Simulating deforestation in Minas Gerais, Brazil, under changing government policies and socioeconomic conditions

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Objectives

(I) Understand implications of government policy and economics on rates and locations of deforestation

(II) Analyze costs of cutting natural land and model the influence these values have on agricultural production

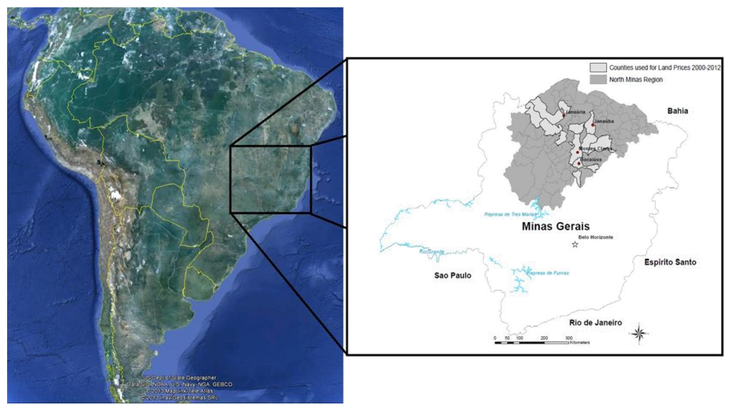


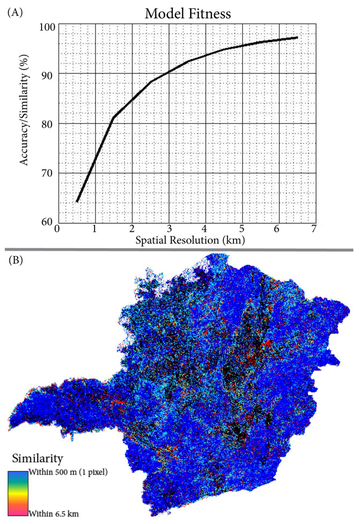
Figure 1: *Study area (Minas Gerais) and counties where land price data was collected.*

Background

- Combining spatial information with government policy and socioeconomic data in Brazil is not common in areas outside of the Amazon.[1]
- Agricultural expansion, an important economic influence in Minas Gerais, is a major driver of deforestation in the tropics.
- Deforestation has been expanding in Brazil (75% of the original Atlantic Forest & 50% of the Cerrado was cut by 2009)[2], and the Forest Code(1965), the major environmental legislation in the country, was revised to relax restrictions and reduce penalties for illegal clearing.
- Despite legislation requiring the protection of natural biomes, the worst areas are preserved, leading to a large loss in biodiversity and ecosystem services.

Methods and Results

Spatial Model



- Dinamica EGO (Environment for Geoprocessing Objects) modelling platform was used to track historical deforestation and simulate future scenarios.
- The platform uses weights of evidence and probability maps,[3] created based on biogeophysical and socioeconomic variables, to track land cover changes through time.
- The simulation model was validated at 85% accuracy (based on cover type) within 1 pixel (1.5 km).
- The projected maps were regionalized to analyze the trends in deforestation rate, fragmentation, & the probability of cover change between different years.

Figure 3: *(Top) Model fitness (similarity) as a function of distance; (Bottom) Similarity map (agricultural area), with blue as a good fitness and red as a poor fitness.*

Landscape Simulation and Parameters Results

- The Forest Code scenario (increased rate of deforestation) exhibits the most fragmented remaining natural landscape and has the smallest remaining area of natural biomes in 2020.
- The Aichi Target model (decreased deforestation) results in the most intact landscape.
- The location of deforestation is consistently higher in the northwest of the state in all three scenarios, and shrubland is preferentially cut in all models when compared to forest loss.

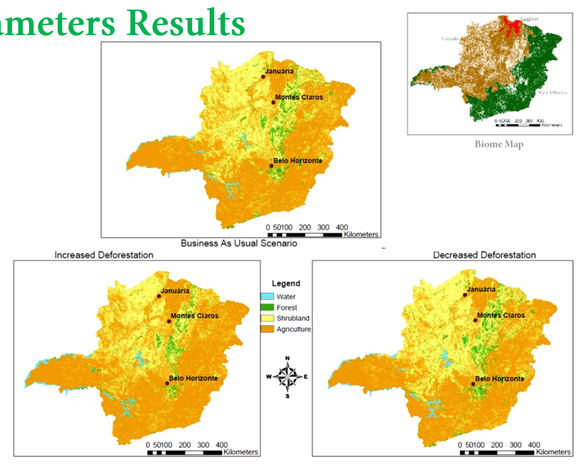


Figure 3: *Results from 2012 of the three model simulations: (left) Business as Usual (calculated by the model); (centre) Increased deforestation (based on reduced restrictions of the Forest Code); (right) Decreased deforestation (based on the Aichi biodiversity targets).*

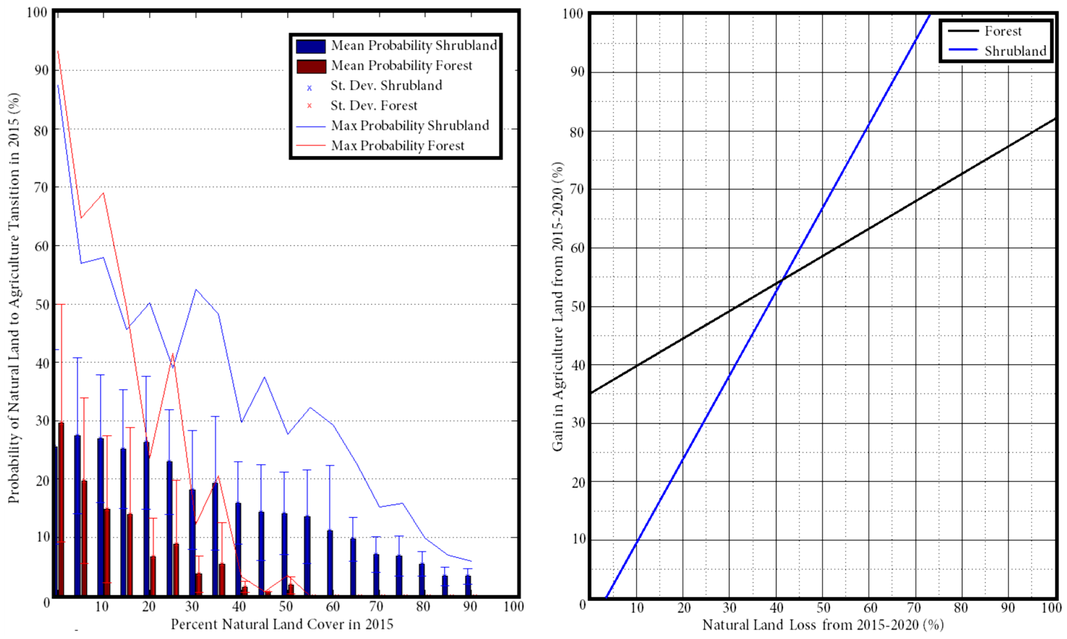


Figure 3: *(left) The probability of transition as a function of the amount of remaining ecosystems. Shrubland has a higher probability of transition compared to forest when there is a larger extent remaining. (right) Decreases in shrubland and forest are correlated to increases in agricultural land.*

- The highest probability of transition occurs in regions that contain the least remaining amount of natural land. In areas where there is a reduction in original ecosystems, there is a proportional increase in cropland extent.

Economic Model

- A linear optimization resource allocation model (GAMS) was created using the agriculture revenue and land price data from Brazil. The land available and trends in land conversion were derived from the spatial model.
- The economic model determined the optimal area of additional land purchased/converted for agriculture annually to maximize profit over a 13 year period.
- Three scenarios were run for profit maximization: 1) biodiversity cost not accounted for; 2) biodiversity value as a cost; 3) biodiversity value + an additional $800 USD cost.

Historical Trends and Biodiversity Value

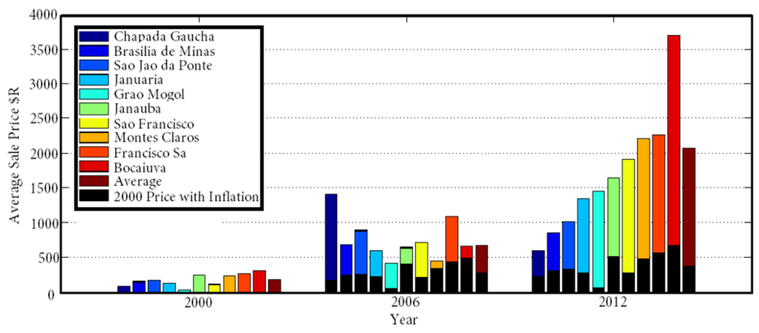


Figure 4: *County land prices from the North region of Minas Gerais which include the price from 2000 if subject to inflation and the actual prices in 2006 and 2012.*

Value of Land -2008

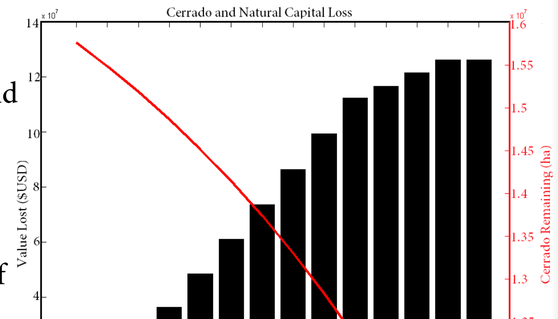
Biome	Value
Cerrado	357,895,693
Mata Atlantica	303,438,607
Caatinga	82,972,053
Pantanal	6,178,964
Total ($USD)	**750,485,317**

Table 1: *Calculated biodiversity values based on species in Minas Gerais and the cost of utilities and maintenance of the plants.*

- County land prices have increased exponentially from 2000, agriculture revenue has outpaced inflation rates over the past decade, and the value of biodiversity in the state (calculated by cost of maintaining species ex-situ) amounted to over 750 million USD in 2008.

Resource Allocation Optimization Model Results

- For the profit maximization scenario that does not account for biodiversity, nearly 25% of the remaining Cerrado land could be deforested and result in a natural capital loss of nearly $100 million USD.
- By accounting for the biodiversity costs, 1 million hectares of Cerrado could be saved by 2023 with a minimal reduction to the growth of the State GDP (0.3%).
- When the additional value scenario is run, there is greater conservation of Cerrado but with a larger economic cost.



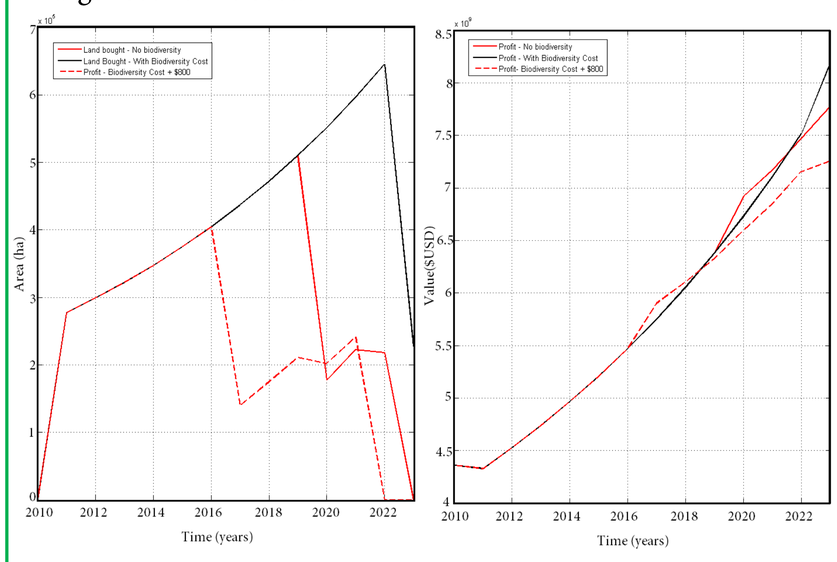


Figure 5: *(above) The remaining Cerrado decreases by 25% over the 13 year period with an increasing loss in natural capital if biodiversity value is not accounted for in the resource allocation model; (left) With biodiversity accounted for (and additional value added), there is a reduction in the optimal amount of land bought; (right) Rate of profit increase is slightly depressed if biodiversity is accounted for, and continues to reduce if additional value is added to the biodiversity cost.*

Conclusions

- The rates of deforestation in Minas Gerais are primarily driven by policy, while the locations of deforestation are instead influenced by economics and landscape parameters.
- It is more economically viable to alter areas near existing farms, and to cut shrubland when compared to forest land. These phenomena were detected in the results which show a higher probability of deforestation in areas with less remaining natural land, and determined that shrublands have higher rates of change in more intact regions compared to forests.
- The influx of capital invested into the agricultural industry, shown by higher land prices and revenue derived from croplands, indicates an increasing accessibility to farming, a trend corroborated by the economic optimization model. This can lead to difficulty in preserving sensitive biomes in the near future unless an ecosystem value is accounted for.
- Targeted, localized conservation strategies or biodiversity value accounting in Cost-Benefit Analysis may be useful for maximizing conservation efforts without severely impacting economic growth and development in Minas Gerais.

Literature Cited

1 Sparovek G, Berndes G, Klug ILF, Barretto AGO (2010). Brazilian Agriculture and Environmental Legislation: Status and Future Challenges. Environmental Science Technology 44: 6046-6053.
2 Secretaria de biodiversidade e Florestas, IBAMA (n.d.), Projeto de Monitoramento do Desmatamento does Biomas Brasileiros por Satelite-PMDBBS. Retrieved from http://siscom.ibama.gov.br/monitorabiomas
3 Soares-Filho, B.S., Rodrigues, H.O., Costa, W.L.S., (2009), Modelling Environmental Dynamics with Dinamica EGO. Universidade Federal de Minas Gerais.

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