INSTITUTO NACIONAL DE PESQUISAS DA AMAZÔNIA - INPA
PROGRAMA DE PÓS-GRADUAÇÃO EM ECOLOGIA

Limitations in the use of species distribution models for environmental impact assessments in the Amazon

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Manaus, Amazonas
Setembro 2013

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Dissertação apresentada à Coordenação do Programa de Pós-Graduação em Ecologia, como parte dos requisitos para obtenção do título de mestre em Ciências Biológicas, área de concentração em Ecologia.

Manaus, Amazonas
Setembro 2013

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C289 Carneiro, Lorena Ribeiro de Almeida
Limitations in the use of species distribution models for environmental impact assessments in the Amazon / Lorena Ribeiro de Almeida Carneiro. --- Manaus : [s.n], 2013.
--, -- f. : il. color.

Dissertação (Mestrado) --- INPA, Manaus, 2013.
Orientador : William Ernest Magnusson.
Coorientadores : Albertina Pimentel Lima, Ricardo Bomfim Machado.
Área de concentração : Ecologia.

1. Distribuição de espécies. 2. Hidrelétricas. 3. Impacto ambiental. I. Título.

CDD 574.522

Sinopse

Intensamente utilizada e debatida pela comunidade científica nos últimos anos, a modelagem de distribuição de espécies foi apontada como uma potencial ferramenta para direcionar decisões político-administrativas no contexto do licenciamento ambiental de empreendimentos no Brasil e na Amazônia. Nesse estudo utilizamos dados reais coletados na avaliação de impacto ambiental de um grande aproveitamento hidrelétrico localizado no Rio Madeira – Rondônia – Brasil, para avaliar as limitações e potencialidades do uso das técnicas de modelagem no direcionamento de decisões no contexto do licenciamento na região. Os resultados sugerem que, para viabilizar abordagens utilizando modelos de distribuição de espécies alvo no auxílio de demandas voltadas à avaliação de impacto no bioma Amazônico é necessário, ou expandir as áreas de amostragem dos estudos obrigatórios prévios, definida pelo órgão ambiental regulador, ou investir em estratégias de levantamentos integrados e comparativos da biodiversidade na região, com o objetivo de melhorar o cenário amostral e suprir os pré-requisitos do uso das técnicas.

Agradecimentos

Minha afetuosa gratidão,

Aos meus orientadores Prof. Bill, Albertina e Ricardo pela inspiração, ensinamentos, paciência e apoio nesses dois anos. Foi um privilégio e um prazer trabalhar com vocês!

Ao Programa de Pós-graduação em Ecologia do Instituto Nacional de Pesquisas da Amazônia – INPA pela vivência e formação profissional na Amazonia.

Aos pesquisadores Bárbara Zimbres, Renata Dias Françoso, Yuri Salmona (Laboratório de Planejamento para Conservação da Biodiversidade (UnB), Victor J. T. Perdigão (Eletronorte), Stéphany Watzel, André Luis Sousa, Darren Norris, Pedro Ivo Simões, Igor Kaffer (UFAM), Sérgio Henrique (MMA) e David Cho (IBAMA) pelo apoio na construção das idéias e das análises. À David Tonks, Luciene Robichaud, Stéphanie DeAlmeida pelas revisões de tradução.

Aos fundamentais Jefferson Barros, Julia Verba, Eveline Salvático, Yuri Feitosa, Layon Demarchi, Sinomar Fonseca, Matheus Montanha e demais amigos pela parceria dos dias, sorrisos e paisagens. Também aos familiares e amigos brasilienses que mesmo distantes foram presentes em bons pensamentos.

Ao Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq pela concessão da bolsa de pesquisa.

À equipe de monitoramento da herpetofauna do Aproveitamento Hidrelétrico de Santo Antônio e aos colaboradores do Programa de Pesquisa em Biodiversidade (PPBio/Cenbam) pelo generoso compartilhamento dos dados.

Grata também aos pesquisadores Peterson Townson, José Diniz Filho, Eduardo Vertincinque, Bruce Nelson, Karl Didier e Marcelo Gordo pelas contribuições e detalhamento do estudo.

Limitações no uso da modelagem de distribuição de espécies no contexto das avaliações de impacto ambiental de empreendimentos na Amazônia.

Resumo: A modelagem preditiva de distribuição de espécies foi apontada como uma potencial ferramenta para direcionar decisões nos processos de licenciamento ambiental de empreendimentos na Amazônia. Nesse manuscrito apresentamos um estudo de caso utilizando dados da anurofauna levantada no estudo de impacto ambiental de impacto de um aproveitamento hidrelétrico localizado no Rio Madeira – Rondônia – Brasil, para avaliar se o uso dos MDEs é adequado para orientar decisões nos processos de licenciamento na região. Como as estratégias de conservação envolvem a priorização de alvos, primeiramente definimos as espécies da anurofauna (Ordem Anura) prioritárias para as ações de manejo e analisamos suas respectivas situações amostrais. Posteriormente, à luz do que é previsto na legislação ambiental do país e diante as recomendações descritas na literatura especializada sobre o uso das ferramentas, discutimos as limitações e potencialidades da utilização dessas técnicas para orientação de ações mitigatórias e compensatórias na região. Os resultados mostraram que a maior parte das espécies alvo não dispuseram de dados de presença representativos para o treinamento dos modelos, pois elas são, em sua maior parte, ainda não descritas. Logo, o uso dos algoritmos somente seria indicado utilizando uma parcela dos alvos selecionados ou com táxons não prioritários. Considerando as inúmeras lacunas de conhecimento sobre a distribuição dos táxons na Amazônia, e ainda que os inventários de fauna no contexto do licenciamento são tipicamente realizados nas adjacências da área prevista para ser impactada, os modelos de distribuição de espécies precisariam extrapolar os registros de presença dos táxons alvo para assim orientar nas decisões de manejo em ampla escala. Os resultados das simulações que extrapolaram os dados geograficamente corroboraram diversos autores que sugerem a diminuição da robustez das predições com o aumento da extensão das extrapolações. Nós concluímos que o uso dos modelos nesse contexto requer a expansão das áreas amostradas nos estudos de impacto ou que haja investimentos em estudos estratégicos que forneçam dados integrados e comparativos no âmbito do bioma para melhorar a situação amostral na região e suprir os pré-requisitos do bom uso dessas técnicas.

Limitations in the use of species distribution models for environmental impact assessments in the Amazon

Abstract: Species distribution models (SDMs) have been recognized as a potential tool for guiding decisions regarding the process of environmental licensing in the Amazon. In this paper, we present a case study using data on frogs that were obtained from the impact assessment of a hydroelectric project located on the Rio Madeira, Rondônia, Brazil, to evaluate the use of SDMs in the decision-making process for licensing works in the Amazon Basin. Because conservation strategies must prioritize targets, we defined the priority species for management actions and analyzed their respective sampling situations. Based on the expectations of environmental legislation in Brazil and using the tools recommended in the literature, we discussed the limitations and potential use of SDM techniques for guiding mitigation actions in the region. The results showed that there were insufficient data for most of the target species to be included in the distribution models because most species have not yet been described. Because there are numerous gaps in the Brazilian samples and the current mandatory surveys are typically conducted in areas adjacent to the affected areas, the models must extrapolate beyond the sampled data to guide decisions, such as defining areas to be used to offset the effects. The results of geographical extrapolation simulations, using species collected in the affected area, were corroborated by several authors who suggested that the robustness of predictions decreases with the extension of the extrapolations. We conclude that the use of SDMs for supporting decisions to license projects in the Amazon requires expanded sampling areas for impact studies or an investment in integrated and comparative survey strategies to improve biodiversity sampling and to fulfill the prerequisites for the use of such techniques.

Sumário

Introdução geral

O amparo científico é reconhecidamente importante no subsídio de decisões político-administrativas no âmbito das questões ambientais de um país. No Brasil, um exemplo dessa sinergia entre pesquisa e deliberação governamental previsto por lei, se refere aos processos de licenciamento ambiental. Nesses processos, os órgãos ambientais públicos buscam conciliar a instalação e funcionamento de atividades potencialmente causadoras de impacto com a conservação do meio ambiente. Para isso, estudos multidisciplinares prévios são solicitados aos interessados que desejam instalar empreendimentos ou renovar suas licenças de operação.

Sendo os estudos ambientais desenhados, orientados e analisados pelos órgãos ambientais governamentais, cabe à comunidade científica a incumbência do acompanhamento e discutir as abordagens e técnicas utilizadas pelos agentes públicos, nas mais diversas deliberações referentes ao manejo ou conservação da biodiversidade. Nesse sentido, esse manuscrito teve como objetivo avaliar a viabilidade do uso das ferramentas de modelagem de distribuição de espécies, amplamente utilizada e discutida pela comunidade científica nos últimos anos, no subsídio de decisões no contexto da avaliação de impacto de empreendimentos na Amazônia. Com os resultados esperamos contribuir com o aprimoramento dos processos de comando e controle de impacto, exercidos pela poder público brasileiro.

Objetivos

Objetivo geral:

Avaliar o desempenho de modelos de distribuição de espécies no orientação de questões práticas no contexto do licenciamento ambiental de empreendimentos na Amazônia.

Objetivos específicos:

1. Avaliar a situação amostral dos táxons alvo na parametrização dos modelos;

2. Avaliar o desempenho dos modelos em ocasiões de extrapolação e interpolação geográfica e ambiental dos dados de presença dos alvos.

3. Orientar tomadores de decisões sobre as limitações e potencialidades do uso das ferramentas de modelagem de distribuição no auxílio de diferentes demandas do licenciamento;

Capítulo 1

Carneiro, L.R.A.; Lima, A.P.; Machado, R.B.; Magnusson, W.E.
2013. Limitations in the use of species distribution models for environmental impact assessments in the Amazon.
Manuscrito submetido para Journal of Environmental Management

Limitations in the use of species distribution models for environmental impact assessments in the Amazon

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Abstract: Species distribution models (SDMs) have been recognized as a potential tool for guiding decisions regarding the process of environmental licensing in the Amazon. In this paper, we present a case study using data on frogs that were obtained from the impact assessment of a hydroelectric project located on the Rio Madeira, Rondônia, Brazil, to evaluate the use of SDMs in the decision-making process for licensing works in the Amazon Basin. Because conservation strategies must prioritize targets, we defined the priority species for management actions and analyzed their respective sampling situations. Based on the expectations of environmental legislation in Brazil and using the tools recommended in the literature, we discussed the limitations and potential use of SDM techniques for guiding mitigation actions in the region. The results showed that there were insufficient data for most of the target species to be included in the distribution models because most species have not yet been described. Because there are numerous gaps in the Brazilian samples and the current mandatory surveys are typically conducted in areas adjacent to the affected areas, the models must extrapolate beyond the sampled data to guide decisions, such as defining areas to be used to offset the effects. The results of geographical extrapolation simulations, using species collected in the affected area, were corroborated by several authors who suggested that the robustness of predictions decreases with the extension of the extrapolations. We conclude that the use of SDMs for supporting decisions to license projects in the Amazon requires expanded sampling areas for impact studies or an investment in integrated and comparative survey strategies to improve biodiversity sampling and to fulfill the prerequisites for the use of such techniques.

Keyword: EIA/RIMA, environmental licensing, fauna surveys, Hydroelectric developments, species distribution

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Palavras-chave: EIA/RIMA, licenciamento ambiental, levantamentos de fauna, empreendimentos hidrelétricos, distribuição de espécies

1. Introduction

Species distribution models (SDMs) have many potential uses for conservation planning (Araújo et al. 2004, Ferrier 2002, Lopez-Lopez et al. 2007, Traill and Bigalke 2006). Tôrres and Vercillo (2012) suggested using these tools to guide decisions related to environmental licensing in Brazil, which is considered an important instrument for the country's environmental policy and is a mandatory government control procedure that is enforced prior to the installation of facilities or activities that may interfere with the environment (Law No. 6.938/1981, article 10, of Law Decree No. 99.274/1990 art. 17, Res CONAMA No. 237/1997, Res CONAMA No. 001/1986). There are three distinct stages that occur prior to granting an environmental permit: preliminary licensing, installation licensing and operational licensing. In each stage, the contractor must conduct specific studies, while the government agencies assess the environmental feasibility of the project and make decisions concerning actions required to mitigate environmental damage (Complementary law No 140/2011).

In addition to mitigation measures that seek to minimize the negative effects, the licensing process also provides environmental compensation for the permanent or temporary use of natural resources that become unavailable (Giasson and Carvalho, 2012). These environmental offsets can be used for land regularization or for the implements or maintains protected areas, which are selected according to priorities and guidelines set by the Federal Board of Environmental Compensation - CFCA (MMA Ordinance No. 416/2010). Based on these guidelines, the Federal Environmental Compensation Committee (CCAF) defines the allocation of compensation (Decree Law No. 4.340/2002, Decree No. 6.848/2009).

Tôrres and Vercillo (2012) suggested that SDMs should be used by licensing agencies as potential tools to improve environmental study requirements, reduce the subjectivity of impact analyses, and improve mitigation and compensation measures. Therefore, SDMs could indicate areas that are environmentally appropriate or inappropriate for the target species and assist in management actions, such as locating sample sites, relocating sites that are expected to be impacted, and selecting reserves to offset the damage. Several authors have indicated limitations in the use of SDMs, especially when the amount of data is insufficient for parameterizing the models (Kadmon et al. 2003, Stockwell and Peterson 2002, Wisz et al. 2008), whereas others have questioned the robustness of the predictions based on extrapolations (Elith and Leathwick 2009, Miller et al. 2004). However, no studies have analyzed the use of SDMs to support decisions regarding environmental licensing in tropical regions.

In this paper, we evaluate a case study using data collected during the environmental licensing of a hydroelectric plant constructed in the Amazon Basin to assess whether SDMs are appropriate for guiding management requirements in the region based on the type and quality of information that is typically generated by environmental impact studies. We do not discuss the conceptual or theoretical evaluations of species modeling tools' functions or the effectiveness of theoretical modeling techniques because these topics have been extensively discussed in the literature (Araújo and Guisan 2006, Elith and Graham 2009, Elith et al. 2011, Royle et al. 2012). Instead, our goal was to evaluate whether the species modeling tools are adequate to guide decisions related to environmental licensing in the Amazon based on the requirements described in the literature for the proper functioning of the modeling techniques.

1.1 Case study

The Santo Antônio hydroelectric plant on the upper Madeira River is located approximately seven kilometers from the city of Porto Velho, Rondônia State, and began operation in March 2012. As part of the licensing process, an investigation of the local herpetofauna was conducted between February 2010 and November 2011; five field surveys were undertaken. The objective of the surveys was to identify the herpetofauna in the area that may be impacted by the project and to quantify the potential effects of directly filling the dam on the sampled species and biological communities. The sample design was defined by a team of consultants, scientists responsible for the study, and public officials from the Brazilian Institute of Environment and Renewable Natural Resources according to legal guidelines, which require an environmental assessment of the affected area (art. 6 of CONAMA Resolution No 001/86).

Because of the time and financial constraints involved in implementing mitigation actions, conservation strategies should target the most threatened species (Loyola and Lewinsohn 2009). Therefore, the first task was to identify target species for management actions and to verify the availability of occurrence data for those species to calibrate the model at the scales at which decisions need to be taken.

The licensing agency may require local- to national-scale assessments depending on the decision scenario and extent of the effects (minutes from regular meeting No. 9 of CCAF-10/2012, Complementary law No 140/2011, CONAMA Resolution No. 237/1997). For example, models at a local scale might be useful for the installation of sample sites to determine the distribution of species threatened by the project. Moreover, models based on large catchments (federal environmental planning units) might be used to investigate the biological irreplaceability of environments expected to be affected. Thus, we considered three spatial scales in our analyses. The direct influence area of the project (AID) is considered to be the local spatial scale; the Amazon hydrographic region, which is used as a planning and management unit (Law No. 9.433/97) to meet the requirements of impact relocation decisions, is considered the second spatial scale; and the mosaic of protected areas that could receive indemnities as a result of the effects of the project is considered the third spatial scale.

In this study, we only considered amphibious species as target species because they are frequently used as bioindicators of human disturbances in terrestrial and aquatic ecosystems (Barros 2005, Heyer et al. 1994). Moreover, two *Allobates* species in the project area could be used to evaluate the model results because data were available on their presence and absence in areas outside the area affected by the dam.

1.2 Species distribution models for impact assessment decisions

Most species distribution algorithms attempt to identify locations with similar environmental conditions to those at sites where the taxa of interest are known to occur (Saupe et al. 2012). Royle et al. (2012) suggested that models that estimate the probability of occurrence would be more robust and ecologically coherent. Although their technique is compatible with presence-only records, the authors emphasized the need for random sampling within species distributions for estimates produced by formal quantitative methods (Royle et al. 2012).

When data are available throughout the range of the species, occurrence information can be interpolated. Moreover, in principle, it should be possible to estimate both the probability of occurrence (Royle et al. 2012) and environmental suitability (Elith et al. 2011). However, in tropical regions, information on the distribution of most taxa is rare, is usually concentrated in specifically selected locations, and is systematically sampled (Cayuela et al. 2009, Feeley and Silman 2011, Moerman and Estabrook 2006).

Elith et al. (2011) also suggested that using random sampling within the distribution of the species is preferable in approaches that use index-based methods (Elith et al. 2006, Elith et al. 2011, Hernandez et al. 2006, Wiza et al. 2008). However, to identify areas where target species may occur, algorithms may be required to extrapolate predictions beyond the sampled areas in impact studies. Geographical extrapolations beyond the known area of occurrence may or may not involve extrapolation beyond the range of environmental variables used in the construction of the models. In this situation, estimating the probability of occurrence is not possible, but the environmental suitability is possible (Elith et al. 2011).

Models must extrapolate or interpolate information gathered in the area of biological surveys (AID) so that their predictions support management decisions at different spatial scales. In this study, we assessed whether the products of environmental suitability models are appropriate to guide the type of management concerns identified by Tôrres and Vercillo (2012), which require geographically interpolated or extrapolated data of the target species. Knowledge of the practical limitations of distribution models will assist environmental agencies and consultants when planning management decisions and future sampling design studies in tropical regions.

2. Material and methods

2.1 Target species selection

Technical evaluations of the fauna in Brazilian environmental assessments are based on biological surveys undertaken in the project's affected area (IBAMA Normative Instruction No. 146/07, CONAMA Resolution No. 001/86). The fauna survey undertaken for the Santo Antônio licensing was conducted in the area of direct impact (AID). Therefore, we consider these limits as the local scale for determining the requirements of environmental studies (Fig 1). A central objective of these surveys was to support the definition of management and conservation strategies for species threatened by the installation and operation of the project (target species).

Current Brazilian law does not specify criteria for selecting targets in environmental impact studies. However, the CONAMA Resolution No. 001/86, article 6°, and the IBAMA Normative Instruction No. 146/07 (restricted to the licensing of hydroelectric power plants by the IBAMA Normative Instruction No. 10/2009, article 5°) stipulate that species that indicate environmental quality and scientific or economic value and are endangered or rare must be highlighted in the results of environmental evaluations for mitigation efforts.

However, the lack of knowledge regarding the biodiversity in the Amazon limits the classification of most organisms detected in surveys in the categories required by law. Numerous Amazonian species remain poorly understood. Moreover, many species are categorized as “data deficient” by the International Union for Conservation of Nature (IUCN). Others species that are considered threatened on a national scale are often abundant in the Amazon biome. Therefore, we used data gathered during the surveys for our target selection and focused on species with limited known distributions outside the AID.

The sampling design used in the environmental impact studies was based on the RAPELD method (Costa and Magnusson 2010, Magnusson et al. 2005, Magnusson et al. 2013), which was adapted to measure the impact of dam flooding on the spatial distribution of terrestrial organisms. Modules with two trails perpendicular to the original course of the river were systematically distributed in the area expected to be affected by the project (ADA). The arrangement of the modules perpendicular to the river was used to assess the impact of the flooding gradient on the detected species. In each trail, 250-m-long permanent plots were installed at 1 km intervals beginning on the riverbank. Extra plots were installed at 0 and 1000 m to better evaluate the riparian areas. The plots followed the altitudinal contours to minimize the internal variation in the distance to the water table and soil; therefore, these variables can be used to predict species distributions (Figure 1). Frogs were sampled using an active search technique that was limited by time, pitfall traps installed in permanent plots, and random encounters along the access trails (details of the methods are available in Lima et al., 2011; Technical Information No. 65/2008 - COHID / CGENE / DILIC / IBAMA).

The selected target species were exclusively detected in the area that was expected to be flooded by the reservoir (ADA). We used the smallest distance between the estimated maximum level of flooding and local detection of each specimen to measure the degree of threat. Values equal to 0 indicated points located at the edge of the expected flooding zone, negative values refer to the distance (meters) between species observations and the flooding edge in the direction toward the center of the dam, and positive values indicate distances from the edge of the dam away from flooded areas.

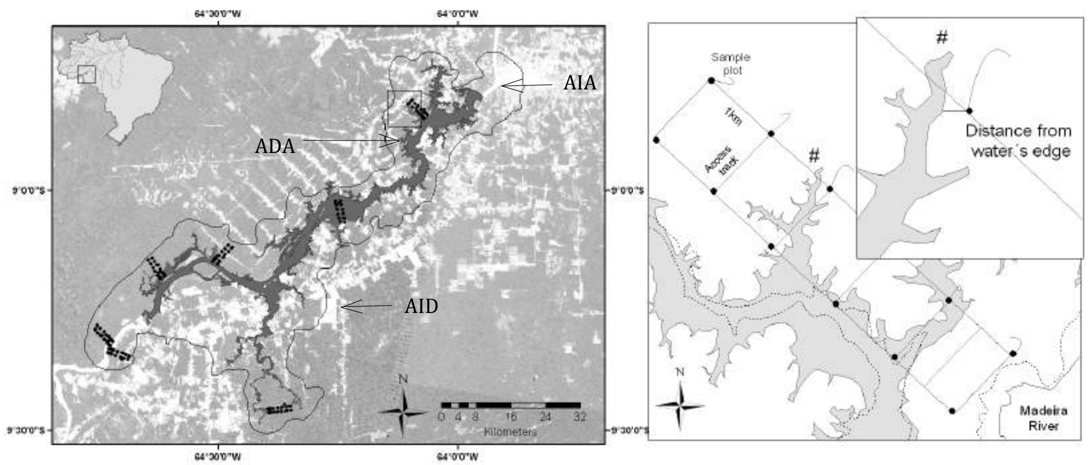


Figure 1. Left side: a map of the distribution of sample modules (groups of points) in the area of direct impact (the thin line represents the buffer around the impacted area). The maximum flood elevation resulting from the filling of the reservoir represents the directly affected area (dark gray area). Right side: a schematic drawing of a sample module positioned perpendicular to the Madeira River in which the points represent the beginning of the permanent plots. The inset shows an example of a distance considered in the analysis for selecting the target species. Species that were only detected in the submerged area were considered targets because they are directly threatened by the filling of the dam.

Management strategies depend on the spatial scale of the analysis (Hortal et al. 2010). Therefore, species widely distributed in the Amazon might be impacted locally by the installation of an enterprise; however, these species might not be threatened over larger areas. Other species might be threatened at all spatial scales if they are only detected in impacted areas. To filter the criteria for prioritizing management actions based on the biological complementarity (Caro 2010) between the area expected to be flooded (directly affected area - ADA) and areas adjacent to the impacted area (indirectly affected area - AIA), we also considered the complementarity of species distributions between the ADA and other surveyed regions of the Amazon biome. To evaluate the complementarity of the ADA with areas distant from those directly sampled, we sought occurrence records of target taxa defined at the local scale in collections provided by museums and online databases (SpeciesLink, GBIF, IUCN, Encyclopedia of Life) and by consulting experts.

2.2 Species distribution models for impact assessment decisions

Species distribution models were interpolated and extrapolated in both geographic and environmental space. Geographic space refers to the broad geographic area between the target detection area and the area of inference as defined by management concerns. Such inferences in geographic space can also add environmental extrapolations between distant or neighboring regions if there are large variations in temperature, humidity, fauna, and flora. Extensive environmental extrapolation in which the training data are not representative of the environmental conditions in the area of inference increase model uncertainties (Elith et al. 2006, Pearson et al. 2006, Thuiller et al. 2004).

To evaluate model performance when conducting geographical or environmental extrapolations and interpolations, we divided the analysis into two parts. The first part evaluates the environmental extrapolation models (which were generated with the target species) between the species occurrence area and the region of management concern. In the second analysis, we used reliable presence and absence data for two species with known geographic distributions to evaluate the performance of the models when interpolating within or extrapolating outside of the geographical limits of the training data.

The maximum entropy algorithm (MaxEnt) of the geographic distribution of species (Phillips et al. 2006) generally performs better than alternative procedures when sampling limitations are in effect (Elith et al. 2006, Elith and Leathwick 2009, Hernandez et al. 2006, Wiza et al. 2008). Maximum entropy refers to a type of statistical inference arising from information theory and provides a constructive criterion for determining probability distributions based on partial knowledge. The algorithm allows approaches with only presence data and predictions by interpolation or extrapolation; therefore, we used the MaxEnt algorithm to parameterize the models used in the analyses.

Because the environmental predictors change according to the spatial scale (local to regional) of the analysis (Hortal et al. 2010), each model used different layers that could reflect ecological requirements, had strong relationships to the data (selected according to a jackknife test), and were not strongly correlated (Pearson correlation ≤ 0.8) (Elith et al. 2006, Elith et al. 2010). Detailed variables at the local scale and measures of the interactions between species were not available for inclusion in the models.

2.2.1 Effects of environmental interpolations and extrapolations on management requirements

Elith et al. (2010) developed a measurement of environmental similarity that they called multivariate environmental similarity surfaces (MESS). MESS are used to alert and minimize errors in extrapolation approaches with species distribution models (see technical details in Elith et al. 2010 - Appendix S3). The MESS analysis is similar to the BIOCLIM algorithm (Busby 1991); however, MESS analysis uses percentiles that are extended to produce negative values referring to sites where at least one variable has a value that is outside the environmental range of the reference set (Elith et al. 2010).

We generated models with target species data to assess the extent of extrapolation in two areas of interest and to assess whether the environments are similar or different between the area of interest and environments where the target species have been sampled regardless of their suitability (Saupe et al. 2012). One area of interest is the directly impacted area (AID), wherein the models assist in determining the distribution of targets; the other area of interest is the mosaic of protected areas selected by the Federal Environmental Compensation Committee (minutes from regular meeting No.10/2012). In total, 21 protected areas under municipal, state, and federal government administration were compensated for maintenance purposes (minutes from regular meeting No. 9 of CCAF-10/2012). To generate MESS maps, we prepared the reference masks with an ASCII grid. The value "1" represented pixels used in training the models with occurrence data. Moreover, "NoData" was used outside the model area (Elith et al, 2010).

2.2.2 Effects of geographical interpolations and extrapolations

We used data from two species of the family Aromobatidae that were detected in the surveys of the area affected by the dam for which presence and absence data were available within and outside the area affected by the project (Caldwell and Lima 2003, Kaefer et al. 2012, Lima et al. 2007, Lima et al. 2010, Simões et al. 2008, Simões et al. 2010). Although the two species were not considered targets in this study, they allowed us to simulate limited sampling and thus evaluate the model predictions in cases where the algorithm must interpolate and extrapolate predictions to guide environmental compensation. Furthermore, many taxa in this family are included as targets in environmental impact studies because they have restricted distributions, do not migrate, are territorial and short-lived, and have restricted gene flow between adjacent sites (Kaefer et al. 2013). Therefore, environmental perturbations in their areas of occurrence may be considered threats to the species.

The effect of incomplete sampling on the prediction of environmentally appropriate areas by extrapolation and interpolation was measured by dividing the distribution data for both species into three macro-scale groups (Amazon Basin) and two local-scale groups (AID). Each group had a similar number of records, so that, at a local scale, a partition was used for training and the other for test. To increase the number of records for model construction at the macro-scale, we used two groups for training each species and one for testing.

The algorithm performance was measured using the AUC test values (the area under the curve of a graph characteristic of the receiver) as a measure of the failure rate. The models were also run at each spatial scale with all available occurrences for each species, with 20% of the occurrences randomly assigned by the algorithm to test the models. The average of the AUC test results for 10 random arrangements was used as result.

Because we considered predictions of environmental suitability, commission errors were not considered inappropriate. However, such errors are not desirable in publicly subsidized actions because if resources for further surveys are not available, then agencies will be more likely to interpret the results as the probability of occurrence rather than potential environmental suitability. To better visualize the maps of environmentally appropriate areas, each image (raster map) prediction was imported into ArcGIS 9.3 to reclassify the images based on the “minimum training presence” thresholds; the differences between the predicted areas and the known species distribution ranges were illustrated and discussed. Interpretations were based on a simple heuristic scheme for the BAM diagram (Soberón and Peterson 2005, Soberón 2007), which summarizes the joint effects of external biotic and abiotic characteristics and dispersal on species distribution predictions.

The species selected for the simulations were *Allobates nidicola* (Lima et al. 2007), which was recently described and has a distribution restricted to the Purus-Madeira interfluve, and *Allobates femoralis* (Boulenger 1883), which is widely distributed. Similar to many Amazonian species with a wide distribution, *A. femoralis* may be a species complex; however, the classification follows the current state of knowledge regarding the taxon (Amézquita et al. 2009, Simões et al. 2010). Occupancy estimates and detection for these species were performed using data from sampling repetitions in different monitoring campaigns through hierarchical models that considered imperfect detection (Mackenzie et al. 2003) and using the Presence software (Hines 2006). Because of the known demographic characteristics of species in this family, we used the “single species” model with colonization and extinction parameters held constant.

The probabilities of detection (ρ) for individual surveys for both taxa (Table 2) were sufficiently high; therefore, we are confident that the absence records for areas that have been repeatedly surveyed, such as those used in our modeling component, indicated the absence of the species from the area.

Table 1: Summary of the models and parameter estimates of *A. femoralis* and *A. nidicola*, including the values of the Akaike information criterion (AIC), number of parameters (k), occupancy (Ψ), and detection (ρ).

Specie	Model	AIC	-2log (likelihood)	K	Ψ	Std. err	95% conf. Interval	ρ	Std. err	95% conf. interval
A. femoralis	psi(.),gamma(.),eps(.),p(.)	321.382	317.382	2	0.57	0.06	0.45-0.68	0.59	0.04	0.51-0.67
A.nidicola	psi(.),gamma(.),eps(.),p(.)	161.639	157.639	2	0.27	0.07	0.16-0.43	0.31	0.07	0.19-0.47

3. Results

3.1 Target species selection

The anuran species found in the reservoir's affected area formed three groups that had different management priorities (Figure 2). The first group included species that were only found in locations distal to large bodies of water; therefore, they were far from the areas that were impacted by the project. The second group was composed of taxa detected close to and far away from the area to be flooded. A third group included species that were only found in areas where flooding was expected. Species in the third group were considered potentially threatened by the project and therefore were considered target species. Among the detected target species, eight species were previously recorded elsewhere in the Amazon Basin, far from the dam location. For these species, the impact of the dam on the taxa was restricted to the scale of the project site (Table 1). One species has only been observed outside of Brazil (*Altigius alios*). Moreover, *Hidrolaetare caparu* has only been detected in one other location in Brazil and is typical of Bolivia (Ferrão and Lima - personal communication). Accordingly, these species are important targets for national biological heritage. Seven of the target taxa were potentially undescribed species and would be considered target species (scientific value) based on current legislation. Other potentially undescribed species were also detected in areas distal to the main affected area (e.g., *Allobates* sp3) or sampled widely across the analyzed spatial gradient (*Allobates* sp1 *autazes*, *Osteocephalus* aff. *oophagus*). The macro-scale distributions of these species are not available.

None of the detected target species were classified as threatened by the IUCN Red List or the official list of Brazilian threatened fauna species (MMA Instruction No. 03/2003). Moreover, none of the target species had economic value.

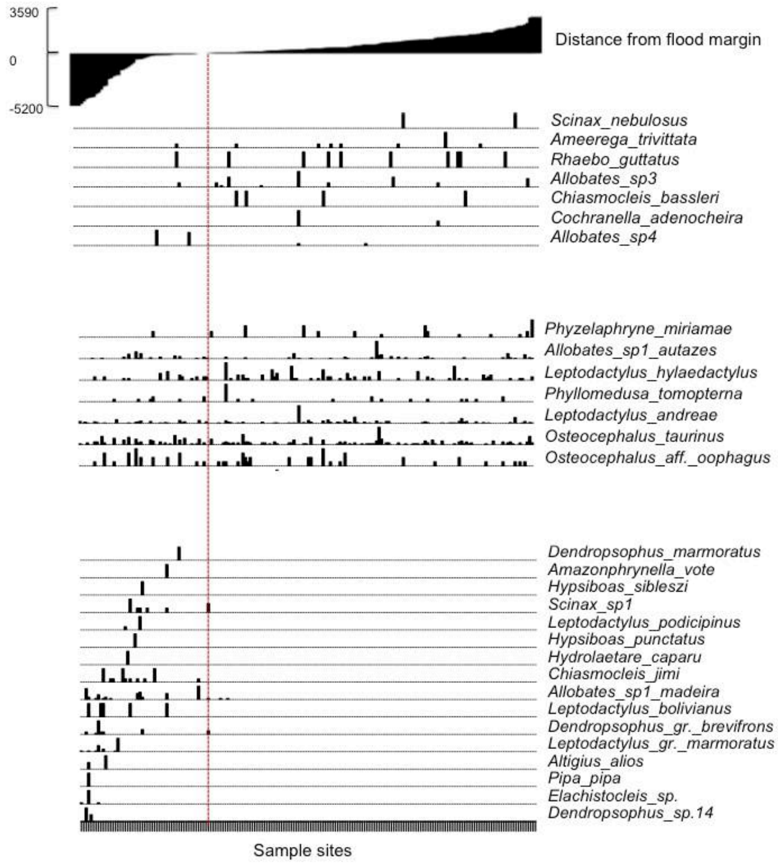


Figure 2: Relative number of individuals detected per plot in relation to the distance of the plot (m) from the edge of the expected flood area (impact of the dam flooding - predicted maximum quota = 70.5 m). Data on which the figure is based are provided in Appendix 1.

Table 2: Diagnosis of species occurrence and complementarity between the area directly affected by the dam and areas in the state of Rondônia (RO), other areas in the Legal Brazilian Amazon, and the entire Amazon, which includes areas in other countries. “X” represents regions where the species have been previously recorded. Question marks indicate regions in which the species have not been detected. *According to Ferrão and Lima (personal communication), *Hidrolaetare caparu* was also recorded by M. Gordo in the Corumbiaria State Park; its typical locality is Bolivia.

Target species	**Independent occurrence records**	**Status IUCN**	**State (RO)**	**Brazilian Amazon**	**Foreign Amazon**
Dendropsophus marmoratus	1	Least Concern	**X**	**X**	**X**
Leptodactylus podicipinus	2	Least Concern	**X**	**X**	**X**
Hypsiboas punctatus	1	Least Concern	**X**	**X**	**X**
Leptodactylus bolivianus	5	Least Concern	**X**	**X**	**X**
Pipa pipa	1	Least Concern	**X**	**X**	**X**
Amazonphrynella vote	1	-	**X**	**X**	?
Allobates sp1 madeira	15	Least Concern	?	**X**	**X**
Hypsiboas sibleszi	1	Least Concern	?	**X**	**X**

Chiasmocleis jimi	10	Data Deficient	?	**X**	?
Hydrolaetare caparu	1	Data Deficient	?	?	**X***
Altigius alios	2	Data Deficient	?	?	**X**
Elachistocleis sp.	3	-	?	?	?
Dendropsophus sp14	2	-	?	?	?
Leptodactylus gr. *marmoratus*	7	-	?	?	?
Dendropsophus gr. *bevifrons*	7	-	?	?	?
Scinax sp1	6	-	?	?	?

3.2 Species distribution models for impact assessments

Fourteen species (87.5%) considered to be local-scale targets based on their distributions in the affected area (group 3) had less than 10 records of occurrence for the parameterization of the models at this scale. Of these species, the potentially undescribed species (*Elastichocleis* sp., *Dendropsophus* sp.14, *Leptodactylus* gr. *marmoratus*, *Dendropsophus* gr. *brevifrons*, and *Scinax* sp1) had the same number of records at both local and wider spatial scales because they were only detected in the study site.

3.2.1 Effects of environmental interpolations and extrapolations on management decisions

Less than 2% of the area in the mosaic of protected units was similar to or representative of the sampling locations where the target species were detected. Because over 98% of the pixels selected to receive compensation had at least one variable outside the data range used to train the models, they were considered novel environments. Among the 21 reserves, eight did not have areas similar to the occurrence sites of the target species. Moreover, *Hydrolaetare caparu* could not be analyzed because it only had one occurrence record.

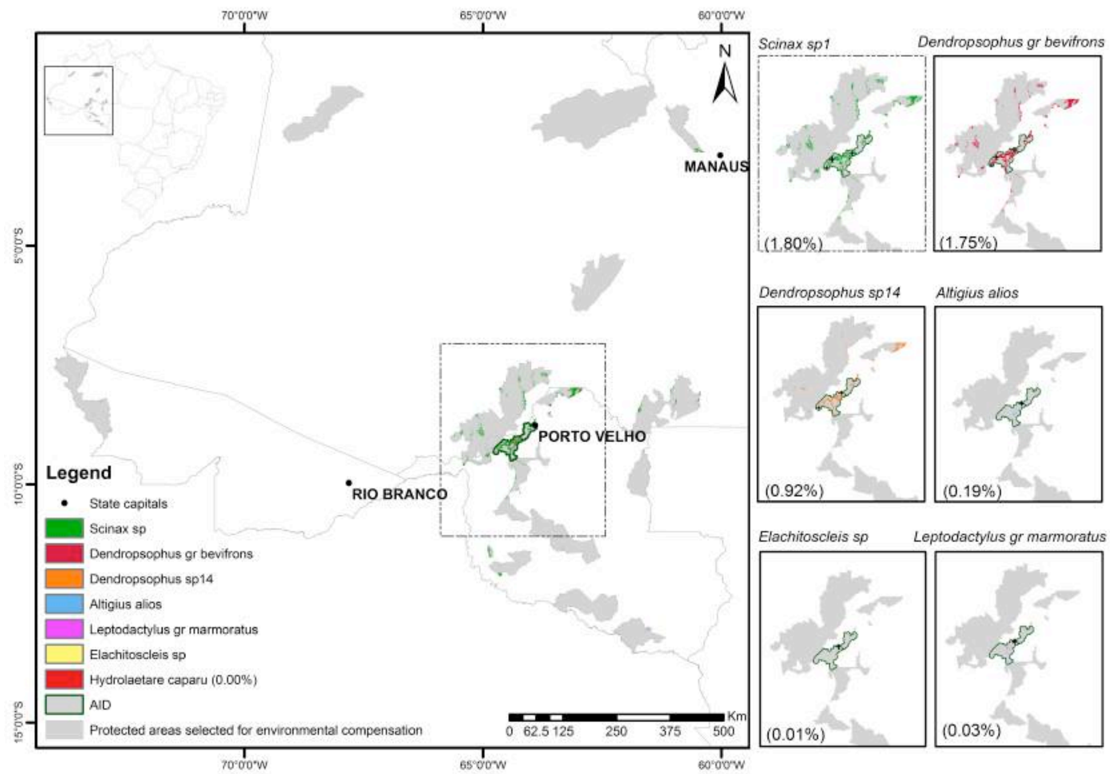


Figure 3: The results of the multivariate environmental similarity surfaces (MESS) method for each target species and the mosaic of protected areas programmed to receive compensation funds. The highlighted areas had environmental values similar to areas in which the individual species was detected.

At the local scale, similarity values were more representative and ranged from 0.36% for the *Elachistocleis* sp. model to 26.5% for the *Dendropsophus* gr. *bevifrons* model. MESS maps results were influenced by the complete distribution of the reference points (Elith et al. 2010, Franklin 2009, Kadmon et al. 2003), which may explain the low similarity values between *Leptodactylus* gr. *marmoratus* and *Dendropsophus* gr. *bevifrons* in the MESS model, even though the same number of records was used for both the testing and training processes.

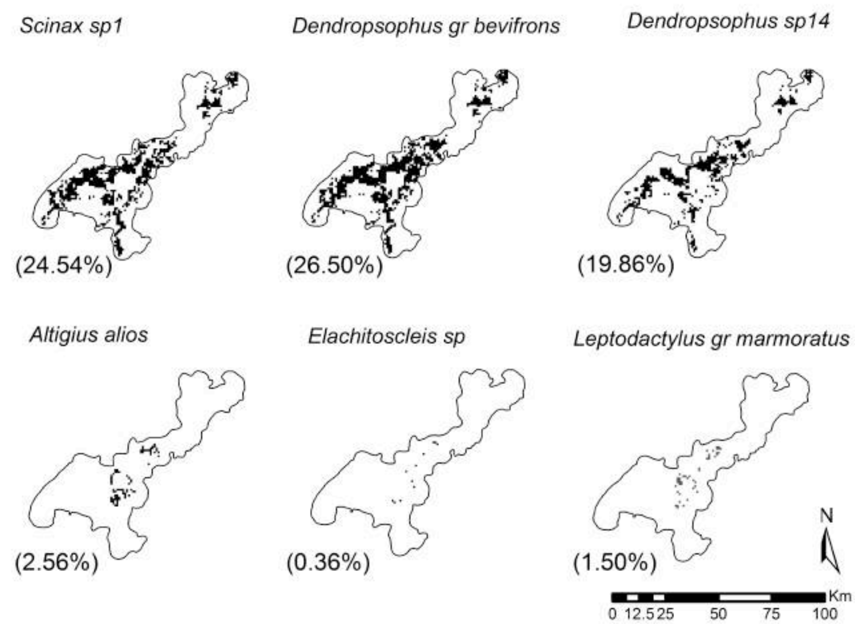


Figure 4: Multivariate environmental similarity surfaces (MESS) for each target species (except *H. caparu*) in the directly affected area (AID) for use in environmental assessments.

3.2.2 Effects of geographical interpolations and extrapolations on management decisions

Models generated with known species distributions at both spatial scales exhibited lower AUC values (Figure 4-C, D and Figure 3-A, E, F) when the test records were predicted by the extrapolation of training records. Models in which the validation records were within the distribution of the training records (interpolation) had better performances (Figure 5-A, C, G and Figure 6-B, E). The large-scale prediction of *A. nidicola* (Figure 5-E), which was intended to represent the extrapolation arrangement, exhibited a better AUC performance. However, because of the amount of available data, the training partition was located adjacent to the training test (interpolation), which may explain the good performance of the model. At a local scale, the models also had omission errors and low performances; however, there was less variation between the AUC of the test predictions generated by extrapolation and interpolation of the data (Figure 6).

Omission and commission errors were found for the biome-scale *A. nidicola* models because the species was predicted to be widespread in many parts of the basin even though it is known to be restricted to the Purus-Madeira interfluve. The predictions indicated greater environmental suitability along the lower reach of Amazon River than in the region where the taxa actually occur.

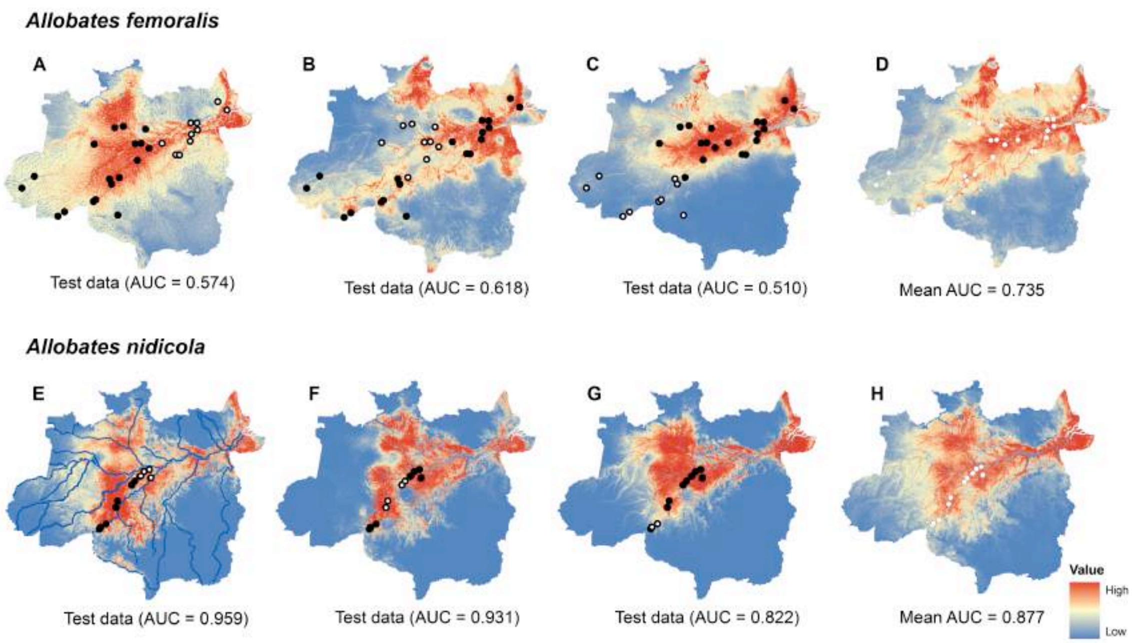


Figure 5: Predictions of environmentally suitable areas for the occurrence of *Allobates femoralis* and *Allobates nidicola* at the scale of the Brazilian Amazon Basin. Records of occurrence for each species were separated into 3 groups according to distance for evaluating the predictions using model interpolation and extrapolation when sampling was incomplete. The training records for the simulation models are black; the validation points are white. Models "d" and "h" included all available occurrences; 20% of the occurrences were randomly assigned by the algorithm to test the models. The AUC values reflected the ability of the model to predict the test points.

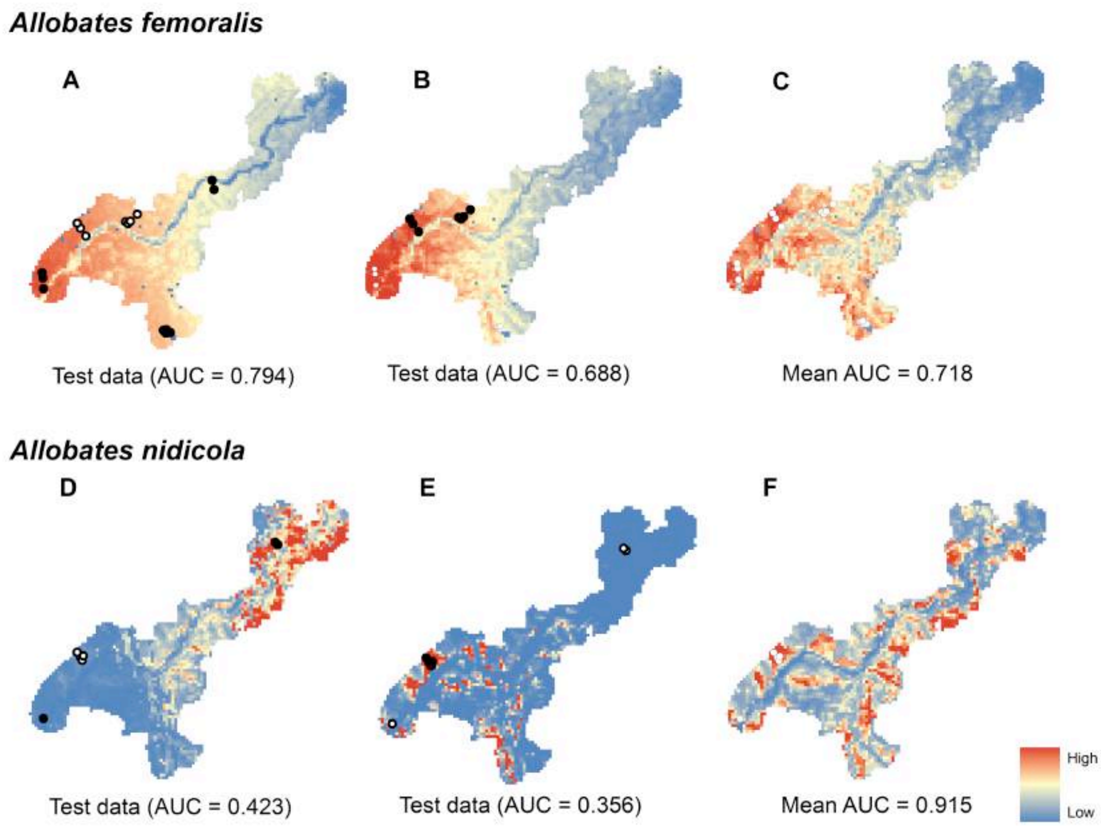


Figure 6: Predictions of environmentally suitable areas for the occurrence of *Allobates femoralis* and *Allobates nidicola* at the local scale (directly affected area - AID). Because of the small number of data points at this spatial scale, the records were divided into two groups to simulate the extrapolated and interpolated predictions. The points in black were used for training; white dots indicate the test records. Models "C" and "F" included all available occurrences; 20% of the occurrences were randomly assigned by the algorithm to test the models.

4. Discussion

4.1 Target species selection

Some of the criteria suggested in current Brazilian legislation for identifying target species in environmental impact studies (Resolution CONAMA No. 001/86, IN IBAMA No. 146/07) do not reflect the type of damage expected in the Amazon Basin; therefore, these criteria were not suitable for identifying conservation priorities in the region. The criteria related to the degree of threat for a species according to categories adopted by the IUCN or national lists of threatened species proved particularly uninformative because all of the target species considered in this study were not listed or were categorized as “data deficient”. Furthermore, the degree of threat in the classification is dependent on the spatial scale of the analysis; therefore, many of the taxa categorized as threatened according to national and international lists are not considered threatened in the Amazon biome. For example, the installation of a new development in the Amazon may favor giant otter (*Pteronura brasiliensis*) population growth; the giant otter is a species categorized as endangered (EN) by the IUCN and as vulnerable (VU) on the Brazilian red list (Rosas et al. 2007). Such lists may have national value; however, their use for prioritizing targets should be reviewed and adapted to regional scales.

Because of the substantial knowledge gaps that are characteristic of tropical regions (Bini et al. 2006, Tuomisto and Ruokolainen 1997). and the short time frame for evaluating the impacts on wildlife, target selection should be cautious and grounded in results from studies conducted in the project area. These studies must include sample designs adapted to measure the impact of the installation on elements of local biodiversity in relation to the known distributions of these elements (Magnusson et al. 2013).

In the Santo Antônio case study, most of the species defined as targets have not yet been described in the literature; therefore, scarce data were available for the model parameterizations. Our results are consistent with the conclusions of Cayuela et al. (2009), who indicated that the taxa most in need of conservation measures in tropical regions are those in which the distribution models are less likely to be successfully implemented.

Indirect negative damages can affect key species distal to the flooded areas. However, because of the short time during which measures can be proposed and incipient studies made with comparable sampling designs, such damage might not be determined until the later impact stages. Given the rapid expansion of infrastructure projects in forested areas, the data produced in the impact assessments must be integrated to guide future species distribution studies and mitigation decisions at large geographic scales.

4.2.1 Effects of environmental interpolations and extrapolations on management decisions

Because of possible difficulties in detection and the existence of numerous sampling gaps in the Amazon Basin, many of the taxa surveyed and defined as targets in this study might have distributions that extend well beyond the affected area and might not be compromised by the impacts of the project. However, considering the precautionary principle (CDB 1992) and because the Amazon is a region of high endemism (Kaefer et al 2012, Ribas et al. 2007, Wallace, 1852), licensing agents must make at least the minimal effort required to expand the information on these targets before issuing authorizations and take steps to protect potential new occurrence sites of these species.

Predictions of environmental suitability also become highly uncertain and undesirable in cases of policy planning for conservation when models are used to predict areas with environmental characteristics that are dissimilar to the area used to calibrate the model (Thuiller et al. 2004, Williams and Jackson 2007). Extrapolations are susceptible to omission errors (Sinclair et al. 2010) because the dataset used for the model parameterization cannot represent all conditions in the extrapolated region. MESS analysis has been used for evaluating the similarity or novelty of environments to indicate where the models are most informed, to guide decisions based on predictions, and to assist in model interpretation (Elith et al. 2010). Furthermore, MESS can be used to identify and reject models with fitted functions that extrapolate in ways that are biologically implausible.

The goal of compensation is to permanently or temporarily compensate for the use of natural resources that become unavailable to the environment (Giasson and Carvalho 2012). In a scenario related to the selection of regions for compensation, the models would have to extrapolate predictions beyond the available calibration data and then predict environmentally appropriate areas for the occurrence of the target species. As seen in the models used for the species of interest, 98% of the mosaic area was not representative of the data used for training; therefore, the SDM tools for guiding management decisions produces highly uncertain results and may not be superior to other approaches, such as the use of expert opinions.

Tôrres and Vercillo (2012) suggested that distribution modeling tools might improve the targeting requirements of environmental impact studies. Such requirements would be related to the installation of sampling locations; however, the scarce occurrence records of target species are a major limitation. Models are clearly influenced by the number of records used for predictions (Austin et al. 2006, Carroll and Pearson 1998, Hernandez et al. 2006, Kadmon et al. 2003, Pearce and Ferrier 2000, Rushton et al. 2004, Stockwell and Peterson 2002). Thus, the possible approaches using such methods will be restricted to species that have sufficient occurrence records, which were not found for the targets identified in the Santo Antônio case study. Therefore, the use of these models is restricted to MESS analyses or would require using species not that are considered immediately threatened by the project. In this scenario, the models could only assist in other stages of the licensing process (e.g., post-impact monitoring) or as a request for clarification or supplementation to the analyses of the studies (Res CONAMA No. 237/97, IV) because the sample design and resulting sample sites in the environmental studies are predefined in the Terms of Reference document according to secondary biodiversity data for the area that will be impacted.

Secondary data are not available for the vast majority of Amazonian regions, which precludes the use of these tools to guide the installation of sampling units in the initial stage of the study prior to the issuance of the license. Nevertheless, additional restrictions, which are discussed in the literature, should be considered prior to analysis. The most important restriction refers to space disagreement between the sampled areas, which are typically defined by licensing agents as the regions adjacent to the affected area (directly affected area - buffer Figure 1), and areas where decisions concerning compensation must be made, which are typically outside that area.

4.2.2 Effects of geographical interpolations and extrapolations on management decisions

The simulations with *A. nidicola* and *A. femoralis* data showed that at the local and biome-wide spatial scales, the models for which geographic predictions were extrapolated beyond the training area had poor predictive performance compared to predictions generated by interpolation. Studies have shown that the projections of models through time and space can be variable (Barbet-Massin et al. 2010, Dormann et al. 2007, Thuiller et al. 2004, Zurell et al. 2012) and are not recommended for the guidance of policy decisions without prior validation.

The problems posed by extrapolation are likely to be even greater in the Amazon compared to more topographically and climatically variable areas because species interactions or historical factors that are difficult to quantify are likely to be more important than the environmental data available for modeling (Ribas et al. 2007, Wallace 1852). The BAM diagram (Saupe et al. 2012, Soberón and Peterson 2005, Soberón 2007) illustrates other critical points for the formulation of robust models. When estimates of the area of occurrence are required for compensation or relocation of the project, studies must ascertain favorable conditions for the occurrence of the species (environmental predictors simulating the fundamental ecological niche) and the factors that restrict the species' spread (biotic and historical factors that restrict geographic dispersion). Otherwise, commission errors will be inevitable (Godsoe 2010, Saupe et al. 2012), as seen in the models for *A. nidicola* at large spatial scales. The predictions of these models indicated greater environmental suitability of the species near the mouth of the Amazon River than in the region where the taxon is actually present, which is restricted to the Purus-Madeira interfluve.

Despite the classic studies of biogeographical processes that influence the distribution patterns of organisms in Amazonia (Gascon et al. 1998, Gascon et al. 2000, Kaefer et al. 2012, Ribas et al. 2007, Ribas et al. 2011, Wallace 1852), many of these processes remain unknown. Moreover, there is even disagreement about the most important historical events that occurred in the region (e.g., Hoorn et al. 2010, Rossetti et al. 2005). Such historical and geographical processes are independent of the current environmental conditions; even with the inclusion of information regarding past climates and paleolandscapes, directed studies with targets are necessary to evaluate other possible dispersal barriers.

With the appropriate precautions (as cited above), SDMs could be used to guide new collection sites and clarify unanswered questions in previous studies . In the case presented here, lawmakers were seeking potential environmentally appropriate areas within the geographic occurrence of the target taxa (Elith et al. 2009). However, the processes that shape biodiversity vary with the spatial scale of the model; therefore, the use of inappropriate scales can compromise the usefulness of the models and misrepresent the distribution patterns (Guisan and Thuiller 2005, Hortal et al. 2010, Kristiansen et al. 2009, Nogués-Bravo and Araújo 2006, Whittaker et al. 2001). Additional sample units that both record species occurrence and measure environmental predictors that cannot be obtained by remote sensing are required. However, the extrapolation of these variables to regions beyond the area of origin involves many uncertainties and is dependent on the nature of the predictor.

Despite the present adverse scenario, species distribution models have great potential to assist in conservation by contributing to strategic decisions regarding environmental impacts in tropical regions (Cayuela et al. 2009). For this potential to be realized, environmental agencies must develop strategies to reduce spatial uncertainties in predictions of species distribution while also investing in improvements to the current state of knowledge of the region’s biodiversity. An alternative for overcoming the challenges listed here might be to expand the sample area defined by the licensing agents beyond the regions proximal to the project's affected area. If this action is performed, the use of permanent plots with multiple surveys could provide data on the detection probabilities for better evaluating the probability of false absences. Furthermore, sampling larger areas would allow the interpolation of collected data and reduce inaccuracies caused by geographical and environmental extrapolation models. Refined environmental variables could also be collected in the field to produce better local-scale models. If the sample expansion conflicts with urgent deadlines for installing economic ventures, an alternative conservation strategy would be to invest in consolidate programs of long-term ecological research that are integrated with surveys to monitor the biodiversity in the region. These surveys should be performed before short-term studies that are associated with licensing individual sites are required (Costa and Magnusson 2010, Magnusson et al. 2005, Magnusson et al. 2013).

5. Conclusions

We conclude that the lack of knowledge regarding the distribution of species poses a risk to biodiversity when potentially damaging enterprises are licensed in the Amazon. However, the use of modeling tools to overcome such deficits and to guide the requirements within impact assessments remains challenging because of the large areas involved in management decisions, limited sampling associated with impacts, and the lack of secondary data for calibration of the models in the region. SDMs may be useful for some aspects of licensing processes in the Amazon; however, managers must understand the practical limitations of these tools for answering the demands identified by Tôrres and Vercillo (2012).

Because of the urgency of obtaining information related to species distributions in the Amazon, the responsibility of filling these gaps in biological information cannot rest exclusively with the scientific community. Many projects are being planned for the Amazon region; therefore, it is important that the information required by the environmental licensing procedures in the Amazon be comparable to perform analyses of biological complementarity between regions in the basin on short notice and to enable the future use of more realistic models with robust regional information.

6. Acknowledgements

We are grateful for a CNPq for research fellowship for LRAC. The herpetofauna monitoring team of the Santo Antônio Hydroelectric plant provided the data. Coordination was undertaken by the Program for Biodiversity Research (PPBio) and the INCT-CENBAM. We thank Barbara Zimbres, Renata Dias Françoso, Yuri Salmona (Planning Laboratory for Biodiversity Conservation - UNB), Victor Perdigão, Jefferson Barros, Stéphany Watzel, André Sousa, Darren Norris, Pedro Ivo Simões, Igor Kaffer, David Cho, and Sergio Carvalho for their support in the construction of ideas and analysis. David Tonks, Luciene Robichaud and Stephanie DeAlmeida helped with translations. Peterson Townson, José Diniz Filho, Eduardo Vertincinque, Bruce Nelson, Karl Didier, and Marcelo Gordo provided comments on previous drafts.

7. References

Amézquita, A.; Lima, A.P.; Jehle, R.; Castellanos, L.; Ramos, O.; Crawford, A.; Gasser, H.; Hoedl, W. 2009. Calls, colours, shape, and genes: a multi-trait approach to the study of geographic variation in the Amazonian frog Allobates femoralis. Biological Journal Of The Linnean Society, 98 (4):826-838.

Araújo, M.B.; Densham, P.J.; Williams, P.H. 2004. Representing species in reserves from patterns of assemblage diversity. Journal of Biogeography, 31:1037-1050.

Araújo, M.B. and A. Guisan. 2006. Five (or so) challenges for species distribution modelling. Journal of Biogeography, 33: 1677–1688.

Austin, M.P.; Belbin, L.; Meyers, J.A.; Doherty, M.D.; Luoto, M. 2006. Evaluation of statistical models used for predicting plant species distributions: role of artificial data and theory. Ecological Modelling, 199:197–216.

Barbet-Massin, M.; Thuiller, W.; Jiguet, F. 2010. How much do we overestimate future local extinction rates when restricting the range of occurrence data in climate suitability models? Ecography, 33:878-886.

Barros, F.B. 2005. Sapos e seres humanos: Uma relação de preconceitos? Textos do Núcleo de Estudos Integrados Sobre Agricultura Familiar, 9:1-11.

Bini, L.M.; Diniz, J.A.F.; Rangel, T.; Bastos, R.P.; Pinto, M.P. 2006. Challenging Wallacean and Linnean shortfalls: knowledge gradients and conservation planning in a biodiversity hotspot. Divers. Distrib, 12:475-482.

Brasil. Constituição Federal de 1988. Nós, representantes do povo brasileiro, reunidos em Assembléia Nacional Constituinte para instituir um Estado Democrático, destinado a assegurar o exercício dos direitos sociais e individuais, a liberdade, a segurança, o bem-estar, o desenvolvimento, a igualdade e a justiça como valores supremos de uma sociedade fraterna, pluralista e sem preconceitos, fundada na harmonia social e comprometida, na ordem interna e internacional, com a solução pacífica das controvérsias, promulgamos, sob a proteção de Deus, a seguinte Constituição da República Federativa do Brasil.

Brasil. Lei nº 6.938, de 31 de agosto de 1981. Dispõe sobre a Política Nacional do Meio Ambiente, seus fins e mecanismos de formulação e aplicação, e dá outras providências.

Brasil. Lei nº 9.433 de 8 de janeiro de 1997. Institui a Política Nacional de Recursos Hídricos, cria o Sistema Nacional de Gerenciamento de Recursos Hídricos, regulamenta o inciso XIX do art. 21 da Constituição Federal, e altera o art. 1º da Lei nº 8.001, de 13 de março de 1990, que modificou a Lei nº 7.990, de 28 de dezembro de 1989.

Brasil. Lei complementar nº140 de 8 de dezembro de 2011. Fixa normas, nos termos dos incisos III, VI e VII do caput e do parágrafo único do art. 23 da Constituição Federal, para a cooperação entre a União, os Estados, o Distrito Federal e os Municípios nas ações administrativas decorrentes do exercício da competência comum relativas à proteção das paisagens naturais notáveis, à proteção do meio ambiente, ao combate à poluição em qualquer de suas formas e à preservação das florestas, da fauna e da flora; e altera a Lei no 6.938, de 31 de agosto de 1981.

Brasil. Decreto nº 6.848 de 14 de maio de 2009. Altera e acrescenta dispositivos ao Decreto nº 4.340, de 22 de agosto de 2002, para regulamentar a compensação ambiental.

Brasil. Decreto de Lei nº 99.274, de 6 de junho de 1990. Regulamenta a Lei nº 6.902, de 27 de abril de 1981, e a Lei nº 6.938, de 31 de agosto de 1981, que dispõem, respectivamente sobre a criação de Estações Ecológicas e Áreas de Proteção Ambiental e sobre a Política Nacional do Meio Ambiente, e dá outras providências.

Brasil. Decreto de Lei nº 4.340 de 22 de agosto de 2002. Regulamenta artigos da Lei nº 9.985, de 18 de julho de 2000, que dispõe sobre o Sistema Nacional de Unidades de Conservação da Natureza - SNUC, e dá outras providências.

Brasil. Resolução CONAMA nº 001, de 23 de janeiro de 1986. Dispõe sobre o licenciamento ambiental e sobre o estudo prévio de impacto ambiental.

Brasil. Resolução CONAMA nº 237, de 19 de dezembro de 1997. Revisa procedimentos e critérios utilizados no licenciamento ambiental, de forma a incorporar ao sistema de licenciamento os instrumentos de gestão ambiental e a integrar a atuação dos órgãos do SISNAMA na execução da Política Nacional do Meio Ambiente.

Busby, J.R. 1991. BIOCLIM – A bioclimatic analysis and predictive system. In Nature Conservation: Cost Effective Biological Surveys and Data Analysis- CSIRO: Canberra, AUS. 68 pp.

Caldwell, J.P.; Lima, A.P. 2003. A New Amazonian Species of Colostethus (Anura Dendrobatidae) with a Nidicolous tadpole. Herpetologica, 59(2):218-233.

Carroll, S.S.; Pearson, D.L. 1998. The effects of scale and sample size on the accuracy of spatial predictions of tiger beetle (Cicindelidae) species richness. Ecography, 21:401-414.

Cayuela, L.; Golicher, D.J.; Newton, A.C.; Kolb, M.; Albuquerque, F.S.; Arets, E.J.M.M.; Alkemade, J.R.M., Perez, A.M. 2009. Species distribution modeling in the tropis: problems, potentialities, and the roles of biological data for effective species conservation. Tropical Conservation Science, 2(3):319-2009.

Convention on Biological Diversity - CDB . 1992. (http://www.cbd.int/convention/text/) . Acessed on 04/02/20113.

Costa, F.; Magnusson, W.E. 2010. The Need for Large-Scale, Integrated Studies of Biodiversity the Experience of the Program for Biodiversity Research in Brazilian Amazonia. Natureza & Conservação, 8: 3-12.

Dormann, C.F. 2007. Promising the future? Global change projections of species distributions. Basic Appl. Ecol, 8:387–97.

Elith, J.; Graham, C.H.; Anderson, R.P.; Dudík, M.; Ferrier, S. Guisan, A.; Hijmans, R.J.; Huettmann, F.; Leathwick, J.R.; Lehmann, A.; Li, J.; Lohmann, L.G.; Loiselle, B.A.; Manion, G.; Moritz, C.; Nakamura, M.; Nakazawa, Y.; Overton, J.M.; Peterson, A.T.; Phillips, S.J.; Richardson, K.; Scachetti-Pereira, R.; Schapire, R.E.; Soberón, J.; Williams, S.; Wisz, M.S.; Zimmermann, N.E. 2006. Novel methods improve prediction of species' distributions from occurrence data. Ecography, 29:129-51.

Elith, J.; Graham, C.H. 2009. Do they? How do they? Why do they differ? On finding reasons for differing performances of species distribution models. Ecography, 32:66-77.

Elith, J.; Kearney, M.; Phillips, S. 2010. The art of modelling range-shifting species. Methods in Ecology and Evolution, 1: 330–342.

Elith, J.; Leathwick, J. 2009. Species distribution models: Ecological explanation and prediction across space and time. Evolution and Systematics, 40:677-69.

Elith, J.; Phillips, S.J.; Hastie, T.; Dudík, M.; Chee, Y.E.; Yates, C.J. 2011. A statistical explanation of MaxEnt for ecologists. Diversity and Distributions, 17:43–57.

Feeley, K.J.; Silman, M.R. 2011. The data void in modeling current and future distributions of tropical species. Global Change Biology, 17:626–630.

Ferrier, S. 2002. Mapping spatial pattern in biodiversity for regional conservation planning: Where to from here? Systematic Biology, 51:331-363.

Franklin, J. 2009. *Mapping Species Distributions*: *Spatial Inference and Prediction.* Cambridge University Press, Cambridge, UK. 320pp.

Gascon, C.; Lougheed, S.C.; Bogart, J.P. 1998. Patterns of genetic population differentiation in four species of Amazonian frogs: A test of the riverine barrier hypothesis. Biotropica, 30:104-119.

Gascon, C.; Malcolm, J.R.; Patton, J.L.; Silva, M.N.F.; Bogart, J.P.; Lougheed, S.C.; Peres, C.A.; Neckel, S.; Boag, P.T. 2000 Riverine barriers and the geographic distribuion of Amazonian species. Proceedings of the National Academy of Sciences of the United States of America. 97:13672-113677.

Giasson, M.M.; Carvalho, S.H.C. 2012.Mecanismo de compensação ambiental federal no Brasil: impactos negativos e os recursos revertidos para unidades de conservação. Anais do 1o Congresso Brasileiro de Avaliação de Impactos - Associação Brasileira de Avaliação de Impactos.

Godsoe, W. 2010. Regional variation exaggerates ecological divergence in niche models. Systematic Biology, 59:298-306.

Guisan, A.; Zimmermann, N.E. 2000. Predictive habitat distribution models in ecology. Ecological Modelling, 135:147–186.

Guisan, A.; Thuiller, W. 2005. Predicting species distribution: offering more than simple habitat models. Ecology Letters, 8:993–1009.

Hernandez, P.A.; Graham, C.H.; Master, L.L.; Albert, D.L. 2006. The effect of sample size and species characteristics on performance of different species distribution modeling methods. Ecography, 29:773–785.

Heyer, W.R.; Donnely, M.A.; McDiarmid, R.W.; Hayek, L.C.; Foster, M.S. 1994. Measuring ands monitoring biological diversity. Standard methods for Amphibians. Smithsonian Institution Press, Washington, 1994, 384p.

Hines, J. E. 2006. PRESENCE2 - Software to estimate patch occupancy and related parameters. USGS-PWRC. http://www.mbr-pwrc.gov/software/presence.html

Hoorn, C.; Wesselingh, F. P. 2010. Amazonia: landscape and species evolution. Blackwell Publishing, Oxford, 2010, 447p.

Hortal, J.; Roura-Pascual, N.; Sanders, N. J.; Rahbek, C. 2010. Understanding (insect) species distributions across spatial scales. Ecography, 33:51-53.

Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis – IBAMA. Instrução Normativa nº 146 de 10 de janeiro de 2007. Considerando a necessidade de estabelecer critérios e padronizar os procedimentos relativos à fauna no âmbito do licenciamento ambiental de empreendimentos e atividades que causam impactos sobre a fauna Silvestre.

Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis – IBAMA. Portaria Normativa nº 10 de 25 de maio de 2009. Sem prejuízo dos dispositivos da legislação de tutela à fauna, a aplicação da Instrução Normativa nº 146, 10 de janeiro de 2007, fica restrita ao licenciamento de empreendimentos de aproveitamento hidrelétrico.

Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis – IBAMA. Instrução Normativa nº 65 de 13 de abril de 2005. Estabelece, no âmbito desta Autarquia, os procedimentos para o licenciamento de Usinas Hidrelétricas – UHE e Pequenas Centrais Hidrelétricas – PCH, consideradas de significativo impacto ambiental, e cria o Sistema Informatizado de Licenciamento Ambiental Federal – SISLIC, Módulo UHE/PCH.

Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis – IBAMA. Informação Técnica nº 65 de 8 de agosto de 2008. Plano de Trabalho de monitoramento da Fauna Terrestre do Aproveitamento Hidrelétrico Santo Antonio.

Kadmon, R.; Farber, O.; Danin, A. 2003. A systematic analysis of factors affecting the performance of climatic envelope models. Ecological Applications, 13:853–867.

Kaefer, I.L.; Tsuji-Nishikido, B.M.; Lima, A.P. 2012. Beyond the river: underlying determinants of population acoustic signal variability in Amazonian direct-developing Allobates (Anura: Dendrobatoidea). Acta Ethologica, 15:187-194.

Kaefer, I.L.; Tsuji-Nishikido, B.M.; Mota, E.P. ; Faria, I.P.; Lima, A.P 2013. The early stages of speciation in Amazonian forest frogs: phenotypic conservatism despite strong genetic structure. Evolutionary Biology, 40: 228-245.

Kristiansen T.; Svenning j.C.; Grandez C.; Salo J.; Balslev H. 2009. Commonness of Amazonian palm (Arecaceae) species: Cross-scale links and potential determinants. Acta Oecologica, 35: 554– 562.

Lima, A.P.; Sanchez, D.E.A.; Souza, J.R.D. 2007. A new Amazonian species of the frogs genus Colostethus (*Dendrobatidae*) that lays its eggs on undersides of leaves. Copeia, 2007:114-122.

Lima, A.P.; Caldwell, J.P.; Biavati, G.M.; Montanarin, A. 2010. A new species of Allobates (Anura: Aromobatidae) from Paleovárzea Forest in Amazonas, Brasil. Zootaxa, 2337:1-17.

Lima, A.P.; Simões, P.I; Kaefer, I.L.; Fraga, R. e Araújo, M.C. 2011. *Estudos ambientais no Rio Madeira, no trecho Cachoeira de Santo Antônio: Herpetofauna terrestre*. Relatório elaborado para Santo Antônio Energia S.A. como parte do estudo de monitoramento para licenciamento da UHE de Santo Antônio.

Lopez-Lopez, P.; Garcia-Ripolles, C.; Soutullo, A.; Cadahia, L.; Urius, V. 2007. Identifying potencially suitable nesting habitat for golden Eagles applied to “important bird area” design. Animal Conservation, 10:208-2018.

Loyola, R.D.; Lewinsohn, T.M. (2009) Diferentes abordagens para a seleção de prioridades de conservação em um contexto macrogeográfico. Megadiversidade, 5:29-42.

Nogués-Bravo; Araújo, M. 2006. Species richness, area and climate correlates. Global Ecology and Biogeography, 15: 452– 460.

MacKenzie, D.I.; Nichols, J.D.; Hines, J.D.; Knutson, M.G.; Franklin, A.B. 2003. Estimating Site Occupancy, Colonization, and Local Extinction when a Species is Detected Imperfectly. Ecology, 84(8):2200-2207.

Magnusson, W.E.; Lima, A.P.; Luizão, R.; Luizão, F.; Costa, F.R.C.; Castilho, C.V. e Kinupp, V.F. 2005. RAPELD: uma modificação do método de Gentry para inventários de biodiversidade em sítios para pesquisa ecológica de longa duração. Biota Neotrop. 5(2):1-6.

Magnusson W., Braga-Neto R., Pezzini F., Baccaro F., Bergallo H., Penha J., Rodrigues D., Verdade L., Lima A., Albernaz, A., Hero J-M., Lawson B., Castilho C., Drucker D., Franklin E., Mendonça F., Costa F., Galdino G., Castley G., Zuanon J., Vale J., Santos

J., Luizão R., Cintra R., Barbosa R., Lisboa A., Koblitz R., Cunha C., Mendes Pontes A. 2013. *Biodiversity and Integrated Environmental Monitoring*. 1. ed. Áttema Editorial :: Assessoria e Design, Manaus, 2013. 352p

Ministério do Meio Ambiente - MMA – Portaria n 416 de 3 de novembro de 2010. Criaa, no âmbito do Ministério do Meio Ambiente, a Câmara Federal de Compensação Ambiental-CFCA, integrada por representantes, titular e suplente, indicados.

Miller, J.R.; Turner, M.G.; Smithwick, E.A.H.; Dent, C.L.; Stanley, E.H. 2004. Spatial Extrapolation: The Science of Predicting Ecological Patterns and Processes. BioScience, 54(4):310-320.

Moerman, D.E.; Estabrook, G.F. 2006. The botanist effect: counties with maximal species richness tend to be home to universities and botanists. Journal of Biogeography, 33:1969-1974.

Pearce, J.; Ferrier, S. 2000. An evaluation of alternative algorithms for fitting species distribution models using logistic regression. Ecological Modelling, 128:127–147.

Pearson, R. G., W. Thuiller, M. B. Araújo, E. Martínez-Meyer, L. Brotons, C. McClean, L. Miles, P. Segurado, T. P. Dawson, and D. C. Lees. 2006. Model-based uncertainty in species' range prediction. Journal of Biogeography 33:1704–1711.

Phillips, S.J.; Anderson, R.P.; Schapire, R.E. 2006. Maximum entropy modeling of species geographic distributions. Ecol. Model, 190:231-259.

R Development Core Team (2008) R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Disponível em: http:// www.R-project.org.

Ribas, C. C.; Aleixo A.; Nogueira, A. C. R.; Miyaki, C. Y.; Cracraft, J. 2011. A palaeobiogeographic model for biotic diversification within Amazonia over the past three million years. Proceedings - Royal Society. Biological Sciences, 279:681-689.

Ribas C.C.; Miyaki C.Y. 2007. Análise comparativa de padrões de diversificação em quatro gêneros de psitacídeos neotropicais. Revista Brasileira de Ornitologia, 15(2): 245-252.

Rosas, F.C.W.; de Mattos, G.E.; Cabral, M.M.M. 2007. The use of hydroelectric lakes by giant otters Pteronura brasiliensis: Balbina lake in Central Amazonia, Brazil. Oryx, 41(4):520-524.

Rossetti, D.F.; Toledo, P.M.; Góes, A.M. 2005. New geological framework for WesternAmazonia (Brazil) and implications for biogeography and evolution. Quaternary Research, 63:78–89.

Royle, J.A.; Chandler, R.B.; Yackulic, C.; Nichols, J.D. 2012. Likelihood analysis of species occurrence probability from presence-only data for modelling species distributions. Methods in Ecology and Evolution, 3:545–554.

Rushton, S.P.; Ormerod, S.J.; Kerby, G. 2004. New paradigms for modelling species distributions? Journal of Applied Ecology, 41:193 –200.

Saupe, E.E.; Barve, V.; Myers, C.E.; Soberón, J.; Barve, N., Hensz, C.M., Peterson, A.T.; Owens, H.L.; Lira-Noriega A. 2012. Variation in niche and distribution model performance: The need for a priori assessment of key causal factors. Ecological Modelling, 237-238:11-22.

Simões, P.I.; Lima, A.P.; Magnusson, W.E.; Hodl, W.; Amézquita, A. 2008. Acoustic and Morphological Differentiation in the Frog *Allobates femoralis* : Relationships with the Upper Madeira River and Other Potential Geological Barriers. Biotropica, 40:607-614.

Simões, P.I.; Lima, A.P.; Farias, I.P. 2010. The description of a cryptic species related to pan-Amazonian frog Allobates femoralis (Boulenger 1883) (Anura: Aromobatidae). Zootaxa 4:1-28.

Sinclair, S. J.; White, M. D.; Newell, G. R. 2010. How useful are species distribution models for managing biodiversity under future climates? Ecology and Society 15(1):8.

Soberón, J.; Peterson, A.T. 2005. Interpretation of models of fundamental ecological niches and species' distributional areas. Biodiversity Informatics, 2:1–10.

Soberón, J. 2007. Grinnellian and Eltonian niches and geographic distributions of species. Ecology Letters, 10:1115–1123.

Stockwell, D.R.B.; Peterson, A.T. 2002. Effects of sample size on accuracy of species distribution models. Ecological Modelling, 148: 1–13.

Caro, T. M. 2010. Conservation by Proxy: Indicator, umbrella, keystone, flagship, and other surrogate species. Island Press, EUA, 2010, 373p.

Tôrres, N.M.; Vercillo, U.E. 2012. Como ferramentas de modelagem de distribuição de espécies podem subsidiar ações de governo? Natureza e Conservação, 10(2): 228-230.

Thuiller, W.; Brotons, L.; Araújo, M. B.; Lavorel, S. 2004. Effects of restricting environmental range of data to project current and future species distributions. Ecography, 27:165–172.

Traill, L.W.; Bigalke, R.C. 2006. A presence-only habitat suitability model for large grazing African ungulates and its utility for wildlife management. African Journal of Ecology, 45:347-354.

Tuomisto, H.; Ruokolainen, K. 1997. The role of ecological knowledge in explaining biogeography and biodiversity in Amazonia. Biodiversity and Conservation, 6:347-357.

Zurell, D.; Elith, J.; Schröder, B. 2012. Predicting to new environments: tools for visualizing model behaviour and impacts on mapped distributions. Diversity and Distributions, 18:628-634.

Wallace, A.R. 1852. On the monkeys of the Amazon. Proceedings of the Zoology Society of London, 20:107-110.

Whittaker, R.J.; Araujo, M.B.; Paul, J.; Ladle, R.J.; Watson, J.E.M.; Willis, K.J. 2005. Conservation Biogeography: assessment and prospect. Diversity and Distributions, 11:3-23.

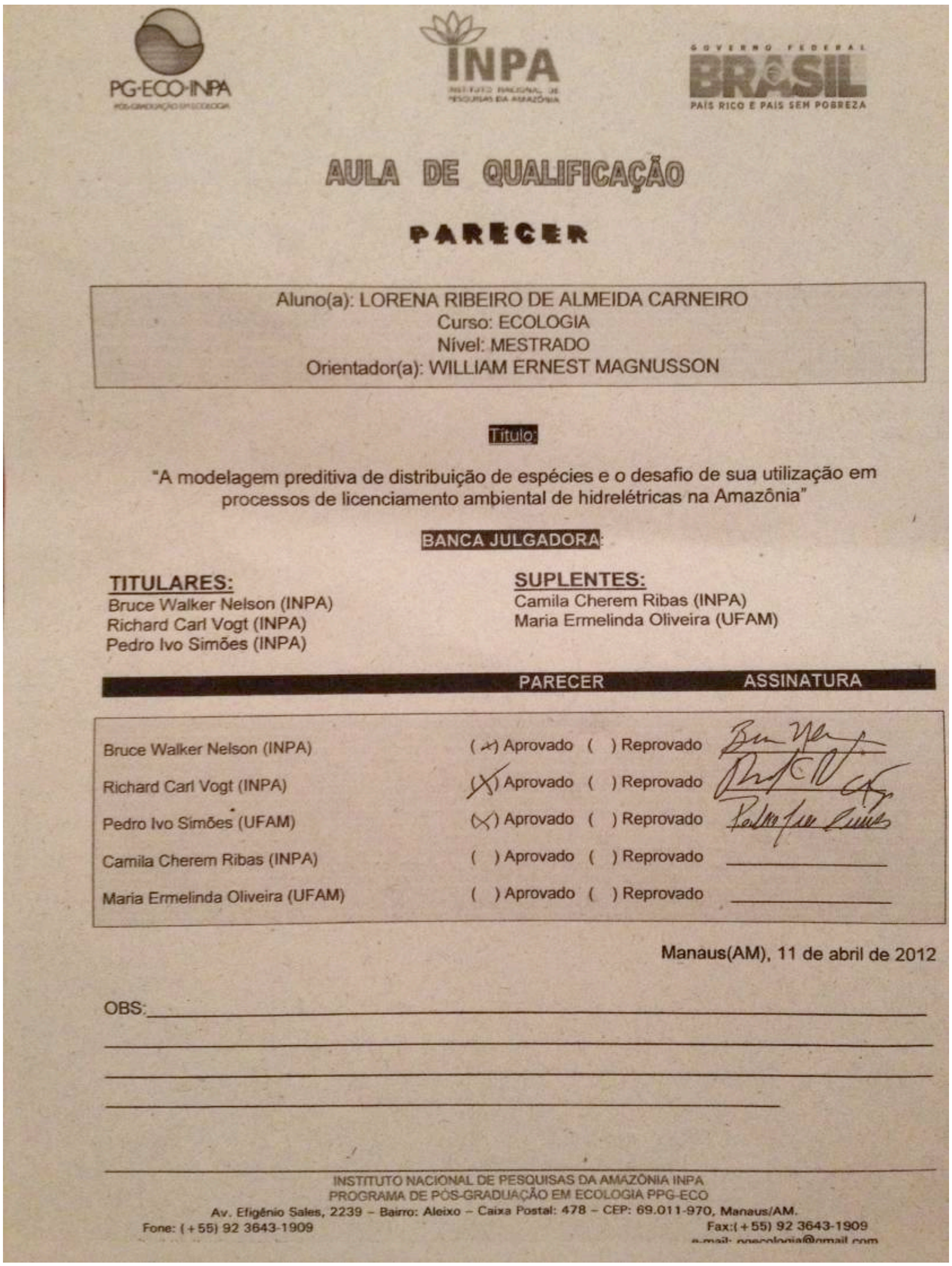
Williams, J. W.; Jackson, S. T. 2007. Novel Climates, No-Analog Plant Communities, and Ecological Surprises: Past and Future. Frontiers in Ecology and Evolution, 5: 475-482.

Wisz, M. S.; Hijmans, R. J.; Li, J.; Peterson, A. T.; Graham, C. H.; Guisan, A. 2008. Predicting Species Distributions Working Group. Effects of sample size on the performance of species distribution models. Diversity and Distributions, 14:763-773.

8. Attachments

8.1. ATAS DAS BANCAS AVALIADORAS

8.1.1. Ata da banca avaliadora da aula de qualificação:



PG-ECO-INPA

INPA

GOVERNO FEDERAL BRASIL PAÍS RICO É PAÍS SEM POBREZA

AULA DE QUALIFICAÇÃO

PARECER

Aluno(a): LORENA RIBEIRO DE ALMEIDA CARNEIRO
Curso: ECOLOGIA
Nível: MESTRADO
Orientador(a): WILLIAM ERNEST MAGNUSSON

Título:

"A modelagem preditiva de distribuição de espécies e o desafio de sua utilização em processos de licenciamento ambiental de hidrelétricas na Amazônia"

BANCA JULGADORA:

TITULARES:
Bruce Walker Nelson (INPA)
Richard Carl Vogt (INPA)
Pedro Ivo Simões (INPA)

SUPLENTES:
Camila Cherem Ribas (INPA)
Maria Ermelinda Oliveira (UFAM)

	PARECER		ASSINATURA
Bruce Walker Nelson (INPA)	(X) Aprovado	( ) Reprovado	[signature]
Richard Carl Vogt (INPA)	(X) Aprovado	( ) Reprovado	[signature]
Pedro Ivo Simões (UFAM)	(X) Aprovado	( ) Reprovado	[signature]
Camila Cherem Ribas (INPA)	( ) Aprovado	( ) Reprovado	
Maria Ermelinda Oliveira (UFAM)	( ) Aprovado	( ) Reprovado	

Manaus(AM), 11 de abril de 2012

OBS:

INSTITUTO NACIONAL DE PESQUISAS DA AMAZÔNIA INPA
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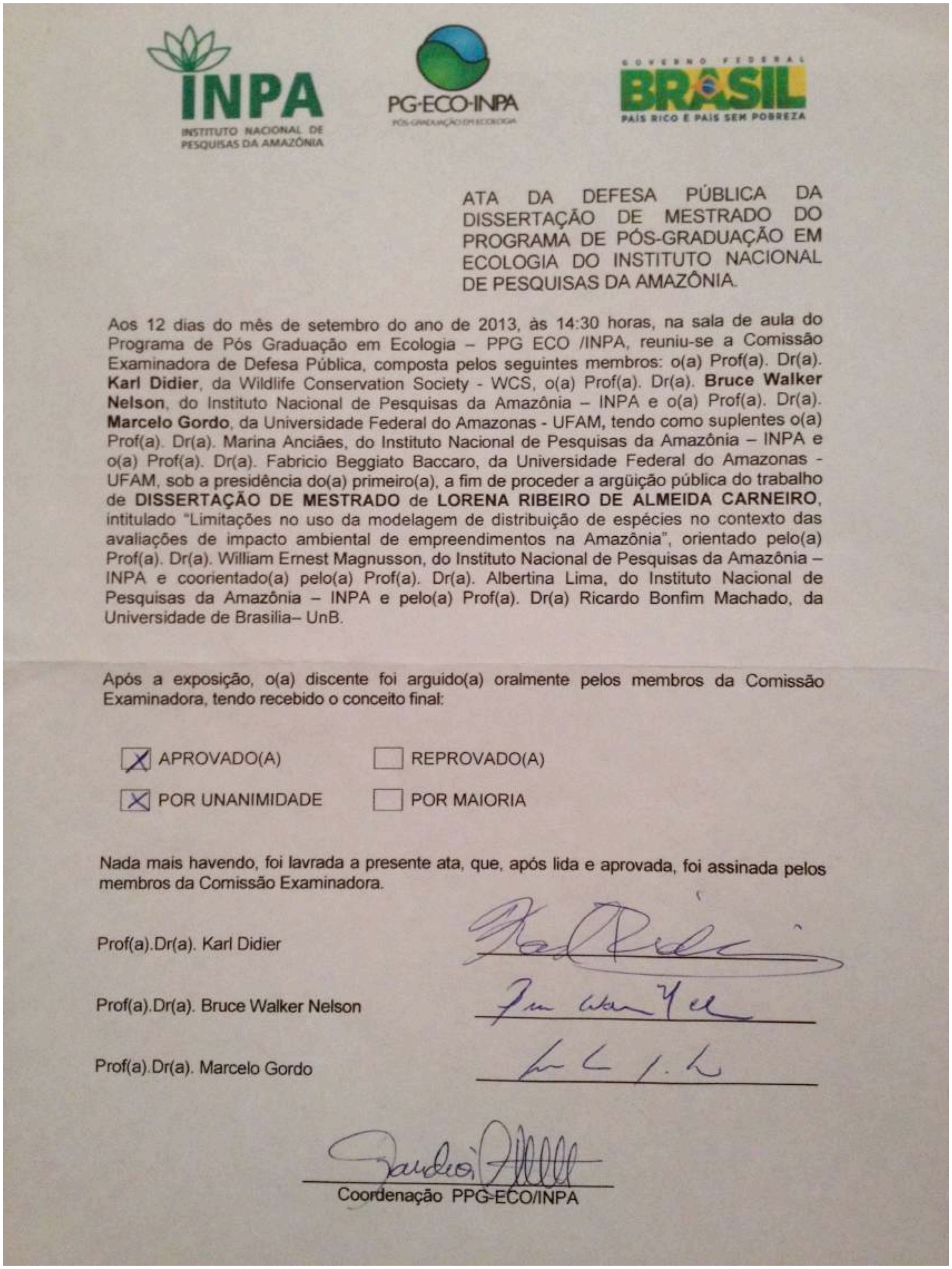
e-mail: ppgecologia@gmail.com

8.1.2. Ata da banca avaliadora da defesa de mestrado:



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PAÍS RICO É PAÍS SEM POBREZA

ATA DA DEFESA PÚBLICA DA DISSERTAÇÃO DE MESTRADO DO PROGRAMA DE PÓS-GRADUAÇÃO EM ECOLOGIA DO INSTITUTO NACIONAL DE PESQUISAS DA AMAZÔNIA.

Aos 12 dias do mês de setembro do ano de 2013, às 14:30 horas, na sala de aula do Programa de Pós Graduação em Ecologia – PPG ECO /INPA, reuniu-se a Comissão Examinadora de Defesa Pública, composta pelos seguintes membros: o(a) Prof(a). Dr(a). **Karl Didier**, da Wildlife Conservation Society - WCS, o(a) Prof(a). Dr(a). **Bruce Walker Nelson**, do Instituto Nacional de Pesquisas da Amazônia – INPA e o(a) Prof(a). Dr(a). **Marcelo Gordo**, da Universidade Federal do Amazonas - UFAM, tendo como suplentes o(a) Prof(a). Dr(a). Marina Anciães, do Instituto Nacional de Pesquisas da Amazônia – INPA e o(a) Prof(a). Dr(a). Fabricio Beggiato Baccaro, da Universidade Federal do Amazonas - UFAM, sob a presidência do(a) primeiro(a), a fim de proceder a argüição pública do trabalho de **DISSERTAÇÃO DE MESTRADO** de **LORENA RIBEIRO DE ALMEIDA CARNEIRO**, intitulado "Limitações no uso da modelagem de distribuição de espécies no contexto das avaliações de impacto ambiental de empreendimentos na Amazônia", orientado pelo(a) Prof(a). Dr(a). William Ernest Magnusson, do Instituto Nacional de Pesquisas da Amazônia – INPA e coorientado(a) pelo(a) Prof(a). Dr(a). Albertina Lima, do Instituto Nacional de Pesquisas da Amazônia – INPA e pelo(a) Prof(a). Dr(a) Ricardo Bonfim Machado, da Universidade de Brasilia– UnB.

Após a exposição, o(a) discente foi arguido(a) oralmente pelos membros da Comissão Examinadora, tendo recebido o conceito final:

[X] APROVADO(A) [ ] REPROVADO(A)

[X] POR UNANIMIDADE [ ] POR MAIORIA

Nada mais havendo, foi lavrada a presente ata, que, após lida e aprovada, foi assinada pelos membros da Comissão Examinadora.

Prof(a).Dr(a). Karl Didier ____________

Prof(a).Dr(a). Bruce Walker Nelson ____________

Prof(a).Dr(a). Marcelo Gordo ____________

____
Coordenação PPG-ECO/INPA

8.1.3. Ata da banca avaliadora da dissertação (trabalho escrito):

Instituto Nacional de Pesquisas da Amazônia - INPA
Programa de Pós-graduação em Ecologia

Avaliação de dissertação de mestrado

Título: **Limitações no uso da modelagem preditiva de distribuições de espécies em avaliações de impacto ambiental de empreendimentos na Amazônia**
Aluno: **LORENA RIBEIRO DE ALMEIDA CARNEIRO**

Orientador: **William Magnusson** Co-orientadores: **Ricardo Machado e Albertina Lima**

Avaliador: **Eduardo Venticinque**

Por favor, marque a alternativa que considerar mais apropriada para cada ítem abaixo, e marque seu parecer final no quadro abaixo

	Muito bom	Bom	Necessita revisão	Reprovado
Relevância do estudo	(x)	( )	( )	( )
Revisão bibliográfica	( )	(x)	( )	( )
Desenho amostral/experimental	( )	(x)	( )	( )
Metodologia	( )	( )	(x)	( )
Resultados	( )	( )	(x)	( )
Discussão e conclusões	( )	( )	(x)	( )
Formatação e estilo texto	( )	(x)	( )	( )
Potencial para publicação em periódico(s) indexado(s)	( )	(x)	( )	( )

PARECER FINAL

( ) **Aprovada** (indica que o avaliador aprova o trabalho sem correções ou com correções mínimas)

(X) **Aprovada com correções** (indica que o avaliador aprova o trabalho com correções extensas, mas que não precisa retornar ao avaliador para reavaliação)

( ) **Necessita revisão** (indica que há necessidade de reformulação do trabalho e que o avaliador quer reavaliar a nova versão antes de emitir uma decisão final)

( ) **Reprovada** (indica que o trabalho não é adequado, nem com modificações substanciais)

Lima, 27/04/2013, ____
Local Data **Assinatura**

Comentários e sugestões podem ser enviados como uma continuação desta ficha, como arquivo separado ou como anotações no texto impresso ou digital da tese. Por favor, envie a ficha assinada, bem como a cópia anotada da tese e/ou arquivo de comentários por e-mail para pgecologia@gmail.com e flaviacosta001@gmail.com ou por correio ao endereço abaixo. O envio por e-mail é preferível ao envio por correio. Uma cópia digital de sua assinatura será válida.

Endereço para envio de correspondência:

Flavia Costa
DCEC/CPEC/INPA
CP 478
69011-970 Manaus AM
Brazil

Instituto Nacional de Pesquisas da Amazônia - INPA
Programa de Pós-graduação em Ecologia

Avaliação de dissertação de mestrado

Título: **Limitações no uso da modelagem preditiva de distribuições de espécies em avaliações de impacto ambiental de empreendimentos na Amazônia**
Aluno: **LORENA RIBEIRO DE ALMEIDA CARNEIRO**
Orientador: **William Magnusson** Co-orientadores: **Ricardo Machado e Albertina Lima**

A. Townsend Peterson

Por favor, marque a alternativa que considerar mais apropriada para cada ítem abaixo, e marque seu parecer final no quadro abaixo

	Muito bom	Bom	Necessita revisão	Reprovado
Relevância do estudo	(X)	( )	( )	( )
Revisão bibliográfica	( )	( )	(X)	( )
Desenho amostral/experimental	( )	( )	(X)	( )
Metodologia	( )	( )	(X)	( )
Resultados	( )	( )	(X)	( )
Discussão e conclusões	( )	(X)	( )	( )
Formatação e estilo texto	(X)	( )	( )	( )
Potencial para publicação em periódico(s) indexado(s)	( )	( )	(X)	( )

PARECER FINAL

( ) **Aprovada** (indica que o avaliador aprova o trabalho sem correções ou com correções mínimas)

( ) **Aprovada com correções** (indica que o avaliador aprova o trabalho com correções extensas, mas que não precisa retornar ao avaliador para reavaliação)

(X) **Necessita revisão** (indica que há necessidade de reformulação do trabalho e que o avaliador quer reavaliar a nova versão antes de emitir uma decisão final)

( ) **Reprovada** (indica que o trabalho não é adequado, nem com modificações substanciais)

Lawrence, Kansas, USA — **5 May 2013,**
Local — **Data** — **Assinatura**

Comentários e sugestões podem ser enviados como uma continuação desta ficha, como arquivo separado ou como anotações no texto impresso ou digital da tese. Por favor, envie a ficha assinada, bem como a cópia anotada da tese e/ou arquivo de comentários por e-mail para pgecologia@gmail.com e flaviacosta001@gmail.com ou por correio ao endereço abaixo. O envio por e-mail é preferível ao envio por correio. Uma cópia digital de sua assinatura será válida.

Endereço para envio de correspondência:

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Instituto Nacional de Pesquisas da Amazônia - INPA
Programa de Pós-graduação em Ecologia

Avaliação de dissertação de mestrado

Título: **Limitações no uso da modelagem preditiva de distribuições de espécies em avaliações de impacto ambiental de empreendimentos na Amazônia**
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Por favor, marque a alternativa que considerar mais apropriada para cada ítem abaixo, e marque seu parecer final no quadro abaixo

	Muito bom	Bom	Necessita revisão	Reprovado
Relevância do estudo	(X)	( )	( )	( )
Revisão bibliográfica	( )	(X)	( )	( )
Desenho amostral/experimental	( )	(X)	( )	( )
Metodologia	( )	(X)	( )	( )
Resultados	(X)	( )	( )	( )
Discussão e conclusões	(X)	( )	( )	( )
Formatação e estilo texto	(X)	( )	( )	( )
Potencial para publicação em periódico(s) indexado(s)	( )	(X)	( )	( )

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