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Supplementary Materials for

Cracking Brazil's Forest Code

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Other Supplementary Material for this manuscript includes the following:

Input data, models, and main outputs of the Forest Code analyses available at www.csr.ufmg.br/forestcode.

Materials and Methods

S§1. Quantifying the impacts of revision to the Forest Code

Here, we evaluate how recent modifications (Table S1) to the Forest Code (FC) (Law No. 12,727, 10/17/2012) changed the spatial distribution and area of land designated for conservation or restoration of native ecosystems (Figs. S1 and S2), compared to the former version [Law No. 4.771, 09/15/1965, modified by provisional measures (MPs) no. 1.1511, 06/25/1996 and 2.166-67, 08/24/2001]. In doing so, we provide estimates of these new requirements, as well as the level of uncertainty resulting from the methods and data sets used. The study aims to provide decision-makers with a spatially explicit understanding of the impacts of the FC revision on forest conservation in Brazil and the magnitude of the effort required to fully implement the new law.

S§2. Methods

Quantifying the conservation and restoration requirements of both versions of the FC is not a trivial task because of Brazil's continental scale. There are many data limitations, including the absence of a unified national land-registry database that integrates information on the approximately five million rural properties; a lack of fine-scale maps of the drainage network and river widths; and inconsistent information on the remaining native vegetation for all biomes. For example, monitoring the 30-m-minimum RPA (Riparian Preservation Area) width for conservation would require an integrated database spanning the entire national territory, with a cartographic accuracy equal to or higher than 15 m (that is, a scale of 1:50,000 or higher). The absence of an ideal, integrated database does not impede the development of national-level estimates, as attempted in previous analyses (*12*). Several mapping projects of vegetation remnants and cartographic databases are available for Brazil at various scales (Table S6). These data sets enable estimation of the FC balance (debts and surpluses—i.e., areas that must be reforested and areas that may be legally deforested) with reasonable accuracy, given that the aggregated uncertainty is sufficiently large to encompass the cartographic uncertainty arising from combining data sets with different spatial scales. Moreover, improvements in computing capacity have enabled increasingly fine-scale reanalysis of these massive databases, making it feasible to assess the FC balance throughout the Brazilian territory at the microwatershed scale.

In this study, we developed a unified cartographic database with a grid-cell resolution of 60 m × 60 m. This resolution allows quantification of 30-m RPA, combined on either side of a watercourse and is compatible with the cartographic scale of drainage maps used (Table S6). For each input data layer of Table S6, we generated a cartographic raster (matrix) with 71,000 columns and 73,000 rows in the Albers Conical Equal-Area projection, which minimizes distortion of area. Our analytical models were implemented using Dinamica EGO freeware (*13*) (csr.ufmg.br/dinamica) and Excel 2103 64 bits, and all processing was performed using the computing resources of the Center for Remote Sensing (www.csr.ufmg.br) of the Federal University of Minas Gerais (Belo Horizonte, Brazil). All input data, analytical models, and main outputs are available for download at csr.ufmg.br/forestcode. The user-friendly graphical interface of Dinamica EGO allows for designing a model as a diagram, whose graph of operators establishes a visual data flow (Fig. S7). Users can add comments to and name operators and submodels with aliases to make the model diagram self-explanatory. By opening the FC models on the Dinamica EGO graphical interface, users will be able to follow the model diagrams and understand the algorithms employed in each model step. All calculation, logical or arithmetical, is stored within the operator and can be accessed by opening its calculation window. In addition, models can also be viewed and edited as a script language by using a text editor.

In the absence of a unified land registry for the entire country of Brazil, we chose to use 12th-order watersheds (Ottobacias) provided by ANA (Brazil's National Water Agency) as a proxy for rural properties (Table S6, watersheds_otto_12_reclass.tif in Inputs at csr.ufmg.br/forestcode). These watersheds constitute 166,000 units with a mean area of 3683 ha (considering their portions where the FC is applicable). Our analysis indicates that, when estimating the FC balance, the uncertainty associated with using microwatersheds to represent rural properties is inversely proportional to the number of properties contained within that microwatershed (section S§2.6) and directly proportional to the microwatershed size. That is, the smaller the watersheds and larger the number of properties contained therein, the lower the uncertainty. We therefore estimated the uncertainty associated with each microwatershed and calculated a total value by adding it to the uncertainty estimate for the FC balance derived from estimation of RPA width as calculated below. In addition, we validated our analysis of the FC balance by comparing figures obtained by using the microwatershed methodology with those obtained by using the INCRA (National Institute for Colonization and Agrarian Reform) data set (Table S6) of rural properties (section S§2.5).

The models applied to our analyses are grouped into three sets: Preparatory, Main, and Ancillary models (see tables at csr.ufmg.br/forestcode). Models that are dependent on other models' outputs are numbered in order to provide the sequence of execution.

To compute the remaining areas of native vegetation (remnants.tif in Inputs at csr.ufmg.br/forestcode), we integrated the most comprehensive national database of maps from PRODES (Project of Monitoring Deforestation in Legal Amazon), SOS Mata Atlântica, and PMDBBS (Project for Satellite-based Monitoring of Deforestation in the Brazilian Biomes) (Table S6). Models applied to obtain this integrated map of remnants include *1_campos_em_MA_ibama.ego* and *2_add_remnants.ego*—model names are written in italic (Preparatory models at csr.ufmg.br/forestcode).

For the calculation of the FC balance (surplus and debts), we quantified for each microwatershed the total area where the FC is applicable, named hereafter accountable areas (i.e., the total area occupied by rural properties). To map these areas (accountable_and_non_areas.tif in Inputs at csr.ufmg.br/forestcode), we subtracted urban areas, water bodies, conservation reserves, indigenous lands, and 30-m buffers along roads and railroads from the microwatershed's total area (*accountable_areas.ego* in Preparatory models at csr.ufmg.br/forestcode).

As established by both FC laws, the required Legal Reserve (LR) area is a proportion of the property area—i.e., in our analyses, the microwatershed accountable area. As this proportion varies across Brazil (Table S1), we combined maps of the Legal Amazon and vegetation physiognomy (Table S6) to calculate LR percentage for both conservation and restoration rules (*legal_reserve_percent_ativo.ego*, *legal_reserve_percent_passivo.ego* in Preparatory models at csr.ufmg.br/forestcode). When a microwatershed is split between regions with different requirements (i.e., the Cerrado and Amazon), the appropriate rules were weighted according to the proportion of the microwatershed in each region and summed to arrive at a final estimate for the microwatershed.

The main sequence of models to obtain both the new and old FC balances is depicted in Fig. S8. At the top, a set of preparatory models output the main spatial inputs for a central model named *1_1_forest_code.ego* in Main at csr.ufmg.br/forestcode, which are (i) remnants.tif, (ii) rivers.tif, (iii) watersheds_otto_12_reclass.tif, (iv) accountable_and_non_areas.tif, (v) legal_reserve_percent.tif, (vi) legal_reserve_percentpass.tif (the latter depicts LR percentage for restoration purpose) (vii) apps_non_hierarchical.tif, (viii) apps_hierarchical.tif, and (ix) apps_reconstituicao.tif. The last three maps consist of buffer zones along river and water streams and bodies that represent RPA width requirements.

A major source of uncertainty inherent in mapping RPA buffers stems from the lack of information about stream widths, which determine buffer-width requirements (Table S1). The drainage basin data layer from ANA (Table S6) includes information on watershed hierarchy (the first order representing the longest river) but not stream width. We therefore assigned a hypothetical width based on the river order within the drainage basin, as specified in Table S7 to produce maps vii and viii (APP, Portuguese acronym for "Área de Proteção Permanente"—Area of Permanent Preservation). We developed two databases of RPAs for conservation purpose, the first considering fixed 30-m buffers along all watercourses (map vii) and the second (map viii) using the hierarchy specified in Table S7. Sparovek *et al*. (*12*) used a similar method, but our analysis was conducted at a finer spatial scale than that established by those authors. Taking the mean value of RPA width for each microwatershed, we defined the uncertainty as 75% of the difference relative to the maximum value, because the chance of extreme values is low. Last, the map apps_reconstituicao.tif contains river buffer widths according to Table S1, Article no. 61 §6 and Article no. 61-B of the new FC. Note that for this particular case, the minimum RPA width is half of the cell resolution, thus areas of RPA widths <30 m are calculated using a discount factor within the model *1_Forestcode_balance.xlsx* in Main models at csr.ufmg.br/forestcode.

In addition to the input maps, another set of preparatory models produce the spatial representation of the fiscal modules, which vary in size throughout Brazilian municipalities and, thus, within each microwatershed. The size of fiscal modules and information on average size of rural properties, including the number of properties and their extent, are obtained from the 2006 national agricultural census (*14*). Because these data are organized according to municipal units, the first step in our spatial analysis involved converting the municipality data into units of microwatershed by calculating the proportion of municipal areas relative to the area of each microwatershed. These models then generate the areal percentage of properties per fiscal module and convert the resulting municipality data into microwatershed representation (*1_calcPercent_module.ego*, *2_muni_to_water_modulo_fiscais&MF.ego*). Next, the models *1_calc_muni_state_PApercent.ego* and *2_muni_to_water_PApercent.ego* calculate the municipality percentage covered with protected areas (Article no. 12 §§ 4 and 5, Table S1) and convert these values into microwatershed representation (Preparatory models at csr.ufmg.br/forestcode). Both sets of models' output tables are in CSV (Comma-Separated Value) format.

In turn, model *1_1_forest_code.ego* calculates the basic areal information per each microwatershed, outputting a table (forestcode.csv) containing the following variables: (i) microwatershed area, (ii) total remnant forest area, (iii) accountable area, (iv) remnants in accountable area, (v) area of hierarchical RPA requirement, (vi) area of nonhierarchical RPA requirement, (vii) river width, (viii) percent of LR requirement for conservation, (ix) percent of LR requirement for restoration, and (x) area of RPA requirement for restoration.

Because none of the land-cover maps have sufficient spatial accuracy to detect remnant vegetation along RPAs, we calculated the combined area of LR and RPA within each microwatershed unit, adding the RPA requirement area to the LR requirement area in each microwatershed. Area of RPA to be restored was estimated indirectly, see end of this section and S§2.6. To evaluate the balance (i.e., compliance level) of the FC, we subtracted the total area required for RPAs and LRs from the remaining areas of native vegetation in accountable areas of each microwatershed. We defined a positive result as an environmental surplus and a negative result as an environmental debt. To estimate the environmental debt, we evaluated the impact of reducing the LR from 80 to 50% of properties in the Legal Amazon (Table S1), for the case of restoration in areas indicated for agricultural consolidation (deemed suitable for agriculture or cattle production) by the state-level Ecological and Economic Zoning programs (ZEE). To define those areas, we used the ZEE suggested by the Ministry of the Environment (MMA, Table S6), given the variability in state-level ZEE planning processes. In Legal Amazon, we maintained 80% for LR in Areas for Environmental Protection (APAs)―a land-use zone that allows private properties within it.

Although the rules governing forest conservation did not change under the revised FC, save for the definition of Hilltop Preservation Areas―HPAs (Table S1), those governing restoration became far more complex. First, the restoration of the RPA debt along watercourses is now regulated by a rule called the "*escadinha*" (little staircase), which specifies the buffer to be restored according to the property size (defined by the number of fiscal modules) and width of the river. Small properties (up to four fiscal modules) are now exempt from restoring their LR in areas that are already deforested and in production (i.e., consolidated—defined as rural properties with human occupation predating 22 July 2008). Additionally, LRs in the Amazon may be reduced to 50% when the municipality has more than 50% of its area occupied by public conservation areas and indigenous reserves or when the state has an approved ZEE and more than 65% of its territory occupied by public conservation areas and indigenous reserves. Finally, RPAs are now included when calculating the total area of LR, as long as the property is registered in the Rural Environmental Registry (CAR, Table S1). Because all properties are legally obligated to enter the system, we assume that 100% of rural properties in Brazil will obtain a CAR registration.

To calculate the FC debt, we did not consider HPAs, because the new FC does not stipulate the restoration of this type of APP in consolidated areas. Furthermore, the calculation of the FC surplus—i.e., land that exceeds the conservation requirements of the FC and thus can be legally deforested—does not account for the fact that a small fraction (≤3%) of this total may be located in HPAs, where deforestation is not allowed. Nonetheless, HPA areas are implicitly represented in our analysis because LR are more likely to be located in these areas, which may be less suitable for agricultural production.

The table forestcode.csv plus the tables PA_water_percent.csv, water_mf_mf_percent.csv, and waterModulos_fiscais.csv output from the preparatory models together with the output from *1_2_biomass_average.ego* are input for the model *1_Forestcode_balance.xlsx*. One needs to copy the tables and paste them on the right space of the spreadsheet as identified by the tabs with the corresponding names. The Excel model incorporates the complex set of rules (cell formulas can be traced back in order to map the rules) that quantifies for each microwatershed the FC balance in terms of debt and surplus, as well as the changes to these rules under the new FC (Table S1). The results in terms of surplus, debts, and their respective carbon stock and sequestration potential for the old and new FC versions appear on the tab "forestcode" of *1_Forestcode_balance.xlsx*. We then produced aggregate estimates of debts and surplus for each biome and state by combining microwatershed data on the FC balance with spatial information on municipal, biome, and microwatershed boundaries. In order to do so, these data are extracted and ported to tables named output_##.csv, where # symbol is a placeholder for a sequential number (e.g., 01, 02). These CSV tables must have only two columns, the first representing the microwatershed code and the second the associated data. Then the models *2_forest_code_water_muni.ego* and *3_sum_state_biome.ego* (Main models at www.csr.ufmg.br/forestcode) are used, first, to convert look-up tables indexed by microwatershed to look-up tables indexed by munibiomes (spatial unit consisting of a unique combination of municipality and biome output from *cross_muni_biomes.ego* in Preparatory models) and, second, to totalize data per state and biome (Tables S2 to S4). Because large blocks of forests in the state of Amazonas remain undesignated public land to date (*15*), we ignored the surplus of this state in summing the grand total of the FC surplus (Table S4).

Finally, we estimated both the extent of RPAs to be restored along watercourses and the likelihood of their being occupied by agriculture using an indirect method, which we refer to as the spatial Bootstrap (see section S§2.6). This calculation is performed using the models *1_muni_to_water_PAM.ego* and *2_Calc_APP_andUncertainties.xlsx* in Ancillary models at csr.ufmg.br/forestcode. For this calculation, we assumed that at least 90% (this figure is conservative; it could be even higher) of the 24 Mha of soybean croplands plus 7.6 Mha of single-cropped cornfields in Brazil occur outside of RPAs, given that mechanized agriculture (e.g., soybeans and corn) cannot operate in riparian areas because of the high water table. The resulting 28.5 Mha (0.9*31.6) represents 40% of all croplands (±70 Mha). Next, we used the spatial bootstrap simulation to estimate the probability of any cropland (mechanized or not) occurring within RPAs. Finally, to estimate the area of RPAs realistically occupied by croplands, we multiplied the probability of any cropland occurring in RPAs (calculated from the spatial bootstrap) by 0.6 (1 minus 0.4—or the probability of nonmechanized agriculture occurring in RPAs). This combined calculation yields the total area of cropland that is likely to fall within RPAs.

S§2.1. Estimates of potential CO_2 emissions and sequestration

For each microwatershed, we multiplied the areas of surpluses and debts by the mean potential biomass of native vegetation to estimate the potential for carbon sequestration via restoration projects, as well as the potential CO_2 emissions from future (legal) deforestation of environmental surplus areas. The potential biomass map reconstructs the biomass of the original vegetation present in the Brazilian biomes (*16*). We added 20% to the overall uncertainty estimate to account for the inherent uncertainty in the biomass map. We assumed that carbon content is 50% of woody biomass (*17*) and that 85% of the carbon contained in trees is released to the atmosphere after deforestation (*18*).

S§2.2. Potential market for CRA

Article 44 of Law no. 12.651, 05/25/2012 specifies that the "Cota de Reserva Ambiental" (Portuguese acronym, CRA—Environmental Reserve Quota) is a tradable legal title to areas with intact or regenerating native vegetation exceeding FC requirements. The CRA (surplus) on one property may be used to offset an LR debt on another property within the same biome and, preferably, the same state. Paragraph §4 stipulates that the LRs of small landholders (up to four fiscal modules) can also constitute CRA titles.

To quantify the potential market for CRAs, we used the model *1_Compensation_with_CRAs.xlsx* (Ancillary models at csr.ufmg.br/forestcode) first to calculate the extent of native vegetation exceeding FC requirements in microwatersheds within unique combinations of biomes and states. We then compared these quantities with the total LR debt within the same territorial units. If the total LR debt was less than the FC surplus, we deducted this difference from the total amount of FC surplus to estimate the potential regional (biome and state unit) market for CRA. In other words, the potential CRA market depends on both availability of CRAs and LR debts within the same biome and state. Regulation of the CRA under paragraph §4 still depends on implementation of specific legislation by each Brazilian state (*19*). Because our estimates did not account for these criteria, our figures for the potential market for CRA may be conservative.

S§2.3. Pasturelands suitable for growing crops

We estimated the extent of suitable pasturelands for growing crops by applying the following sequence of models: *1_deviance_slope.ego* and *2_suitability.ego* in Preparatory models, and *1_1_calc_aptitute.ego*, *2_sum_state_biome.ego* *1_Apt_per_municipalities.xlsx* and *2_Compesantion_after_CRAs_in_inapts.xlsx* in Ancillary models at csr.ufmg.br/forestcode.

Our calculation of suitable areas for cropland included areas with slopes less than 15%—appropriate for use of the heavy machinery required by agribusiness (*20*)—and eliminated areas with soils that are highly unsuitable for agriculture. As in Nepstad *et al.* (*21*), our soil criteria excluded soils with strong edaphic restrictions (e.g., ultisols, lithosols, dysthropic podzols, sands, and hydromorphic soils). Comparing our suitability map to soy and sugarcane croplands identified by the CANASAT project (*22*), we found that 90% of existing croplands fell within areas classified as suitable. To calculate the amount of pasturelands suitable for agriculture—and hence the extent of unsuitable pasturelands that could be used for forest restoration—we first deducted the ~70 Mha of existing croplands estimated by the Instituto Brasileiro de Geografia e Estatística (IBGE) (*23*) from the roughly 290 Mha of land currently in production in Brazil. Of the 220 ± 10 Mha of pastures in various stages of occupation and productivity, ~60% could be utilized for crops, if one assumes no climatic restrictions (Figs. S4 and S9). The uncertainty bounds estimated for pastureland extent arise from uncertainties in the scales of maps of remaining vegetation in Brazil, particularly for biomes other than the Amazon (Table S6).

S§**2.4. Mapping Hilltop Preservation Areas**

The models *1_brasil_hill_top_old_code_per_watershed_5.ego, 2_brasil_hill_top_new_code_per_watershed_5.ego* in Ancillary models at csr.ufmg.br/forestcode) were designed for calculating HPAs according to the old and new definitions of the FC.

They comprise the following steps (Fig. S10): First, the elevation map is quantized into hypsometric slices. Contiguous slices are labeled as individual elevation patches. For each elevation patch, the algorithm calculates the mean elevation, slope, area, and neighboring patches. Each patch consists of a node that is inserted into a computer graph algorithm, which orders all nodes from local minima to local maxima, forming a tree graph. The algorithm then uses the CalcHillTop operator (Fig. S11) to analyze this graph and outputs tables of hilltops, hill heights, hill slopes, plateaus, and local minima and maxima. The CalcHillTop operator was designed by Leandro Lima for use in the Dinamica EGO software platform. Visual inspections of the three-dimensional (3D) digital terrain models (Fig. S12) indicated an accuracy of 80% for the mapping algorithm. Because of the high complexity of this algorithm and its sensitivity to spatial resolution and slicing threshold of the elevation map, we only calculated the relative impact (percent of reduction) of the new definition of HPAs (Table S8).

S§2.5 Validation of the FC balance with INCRA rural properties

We applied a data set from INCRA (Institute for Agrarian Reform) containing 62,897 rural properties distributed throughout Brazil to validate our analysis of the FC balance. (See sequence of models employed for validation in Validation at csr.ufmg.br/forestcode.) Table S9 shows a comparison between the INCRA data set of rural properties and ANA microwatersheds. The accountable area of the latter is 6.72 larger than that of the former. We multiplied by this ratio the total figures for the FC surplus and debts (before and after revision) obtained by using the INCRA data set to compare with the figures obtained by using ANA microwatersheds. After scaling up, we found a deviance of 11% between figures for the FC surplus and 7% between figures for the old FC debt, which conform to the uncertainty bounds of our analysis. For the new FC debt, we initially found a large difference between figures because of difference in property size distribution from INCRA sample to IBGE census data (Table S9). We fixed this difference by applying the same rules that govern the requirements for restoration as if INCRA sample had the same property size distribution of IBGE census data. After this adjustment and scaling up by 6.72, we found a deviance of only 6% (Table S10). We also compared the spatial matching between maps of percentage of municipality in compliance with the FC obtained from both analyses (Fig. S13). We applied two pairwise tests. The Contingency Coefficient test (*24*) with 10 categorical intervals (*2_determinie_correlation10_intervals.ego*) yielded a correlation of 74% and the Reciprocal Similarity method (*13*) with 4 categorical intervals (*3_pattern_maching_4_intervals.ego*) resulted in a spatial matching of 74%.

S§2.6 Spatial bootstrap of the RPA calculation, area of RPA occupied by croplands, and model uncertainties

Bootstrapping is a statistical technique used to estimate parameters for small sample sizes, including the distribution of the mean and its variance. The technique uses repetitive sampling, with substitution of the samples selected from the data, using a Monte Carlo simulation with a large number of iterations (1000 to 10,000, for example). In this study, we adapted bootstrap methods to estimate the RPA debt (area to be restored), RPA area potentially occupied by crops, and uncertainty related to the use of ANA microwatersheds as a proxy for properties. To do so, we first created a map with 100 cells (10 × 10) to represent a microwatershed. We then used Dinamica EGO to run spatial simulations that varied the extents and locations of vegetation remnants, LRs, RPAs, crop area, and the number of properties within a watershed.

A set of simulations was carried out by varying the extent of vegetation remnants from 20 to 80% and the width of the RPA from 10 to 50% of the microwatershed. The model (1_Uncertainty_of_app&legal_reserve.ego in Ancillary models at csr.ufmg.br/forestcode) randomly allocates remnant vegetation and RPAs to cells, using a suite of 10,000 repetitions. For each iteration, we superimposed the simulated vegetation remnants on the simulated RPAs and compared the results to the calculated debt (Fig. S14). Based on the convergence of results, we concluded that the mean RPA debt, expressed as a percentage of the accountable area of each microwatershed, could be approximated using the following equation:

$$RPAd \approx RPAa - RPAa \times RVa / MWa \qquad \text{(Eq. S1)}$$

Where *RPAd* is the RPA debt, *RPAa* is the RPA area, *RVa* is the remnant vegetation area, and *MWa* is the microwatershed area.

In the same manner, we estimated the uncertainty in the calculation of the RPA debt at one standard deviation (*Sdd*) as follows:

$$Sdd \approx 1 - RPAd^2 / RPAa \qquad \text{(Eq. S2)}$$

By extension, we used the equations below to infer the area of RPA debt that is potentially occupied by croplands, as well as its respective uncertainty at one standard deviation (*Sdc*):

$$RPAc \approx RPAd \times CRa / WCa \qquad \text{(Eq. S3)}$$

Where *RPAc* is the RPA area potentially occupied by croplands, *CRa* is the total cropped area within the microwatershed, and *WCa* is the microwatershed area converted to croplands.

$$Sdd \approx 1 - RPAc^2 / RPAa \qquad \text{(Eq. S4)}$$

Another set of simulations (*2_Uncertainty_from_propertysize.ego* in Ancillary models at csr.ufmg.br/forestcode) demonstrated that, given the large number of microwatersheds used in the analysis, the uncertainty in the balance of the LR depends on: 1) the number of properties within a microwatershed; 2) the stipulated percentage of the LR in a given microwatershed; and 3) the percentage of debt or surplus relative to the accountable area of the microwatershed (Fig. S15). To simplify, we derived a mean estimate of this parameter for each microwatershed such that (Fig. S16):

$$U = 2.542 \times NPw^{-1.11} \qquad \text{(Eq. S5)}$$

Where U of the mean uncertainty and NPw is the number of properties within each microwatershed.

Finally, we modified the above equation to account for the fact that the uncertainty tends to zero when the number of properties is equal to 1 or the area of vegetation remnants approaches 0% or 100% of the accountable microwatershed area. We therefore applied the following rule to estimate the uncertainty of the forest code balance:

If $NPw = 1$ or $RVa < 5\%$ or $RVa > 95\%$, then $U = 0$, else $U = 2.542 \times NPw^{-1.11}$ (Eq. S6)

On the basis of the above calculations, we estimated that the total uncertainty arising from using microwatersheds as a proxy for rural properties (considering two standard deviations) was 0.6 Mha—representing just 3% of the total environmental debt under the revised FC. This suggests that the methodology employed in this study is robust and provides a reasonably good approximation of the FC balance.

Supplementary Text

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Fig. S1.

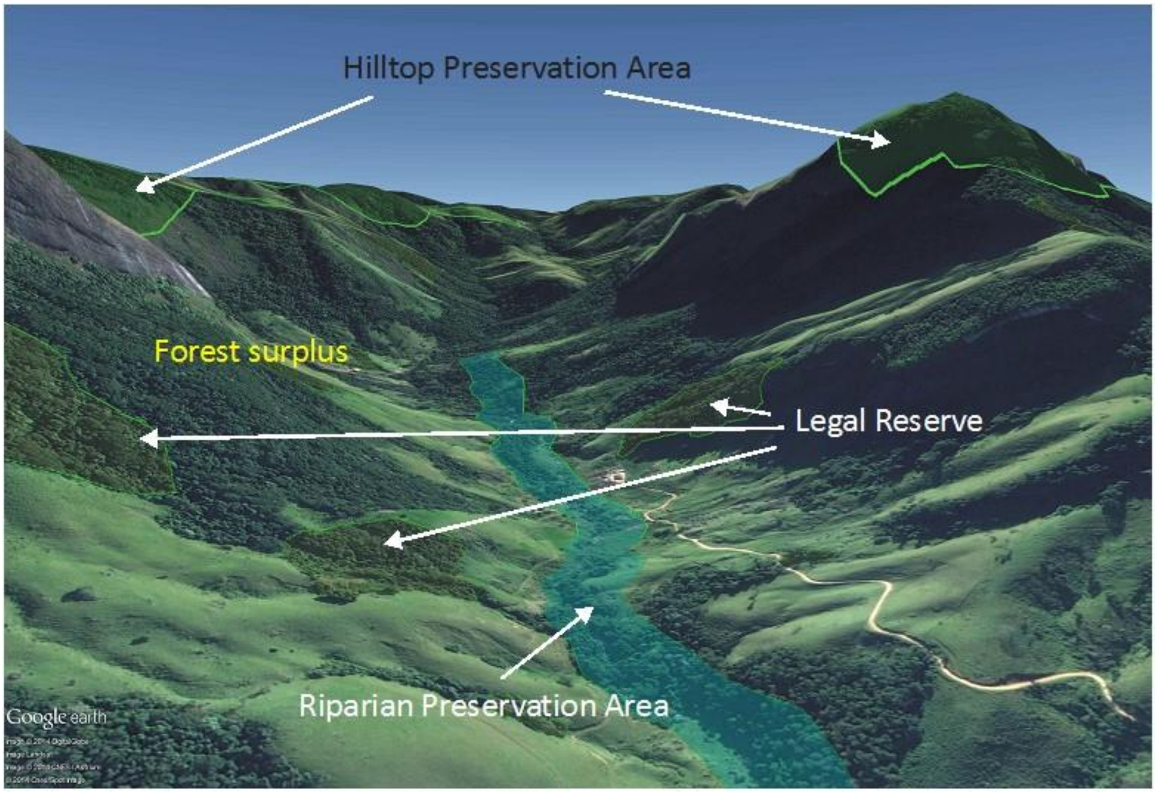

Fig. S1. Spatial representation of the main requirements of the FC on a Google Earth 3D view. Forest surplus represents extent of native vegetation that exceeds FC requirements.

Fig. S2.

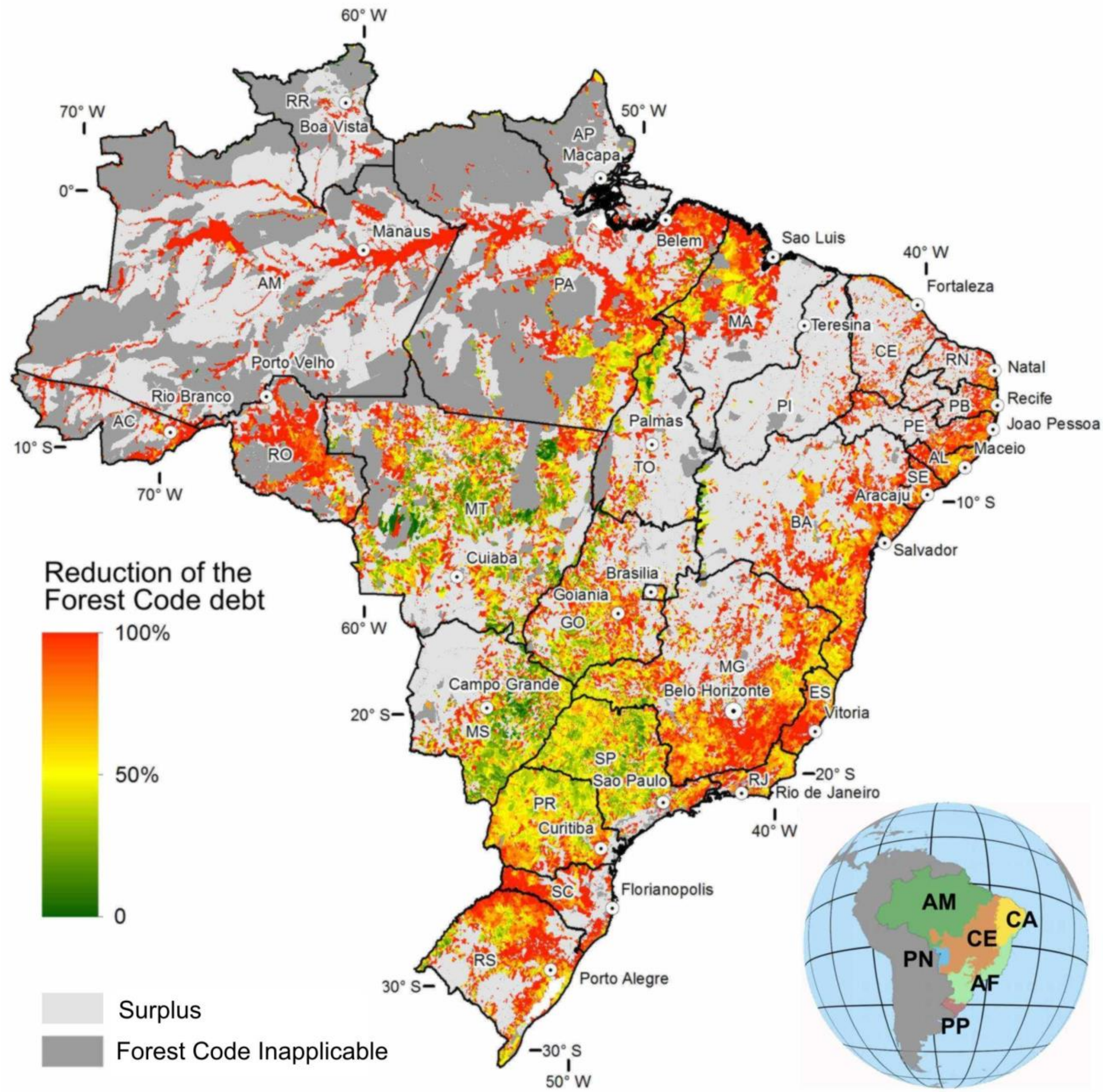

Fig. S2. Reductions in the environmental debt resulting from revisions to the FC. "Forest Code Inapplicable" refers to areas where other legislation (e.g., protected areas) supersedes the FC. AC, Acre; AM, Amazonas; AP, Amapá; BA, Bahia; CE, Ceará; GO, Goiás; MA, Maranhão; MG, Minas Gerais; MS, Mato Grosso do Sul; MT, Mato Grosso; PA, Pará; PI, Piauí; PR, Paraná; RO, Rondônia; RR, Roraima; RS, Rio Grande do Sul; SP, São Paulo; SC, Santa Catarina; TO, Tocantins. RN, Rio Grande do Norte; PB, Paraíba; PE, Pernambuco; AL, Alagoas; SE, Sergipe; ES, Espírito Santo; RJ, Rio de Janeiro. Biomes: AM, Amazon; CE, Cerrado; CA, Caatinga; AF, Atlantic Forest; PN, Pantanal; PP, Pampas.

Fig. S3.

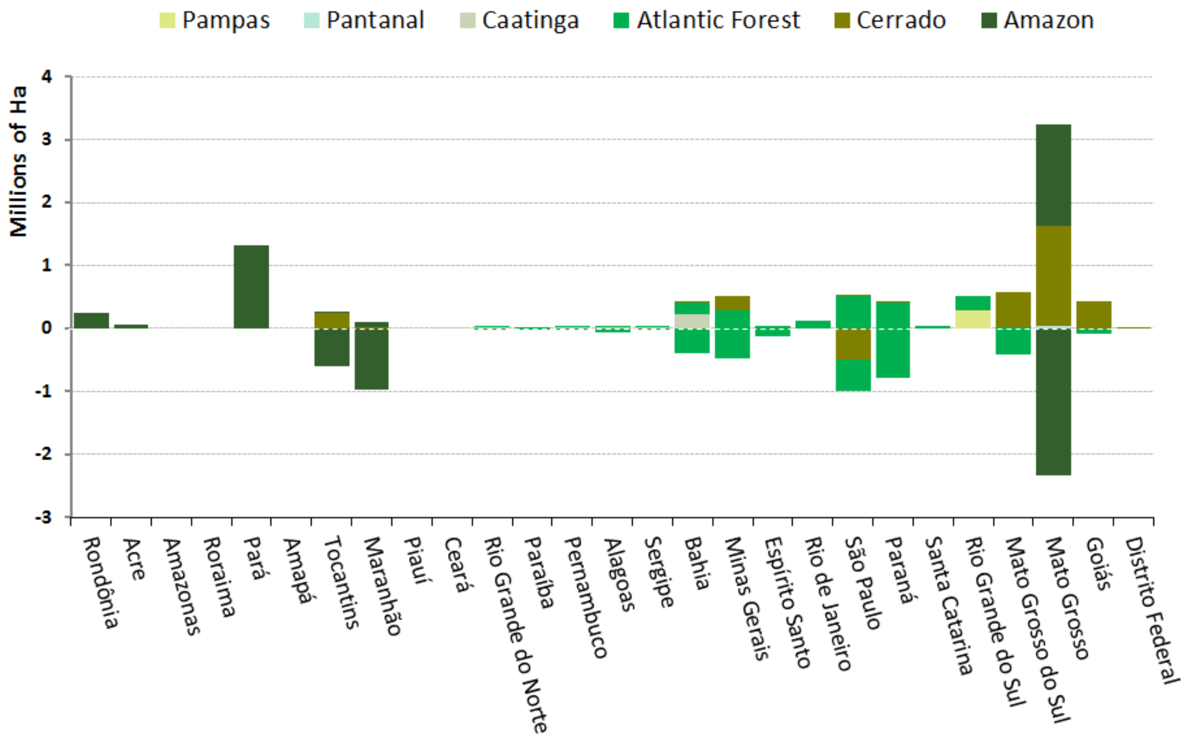

Fig. S3. Potential for forest compensation of LR debts via the Environmental Reserve Quotas (CRAs) within the same biome (colors) and state (horizontal axis). Positive numbers indicate a reduction (offset) in the LR debt using CRAs and negative numbers indicate the remaining debt after offset.

Fig. S4.

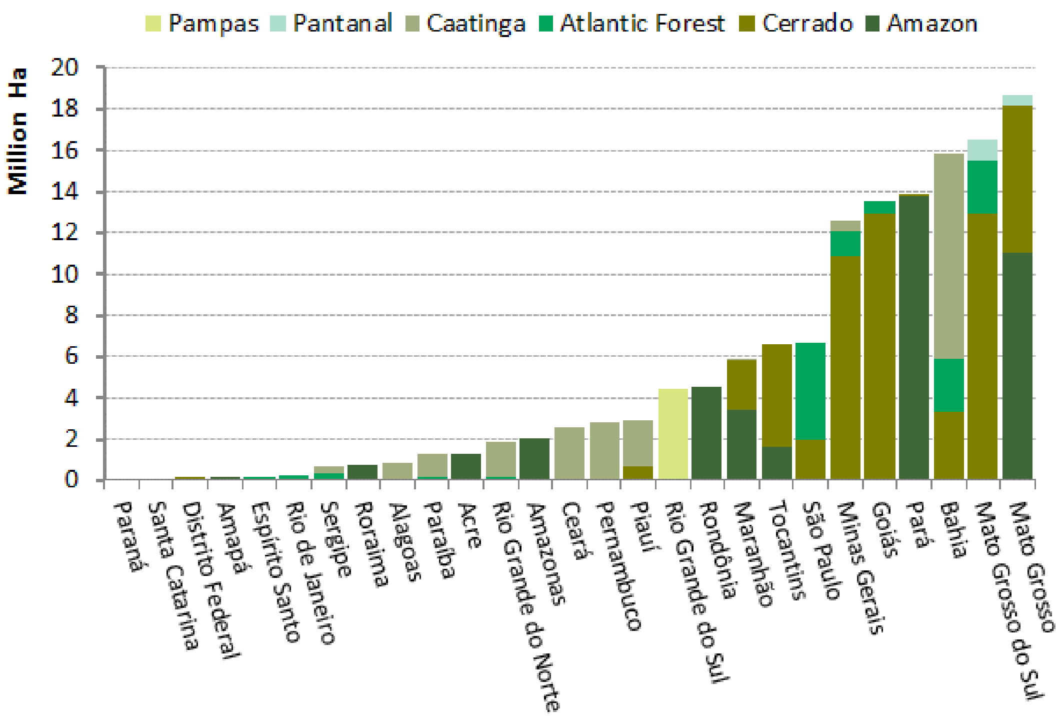

Fig. S4. Pasturelands suitable for agriculture, without considering climatic or land-use zoning restrictions, per biome (colors) and state (horizontal axis).

Fig. S5.

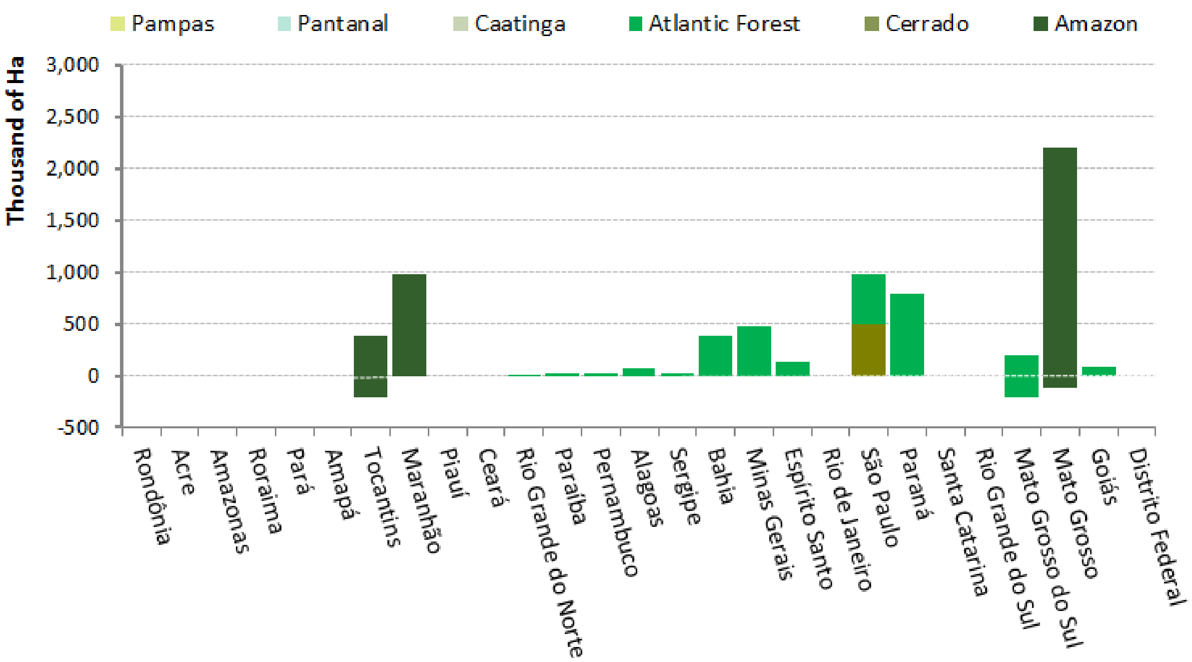

Fig. S5. Potential for restoration of the LR debt (after compensation via the CRA, Fig. S2) on pasturelands unsuitable for mechanized agricultural, per biome (colors) and state (horizontal axis). Positive numbers indicate the area restored (debt reduction) and negative numbers indicate the remaining LR debt that must be restored on arable lands.

Fig. S6.

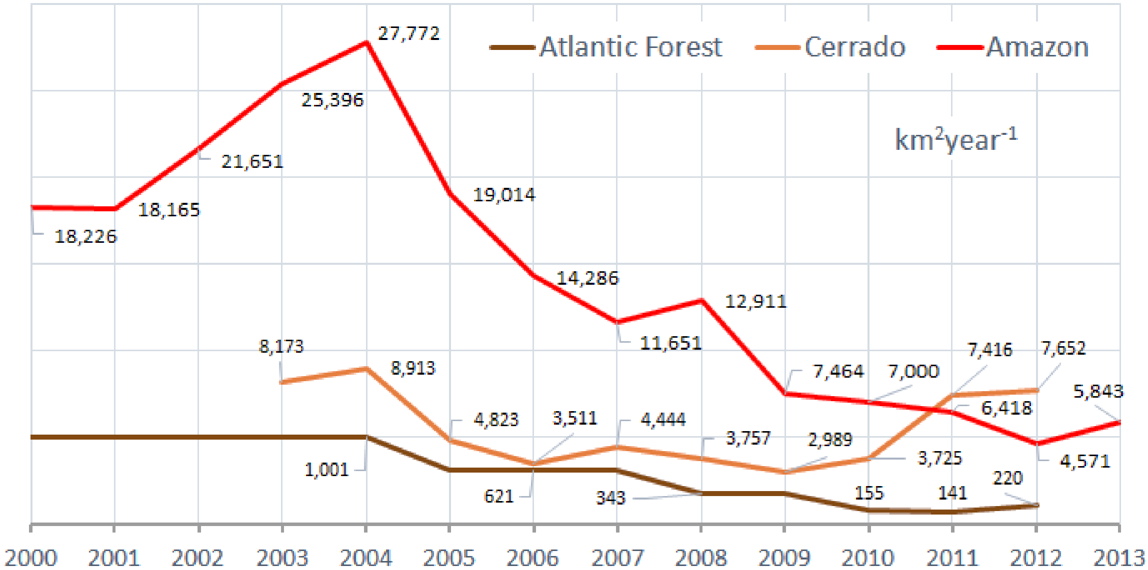

Fig. S6. Deforestation trajectories (km^2·year^{-1}) in the three major Brazilian biomes. Note that deforestation rates for the Atlantic Forest are depicted on a different scale than that of the Amazon and Cerrado. Data for the Amazon come from INPE (*25*), for Cerrado from LAPIG (*26*), and for the Atlantic Forest from Fundação SOS Mata Atlântica (*27*).

Fig. S7

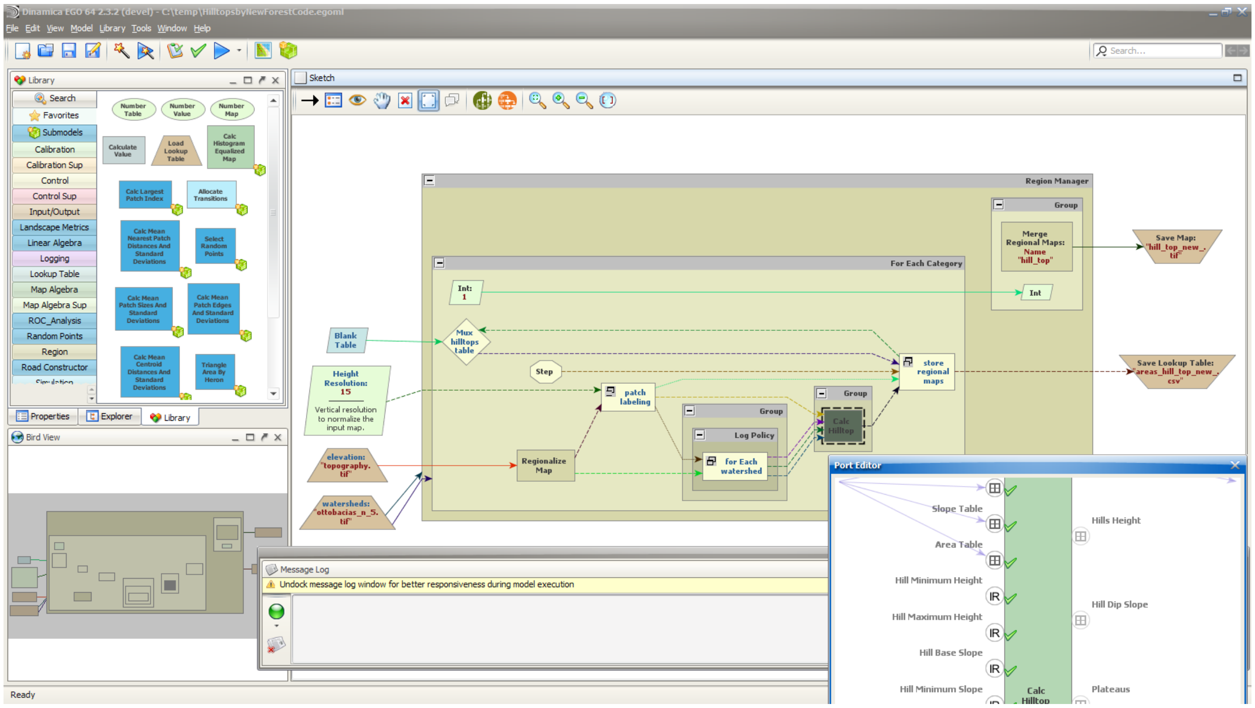

Fig. S7. Dinamica EGO graphical interface showing a model diagram. Operators are connected with arrows to establish a visual data flow. Each operator can be edited and its output viewed.

Fig. S8.

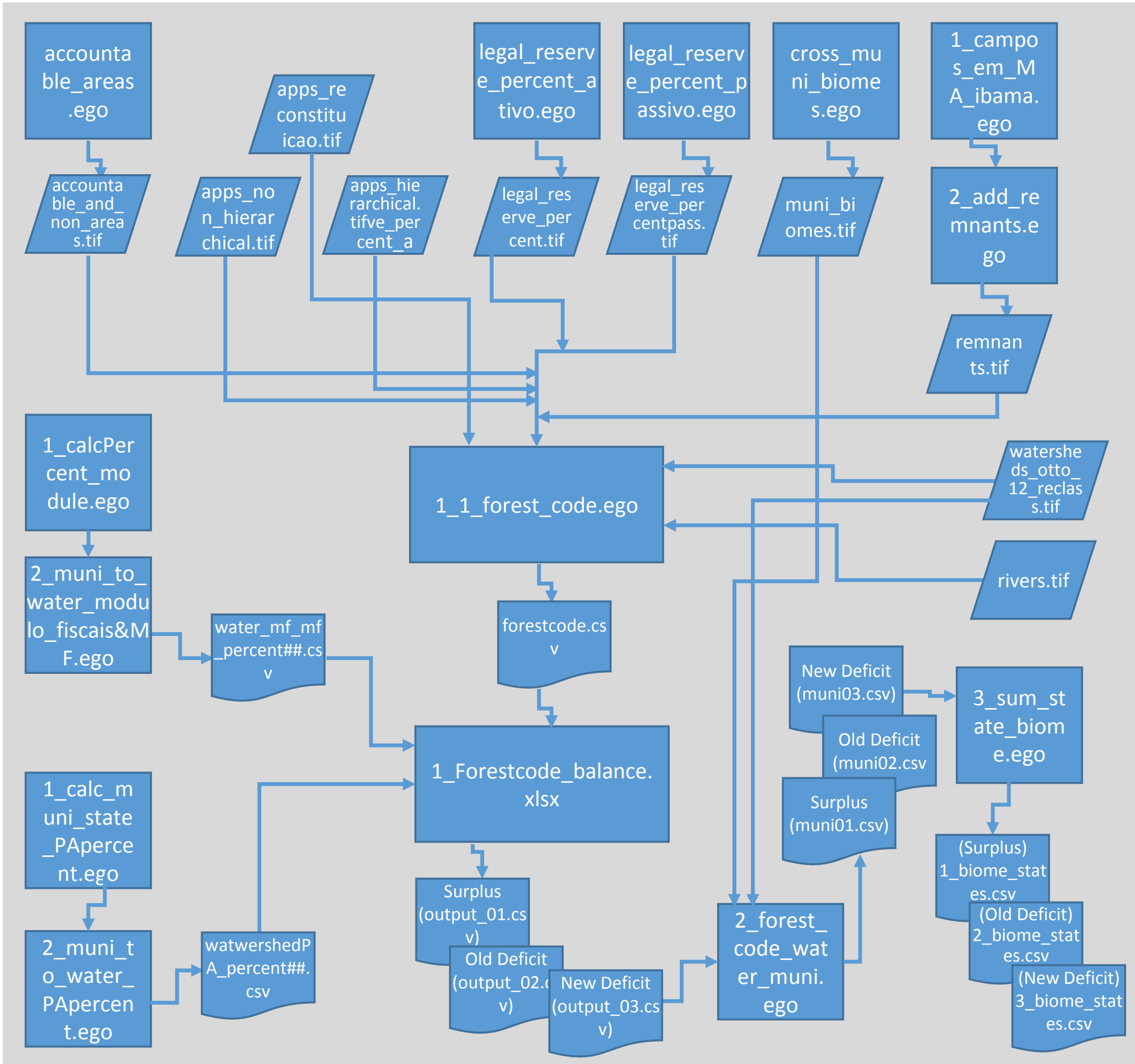

Fig. S8. Flowchart of FC main models.

Fig. S9.

Fig. S9. Land use map of Brazil, showing pasturelands with varying suitability for croplands.

Fig. S10.

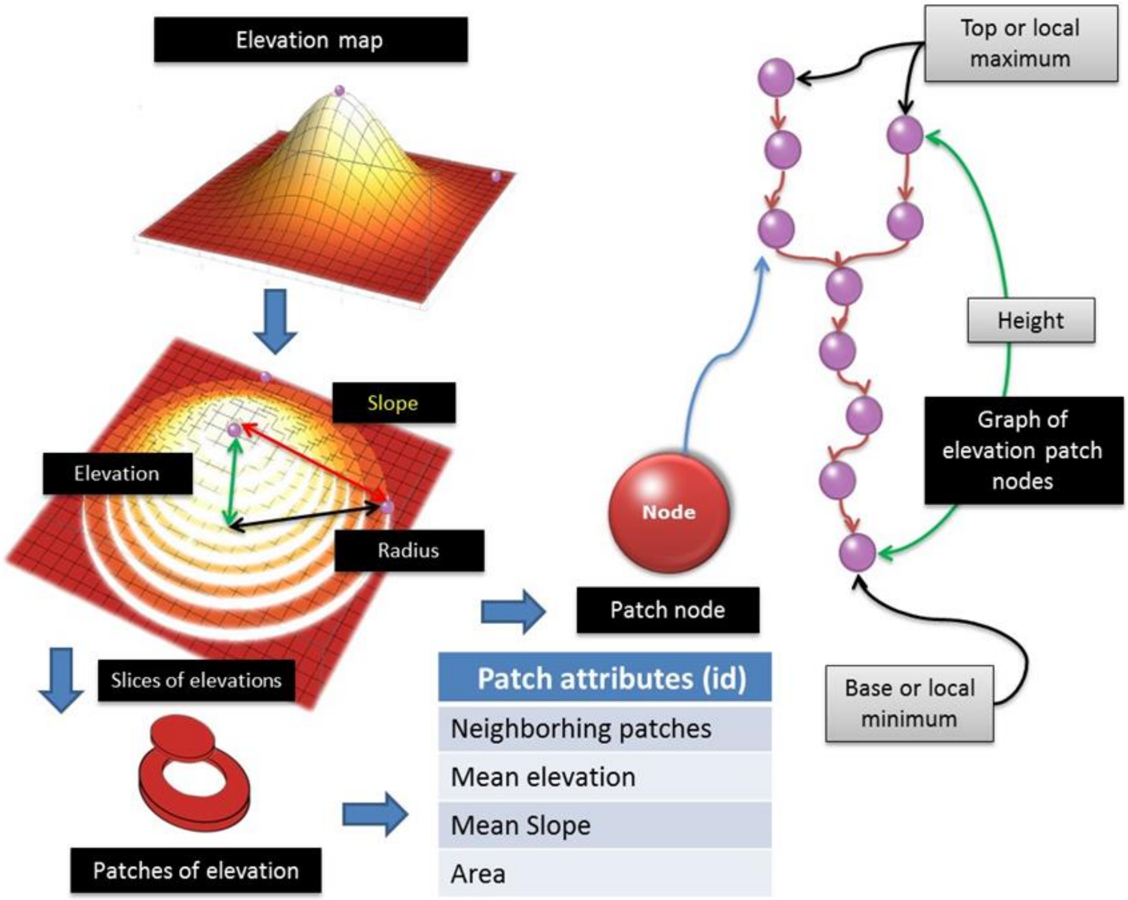

Fig. S10. Flowchart of the hilltop-mapping algorithm.

Fig. S11.

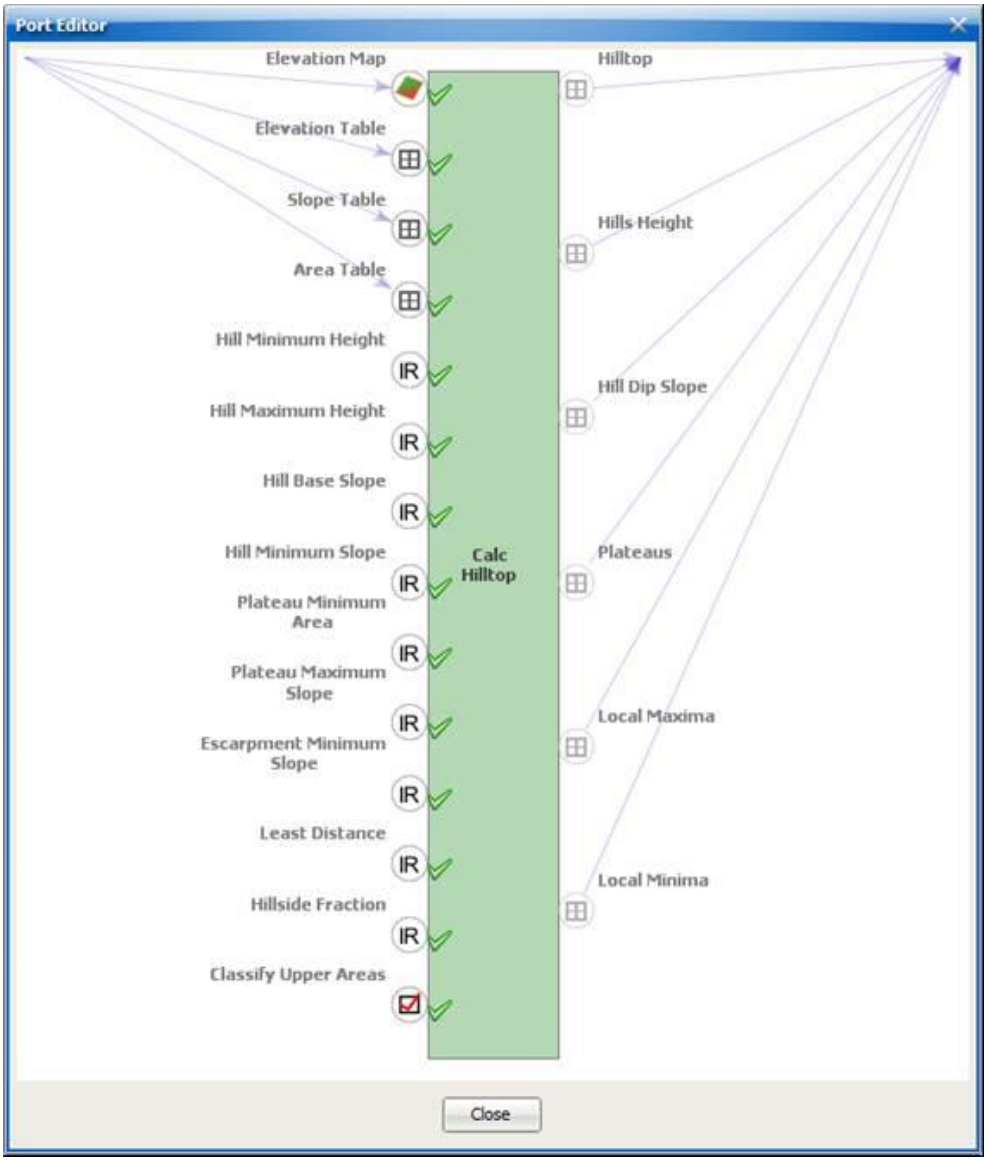

Fig. S11. Graphical interface of input and output ports of CalcHillTop operator.

Fig. S12.

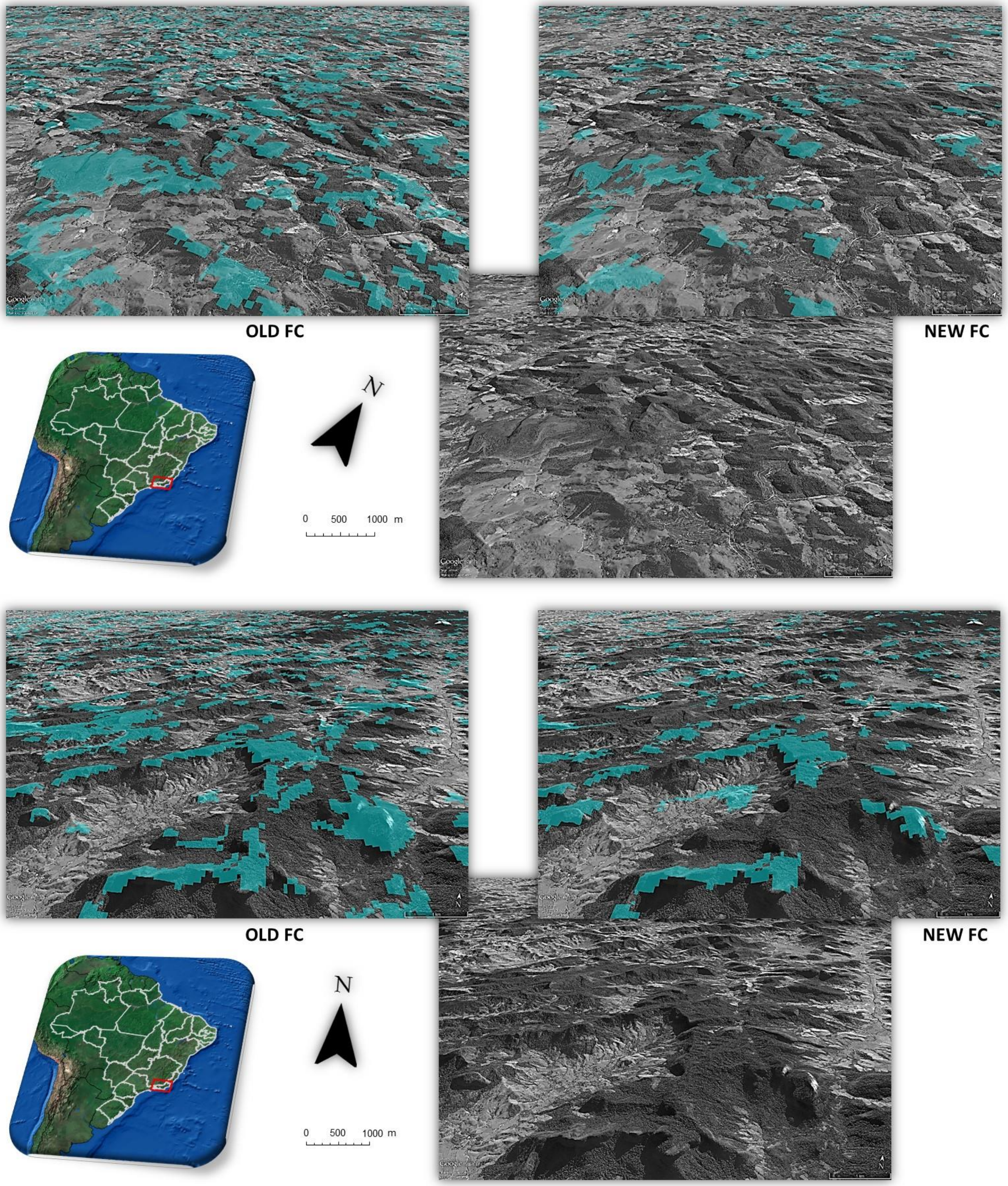

Fig. S12. 3D Google Earth diagrams overlaid with HPAs mapped according to the old and new FC definitions. Note the reduction of these areas after the revisions to the FC.

Fig. S13.

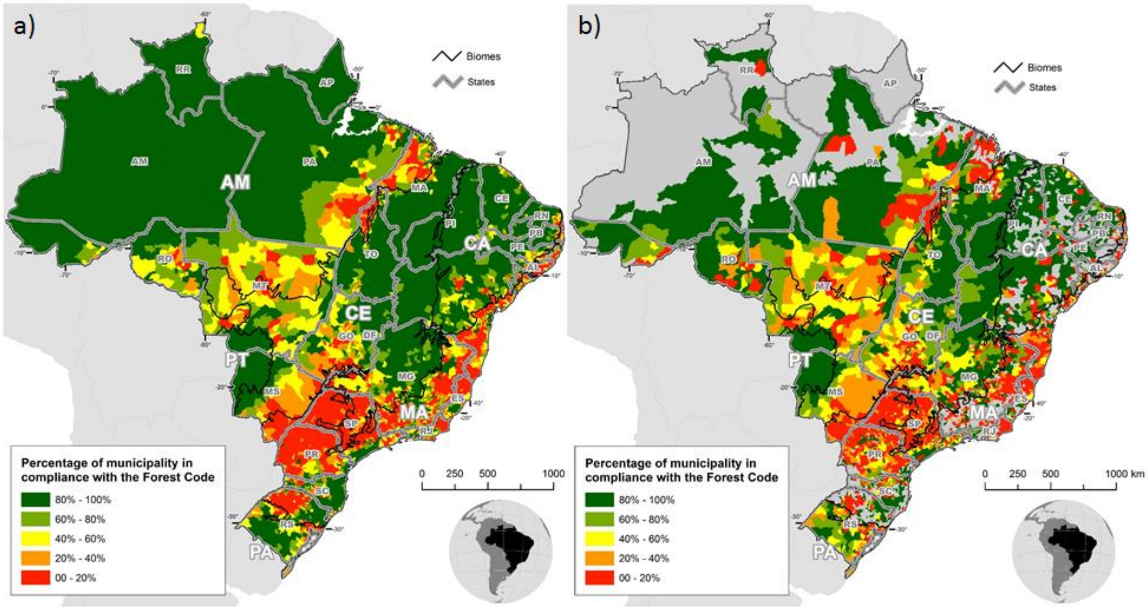

Fig. S13. Percentage of municipality in compliance with the new FC. Maps (a) estimated by watershed balance, (b) estimated by using INCRA-certified private rural properties.

Fig. S14.

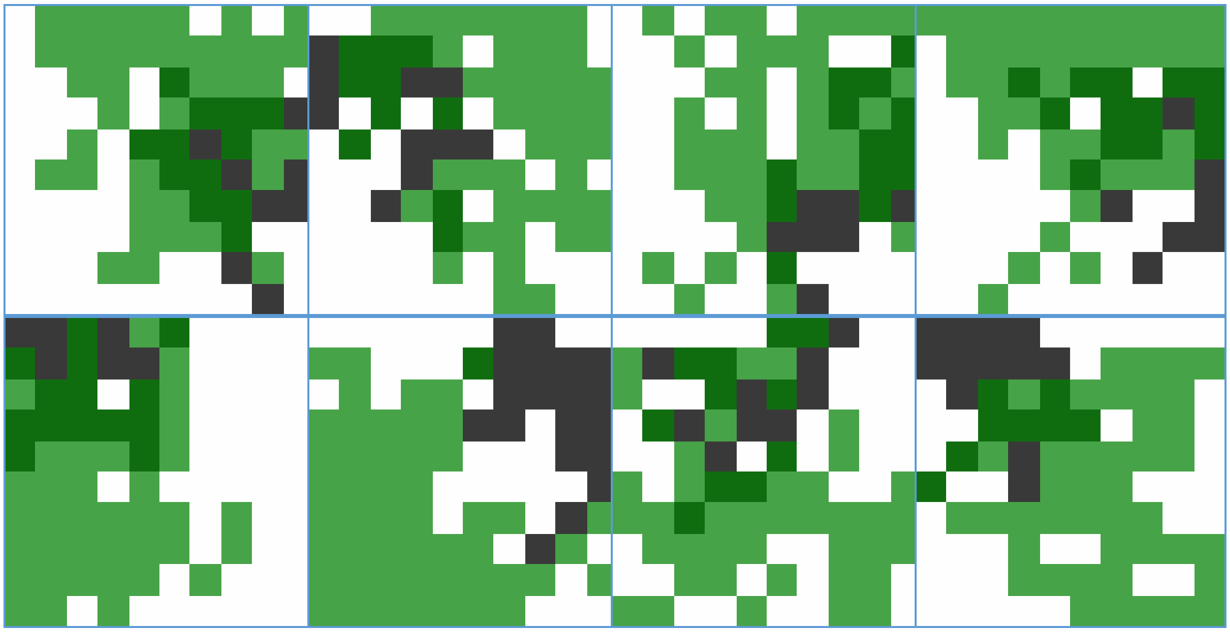

Fig. S14. Simulations with random allocation of RPA of 20 cells (black) and vegetation remnant of 50 cells (light green) within a 100-cell watershed. Dark green corresponds to the RPA with vegetation remnant and white to the absence of RPA and vegetation remnant. On average, the RPA debt is approximately 10 cells.

Fig. S15.

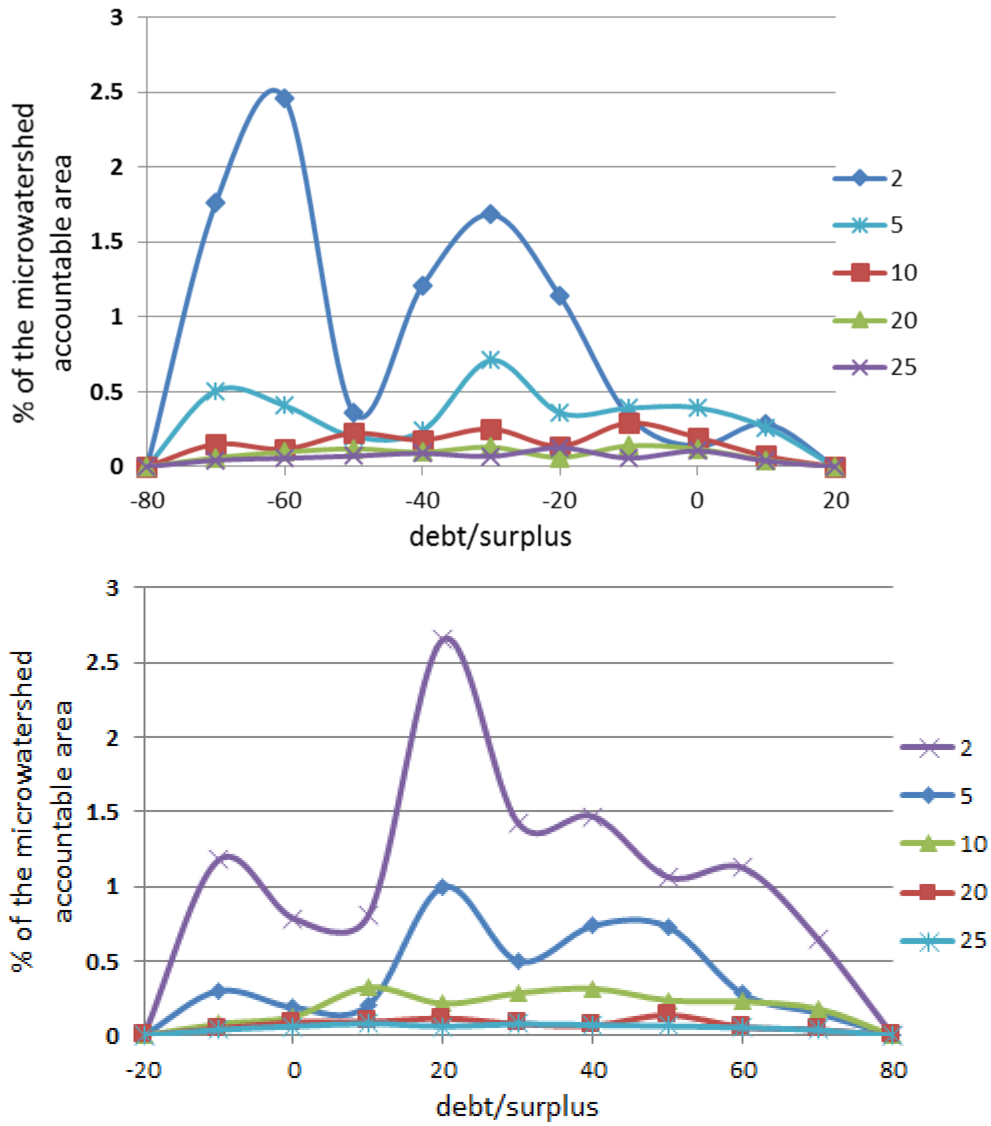

Fig. S15. Uncertainty (in percentage of the microwatershed accountable area) in the calculation of the "forest balance" relative to the number of properties within a microwatershed and the fraction occupied by the environmental debt or surplus. (above) 80% of legal reserve, (below) 20% of legal reserve. The number of properties varies from 2 to 25 (color lines).

Fig. S16.

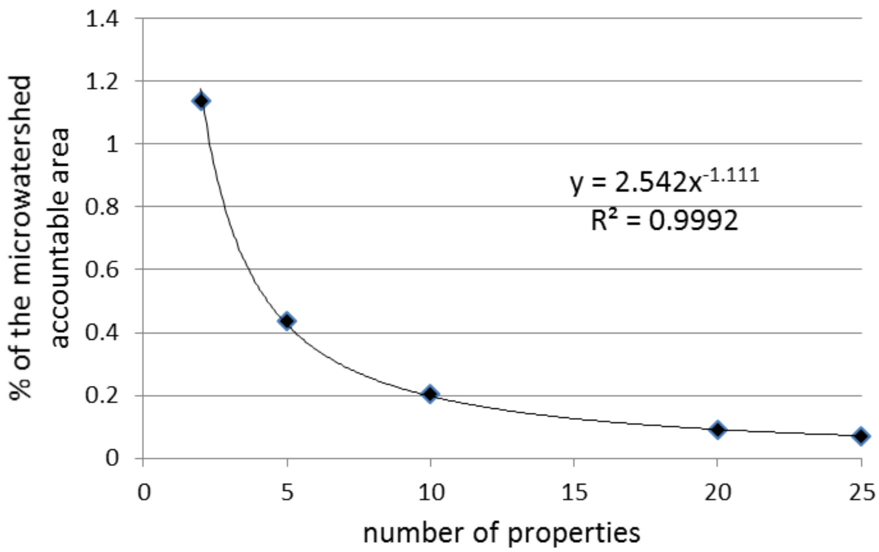

Fig. S16. Relation between the uncertainty (in percentage of the microwatershed accountable area) of forest balance estimates per microwatershed and the number of properties within it.

Table S1. Principal differences between the old and new FCs.

Old FC (Law no. 4.771, 09/15/1965 modified by MPs no. 1.1511, 06/25/1996 and 2.166-67, 08/24/2001)	New FC (Law no. 12.651, 05/25/2012, modified by Law no. 12.727 and Decree 7.830, 10/17/2012)	Reduction due to article
Legal Reserve (LR)		
Conservation measures		
Article no. 16 I. Located in the Legal Amazon: a. 80% of properties located in forested areas; b. 35% of properties located in Cerrado areas; c. 20% of properties located in grassland areas; II. Located in other regions of Brazil: a. 20% of the property	Article no. 12 The same.	−
Restoration measures*		
Article no. 16 §5 50% of properties, exclusively for the purpose of regularization (coming into compliance), where designated as a consolidation zone by the Ecological-Economic Zoning – ZEE.	Article no. 13 The same.	−
Otherwise Article nº 16 § nº 5, same as conservation.	Article no. 15 RPAs now count toward the required percentage of a property's Legal Reserve, as long as the property adheres to the Rural Environmental Registry (CAR).	≈4 Mha (Million hectares)
	Article no. 67 In properties with up to 4 fiscal modules, the Legal Reserve consists of the area occupied by native vegetation as of 22 July 2008.	≈17 Mha
	Article no. 12 §4 50% in Amazonian municipalities with more than 50% of their areas occupied by public conservation areas or indigenous lands.	≈1 Mha (both articles)
	Article no. 12 §5 50% in Amazonian municipalities when the state has an approved Ecological-Economic Zoning Plan and more than 65% of its territory occupied by public conservation areas or indigenous lands.	

Riparian Preservation Areas (RPAs)		
Conservation measures		
Article no. 2	Article no. 4	−
Buffers: 30 m, for watercourses less than 10 m wide; 50 m, for watercourses from 10 m to 50 m wide; 100 m, for watercourses from 50 m to 200 m wide; 200 m, for watercourses from 200 m to 600 m wide; 500 m, for watercourses wider than 600 m; Areas surrounding natural lakes and ponds, with minimum width of: 100 m, in rural areas, except for water bodies with surface areas of up to 20 ha, whose buffer width shall be 50 m.	The same.	
Restoration measures*		
Same as conservation.	Article no. 61 §6 ≤ 1 fiscal module: restoration of 5-m riparian buffer from the edge of the regular stream channel, regardless of the width of the watercourse. From 1 to 2 fiscal modules: 8 m. From 2 to 4 fiscal modules: 15 m. From 4 to 10 fiscal modules: 20 m for watercourses up to 10 m wide. For wider streams, the rules for properties larger than 10 fiscal modules apply. ≥10 fiscal modules: half the width of the stream channel, observing a minimum of 30 m and maximum of 100-m buffers from the edge of the regular stream channel. For lakes, idem up to 4 modules, 30 m for larger modules.	≈8 Mha
	Article no. 61-B <2 fiscal modules: RPA not to exceed 10% of the total area of the property or 2 to 4 fiscal modules: RPA not to exceed 20% of the total area of the property.	≈0 Mha

Hill Top Preservation Areas (HPAs)		
Conservation measures		
CONAMA resolution 303, 03/20/2002	Article no. 4	87%
Hilltops with a minimum height of 50 m (measured from the base), maximum height of 300 m, and mean slope ≥17%. Hilltops are defined as areas situated above two-thirds of the total height. Elevation higher than 1800 m. Areas situated above two-thirds of the height of hills and ridges, with height >300 m, mean slope ≥30%, and hilltops <500 m away. Mesas with more than 10 ha and slope <10%, characterizing plateaus with elevation >600 m. Mesa escarpment with min. horizontal width of 100 m. Baseline defined as the horizontal surface of the adjacent plain or water surface, or upon the nearest saddle point in undulated terrain.	Hilltops and ridges with minimum height of 100 m and mean slope ≥25%. Does not specify maximum height. Hilltops defined as areas situated above two-thirds of the total height. Elevation higher than 1800 m. All areas with slope ≥45%. Mesa escarpment with min. horizontal width of 100 m. Baseline defined as the horizontal surface of the adjacent plain or water surface, or on the nearest saddle point in undulated terrain.	
Restoration measures		
Same as conservation.	Absent.	Not quantified

*Restoration applies to the consolidated rural area—that is, the portion of the rural property with deforestation (anthropic occupation) predating 22 July 2008.

Table S2.Environmental debt in LRs and reduction in their areas (ha) under the revised FC, summarized by biome and state. Values in brackets correspond to the percent reduction relative to requirements under the former FC.

States\Biomes	Amazon	Atlantic Forest	Cerrado	Caatinga	Pampas	Pantanal	State totals
Amapá	- (100%)	-	-	-	-	-	- (100%)
Roraima	- (100%)	-	-	-	-	-	- (100%)
Piauí	-	-	- (100%)	- (100%)	-	-	- (100%)
Amazonas	- (100%)	-	-	-	-	-	- (100%)
Distrito Federal	-	-	11.1E+3 (56%)	-	-	-	11.1E+3 (56%)
Rio Grande do Norte	-	6.9E+3 (70%)	-	11.2E+3 (53%)	-	-	18.1E+3 (61%)
Ceará	-	-	-	20.2E+3 (57%)	-	-	20.2E+3 (57%)
Paraíba	-	23.3E+3 (56%)	-	- (100%)	-	-	23.3E+3 (67%)
Sergipe	-	25.1E+3 (79%)	-	15.7E+3 (76%)	-	-	40.8E+3 (78%)
Santa Catarina	-	46.5E+3 (88%)	-	-	16.0E+0 (81%)	-	46.5E+3 (88%)
Acre	57.8E+3 (90%)	-	-	-	-	-	57.8E+3 (90%)
Pernambuco	-	39.2E+3 (74%)	-	27.1E+3 (84%)	-	-	66.3E+3 (79%)
Alagoas	-	71.2E+3 (55%)	-	24.5E+3 (75%)	-	-	95.7E+3 (62%)
Rio de Janeiro	-	120.8E+3 (57%)	-	-	-	-	120.8E+3 (57%)
Espírito Santo	-	179.0E+3 (64%)	-	-	-	-	179.0E+3 (64%)
Rondônia	240.6E+3 (85%)	-	102.0E+0 (56%)	-	-	-	240.7E+3 (85%)
Rio Grande do Sul	-	217.7E+3 (77%)	-	-	287.3E+3 (49%)	-	505.0E+3 (67%)
Goiás	-	81.6E+3 (39%)	431.6E+3 (54%)	-	-	-	513.2E+3 (52%)
Bahia	-	563.6E+3 (52%)	22.5E+3 (26%)	233.3E+3 (71%)	-	-	819.4E+3 (60%)
Tocantins	604.2E+3 (31%)	-	238.3E+3 (53%)	-	-	-	842.4E+3 (39%)
Mato Grosso do Sul	-	433.0E+3 (28%)	559.8E+3 (31%)	-	-	- (100%)	992.8E+3 (28%)
Minas Gerais	-	764.2E+3 (68%)	233.8E+3 (62%)	- (100%)	-	-	998.0E+3 (67%)
Maranhão	1.1E+6 (61%)	-	27.1E+3 (91%)	- (100%)	-	-	1.1E+6 (64%)
Paraná	-	1.2E+6 (48%)	13.6E+3 (40%)	-	-	-	1.2E+6 (48%)
Pará	1.3E+6 (68%)	-	- (100%)	-	-	-	1.3E+6 (68%)
São Paulo	-	1.0E+6 (43%)	522.6E+3 (39%)	-	-	-	1.5E+6 (42%)
Mato Grosso	3.9E+6 (41%)	-	1.6E+6 (34%)	-	-	37.7E+3 (51%)	5.6E+6 (40%)
Totals	7.2E+6 (59%)	4.8E+6 (57%)	3.7E+6 (44%)	332.0E+3 (73%)	287.3E+3 (49%)	37.7E+3 (3%)	**16.3±1E+6**

Table S3. Environmental debt in RPAs and reduction in their areas (ha) under the revised FC, summarized by biome and state. Values in brackets correspond to the percent reduction relative to the former FC.

States\Biomes	Cerrado	Atlantic Forest	Amazon	Caatinga	Pampas	Pantanal	State totals
Distrito Federal	3.6E+3 (46%)	-	-	-	-	-	3.6E+3 (46%)
Amapá	-	-	6.8E+3 (66%)	-	-	-	6.8E+3 (66%)
Roraima	-	-	11.5E+3 (57%)	-	-	-	11.5E+3 (57%)
Acre	-	-	17.4E+3 (66%)	-	-	-	17.4E+3 (66%)
Sergipe	-	15.4E+3 (82%)	-	6.5E+3 (88%)	-	-	21.9E+3 (84%)
Alagoas	-	26.7E+3 (80%)	-	8.7E+3 (86%)	-	-	35.4E+3 (82%)
Paraíba	-	8.5E+3 (82%)	-	30.5E+3 (82%)	-	-	39.0E+3 (82%)
Rio Grande do Norte	-	4.8E+3 (82%)	-	46.5E+3 (81%)	-	-	51.3E+3 (81%)
Espírito Santo	-	59.5E+3 (82%)	-	-	-	-	59.5E+3 (82%)
Rio de Janeiro	-	59.9E+3 (74%)	-	-	-	-	59.9E+3 (74%)
Pernambuco	-	20.1E+3 (84%)	-	46.3E+3 (81%)	-	-	66.3E+3 (82%)
Piauí	19.5E+3 (69%)	-	-	47.1E+3 (70%)	-	-	66.7E+3 (70%)
Santa Catarina	-	67.2E+3 (82%)	-	-	21.4E+0 (83%)	-	67.2E+3 (82%)
Rondônia	31.2E+0 (35%)	-	75.4E+3 (48%)	-	-	-	75.4E+3 (48%)
Ceara	-	-	-	76.5E+3 (81%)	-	-	76.5E+3 (81%)
Amazonas	-	-	120.7E+3 (52%)	-	-	-	120.7E+3 (52%)
Tocantins	104.1E+3 (52%)	-	27.8E+3 (73%)	-	-	-	131.8E+3 (59%)
Maranhão	58.8E+3 (77%)	-	74.1E+3 (76%)	2.3E+3 (77%)	-	-	135.1E+3 (76%)
Paraná	4.0E+3 (19%)	227.8E+3 (47%)	-	-	-	-	231.7E+3 (47%)
Para	196.9E+0 (33%)	-	307.6E+3 (66%)	-	-	-	307.8E+3 (66%)
Rio Grande do Sul	-	94.6E+3 (81%)	-	-	213.8E+3 (63%)	-	308.4E+3 (71%)
Mato Grosso do Sul	241.4E+3 (34%)	79.1E+3 (30%)	-	-	-	22.2E+3 (50%)	342.7E+3 (34%)
Bahia	65.0E+3 (60%)	154.3E+3 (80%)	-	144.7E+3 (82%)	-	-	363.9E+3 (79%)
São Paulo	132.0E+3 (19%)	248.7E+3 (45%)	-	-	-	-	380.7E+3 (38%)
Goiás	373.9E+3 (46%)	31.4E+3 (26%)	-	-	-	-	405.3E+3 (44%)
Mato Grosso	227.7E+3 (46%)	-	257.9E+3 (43%)	-	-	20.0E+3 (49%)	505.6E+3 (45%)
Minas Gerais	322.0E+3 (61%)	290.0E+3 (71%)	-	8.7E+3 (64%)	-	-	620.7E+3 (66%)
Totals	1.6E+6 (51%)	1.4E+6 (70%)	899.2E+3 (60%)	417.7E+3(81%)	213.8E+3 (63%)	42.2E+3 (49%)	**4.5±1E+6**

Table S4. Environmental surplus or area of land (ha) that is legally available for conversion (deforestation) from native vegetation to other uses, summarized by biome and state.

States/Biomes	Cerrado	Caatinga	Amazon	Pantanal	Atlantic Forest	Pampas	Totals
Espírito Santo	-	-	-	-	44.6E+3	-	44.6E+3
Distrito Federal	44.6E+3	-	-	-	-	-	44.6E+3
Alagoas	-	51.5E+3	-	-	6.0E+3	-	57.5E+3
Rio de Janeiro	-	-	-	-	127.7E+3	-	127.7E+3
Sergipe	-	139.9E+3	-	-	9.0E+3	-	148.9E+3
Rondônia	404.1E+0	-	310.8E+3	-	-	-	311.2E+3
Paraná	23.5E+3	-	-	-	412.5E+3	-	435.9E+3
São Paulo	31.6E+3	-	-	-	510.2E+3	-	541.8E+3
Acre	-	-	831.2E+3	-	-	-	831.2E+3
Amapá	-	-	913.0E+3	-	-	-	913.0E+3
Santa Catarina	-	-	-	-	1.1E+6	48.3E+0	1.1E+6
Rio Grande do Norte	-	1.4E+6	-	-	5.6E+3	-	1.4E+6
Paraíba	-	1.5E+6	-	-	2.0E+3	-	1.5E+6
Roraima	-	-	1.9E+6	-	-	-	1.9E+6
Pernambuco	-	2.0E+6	-	-	16.7E+3	-	2.0E+6
Pará	1.2E+3	-	3.0E+6	-	-	-	3.0E+6
Rio Grande do Sul	-	-	-	-	664.0E+3	3.0E+6	3.7E+6
Goiás	4.5E+6	-	-	-	1.1E+3	-	4.5E+6
Ceará	-	5.1E+6	-	-	-	-	5.1E+6
Mato Grosso do Sul	1.1E+6	-	-	5.3E+6	21.6E+3	-	6.4E+6
Tocantins	6.4E+6	-	8.5E+3	-	-	-	6.4E+6
Maranhão	6.7E+6	154.7E+3	77.1E+3	-	-	-	6.9E+6
Minas Gerais	6.4E+6	228.2E+3	-	-	281.8E+3	-	6.9E+6
Mato Grosso	4.0E+6	-	1.6E+6	2.0E+6	-	-	7.6E+6
Amazonas	-	-	10.5E+6	-	-	-	10.5E+6
Piauí	4.9E+6	7.1E+6	-	-	-	-	12.0E+6
Bahia	5.9E+6	8.1E+6	-	-	176.8E+3	-	14.1E+6
Totals	39.9E+6	25.8E+6	8.6E+6	7.3E+6	3.4E+6	3.0E+6	**88±6E+6**

The grand total of the FC surplus does not include the surplus of the state of Amazonas (10.5 Mha), because large blocks of forests in this state remain undesignated public land to date (*15*).

Table S5. Main activities supported by the ABC (low-carbon agriculture) investment program. ABC provides US$ 1.5 billion in annual subsidized loans to the above activities in order to reduce Green House Gas emissions from agriculture (*28*).

Activities
Recovery of degraded pasture
Crop, livestock, and forestry integration
FC compliance including forest restoration
Treatment of agriculture residues for bioenergy generation
Organic agriculture
Direct seeding (i.e., no-till agriculture)
Improved forestry management, especially for charcoal production
Biological nitrogen fixation
Oil palm (*Dedenzeiro*) plantation on degraded pastureland

Table S6. Data sets used in the FC analysis. PNLT: National Plan for Logistics and Transport, IBGE: Brazilian Institute for Geography and Statistics, SFB: Serviço Florestal Brasileiro, IPAM: Instituto de Pesquisas Ambientais da Amazônia, MMA: Ministry of the Environment, INCRA: Institute for Agrarian Reform, CSR: Center for Remote Sensing, UFMG, ANA: Brazilian National Water Agency, NASA: National Aeronautics and Space Administration, ICMBio: Instituto Chico Mendes de Conservação da Biodiversidade, PRODES: Project for Monitoring Deforestation in the Amazon (*25*), PMDBBS: Project for Monitoring Deforestation in the Brazilian Biomes via Satellite (*29*) Terra Class (*30*), SOS: Fundação SOS Mata Atlântica (*27*). Leite *et al*. 2012 (*16*). PAM: Municipal Agricultural Production.

Theme	Map	Source	Date	Scale
Infrastructure	Railroad network	PNLT	2009	1:1,000,000
	Road network	PNLT	2009	1:1,000,000
Demography and administrative limits	Urban areas within Brazilian census tracts	IBGE	2010	1:100,000
	Municipalities of Brazil	IBGE	2010	1:100,000
	States of Brazil	IBGE	2010	1:100,000
	Brazilian Legal Amazon	MMA	2011	1:5,000,000
	Certified rural properties	INCRA	2013	1:100,000
Protected Areas	Protected Areas including indigenous reserves, sustainable use areas, and strict protected areas	CSR	2012	1:100,000
	(APA) Areas of Environmental Preservation	CSR	2012	1:100.000
ZEE	Ecological and economic zoning	MMA	2007	1:5.000.000
Hydrography	Ottobacias (watersheds) with order up to 12	ANA	2010	1:100.000
	Hydrographic network	ANA	2010	1:100.000
	Perennial rivers with two margins, lakes, and reservoirs	IBGE	2006	1:1.000.000
Physiography	Principal vegetation classes in Brazil	IBGE	2002	1:5,000,000
	Biomes of Brazil	IBGE	2011	1:5,000,000
	Potential biomass of the original vegetation	Leite *et al* (*16*)	2012	1:5,000,000
	Brazilian Soils Map, classified according to the Brazilian System for Soil Classification developed by EMBRAPA	IBGE	1999	1:5,000,000
	Topography from Space Shuttle Radar Topographic Mission	NASA	2011	1:250,000
Remaining native vegetation	Remnants in the Cerrado biome	PMDBBS		1:250,000
	Remnants in the Pampas biome	PMDBBS	2009	1:250,000
	Remnants in the Caatinga biome	PMDBBS	2009	1:250,000
	Remnants in the Pantanal biome	PMDBBS	2009	1:250,000
	Remnants in the Amazon biome	PRODES	2011	1:250,000
	Remnants in the Atlantic Forest biome	SOS	2009	1:250,000
	Secondary vegetation in Amazonia	TERRACLAS	2012	1:100,000
	Cerrado Deforestation from 2009 to 2010	PMDBBS	2011	1:250,000
Census data	Agricultural Census	IBGE	2006	1:100,000
	PAM	IBGE	2011	1:100,000

Table S7. RPA widths associated with ANA watershed hierarchy.

Order	Width (m)
1	240
2	180
3	90
4	60
5	60
6	30
7	30
8	30
9	30
≥10	30

Table S8. Absolute and relative changes in areas of HPAs from the old to the new FC.

State	Old definition (ha)	New definition (ha)	Relative change (%)
Acre	120.6E+3	4.0E+3	–97
Alagoas	332.5E+3	29.6E+3	–91
Amazonas	1.5E+6	159.0E+3	–89
Amapá	931.2E+3	42.7E+3	–95
Bahia	2.9E+6	403.4E+3	–86
Ceará	762.5E+3	170.1E+3	–78
Brasília - DF	19.4E+3	116.6E+0	–99
Espirito Santo	965.8E+3	228.4E+3	–76
Goiás	1.5E+6	206.8E+3	–86
Maranhão	2.1E+6	263.2E+3	–88
Minas Gerais	5.9E+6	945.2E+3	–84
Mato Grosso do Sul	145.2E+3	94.9E+3	–35
Mato Grosso	2.1E+6	306.7E+3	–86
Pará	7.3E+6	483.2E+3	–93
Paraíba	343.2E+3	43.6E+3	–87
Pernambuco	620.8E+3	92.6E+3	–85
Piauí	1.3E+6	238.0E+3	–82
Paraná	1.5E+6	141.6E+3	–90
Rio de Janeiro	767.0E+3	206.1E+3	–73
Rio Grande do Norte	186.3E+3	36.4E+3	–80
Rondônia	578.5E+3	65.2E+3	–89
Roraima	1.3E+6	194.6E+3	–85
Rio Grande do Sul	1.2E+6	181.7E+3	–85
Santa Catarina	1.2E+6	207.4E+3	–82
Sergipe	88.5E+3	2.5E+3	–97
São Paulo	1.3E+6	178.5E+3	–87
Tocantins	917.9E+3	162.5E+3	–82
Totals	**38.0E+6**	**5.1E+6**	**–87**

Table S9. Comparison between data of ANA 12 watersheds and INCRA private properties.

	FC applicable area (ha)	No. of units	Average size	Distribution by Fiscal Modules in terms of area (%)					
				≤1	≤2	≤3	≤4	>4 & ≤10	>10
ANA 12 watersheds	612,928,419	166,443	3,683	14	24	29	33	16	51
INCRA properties	91,187,213	62,897	1,595	7	12	15	18	17	65
Ratio	6.72	2.65	2.31						

Table S10. FC balance using ANA 12 watersheds and INCRA private properties and relative deviance.

				After area adjustment			After agrarian adjustment	
(Unit in ha)	Surplus	Old deficit	New deficit	Surplus	Old deficit	New deficit		New deficit
ANA 12 Watersheds	98.6E+6	49.7E+6	20.7E+6	98.6E+6	49.7E+6	20.7E+6		20.7E+6
INCRA properties	16.4E+6	8.0E+6	6.5E+6	110.3E+6	53.6E+6	44.0E+6	2.9E+6	19.5E+6
				–11%	**–7%**			**6%**

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Additional Data

Additional data of the FC analyses available at www.csr.ufmg.br/forestcode.