SUPPLEMENTARY MATERIAL

1. Cartographic input data

Table S1. Dataset used as input for spatial analysis

Map	Source*	Data	Scale
States of Brazil	IBGE	2010	1:100,000
Brazilian Biomes	IBGE	2011	1:5,000,000
Urban areas within Brazilian census tracts	IBGE	2010	1:100,000
Hydrographic network	ANA	2010	1:100,000
Remaining native vegetation in Brazil	CSR	2016	1:250,000
Elevation (ASTER Global Digital Elevation Map)	NASA	2015	1:50,000
Absolute Forest Code balance per watershed	CSR	2014	1:250,000
Land use in Brazil in 2012 (OtimizAgro)	CSR	2016	1:250,000
Simulated land use in Brazil in 2030 (OtimizAgro)	CSR	2016	1:250,000
Pastureland prices in Brazil	CSR	2016	1:250,000
Forested land prices in Brazil	CSR	2016	1:250,000
Brazil historical land use (1940-2012) - Planted pasture intensity	Dias *et al* 2016	2016	1:250,000
Historical average precipitation (30-year period / Climatological Normal)	INMET	2015	1: 100,000
Priority areas for flora conservation (Ecological Economic Zoning)	ZEEMG	2006	1:50,000
Priority areas for fauna conservation (Ecological Economic Zoning)	ZEEMG	2006	1:50,000
Index of superficial water availability (Areas under water stress)	ANA	2013	1:100,000
Potential vegetation biomass	Soares Filho *et al* 2016	2016	1:5,000,000

* IBGE – Instituto Brasileiro de Geografia e Estatística / Catalogo de Metadados (http://www.metadados.geo.ibge.gov.br/geonetwork_ibge/srv/por/main.home)
ANA – Agência Nacional de Águas / Portal de Metadados Geoespaciais (http://metadados.ana.gov.br/geonetwork/srv/pt/main.home)
CSR – Centro de Sensoriamento Remoto / Servidor de Mapas (http://maps.csr.ufmg.br/)
INMET – Instituto Nacional de Meteorologia / BDMEP - Banco de Dados Meteorológicos para Ensino e Pesquisa (http://www.inmet.gov.br/portal/index.php?r=bdmep/bdmep)
ZEEMG – Zoneamento Ecológico do Estado de Minas Gerais (http://www.zee.mg.gov.br/)

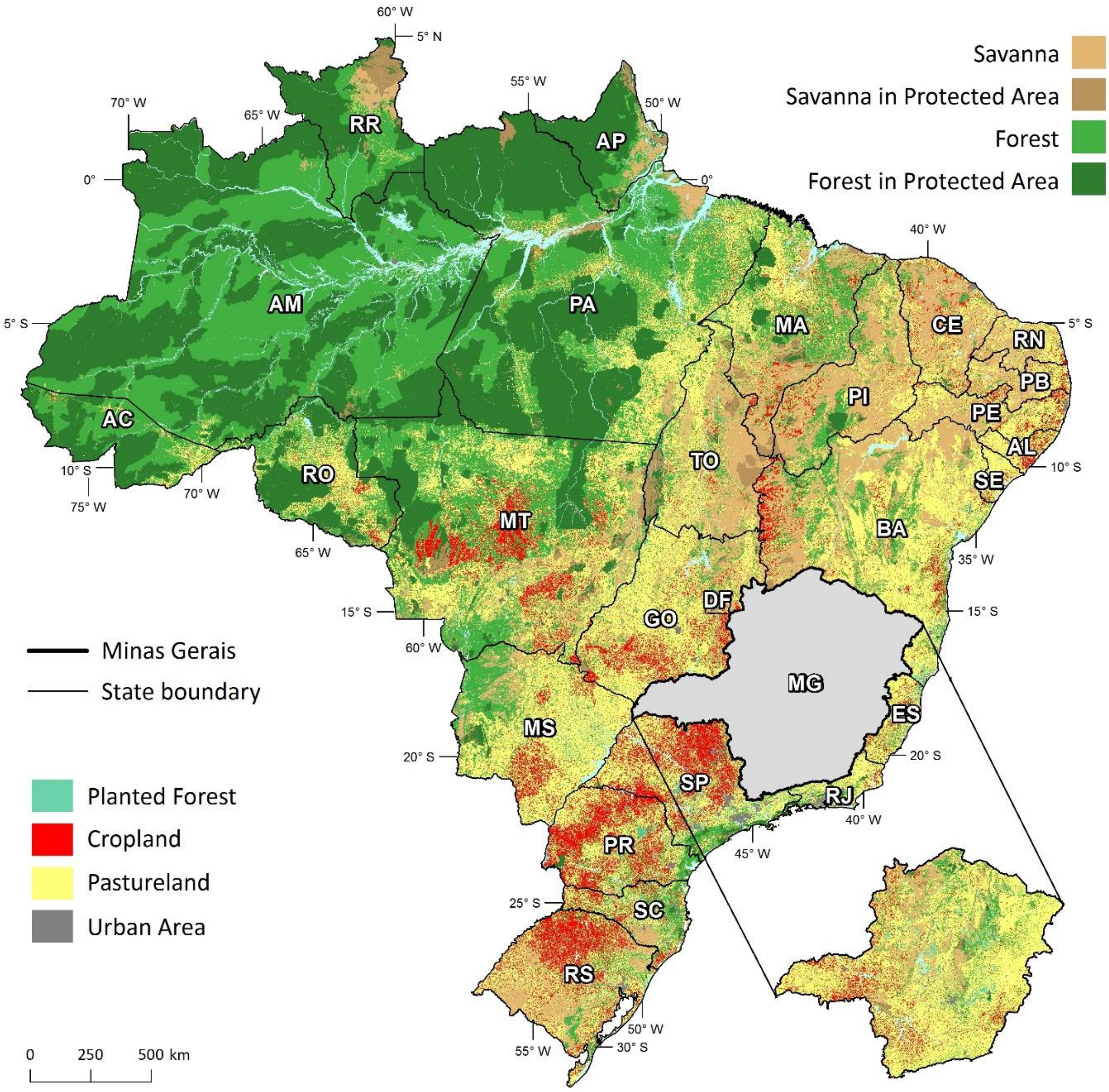

Figure S1: Land use in Brazil and Minas Gerais state in 2012 from Soares-Filho *et al* (2016).

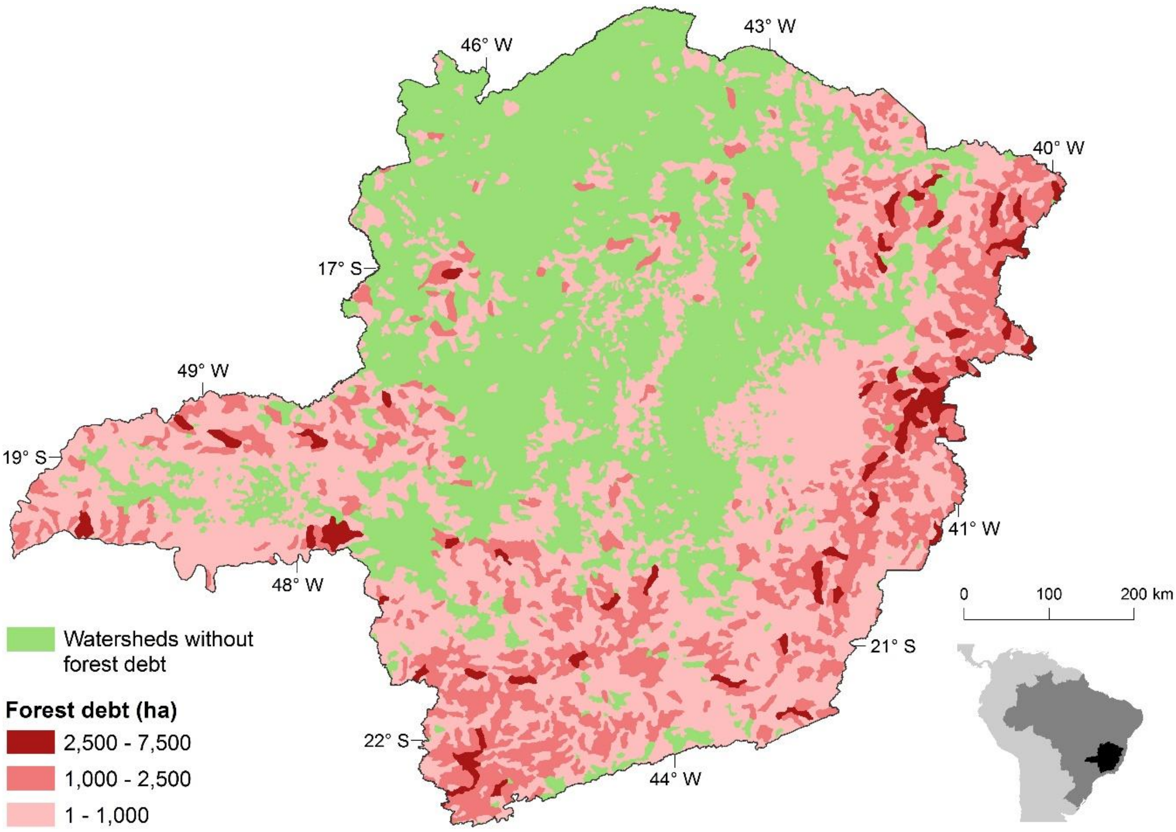

Figure S2: Forest Code debt in Minas Gerais state according Soares-Filho *et al* (2014).

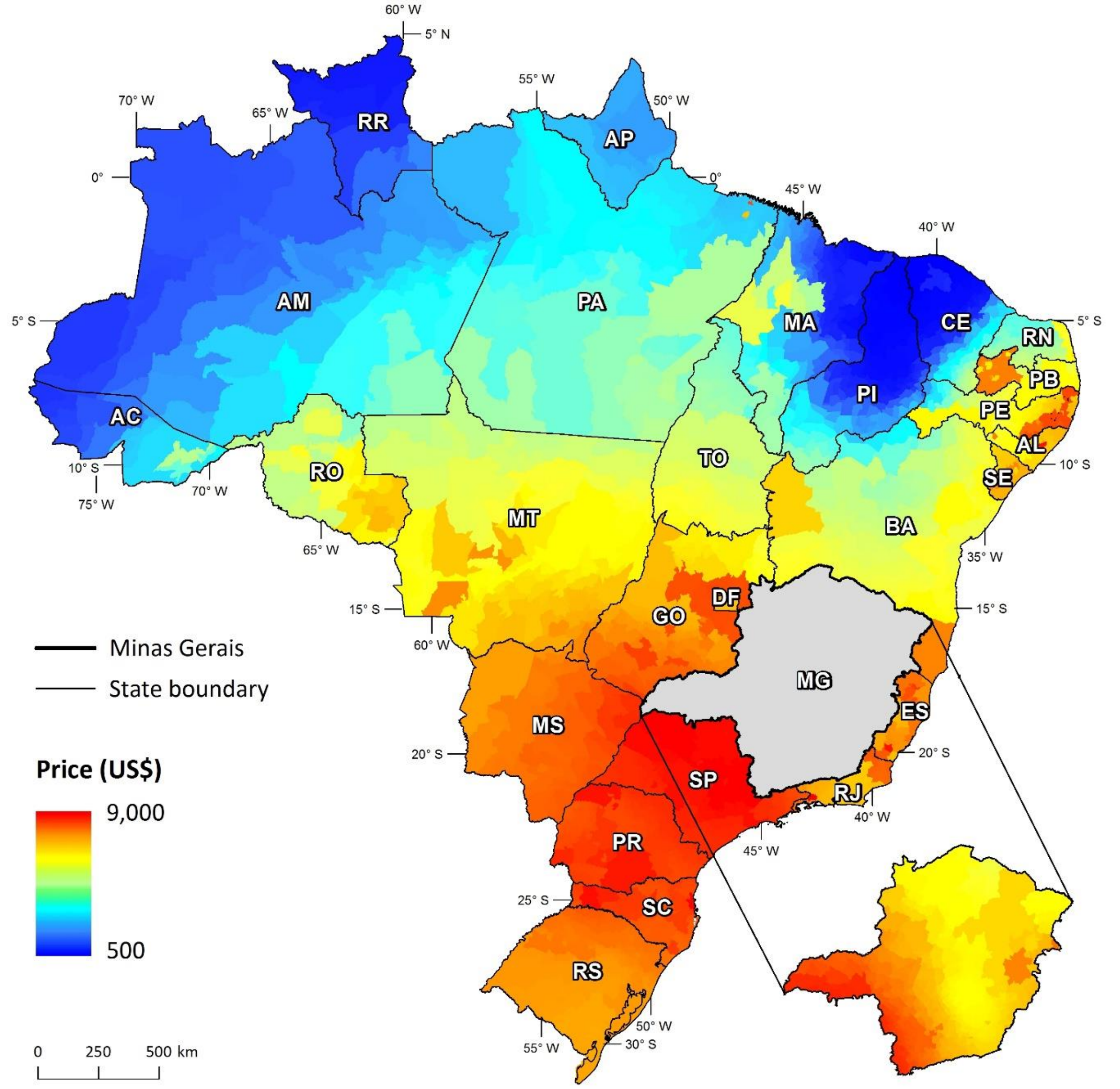

Figure S3: Pastureland prices from Soares-Filho *et al* (2016).

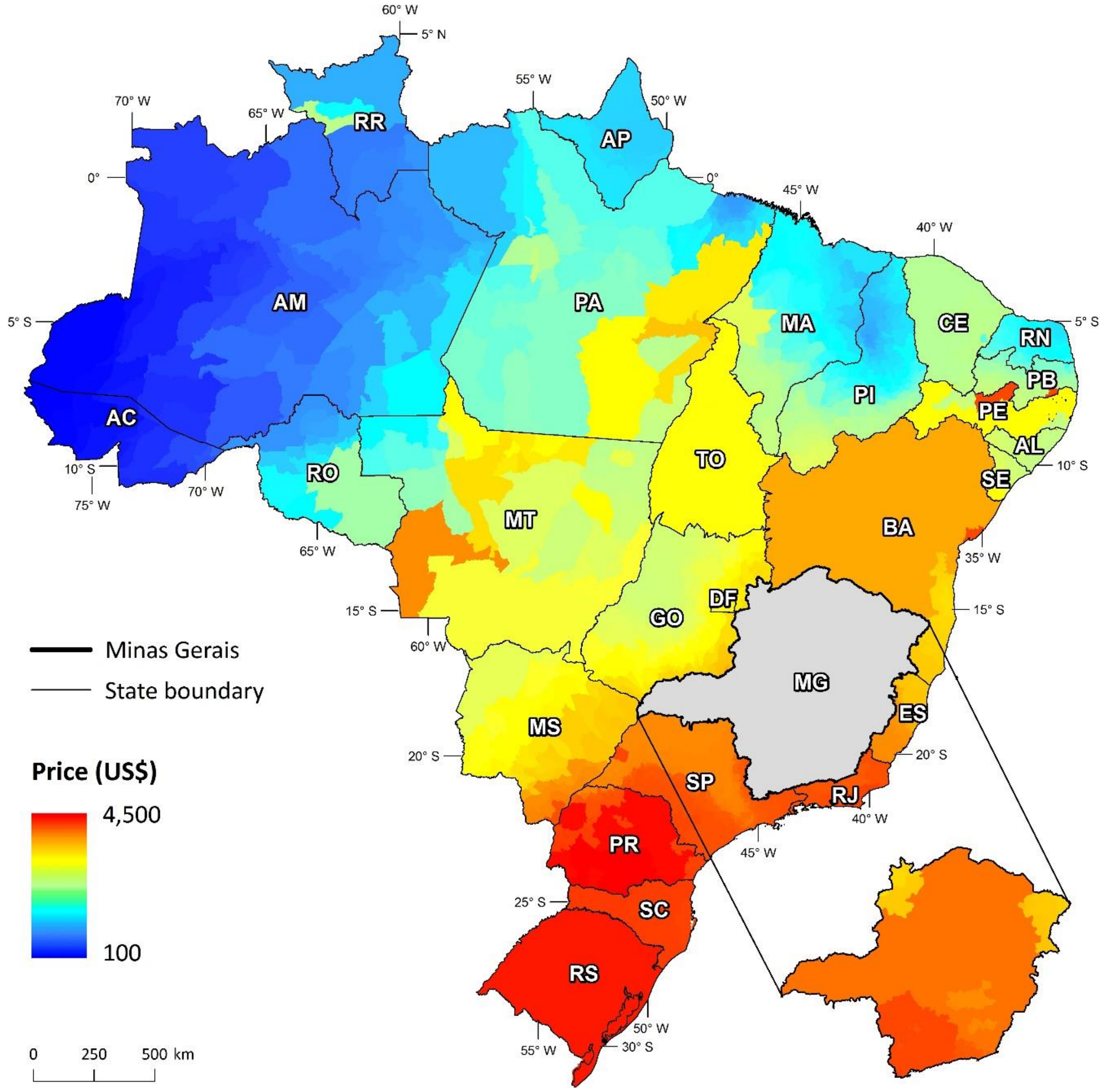

Figure S4: Forested land prices from Soares-Filho *et al* (2016).

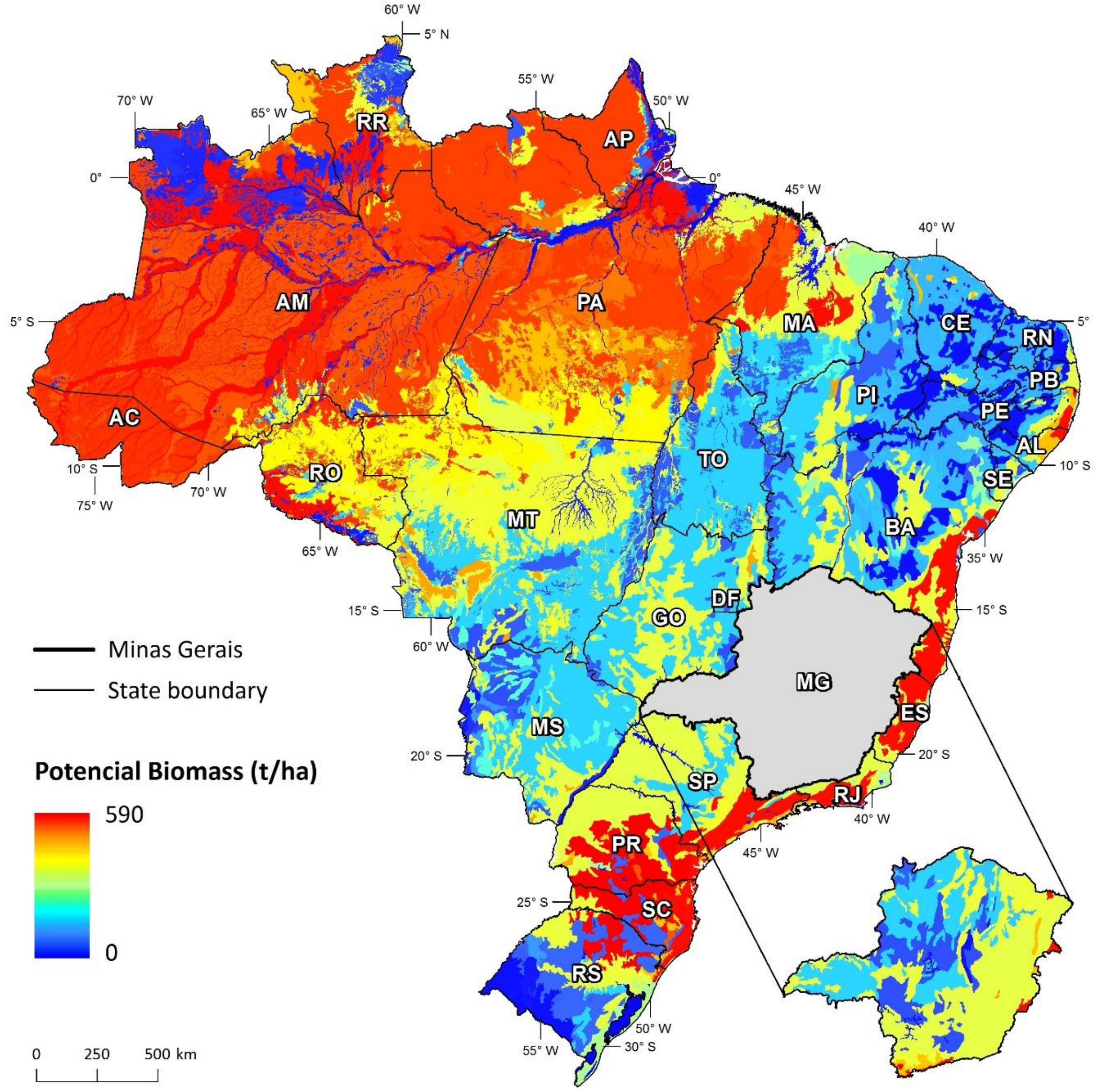

Figure S5: Potential above and below ground biomass from Soares-Filho *et al* (2016). Values greater than 305t/ha were used to select priority restoration areas for enhancing carbon sequestration.

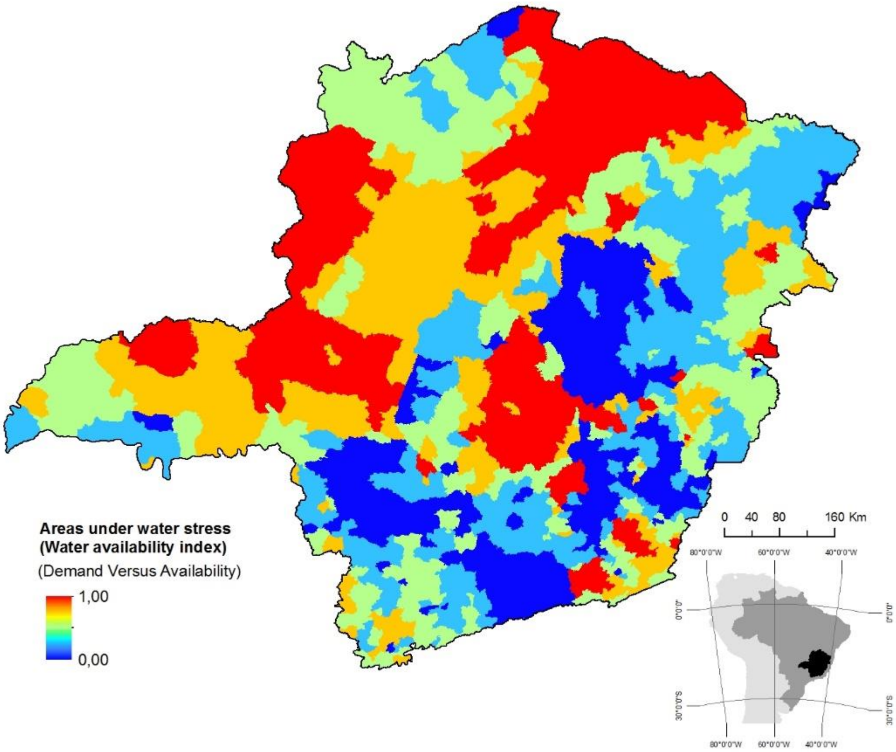

Figure S6. Map of priority areas for water protection (ANA 2013). Values greater than 0.5 were used to select priority restoration areas for enhance water protection.

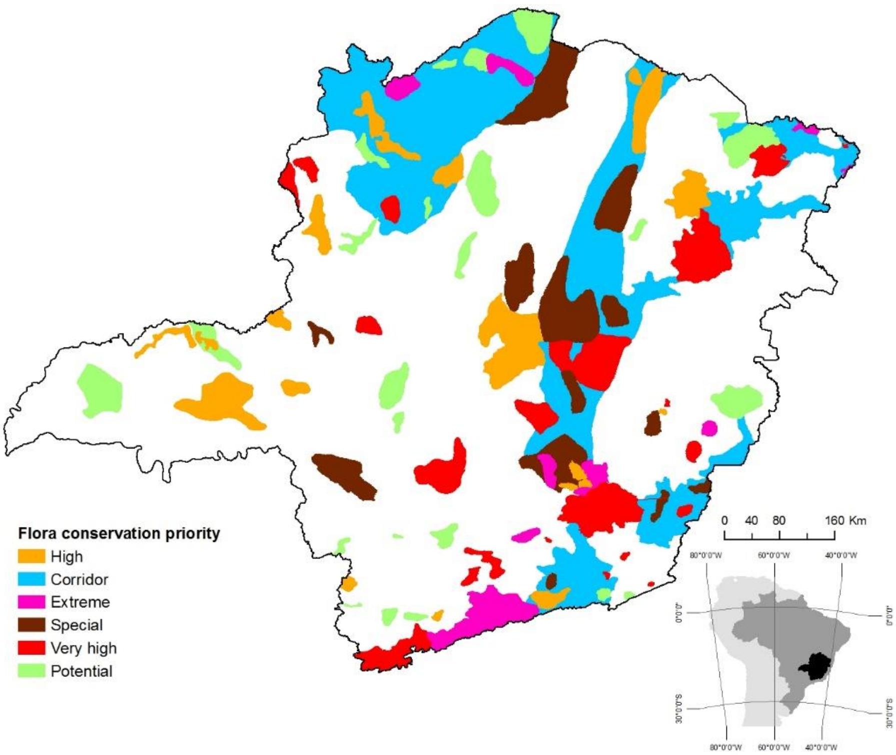

Figure S7. Map of priority areas for flora conservation from Minas Gerais State Ecological-Economic Zoning (ZEEMG 2006).

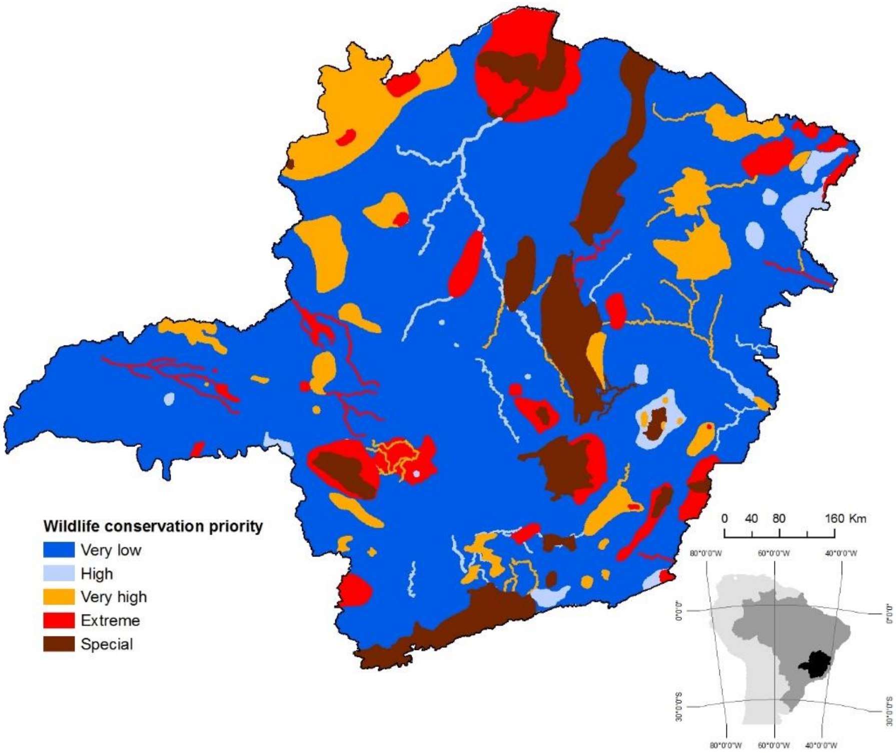

Figure S8. Map of priority areas for fauna conservation from Minas Gerais State Ecological-Economic Zoning (ZEEMG 2006).

2. Spatial analysis and restoration simulations

2.1 Identifying concave areas and low-lying topographic areas

Spatial analysis and restoration simulations were performed using Dinamica EGO freeware (Soares-Filho *et al* 2013). Dinamica EGO consists of a sophisticated platform for environmental modeling for the design from the very simple static spatial model to very complex dynamic ones, which can involve a series of complex spatial algorithms for the analysis and simulation of space-time phenomena.

We used the "Calc Flow Direction Map" functor (http://csr.ufmg.br/dinamica/) to calculate a flow direction map using the elevation map of Minas Gerais state (Aster, 30 meters) (NASA 2015). The values in the output map indicate the directions for each cell as follows:

32	64	128
16	x	1
8	4	2

where X is the current cell and the other cells indicate their corresponding position mask. The resulting directions can be summed to pack several directions in a single value.

That output, in turn, is used to calculate the cumulative flow map using the "Calc Cumulative Flow Map" functor to estimate a cumulative flow map using the flow direction map, the elevation map and a flow partition map. The resulting map indicates the flow received by every cell directly and indirectly. Next, the model scans the entire map searching and selecting the largest central values (after testing if the cell has the higher value locally) within a window of 300m X 300m. Finally, to map these concave areas and low-lying topographic areas (accumulation areas, 300m), we subtracted urban areas and water bodies (Figure S1).

2.2 Histogram equalization

Histogram equalization (Gonzalez and Wood 2008) is calculated by using the following equations for each landscape factor related to natural regeneration potential:

$$\boldsymbol{Eq(1)\text{: } px(i) = p(x = i) = \frac{ni}{n}, 0 \leq i < L}$$

Where: px (i) = image's histogram for pixel value i, normalized to [0.1].,
ni = number of occurrences of level i, n = total number of pixels in the image, and L = total number of levels in the image.
Then, a cumulative distribution function corresponding to p_x is defined as follows:

$$\boldsymbol{Eq(2)\text{: } cdf_x(i) = \sum_{j=0}^{i} px(j)}$$

Where: $cdf_{x=}$ the cumulative distribution function or the image's accumulated normalized histogram. Afterwards, a transformation of the form y = T(x) is carried out to produce a new image {y} with a linearized cumulative distribution function (CDF) across the value range, i.e.:

$$\boldsymbol{Eq(3)\text{: } cdf_y(i) = iK}$$

where k is a constant. Then, an inverse distribution function is defined as:

$$\boldsymbol{Eq(4)\text{: } cdf_y(y^{`}) = cdf_y(T(K)) = cdf_x(K)}$$

where k is in the range [0.L]). T maps the levels into the range [0.1], since the model used a normalized histogram of {x}. In order to map the values back into their original range, the following simple transformation needs to be applied on the result as follows:

$$\boldsymbol{Eq(5)\text{: } y^{`} = y\,.\,(\max\{x\} - \min\{x\}) + \min\{x\}}$$

Because of the remapping, the lower limit of the resulting histogram can be lower than the minimum value in the input map. The upper limit of the histogram can be greater than the maximum value in the input map or vice-versa. All output maps are reclassified using an equalized approach ranging from 0 to 100 in order to standardize all landscape factors related to natural regeneration potential and allow algebra operations between the maps.

2.3 Allocating pasture to restoration

The restoration simulation uses as a local cellular automata rule (Soares-Filho *et al* 2013) in its transition engine composed of two complementary transition functions, the expander and patcher functors (http://csr.ufmg.br/dinamica/).The former is dedicated only to the expansion or contraction of previous patches of restoration and the latter is designed to generate or form new patches through a seeding mechanism.

To allocate restoration transitions we used the “Patcher and Expander” operation (functor Allocate Transition”) which can be split in two main stochastic processes: choosing a patch seed and forming the patch itself. First, choosing the patch seed is carried out by collecting all cell values (probabilities) were that transition is possible (pastureland), sorting them by their probabilities, and them keeping only the subset of cells with the highest probabilities. The number of cells to keep is calculated multiplying the number of expected transitions by a prune factor parameter (used to specify the size of the vector where cells are ranked for subsequent draw). The resulting cells are the pivot candidate cells or seeds. To choose a seed, one cell is randomly selected using a uniform probability from the pool of pivot candidates and tested to check if it is higher that a second uniform probability. All cells from the subset with the highest probabilities can be selected as long as they go through this process of selection that tends to favor those with higher probabilities (if they are drawn they are more likely to pass the test), but this process not excludes the chance to select those with lower values. After passing the test, the cell is used as a pivot to generate a new patch.

The second process is dedicated to the expansion or contraction of previous patches of a restoration patch by selecting the cell pivot neighbors using a window with 5 lines and 5 columns. The window is centered on the pivot cell and all neighbors where the transitions are possible (pastureland) are collected and placed on a patch formation pool. Then, a cell is drawn from that pool using the same approach used to select a pivot cell, including the rejection test, to be used as part of the patch. If a cell is already in that pool, its probability is increased (or decreased) using the isometry as a factor. Then, the process continues until the number of cells expected for that patch is reached. The number of cells in a patch is chosen as random number from a normal distribution defined using the mean and variance patch sizes.

To calibrate the spatial pattern simulation of the restoration patches, parameters of formation (50% of formation of new patches) and expansion percentage (50% of expansion of existing patches) were calibrated setting the medium size (3 ha), the variance (1.5 ha) and fragment isometry (10). These values aimed to reflect the observed data of regenerated forest fragments under natural regeneration processes by Martins *et al* (2014).

3. Restoration methods dataset

Table S2. Restoration methods, techniques, inputs, services, and costs in Reais (R$)

RESTORATION METHODS AND ACTIVITIES					
Restoration method	**Techniques or practices**	**Inputs**	**Services**	**Total cost per hectare**	**Source**
1) Passive restoration (PASRE)	Fencing	1687.50*	400.00	2087.50	State Environmental System (SISEMA)
2) Assisted natural regeneration (ANR)	Fencing	1687.50*	400.00	2087.50	State Environmental System (SISEMA)
	Fire Protection	0.00	60.00	60.00	
	Control of invasive species	90.00	60.00	150.00	
	Combating ants	60.00	160.00	220.00	
	Management of regenerating individuals	0.00	140.00	140.00	
	Artificial perches	120.00	160.00	280.00	
	Total			2,937.50	

3) Partial planting (PARPLAN)	Fencing	1687.50*	400.00	2087.50	State Environmental System (SISEMA)
	Fire protection	0.00	60.00	60.00	
	Soil preparation	0.00	521.50	521.50	
	Fertilizing	500.00	200.00	700.00	
	Control of invasive species	90.00	60.00	150.00	
	Seedlings	2097.90**	0.00	2097.90	
	Combating ants	60.00	160.00	220.00	
	Termiticide	50.00	0.00	50.00	
	Planting	0.00	240.00	240.00	
	Replanting	699.30	80.00	779.30	
	Freight		5.29	5.29	
	Total			6,911.49	
4) Total Planting (TOTPLAN)	Fencing	1687.50*	400.00	2087.50	State Environmental System (SISEMA)
	Fire protection	0.00	60.00	60.00	
	Soil preparation	0.00	1.040.00	1.040.00	
	Fertilizing	500.00	200.00	700.00	
	Control of invasive species	90.00	60.00	150.00	
	Seedlings	5.247.90**	0.00	5.247.90	
	Combating ants	60.00	160.00	220.00	
	Termiticide	50.00	0.00	50.00	
	Planting	0.00	240.00	240.00	
	Replanting	699.30	80.00	779.30	
	Freight		5.29	5.29	
	Total			10,579.99	
MAINTENANCE 1º YEAR					
2) Assisted natural regeneration (ANR)	Fire protection	0.00	60.00	60.00	State Environmental System (SISEMA)
	Combating ants	60.00	70.00	130.00	
	Control of invasive species	60.00	60.00	120.00	
	Management of regenerating individuals	0.00	140.00	140.00	
	Seed rain translocation	80.00	140.00	220.00	
	Total			670.00	
3) Partial planting (PARPLAN)	Crowing of seedlings	80.00	140.00	220.00	State Environmental System (SISEMA)
	Topdressing	40.00	0.00	40.00	
	Combating ants	60.00	160.00	220.00	
	Fertilizing	150.00	0.00	150.00	
	Fire protection	0.00	60.00	60.00	
	Management of advanced natural regeneration	0.00	70.00	70.00	
	Total			760.00	
4) Total Planting (TOTPLAN)	Crowing of seedlings	80.00	140.00	220.00	State Environmental

	Topdressing	40.00	0.00	40.00	System (SISEMA)
	Combating ants	60.00	160.00	220.00	
	Fertilizing	150.00	0.00	150.00	
	Fire protection	0.00	60.00	60.00	
	Total			690.00	
	MAINTENANCE 2º YEAR				
2) Assisted natural regeneration (ANR)	Fire protection	0.00	60.00	60.00	State Environmental System (SISEMA)
	Combating ants	60.00	70.00	130.00	
	Management of regenerating individuals	0.00	140.00	140.00	
	Seed rain translocation	80.00	140.00	220.00	
	Total			550.00	
3) Partial planting (PARPLAN)	Crowing of seedlings	80.00	400.00	480.00	State Environmental System (SISEMA)
	Combating ants	60.00	140.00	200.00	
	Fire protection	0.00	60.00	60.00	
	Management of advanced natural regeneration	0.00	140.00	140.00	
	Total			880.00	
4) Total Planting (TOTPLAN)	Crowing of seedlings	80.00	400.00	480.00	State Environmental System (SISEMA)
	Combating ants	60.00	160.00	220.00	
	Fire protection	0.00	60.00	60.00	
	Total			760.00	

* depending on the area to be fenced – 200m / 300m / 400m: 1,125.00 / 1,687.50 / 2,250.00, respectively
** depending on amount of seedlings – 666 / 999 / 1667 per ha : 2,097.90 / 3,146.85 / 5,247.90. respectively
***exchange rate: (1 US$ = 3.33; mean rate of 2015)

Table S3. Rural technical assistance provided by the Rural Technical Assistance Agency - EMATER/MG. Activities and costs in Reais (R$)

Rural technical assistance dataset			
Technical assistance costs for restoration projects (LR and PPR)			
Work hours		80.00	Without bank financing
Transportation, food, and stay costs	Cost per km	1.30	Without bank financing
Transportation, food, and stay costs	Cost per km	19.00	Without bank financing
Environmental compliance projects of LR and PPR with rural credit	Only the development of the project: 0.5%	Percentage charged	Projects with bank financing
Environmental compliance projects of LR and PPR with rural credit	Elaboration and technical support: 2%	Percentage charged	Projects with bank financing
Samples and Agricultural State Programs covered to estimate the average costs			
Towns served	789 (93% of the state)		
Minas Sem Fome project	250,000 farmers		
Certifica Minas Café project	1633 properties in 214 towns		
Programa Minas Leite project	1160 properties in 386 towns		
PNAE e PAA projects	17 thousand farmers		
Brasil Sem Miseria project	8.2 thousand families until November		
Jaíba Project	1830 producers attended		
Preservação da Bacia do São Francisco project	56 municipalities		
Professionals	400 technicians		
Vehicles	400 units		
Notebooks	640 units		

* Exchange rate: (1 US$ = 3.33; mean rate of 2015)

Table S4. Monitoring, analysis, and evaluation preliminary costs in Reais (R$)

Regional Environmental Regularization Office of Januaria/Minas Gerais			
Inputs/Activities	**Costs/efforts**	**Detailed information**	
Land use registry and validation	35 Registrations	35 registrations were completed by 03 employees, with an average estimate of 2 hours spend for each register.	
3 employees	2.91 days for each employee	Each employee works on average 40 hours / month	
Environmental Manager	3 employees	Each employee works on average 40 hours / month	
Environmental Technical	2 employees	Each employee works on average 40 hours / month	
MGS	3 employees	Each employee works on average 40 hours / month	
Northwest Regional Office (sample)			
Maturity	3 employees at a cost of 4,542.40	Each employee works on average 40 hours / month	Number of employees: 3
Daily	1 employee at a cost of 1,563.55	Each employee works on average 40 hours / month	Focal point: 1
Estimated cost for SICAR registry	504.69 per each validation	Validation needed (expected): 570,000 – 590,000 registries / 3 years	
Maintenance and update of information technology systems	764,000 per year	Analysis and validation	
Capacity building and operational costs	386,00 per year	Analysis and validation	
Estimates of land-use registry validation		**308 to 317 million**	

* Exchange rate: (1 US$ = 3.33, mean rate of 2015)

Table S5: Administrative costs of the State Program "Bolsa Verde". Costs in Reais (R$)

Item	Phase	Type of cost	Total
Preparation Notice	Pre-Announcement	Salary, labor charges	27,000
Celebration Partnerships	Pre-Announcement	Daily work	2,100
Celebration Partnerships	Pre-Announcement	Vehicle	25,000
Celebration Partnerships	Pre-Announcement	Fuel	1,200
Celebration Partnerships	Pre-Announcement	Office supplies, salary, labor charges	18,000
Celebration Partnerships	Pre-Announcement	Service provision (IOF Publishing)	6,384
Capacity	Pre-Announcement	Daily work	8,400
Capacity	Pre-Announcement	Vehicle	25,000
Capacity	Pre-Announcement	Fuel	3,000
Capacity	Pre-Announcement	Material disclosure Program	3,000
Divulgation	Pre-Announcement	Material disclosure Program	1,000
Receiving proposals	Register	Daily work	540,540
Receiving proposals	Register	Vehicle	173,333.33
Receiving proposals	Register	Fuel	46,800
Receiving proposals	Register	Vehicle maintenance	6,500
Receiving proposals	Register	GPS	6,500
Receiving proposals	Register	PC e GIS	32,500
Receiving proposals	Register	Office supplies	3,250
Receiving proposals	Register	Camera	9,100
Receiving proposals	Register	Salary, labor charges	117,000
Receiving proposals	Register	Salary, labor charges	9,000
Analysis of proposals	Analysis	Salary, labor charges	60,000
Analysis of proposals	Analysis	Daily work	50,400
Analysis of proposals	Analysis	Vehicle	130,000
Analysis of proposals	Analysis	Fuel	15,600
Analysis of proposals	Analysis	Office supplies	3,250
Analysis of proposals	Analysis	PC e SIG	50,000
Analysis of proposals	Analysis	Analysis for resources	10,000
Publishing results	Results	Service provision (IOF Publishing)	425.60
Results resources	Post-results	Salary, labor charges	18,000
Results resources	Post-results	Office supplies	0
Results resources	Post-results	Service provision (IOF Publishing)	425.60
Results resources	Post-results	PC e SIG	7,500
Benefit payment (p1)	Payment	Salary, labor charges	27,000
Benefit payment (p1)	Payment	Salary, labor charges	9,000

Benefit payment (p1)	Payment	Salary, labor charges	3,000
Benefit payment (p1)	Payment	Salary, labor charges	117,000
Benefit payment (p1)	Payment	Daily work	98,280
Benefit payment (p1)	Payment	Vehicle	130,000
Benefit payment (p1)	Payment	Fuel	93,600
Benefit payment (p1)	Payment	Office supplies	6,500
Benefit payment (p1)	Payment	Benefit PSA	19,184,166
Verification and monitoring	Monitoring	Salary, labor charges	63,000,00
Verification and monitoring	Monitoring	Salary, labor charges	273,000
Verification and monitoring	Monitoring	Daily work	434,700
Verification and monitoring	Monitoring	Vehicle	130,000
Verification and monitoring	Monitoring	Fuel	109,200
Verification and monitoring	Monitoring	Office supplies	3,250
Verification and monitoring	Monitoring	Vehicle maintenance	13,000
Total cost	**with payments**		**22,104,904.53**
Total cost	**without payments**		**2,920,738.53**

* Exchange rate: (1 US$ = 3,33; mean rate of 2015)

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