# The use of ecological niche modeling in the evaluation of priority areas for the conservation of the State of São Paulo's Cerrado considering global climate change.

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## Introduction

The use of ecological niche modeling to evaluate the impact of climate change on biodiversity is a practice that is becoming more frequent (Peterson et al. 2002, Oberhauser and Peterson 2003, Siqueira and Peterson 2003, Thomas et al. 2004, Pearson et al. 2006b). A possible application aims at indicating priority areas for future conservation of species. Ecological niche modeling was used to evaluate the impact of climate change on priority areas for future conservation of São Paulo's Cerrado (Brazilian Savannah) (Figure 1 and 2).


Figure 1: State of São Paulo


Figure 2: Cerrado

## Methodology

- Three algorithms were used (Support Vector Machine – SVM, Genetic Algorithm for Rule-set Production GARP, both available at openModeller[1], and Maximum Entropy, available at Maxent[2].
- Occurrence points (1837 unique records) of 25 species were obtained through inventories and through the speciesLink network[3]. Species were chosen based on their endemism (only occur in the Cerrado) and on the number of records available, selecting those that had at least 20 occurrence points.
- Among the 25 listed species (table 1) *Vochysia tucanorum* Mart. (VOCHYSIACEAE) with the largest number of occurrence points (172) was selected to test the method.
- The data was divided into two groups, 70% for training and 30% for testing.
- Future climate projections of WorldClim[4] () were used for maximum and minimum temperature and precipitation projected for the years 2020 and 2080. Climate models CCCMA, CSIRO, and HDCM3 were used for two different scenarios of gas emission A2a (a pessimist scenario) and B2a (an optimistic scenario).
- The coldest, hottest, driest and most humid months were select for each period. The altitude was used for all projections, present and future.
- The models that were generated were cut based on suitability of environmental values that would accept up to 10% of omission concerning the training points. The limits of environmental suitability adopted were 0.329 for Maxent, 0.382 for SVM, and 0.1 for GARP.
- Intersection ensemble techniques were used for the different algorithms and climate models and addition ensemble for the different scenarios (Araujo & New 2006).

1. http://openmodeller.sourceforge.net
2. http://www.cs.princeton.edu/~schapire/maxent/
3. http://splink.cria.org.br
4. http://www.worldclim.org/

Table 1: Typical cerrado species that occur in the State of São Paulo

| Species | Points |
|---|---|
| *Vochysia tucanorum* | 172 |
| *Anemopaegma arvense* | 127 |
| *Qualea grandiflora* | 112 |
| *Anadenanthera falcate* | 111 |
| *Tocoyena* | 106 |
| *Stryphnodendron obovatum* | 104 |
| *Ouratea spectabilis* | 96 |
| *Styrax camporum* | 94 |
| *Erythroxyllum suberosum* | 85 |
| *Caryocar brasiliense* | 79 |
| *Ocotea pulchella* | 78 |
| *Eugenia aurata* | 75 |
| *Annona coriacea* | 73 |
| *Aspidosperma tomentosum* | 61 |
| *Dalbergia miscolobium* | 54 |
| *Jacaranda caroba* | 54 |
| *Bowdichia virgilioides* | 53 |
| *Styrax ferrugineus* | 52 |
| *Rudgea viburnoides* | 43 |
| *Stryphnodendron adstringens* | 38 |
| *Austroplenckia populnea* | 33 |
| *Cochlospermum regium* | 32 |
| *Strychnos pseudoquina* | 25 |
| *Tabebuia aurea* | 24 |
| *Vochysia cinnamomea* | 22 |

## Results

As a result of this work an area was obtained where environmental conditions predicted for the future are optimal for the species analyzed. The algorithms' performance was evaluated by the Area Under Curve (AUC) obtained through ROC analysis (Fawcett 2003), for present data. The resulting models were considered satisfactory for the exercise (Table 2) as all AUC were greater then 0.7 (Elith et al. 2006).

Table 2: Results ROC analysis with AUC values for different algorithms used

| | Maxent | GARP | SVM |
|---|---|---|---|
| AUC training | 0.827 | 0.739 | 0.769 |
| AUC external test | 0.781 | 0.739 | 0.722 |

A consensus model was calculated (through intersection) for the models generated by the different algorithms and by the different climate models . After that the maps resulting from different scenarios (future) were added. As a result we have 3 models (present, 2020 and 2080) with the area of optimal climate for the species studied (Figures 3 and 4 Table 3).

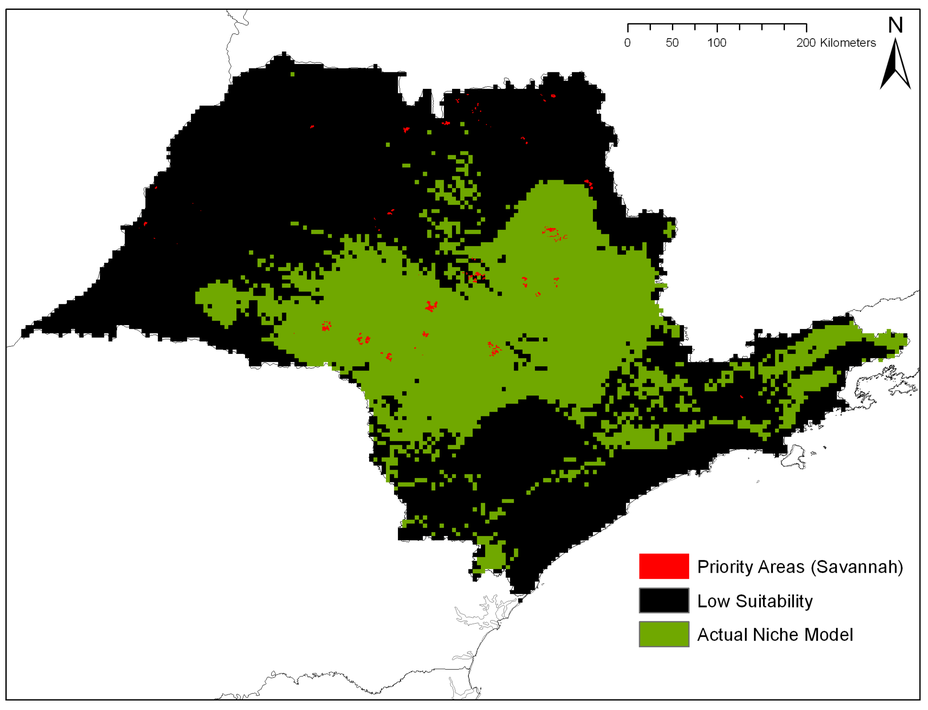


Figure 3. Map of ideal climate distribuion for the ocorrence of *Vochysia tucanorum* in the present and the priority areas for the Cerrado conservation

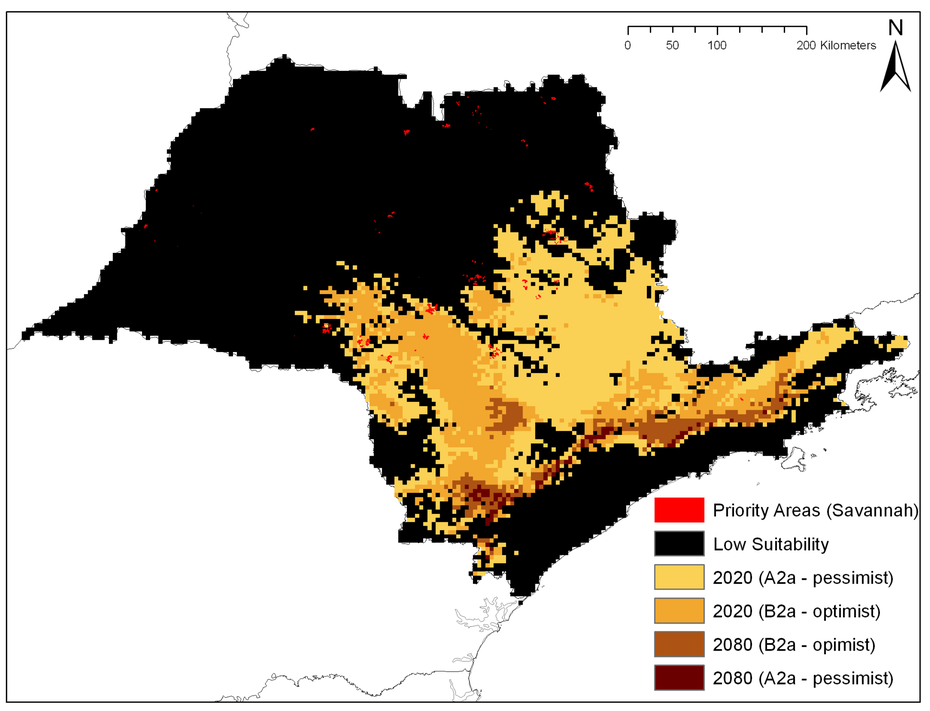


Figure 4. Map of ideal climate distribuion for the ocorrence of *Vochysia tucanorum* in different future scenarios and the priority areas for the Cerrado conservation.

Table 3: Area of ideal climate distribution for the occurrence of *Vochysia tucanorum* in the State of São Paulo

| Potencial Distribution of V. tucanorum | Area (Km2) |
|---|---|
| Present | 110200 |
| Future (2020) scenario A2a | 86425 |
| Future (2020) scenario B2a | 42750 |
| Future (2080) scenario A2a | 4975 |
| Future (2080) scenario B2a | 18050 |

The next step was to analyze whether the priority areas determined for the Cerrado at the workshop "Priority areas for biodiversity conservation in the state of São Paulo" are adequate, considering future climate change, for this specie.

## Conclusions

For the species analyzed, the ideal climatic regions for the occurrence of *Vochysia tucanorum* are reduced between 22 (A2a) to 62% (B2a) in 2020 and between 83 (B2a) to 95% (A2a) in 2080, when comparing the present with both future climate scenarios.
The priority area today indicated for the conservation of Cerrado species covers about 243 km$^2$, but when considering climate change for 2020 this area is reduced to 210 km$^2$ (optimist scenario). In 2080, for both climate scenarios, none of the areas today selected as priority areas fall within an ideal climate region.
The next phase of this work is to apply this methodology to all 24 species to analyze in a more generic way the impact of climate change in the future distribution of Cerrado in the State of São Paulo.

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