NGOs and government agencies (*14*). Monitoring and compliance mechanisms established by the SoyM offer a model for expanding supply-chain governance to other soy-producing regions and commodities.

We argue that the CAR and FC are not yet sufficient replacements and are unlikely to be fully implemented when the SoyM expires in 2016. Instead, the SoyM should be further extended and strengthened in the Amazon biome through expanded monitoring and exclusion of all deforestation on soy-producing properties, including small clearings and those located in indigenous lands and rural settlements, where soy production is expanding (SM). The SoyM should also be expanded to include the Cerrado biome to reduce conversion of remaining native vegetation.

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SUPPLEMENTARY MATERIALS

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Supplementary Materials for

Brazil's Soy Moratorium

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Supplementary Text

S§1 Background on the Soy Moratorium (SoyM) and related environmental policies

In 2006, public protests over the Cargill soy terminal in Santarém and a provocative publication by Greenpeace (*15*) called international attention to deforestation associated with soybean production in the Brazilian Amazon. In response to the reputational risk this attention posed to the soy industry, the Brazilian Association of Vegetable Oil Industries (ABIOVE) and the Association of Cereal Exporters in Brazil (ANEC), which together purchase 90% of the soy produced in the Amazon, signed the zero-deforestation SoyM agreement, pledging to no longer purchase soybeans produced on lands deforested after July of 2006 in the Amazon Biome. The SoyM operates as a "market exclusion" policy (*16*). Producers in violation lose market access for their soy, but neither traders nor producers receive any price benefit for complying with the agreement. Soy farmers in the Brazilian Amazon also rely heavily on traders to finance their production. Consequently, soybean producers have strong incentives to comply with the SoyM (*17*).

The SoyM was drafted in cooperation with several high-profile environmental groups and resulted in the formation of the Soybean Working Group (GTS) to oversee the implementation and monitoring of the agreement. The Brazilian government became involved in the SoyM in 2008 when the Ministry of the Environment (MMA) officially joined the GTS and the Brazilian Institute for Space Research (INPE) was brought in to lead the monitoring efforts to identify places where soy was being grown on land deforested after the cut-off date (*17*). Industry, nongovernmental organizations (NGOs), and government members of the GTS share a mutual interest in the success of the SoyM, although government and NGO participation has been criticized as tacit endorsement of large-scale agriculture over alternative land-use strategies (*18*).

The SoyM has been renewed annually following the initial 2-year agreement (2006–2008). The most recent renewal, announced in November 2014, is for 18 months and will end in May 2016. The latest SoyM renewal agreement features important changes from the original terms, corresponding with what ABIOVE refers to as a "new agenda" for soybean production in Brazil's Amazon biome (*2*). The most important of these changes shifts the cut-off date for deforestation of soy-producing areas from July 2006 to July 2008, to match the FC's cutoff date for Legal Reserve (LR) deficits that may be compensated off-property (*1, 19*). Following the planned end of the SoyM in May 2016, ABIOVE plans to shift from market exclusion of soybeans produced in recently deforested areas to promoting CAR in major soybean producing municipalities, encouraging agricultural best practices, and developing a compensation mechanism for producers who maintain forested areas on their properties (*19*).

Annual monitoring for the SoyM builds on Brazil's existing system to map deforestation in the Amazon region (PRODES) (*20*). The first step is to identify large deforestation events (≥25 ha) in the monitored municipalities. Small clearings are aggregated across years, so cumulative deforestation may eventually reach the 25-ha threshold for monitoring (*21*). Time series of NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) satellite imagery are then used to determine the postclearing land use in areas of recent deforestation (*6, 21, 22*). Areas determined to have crops are investigated with higher-resolution Landsat and Resourcesat imagery and are ultimately surveyed by air to confirm the presence of soybeans. Field visits to verify the presence of soybeans were conducted in the earlier years of the SoyM. If a violation of the SoyM is confirmed, the property is added to the blacklist managed by the GTS and checked by soy traders before purchase.

While the scope of the SoyM includes the entire Brazilian Amazon, the monitoring system is limited to municipalities in the states of Mato Grosso, Pará, and Rondônia with at least 5000 ha of soybeans planted in the current or previous year, or predicted to be grown in the coming year. Protected areas, indigenous territories, and INCRA settlements (Instituto Nacional de Colonização e Reforma Agrária) are excluded from the monitoring. The GTS estimates that they are monitoring 97% of the soybean production in the Brazilian Amazon (*21*).

The establishment of the SoyM coincided with a surge of new federal environmental policies covering the Brazilian Amazon biome and other soy-producing regions (*14*). Recent policy impact studies emphasize the importance of multiple factors for recent declines in Amazon deforestation, including changes in prices and profitability of agricultural commodities (*23*). For example, previous research points to changes in deforestation dynamics in response to expansion of the protected area system (*24*), economic restrictions on "blacklisted" municipalities (*25*), improved enforcement of illegal deforestation (*11, 25*), and the SoyM (*5*).

Materials and Methods

S§2.1. Tracking Soy Expansion Pathways Across the Amazon and Cerrado Biomes

We used two satellite-based datasets to track the area and location of annual soy expansion from 2001 to 2014 (Amazon biome) and 2001 to 2013 (Cerrado biome) (fig. S1). Both products were based on MODIS data. For the Amazon biome, we used the soy expansion data for the crop years 2000/01–2013/14 based on MODIS imagery (*26*) following Rudorff *et al*. (*6, 22*) and Risso (*28*). The analysis concentrated on the Amazon biome portion of 88 municipalities with at least 1,000 ha in soy production in three states — Mato Grosso, Pará, and Rondônia (fig. S2). The GTS monitors only those municipalities with over 5,000 ha planted in soy but our analysis also considered new frontiers of soybean expansion. For the property-level analyses described below, we included only the 69 municipalities within Mato Grosso.

For the Cerrado biome, we analyzed the 16-day MODIS Normalized Difference Vegetation Index (NDVI) product (MOD13Q1) (*29, 30*) to estimate the annual cropland expansion at 250m spatial resolution. The classification approach identified large areas (≥ 1 km^2) of mechanized crop production based on annual, wet- and dry-season phenology metrics as in previous studies (*4, 5, 30*). Seven phenology metrics and one tree cover metric were produced per year: annual (year $n - 1$: DOY 273–year n: DOY 272) mean, standard deviation; dry-season (year n: DOY 113–273) mean, maximum, minimum, standard deviation; wet-season (year $n - 1$: DOY 273–year n: DOY 112) standard deviation; and percent tree cover. A 2-year temporal identification method was used to minimize possible false identification of soy.

Training data for the decision-tree classifier were based on expert knowledge of the study region. Equal numbers of cropland and non-cropland pixels were digitized to produce an extensive training data pool. The decision-tree classifier (*31, 32*) was developed with training data from 2012 to 2013. Cropland and non-cropland classes were separated based on MODIS phenology metrics, percent tree cover, and slope and elevation derived from the Shuttle Radar Topography Mission (SRTM) (*33–35*).

Spatial and temporal information were used to filter the Cerrado classification results. New cropland areas were limited to large patches (≥1 km^2) that were classified as cropland in at least two successive years during 2001–2013. The cropland classification was validated using 1,372 aerial photos taken in 2007 by INPE (*36*), 317 ground data points for the year 2010 (*5*), and an additional 904 (2010) and 702 (2011) ground data points (*37*). The aerial and ground photos were visually interpreted to identify cropland patches and validated against the cropland classification. Overall accuracy ranged from 76% (TerraClass 2010) to 94% (INPE air photos).

As noted, our analysis for the Cerrado biome mapped the broad category of large-scale crop production, but not specifically soy. However, we assumed that the vast majority of the cropland was planted in soy because the classification approaches targeted the soy-growing season. In much of the soy-producing region of the Amazon and the Cerrado, two and sometimes three crops are planted per year, but in nearly all cases one of those crops is soy. Soy is by far the most reliably profitable crop produced at large scales; as such, most farmers produce only soybeans during the soybean "season" (roughly September to January, with some variation across the regions). Commercial silos are also unlikely to accept crops other than soy at the beginning of the year, further discouraging production of other crops. Cotton is the only other major crop planted at roughly the same time as soy in the Cerrado. However, cotton is typically planted 30-60 days after soybeans because of the different end dates of the obligatory "sanitary periods" for the two crops. In regions where only one crop per year is typical, soybean is part of most interannual rotational systems at the large scales our analysis targeted.

We used annual deforestation maps for the Amazon and Cerrado to identify the year of deforestation in areas of soy expansion. We defined "soy expansion" for each given year as only those areas that were classified as soy for the first time in that year, and not in any previous study year. We defined "deforestation for soy" as soy expansion into a region of forest or cerrado that was cleared within the preceding three years. These areas were unlikely to have been part of any other production system based on timing of deforestation activity and planting schedules. PRODES data for the Brazilian Amazon provide annual estimates of primary forest clearing >6.25 ha since 2001 and cumulative deforestation between 1988 and 2000 (*20*). LAPIG deforestation data for the Cerrado biome begin in 2003, with annual estimates of new clearings ≥25 ha (*38*). Cumulative cerrado clearing before 2003 was estimated using land cover data from PROBIO (Projeto de Conservação e Utilização Sustentável da Diversidade Biológica Brasileira) (*39*). In some cases, soy expansion did not overlap with deforested areas. Areas of disagreement between annual soy maps and deforested areas for the Cerrado (9%) and Amazon (2%) were excluded from the analysis of annual soy expansion pathways.

S§2.2. Soy expansion in the Cerrado biome

Few efforts have focused on reducing deforestation in the Cerrado compared to national and international attention to deforestation rates in the Brazilian Amazon (*7*). For example, there is not yet routine monitoring in the Cerrado by the Brazilian government as there is in the Amazon. Since the 1970s, the Cerrado has been one of the most rapidly converted ecosystems in the world, driven mainly by expansion of crop and pasturelands (*40*). Nearly 60,000 km^2 of cerrado have been cleared for agricultural expansion since 2003 (*7*), and we estimated that 21% of this land is now used for soy production. Moreover, 74% of the new soybean plantings during 2010–2013 within our Amazon-Cerrado study area were in the Cerrado, and 36% of these occurred in Mapitoba alone. Some of this soy expansion could be leakage in response to the SoyM but additional research is needed to assess the impact of the SoyM and other Amazon policies on soy expansion in the Cerrado. Rapid losses of cerrado vegetation in recent years threaten the biome's high biodiversity (*41, 42*), its role in hydrological cycles, and its importance as a carbon sink (*43*), as well as its interactions with Amazon forest. Moreover, 65% of the native cerrado vegetation met the definition of forests established by the Brazilian government (areas >0.5 ha with trees > 5 m and a canopy cover of more than 10%) (*44*). In Mapitoba, 81% of remaining cerrado vegetation satisfies these criteria.

S§2.3. Analysis of registered properties

We combined PRODES deforestation data with property registration databases to estimate the portion of 2014 Amazon deforestation that occurred within different categories of land in Mato Grosso and Pará. Property boundaries came from the CAR and LAU (Unique Environmental License) databases administered by the Secretariats of the Environment (SEMA) for Mato Grosso and Pará (data accessed 03/2014 and 11/2014, respectively; *45, 46*). These databases include georeferenced boundaries of rural properties, as well as existing LRs and Permanent Preservation Areas. Property registration has been based on self-declaration and verified by the state environmental agency only after the process of issuing the CAR begins. Under the statewide CAR system administered by Mato Grosso from 2009 until the present, a licensed technician was required to submit the initial georeferenced property boundaries with the registration. However, the federal SICAR established in the 2012 FC does not require a technician or specialist to draw the property boundaries. It is important to note that property registration is not equivalent to obtaining a legal land title, and conflicting claims may exist.

To estimate the portion of 2014 deforestation that occurred on registered properties, we used the registration date in the CAR and LAU datasets to identify those properties that were registered by the start of the 2014 PRODES year (8/2013). In Pará, the date of registration in the CAR dataset reflects when the owner entered his or her information into the system. In Mato Grosso, however, the only date provided is for when the CAR or LAU was issued by SEMA, which is an administrative decision not tied to decision-making by the landowner. Delays of months to years between application and issue date for the CAR and LAU have been common in Mato Grosso. We assumed that all properties in the Mato Grosso database began the registration process prior to the 8/2013 start of the 2014 PRODES year (12/3/2013 was the latest CAR issue date in the dataset). We estimated that in 2014, 52,672 ha of deforestation occurred within CAR properties in Pará, with 18,272 ha falling within CAR-registered INCRA settlements (26,165 ha inside LRs). In Mato Grosso, 23,546 ha of the 2014 deforestation occurred inside CAR properties (11,632 ha inside LRs). Our estimates are conservative because we excluded properties that registered during the PRODES year since we could not determine if these properties deforested before or after registering.

For the analysis of soy properties, we also used property boundary information from INCRA's CCIR (Rural Property Registration Certificate) database (data accessed 07/2014, *47*). Properties in the CAR and LAU systems were designated as "registered." A "mapped property" is one for which we had boundary data and includes CAR, LAU, and INCRA. Approximately 65% of soy area planted 2007–2014 in the Amazon biome portion of Mato Grosso is registered. By adding in the INCRA CCIR data to CAR and LAU, we were able to map property boundaries for 74% of soy produced in the Amazon region of Mato Grosso (fig. S3).

We standardized the publicly available property boundary datasets for Mato Grosso to create a single dataset and address issues of overlap between properties. Overlapping properties within the individual datasets were relatively rare (10.6% of MT-CAR and 0.9% of MT-LAU properties had overlaps >5% of the property area). In most cases, overlaps were along property edges. Our final dataset for Mato Grosso consisted of 26,894 registered properties, and prioritized CAR and LAU because we were most interested in tracking these registered properties.

S§2.4. Property-level deforestation and forest cover in Mato Grosso's Amazon Biome

Direct deforestation for soy production declined sharply after the SoyM (table S1). However, 627 soy properties in Mato Grosso illegally cleared forest, but did not plant soy on the cleared area, following the SoyM (table S4). This estimate excluded cases of legal deforestation (36 properties with ≥80% forest cover), lag times >3 years between deforestation and crop production (111 properties), and cases where landholders may have since compensated for clearing prior to 2008 (77 properties). Note that the SoyM violations reported by the SoyM monitoring team cover the Amazon biome whereas the FC violations that we identified on soy properties are only from those in MT. Consequently, the estimate that soy properties were more than five times more likely to violate the FC than the SoyM may be conservative.

We estimated the area of primary forest remaining on properties using PRODES (*20*), and remaining secondary forest using TerraClass (*37*) for both soy and non-soy properties within the study area. Overall, soy properties have less forest remaining than surrounding properties (table S5). On average, mapped soy properties retained 28% of their area in forest, and only 2% of these soy properties had ≥80% forest remaining, as required under the FC. Including primary and secondary forest areas, nearly 4% of soy properties had ≥80% forest remaining compared to 18% of non-soy properties in the same municipalities. We were unable to assess standing forest on properties accounting for the remaining 26% of soy area that is not mapped by CAR, LAU, or INCRA.

S§2.5. Analysis of embargoes for illegal deforestation

Penalization rates were assessed using deforestation events in 2007–2013 and the IBAMA spatial database of embargoed areas (data accessed 05/2014, *48*). Adjacent PRODES polygons were aggregated annually within 2007–2013 to identify deforestation events ≥25 ha. Descriptions of the infractions in the IBAMA database were used to identify the 2,988 embargoes in Mato Grosso that were related to Amazon deforestation.

We estimated the portion of all deforestation that was embargoed as well as deforestation specifically in registered properties. For the estimates of embargoes on all deforestation, we counted a deforestation event as embargoed if 10% of the embargo area was within the deforested area polygon. We also provided evidence of any overlap ≥1% between the embargo and deforestation areas (table S6). In some cases, the IBAMA embargoed database provided only limited area information. Approximately 75% of infractions had either a complete polygon or location with associated area information in the attribute table. For infractions where only a point and an associated area were provided, we created a circle around the point equal in size to the embargoed area. The remaining 25% consisted of a location without area information; consequently, we may have underestimated overlaps between these location-only embargoes and deforestation events because of missing information.

We emphasized a subset of these results focused on registered properties in the main text, given these complications with the embargo dataset. This more conservative approach better accounts for all of the embargo information, including dots without area information, because the dot location can fall anywhere in the property rather than only within the deforested area (table S7).

A small portion of the deforestation events may have been within the law and not subject to an embargo. For example, we estimate that ~9% of registered properties in Mato Grosso with 2014 deforestation may have the required LRs to legally permit additional deforestation. Infractions may be removed from the embargo database upon payment of the associated fine; however, less than 2% of the US$ 6 billion in environmental fines issued by IBAMA from 2009 to 2013 have been paid, and consequently very few properties have left the list (*49*). Embargoes can also be added after deforestation, so the percent of deforestation from any given year that is penalized may increase over time.

Consulting the list of embargoes is not adequate to avoid purchase from embargoed properties. We compared producer identification numbers on the CAR/LAU property databases and the IBAMA map of embargoed areas in the Amazon biome portion of Mato Grosso. There were 4,181 total embargoes in this part of the state, and 1,582 fell on a CAR or LAU property. Of the 1,198 registered properties containing ≥10% of an embargoed polygon, 619 (52%) had matching producer information. When we restricted the comparison to only instances where at least 90% of the embargo overlapped with the property, 60% (486/806) had matching owner information. Ownership information may change through sale of the property, transfer of ownership to family members, or for other reasons. IBAMA can also assign embargoes to individuals besides the property owner, such as the property manager. These inconsistencies present another obstacle for pursuing a deforestation-free supply chain in the absence of the SoyM (12% of soy properties have embargoes in Mato Grosso, and 14% in Pará).

S§2.6. Land suitable for soy expansion in the Amazon and Cerrado Biomes

We estimated the area of land under forest and cerrado, and of previously cleared land suitable for soy production using the suitability data from Soares-Filho *et al.* (*1*). The suitability maps considered slope (*33*), soils, and climate zoning information for current soy cultivars (*50*) based on hydrological balance and thermal normals from processing WorldClim and Climond databases (*51, 52*). Weights of evidence were derived by cross tabulating the suitability map with maps of current soy production and scaling the values from 0 to 100. Any cell that scored 65 or over was considered suitable.

Suitable lands were further limited following Soares-Filho *et al.* (*1*) methods to exclude protected and indigenous areas, urban areas, roads, water bodies, and areas already planted to soy. In order to quantify the suitable land available in cleared and vegetated areas, we overlaid our suitability map on deforestation maps for the Amazon and Cerrado. For the Amazon biome, we used PRODES to identify deforestation (20) but also used Terraclass to modify PRODES by identifying deforested areas that have since grown back as secondary vegetation (37); for the Cerrado biome, we merged together deforested areas identified in the PROBIO 2002 land cover map (39) and the PMDBBS deforestation dataset from IBAMA (53) (fig. S4, table S8).

Most of the unprotected primary forest area in the Amazon Biome was categorized as unsuitable for soy expansion (91.2%). Suitable lands were most abundant in Mato Grosso and Rondônia, with 42% and 32%, respectively, of their remaining primary forest on areas potentially suitable for soy cultivation. However, it is important to note that only a relatively small portion of these suitable forest regions could be legally cleared under the FC.

In the Cerrado biome, there were 42.5 Mha of cleared lands suitable for soy production, which is enough to more than triple current planted soy area (~13 Mha). However, in the Mapitoba region, there were only 1.9 Mha of already cleared suitable land. Given that soy expanded by 1.4 Mha in Mapitoba 2007–2013, there could be a scarcity of suitable cleared land there in the coming years. This shortage in Mapitoba increases the likelihood that soy will expand into the region's 3.5 Mha of suitable area under natural vegetation.

Legal reserve requirements under Brazil's FC could provide a further constraint on the areas of suitable land that could be converted to soy production in the Amazon and Cerrado biomes. Based on data and methods developed in Soares-Filho *et al*. (*1*), we approximated the area of suitable lands under native vegetation for each 12th order micro-watershed that could be legally cleared in the Brazilian Amazon and Cerrado biomes. We created maps of potentially vegetated areas (excluding water bodies, roads, railroads, urban areas, protected areas, and indigenous areas), remnant vegetation areas as of 2014, and areas suitable for soy expansion, at 60m spatial resolution. The map of remnant vegetation areas created by Soares-Filho *et al.* was updated by overlaying PRODES deforestation through 2014 for the Amazon and LAPIG deforestation through 2013 for the Cerrado and removing any newly deforested areas. For each micro-watershed, we calculated the area of vegetation exceeding FC requirements that was suitable for soy production. All modeling was performed using Dinamica EGO. Based on these models, there may be as much as 2.0 Mha in the Brazilian Amazon and 10.9 Mha in the Cerrado of remaining vegetation on suitable lands that could be legally cleared under the FC. These results likely overestimate the actual area for legal expansion of soy production, based on private property delineations within each watershed and restricted clearing in areas of permanent preservation (APP) as well as economic and social constraints not considered here.

Suitability maps compare favorably to areas of recent expansion of soy production. Data from 2001 to 2011 in the Amazon region were excluded from this comparison, because these data were used in the creation of the suitability maps (*1*). Approximately

83% of Amazon soy expansion during 2012–14 and 80% of Cerrado soy expansion during 2001–2013 occurred in areas mapped as suitable for soy production.

S§2.7. Opportunity costs for producers under SoyM

One critique of the SoyM is that it prevents soy farmers from legally clearing land, as permitted under the FC, without compensation for this opportunity cost (*2, 17*). However, only 2% of mapped soy farms in Mato Grosso have forest areas that could be legally cleared. On average, these soy farms in Mato Grosso maintain 28% of their original forest cover.

The latest SM terms of agreement marginally increased the available land for soy expansion by aligning the SM's deforestation cutoff date (previously July 2006) with the FC's cutoff date for off-property compensations of LRs (July 2008) (279,018 ha, 3.1%, table S9, *1*). Given the paucity of forest land that can be legally cleared on existing soy farms, at least some expansion of soy production in Mato Grosso is likely to proceed on new properties with lands suitable for soy production (SM§2.6). Thus, expansion of soy through legal deforestation on new properties continues to be an important opportunity cost of the SoyM.

S§2.8. Moratorium loopholes and leakage

Compliance with the SoyM has been extremely high, but potential loopholes and leakage could reduce its impact on deforestation. For example, soy from properties in violation of the SoyM could be sold through a property with no violations ("soy laundering"). Producers could also sell to small-scale or local buyers, who are not part of the SoyM, to avoid the regulations. However, monitoring efforts have identified very little illegal soy production (*6, 22*), which indicates that producers have generally not taken advantage of these loopholes (*21*).

Soy produced on recently deforested lands could also enter the supply chain through deforestation on areas not currently monitored by the SoyM, such as INCRA settlements and aggregated clearings smaller 25 ha (adjacent clearings aggregated across all years, 2007–2014). INCRA settlements contain 1.5 Mha and 0.5 Mha of suitable land under primary vegetation in the Amazon and Cerrado biomes, respectively. Nearly 26% of PRODES 2007–2014 deforestation occurred within INCRA settlement areas in the major soy-producing states of the Amazon—Mato Grosso, Pará, and Rondônia. Since the beginning of the SoyM, more than 130,000 ha of soy expansion has occurred within INCRA settlement areas in the Amazon, approximately 7% of the overall soy expansion in the Brazilian Amazon biome during this time. Nearly 5% of the soy expansion on INCRA lands since 2007 involved deforestation. Smaller clearings accounted for 17% of Amazon deforestation in Mato Grosso from 2007 to 2014, yet these areas are also excluded from the SoyM monitoring system. On soy properties, 11% of the deforested area from 2007 to 2014 was in aggregated clearings smaller than 25ha. Expanding the SoyM monitoring efforts to account for soy expansion in INCRA settlements and small clearings would close these loopholes and reduce the risk of deforestation in the soy supply chain.

The potential for indirect land use change (ILUC) in response to the SoyM is an important but not yet quantified issue. For example, deforestation avoided by the SoyM could potentially leak into the Cerrado biome as soy production expands in new regions with fewer constraints. In addition, the ongoing expansion of new soy fields in areas previously cleared for other uses, such as pasture, may displace pasturelands into forested areas leading to more deforestation (*54, 55*). Lastly, the ongoing clearing on soy properties that is not planted to soy could indicate the potential for within-property leakage as producers continue to deforest for other purposes not covered by the SoyM (*56*). However, government policies that aim to reduce Amazon deforestation may already mitigate some of the ILUC potential from soy expansion (*57*). The 2009 zero-deforestation cattle agreements and increasing soy-cattle integration may also help reduce potential displacement and leakage from the SoyM. More work is needed to assess the evolving and complex spatial and temporal linkages among cattle, soy, and other agricultural production in Brazil.

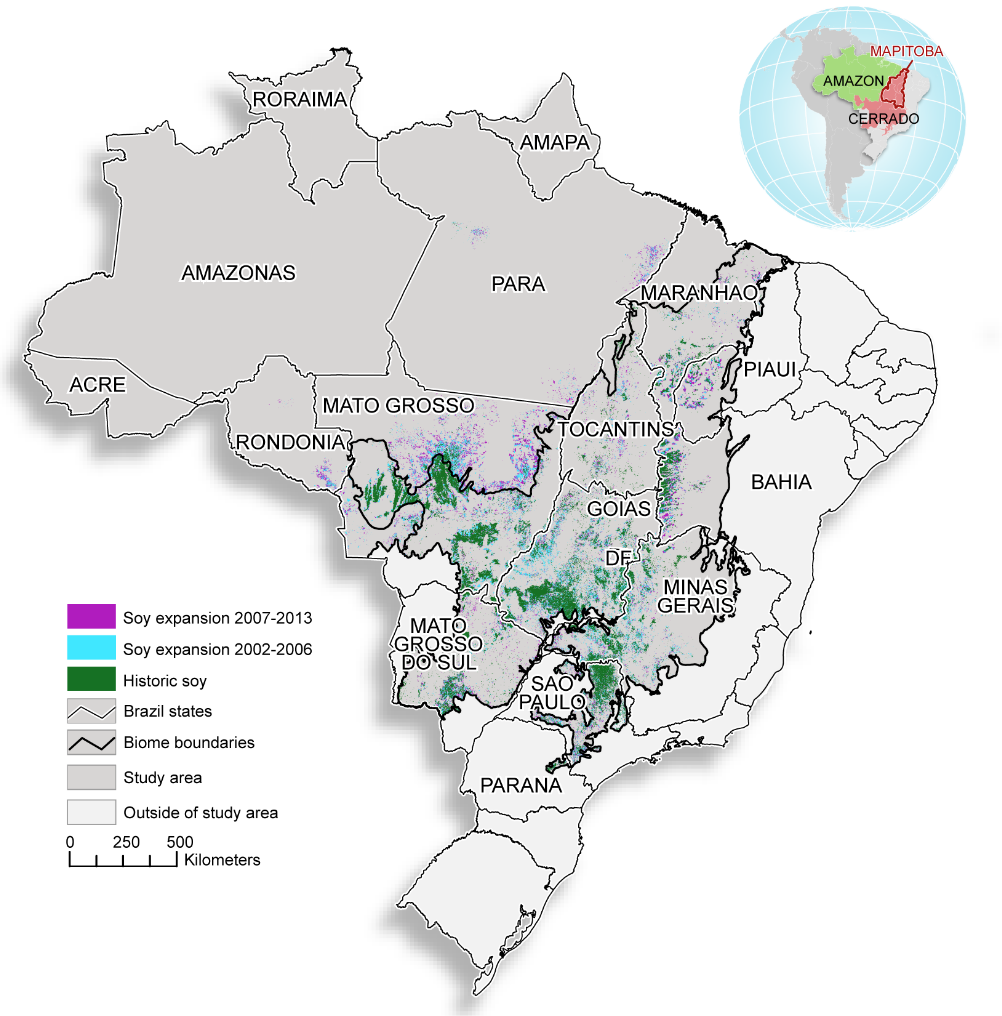

Fig S1.

Soy expansion in the Amazon and in the Cerrado biomes (2001–2013). Location and area of soybean expansion before and after the SoyM was established in 2006 were derived from satellite data time series. The time period for the map ends in 2013 to allow for comparability between the biomes (see §2.1).

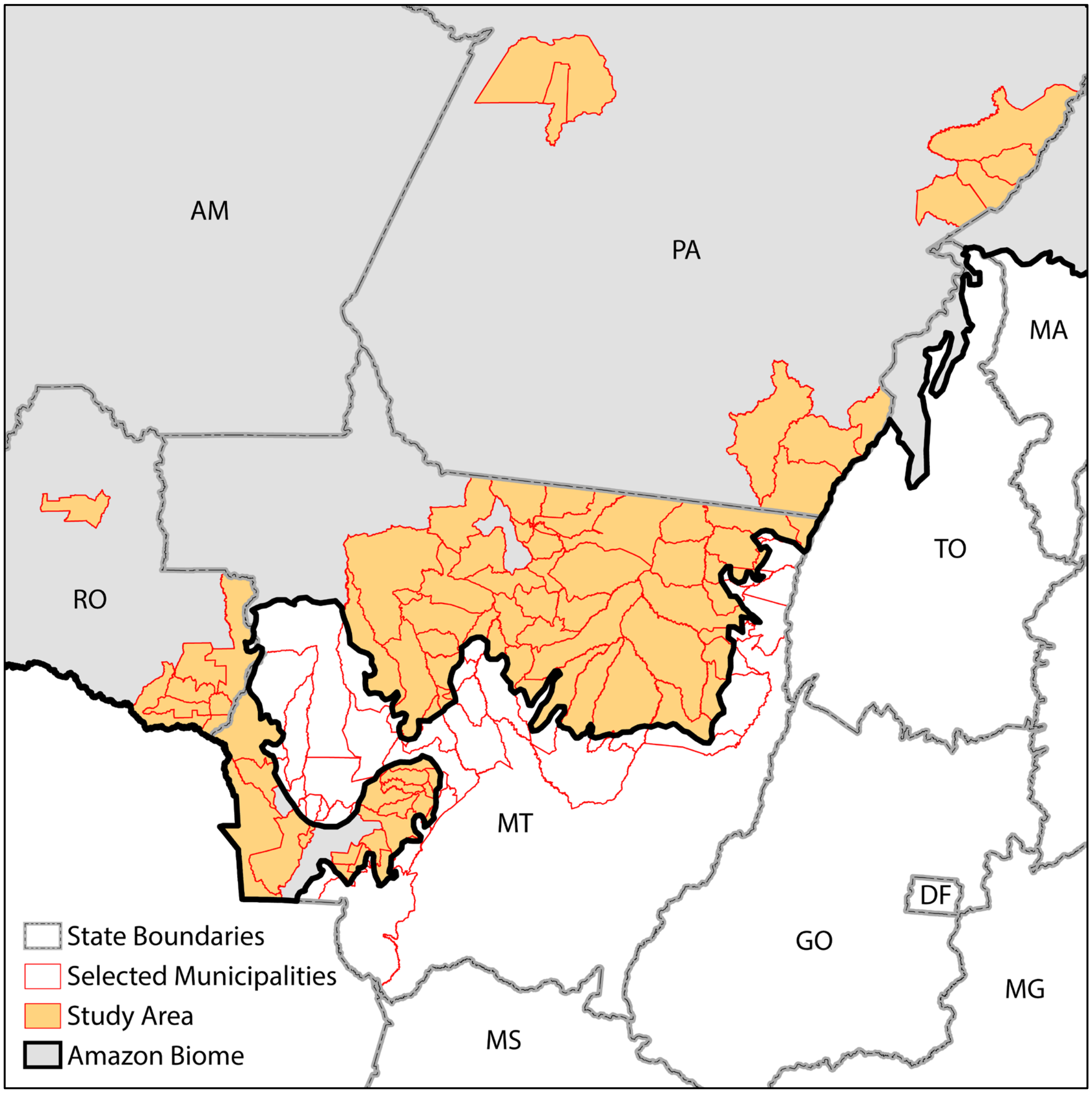

Fig. S2.

Map of study area, which included the 88 municipalities with more than 1000 ha of soy in the Brazilian Amazon biome (Cerrado portion of border municipalities was excluded). The property-level analysis included only the 69 municipalities in Mato Grosso.

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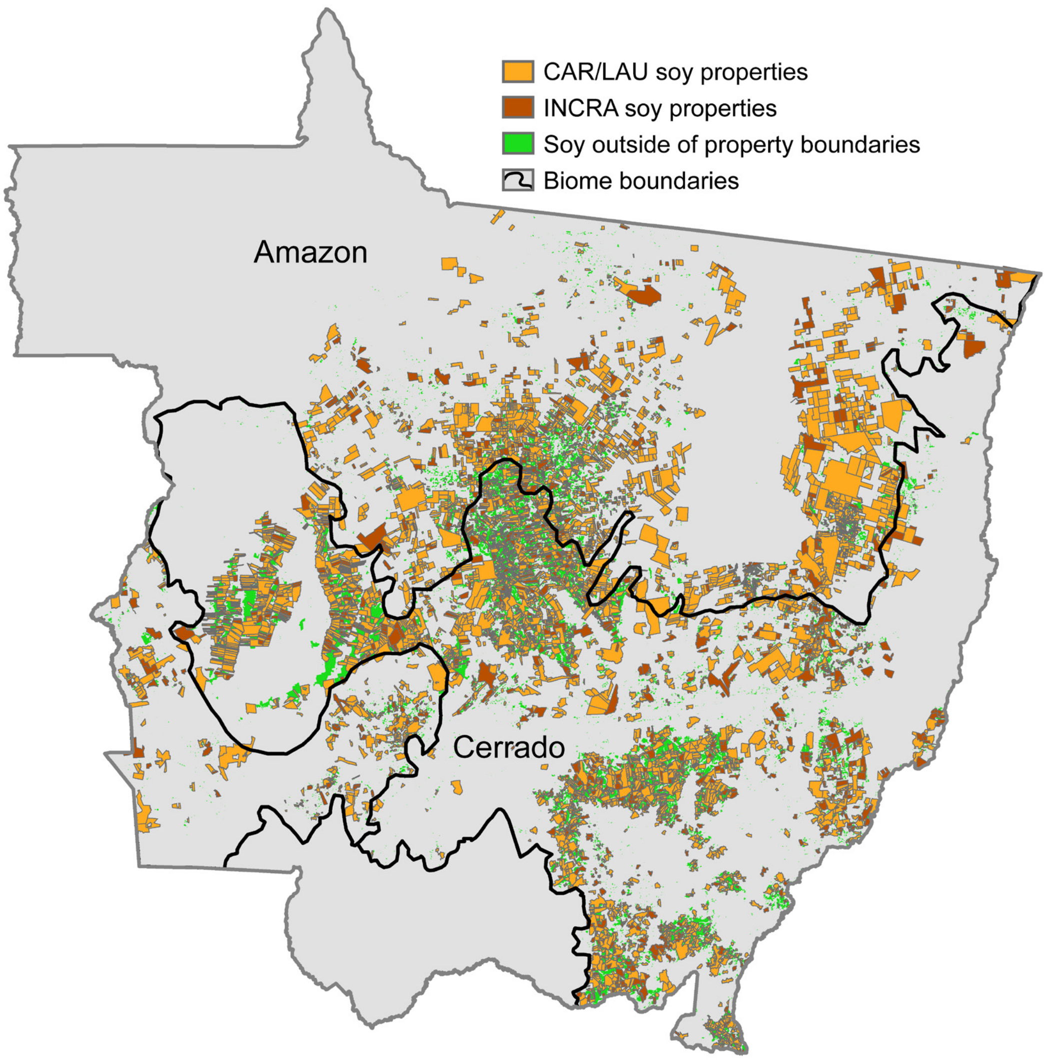

Fig. S3

Property boundaries and location of planted soy in Mato Grosso (2007–2014 for Amazon biome, and 2007–2013 for Cerrado biome). Includes CAR, LAU, and INCRA CCIR databases.

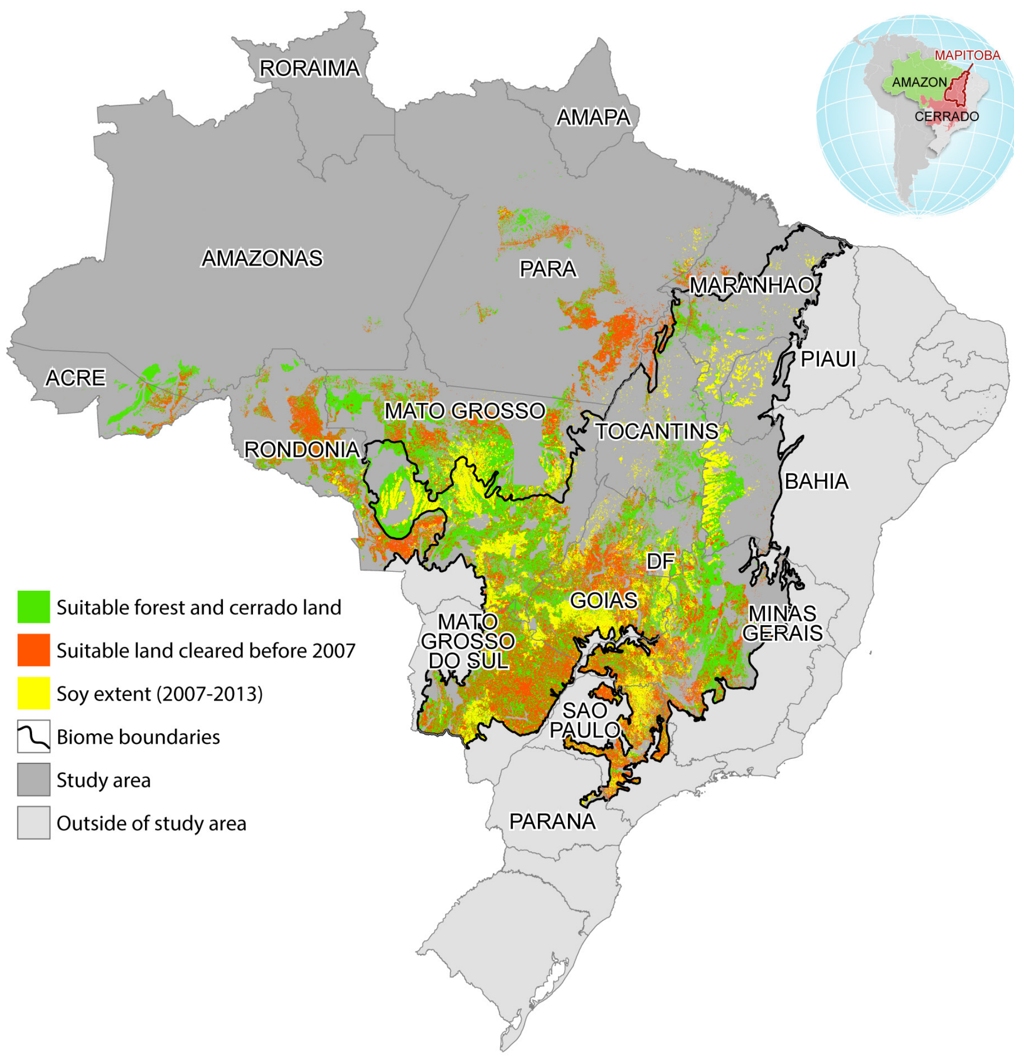

Fig. S4

Soy suitability map for the Amazon and Cerrado biomes highlighting potential expansion on areas with native vegetation and on previously cleared areas (table S8).

Table S1.

Soybean expansion through direct deforestation within the Amazon biome study area. Total deforestation (ha) and the fraction of deforestation for soy production are shown for 88 municipalities with more than 1000 ha of soy in Mato Grosso, Pará, and Rondônia. Direct deforestation for soy was defined as soy expansion within three years of deforestation.

Deforestation year	**Crop expansion year**													
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2012–14**
Pre-2002	92,994 (99.9)	188,862 (92.3)	175,626 (82.9)	382,177 (70.5)	133,759 (63.9)	75,495 (66.0)	110,412 (57.1)	82,072 (59.5)	70,542 (52.7)	179,967 (63.5)	119,104 (67.1)	213,291 (70.0)	257,756 (69.7)	590,151 (69.2)
2002	106 (0.1)	15,532 (7.6)	20,980 (9.9)	52,490 (9.7)	13,571 (6.5)	5,367 (4.7)	9,153 (4.7)	5,897 (4.3)	6,192 (4.6)	12,456 (4.4)	8,635 (4.9)	14,454 (4.7)	20,139 (5.4)	43,228 (5.1)
2003	-	187 (0.1)	14,928 (7.0)	69,763 (12.9)	34,869 (16.6)	10,549 (9.2)	16,550 (8.6)	10,383 (7.5)	10,109 (7.6)	22,902 (8.1)	11,171 (6.3)	18,037 (5.9)	23,398 (6.3)	52,607 (6.2)
2004	-	-	284 (0.1)	37,593 (6.9)	23,278 (11.1)	15,327 (13.4)	35,266 (18.2)	21,868 (15.9)	21,524 (16.1)	29,121 (10.3)	20,724 (11.7)	23,388 (7.7)	26,627 (7.2)	70,738 (8.3)
2005	-	-	-	448 (0.1)	3,939 (1.9)	6,258 (5.5)	14,178 (7.3)	10,896 (7.9)	17,995 (13.5)	24,209 (8.5)	8,805 (5.0)	17,943 (5.9)	21,730 (5.9)	48,477 (5.7)
2006	-	-	-	-	36 (0.0)	1,319 (1.2)	6,091 (3.2)	3,988 (2.9)	3,928 (2.9)	5,728 (2.0)	2,670 (1.5)	4,115 (1.3)	4,479 (1.2)	11,263 (1.3)
2007	-	-	-	-	-	19 (0.0)	1,573 (0.8)	1,549 (1.1)	1,552 (1.2)	2,340 (0.8)	1,484 (0.8)	3,348 (1.1)	3,242 (0.9)	8,074 (0.9)
2008	-	-	-	-	-	-	111 (0.1)	1,209 (0.9)	1,578 (1.2)	2,805 (1.0)	1,835 (1.0)	4,689 (1.5)	3,992 (1.1)	10,517 (1.2)
2009	-	-	-	-	-	-	-	2 (0.0)	302 (0.2)	2,096 (0.7)	823 (0.5)	1,350 (0.4)	1,783 (0.5)	3,956 (0.5)
2010	-	-	-	-	-	-	-	-	12 (0.0)	1,711 (0.6)	1,518 (0.9)	1,312 (0.4)	2,429 (0.7)	5,259 (0.6)
2011	-	-	-	-	-	-	-	-	-	36 (0.0)	725 (0.4)	1,786 (0.6)	2,072 (0.6)	4,582 (0.5)
2012	-	-	-	-	-	-	-	-	-	-	28 (0.0)	1,107 (0.4)	1,318 (0.4)	2,454 (0.3)
2013	-	-	-	-	-	-	-	-	-	-	-	7 (0.0)	1,069 (0.3)	1,076 (0.1)
Previous 3 years	-	-	-	**160,294 (29.5)**	**62,121 (29.7)**	**22,922 (20.0)**	**21,953 (11.4)**	**6,747 (4.9)**	**3,444 (2.6)**	**6,648 (2.3)**	**3,094 (1.7)**	**4,213 (1.4)**	**4,459 (1.2)**	**11,765 (1.4)**
post-2006	**-**	**-**	**-**	**-**	**-**	**19 (0.0)**	**1,684 (0.9)**	**2,759 (2.0)**	**3,444 (2.6)**	**8,989 (3.2)**	**6,413 (3.6)**	**13,600 (4.5)**	**15,905 (4.3)**	**35,918 (4.2)**

Table S2.

Soybean expansion through direct deforestation of native vegetation across the Cerrado biome. Total deforestation (ha) and the fraction of deforestation for soy production are shown for the entire Cerrado biome. Direct deforestation was defined as soy expansion within three years of deforestation.

Deforestation year	**Crop expansion year**											
	0	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2011–13**
Pre-2003	1,530,019 (99.5)	1,445,823 (94.8)	865,860 (85.4)	711,082 (77.6)	312,741 (75.6)	484,594 (80.3)	348,207 (67.7)	185,076 (62.2)	487,418 (73.7)	393,617 (75.4)	385,447 (74.8)	1,451,558 (72.7)
2003	7,668 (0.5)	68,392 (4.5)	68,121 (6.7)	90,572 (9.9)	23,297 (5.6)	20,673 (3.4)	18,641 (3.6)	8,476 (2.8)	16,072 (2.4)	9,483 (1.8)	8,712 (1.7)	42,743 (2.1)
2004	--	10,260 (0.7)	71,521 (7.1)	88,855 (9.7)	40,159 (9.7)	28,839 (4.8)	38,156 (7.4)	16,106 (5.4)	27,762 (4.2)	16,327 (3.1)	13,708 (2.7)	73,903 (3.7)
2005	--	--	8,247 (0.8)	21,536 (2.3)	19,957 (4.8)	22,092 (3.7)	25,701 (5.0)	14,363 (4.8)	11,498 (1.7)	9,168 (1.8)	6,808 (1.3)	41,838 (2.1)
2006	--	--	--	4,445 (0.5)	13,729 (3.3)	17,461 (2.9)	16,719 (3.3)	6,628 (2.2)	6,548 (1.0)	5,456 (1.0)	2,633 (0.5)	21,265 (1.1)
2007	--	--	--	--	3,813 (0.9)	25,153 (4.2)	23,014 (4.5)	15,991 (5.4)	15,292 (2.3)	9,170 (1.8)	6,614 (1.3)	47,067 (2.4)
2008	--	--	--	--	--	4,303 (0.7)	37,170 (7.2)	26,890 (9.0)	35,281 (5.3)	19,625 (3.8)	13,368 (2.6)	95,164 (4.8)
2009	--	--	--	--	--	--	6,529 (1.3)	21,883 (7.4)	25,818 (3.9)	19,249 (3.7)	7,885 (1.5)	74,835 (3.7)
2010	--	--	--	--	--	--	--	2,241 (0.8)	23,873 (3.6)	15,451 (3.0)	13,747 (2.7)	55,311 (2.8)
2011	--	--	--	--	--	--	--	--	11,389 (1.7)	19,088 (3.7)	37,130 (7.2)	67,606 (3.4)
2012	--	--	--	--	--	--	--	--	--	5,414 (1.0)	17,237 (3.3)	22,651 (1.1)
2013	--	--	--	--	--	--	--	--	--	--	1,689 (0.3)	1,689 (0.1)
Previous 3 years	-	-	-	**205,408 (22.4)**	**77,658 (18.8)**	**69,009 (11.4)**	**83,433 (16.2)**	**67,005 (22.5)**	**96,361 (14.6)**	**59,202 (11.3)**	**69,803 (13.6)**	**292,370 (14.7)**
post-2006	**-**	**-**	**-**		**3,813 (0.9)**	**29,456 (4.9)**	**66,714 (13.0)**	**67,005 (22.5)**	**111,653 (16.9)**	**87,997 (16.9)**	**97,669 (19.0)**	**364,324 (18.3)**

Table S3.

Soybean expansion through direct deforestation of native vegetation in the Mapitoba region, comprised by parts of Maranhão, Piauí, Tocantins, and Bahia states. Total deforestation (ha) and the fraction of deforestation for soy production are shown for the Cerrado portion of Mapitoba. Direct deforestation was defined as soy expansion within three years of deforestation.

Deforestation year	Crop expansion year											
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2011–13
Pre-2003	176,967 (98.9)	185,135 (87.0)	147,860 (62.7)	96,401 (46.1)	41,578 (38.8)	68,920 (45.1)	92,404 (41.0)	49,102 (34.9)	66,826 (33.6)	63,611 (38.2)	56,953 (36.0)	236,492 (35.6)
2003	2,002 (1.1)	22,148 (10.4)	38,896 (16.5)	37,879 (18.1)	12,015 (11.2)	9,284 (6.1)	10,967 (4.9)	4,948 (3.5)	5,676 (2.9)	4,522 (2.7)	3,161 (2.0)	18,307 (2.8)
2004	--	5,575 (2.6)	43,724 (18.5)	56,661 (27.1)	23,699 (22.1)	18,115 (11.9)	26,024 (11.5)	11,500 (8.2)	16,915 (8.5)	10,400 (6.2)	5,556 (3.5)	44,370 (6.7)
2005	--	--	5,326 (2.3)	14,743 (7.0)	15,160 (14.1)	16,071 (10.5)	21,024 (9.3)	10,605 (7.5)	7,326 (3.7)	6,895 (4.1)	3,651 (2.3)	28,477 (4.3)
2006	--	--	--	3,446 (1.6)	11,484 (10.7)	14,766 (9.7)	14,274 (6.3)	5,360 (3.8)	4,023 (2.0)	3,872 (2.3)	1,724 (1.1)	14,979 (2.3)
2007	--	--	--	--	3,327 (3.1)	21,701 (14.2)	20,848 (9.2)	13,636 (9.7)	12,616 (6.4)	7,571 (4.5)	4,269 (2.7)	38,093 (5.7)
2008	--	--	--	--	--	3,793 (2.5)	34,851 (15.4)	24,549 (17.4)	32,567 (16.4)	18,200 (10.9)	11,990 (7.6)	87,306 (13.1)
2009	--	--	--	--	--	--	5,196 (2.3)	18,891 (13.4)	20,769 (10.5)	15,508 (9.3)	6,305 (4.0)	61,473 (9.3)
2010	--	--	--	--	--	--	--	2,171 (1.5)	22,147 (11.2)	14,540 (8.7)	13,065 (8.3)	51,922 (7.8)
2011	--	--	--	--	--	--	--	--	9,731 (4.9)	16,585 (9.9)	34,163 (21.6)	60,478 (9.1)
2012	--	--	--	--	--	--	--	--	--	4,982 (3.0)	16,191 (10.2)	21,174 (3.2)
2013	--	--	--	--	--	--	--	--	--	--	1,074 (0.7)	1,074 (0.2)
Previous 3 years	--	--	--	112,729 (53.9)	53,670 (50.0)	56,332 (36.9)	75,169 (33.3)	59,247 (42.1)	85,214 (42.9)	51,616 (31.0)	64,492(40 .8)	260,569 (39.2)
post-2006	--	--	--	--	3,327 (3.1)	25,495 (16.7)	60,895 (27.0)	59,247 (42.1)	97,830 (49.3)	77,387 (46.4)	87,056 (55.1)	321,520 (48.4)

Table S4.

Deforestation on soy and non-soy properties mapped by CAR, LAU, and INCRA databases within the Amazon biome portion of Mato Grosso during 2007–2014. Adjacent deforestation polygons within each year were aggregated. Approximately 12% of 2007–2014 deforestation in Mato Grosso occurred on soy properties.

	Number of mapped soy properties (≥25 ha soy)	Number and (%) of soy properties with at least one year of ≥6.25 ha deforestation in 2007–2014	Number and (%) of soy properties with at least one year of ≥25 ha deforestation in 2007–2014)	Number of mapped non-soy properties	Number and (%) of non-soy properties with at least one year of ≥6.25 ha deforestation in 2007–2014)	Number and (%) of non-soy properties with at least one year of ≥25 ha deforestation in 2007–2014
CAR	2,561	631 (24.6)	328 (12.8)	12,729	2,045 (16.1)	773 (6.1)
LAU	436	107 (24.5)	53 (12.2)	1,462	301 (20.6)	123 (8.4)
INCRA	466	113 (24.3)	61 (13.1)	1,385	352 (25.5)	177 (12.8)
CAR + LAU	2,987	738 (24.7)	381 (12.7)	14,191	2,346 (16.5)	896 (6.3)
All	**3,463**	**851 (24.6)**	**442 (12.8)**	**15,576**	**2,698 (17.3)**	**1,073 (6.9)**

Table S5.

Remaining forest on all soy and non-soy mapped properties in the Amazon biome portion of Mato Grosso (base year 2014)**.**

	Number of mapped soy properties (≥25 ha soy)	Soy properties with ≥80% forest cover		Number of mapped non-soy properties	Non-soy properties with ≥80% forest cover	
		Number	Percent (%)		Number	Percent (%)
CAR	2,561	38	1.5	12,729	1,096	8.6
LAU	436	25	5.7	1,462	797	54.5
INCRA	466	14	3.0	1,385	344	24.8
Total	**3,463**	**77**	**2.2**	**15,576**	**2,237**	**14.4**

Table S6.

The number and portion of deforestation events in the Mato Grosso Amazon biome that were embargoed by May 2014 for illegal deforestation, 2009–2013. The number of embargoes increased dramatically after 2009. Most embargoes had only a partial overlap with detected deforestation events.

Year of deforestation	Number of deforestation events ≥25 ha	Deforestation events overlapping with ≥10% of the area of an embargo		Deforestation events overlapping with ≥1% of the area of an embargo	
		Number	Percentage (%) of total	Number	Percentage (%) of total
2013	874	209	24	271	31
2012	623	184	30	248	40
2011	765	188	25	245	32
2010	525	99	19	146	28
2009	545	73	13	110	20

Table S7.

Portion of registered properties in the Amazon biome portion of Mato Grosso that had deforestation ≥25 ha and that were embargoed by IBAMA as of May 2014.

Year of PRODES deforestation ≥25 ha	Number of CAR/LAU properties with deforestation	Properties with deforestation that were embargoed	
		Number	Percentage (%)
2014	148	56	38
2013	154	85	55
2012	130	66	51
2011	189	101	53
2010	143	55	38
2009	131	60	46

Table S8.

Total suitable area (000 ha) for soy by state and biome. All suitable areas for soy within the Amazon and Cerrado biomes outside of protected and indigenous areas and those areas already planted to soy are included.

UF	Amazon cleared	Amazon forest	Amazon other	Amazon total	Cerrado cleared	Cerrado noncleared	Cerrado total	Amazon + Cerrado Total
Acre	508	868	0	1,376	0	0	0	1,376
Amazonas	257	757	1	1,014	0	0	0	1,014
Amapá	0	0	1	1	0	0	0	1
Bahia	0	0	0	0	691	1,571	2,262	2,262
Distrito Federal	0	0	0	0	1	0	2	2
Goiás	0	0	0	0	9,943	3,097	13,040	13,040
Maranhão	254	91	0	345	366	468	833	1,178
Minas Gerais	0	0	0	0	8,737	3,569	12,306	12,306
Mato Grosso do Sul	0	0	0	0	12,621	2,823	15,444	15,444
Mato Grosso	6,809	8,808	1,120	16,737	6,458	6,946	13,404	30,141
Pará	3,640	1,677	176	5,493	0	0	0	5,493
Piauí	0	0	0	0	44	76	120	120
Paraná	0	0	0	0	24	2	26	26
Rondônia	3,433	1,865	328	5,626	0	1	2	5,628
Roraima	0	0	0	0	0	0	0	0
São Paulo	0	0	0	0	2,825	359	3,184	3,184
Tocantins	435	127	0	561	820	1,414	2,235	2,796
Total	**15,336**	**14,193**	**1,625**	**31,155**	**42,529**	**20,328**	**62,857**	**94,012**
Mapitoba Total	**689**	**218**	**0**	**907**	**1,920**	**3,529**	**5,449**	**6,356**

Table S9.

Estimate of additional land suitable for soy production (ha) gained by moving the SoyM cutoff date from 2006 to 2008.

State/ Region	Cleared before 2007; eligible under SoyM	Cleared 2007–2008; newly eligible under SoyM	Percentage (%) of additional land for soy expansion by moving SoyM cut-off date to July 2008
MT	8,341,383	279,018	3.3
PA	3,865,503	155,228	4.0
RO	4,194,284	92,003	2.2
Total Amazon	**18,013,018**	**563,057**	**3.1**

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