Universidade de Brasília

Instituto de Ciências Biológicas

Programa de Pós-Graduação em Ecologia

Répteis Squamata endêmicos do Cerrado: Perdas de hábitat e conservação em cenários futuros

Pietro Longo Hollanda de Mello

Brasília-DF

2014

Universidade de Brasília

Instituto de Ciências Biológicas

Programa de Pós-Graduação em Ecologia

Répteis Squamata endêmicos do Cerrado: Perdas de hábitat e conservação em cenários futuros

Orientador: Dr. Cristiano de Campos Nogueira

Dissertação apresentada ao Instituto de Ciências Biológicas da Universidade de Brasília como parte dos requisitos necessários à obtenção do título de Mestre em Ecologia.

Brasília-DF

2014

Pietro Longo Hollanda de Mello

Répteis Squamata endêmicos do Cerrado: perdas de hábitat e conservação em cenários futuros. Dissertação realizada com o apoio da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) e aprovada junto ao Programa de Pós-Graduação em Ecologia da Universidade de Brasília como requisito para obtenção do título de Mestre em Ecologia.

Comissão Examinadora:

____

Prof. Dr. Cristiano de Campos Nogueira

Presidente/Orientador

Eco/UnB

____

Prof. Dr. Reuber Albuquerque Brandão

Membro Titular

Zoo/UnB

____

Prof[a]. Dr[a]. Paula Hanna Valdujo

Membro Titular

WWF

____

Prof[a]. Dr[a]. Lilian Gimenes Giugliano

Membro Suplente

BioAni/UnB

Brasília, de de 2014

À minha mãe e ao meu pai,

Obrigado por tudo, amo vocês.

"I've found it is the small everyday deeds of ordinary folk that keep the darkness at bay... small acts of kindness, and love."

J.R.R.Tolkien

AGRADECIMENTOS

Agradeço à minha mãe Rosany e meu pai Fernando por tudo, nuncas os deixarei e eles nunca me deixarão.

Agradeço por estar vivo e pela oportunidade de conhecer as pessoas maravilhosas que me cercam e ter a capacidade de aprender, ensinar e lutar pelo que eu penso estar correto. Como não sei bem se há algo além do que vivemos aqui, mas sinto que estamos todos unidos de alguma maneira, escolho agradecer à Deus por essa benção, seja qual for sua forma ou religião.

Agradeço à minha família toda, tios, tias, primos e primas e especialmente aos meus avôs Mario e Fernando, minhas avós Mafalda e Yvone, ao meu Tio Paulo e à minha afilhada Bianca pelo apoio.

Agradeço à minha namorada Sofia e aos meus amigos do SCAP (Marcos, Guth, André, Filipe, Brito, Rafael, Elias, Diója, Diogo, Radan, João, Tiago e Vitor) pelo apoio incondicional em todos os momentos, sem vocês, talvez tivesse enlouquecido, vocês foram e serão sempre cruciais para minha vida.

Agradeço aos meus amigos Gabriel Lott, Eduardo Pedra, Pabllo Candeira, Guilherme Carneiro e Nathália Lott por estarem comigo desde o começo do Mestrado e também me apoiarem sempre.

Agradeço aos meus amigos de Foz do Iguaçu por sempre estarem comigo: Marcel, Thiago Novaes, Thiago Pimenta e Nelson Scardua. Agradeço também por ter morado em Foz, acredito que devo ao contato intenso com a natureza que lá tive o fato de ter escolhido ser Biólogo.

Agradeço aos meus colegas de curso que entraram comigo por fazerem essa jornada comigo. Agradeço principalmente ao Brito, Thiago Filadelfo, Vivian, Alan, Pedrom Guth e Gabriel pelos momentos de conversa e relaxamento nesses dois anos.

Agradeço a todos os colegas da UNEMAT pela oportunidade de ficar meses no campo com vocês. Infelizmente um deles passou desta vida muito jovem, uma pessoa à quem devo conversas e divagações muito agradáveis, Liandre,você foi e continua sendo uma grande amiga, mesmo em pouco tempo. Fique em paz.

Agradeço aos meus amigos da Coleção Herpetológica da Universidade de Brasília pela companhia nos campos e fora deles, pelas conversas e pelos momentos de relaxamento, além do incrível profissionalismo e organização. Agradeço com maior ênfase ao Leonardo, à Jéssica, à Isis, ao Guth, ao Josué, às Anas, ao Carlos, ao Fabricius, ao Renan, ao Guarino, à Cecília e ao Santos.

Agradeço ao meu orientador Cristiano de Campos Nogueira, que apesar da distância se mostrou compreensivo e me auxiliou e orientou durante momentos críticos do trabalho, espero que possamos continuar a trabalhar juntos futuramente.

Agradeço ao Prof. Dr. Ricardo B. Machado pelo auxílio na dissertação e pela oportunidade de trabalhar em Co-autoria com o mesmo no artigo que será oriundo desta dissertação.

Agradeço à banca convidada (Prof. Dr. Reuber Brandão, Profª. Drª. Paula Valdujo, Profª. Drª. Lilian Giugliano) por aceitarem ao convite. Respeito e admiro estes profissionais e acredito que com o auxílio dos mesmos essa dissertação ganhará muito.

Agradeço a todos os professores que ministraram aulas para mim e para os meus colegas durante o curso.

Agradeço ao Prof. Dr. Reuber Brandão e ao Prof. Dr. Guarino Colli pelas oportunidades de monitoria em matérias por eles ministradas.

Agradeço ao Yuri e ao Josué pelo apoio no uso de programas de distribuição e de construção de mapas.

Agradeço à CAPES pela minha bolsa de Mestrado durante esse 48 meses.

Agradeço à Universidade de Brasília não apenas pela oportunidade de fazer o Mestrado na mesma, mas também pela graduação. Esta Universidade me formou como profissional qualificado em Ciências Biológicas.

Agradeço ao IB, a todo secretariado, tanto da graduação, quanto da Pós-Graduação em Ecologia, principalmente à Vanessa que sanou tantas dúvidas e foi sempre solicita, não apenas comigo, mas com todos que conheço.

Agradeço à Profª. Drª. Ivone Diniz e ao Prof. Dr. Emerson Vieira pelo curso de Pós-Graduação em Ecologia ser recentemente reconhecido com Conceito 6 na CAPES.

Agradeço a todas instituições que me auxiliaram indiretamente neste trabalho, tanto universidades, quanto instituições fomentadoras, citando: Coleção Herpetológica da Universidade de Brasília, Museu de Zoologia da Universidade de São Paulo e Instituto Butantan.

ÍNDICE

INTRODUÇÃO GERAL

Com pouco mais de 2 milhões de km², aproximadamente 20% da superfície do país e 12% da cobertura continental, o Cerrado é o segundo maior domínio fitogeográfico brasileiro (Eiten, 1972; Ab'Saber, 1977; Ratter *et al.*, 1997; Oliveira-Filho & Ratter, 2002; Silva & Bates, 2002). Dominado por uma vegetação aberta e savânica, possui solos empobrecidos, além de uma proeminente estratificação horizontal de suas fitofisionomias (Oliveira-Filho & Ratter, 2002). Em duas décadas 340 novas espécies de vertebrados foram descritas para a região (Machado *et al.*, 2009), eno último grande inventário de Squamata no Cerrado foi identificada a segunda maior proporção de endemismo entre os Tetrapoda, com um total 267 espécies, sendo 103 destas (39%) endêmicas (Nogueira *et al.*, 2011).

No cenário global contemporâneo de elevadas ameaças a espécies e investimentos relativamente baixos em conservação (Pimm *et al.*, 1995) o Cerrado figura entre as 34 áreas apontadas como *hotspots* globais (Myers *et al.*, 2000; Myers, 2003; Mittermeier *et al.*, 2004), i.e. áreas que apresentam concentrações excepcionais de espécies endêmicas, sofrendo com perdas expressivasde hábitat (Myers *et al.*, 2000). Único *hotspot* savânico do planeta, o Cerrado é apontado como uma das áreas prioritárias para investimentos em conservação global (Myers *et al.*, 2000). Ainda assim a região encontra-se cada vez mais ameaçada pela perda de sua cobertura original (Machado *et al.*, 2004; Klink & Machado, 2005), onde grupos com distribuições regionalizadas e elevados níveis de endemismo, *e.g.* Squamata (Nogueira *et al.*, 2011), podem sofrer ainda mais com as perdas não homogêneas dentro do domínio (Klink & Moreira, 2002; Silva & Bates, 2002; Machado *et al.*, 2004).

Como indicado em Colli *et al.* (2002), a maior parte dos estudos iniciais sobre diversidade da herpetofauna do Cerrado descreveu assembleias pobres (Vanzolini, 1948, 1976, 1988; Vitt, 1991; Vitt & Caldwell, 1993), dominadas por espécies generalistas, compartilhadas com a Caatinga semiárida e com o Chaco (Vanzolini, 1963, 1976, 1988). Todavia, novos dados e interpretações descrevem um domínio com uma diversidade horizontal de hábitats que abriga uma herpetofauna única, diversa e com espécies restritas a distintas porções e formações fitofisionômicas (Colli *et al.*, 2002; Nogueira *et al.*, 2009, 2011; Valdujo *et al.*, 2012). Em trabalhos recentes, padrões biogeográficos temporais e espaciais começaram a ser destacados (Werneck & Colli, 2006; Costa *et al.*, 2007), abrindo possibilidades para análises mais profundas da história das faunas de Squamata do Cerrado (Nogueira *et al.*, 2011).

Contrastando com este aumento no número de espécies identificadas para Squamata no Cerrado, na última década houve a diminuição da cobertura total de vegetação natural do Cerrado (Klink & Machado, 2005).

Mais de 50% de sua área original já foi desmatada (MMA, 2011),devido principalmente à expansão do agronegócio(Alho & Martins, 1995; Ratter *et al.*, 1997; Klink & Moreira, 2002).Concomitantemente, unidades de conservação de proteção integral, no Cerrado são pequenas e concentradas em poucas regiões, cobrindo menos de 2% do domínio até o ano de 2004 (Klink & Machado, 2005).

Da mesma forma que no Cerrado, elevadas taxas de perda de áreas naturais vêm acontecendo em todo o globo, associados a um aumento do risco de extinção de espécies (Wilcox & Murphy, 1985; Tilman *et al.*, 1994; Sala *et al.*, 2000; Brooks *et al.*, 2002). Lamentavelmente, nosso conhecimento sobre a biodiversidade do planeta ainda é inadequado, com estimativas globais variando em ordens de magnitude, e muito da diversidade que conhecemos ainda a ser formalmente catalogada, *i.e.* Impedimento Linneano (Brown & Lomolino, 1998; Whittaker *et al.*, 2005). Ademais, dentre as espécies que conhecemos, também temos, para vários taxa, um conhecimento inadequado de suas distribuições globais, regionais e até mesmo locais, um problema denominado por Lomolino (2004) como Impedimento Wallaceano . Neste cenário, Whittaker *et al.* (2005) evidenciaram a "Biogeografia da Conservação", uma vertente dos estudos biogeográficos que busca aplicar princípios, teorias e análises biogeográficas - relativos às dinâmicas distribucionais de táxons individual e coletivamente – a problemas referentes à conservação da biodiversidade.

Deste modo, em face ao elevado ritmo de perda de hábitat e à falta de tempo hábil para um levantamento e acompanhamento para diagnose de todas as espécies nos seus respectivos ambientes, a utilização de dados de coleções e modelos de distribuição potencial apresenta-se como opção pouco dispendiosa e também eficiente em iniciativas para estudos de padrões gerais biogeográficos e de conservação (Ferrier, 2002; Loiselle *et al.*, 2003; Raxworthy *et al.*, 2003; Kadmon *et al.*, 2004; Soberón & Peterson, 2004; Guisan & Thuiller, 2005; Drew, 2011). O desenvolvimento de modelos de distribuição de espécies é acompanhado por uma produção constante de artigos abordando novas metodologias, vieses e soluções para seus problemas (Peterson & Cohoon, 1999; Graham *et al.*, 2004; Phillips *et al.*, 2004; Hernandez *et al.*, 2006; Peterson, 2006), além de revisões comparativas quanto à eficácia de uma ou outra abordagem (*e.g.* Guisan & Zimmermann, 2000; Elith *et al.*, 2006).

Embasado na biogeografia da conservação, que tem como uma das suas principais ferramentas a utilização de dados computadorizados e ferramentas analíticas para auxiliar na solução de problemas ligados à conservação da biodiversidade (Whittaker *et al.*, 2005), busquei neste estudo avaliar os impactos atuais e futuros da perda de hábitat sobre a diversidade e distribuição dos répteis Squamata endêmicos do Cerrado. Meu objetivo central é avaliar como estes cenários de perda interferirão no grau de risco de extinção de cada espécie, classificando cada espécie de acordo com as categorias de ameaça da União Internacional Para Conservação da Natureza - IUCN (IUCN, 2010; Bird *et al.*, 2011).

Para tal, elaborei mapas atualizados de distribuição para todas 105 espécies de Squamata endêmicos do Cerrado por meio de modelos de distribuição espacial (Species distribution models - SDM) (*ver* Guisan & Zimmermann, 2000; Elith *et al.*, 2006) ou mapas de micro bacias quando para representar a distribuição das espécies raras e com poucos registros de ocorrência (*ver* Nogueira *et al.*, 2010). Os mapeamentos partiram de uma base de registros previamente revisada contendo dados de coleção e fontes bibliográficas seguras (*ver* Nogueira *et al.*, 2011). Os mapas de distribuição produzidos foram cruzados com projeções futuras para remanescentes de áreas nativas do Cerrado em dois cenários distintos, um no qual as taxas atuais são mantidas sem intervenção ou controle governamental (cenário BAU – *Business as Usual*), e outro construído a partir da ação governamental para redução das taxas de desmatamento (cenário GOV – *Governance*). Cada cenário foi ainda estudado em dois intervalos de tempo: de 2010 a 2020 e de 2010 a 2030. Como demandado pela IUCN, além dos diferentes cenários para inserção de margem de incerteza na análise, revisei todas as espécies utilizando os critérios A e B, dependentes de dados de distribuição espacial (IUCN, 2010).

Frente aos resultados, fiz a diagnose da distribuição das espécies ameaçadas revisadas neste trabalho frente aos padrões de ameaça impostos pelo desmatamento. A partir desta identifiquei três tipos áreas prioritárias à conservação: áreas de crise (pontos de alta diversidade que provavelmente serão perdidos nos próximos dez anos), áreas de refúgio (pontos de alta diversidade, mas que deverão ser mantidos nos próximos dez anos) e áreas altamente insubstituíveis (*cf.* Bird et al., 2011).

O segundo objetivo do trabalho é calcado em uma das constatações centrais da biogeografia da conservação: tanto espécies quanto ameaças não estão distribuídas ao acaso no espaço (Whittaker *et al.*, 2005; Ladle & Whitakker, 2011). Para grupos de Squamata endêmicos do Cerrado, análises recentes detectaram níveis significativos de regionalização, formando sete conjuntos de espécies co-distribuídas e regionalizadas (Nogueira *et al.*, 2011). Desta forma testei se a perda de hábitat se dá de maneira aleatória no Cerrado através destes conjuntos regionais de espécies endêmicas. Com este objetivo comparei as perdas de hábitat das espécies de Squamata endêmicos do Cerrado entre e dentro de cada um dos elementos bióticos (EB) (Guedes *et al.*, 2014). Esta análise foi construída a partir da intersecção das áreas de distribuição de cada uma das espécies pertencentes a cada EB com as perdas de superfície do domínio ocorridas até 2010. Por fim, as perdas sofridas dentro e entre cada EB foram comparadas via teste de Kruskall-Wallis, utilizando cada espécie como uma amostra distinta das perdas para cada EB. No trabalho assumi que diferenças significativas para o teste entre quaisquer dois EBs representam perdas diferenciadas entre regiões dentro do Cerrado. Verifiquei também a representatividade das unidades de conservação de proteção integral frente aos padrões de regionalização de Squamata do Cerrado, testando se a proteção se dá de modo aleatório nos diferentes EBs (*cf.* Guedes *et al.*, 2014).

Escolhi utilizar a análise de EB como metodologia de agrupamento de espécies devido à sua estruturação metodológica. A análise de EB é um método relativamente recente de detecção de padrões biogeográficos que testa duas predições centrais do modelo de diversificação vicariante (Hausdorf, 2002; Hausdorf & Hennig, 2003), um dos processos tidos como principais na distribuição da diversidade biológica do planeta (Croizat *et al.*, 1974; Crisci, 2001; Hausdorf & Hennig, 2004). Segundo a análise, se processos vicariantes foram importantes no passado, devemos observar duas características principais no conjunto de distribuições presentes numa dada região ou área: (1) grupos de espécies significativamente co-distribuídas (EB), cujas distribuições são mais próximas entre si do que com outros grupos de espécies, devem existir e ser detectáveis, como assinaturas de processos históricos de segregação de biotas; e (2) espécies filogeneticamente próximas deverão compor EB distintos, como resultado da segregação histórica (Hausdorf, 2002; Hausdorf & Hennig, 2003).

Deste modo, EB podem ser interpretados não apenas como um mero padrão espacial de regionalização, mas também como o resultado de processos históricos de segregação vicariante, causada pelo surgimento de barreiras biogeográficas históricas (Hausdorf, 2002). Portanto, ao analisarmos as perdas de hábitat e a distribuição de unidades de conservação de proteção integral sobre EB estamos não apenas considerando a proteção de padrões regionais, mas principalmente, a proteção de processos históricos geradores de biodiversidade que se manifestam através dos conjuntos de espécies significativamente regionalizados (*e.g.* Guedes *et al.*, 2014).

Como último passo do trabalho, para identificar eventuais diferenças na distribuição da cobertura de áreas de conservação permanente através do domínio do Cerrado, realizei outras duas análises: (a) verifiquei a cobertura das unidades de conservação de proteção integral frente a cada uma das áreas prioritárias à conservação; (b) comparei a cobertura das mesmas entre cada um dos diferentes EB distribuídos pelo domínio.

Esta dissertação tem seu único capítulo estruturado em formato de artigo a ser submetido para o periódico Diversity and Distributions em co-autoria com meu orientador, Cristiano de C. Nogueira e e o Prof.Dr.Ricardo B. Machado, pesquisador e docente da Universidade de Brasília. Todas suas citações, tabelas, figuras e lista de referências bibliográficas seguem o formato exigido pelo periódico. O Apêndice "Appendix S1" foi separado em três partes para facilitar sua visualização.

REFERÊNCIAS

Ab'Saber, A.N. (1977) Os domínios morfocliáticos da América do Sul: Primeira aproximação. *Geomorfologia*, **52**, 1-22

Alho, C.J.R., Martins E.S. (1995) Bit by bit the Cerrado loses space. Brasília, DF Brazil: WWF

Bird, J.P., Buchanan, G.M., Lees, A.C., Clay, R.P., Develey, P.F., Yépez, I & Butchart, H.M. (2011) Integrating spatially explicit projections into extinction risk assessments: A reassessment of Amazonian avifauna incorporating projected deforestation. *Diversity and distributions*, 1-9

Brooks, T.M., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A.B., Rylands, A.B., Konstant, W.R., Flick, P., Pilgrim, J., Oldfield, S., Magin, G. & Hilton-Taylor, C. (2002) Habitat loss and extinction in the hotspots of biodiversity, *Conservation Biology*. **16**, 909-923.

Brown, J.H., Lomolino, M.V. (1998) *Biogeography*, 2nd ed. Sinauer Associates, Sunderland, MA, 691pp.

Colli, G.R., Bastos, R.P. & Araújo, A.F.B. (2002) The characters and dynamics of the Cerrado herpetofauna. The Cerrados of Brazil: Ecology and Natural History of a Neotropical Savanna (ed. by P.S. Oliveira and R.J. Marquis), pp. 223-241. *Columbia University Press,* New York.

Costa, G.C., Nogueira, C., Machado, R.B. & Colli, G.R. (2007) Squamate richness in the Brazilian Cerrado and its environmental-climatic associations. *Diversity and Distributions*, **13**, 714-724.

Crisci, J.V. (2001) The voice of historical biogeography. *Journal of Biogeography*, **28**, 157-168.

Croizat, L., Nelson, G. & Rosen, D.R. (1974) Centers of origin and related concepts. *Systematic Zoology*, **23**, 265-287.

Drew, J. (2011) The role of natural history institutions and bioinformatics in conservation biology. *Conservation Biology*, **25**, 1250-1252

Eiten, G. (1972) The Cerrado vegetation of Brazil. *The Botanical Review*, **38**, 201-341

Elith, J., Graham, C.H., Anderson, R.P., Dudik, 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., Soberon, J., Williams, S., Wisz, M.S. & Zimmermann, N.E. (2006) Novel methods improve prediction of species' distributions from occurrence data. *Ecography*, **29**, 129–151

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

Graham, C.H., Ferrier, S., Huettman, F., Moritz, C. & Peterson, A.T. (2004) New developments in museum-based informatics and applications in biodiversity analysis. *Trends in Ecology & Evolution*, **19**, 497-503.

Guedes, T.B., Sawaya, R.J. & Nogueira, C.C. (2014) Biogeography, vicariance, and conservation of snakes of the neglected and endangered Caatinga region, Northeastern Brazil. *Journal of Biogeography*.

Guisan, A. & Zimmermann, N.E. (2000) Predictive habitat distribution models in ecology. *Ecology Modelling*, **135**, 147-186.

Guisan, A. & Thuiller, W. (2005) Predicting species distribution: offering more than simple habitat models. *Ecology Letters*, **8**, 993-1009.

Hausdorf, B. (2002) Units in biogeography. *Systematic Zoology*, **51**, 648-652.

Hausdorf, B. & Hennig, C. (2003) Biotic element analysis in biogeography. Systematic Biology, **52**, 717-723.

Hausdorf, B. & Hennig, C. (2004) Distance-based parametric bootstrap tests for clustering of species ranges. *Computational Statistics and Data Analysis*, **45**, 875–895.

Hernandez, P.A., Graham, C.H., Master, L.L. & Albert, D.L. (2006) The effect of samples size and species characteristics on performance of different species distribution modeling methods. *Ecography*, **29**, 773-785.

IUCN (2010) Guidelines for using the IUCN Red List Categories and Criteria: version 8.1. IUCN Species Survival Commission, International Union for the Conservation of Nature, Gland, Switzerland and Cambridge, UK.

Kadmon, R., Farber, O. & Danin, A. (2004) Effect of roadside bias on the accuracy of predictive maps produces by bioclimatic models. *Ecological Applications*, **14**, 401-413.

Klink, C.A. & Moreira, A.G. (2002) Past and current human occupation, and land use. *The Cerrados of Brazil: Ecology and Natural History of a Neotropical Savanna* (ed. by P.S. Oliveira and R.J.Marquis), pp.69-88. Columbia University Press, New York, New York.

Klink, C.A. & Machado, R.B. (2005) Conservation of the Brazilian Cerrado. *Conservation Biology,* **19**, 707-713.

Ladle, R.J. & Whittaker, R.J. (2011) *Conservation biogeography*,. Oxford: Wiley-Blackwell, New York.

Loiselle, B.A., Howell, C.A., Graham, C.H., Goerck, J.M., Brooks, T., Smith, G.S. & Williams, P.H. (2003) Avoiding pitfalls of using species distribution models in conservation planning. *Conservation Biology*, **17**, 1591-1600.

Lomolino, M.V. (2004) Conservation biogeography. *Frontiers of Biogeography: New Directions in the Geography of nature* (ed. by M.V. Lomolino and L.R. Heaney). Sinauer Associates, Sunderland, Massachusetts.

Machado, R.B., Ramos Neto, M.B., Pereira, P., Caldas, E., Gonçalves, D, Santos, N., Tabor, K. & Steininger, M. (2004) Estimativas de perda da área do Cerrado brasileiro. *Conservation International do Brasil*, Brasília (in Portuguese).

Machado, R.B., Aguiar, L.S., Castro, A.A.J.F., Nogueira, C.C. & Ramos Neto, M.B. (2009) Caracterização da fauna e flora do Cerrado. *Savanas: Desafios e Estratégias para o Equilíbrio entre Sociedade, Agronegócio e Recursos Naturais* (ed. By F.G. Faleiro and A.L. Farias Neto). pp.295-300, Embrapa Cerrados, Planaltina, Brazil.

Mittermeier, R.A., Robles Gil, P., Hoffmann, M. *et al.* (2004) *Hotspots Revised*, Mexico City, CEMEX.

MMA (2011) Monitoramento do desmatamento nos biomas brasileiros por satélite, acordo de cooperação técnica MMA/IBAMA, monitoramento do bioma Cerrado 2009-2010

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B. & Kent, J. (2000) Biodiversity hotspots for conservation priorities. *Nature*, **403**, 853-858.

Myers (2003) Biodiversity hotspots revised. *BioScience*, **53**, 916-917.

Nogueira, C., Colli, G.R. & Martins, M. (2009) Local richness and distribution of the lizard fauna in natural habitat mosaics of the Brazilian Cerrado. *Austral Ecology*, **34**, 83-96.

Nogueira C., Buckup, P.A., Menezes, N.A., Oyakawa, O.T., Kasecker, T.P., Ramos Neto, M.B. & Silva, J.M.S. (2010) Restricted-range fishes and the conservation of brazilian freshwaters. *Plos one*, **5**(6), e11390

Nogueira, C., Ribeiro, S, Costa, G.C. & Colli, G.R. (2011) Vicariance and endemism in a Neotropical savanna hotspot: Distribution patterns of Cerrado squamate reptiles. *Journal of Biogeography*, 1-16.

Oliveira-Filho, P.S. & Ratter, J.A. (2002) Vegetation Physiognomies and woody flora of the Cerrado Biome. *The Cerrados of Brazil: Ecology and Natural History of a Neotropical Savanna*. (ed. by P.S. Oliveira and R.J. Marquis). Columbia University Press, New York.

Peterson, A.T. (2006) Uses and requirements of ecological niche models and related distributional models. *Biodiversity Informatics*, **3**, 59-72.

Peterson, A.C. & Cohoon, K.C. (1999) Sensitivity of distributional prediction algorithms to geographic data completeness. *Ecological Modelling*, **117**, 159-164.

Phillips, S.J., Dudik, M. & Shapire, R.E. (2004) *A maximum entropy approach to species distribution modeling. Proceedings of the 21st international conference on machine learning* (ed. by Greiner, R. & Schuurmans, D.) pp.655-662. ACM Press Banff, Canada.

Pimm, S.L., Russell, G.J., Gittleman, J.L. & Brooks, T.M. (1995) The future of biodiversity. *Science*, **269**, 347-350.

Ratter, J.A., Ribeiro, J.F. & Bridgewater, S. (1997) The Brazilian Cerrado vegetation and threats to its biodiversity. *Annals of Botany*, **80**, 223-230.

Raxworthy,C., Martinez-Meyer, E., Horning, N., Nussbaum, R.A., Schneider, G.E., Ortega-Huerta, M.A. & Peterson, T. (2003) Predicting distributions of known and unknown reptiles species in Madagascar. *Nature*, **426**, 837-841.

Sala, O.E., Chaping, F.S.I, Armesto, J.J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L.F., Jackson, R.B., Kinzig, A., Leemans, R., Lodge, D.M., Mooney, H.A., Oetersheld, M., Poff, N.L., Sykes, M.T., Walker, B.H., Walker, M., Wall, D.H. (2000) Global biodiversity scenarios for the year 2100. *Science*, **287**, 1770-1774.

Silva, J.M.C. & Bates, J.M. (2002) Biogeographic patterns and conservation in the South American Cerrado: A tropical savanna hotspot. BioScience, 52, 225-233.

Soberón, J. & Peterson, A.T. (2004) Biodiversity informatics: Managing and applying primary biodiversity data. *Philosophical Transactions of the Royal Society of London Series B, Biological Sciences*, **359**, 689-698.

Tilman, D., May, R.M., Lehman, C.L. & Nowak, M.A. (1994) Habitat destruction and the extinction debt. *Letters to Nature*, **371**, 65-66.

Valdujo P.H., Silvano, D.L., Colli, G. & Martins, M. (2012) Anuran species composition and distribution patterns in Brazilian Cerrado, a Neotropical hotspot. *South American Journal of Herpetology*, **7**, 63-78.

Vanzolini, P.E. (1948) Notas sobre os ofídios e lagartos da Cachoeira de Emas, no município de Pirassununga, estado de São Paulo. *Revista Brasileira de Biologia.*, **8**, 377-400.

Vanzolini, P.E. (1963) Problemas Faunísticos do Cerrado. *Simpósio sobre o Cerrado* (ed. M. Ferri) pp.307-20. *Editora da Universidade de São Paulo*, São Paulo.

Vanzolini, P.E. (1976) On the lizards of a cerrado-caatinga contact, evolutionary and zoogeographical implications (Sauria). *Papéis Avulsos de Zoologia São Paulo*, **29**, 111-119.

Vanzolini, P.E. (1988) Distribution patterns of South American lizards. *Proceedings of a Workshop on Neotropical Distribution Patterns* (ed. by P.E. Vanzolini and W.R. Heyer) pp. 317-343. Academia Brasileira de Ciências, Rio de Janeiro.

Vitt, L.J. (1991) An introduction to the ecology of Cerrado lizards. *Journal of Herpetology*, **25**, 79-90.

Vitt, L.J. & Caldwell, J.P. (1993) Ecological observations on Cerrado lizards in Rondônia, Brazil. *Journal of Herpetology*, **27**, 46-52.

Werneck, F.P. & Colli, G.R. (2006) The lizard assemblage from seasonally dry tropical forest enclaves in the Cerrado biome and its association with the Pleistocenic Arc. *Journal of biogeography*, **33**, 1983-1992.

Whittaker, R.J., Araújo, M.B., Jepson, P., Ladle, R.J., Watson, J.E.M. & Willis, K.J. (2005) Conservation biogeography: Assessment and prospect. *Diversity and Distributions*, **11**, 3-23.

Wilcox B.A. & Murphy, D.D. (1985) Conservation Strategy: The effects of fragmentation on extinction. *The American Naturalist*, **125**, 879-887.

Article type: Biodiversity research

Habitat loss and conservation of Brazilian Cerrado endemic Squamate Reptiles

Pietro L.H. de Mello[1], Ricardo B. Machado[2] & Cristiano C. Nogueira[2,3]

[1] Programa de Pós-Graduação em Ecologia, Instituto de Ciências Biológicas (IB), Universidade de Brasília (UnB), 70910-900, Brasília, DF, Brazil. Corresponding author: hollandademello@gmail.com

[2] Departamento de Zoologia, Instituto de Ciências Biológicas (IB), Universidade de Brasília (UnB), 70910-900, Brasília, DF, Brazil.

[3] Present adress: Museu de Zoologia da Universidade de São Paulo (MZUSP), Laboratório de Herpetologia. Av.Nazaré, 481, Ipiranga, 04263-000, São Paulo, SP, Brazil.

ABSTRACT

Aim To assess extinction risk of Cerrado endemic Squamates based on spatially explicit scenarios of future habitat loss; test if habitat losses pose significant, non-random threats to Cerrado biogeographical patterns; test if biogeographical patterns and priority protection areas detected for Cerrado endemic Squamates are adequately represented by the existing protected areas network.

Location Brazilian Cerrado.

Methods For all 105 Cerrado endemic Squamates we revised extinction risk estimates through inferred population declines combining updated species distribution maps with spatially explicit future habitat loss scenarios. We overlapped remaining species ranges in order to detect three major regions of conservation concern indicating short and long term spatial priorities for conservation. Finally, we examined the overlap between biogeographical units and spatial patterns of habitat loss and protected area coverage.

Results The number of threatened species rose from three (2.85% of total, current redlist) to at least 78 (74%). Habitat loss and protected area coverage are significantly different between biotic elements; crisis and refugia areas are located in the south-central region, while irreplaceable areas are scattered through Cerrado remaining areas; all three priority regions are currently poorly protected, and the southern biotic element is less protected than its northern counterparts.

Main conclusions The application of the IUCN Red List criteria here presented substantially raised the number of accessed and threatened species, being recommended for other taxonomic groups in highly threatened and still poorly studied regions. Important areas are not secured and biogeographical process and patterns may be lost in the near future if proper action is not taken. There is an urgent need for expanding protected area cover and to reduce the pace of deforestation in the Cerrado.

Keywords: Biodiversity, Conservation biogeography, Deforestation, Distribution patterns, IUCN status, Species distribution models.

INTRODUCTION

Biodiversity and its threats are not randomly distributed throughout the world (Myers *et al.*, 2000; Whittaker *et al.*, 2005; Ladle & Whittaker, 2011) and diverse approaches to planning global protection areas for biodiversity have been developed (Whittaker *et al.*, 2005). The incorporation in the early 2000's of habitat loss along with species diversity (Myers *et al.*, 2000), due to the recent alarming rates of the former (Brooks *et al.*, 2002; Fahrig, 2003), is one of them . As a response to such elevated habitat loss and its direct negative effects on biodiversity (Wilcox & Murphy, 1985; Sala *et al.*, 2000; Brooks *et al.*, 2006; Collen *et al.*, 2009; Bohm *et al.*, 2013), a new branch of biodiversity science has gained strength: Conservation Biogeography (Whittaker *et al.*, 2005, Ladle & Whittaker, 2011).

This new area merges the traditional biogeographical concern with species distribution through space and time (Brown & Lomolino, 1998) with the application of biogeographical principles, theories and analyses to present alternatives and solutions to the urgent problems related to the conservation of biodiversity (Whittaker *et al.*, 2005). Biogeographical units provide highly valuable information on what spatial portions of biodiversity should be conserved (Crisci, 2001; Whittaker *et al.*, 2005), and among the criteria for detecting areas of high conservation value, endemism patterns stand out as both highly relevant and corresponding to biogeographic questions (Pullin, 2002).

Noteworthy in this worldwide scenario of the biodiversity crisis (McKinney & Lockwood, 1999; Pimm & Raven, 2000; Davies *et al.*, 2006) is the Brazilian Cerrado and its endemic Squamate. As happens globally biodiversity and its threats are not randomly distributed in the region (Myers *et al.*, 2000; Whittaker *et al.*, 2005; Ladle & Whittaker, 2011), with deforestation following a south-north trend (Klink & Moreira, 2002; Silva & Bates, 2002; Machado *et al.*, 2004) and most of this conversion occurring in open, interfluvial savanna habitats (Klink & Machado, 2005). Due to its high levels of vascular plant endemism (*e.g.* Ratter *et al.*, 1997), and such high percentages of habitat loss (Machado *et al.*, 2004) the Cerrado region is the only savanna included among the 34 hotspots of biodiversity (Myers *et al.*, 2000; Myers, 2003; Mittermeier *et al.*, 2004).

Recent studies have shown that the Cerrado harbours a rich (over 260 species) and highly endemic Squamate fauna, with 103 endemic species, about 40% of total richness (Nogueira *et al.*, 2011). This fauna is now known to be dominated by species tightly associated to specific microhabitats (Gainsbury & Colli, 2003; Mesquita *et al.*, 2006), and unevenly distributed in habitat mosaics (Colli *et al.*, 2002; Nogueira *et al.*, 2005). Observed regionalized, significant patterns of species co-ocurrence in the group agree with the prediction of the vicariant model of diversification, indicating that current diversity and distributional patterns are a possible result of a long history of allopatric diversification and *in situ* speciation (Nogueira *et al.*, 2011).

However, despite advances in detecting biogeographical patterns in the Cerrado, we still know little about the threat levels and future impacts of habitat loss on this previously poorly studied fauna. Even with recent efforts to expand the coverage of threat assessments in Reptilia (Bohm *et al.*, 2013) only twelve of the 103 Cerrado endemic Squamate species (Nogueira *et al.*, 2011) had been assessed until January 2014 in the Red List of Threatened Species - IUCN (IUCN, 2014). Three of them (*Bachia bresslaui*, *Philodryas livida* and *Tantilla boipiranga*) were classified in threatened categories. Furthermore habitat loss, which is the single most important threat to Reptiles worldwide (Gibbons *et al.*, 2000, Vié *et al.*, 2008; Collen *et al.*, 2009; Bohm *et al.*, 2013), tends to increase in Brazil due to the approval of the new National Forest Code (Brasil, 2012). The coincidence of the group's local richness, endemism and habitat loss in open interfluvial plateaus threatens to erase ancient and highly complex evolutionary patterns and processes (Nogueira *et al.*, 2011).

In this study, we aim to: reassess extinction risk of the Cerrado endemic Squamates (Nogueira *et al.*, 2011) by inferring the population decline based on herein built projected deforestation estimates under governance (GOV) and business as usual (BAU) scenarios, for two future time frames; evaluate the conservation of biogeographical patterns and processes by contrasting regionalized species distributions with satellite based habitat loss and protected area cover, searching for non-random patterns; test the hypothesis that protected areas are randomly distributed across the Cerrado in order to verify if current protection areas throughout the region representatively covers regions of Squamate biogeographical patterns and processes; and based on revised distribution maps and future habitat loss patterns we map three types of spatial priorities in the Cerrado (*cf.* Bird *et al.*, 2011), namely: (a) crisis areas (b) refugia areas and (c) highly irreplaceable areas. These three types of spatial priorities will enable us to: (1) evaluate the capacity of future remaining areas to buffer against future loss; and (2) to detect priority sites for future expansion and management of the protected area network in the face of rapid projected land coverage modifications.

METHODS

Study area

The Cerrado is the second largest South American domine of phytophisiognomies (Ab'Saber, 1977; Ratter *et al.*, 1997; Silva & Bates, 2002) covering 2.03 million km^2, around 23% of the Brazilian territory. It is a seasonally dry tropical savanna (Nimer, 1979), with two major geomorphological units (Silva, 1997; Silva *et al.*, 2006): gently rolling or level headwater plateaus, dominated by open grassy savannas and grasslands; and peripheral depressions that harbors a more complex matrix of savannas and semi decidous forests crossed by widespread tracts of gallery forests along major drainage systems (Eiten, 1972; Cole, 1986; Oliveira-Filho & Ratter, 2002). Detailed data on Cerrado ecology and natural history can be found in Oliveira & Marquis (2002).

Data sources

Prior to building each species' potential distribution we used the Brazilian Biomes Map (IBGE, 2004) to define approximate limits of the Brazilian Cerrado, and restricted all projections of land coverage modifications and species distributions to these boundaries.Endemic species, or distributions in marginal and peripheral Cerrado areas were not considered. Past land coverage modifications for the Cerrado (2002 and 2010) were obtained from the Project of Satellite Deforestation Monitoring of Brazilian Biomes (PMDBBS, 2013). Cerrado protected areas were defined as those in categories I-III in Dudley (2008) of the current Brazilian protected area system (Brasil, 2000) to define strictly protection areas.

We downloaded all 19 climatic variables and altitude from the WorldClim project (Hijmans *et al*,2005). To define which variables should be included in the model we built a correlation matrix (*see* Costa *et al*., 2010), and retained only the following non correlated ($r>0.9$) layers: altitude (ALT), mean diurnal temperature range (BIO2), isothermality (BIO3), temperature seasonality (BIO4), maximum temperature of warmest month (BIO5), minimum temperature of the coldest month (BIO6), temperature annual range (BIO7), mean temperature of wettest quarter (BIO8), mean temperature of the warmest quarter (BIO10), annual precipitation (BIO12), precipitation of the driest month (BIO14), precipitation seasonality (BIO15), precipitation of the wettest month (BIO16), precipitation of the warmest quarter (BIO18), and precipitation of the coldest quarter (BIO19). To maintain consistency we represented all variables at 5 x 5 km spatial resolution, and processed species distribution data and habitat loss in a geographical information system.

Endemic Squamate species detected in Nogueira *et al*.(2011) were mapped based on a revised database of vouchered point locality records in zoological collections, and complemented by standardized fieldwork to fill former sampling gaps (*see* Nogueira *et al*., 2009, 2011). This list was further updated with a compilation of more recent literature records, from 2010 onwards (Appendix S1). Species names follow Bérnils & Costa (2012). Current data on assessed species and their respective risk categories were obtained from through an individual conference for each species on the online IUCN`s RedList, in January 2014 (IUCN, 2014).

Model construction of land coverage modification

Our land coverage modification model projected the natural coverage for the entire Cerrado from 2010 to 2020 and to 2030. We used the Land Change Modeler (LCM) available in Idrisi selva software (Eastman, 2011) to build two different scenarios: Business as usual (BAU) and Governance (GOV) on an yearly basis. We created both scenarios using the euristic algoritm and a transition probability matrix based on the comparison of the deforestation observed between 2002 and 2008 years. As explanatory variables, we used digital elevation model and annual accumulated precipitations (Hijmans *et al.*, 2005), proximity to roads, proximity to recent deforested areas and proximity to cities (Brasil, 2013).

The BAU scenario represents a future situation for the natural coverage of the Cerrado when the Government takes no intervention action. It means that Brazil will maintain the current deforestation rate, estimated in 14,200 km^2/year (Brasil, 2009), and no further protected area will be created on the Cerrado. On the other hand, the GOV scenario assumes a total reduction on the deforestation rate on the priority areas for biodiversity conservation as defined by Brasil (2006) and maintenance of all strict protection areas as they are nowadays. The GOV scenario was built based on the UN's Aichi biodiversity target 5 that expects that the rate of loss of all natural habitats is at least halved by 2020 (CBD, 2013). Thus, in GOV scenario we assumed that the probability of habitat loss was halved between 2008-2020 and 2020-2030, not allowing habitat loss in permanent protection areas. Details about the assessment of models precision can be viewed in Faleiro *et al.* (2013).

Estimating species ranges

We estimated species' distribution through two different methods. For species with at least 11 locality records, we produced species distribution models via Maxent (Phillips *et al.*, 2004, 2006; Phillips & Dudik, 2008). Maxent is a presence-only, new generation distribution model (SDM) algorithm that has been shown to outperform other modeling techniques (Phillips *et al.*, 2004; Elith *et al.*, 2006; Costa *et al.*,2010). To use all the information available in our dataset, beyond using Maxent v.3.3.3k default program parameters (*see* Phillips & Dudik, 2008), each species had ten different jackknifed replicates built under "randomseed" bootstrapping. By selecting "randomseed" in Maxent we ordered the program to select a different random test/train partition and a different random subset of the background each time the analysis ran. Model performance was verified through AUC (Fielding & Bell, 1997; Manel et al., 2011, but see Luoto *et al.*, 2005 and Peterson *et al.*, 2008 for critics) (*see* Data S1 for further details and threshold).

Although Maxent has been shown to have good performance with small samples (Elith *et al*., 2006; Garcia, 2006; Phillips & Dudik, 2008; Costa *et al.*, 2010) we obtained inconsistent model outputs for some of our data. Consequently for species with ten or less locality records we mapped ranges according to the intersection of presence records and small scale watershed limits (*see* Data S1). In this approach we used the group of all adjacent watersheds that were in contact with a 50km radius buffer centered in each georeferenced collection point. Since watersheds are commonly divided in smaller components, their chosen order of magnitude must be related to the research purposes: in this paper we use the 5th order Ottobasins. Ottobasins are watersheds defined as part of the Brazilian National Hydrographic Division (Brasil, 2003), following the Pfafstetter (1987) method. According to this classification, 1st order Ottobasins correspond to the ten largest South American watersheds, the following order Ottobasin is always a subdivision of the preceding based on its major tributaries from its mouth to its headwaters. We chose watersheds due to its awareness to regional topographic characteristics (Nogueira *et al.*, 2010).

Identifying threatened species

To assess extinction risk we used as a baseline each species' distribution in 2010, based on PMDBBS Cerrado reminiscent areas (PMDBBS, 2013). Projected changes in the area of natural vegetation cover were converted into percentage declines, and equivalent population declines. We based projected population declines on the Cerrado according to BAU and GOV scenarios and adjusted decline estimates incorporating uncertainty in generation lengths and habitat type (*see* Data S1). Due to lack of information about generation length, which is generally inferred or approximated for higher taxa in Squamate (Greene, 1997; Pianka & Vitt, 2003), uncertainty was implemented by using two time frames: (1) 2010-2020, chosen as our default period, since most endemic Squamate are small bodied , and species with such characteristics may show generation lenghts up to ca. 3 years (Greene, 1997; Pianka & Vitt, 2003), fulfilling the the "ten years or three generations" reccommendation, under criterion A4c (IUCN, 2010); and (2) 2010-2030, chosen with a more exploratory purpose, aiming to show a possible risk trend to larger and longer living Squamate.

Habitat type uncertainty was implemented to account for the fact that species from open, interfluvial areas are more impacted by habitat loss than forest species, as open interfluves are the main targets for mechanized agriculture and cattle farming (Brasil, 1965, 2012; Klink & Machado, 2005). Moreover, Squamate Reptiles are dominated by species with relatively low dispersal ability, small ranges (Gaston, 1996) and with high habitat and microhabitat fidelity (Greene, 1997; Pianka & Vitt, 2003). Open area species or species with lack of proper information had a 1:1 estimated habitat/population loss. For forest, generalist and riparian species a 1:0.8 estimated habitat/population loss was implemented (Appendix S1). The 0.2 difference between forest and riparian species is based in our assumption that all possible available open areas would eventually be converted to agriculture (Klink & Machado, 2005), and therefore species typical of open habitat would suffer a bigger impact than forest and riparian ones. Habitat preferences for each species were obtained in Nogueira *et al.* (2011).

The same analysis was implemented between the years 2000-2010 in order to compare if such threats were already menacing the Cerrado endemic Squamate fauna in the recent past. Species were majorly reassigned to criterion A4c, based on an inferred population decline through projected habitat loss (IUCN, 2010; Bird *et al.*, 2011) in a time period including both the past and the future and B1ab(i,iii) for expected remaning area coverage (IUCN,2001) (*see* Data S1 for further details). Revised categories were assigned where the registered rate of decline warranted species uplisting in relation to previous classifications in different scenarios.

Biogeographical patterns

We analyzed the conservation of biogeographical patterns by comparing habitat loss among species ranges within and among biotic elements (BE) (Hausdorf, 2002). The BE analysis was implemented in Nogueira *et al.*(2011) to the endemic Squamate location dataset. Biotic element analysis is a method for detecting biogeographical patterns that tests two central predictions of the vicariant model (Hausdorf, 2002; Hausdorf & Hennig, 2003). According to the analysis, if vicariant processes were important in the past: (a) we should observe species groups significantly co-distributed (Biotic elements, BE) with distributions, which must exist and be detectable, closer to one another than to other species groups; and (b) philogenetically close species must compose diferent BE, as a result of historical segregation (Hausdorf, 2002; Hausdorf & Hennig, 2003). The seven proposed BE (Nogueira *et al.*, 2011) are widespread throughout the Cerrado.

Percentages of habitat loss for each species in the BE were obtained by clipping projected original distributions (totally conserved) with the remaining areas obtained in PMDBBS's 2010 maps (PMDBBS, 2013), and with 2020 spatially explicit projections. As most species forming BE are narrow ranged and known from limited records we estimated distribution areas for each of the 49 species forming BE (Nogueira *et al.*,2011) using the watershed approach. We opted not to use the Maxent approach in this analysis because it could over-predict a potential distribution in regions disconnected from point localities (Loiselle *et al.*, 2003; Eken *et al.*, 2004), an undesired result in our biogeographical analysis. All spatial analysis was performed using ArcGis 9.3.1 (ESRI, 2009) and Xtools Pro10.

Biogeographical patterns and habitat loss

To calculate differences within BE rates of expected and observed habitat loss for each species within each BE were compared by Kolmogorov-Smirnoff tests (*see* Crawley, 2007). Each species' expected habitat loss was calculated as: (each species estimated range) x (the averaged percentage of habitat loss of all species within its BE) (Guedes *et al.*, 2014). Observed and expected habitat loss values in all analysis were *logit* transformed (*see* Warton & Hui, 2011) in R's package *car* (R Core Team, 2013). Observed habitat loss and protected area coverage was compared among BE by Kruskal-Wallis (Hollander & Wolf, 1973) and multiple comparison tests (*see* Siegel & Castellan, 1988) via package *pgirmess* in R (R Core Team, 2012). To test if the mapping technique had an effect on the result of habitat loss estimates we built Maxent and Watershed estimated species distribution areas for all species with 11 or more locality points and compared their results in habitat losses through Kruskal-Wallis test (Hollander & Wolf, 1973). We considered a significance level of 0.05 for all statistical analyses.

Priority areas for conservation

Priority areas for conservation were identified *sensu* Bird *et al.* (2011): (1) Crisis areas – all species remaining areas in 2010 were overlaid and we selected the top 10% pixels with highest diversity expected to be lost in the next 10 years; (2) Refugia – as in Crisis areas, but with the top 10% pixels with highest diversity not expected to be lost within the next 10 years; (3) Highly irreplaceable areas – the value of each 5km² pixel to each species was calculated as 1/[total extent of suitable habitat in 2010], and these values were summed for all species occurring in each pixel to assess aggregate pixel irreplaceability. We compared the distribution of crisis areas, refugia and highly irreplaceable areas with the distribution of current permanent protected areas (PAs).

RESULTS

Updated range maps, projected area losses and extinction risk reassessment

Based on our projections, remaining areas are expected to have been reduced respectively 55 and 62% in 2020 under BAU and GOV scenarios in comparison to its original coverage (Fig. 1). We expect a minimum loss of 0.94% per year through GOV 2030 scenario and a maximum of 1.78% to our BAU 2020 scenario (Table 1). There is no significant difference for species' habitat loss between Maxent and watershed approaches when both are built for the same species (Kruskall-Wallis = 1.6396, df=1, P = 0,2004).

In our reassessment between 2010 and 2020 under both IUCN criteria "A" and "B", and incorporating variation in population responses to fragmentation depending upon habitat type, 88 species (83.80%) were classified in threatened categories under GOV scenario and 90 (85.71%) under BAU scenario. Reassessed categories for both scenarios accounting for different uncertainties are available in Fig. 2. Among the seven species assessed as Critically Endangered (CR) in BAU 2020 scenario (*Amphisbaena sanctaeritae*, *Bothrops itapetiningae*, *Liotyphlops schubartii*, *Phalotris multipunctatus*, *P.lativittatus*, *Philodryas livida* and *Trilepida koppesi*), four of them (*Amphisbaena sanctaeritae*, *Phalotris multipunctatus*, *Philodryas livida* and *Trilepida koppesi*) are part of the southern located Paraná-Paraguay BE (Fig. 3), and the other three are not part of any BE (Nogueira *et al.*, 2011). Losses per species between its original coverage and 2010 ranged from 3% to 99% in the same taxa throughout the region (Appendix S1). For Maxent modelled species all AUC values were above 0.75, considered as good model performance (Elith, 2002).

Biogeographical patterns, habitat loss and protected area coverage

No significant differences between observed and expected habitat loss among species within each BE were detected (Appendix S2). Habitat loss, however, was significantly different among BE (Kruskall-Wallis = 25.9405, df = 6,P <0.005) (Table 2), with percentage of losses in BE 3 (Paraná-Paraguay) being significantly different than those in BE 1 (Tocantins-Serra Geral, obs. df. = 31.48, critical dif. = 19.76) and BE 2 (Paraguay-Guaporé, obs. dif = 24.35, critical dif = 22.97) (Fig 3.a), a pattern expected to continue in our projected BAU 2020 scenario (Kruskall-Wallis = 31.7341, df = 6,P < 0.0005; Tocantins-Serra Geral, obs.dif = 32.59, critical dif = 20.79; Paraguay-Guaporé, obs.dif = 31.83, critical dif = 24.17) (Fig. 3b). In general, species in BE were poorly covered by protected areas, with an average of 2% PA coverage (Appendix S3). Additionally, PA distribution was significantly different between BE 1 (Tocantins-Serra Geral) and 3 (Paraná-Paraguay) (Kruskall-Wallis = 15.0397, df = 6, P < 0.05; obs.dif = 22.47, critical dif = 19.76), where the first has the most coverage and the second one has the least coverage (Fig. 3c).

Priority areas for conservation

Endemic Squamates have higher richness in the central part of the Cerrado, with secondary peaks in the southern and western parts (Fig. 5a). Crisis areas (Fig. 5b) occur solely as an extense narrow line from central Cerrado (from the surroundings of Brasilia) to Northern São Paulo state and are close to Refugia areas in an area west of the Espinhaço range, another area close to Chapada dos Guimarães plateau, and inthe surroundings of the Emas National Park, near the frontier among Goiás, Mato Grosso and Mato Grosso do Sul states. Refugia areas are also foundaround the Chapada dos Veadeiros region (North of Brasília). Highly irreplaceable areas are scattered (Fig. 5c) throughout the region. Irreplaceability areas have the largest continuous area in the Northern

Maranhão state, with secondary regions in Northeastern (Bahia and Piauí) Cerrado and a highly irreplaceable spot in the Western-most part of the region (Western Mato Grosso). Currently, protected areas cover only 1% of Crisis areas, 11% of Refugia areas and 5% of highly irreplaceable areas.

DISCUSSION

A heterogeneously threatened region

High richness of Cerrado endemic Squamate in the South-Central portion of the region is shared with multiple groups: small mammals (Faleiro *et al.*, 2013), amphibians (Bini *et al.*, 2006),and birds (Diniz-Filho *et al.*, 2009). This pattern and other high richness areas at the westernmost portion of the region in Mato Grosso, close to the Pantanal and the Amazon Forest, and around the Emas National Park, one of the key conservation areas in the Cerrado (Redford, 1985), are also shared among our data and Costa *et al.* (2007) results for both endemic and non-endemic Squamate species. However a herein high endemic richness area (Fig. 5) overlaping with the Espinhaço range was not among Costa *et al.* (2007) highest richness values.

The Espinhaço range is a region that also holds high endemism for birds (Silva, 1997), and amphibians (Valdujo *et al.*, 2012), and is an elevated metamorphic ridge that acts as a geographical barrier between the Atlantic Forest and the Brazilian open formations (Ab'Saber, 1977), coupled with a massive environmental heterogeneity. Since Squamate endemism has been suggested to be influenced by historical factors (Vitt *et al.*, 2003; Mesquita *et al.*, 2006; Nogueira *et al.*, 2011) it is no surprise to find a high diversity of endemism in such topographically and ecologically complex regions.

When we incorporated future projected population declines to our distribution models, we revealed that Cerrado endemic Squamate are highly threatened, with an alarming raise in species numbers for threatened categories and species uplisting (Appendix S4). Our data point in the same way of a connection between habitat and species losses (Wilcox & Murphy, 1985; Brooks *et al.*, 2002), the number of endangered species raised from 2 (2.86%) to 78 (74.29% of total) (Fig. 6) in our most conservative approach, where IUCN's B category is not considered and we account for uncertainty in population responses to fragmentation depending upon habitat type. Such relation was already expected, because Squamate Reptiles are highly sensible to area loss (Gibbons *et al.*, 2000; Collen *et al.*, 2009; Bohm *et al.*, 2013), Reptiles have been pointed out as more vulnerable to habitat losses than mammals and birds (Gibbons *et al.*, 2000)., In our reassessment we classified some species in higher risk categories in GOV than in BAU scenarios (Appendix S1). This is a consequence of the different metrics and assumptions when building GOV and BAU scenarios. The BAU scenario estimates a maintainance in previous patterns of habitat loss (2002-2008), while in the GOV scenario registered habitat loss is projected to be halved, irrespectively of what is happening nearby the region. For example, an area isolated from roads and cities with 10000 ha may be expected to lose 1200 ha in the next ten years in the BAU scenario, however if the region held a previous loss of 3000 ha, a future loss of 1500 ha will be predicted under the GOV scenario (50% of reduction), therefore surpassing the loss expected under BAU.

Sadly, the raise in species uplisting to threatened categories when extending deforesting to a wider time frame (20 years), indicates that the longer is a species generation length, theoretically the higher its extinction risk in the Cerrado (Fig. 2). Ten years ago the Cerrado has been projected disappear in 2030 if no proper actions are taken (Machado *et al.*, 2004), and our data still point in the same catastrophic direction (Table 1). As this relation between species projected distributions and habitat losses was evident under both Watershed or Maxent mapping procedures, with no significant difference between total area lost, we conclude that as proposed by Nogueira *et al*. (2011), this uplisting is not a consequence of the chosen model or mapping technique, but rather the result of spatial coincidence of local richness, endemism and high levels of habitat loss.Such coincidence is clearly perceptible when we take in account that most reaclassified threatened species, including all CR, are concentrated in the southern part of the Cerrado. A consequence of the high richness in endemics with narrow modeled distributions in the Parana-Paraguay headwaters (Fig. 3), coupled with a high regional habitat loss, projected to continue in the future(Fig. 1).

Differences in future habitat loss within higher taxa depending on where each species' distribution was located, and the significantly diverging registered habitat losses among Tocantins-Serra Geral and Paraguay-Guaporé BEs from the Paraná-Paraguay BE (Fig. 4, Table 2) indicates that: the latter BE, located in the Southern region of the Cerrado, was and possibily will continue to be more heavily affected by deforestation (only 34% of BE 3 original coverage remains);and the Northern and North-Western parts of the ecoregion suffer less with this particular menace (81% of BE 1 original area still remains).

We chose species within BE for verifying loss patterns in the Cerrado so we could observe the effects of deforestation in biogeographical patterns (Carvalho *et al.*, 2011). The most emperilled detected BE has also the least protection by conservation units, while the least emperilled BE has the highest protection among all

(Appendix S3, Fig. 4c). Since historical factors are important to the formation of Squamate faunas (Vitt *et al.*, 2003; Mesquita *et al.*, 2006; Nogueira *et al.*, 2011), and assuming that these significantly similar range groups defined by BE are likely to share a common biogeographic history (Hausdorf, 2002), our data shows that we may be losing historical information in regions of the Cerrado in an accelerated pace along with its diversity, due to a non-random pattern of habitat loss and an unrepresentative distribution of conservation units throughout biogeographical patterns, a situation that we can't afford (Whittaker *et al.*, 2005).

As seems to happen worldwide (Pimm *et al.*, 1995) a gradual rise in the number of threatened species related to the expansion of anthropic occupation occurs in the Cerrado: the South region overlaps with Southeastern Brazil, the Country most populated region that harbours its three largest metropolitan regions (IBGE, 2010), and with our most imperiled BE; the Central region of the Cerrado co-occurs with a more recently occupied region of Brazil (Klink & Moreira, 2002), and we did not find significant difference between the BE located in this part of the Cerrado either when comparing with the most conserved BE 1 and 2, or the most endangered BE 3 (Fig. 4); finally the North, North-Western and Far Western regions are farther away from Brazilian economical centers than their Southern counterparts (IBGE, 2011) and are least emperilled.

Priority conservation areas

Crisis and Refugia areas detected herein are centered in the southernmost part of the Cerrado, close to each other (Fig. 5b), resembling a possible future gradient of habitat loss. However, Refugia areas have wider protection coverage than Crisis areas. The higher protection in Refugia appears to be a consequence of its coincidence with rocky parts of the region that overlap with rocky outposts, such as the Espinhaço range and the Chapada dos Guimarães (Scott *et al.*, 2001). While Crisis areas have most of their points overlapping with the poorly protected Paraná-Paraguay BE . Irreplaceable areas on the other hand are scattered (Fig. 5c). This distribution may be a consequence of the Cerrado endemic Squamate's tight association to specific microhabitats (Gainsbury & Colli, 2003; Mesquita *et al.*, 2006), and uneven distribution in habitat mosaics (Colli *et al.*, 2002; Nogueira *et al.*, 2005), with unique species spread throughout its area. Even though highly irreplaceable areas in North and Northeastern parts of the region partly overlap withthe single best protected BE, such irreplaceable areas are not properly covered by PAs, and therefore a future expansion of the protection areas in these regions is still needed (Cavalcanti, 1999; Bini *et al.*, 2006).

We conclude that previous decisions regarding the conservation of the Cerrado were probably based on scenic appealing landscapes or on regions (Espinhaço Range, Chapada dos Veadeiros and Chapada dos

Guimarães) that were not interesting at the moment for agriculture purposes (Cavalcanti *et al*., 1999), a scenario found globally (Margules & Pressey, 2000; Scott *et al.*, 2001, Brooks *et al.*, 2006). However, only recently a considerable continuous area of the Cerrado has been delimited as a protection area based on scientific reasoning: *Parque Nacional da Chapada das Mesas* (Brasil, 2005).

We point out the remaining areas in the central region of the Cerrado, the Espinhaço range, the triple frontier between Goiás, Mato Grosso do Sul and Mato Grosso and the region of Mato Grosso just above the Pantanal (all converging in terms of high species diversity, considerable irreplaceability) as immediate priority conservation areas, while highly irreplaceable areas should be used as guidance to future conservation initiatives. Species here classified or uplisted in IUCN's risk categories (Appendix S1) highlight critically endangered species as priorities, and their reassessment by experts must begin immediately, and include future habitat loss scenarios. Since high habitat losses and numbers of threatened species are expected to raise even following conservative scenarios, deforestation must immediately be reduced in all of Cerrado.

REFERENCES

Ab'Saber, A.N. (1977) Os domínios morfoclimáticos da América do Sul: Primeira aproximação. *Geomorfologia*. **52**, 1-22.

Bérnils, R.B. & Costa, H.C. (2012) Brazilian reptiles: List of species. Version 2012.2. Avaiable at: http://www.sbherpetologia.org.br/. Sociedade Brasileira de Herpetologia. Acessed in 15 December 2013.

Bini, L.M., Diniz-Filho, J.A.F., Rangel, T., Bastos, R.P. & Pinto, M.P. (2006) Challenging Wallacean and Linnean shortfalls: Knowledge gradientes and conservation planning in a biodiversity hotspot. *Diversity and Distributions*, **12**, 475-482.

Bird, J.P., Buchanan, G.M., Lees, A.C., Clay, R.P., Develey, P.F., Yépez, I & Butchart, H.M. (2011) Integrating spatially explicit projections into extinction risk assessments: a reassessment of Amazonian avifauna incorporating projected deforestation. *Diversity and distributions*, 1-9

Böhm, M., Collen, B., Baillie, J.E.M., *et al.* (2013) The conservation status of the world's reptiles. *Biological Conservation***,** **157**, 372-385.

Brasil (1965) Ministério da Agricultura, Instituto Brasileiro de Desenvolvimento Florestal. *Lei no. 4.771* (1965).

Brasil (2000) Presidência da República, Casa Civil, Subchefia para Assuntos Jurídicos. *Lei no. 9.985* (2000).

Brasil (2003) Ministéio do Meio Ambiente, Conselho Nacional de Recursos Hídricos. *Resolução no. 32* (2003).

Brasil (2005) Presidência da República, Casa Civil. *Decreto de 12 de Dezembro de 2005*. Avaiable at: http://www.planalto.gov.br/ccivil_03/_Ato2004-2006/2005/Dnn/Dnn10718.htm (accessed January 10th, 2013).

Brasil (2006) Mapa das áreas prioritárias para conservação, uso sustentável e repartição de benefícios da biodiversidade brasileira - 2006. Ministério do Meio Ambiente - MMA. Avaiable at: http://www.mma.gov.br/biodiversidade/biodiversidade-brasileira/%C3%A1reas-priorit%C3%A1rias. Acessed in October, 2013.

Brasil (2009) Plano de ação para prevenção e controle do desmatamento e das queimadas no Cerrado - PPCerrado. Ministério do Meio Ambiente - MMA, Brasília-DF. Avaiable at: http://siscom.ibama.gov.br/monitorabiomas/. Acessed in October, 2013.

Brasil (2012) Ministério da Agricultura, Instituto Brasileiro de Desenvolvimento Florestal, Lei Número 12.651, de 25 de Maio de 2012. Avaiable at: http://www.planalto.gov.br/ccivil_03/_Ato2011-2014/2012/Lei/L12651.htm#art83 (accessed January 10th, 2013).

Brasil (2013) Dados georeferenciados. Ministério do Meio Ambiente - MMA, Brasília-DF. Avaiable at: http://mapas.mma.gov.br/i3geo/datadownload.htm. Acessed in October, 2013.

Brooks, T.M., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A.B., Rylands, A.B., Konstant, W.R., Flick, P., Pilgrim, J., Oldfield, S., Magin, G. & Hilton-Taylor, C. (2002) Habitat loss and extinction in the hotspots of biodiversity. *Conservation Biology*, **16**, 909-923.

Brooks, T.M., Mittermeier, R.A., Fonseca, G.A.B., Gerlach, J., Hoffmann, M., Lamoreux, J.F., Mittermeier, C.G., Pilgrim, J.D., & Rodrigues, A.S.L. (2006) Global biodiversity conservation priorities. *Science*, **313**, 58-61.

Brown, J.H., Lomolino, M.V. (1998) *Biogeography*, 2nd ed. Sinauer Associates, Sunderland, MA, 691pp.

Carvalho, S.B., Brito, J.C., Crespo, E.J. & Possingham, H.P. (2011) Incorporating evolutionary processes into conservation planning using species distribution data: A case study with the western Mediterranean herpetofauna. *Diversity and Distrtibutions*, **17**, 408-421.

Cavalcanti, R.B. (Scientific Co-oridinator) (1999). Ações prioritárias para conservação da biodiversidade do Cerrado e Pantanal. *Ministério do Meio Ambiente, Furnatura, Conservation International, Fundação Biodiversitas, University of Brasília, Brazil*.

CBD (2013) Aichi Biodiversity Targets. *Conservation on Biological Diversity*. Avaiable at: http://www.cbd.int/sp/targets/ (accessed January 10th, 2013).

Chazdon, R.L., Harvey, C.A., Komar, O., Griffith, D.M., Ferguson, B.G., Martíne-Ramos, M., Morales, H., Nigh, R., Soto-Pinto, L., van Breugel, M. & Philpott, S.M. (2009) Beyond Reserves: A research agenda for conserving biodiversity in human-modified tropical landscapes. *Biotropica*, **41**, 142-153.

Cole (1986) *The Savannas*: *Biogeography and Geobotany*. Academic Press, London.

Collen, B., Ram, M., Dewhurst, N., Clausritzer,V., Kalkman, V., Cumberlidge, N. & Bailie, J.E.M. (2008) Broadening the coverage of biodiversity assessments. *The 2008 Review of the IUCN Red List of Threatened Species* (ed. by Vié, J.C., Hilton-Taylor, C. & Stuart, S.N.), Gland, Switzerland.

Colli, G.R., Bastos, R.P. & Araújo, A.F.B. (2002) The characters and dynamics of the Cerrado herpetofauna. *The Cerrados of Brazil: Ecology and Natural History of a Neotropical Savanna* (ed. by P.S. Oliveira and R.J. Marquis), pp. 223-241. Columbia University Press, New York.

Costa, G.C., Nogueira, C., Machado, R.B. & Colli, G.R. (2007) Squamate richness in the Brazilian Cerrado and its environmental-climatic associations. *Diversity and Distributions*, **13**, 714-724.

Costa, G.C., Nogueira, C., Machado, R.B. & Colli, G.R. (2010) Sampling bias and the use of ecological niche modeling in conservation planning: A field evaluation in a biodiversity hotspot. *Biodiversity Conservation*, **19**, 883-899.

Crawley, M.J. (2007) *The R Book*. Johny Wiley & Sons Ltd. The Atrium, Southern Gate, Chichester, West Sussex, England.

Crisci, J.V. (2001) The voice of historical biogeography. *Journal of biogeography*, **28**, 157-168.

Davies, R.G., Orme, C.D.L., Olson, V., Thomas, G.H., Ross, S.G., Ding, T., Rasmussen, P.C., Stattersfield, A.J., Bennet, P.M., Blackburn, T.M., Owens, I.P.F. & Gaston, K.J. (2006) Human impacts and the global distribution of extinction risk. *Proceedings of Biological Sciences*, **273**, 2127-2133.

Diniz-Filho, J.A.F., Bini, L.M., Oliveira, G., Barreto, B.S., Silva, M.M.F.P., Terribile, L.C., Rangel, T.F.L.V.B., Pinto, M.P., Sousa, N.P.R., Vieira, L.C.G., Melo, A.S., Marco Júnior, P., Vieira, C.M., Blamires, D., Bastos, R.P., Carvalho, P., Ferreira, L.G., Telles, M.P.C., Rodrigues, F.M., Silva, D.M., Silva Jr, N.J. & Soares, T.N. (2009) Macroecologia, Biogeografia e áreas prioritárias para conservação no Cerrado. *Oecologia Brasiliensis*, **13**, 470-497.

Dudley, N (Editor) (2008) *Guidelines for Applying Protected Area Management Categories*. Glando, Switzerland: IUCN. X+86pp.

Eastman, J.R. (2011). IDRISI Selva - Guide to GIS and Image Processing. (Worcester, MA: Clark Labs - Clark University), p. 284.

Eiten, G. (1972) The Cerrado vegetation of Brazil. *The Botanical Review*. **38**, 201-341.

Eken,G., Bennun, L., Brooks, Tm.M, Darwall, W., Fishpool, L.D.C., Foster, M., Knox,D., Langhammer, P., Matiku, P., Radford, E., Salaman, P., Sechrest, W., Smithm, M.L., Spector, S. & Tordoff, A. (2004) Key biodiversity areas as site conservation targets. *BioScience*, **54**, 1110-1118.

Elith, J. (2002) Quantitative methods for modeling species habitat: comparative performance and an application to Australian plants. *Quantitative methods for conservation biology* (ed. by Ferson, S. & Burgman, M.) pp.39-58.

Elith, J., Graham, C.H., Anderson, R.P., Dudik, 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., Soberon, J., Williams, S., Wisz, M.S. & Zimmermann, N.E. (2006) Novel methods improve prediction of species' distributions from occurrence data. *Ecography*, **29**, 129–151.

ESRI (2009) *ArcMap 9.3.1. ESRI*, Redlands, CA, USA.

Fahrig, L. (2003) Effects of habitat fragmentation on biodiversity. *Annual Review of Ecology Evolution and Systematics*, **34**, 487-515.

Faleiro, F.V., Machado, R.B. & Loyola, R.D. (2013) Defining spatial conservation priorities in the face of land-use and climate change. *Biological Conservation*, **158**, 248-257.

Fielding, A.H. & Bell, J.F. (1997) A review of methods for the assessment of prediction errors in conservation presence/absence models. *Environmental Conservation*, **24**, 38-49.

Gainsbury, A.M. & Colli, G.R. (2003) Lizard assemblages from natural Cerrado enclaves in southwestern Amazonia: the role of stochastic extinctions and isolation, **35**, 403-519.

Garcia, A. (2006) Using ecological niche modelling to identify diversity hotspots for the herpetofauna of Pacific lowlands and adjacent interior valleys of Mexico. *Biological Conservation,* **130**, 25-46.

Gaston, K.J. (1996) Species-range-size distributions: Patterns, mechanisms and implications. *Tree*, **11**, 197-201.

Gibbons, J.W., Scott, D.E., Ryan, T.J., Buhlmann, K.A., Tuberville, T.D., Metts, B.S., Greene, J.L., Mills, T., Leiden, Y., Poppy, S. & Winnie, C.T. (2000) The global decline of reptiles, déjà vu amphibians. *BioScience*, **50**, 653-666.

Greene, H.W. (1997) *Snakes: The Evolution of Mystery in Nature*. University of California Press, Berkley, CA.

Guedes, T.B., Sawaya, R.J. & Nogueira, C.C. (2014) Biogeography, vicariance, and conservation of snakes of the neglected and endangered Caatinga region, Northeastern Brazil. *Journal of Biogeography*.

Hausdorf, B. (2002) Units in biogeography. *Systematic Zoology*, **51**, 648-652.

Hausdorf, B. & Hennig, C. (2003) Biotic element analysis in biogeography. Systematic Biology, **52**, 717-723.

Hijmans, R.J., Cameron, S.E., Parra, J.L. *et al.* (2005) Very high resolution interpolated climate surfaces for global land áreas. *Internationa Journal of Climatology*, **25**, 2272-2281.

Hollander, M. & Wolfe, D.A. (1973) *Nonparametric Statistical Methods*. John Wiley & Sons, New York.

IBGE (2004) *Mapa de vegetação do Brasil*. Fundação Instituto Brasileiro de Geografia e Estatística – IBGE, Rio de Janeiro.

IBGE (2010) Censo demográfico 2010. *Instituto Brasileiro de Geografia e estatítistica – IBGE*, Rio de Janeiro. Avaiable at: http://www.ibge.gov.br/home/estatistica/populacao/censo2010/default.shtm (acessed in January 10th, 2014).

IBGE (2011) Produto Interno Bruto dos municípios 2011. *Instituto Brasileiro de Geografia e estatítistica – IBGE*, Rio de Janeiro. Avaiable at: http://www.ibge.gov.br/home/estatistica/economia/pibmunicipios/2011/default.shtm (acessed in January 10th, 2014).

IUCN (2001) IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Comission, *International Union for Conservation of Nature*, Gland, Switzerland and Cambridge, UK.

IUCN (2010) Guidelines for using the IUCN Red List Categories and Criteria: version 8.1. IUCN Species Survival Commission, *International Union for the Conservation of Nature*, Gland, Switzerland and Cambridge, UK.

IUCN (2014) Summary statistics for globally threatened species. *International Union for Conservation of Nature.* Avaiable at: http://www.iucnredlist.org/static/stats (accessed January 10th, 2014).

Klink, C.A., Moreira, A.G. (2002) Past and current human occupation, and land use. *The Cerrados of Brazil: Ecology and Natural History of a Neotropical Savanna* (ed. by P.S. Oliveira and R.J.Marquis), pp.69-88. Columbia University Press, New York, New York.

Klink, C.A. & Machado, R.B. (2005) Conservation of the Brazilian Cerrado. *Conservation Biology*, **19**, 707-713.

Ladle, R.J. & Whittaker, R.J. (2011) *Conservation Biogeography*, Oxford: Wiley-Blackwell, New York.

Loiselle, B.A., Howell, C.A., Graham, C.H., Goerck, J.M., Brooks, T., Smith, G.S. & Williams, P.H. (2003) Avoiding pitfalls of using species distribution models in conservation planning. *Conservation Biology*, **17**, 1591-1600.

Luoto, M., Pöyry, J., Heikkinen, R.K. & Saarinen, K. (2005) Uncertainty of bioclimate envelope models based on the geographical distribution of species. *Global Ecology and Biogeography*, **14**, 575-584.

Machado, R.B., Ramos Neto, M.B., Pereira, P., Caldas, E., Gonçalves, D, Santos, N., Tabor, K. & Steininger, M. (2004) Estimativas de perda da área do Cerrado brasileiro. *Conservation International do Brasil*, Brasília (in Portuguese).

Manel, S., Williams, H.C. & Ormerod, S.J (2001) Evaluating presence- absence models in ecology: The need to account for prevalence. *Journal of Applied Ecology*, **38**, 921-931.

Margules, C.R. & Pressey, R.L. (2000) Systematic conservation planning. *Nature*, **405**, 243-253.

McKinney, M.L. & Lockwood, J.L. (1999) Biotic homogenization: A few winners replacing many losers in the next mass extinction. *Tree*, **14**, 450-453.

Mesquita, D.O., Colli, G.R., Frederico, G.R., França, G.R. & Vitt, L.J. (2006) Ecology of a cerrado lizard assemblage in the Jalapão region of Brazil. *Copeia*, (3), 460-471.

Mittermeier, R.A., Robles Gil, P., Hoffmann, M. *et al.* (2004) *Hotspots Revised*, Mexico City, CEMEX.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B. & Kent, J. (2000) Biodiversity hotspots for conservation priorities. *Nature*, **403**, 853-858.

Myers, N. (2003) Biodiversity hotspots revised. *BioScience*, **53**, 916-917.

Nimer, E (1979) Climatologia do Brasil. Rio de Janeiro: IBGE.

Nogueira, C., Valdujo, P.H. & França, F.G.R. (2005) Habitat variation and lizard diversity in a Cerrado area of Central Brasil. *Studies on Neotropical Fauna and Environment*, 2005, **40**, 105-112.

Nogueira, C., Colli, G.R. & Martins, M. (2009) Local richness and distribution of the lizard fauna in natural habitat mosaics of the Brazilian Cerrado. *Austral Ecology*, **34**, 83-96.

Nogueira C., Buckup, P.A., Menezes, N.A., Oyakawa, O.T., Kasecker, T.P., Ramos Neto, M.B. & Silva, J.M.S. (2010) Restricted-range fishes and the conservation of Brazilian freshwaters. *Plos one*, **5**(6), e11390

Nogueira, C., Ribeiro, S, Costa, G.C. & Colli, G.R. (2011) Vicariance and endemism in a Neotropical savanna hotspot: Distribution patterns of Cerrado squamate reptiles. *Journal of Biogeography*, 1-16.

Oliveira, P.S. & Marquis, R.J. (2002) *The Cerrados of Brazil: Ecology and Natural History of a Neotropical Savanna.* Columbia University Press, New York.

Oliveira-Filho, P.S. & Ratter, J.A. (2002) Vegetation physiognomies and woody flora of the Cerrado. *The Cerrados of Brazil: Ecology and Natural History of a Neotropical Savanna* (ed. by P.S. Oliveira and R.J. Marquis), pp. 91-120. Columbia University Press, New York.

Peterson, A.T., Papeş, M. & Soberón, J. (2008) Rethinking receiber operating characteristic analysis applications in ecological niche modeling. *Ecological Modelling*, **213**, 63-72.

Pfafstetter (1987) Classificação de Bacias Hidrográficas. Rio de Janeiro, 18 de Agosto de 1989.

Phillips, S.J., Dudik, M. & Shapire, R.E. (2004) A maximum entropy approach to species distribution modeling. *Proceedings of the 21st International Conference on Machine Learning* (ed. by R.Greiner and D. Schuurmans) pp.655-662. ACM Press Banff, Canada.

Phillips, S.J., Anderson, R.P. & Schapire, R.E. (2006) Maximum entropy modeling of species geographic distributions. *Ecological Modelling*, **190**, 231-259.

Phillips, S.J. & Dudik, M. (2008) Modeling of species distributions with Maxent: new extensions and a comprehensive evaluation. *Ecography*, **31**, 161-175.

Pianka, E.R. & Vitt, L.J. (2003) *Lizards: windows to the evolution of diversity*. University of California Press, Berkeley, CA.

Pimm, S.L. & Raven, P. (2000) Biodiversity: Extinction by numbers. *Nature*, **403**, 843-845.

Pimm, S.L., Russell, G.J., Gittleman, J.L. & Brooks, T.M. (1995) The future of biodiversity. *Science*, **269**, 347-350.

PMDBBS (2013) Projeto de monitoramento do desmatamento dos biomas brasileiros por satélite. *Centro de Sensoriamento Remoto*, Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis. Avaiable at: http://siscom.ibama.gov.br/monitoradominios/index.htm (acessed July 17th, 2013)

Pullin (2002) *Conservation Biology*. Cambridge University Press, New York.

R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Ratter, J.A., Ribeiro, J.F. & Bridgewater, S. (1997) The Brazilian Cerrado vegetation and threats to its biodiversity. *Annals of Botany*, 80, 223-230.

Redford, K.H. (1985) Emas National Park and the plight of the Brazilian cerrados. *Oryx*, **19** (4), 210-214.

Sala, O.E., Chaping, F.S.I, Armesto, J.J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L.F., Jackson, R.B., Kinzig, A., Leemans, R., Lodge, D.M., Mooney, H.A., Oetersheld, M., Poff, N.L., Sykes, M.T., Walker, B.H., Walker, M., Wall, D.H. (2000) Global biodiversity scenarios for the year 2100. *Science*, **287**, 1770-1774.

Scott, J.M., Davis, F.W., McGhie, R.G., Wright, R.G., Groves, C. & Estes, J. (2001) Nature reserves: Do they capture the full range of America's biological diversity? *Ecological Applications*, **11**(4), 999-1007.

Siegel, S. & Castellan, N.J. (1988) *Nonparametric Statistics for the Behavioral Sciences*. McGraw-Hill, New York.

Silva, J.M.C. (1997) Endemic bird species and conservation in the Cerrado Region, South America. *Biodiversity and Conservation*, **6**, 435-450.

Silva, J.M.C. & Bates, J.M. (2002) Biogeographic patterns and conservation in the South American Cerrado: A tropical savanna hotspot. *BioScience*, **52**, 225-233.

Silva, J.F., Fariñas, M.R., Felfili, J.M. & Klink, C.A. (2006) Spatial heterogeneity, land use and conservation in the Cerrado region of Brazil. *Journal of Biogeography*, **33**, 536-548.

Valdujo, P.H., Silvan, D.L., Colli, G. & Martins, M. (2012) Anuran species composition and distirbution patterns in Brazilian Cerrado, a Neotropical hotspot. *South American Journal of Herpetology*, **7**, 63-78.

Vié, J-C., Hilton-Taylor, C. & Stuart, S.N. (eds.) (2008) *Wildlife in a Changing World – An Analysis of the 2008 IUCN Red List of Threatened Species.* Gland, Switzerland: IUCN. 180pp.

Vitt, L.J., Pianka, E.R., Cooper, W.E. & Schwenk, K. (2003) History and the global ecology of squamate reptiles. *The American Naturalist*, **162,** 44-60.

Warton, D.I. & Hui, F.K.C. (2011) The arcsine in asinine: The analysis of proportions in Ecology. *Ecology*, **92**, 3-10.

Whittaker, R.J., Araújo, M.B., Jepson, P., Ladle, R.J., Watson, J.E.M. & Willis, K.J. (2005) Conservation biogeography: assessment and prospect. *Diversity and distributions*, **11**, 3-23.

Wilcox B.A. & Murphy, D.D. (1985) Conservation Strategy: The effects of fragmentation on extinction. *The American Naturalist*, **125**, 879-887.

Table 1 Cerrado habitat loss patterns in different time frames and scenarios (Business as usual, (BAU) and Governance, (GOV)); OR: original area of Cerrado vegetation (according to the limits in IBGE (2004)): Total area: Cerrado's total original area; LPY 2002: Loss per year starting in 2002; OR (%): Percentage of original area loss; LPY(%).: Percentage loss per year.

	OR[1]	**2002[1]**	**2008[1]**	**2010[1]**	**GOV2020**	**GOV2030**	**BAU2020**	**BAU2030**
Total area	2.039,386	1.136,521	1.051,182	1.037,076	922,056	836,627	772,269	597,016
LPY2002	-	-	14,223	12,430	11,914	10,710	20,236	19,268
OR%	0%	44%	48%	49%	55%	59%	62%	71%
LPY2002%	-	-	1.25%	1.09%	1.04%	0.94%	1.78%	1.69%

Table 2 Habitat loss until 2010 and potential threatened species, considering the timeframe between 2010 and 2020 in BAU scenario for both A4c and B1 ab(i,iii) categories, in each Biotic element for Cerrado Squamate Reptiles. OR: Original area; R2010 Remaining area in 2010; Loss 2010 (%): Percetual loss until 2010; Critically, Endangered, Vulnerable and total threatened species for each one.

BE	Denomination	OR	R2010	Loss 2010 (%)	CR	EN	VU	Total
1	Tocantins-Serra Geral	248,102	163,541.74	34%	-	-	5	5
2	Paraguay-Guaporé	84,539	35,072.96	59%	-	2	3	5
3	Paraná-Paraguay	266,988	51,662.8	81%	4	5		9
4	Guimarães-Roncador	310,142	124,735.84	60%	-	1	6	7
5	Espinhaço	100,530	50,827.73	49%	-	-	7	7
6	Araguaia	299,891	134,191	55%	-	2	3	5
7	Central Plateau	234,991	105,113.28	55%	-	-	3	3

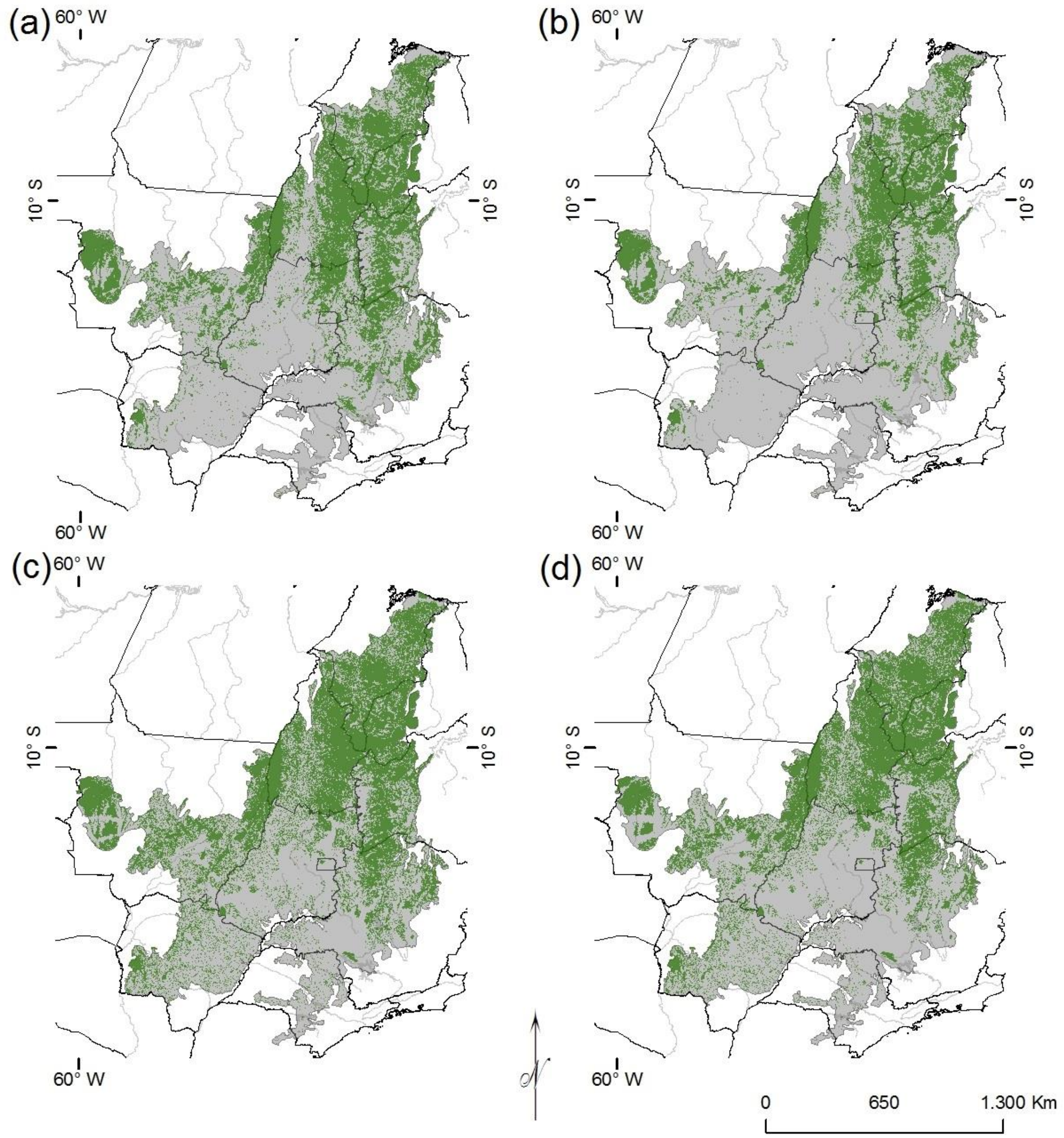

Figure 1. Projected Cerrado remaining areas in: (a) BAU scenario for 2020; (b) BAU scenario for 2030; (c) GOV scenario for 2020; (d) GOV scenario for 2030;

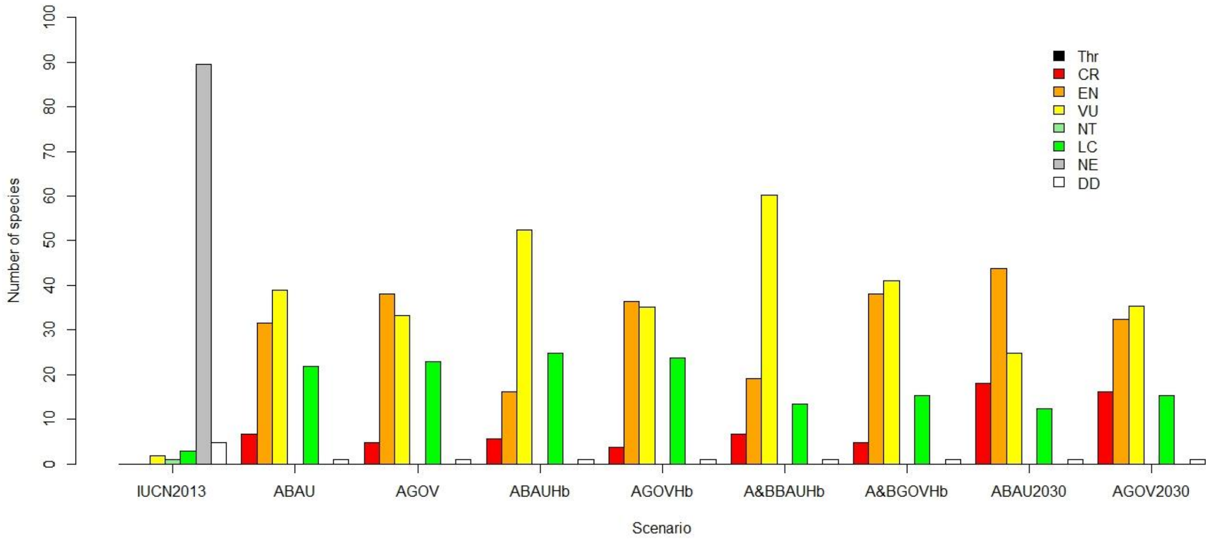

Figure 2. Number of species in each of IUCN categories through different scenarios. Categories: Thr-Threatened; CR-Critically endangere; EN-Endangered; VU-Vulnerable; NT-Near Threatened; LC-Least Concern; NE-Not Evaluated; DD-Data Deficient. Scenarios: IUCN2013-Species' risk categories in 2014; A-Only criteria A4c was used; BAU-Business as Usual; GOV-Governance; Hb-Habitat uncertainty applied; A&B-Categories A4c and B1a,b(i,iii) were applied; 2030-Generation length uncertainty was applied.

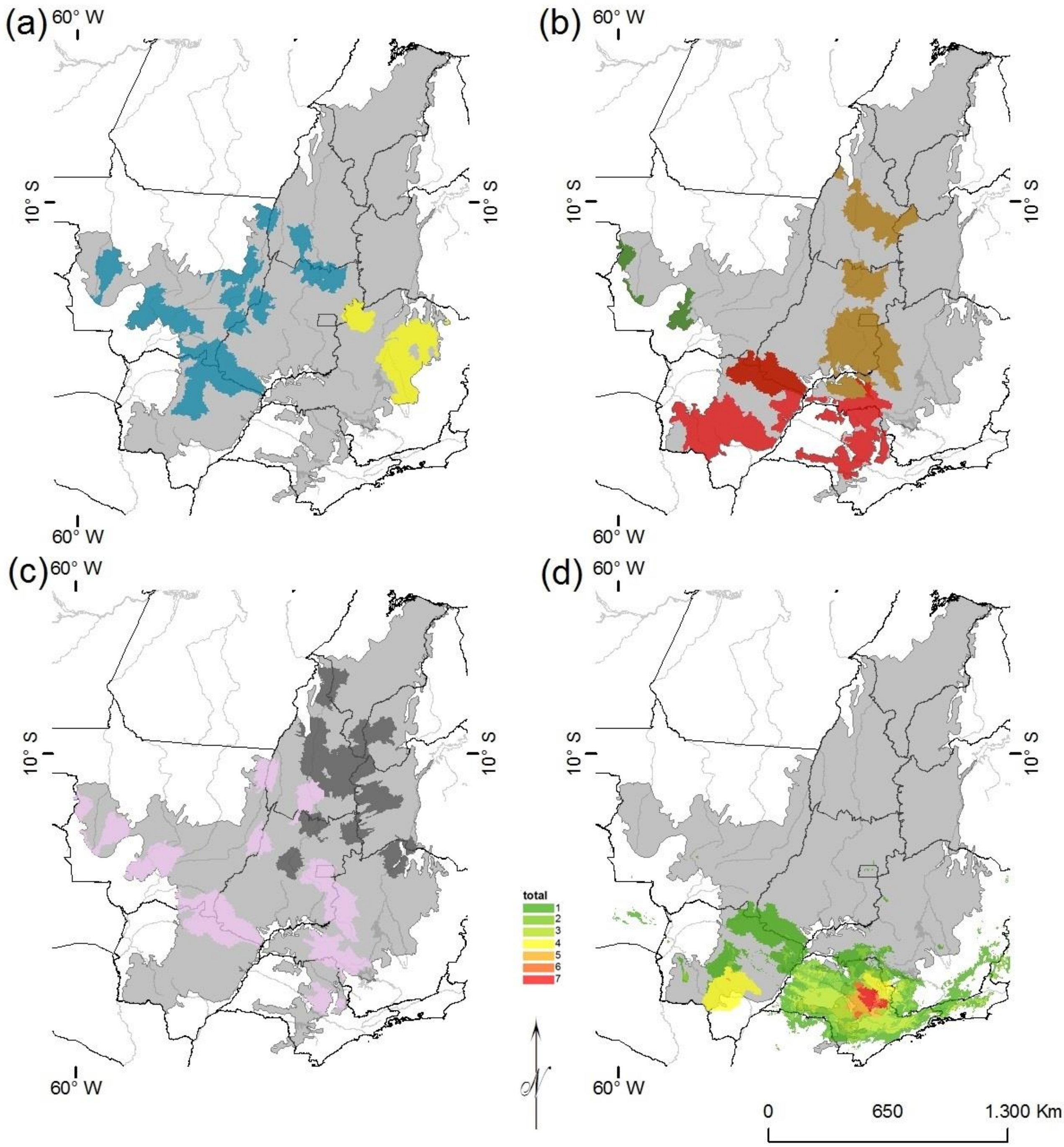

Figure 3. Biotic Elements areas based on their species expected distribution through the watershed approach. From (a) to (c) Blue- Araguaia; Yellow- Espinhaço; Green- Paraguay-Guarporé; Red- Paraná-Paraguay; Brown- Central Plateau; Dark Grey- Tocantins-Serra Geral; Pink- Guimarães-Roncador. (d) The overlapped distribution of all reassessed Critically Endangered species, warmer colors indicates a higher number of species predicted to co-occur.

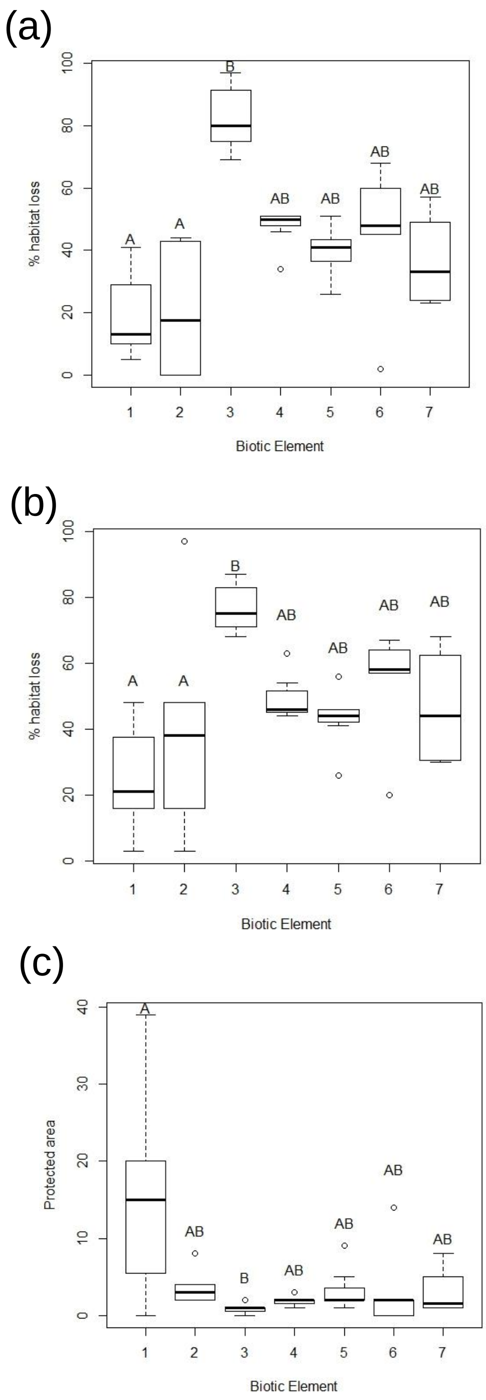

Figure 4. Percentage of habitat loss per Biotic Element (1-7): (A) Until 2010; (B) Between 2010-2020; and (C) Species' percentage of overlapping protected areas and species. Horizontal bars = median; box = first and third quartiles; whiskers = minimum and maximum values. Common letters indicate non-significant differences.

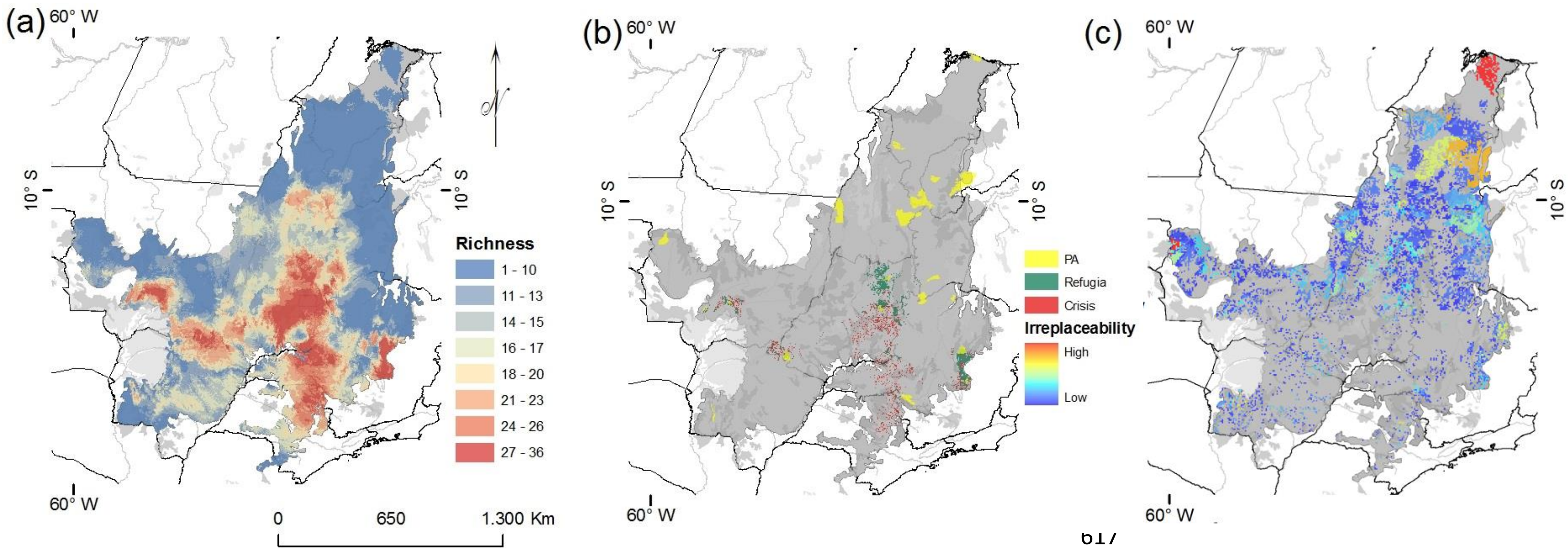

Figure 5. Maps of endemic richness and crisis, refugia and irreplaceab;e areas in the Cerrado (a) Endemic richness based on the overlap of species expected distributions **-** warmer colors indicate a greater predicted co-occurrence of species; (b) Protected aread (Pas, yellow), Refugia (green) , and Crisis areas (red); (c) Highly Irreplaceable Areas, **-** warmer colors indicate higher values of irreplaceability.

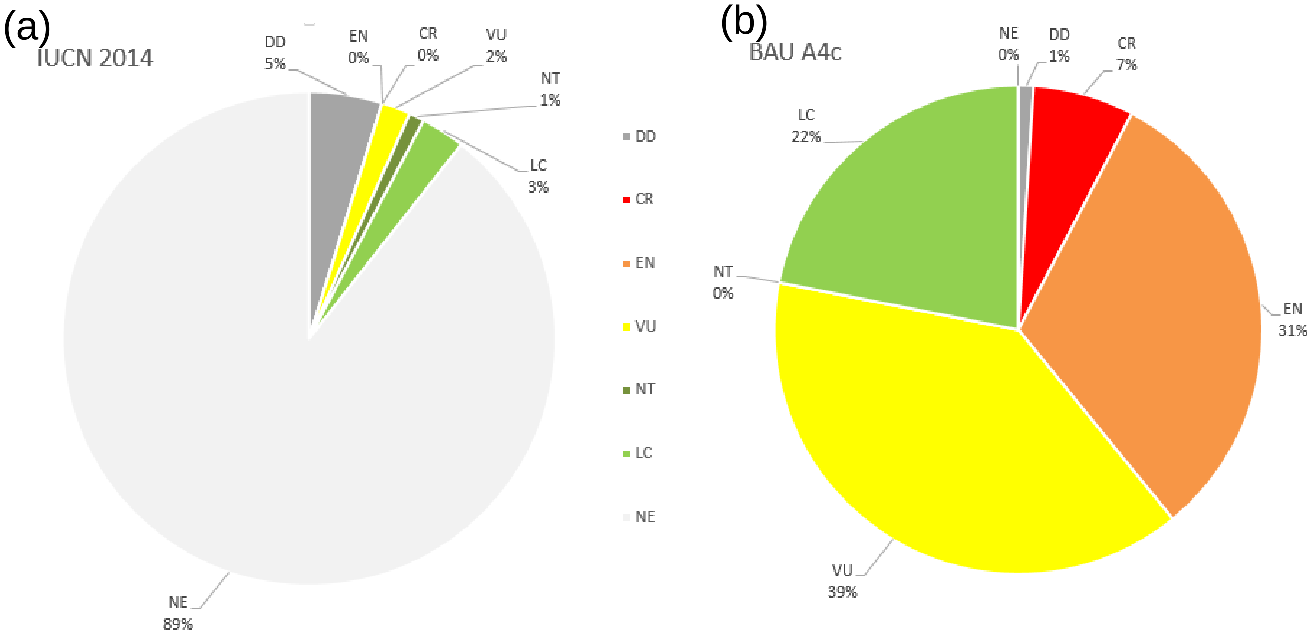

Figure 6. Comparison of the species risk categories in current IUCN redlist (a), and our least alarming reassessment results (b) in IUCN's standard graphic representation of such criteria distribution.

SUPPORTING INFORMATION

Additional Suporting Information may be found in the online version of this article:

Data S1 Background to Materials and Methods

Appendix S1 Species' areas, percentages of habitat loss and IUCN categories

Appendix S2 Biotic Element's species' areas, protection areas and habitat losses

Appendix S3 Area loss comparison within biotic elements

Data S1 Supporting Information; Background to Materials and Methods.

The International Union for the Conservation of Nature (IUCN) Red List

The IUCN's Red List is a worldwide accepted compilation of endangered and not-endangered species obtained through standardized methods (Rodrigues *et al.*, 2006; Mace *et al.*, 2008; IUCN, 2001, 2010), that not only rank species risks through categories, but also highlights what threatens them and in what proportion (IUCN, 2001; Mace *et al*., 2008). Therefore the IUCN RedList helps decision makers in where to prioritize conservation actions by indicating where help seems to be most urgently needed (Rodrigues *et al*., 2006). Not coincidently a recent essay in the conservation status of the world's reptiles (Bohm *et al.*, 2013) uses IUCN's extinction risk criteria to assess the global group panorama.

However not until recently a new "breach" in the IUCN's criteria was formally published in the guidelines to using IUCN Categories and Criteria (IUCN, 2010). And in Criteria A4 in IUCN's point 5.7 "Relationship between loss of habitat and population reduction" the organization states that a reduction in population size may be based on a projected decline in area of occupancy, extent of occurrence and/or quality of habitat (IUCN, 2010). To our knowledge no studies have used this approach for Squamate endemic species in the Cerrado to date. We used the criteria A4 to interpret modeled prediction of Cerrado area losses within species ranges and assign appropriate categories of extinction to individual species under different scenarios and assumptions (*see* Bird *et al.*, 2011) (see *Methods*).

Dealing with uncertainty

As pointed out by Bird *et al*. (2011) in their appendix Data S1, there are several sources of uncertainty in our estimates of population declines: (a) inaccurate generation length estimates; (b) omission and commission errors in the species range maps and the extent of suitable habitat we identified; (c) non-linear/non-directly-proportional population responses to deforestation, particularly where deforestation renders species susceptible to additional factors e.g. hunting and edge effects; etc. However, we hereby provide more background to, and justification for our assumptions and adjustments which we think my render reductions in possible errors and account for uncertainty.

Omission and commission errors in species' range maps and model evaluation

Threshold choice to transform continuous to presence/absence outputs is crucial in SDM and must be done according to the research objectives (Fielding & Bell. 1997; Liu *et al.*, 2013). We aim that our expected presences contain only the highest values in the continuous probability outputs, while reducing omission rates as much as possible. To do so we chose to apply a 10 percentile training presence threshold, i.e. the threshold value corresponds to the model probability where 90% of the occurrence records with the highest model probabilities are presences (*see* Carvalho *et al*., 2011).

Still, threshold delimitations were not enough with species that held few locality points. We obtained inconsistent model outputs with the Maxent approach to these species. It is normal for Maxent outputs not to take in account physical barriers or distances when indicating potential distribution areas (Phillps *et al.*, 2004, 2006). But in our data species with few points tended to be distributed through wide portions of the Cerrado, frequently occupying all of its extension. Therefore, to avoid over-prediction we estimated distribution areas for species with 10 or less points through our Species' watershed based potential distribution method, because it is centered in its registered point localities and still points out as a refined option in species area distribution (Nogueira *et al*., 2010).

When evaluating model results we used the Area Underneath the Receiver-Operating Characteristic (ROC) Curve (AUC) (Hanley & McNeil, 1982; Fielding & Bell, 1997; Manel et al., 2011). AUC measures the ability of a model to discriminate between sites where species are present, versus were they are absent (Elith *et al*.,2006). It is an indicated measure for presence-only algorithms due to its ability to discriminate between proper environmental conditions and random background pixels (Pearson *et al.*, 2006; but see Luoto *et al.*, 2005 and Peterson *et al.*, 2008 for critics).

Biotic element analysis

Biotic element analysis is based on the central assumption that, if vicariant processes fragmented ancestral ranges, groups of significantly clustered and non-random species ranges should emerge and be detectable (Hausdorf, 2002; Hausdorf & Hennig, 2003). It consists of a series of tests in which non-random congruence in species ranges is verified through tests to determine significant spatial clustering (Hausdorf & Hennig, 2004). If there is a significant non-random congruence in species ranges, BEs are than determined through a distance matrix (*see* Hausdorf & Hennig, 2003 for mathematical details).

SUPPORTING REFERENCES

Bird, J.P., Buchanan, G.M., Lees, A.C., Clay, R.P., Develey, P.F., Yépez, I & Butchart, H.M. (2011) Integrating spatially explicit projections into extinction risk assessments: A reassessment of Amazonian avifauna incorporating projected deforestation. *Diversity and Distributions*, 1-9.

Böhm, M., Collen, B., Baillie, J.E.M., Bowles, P., *et al*. (2013) The conservation status of the world's reptiles. *Biological Conservation*, **157**, 372-385.

Carvalho, S.B., Brito, J.C., Crespo, E.J. & Possingham, H.P. (2011) Incorporating evolutionary processes into conservation planning using species distribution data: A case study with the western Mediterranean herpetofauna. *Diversity and Distrtibutions*, **17**, 408-421.

Elith, J., Graham, C.H., Anderson, R.P., Dudik, 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., Soberon, J., Williams, S., Wisz, M.S. & Zimmermann, N.E. (2006) Novel methods improve prediction of species' distributions from occurrence data. *Ecography*, **29**, 129–151.

Fielding, A.H., Bell, J.F. (1997) A review of methods for the assessment of prediction errors in conservation presence/absence models. *Environmental Conservation*, **24**, 38-49.

Hanley, J.A. & McNeil, B.J. (1982) The meaning and use of the area under a receiver operating characteristic (ROC) curve. *Radiology*, **143**, 29-36.

Hausdorf, B. (2002) Units in biogeography. *Systematic Zoology*, **51**, 648-652.

Hausdorf, B. & Hennig, C. (2003) Biotic element analysis in biogeography. *Systematic Biology*, **52**, 717-723.

Hausdorf, B. & Hennig, C. (2004) Distance-based parametric bootstrap tests for clustering of species ranges. *Computational Statistics and Data Analysis*, 45, 875–895.

IUCN (2001) IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Comission. *International Union for the Conservation of Nature*, Gland, Switzerland and Cambridge, UK.

IUCN (2010) Guidelines for using the IUCN Red List Categories and Criteria: version 8.1. IUCN Species Survival Commission, *International Union for the Conservation of Nature*, Gland, Switzerland and Cambridge, UK.

Liu, C., White, M. & Newell, G. (2013) Selecting thresholds for the prediction of species occurrence with presence-only data. *Journal of Biogeography*, 1-12.

Luoto, M., Pöyry, J., Heikkinen, R.K. & Saarinen, K. (2005) Uncertainty of bioclimate envelope models based on the geographical distribution of species. *Global Ecology and Biogeography*, **14**, 575-584.

Mace, G.M., Collar, N.J, Gaston, K.J., Hilton-Taylor, C., Akçakaya, H.R., Leader-Williams, N., Milner-Gulland, E.J. & Stuart, S.N. (2008) Quantification of extinction risk: IUCN's system for classifying threatened species. *Conservation Biology*, **22**, 1424-1442.

Manel, S., Williams, H.C. & Ormerod, S.J (2001) Evaluating presence- absence models in ecology: The need to account for prevalence. *Journal of Applied Ecology*, **38**, 921-931.

Nogueira C., Buckup, P.A., Menezes, N.A., Oyakawa, O.T., Kasecker, T.P., Ramos Neto, M.B. & Silva, J.M.S. (2010) Restricted-range fishes and the conservation of Brazilian freshwaters. *Plos One*, **5**(6), e11390.

Pearson, R.G., Thuiller,W., Araújo, M.B., Martinez-Meyer, E., Brotons, L., McClean, C., Miles, L., Segurado, P., Dawson, T.P & Lees, D.C (2006) Model-Based uncertainty in species range prediction. *Journal of Biogeography*, **33**, 1704-1711.

Peterson, A.T., Papeş, M. & Soberón, J. (2008) Rethinking receiber operating characteristic analysis applications in ecological niche modeling. *Ecological Modelling*, **213**, 63-72.

Phillips, S.J., Dudik, M. & Shapire, R.E. (2004) A maximum entropy approach to species distribution modeling. *Proceedings of the 21st International Conference on Machine Learning* (ed. by Greiner, R. & Schuurmans, D.) pp.655-662. ACM Press Banff, Canada.

Phillips, S.J., Anderson, R.P. & Schapire, R.E. (2006) Maximum entropy modeling of species geographic distributions. *Ecological Modeling*, **190**, 231-259.

Rodrigues, A.S.L., Pilgrim, J.D., Lamoreux, J.F., Hoffmann, J. & Brooks, T.M. (2006) The value of the IUCN Red List for Conservation. *Trends in Ecology and Evolution*, **21**(2), 71-76.

Appendix S1 Species areas, percentage of loss and IUCN categories**.** Group: amp **-** amphisbaenians; liz **-** lizards ; ser **-** serpents. Species. Pts.: Number of locality points for each species. BE: Biotic Element ; Habitat type as defined by Nogueira et al. (2011): O **-** Open ; F **-** Florest ; R **-** Riparian; ? **-** Unknown. G.U.: Geomorphological Unit as defined by Nogueira et al. (2011); P **-** Plateaus (above 500m) ; D **-** Depressions (under 500m) ; G **-** Generalists (species found at both units). PA: Number of Protection Areas in which each species is found. PAC: Protected Area Coverage calculated by the sum of the areas included in PA. OR: Species estimated ranges in original intact Cerrado (in km²). 2000: Species estimated ranges for the Cerrado in 2000 (in km²). 2002 Species estimated ranges for the Cerrado in 2002 (in km²). 2010: Expected species distribution in the Cerrado in the year 2010 (in km²). 2020: Expected species distribution in the Cerrado in the year 2010 (in km²). BAU2020: Expected species distribution in the Cerrado in the year 2020 according to the BAU scenario (in km²). BAU2030: Expected species distribution in the Cerrado in the year 2030 according to the BAU scenario (in km²). GOV2020: Expected species distribution in the Cerrado in the year 2020 according to the GOV scenario (in km²). GOV2030: Expected species distribution in the Cerrado in the year 2030 according to the GOV scenario (in km²). Species with an "*" had their losses multiplied by 0.8 (*see* Methods).

Group	**Species**	**Pts.**	**BE**	**Habitat**	**G.U.**	**PA**	**PA Area**	**OR**	**2000**	**2002**	**2010**	**BAU2020**	**BAU2030**	**GOV2020**	**GOV2030**
liz	*Ameiva parecis* (Colli et al., 2003)	1	2	O	P	2	1438	9179	9055	9024	8902	8610	8443	7536	6270
liz	*Ameivula jalapensis* (Colli et al., 2009)	2	1	O	P	0	0	21330	20675	20492	19757	18592	17785	19004	18800
liz	Ameivula mumbuca (Colli et al., 2003)	2	x	O	P	7	1267	31991	30142	29852	28694	25895	23781	25366	23776
amp	*Amphisbaena absaberi* (Strussmann & Carvalho, 2001)	1	2	O	D	0	0	8944	5400	5243	4618	2566	1649	3111	3046
amp	*Amphisbaena acrobeles* (Ribeiro et al., 2009)	1	1	O	D	9	4738	15800	15791	15692	15296	14531	14343	15000	14995
amp	*Amphisbaena anaemariae* Vanzolini, 1997	9	x	O	P	13	14286	159552	52588	51305	46175	15110	8707	10506	6183
amp	*Amphisbaena bedai* (Vanzolini, 1991)	3	3	?	D	1	258	46720	15903	15303	12904	3176	1635	6196	6106
amp	*Amphisbaena brevis* Strussmann & Mott, 2009	1	4	?	D	1	258	21790	14123	13732	12169	6124	3448	7987	7292
amp	*Amphisbaena carli* Pinna et al., 2010	2	x	?	P	2	5528	18163	13201	12525	9820	6952	5545	6519	5615
amp	*Amphisbaena crisae* Vanzolini, 1997	4	x	O	G	14	26406	86439	43343	42681	40033	25309	23916	28724	27868
amp	*Amphisbaena cuiabana* (Strussmann & Carvalho, 2001)	3	4	O	D	10	19391	43277	27430	26763	24097	15823	12310	16278	12490
amp	*Amphisbaena ibijara* Rodrigues et al., 2003	1	NA	?	D	15	32262	18322	17950	17414	15271	9629	8201	10467	10467
amp	*Amphisbaena kraoh* (Vanzolini, 1971)	4	1	?	G	2	6728	55355	45647	44416	39493	31359	26998	33740	32724

amp	*Amphisbaena leeseri* Gans, 1964	6	3	O	D	1	1202	47231	15955	15359	12972	3206	1635	6137	6047
amp	*Amphisbaena mensae* Castro-Mello, 2000	8	7	O	P	0	0	95267	46364	45302	41055	24189	16929	12055	7730
amp	*Amphisbaena miringoera* Vanzolini, 1971	2	6	?	D	3	75	12482	10021	10003	9931	9712	9712	9931	9931
amp	*Amphisbaena neglecta* Dunn & Piatt, 1936	1	4	?	P	3	0	14220	8367	8147	7266	3542	2033	4655	4311
amp	*Amphisbaena sanctaeritae* Vanzolini, 1974	1	3	?	P	1	281	19145	2854	2778	2475	72	11	357	223
amp	*Amphisbaena saxosa* (Castro-Mello, 2003)	1	1	?	D	2	3205	18298	12224	11793	10065	6156	3994	7021	6064
amp	*Amphisbaena silvestrii* Boulenger, 1902	18	6	O	D	13	3149	120904 5	75584 3	73676 8	66046 6	448975	375779	469816	438944
amp	*Amphisbaena steindachneri* Strauch, 1881	4	2	?	D	15	32262	10840	7997	7827	7146	4880	3801	3804	3095
amp	*Amphisbaena talisiae* Vanzolini, 1995	1	x	?	D	2	5952	13207	6001	5750	4748	1412	669	2136	1884
ser	*Apostolepis albicolaris* Lema, 2002	18	7	O	P	1	290	161915	71057	69541	63480	35284	26469	14119	7444
ser	*Apostolepis ammodites* Ferrarezzi et al., 2005	29	x	O	G	2	1493	555565	33983 4	33106 1	29596 7	197540	159894	184444	163280
ser	*Apostolepis assimilis* (Reinhradt, 1861)	94	x	O	P	13	13652	296518	86470	84245	75345	28976	18543	15022	8849
ser	*Apostolepis cerradoensis* Lema, 2003	2	7	?	P	4	7563	18439	13759	13568	12808	9668	7063	5909	4067
ser	*Apostolepis christineae* Lema, 2002	2	2	?	D	22	40768	12720	8428	8221	7394	4187	2465	5089	4861
ser	*Apostolepis dimidiata* (Jan, 1862)	3	5	O	P	2	4297	16705	10121	9902	9026	4953	3067	1927	1099
ser	*Apostolepis flavotorquata** (Duméril et al., 1854)	25	x	F	G	2	9414	714182	40022 5	38944 5	34632 9	219685	175948	214419	190266
ser	*Apostolepis goiasensis* Prado, 1942	4	x	?	P	0	0	96935	33897	32978	29303	12433	8441	7442	4872
ser	*Apostolepis intermedia* Koslowsky, 1898	1	3	?	D	3	1051	20205	7817	7531	6387	1976	1251	3405	3344
ser	*Apostolepis lineata* Cope, 1887	1	4	?	P	3	419	18860	11969	11620	10225	5043	2779	6643	6020
ser	*Apostolepis longicaudata* Amaral, 1921	3	1	O	G	1	316	52520	48164	47151	43100	37581	34349	39425	38748
ser	*Apostolepis nelsonjorgei* Lema & Renner, 2004	7	7	?	P	0	0	85067	67154	65598	59372	45625	36990	44105	39700
ser	*Apostolepis polylepis* Amaral, 1921	3	1	O	G	4	1315	55705	52606	51476	46955	42898	40524	44083	43536
ser	*Apostolepis serrana* Lema & Renner, 2006	1	6	?	P	15	11683	20709	8344	8160	7425	2344	903	3382	2376
ser	*Apostolepis striata* Lema, 2004	0	2	O	P	1	398	-	-	-	-	-	-	-	-
ser	*Apostolepis vittata* (Cope, 1887)	1	4	?	G	1	378	18860	11969	11620	10225	5043	2779	6643	6020
ser	*Atractus albuquerquei* Cunha & Nascimento, 1983	11	6	O	D	0	0	115170 8	72534 8	70703 7	63379 4	426423	351637	438694	399088
ser	*Atractus edioi* Silva Jr et al., 2005	1	x	?	D	3	1914	17500	12601	12409	11644	8794	6879	6384	5101

liz	*Bachia bresslaui* (Amaral, 1935)	4	x	O	G	1	255	76263	27318	26533	23391	7437	3785	6850	5109
liz	*Bachia cacerensis** Castrillon & Strussmann, 1998	2	2	F	D	13	22560	57873	1802	1791	1746	1746	1746	1631	1505
liz	*Bachia didactyla* Freitas et al., 2011	2	2	O	P	12	6010	4829	4102	4092	4055	4055	4055	3660	2952
liz	*Bachia geralista* Teixeira *et al., 2013*	3	x	?	?	0	0	55724	41517	40302	35442	27252	22604	28237	26309
liz	*Bachia micromela* Rodrigues et al., 2007	1	x	O	D	1	281	11392	8826	8535	7369	4554	3242	5439	5310
liz	*Bachia oxyrhina* Rodrigues et al., 2008	5	1	O	P	8	9531	36186	33827	33153	30455	27146	24715	27157	25752
liz	*Bachia psamophila* Rodrigues et al., 2007	1	x	O	D	1	378	21207	13557	13130	11424	6434	4297	7816	6904
ser	*Bothrops itapetiningae (*Boulenger, 1907)	86	x	O	P	0	0	86780	12585	12264	10980	1527	653	2012	1555
ser	*Bothrops marmoratus* Silva & Rodrigues, 2008	16	x	O	G	1	352	545383	301088	292815	259721	161220	123085	136286	112014
ser	*Bothrops moojeni** Hoge, 1966	117	x	F	G	12	6523	651955	241864	235235	208719	95674	68248	88366	75538
ser	*Bothrops neuwiedi* Wagler, 1824	24	x	O	P	6	3046	122097	38026	37296	34375	16621	11535	5622	3859
ser	*Bothrops pauloensis* Amaral, 1925	68	x	O	P	6	1195	537526	144947	140689	123653	37874	22790	34964	27638
liz	*Cercosaura schreibersii albostrigata** (Griffin, 1917)	18	x	F	D	3	1821	407095	175839	171849	155890	82227	61223	54591	39425
ser	*Chironius flavolineatus* (*Jan, 1863)	44	x	F	G	3	9738	1128609	482129	468866	415814	215747	154390	203096	161433
ser	*Chironius quadricarinatus* (Boie, 1827)	65	x	O	G	0	0	617141	208597	202859	179906	75610	50039	65748	53276
liz	*Coleodactylus brachystoma** (Amaral, 1935)	14	x	F	G	13	8677	1209045	755843	736768	660466	448975	375779	469016	438944
ser	*Drymoluber brazili* (Gomes, 1918)	33	x	O	P	10	556	798691	293793	286356	256607	120493	84177	97362	70547
ser	*Epicrates crassus* Cope, 1862	276	x	O	G	8	4806	586998	212350	206011	180658	80654	57728	88770	74657
ser	*Epictia clinorostris* Arredondo & Zaher, 2010	2	x	?	?	11	10757	29713	13934	13586	12191	5875	3893	7677	6797
ser	*Erythrolamprus frenatus** (Werner, 1909)	22	3	F	G	1	378	149364	27077	26093	22157	3079	1425	7401	7081
ser	*Erythrolamprus maryellenae* (Dixon, 1985)	11	x	O	P	15	25806	947189	548458	534569	479014	313976	254180	294231	254868
liz	*Eurolophosaurus nanuzae* (Rodrigues, 1981)	6	5	O	P	1	316	31644	20642	20227	18566	12184	8836	6045	4191
liz	*Gymnodactylus amarali* Barbour, 1925	45	x	O	G	3	3596	853679	560267	545597	486916	345137	290849	355539	338228
liz	*Gymnodactylus guttulatus* Vanzolini, 1982	1	5	O	P	1	352	17026	13378	13222	12598	9352	7433	4262	3250
liz	*Heterodactylus lundii* Reinhardt & Luetken, 1862	3	x	O	P	2	3095	54976	25193	24585	22151	12005	7335	6915	5380
liz	*Hoplocercus spinosus** Fitzinger, 1843	43	x	F	D	1	258	1168229	585720	569671	505475	296215	235547	312626	279109

ser	*Hydrodynastes melanogigas** Franco et al., 2007	3	1	R	D	1	1732	29319	19429	18801	16290	9611	6657	11453	10348
liz	*Kentropyx paulensis* Boettger, 1893	21	x	O	G	1	398	666056	236130	229824	204596	88497	56217	68632	47406
liz	*Kentropyx vanzoi* Gallagher & Dixon, 1980	13	x	O	D	13	23730	348184	233844	228188	205563	129660	104997	141528	124623
amp	*Leposternon cerradensis* Ribeiro et al., 2008	1	x	?	P	1	387	29888	8149	7920	7007	1599	1183	2485	1996
amp	*Leposternon maximus* Ribeiro et al., 2011	3	x	?	?	13	7195	45560	34004	33106	29512	21866	17717	20957	18538
ser	*Liotyphlops schubarti* Vanzolini, 1948	3	x	?	P	14	7100	36999	11	11	11	11	11	11	11
ser	*Lygophis paucidens* (Hoge, 1953)	20	x	O	G	2	1388	588453	367704	358361	320986	220375	181686	210869	190707
liz	*Manciola guaporicola* (Dunn, 1935)	20	4	O	G	7	3819	503528	210754	205732	185643	94677	73860	86354	75968
liz	*Micrablepharus atticolus* Rodrigues, 1996	33	x	O	G	10	15085	1015501	521231	507692	453537	265141	203789	252518	209196
ser	*Micrurus brasiliensis* Roze, 1967	10	1	O	G	1	255	98330	60208	58326	50796	33217	23832	31872	26023
ser	*Micrurus tricolor* Hoge, 1956	7	x	?	D	0	0	53485	21317	20610	17783	6723	4789	10083	9948
ser	*Mussurana quimi* (Franco et al., 1998)	5	x	O	D	3	11282	104800	29826	29073	26059	6615	3695	7117	5484
liz	*Norops meridionalis* (Boettger, 1885)	48	x	O	P	9	5299	1058025	487638	475054	424716	236539	184037	233108	202982
ser	*Phalotris concolor* Ferrarezzi, 1994	3	x	O	P	8	9866	51128	12471	12211	11171	7865	5502	7266	5550
ser	*Phalotris labiomaculatus* Lema, 2002	4	1	O	D	0	0	44999	35826	34856	30974	23849	20514	25857	24866
ser	*Phalotris lativittatus* Ferrarezzi, 1994	50	x	O	P	2	1240	54901	7806	7628	6917	608	292	778	599
ser	*Phalotris matogrossensis** Lema et al., 2005	23	x	F	D	0	0	361646	93592	90566	78464	19385	12426	34033	32296
ser	*Phalotris multipunctatus* Puorto & Ferrarezi, 1994	3	3	?	P	1	255	49916	8880	8513	7047	180	16	1523	1395
ser	*Phalotris nasutus* (Gomes, 1915)	26	x	O	P	4	504	744846	330380	321821	287586	145781	102251	125754	93128
ser	*Philodryas livida* (Amaral, 1923)	15	3	O	P	3	6773	58435	8294	8083	7236	1109	549	2100	1716
liz	*Placosoma cipoense* Cunha, 1966	1	5	O	P	1	680	14631	9235	9028	8201	4790	2998	1908	1099
ser	*Rhachidelus brazili* Boulenger, 1908	21	x	O	P	1	316	267142	57509	55955	49738	13016	7088	10802	7811
liz	*Rhachisaurus brachylepis* (Dixon, 1974)	3	5	O	P	5	1826	30468	16430	15829	13425	6576	3858	4146	2684
liz	*Salvator duseni* (Lonnberg, 1910)	9	x	O	P	0	0	181952	93541	91411	82890	53225	45107	47479	42228
ser	*Siagonodon acutirostris* Pinto & Curcio, 2011	3	x	?	?	9	5988	45095	42078	41273	38051	33941	30848	34110	32446
ser	*Simophis rhinostoma* (Schlegel, 1837)	67	x	O	P	9	6063	578783	182981	178244	159300	64091	42395	40013	23523
liz	*Stenocercus quinarius* Nogueira & Rodrigues, 2006	13	x	O	P	1	628	1146988	689899	672560	603205	395540	315683	387238	339010

liz	*Stenocercus sinesaccus** Torres-Carjaval, 2005	6	4	F	D	14	14397	95387	49105	48064	43903	23587	17899	26661	23418
ser	*Tantilla boipiranga* Sawaya & Sazima, 2003	1	5	O	P	2	465	14250	9160	8954	8127	4770	2994	1908	1099
ser	*Trilepida brasiliensis* (Laurent, 1949)	5	1	O	G	0	0	72807	64784	63313	57430	50103	43941	50244	47173
ser	*Trilepida fuliginosa* (Passos et al., 2006)	5	x	O	D	1	1213	95010	61826	60299	54192	35685	26035	32554	27520
ser	*Trilepida koppesi* (Amaral, 1955)	7	3	O	G	2	8301	131248	30816	29837	25920	3700	1697	8132	7009
liz	*Tropidurus insulanus* Rodrigues, 1987	2	6	O	D	2	3185	2330	1217	1126	761	303	239	397	397
liz	*Tropidurus itambere* Rodrigues, 1987	57	x	O	P	15	4498	572098	194040	188941	168547	71182	46347	61442	47766
liz	*Tropidurus montanus* Rodrigues, 1987	16	5	O	P	1	316	26622	16904	16675	15760	10774	8353	3517	2650
liz	*Tupinambis quadrilineatus** Manzani & Abe, 1997	24	x	F	D	3	2297	859858	546473	532767	477945	327419	270928	339487	310181
ser	*Xenodon matogrossensis** (Scrocchi & Cruz, 1993)	13	x	F	D	0	0	59827	26221	25437	22302	9144	7100	13464	13464
ser	*Xenodon nattereri* (Steindachner, 1867)	54	x	O	G	16	407	525447	154617	150541	134238	50676	35208	51222	43019
ser	*Xenopholis undulatus** (Jensen, 1900)	19	x	F	P	18	28287	761838	284150	276421	245506	109605	72227	85153	56305

Appendix S1 Species areas, percentage of loss and IUCN categories**.** Group: amp **-** amphisbaenians; liz **-** lizards ; ser **-** serpents. Species. Loss OR-2000 (%): Species' percentage expected original distribution cover lost until the year 2000. Loss 2000-2010 (%): Species' expected area loss between the years 2000 and 2010. Loss OR-2000 (%): Species' percentage expected original distribution cover lost until the year 2010. Loss OR-2020 (%): Species' percentage expected original distribution cover lost until the year 2020 according to BAU scenario. Loss 2010-2020 (%): Species' expected area loss between the years 2010 and 2020 according to the BAU scenario. Loss 2010-2030 (%): Species' expected area loss between the years 2010 and 2030 according to the BAU scenario. GOV loss 2010-2020 (%): Species' expected area loss between the years 2010 and 2020 according to the GOV scenario. GOV loss 2010-2030 (%): Species' expected area loss between the years 2010 and 2030 according to the GOV scenario. Species with an "*" had their losses multiplied by 0.8 (*see* Methods).

Group	Species	Loss OR-2000 (%)	Loss 2000-2010 (%)	Loss OR - 2010 (%)	Loss OR - 2020 (%)	Loss 2010-2020 (%)	Loss 2010-2030 (%)	GOV Loss 2010-2020 (%)	GOV Loss 2010-2030 (%)
liz	*Ameiva parecis* (Colli et al., 2003)	1,35%	1,68%	3,02%	6,20%	3,28%	5,16%	15,35%	29,57%
liz	*Ameivula jalapensis* (Colli et al., 2009)	3,07%	4,44%	7,37%	12,84%	5,90%	9,98%	3,81%	4,85%
liz	Ameivula mumbuca (Colli et al., 2003)	5,78%	4,80%	10,31%	19,06%	9,76%	17,12%	11,60%	17,14%
amp	*Amphisbaena absaberi* (Strussmann & Carvalho, 2001)	39,63%	14,47%	48,37%	71,31%	44,44%	64,29%	32,64%	34,05%
amp	*Amphisbaena acrobeles* (Ribeiro et al., 2009)	0,06%	3,14%	3,19%	8,03%	5,01%	6,23%	1,94%	1,97%
amp	*Amphisbaena anaemariae* Vanzolini, 1997	67,04%	12,19%	71,06%	90,53%	67,28%	81,14%	77,25%	86,61%
amp	*Amphisbaena bedai* (Vanzolini, 1991)	65,96%	18,86%	72,38%	93,20%	75,39%	87,33%	51,98%	52,68%
amp	*Amphisbaena brevis* Strussmann & Mott, 2009	35,19%	13,83%	44,15%	71,90%	49,68%	71,67%	34,37%	40,08%
amp	*Amphisbaena carli* Pinna et al., 2010	27,32%	25,61%	45,93%	61,72%	29,21%	43,53%	33,62%	42,83%
amp	*Amphisbaena crisae* Vanzolini, 1997	49,86%	7,64%	53,69%	70,72%	36,78%	40,26%	28,25%	30,39%
amp	*Amphisbaena cuiabana* (Strussmann & Carvalho, 2001)	36,62%	12,15%	44,32%	63,44%	34,34%	48,91%	32,45%	48,17%
amp	*Amphisbaena ibijara* Rodrigues et al., 2003	2,03%	14,93%	16,65%	47,45%	36,94%	46,29%	31,46%	31,46%
amp	*Amphisbaena kraoh* (Vanzolini, 1971)	17,54%	13,48%	28,66%	43,35%	20,60%	31,64%	14,57%	17,14%
amp	*Amphisbaena leeseri* Gans, 1964	66,22%	18,70%	72,53%	93,21%	75,29%	87,39%	52,69%	53,39%

amp	*Amphisbaena mensae* Castro-Mello, 2000	51,33%	11,45%	56,91%	74,61%	41,08%	58,77%	70,64%	81,17%
amp	*Amphisbaena miringoera* Vanzolini, 1971	19,72%	0,89%	20,44%	22,19%	2,21%	2,21%	0,00%	0,00%
amp	*Amphisbaena neglecta* Dunn & Piatt, 1936	41,16%	13,15%	48,90%	75,09%	51,25%	72,03%	35,94%	40,67%
amp	*Amphisbaena sanctaeritae* Vanzolini, 1974	85,09%	13,26%	87,07%	99,62%	97,10%	99,57%	85,56%	90,99%
amp	*Amphisbaena saxosa* (Castro-Mello, 2003)	33,19%	17,66%	44,99%	66,36%	38,84%	60,32%	30,25%	39,75%
amp	*Amphisbaena silvestrii* Boulenger, 1902	37,48%	12,62%	45,37%	62,87%	32,02%	43,10%	28,87%	33,54%
amp	*Amphisbaena steindachneri* Strauch, 1881	26,23%	10,63%	34,08%	54,98%	31,72%	46,81%	46,77%	56,68%
amp	*Amphisbaena talisiae* Vanzolini, 1995	54,56%	20,87%	64,05%	89,31%	70,26%	85,92%	55,01%	60,33%
ser	*Apostolepis albicolaris* Lema, 2002	56,11%	10,66%	60,79%	78,21%	44,42%	58,30%	77,76%	88,27%
ser	*Apostolepis ammodites* Ferrarezzi et al., 2005	38,83%	12,91%	46,73%	64,44%	33,26%	45,98%	37,68%	44,83%
ser	*Apostolepis assimilis* (Reinhradt, 1861)	71,59%	65,60%	74,59%	90,23%	36,01%	48,16%	69,46%	88,26%
ser	*Apostolepis cerradoensis* Lema, 2003	25,38%	6,91%	30,54%	47,57%	24,52%	44,85%	53,87%	68,25%
ser	*Apostolepis christineae* Lema, 2002	33,74%	12,27%	41,87%	67,08%	43,37%	66,67%	31,18%	34,26%
ser	*Apostolepis dimidiata* (Jan, 1862)	39,41%	10,82%	45,97%	70,35%	45,12%	66,02%	78,64%	87,83%
ser	*Apostolepis flavotorquata** (Duméril et al., 1854)	35,17%	10,77%	51,51%	69,24%	29,25%	39,36%	30,47%	36,05%
ser	*Apostolepis goiasensis* Prado, 1942	65,03%	13,55%	69,77%	87,17%	57,57%	71,19%	74,60%	83,37%
ser	*Apostolepis intermedia* Koslowsky, 1898	61,31%	18,30%	68,39%	90,22%	69,05%	80,40%	46,69%	47,65%
ser	*Apostolepis lineata* Cope, 1887	36,54%	14,57%	45,78%	73,26%	50,68%	72,82%	35,03%	41,13%
ser	*Apostolepis longicaudata* Amaral, 1921	8,29%	10,52%	17,94%	28,44%	12,80%	20,30%	8,53%	10,10%
ser	*Apostolepis nelsonjorgei* Lema & Renner, 2004	21,06%	11,59%	30,21%	46,37%	23,15%	37,70%	25,71%	33,13%
ser	*Apostolepis polylepis* Amaral, 1921	5,56%	10,74%	15,71%	22,99%	8,64%	13,70%	6,12%	7,28%
ser	*Apostolepis serrana* Lema & Renner, 2006	59,71%	11,01%	64,15%	88,68%	68,43%	87,85%	54,45%	68,00%
ser	*Apostolepis striata* Lema, 2004	-	-	-	-	-	-	-	-
ser	*Apostolepis vittata* (Cope, 1887)	36,54%	14,57%	45,78%	73,26%	50,68%	72,82%	35,03%	41,13%
ser	*Atractus albuquerquei* Cunha & Nascimento, 1983	37,02%	12,62%	44,97%	62,97%	32,72%	44,52%	30,78%	37,03%
ser	*Atractus edioi* Silva Jr et al., 2005	28,00%	7,59%	33,46%	49,75%	24,47%	40,92%	45,17%	56,19%
liz	*Bachia bresslaui* (Amaral, 1935)	64,18%	14,38%	69,33%	90,25%	68,21%	83,82%	70,72%	78,16%
liz	*Bachia cacerensis** Castrillon & Strussmann, 1998	77,51%	2,50%	96,98%	96,98%	0,00%	0,00%	5,28%	11,03%
liz	*Bachia didactyla* Freitas et al., 2011	15,06%	1,13%	16,03%	16,03%	0,00%	0,00%	9,73%	27,20%

liz	*Bachia geralista* Teixeira *et al., 2013*	25,50%	14,63%	36,40%	51,09%	23,11%	36,22%	20,33%	25,77%
liz	*Bachia micromela* Rodrigues et al., 2007	22,52%	16,51%	35,31%	60,02%	38,20%	56,00%	26,19%	27,95%
liz	*Bachia oxyrhina* Rodrigues et al., 2008	6,52%	9,97%	15,84%	24,98%	10,86%	18,85%	10,83%	15,44%
liz	*Bachia psamophila* Rodrigues et al., 2007	36,07%	15,73%	46,13%	69,66%	43,68%	62,38%	31,58%	39,57%
ser	*Bothrops itapetiningae (*Boulenger, 1907)	85,50%	12,75%	87,35%	98,24%	86,09%	94,06%	81,68%	85,84%
ser	*Bothrops marmoratus* Silva & Rodrigues, 2008	44,79%	13,74%	52,38%	70,44%	37,93%	52,61%	47,53%	56,87%
ser	*Bothrops moojeni** Hoge, 1966	50,32%	10,96%	67,99%	85,33%	43,33%	53,84%	46,13%	51,05%
ser	*Bothrops neuwiedi* Wagler, 1824	68,86%	9,60%	71,85%	86,39%	51,65%	66,44%	83,64%	88,77%
ser	*Bothrops pauloensis* Amaral, 1925	73,03%	14,69%	77,00%	92,95%	69,37%	81,57%	71,72%	77,65%
liz	*Cercosaura schreibersii albostrigata** (Griffin, 1917)	45,45%	9,08%	61,71%	79,80%	37,80%	48,58%	51,99%	59,77%
ser	*Chironius flavolineatus* (Jan, 1863)	45,82%	11,00%	63,16%	80,88%	38,49%	50,30%	40,93%	48,94%
ser	*Chironius quadricarinatus* (Boie, 1827)	66,20%	13,75%	70,85%	87,75%	57,97%	72,19%	63,45%	70,39%
liz	*Coleodactylus brachystoma** (Amaral, 1935)	29,99%	10,09%	45,37%	62,87%	25,62%	34,48%	23,19%	26,83%
ser	*Drymoluber brazili* (Gomes, 1918)	63,22%	12,66%	67,87%	84,91%	53,04%	67,20%	62,06%	72,51%
ser	*Epicrates crassus* Cope, 1862	63,82%	14,92%	69,22%	86,26%	55,36%	68,05%	50,86%	58,67%
ser	*Epictia clinorostris* Arredondo & Zaher, 2010	53,10%	12,51%	58,97%	80,23%	51,81%	68,06%	37,03%	44,25%
ser	*Erythrolamprus frenatus** (Werner, 1909)	65,50%	14,54%	85,17%	97,94%	68,88%	74,86%	53,28%	54,43%
ser	*Erythrolamprus maryellenae* (Dixon, 1985)	42,10%	12,66%	49,43%	66,85%	34,45%	46,94%	38,58%	46,79%
liz	*Eurolophosaurus nanuzae* (Rodrigues, 1981)	34,77%	10,06%	41,33%	61,50%	34,38%	52,41%	67,44%	77,43%
liz	*Gymnodactylus amarali* Barbour, 1925	34,37%	13,09%	42,96%	59,57%	29,12%	40,27%	26,98%	30,54%
liz	*Gymnodactylus guttulatus* Vanzolini, 1982	21,43%	5,83%	26,01%	45,07%	25,76%	41,00%	66,17%	74,20%
liz	*Heterodactylus lundii* Reinhardt & Luetken, 1862	54,17%	12,07%	59,71%	78,16%	45,80%	66,89%	68,78%	75,71%
liz	*Hoplocercus spinosus** Fitzinger, 1843	39,89%	10,96%	56,73%	74,64%	33,12%	42,72%	30,52%	35,83%
ser	*Hydrodynastes melanogigas** Franco et al., 2007	26,99%	12,92%	44,44%	67,22%	32,80%	47,31%	23,76%	29,18%
liz	*Kentropyx paulensis* Boettger, 1893	64,55%	13,35%	69,28%	86,71%	56,75%	72,52%	66,45%	76,83%
liz	*Kentropyx vanzoi* Gallagher & Dixon, 1980	32,84%	12,09%	40,96%	62,76%	36,92%	48,92%	31,15%	39,37%
amp	*Leposternon cerradensis* Ribeiro et al., 2008	72,74%	14,01%	76,56%	94,65%	77,19%	83,12%	64,54%	71,52%
amp	*Leposternon maximus* Ribeiro et al., 2011	25,36%	13,21%	35,22%	52,01%	25,91%	39,97%	28,99%	37,18%
ser	*Liotyphlops schubarti* Vanzolini, 1948	99,97%	0,00%	99,97%	99,97%	0,00%	0,00%	0,00%	0,00%

ser	*Lygophis paucidens* (Hoge, 1953)	37,51%	12,71%	45,45%	62,55%	31,34%	43,40%	34,31%	40,59%
liz	*Manciola guaporicola* (Dunn, 1935)	58,14%	11,91%	63,13%	81,20%	49,00%	60,21%	53,48%	59,08%
liz	*Micrablepharus atticolus* Rodrigues, 1996	48,67%	12,99%	55,34%	73,89%	41,54%	55,07%	44,32%	53,87%
ser	*Micrurus brasiliensis* Roze, 1967	38,77%	15,63%	48,34%	66,22%	34,61%	53,08%	37,26%	48,77%
ser	*Micrurus tricolor* Hoge, 1956	60,14%	16,58%	66,75%	87,43%	62,20%	73,07%	43,30%	44,06%
ser	*Mussurana quimi* (Franco et al., 1998)	71,54%	12,63%	75,13%	93,69%	74,61%	85,82%	72,69%	78,96%
liz	*Norops meridionalis* (Boettger, 1885)	53,91%	12,90%	59,86%	77,64%	44,31%	56,67%	45,11%	52,21%
ser	*Phalotris concolor* Ferrarezzi, 1994	75,61%	10,42%	78,15%	84,62%	29,59%	50,74%	34,96%	50,31%
ser	*Phalotris labiomaculatus* Lema, 2002	20,38%	13,54%	31,17%	47,00%	23,00%	33,77%	16,52%	19,72%
ser	*Phalotris lativittatus* Ferrarezzi, 1994	85,78%	11,39%	87,40%	98,89%	91,21%	95,78%	88,75%	91,34%
ser	*Phalotris matogrossensis** Lema et al., 2005	59,30%	12,93%	78,30%	94,64%	60,24%	67,33%	45,30%	47,07%
ser	*Phalotris multipunctatus* Puorto & Ferrarezi, 1994	82,21%	20,64%	85,88%	99,64%	97,44%	99,77%	78,38%	80,21%
ser	*Phalotris nasutus* (Gomes, 1915)	55,64%	12,95%	61,39%	80,43%	49,31%	64,45%	56,27%	67,62%
ser	*Philodryas livida* (Amaral, 1923)	85,81%	12,75%	87,62%	98,10%	84,68%	92,42%	70,98%	76,29%
liz	*Placosoma cipoense* Cunha, 1966	36,88%	11,19%	43,95%	67,26%	41,60%	63,44%	76,73%	86,60%
ser	*Rhachidelus brazili* Boulenger, 1908	78,47%	13,51%	81,38%	95,13%	73,83%	85,75%	78,28%	84,30%
liz	*Rhachisaurus brachylepis* (Dixon, 1974)	46,07%	18,29%	55,94%	78,42%	51,01%	71,27%	69,12%	80,01%
liz	*Salvator duseni* (Lonnberg, 1910)	48,59%	11,39%	54,44%	70,75%	35,79%	45,58%	42,72%	49,06%
ser	*Siagonodon acutirostris* Pinto & Curcio, 2011	6,69%	9,57%	15,62%	24,73%	10,80%	18,93%	10,36%	14,73%
ser	*Simophis rhinostoma* (Schlegel, 1837)	68,39%	12,94%	72,48%	88,93%	59,77%	73,39%	74,88%	85,23%
liz	*Stenocercus quinarius* Nogueira & Rodrigues, 2006	39,85%	12,57%	47,41%	65,51%	34,43%	47,67%	35,80%	43,80%
liz	*Stenocercus sinesaccus** Torres-Carjaval, 2005	38,82%	8,47%	53,97%	75,27%	37,02%	47,38%	31,42%	37,33%
ser	*Tantilla boipiranga* Sawaya & Sazima, 2003	35,72%	11,28%	42,97%	66,53%	41,31%	63,17%	76,52%	86,48%
ser	*Trilepida brasiliensis* (Laurent, 1949)	11,02%	11,35%	21,12%	31,18%	12,76%	23,49%	12,51%	17,86%
ser	*Trilepida fuliginosa* (Passos et al., 2006)	34,93%	12,35%	42,96%	62,44%	34,15%	51,96%	39,93%	49,22%
ser	*Trilepida koppesi* (Amaral, 1955)	76,52%	15,89%	80,25%	97,18%	85,72%	93,45%	68,63%	72,96%
liz	*Tropidurus insulanus* Rodrigues, 1987	47,75%	37,47%	67,34%	87,00%	60,20%	68,57%	47,91%	47,91%
liz	*Tropidurus itambere* Rodrigues, 1987	66,08%	13,14%	70,54%	87,56%	57,77%	72,50%	63,55%	71,66%
liz	*Tropidurus montanus* Rodrigues, 1987	36,50%	6,77%	40,80%	59,53%	31,63%	47,00%	77,68%	83,19%

liz	*Tupinambis quadrilineatus** Manzani & Abe, 1997	29,16%	10,03%	44,42%	61,92%	25,20%	34,65%	23,18%	28,08%
ser	*Xenodon matogrossensis** (Scrocchi & Cruz, 1993)	44,94%	11,96%	62,72%	84,72%	47,20%	54,53%	31,70%	31,70%
ser	*Xenodon nattereri* (Steindachner, 1867)	70,57%	13,18%	74,45%	90,36%	62,25%	73,77%	61,84%	67,95%
ser	*Xenopholis undulatus** (Jensen, 1900)	50,16%	10,88%	67,77%	85,61%	44,28%	56,46%	52,25%	61,65%

Appendix S1 Species areas, percentage of loss and IUCN categories**.** Group: amp **-** amphisbaenians; liz **-** lizards ; ser **-** serpents. Species. IUCN 2000-2010: Species categorization in IUCN's redlist criteria according to its' expected population losses from 2000 until 2010. IUCN 2010-2020: Species categorization in IUCN's redlist criteria according to its' expected population losses from 2010 until 2020 according to the BAU scenario. IUCN 2010-2030: Species categorization in IUCN's redlist criteria according to its' expected population losses from 2010 until 2030 according to the BAU scenario. IUCN GOV 2010-2020: Species categorization in IUCN's redlist criteria according to its' expected population losses from 2010 until 2020 according to the BAU scenario according to the GOV scenario. IUCN GOV 2010-2030: Species categorization in IUCN's redlist criteria according to its' expected population losses from 2010 until 2030 according to the BAU scenario according to the GOV scenario. Species with an "*" had their losses multiplied by 0.8 (*see* Methods).

Group	**Species**	**IUCN 2000-2010**	**IUCN 2010-2020**	**IUCN 2010-2030**	**IUCN 2010**	**IUCN GOV 2010-2020**	**IUCN GOV 2010-2030**
liz	*Ameiva parecis* (Colli et al., 2003)				VU B1 ab(i,iii)		
liz	*Ameivula jalapensis* (Colli et al., 2009)				VU B1 ab(i,iii)		
liz	Ameivula mumbuca (Colli et al., 2003)						
amp	*Amphisbaena absaberi* (Strussmann & Carvalho, 2001)		VU A4c	EN A4c	EN B1 ab(i,iii)	VU A4c	VU A4c
amp	*Amphisbaena acrobeles* (Ribeiro et al., 2009)				VU B1 ab(i,iii)		
amp	*Amphisbaena anaemariae* Vanzolini, 1997		EN A4c	CR A4c		EN A4c	CR A4c
amp	*Amphisbaena bedai* (Vanzolini, 1991)		EN A4c	CR A4c	VU B1 ab(i,iii)	EN A4c	EN A4c
amp	*Amphisbaena brevis* Strussmann & Mott, 2009		VU A4c	EN A4c	VU B1 ab(i,iii)	VU A4c	VU A4c
amp	*Amphisbaena carli* Pinna et al., 2010			VU A4c	VU B1 ab(i,iii)	VU A4c	VU A4c
amp	*Amphisbaena crisae* Vanzolini, 1997		VU A4c	VU A4c			VU A4c
amp	*Amphisbaena cuiabana* (Strussmann & Carvalho, 2001)		VU A4c	VU A4c		VU A4c	VU A4c
amp	*Amphisbaena ibijara* Rodrigues et al., 2003		VU A4c	VU A4c	VU B1 ab(i,iii)	VU A4c	VU A4c
amp	*Amphisbaena kraoh* (Vanzolini, 1971)			VU A4c			
amp	*Amphisbaena leeseri* Gans, 1964		EN A4c	CR A4c	VU B1 ab(i,iii)	EN A4c	EN A4c
amp	*Amphisbaena mensae* Castro-Mello, 2000		VU A4c	EN A4c		EN A4c	CR A4c
amp	*Amphisbaena miringoera* Vanzolini, 1971				VU B1 ab(i,iii)		
amp	*Amphisbaena neglecta* Dunn & Piatt, 1936		VU A4c	EN A4c	VU B1 ab(i,iii)	VU A4c	VU A4c

amp	*Amphisbaena sanctaeritae* Vanzolini, 1974		CR A4c	CR A4c	EN B1 ab(i,iii)	CR A4c	CR A4c
amp	*Amphisbaena saxosa* (Castro-Mello, 2003)		VU A4c	EN A4c	VU B1 ab(i,iii)	VU A4c	VU A4c
amp	*Amphisbaena silvestrii* Boulenger, 1902		VU A4c	VU A4c			VU A4c
amp	*Amphisbaena steindachneri* Strauch, 1881		VU A4c	VU A4c	VU B1 ab(i,iii)	VU A4c	EN A4c
amp	*Amphisbaena talisiae* Vanzolini, 1995		EN A4c	CR A4c	EN B1 ab(i,iii)	EN A4c	EN A4c
ser	*Apostolepis albicolaris* Lema, 2002		VU A4c	EN A4c		EN A4c	CR A4c
ser	*Apostolepis ammodites* Ferrarezzi et al., 2005		VU A4c	VU A4c		VU A4c	VU A4c
ser	*Apostolepis assimilis* (Reinhradt, 1861)	EN A4c	VU A4c	VU A4c		EN A4c	CR A4c
ser	*Apostolepis cerradoensis* Lema, 2003			VU A4c	VU B1 ab(i,iii)	EN A4c	EN A4c
ser	*Apostolepis christineae* Lema, 2002		VU A4c	EN A4c	VU B1 ab(i,iii)	VU A4c	VU A4c
ser	*Apostolepis dimidiata* (Jan, 1862)		VU A4c	EN A4c	VU B1 ab(i,iii)	EN A4c	CR A4c
ser	*Apostolepis flavotorquata** (Duméril et al., 1854)			VU A4c		VU A4c	VU A4c
ser	*Apostolepis goiasensis* Prado, 1942		VU A4c	EN A4c		EN A4c	CR A4c
ser	*Apostolepis intermedia* Koslowsky, 1898		EN A4c	CR A4c	VU B1 ab(i,iii)	VU A4c	VU A4c
ser	*Apostolepis lineata* Cope, 1887		VU A4c	EN A4c	VU B1 ab(i,iii)	VU A4c	VU A4c
ser	*Apostolepis longicaudata* Amaral, 1921						
ser	*Apostolepis nelsonjorgei* Lema & Renner, 2004			VU A4c			VU A4c
ser	*Apostolepis polylepis* Amaral, 1921						
ser	*Apostolepis serrana* Lema & Renner, 2006		EN A4c	CR A4c	VU B1 ab(i,iii)	EN A4c	EN A4c
ser	*Apostolepis striata* Lema, 2004	-	-	-	-	-	-
ser	*Apostolepis vittata* (Cope, 1887)		VU A4c	EN A4c	VU B1 ab(i,iii)	VU A4c	VU A4c
ser	*Atractus albuquerquei* Cunha & Nascimento, 1983		VU A4c	VU A4c		VU A4c	VU A4c
ser	*Atractus edioi* Silva Jr et al., 2005			VU A4c	VU B1 ab(i,iii)	VU A4c	EN A4c
liz	*Bachia bresslaui* (Amaral, 1935)		EN A4c	CR A4c		EN A4c	EN A4c
liz	*Bachia cacerensis** Castrillon & Strussmann, 1998				EN B1 ab(i,iii)		
liz	*Bachia didactyla* Freitas et al., 2011				EN B1 ab(i,iii)		
liz	*Bachia geralista Teixeira et al., 2013*			VU A4c			
liz	*Bachia micromela* Rodrigues et al., 2007		VU A4c	EN A4c	VU B1 ab(i,iii)		
liz	*Bachia oxyrhina* Rodrigues et al., 2008						

liz	*Bachia psamophila* Rodrigues et al., 2007	VU A4c	EN A4c	VU B1 ab(i,iii)	VU A4c	VU A4c
ser	*Bothrops itapetiningae (*Boulenger, 1907)	CR A4c	CR A4c	VU B1 ab(i,iii)	CR A4c	CR A4c
ser	*Bothrops marmoratus* Silva & Rodrigues, 2008	VU A4c	EN A4c		VU A4c	EN A4c
ser	*Bothrops moojeni** Hoge, 1966	VU A4c	EN A4c		VU A4c	EN A4c
ser	*Bothrops neuwiedi* Wagler, 1824	VU A4c	EN A4c		CR A4c	CR A4c
ser	*Bothrops pauloensis* Amaral, 1925	EN A4c	CR A4c		EN A4c	EN A4c
liz	*Cercosaura schreibersii albostrigata** (Griffin, 1917)	VU A4c	VU A4c		EN A4c	EN A4c
ser	*Chironius flavolineatus* (*Jan, 1863)	VU A4c	EN A4c		VU A4c	VU A4c
ser	*Chironius quadricarinatus* (Boie, 1827)	VU A4c	EN A4c		EN A4c	EN A4c
liz	*Coleodactylus brachystoma** (Amaral, 1935)		VU A4c			
ser	*Drymoluber brazili* (Gomes, 1918)	VU A4c	EN A4c		EN A4c	EN A4c
ser	*Epicrates crassus* Cope, 1862	VU A4c	EN A4c		EN A4c	EN A4c
ser	*Epictia clinorostris* Arredondo & Zaher, 2010	VU A4c	EN A4c	VU B1 ab(i,iii)	VU A4c	VU A4c
ser	*Erythrolamprus frenatus** (Werner, 1909)	EN A4c	EN A4c		EN A4c	EN A4c
ser	*Erythrolamprus maryellenae* (Dixon, 1985)	VU A4c	VU A4c		VU A4c	VU A4c
liz	*Eurolophosaurus nanuzae* (Rodrigues, 1981)	VU A4c	EN A4c	VU B1 ab(i,iii)	EN A4c	EN A4c
liz	*Gymnodactylus amarali* Barbour, 1925		VU A4c			VU A4c
liz	*Gymnodactylus guttulatus* Vanzolini, 1982		VU A4c	VU B1 ab(i,iii)	EN A4c	EN A4c
liz	*Heterodactylus lundii* Reinhardt & Luetken, 1862	VU A4c	EN A4c		EN A4c	EN A4c
liz	*Hoplocercus spinosus** Fitzinger, 1843	VU A4c	VU A4c		VU A4c	VU A4c
ser	*Hydrodynastes melanogigas** Franco et al., 2007	VU A4c	VU A4c	VU B1 ab(i,iii)		
liz	*Kentropyx paulensis* Boettger, 1893	VU A4c	EN A4c		EN A4c	EN A4c
liz	*Kentropyx vanzoi* Gallagher & Dixon, 1980	VU A4c	VU A4c		VU A4c	VU A4c
amp	*Leposternon cerradensis* Ribeiro et al., 2008	EN A4c	CR A4c	VU B1 ab(i,iii)	EN A4c	EN A4c
amp	*Leposternon maximus* Ribeiro et al., 2011		VU A4c			VU A4c
ser	*Liotyphlops schubarti* Vanzolini, 1948			CR B1 ab(i,iii)		
ser	*Lygophis paucidens* (Hoge, 1953)	VU A4c	VU A4c		VU A4c	VU A4c
liz	*Manciola guaporicola* (Dunn, 1935)	VU A4c	EN A4c		EN A4c	EN A4c
liz	*Micrablepharus atticolus* Rodrigues, 1996	VU A4c	EN A4c		VU A4c	EN A4c

ser	*Micrurus brasiliensis* Roze, 1967		VU A4c	EN A4c		VU A4c	VU A4c
ser	*Micrurus tricolor* Hoge, 1956		EN A4c	EN A4c	VU B1 ab(i,iii)	VU A4c	VU A4c
ser	*Mussurana quimi* (Franco et al., 1998)		EN A4c	CR A4c		EN A4c	EN A4c
liz	*Norops meridionalis* (Boettger, 1885)		VU A4c	EN A4c		VU A4c	EN A4c
ser	*Phalotris concolor* Ferrarezzi, 1994		VU A4c	EN A4c	VU B1 ab(i,iii)	VU A4c	EN A4c
ser	*Phalotris labiomaculatus* Lema, 2002			VU A4c			
ser	*Phalotris lativittatus* Ferrarezzi, 1994		CR A4c	CR A4c	VU B1 ab(i,iii)	CR A4c	CR A4c
ser	*Phalotris matogrossensis** Lema et al., 2005		EN A4c	EN A4c		VU A4c	VU A4c
ser	*Phalotris multipunctatus* Puorto & Ferrarezi, 1994		CR A4c	CR A4c	VU B1 ab(i,iii)	EN A4c	CR A4c
ser	*Phalotris nasutus* (Gomes, 1915)		VU A4c	EN A4c		EN A4c	EN A4c
ser	*Philodryas livida* (Amaral, 1923)		CR A4c	CR A4c	VU B1 ab(i,iii)	EN A4c	EN A4c
liz	*Placosoma cipoense* Cunha, 1966		VU A4c	EN A4c	VU B1 ab(i,iii)	EN A4c	CR A4c
ser	*Rhachidelus brazili* Boulenger, 1908		EN A4c	CR A4c		EN A4c	CR A4c
liz	*Rhachisaurus brachylepis* (Dixon, 1974)		VU A4c	EN A4c	VU B1 ab(i,iii)	EN A4c	CR A4c
liz	*Salvator duseni* (Lonnberg, 1910)		VU A4c	VU A4c		VU A4c	VU A4c
ser	*Siagonodon acutirostris* Pinto & Curcio, 2011						
ser	*Simophis rhinostoma* (Schlegel, 1837)		EN A4c	EN A4c		EN A4c	CR A4c
liz	*Stenocercus quinarius* Nogueira & Rodrigues, 2006		VU A4c	VU A4c		VU A4c	VU A4c
liz	*Stenocercus sinesaccus** Torres-Carjaval, 2005		VU A4c	VU A4c		VU A4c	VU A4c
ser	*Tantilla boipiranga* Sawaya & Sazima, 2003		VU A4c	EN A4c	VU B1 ab(i,iii)	EN A4c	CR A4c
ser	*Trilepida brasiliensis* (Laurent, 1949)						
ser	*Trilepida fuliginosa* (Passos et al., 2006)		VU A4c	EN A4c		VU A4c	VU A4c
ser	*Trilepida koppesi* (Amaral, 1955)		CR A4c	CR A4c		EN A4c	EN A4c
liz	*Tropidurus insulanus* Rodrigues, 1987	VU A4c	EN A4c	EN A4c	EN B1 ab(i,iii)	VU A4c	VU A4c
liz	*Tropidurus itambere* Rodrigues, 1987		VU A4c	EN A4c		EN A4c	EN A4c
liz	*Tropidurus montanus* Rodrigues, 1987		VU A4c	VU A4c	VU B1 ab(i,iii)	EN A4c	CR A4c
liz	*Tupinambis quadrilineatus** Manzani & Abe, 1997			VU A4c			
ser	*Xenodon matogrossensis** (Scrocchi & Cruz, 1993)		VU A4c	EN A4c		VU A4c	VU A4c
ser	*Xenodon nattereri* (Steindachner, 1867)		EN A4c	EN A4c		EN A4c	EN A4c

ser	*Xenopholis undulatus** (Jensen, 1900)	VU A4c	EN A4c	EN A4c	EN A4c

Appendix S2 Area losses comparison within biotic elements. BE: Biotic Element numeration as in Nogueira *et al*. (2011). Denomination: Biotic element's denomination as in Nogueira *et al*. (2011). D: Kolmogorov-Smirnov test result. P-value: For the statistical analyses we considered a significance level of 0.05.

BE	BE name	D	p-value
1	Tocatins-Serra Geral	0,2727	0,8326
2	Paraguay-Guaporé	0,3333	0,9307
3	Paraná-Paraguay	0,25	0,9801
4	Guimarães-Roncador	0,4286	0,5412
5	Espinhaço	0,2857	0,9627
6	Araguaia	0,2	1
7	Central Plateau	0,5	0,7714

Appendix S3 Biotic Elements' species areas, Protection Areas and Habitat losses. Group: amp - amphisbaenians; liz - lizards ; ser - serpents. Species. PA: Number of Permanent Protection Areas in which each species is found. abb.: Abbreviation of the Conservation Unit's names; EESA - Estação Ecológica (Esec) da Serra das Araras; EEIQ - Esec de Iquê ; EEPI - Esec de Pirapitinga; EEUU - Esec de Uruçuí-Una; EETO - Esec Serra Geral do Tocantins; EECP - Parque Nacional (Parna) Cavernas do Peruaçu; EECM - Parna Chapada das Mesas; EECG - Parna da Chapada dos Guimarães; EECV - Parna da Chapada dos Veadeiros; EESB - Parna da Serra da Bodoquena; EESCA - Parna da Serra da Canastra; EESCO - Parna da Serra das Confusões ; EESCI - Parna da Serra do Cipó; EEPE - Parna das Emas; EENP - Parna das Nascentes do Rio Parnaíba; EESV - Parna das Sempre-Vivas; EEPB - Parna de Brasília; EEPA - Parna do Araguaia; EELM - Parna dos Lençóis Maranhenses; EEGV - Parna Grande Sertão Veredas; EERC - Reserva Biológica (Rebio) da Contagem; EEVO - Refúgio de Vida Silvestre (Revis) das Veredas do Oeste Baiano. PA: The species' PA total areas. PA Area: Protected Area Coverage calculated by the sum of the species' original distribution covered by the PAs . BE: Biotic Element number as in Nogueira et al. (2011). BE Name: The Biotic Element's given name as in Nogueira et al. (2011). OR: Expected species' distribution in an original Cerrado coverage (in km²). 2010: Expected species distribution in the Cerrado in the year 2010 (in km²). BE2010: Expected species distribution in the Cerrado in the year 2010 if losses were homogeneous throughout the BE (in km²). OR in PPA (%): Percentage of the area from the species' expected original coverage which is held in PPA.

Group	Species	n.PA	abb.	PPA	PAC	BE	BE Name	OR	2010	BE 2010	OR area in PA (%)
liz	*Ameivula jalapensis* Colli et al., 2009	2	PNP ; ET	14314	3219	1	Tocantins-Serra Geral	21330	19757	14078	15%
amp	*Amphisbaena acrobeles* Ribeiro et al., 2009	2	PNP ; ET	14314	6214	1	Tocantins-Serra Geral	15800	15296	10428	39%
amp	*Amphisbaena kraoh* Vanzolini, 1971	2	PNP ; ET	14314	8877	1	Tocantins-Serra Geral	55355	39493	36534	16%
amp	*Amphisbaena saxosa* Castro-Mello, 2003	0	-	-	-	1	Tocantins-Serra Geral	19298	10065	12737	0%
ser	*Apostolepis longicaudata* Amaral, 1921	3	PNP ; ET ; EU	15665	10338	1	Tocantins-Serra Geral	52520	43100	34663	20%
ser	*Apostolepis polylepis* Amaral, 1921	3	PNP ; ET ; EU	15665	11681	1	Tocantins-Serra Geral	55705	46955	36765	21%
liz	*Bachia oxyrhina* Rodrigues et al., 2008	2	PNP ; ET	14314	7064	1	Tocantins-Serra Geral	36186	30455	23883	20%
ser	*Hydrodynastes melanogigas** Franco et al., 2007	0	-	-	-	1	Tocantins-Serra Geral	29319	16290	19351	0%
ser	*Micrurus brasiliensis* Roze, 1967	3	PCP ; PCV ; ET	7962	533	1	Tocantins-Serra Geral	98330	50796	64898	1%

ser	*Phalotris labiomaculatus* Lema, 2002	2	PNP ; ET	14314	4437	1	Tocantins-Serra Geral	44999	30974	29699	10%
ser	*Trilepida brasiliensis* Laurent, 1949	3	PCM ; PNP ; ET	15914	7803	1	Tocantins-Serra Geral	72807	57430	48053	11%
liz	*Ameiva parecis* Colli et al., 2003	1	EI	2160	398	2	Paraguay-Guaporé	9179	8902	3763	4%
amp	*Amphisbaena absaberi* Strussmann & Carvalho, 2001	1	EA	272	272	2	Paraguay-Guaporé	8944	4618	3667	3%
amp	*Amphisbaena steindachneri* Strauch, 1881	1	EA	272	272	2	Paraguay-Guaporé	10840	7146	4444	3%
ser	*Apostolepis christineae* Lema, 2002	1	EA	272	272	2	Paraguay-Guaporé	12729	7394	5219	2%
ser	*Apostolepis striata* Lema, 2004	-	-	-	-	2	Paraguay-Guaporé	-	-	-	-
liz	*Bachia cacerensis** Castrillon & Strussmann, 1998	2	PE ; EA	1598	1330	2	Paraguay-Guaporé	57873	1746	23728	2%
liz	*Bachia didactyla* Freitas et al., 2011	1	EI	2160	398	2	Paraguay-Guaporé	4829	4055	1980	8%
amp	*Amphisbaena bedai* Vanzolini, 1991	1	PSB	770	441	3	Paraná-Paraguay	46720	12904	8877	1%
amp	*Amphisbaena leeseri* Gans, 1964	1	PSB	770	441	3	Paraná-Paraguay	47231	12972	8974	1%
amp	*Amphisbaena sanctaeritae* Vanzolini, 1974	0	-	-	-	3	Paraná-Paraguay	19145	2475	3638	0%
ser	*Apostolepis intermedia* Koslowsky, 1898	1	PSB	770	441	3	Paraná-Paraguay	20205	6387	3839	2%
ser	*Erythrolamprus frenatus** Werner, 1909	1	PSB; PE; Pca	4075	1913	3	Paraná-Paraguay	149364	45254	28379	1%
ser	*Phalotris multipunctatus* Puorto & Ferrarezi, 1994	0	-	-	-	3	Paraná-Paraguay	49916	7047	9484	0%
ser	*Philodryas livida* Amaral, 1923	2	PSB; PE	2097	1774	3	Paraná-Paraguay	141796	32590	26941	1%
ser	*Trilepida koppesi* Amaral, 1955	1	PE	1326	1326	3	Paraná-Paraguay	131248	25920	24937	1%
amp	*Amphisbaena brevis* Strussmann & Mott, 2009	1	PG	326	326	4	Guimarães-Roncador	21790	12169	8716	1%
amp	*Amphisbaena cuiabana* Strussmann & Carvalho, 2001	1	PG	326	326	4	Guimarães-Roncador	43277	24097	17311	1%
amp	*Amphisbaena neglecta* Dunn & Piatt, 1936	1	PG	326	326	4	Guimarães-Roncador	14220	7266	5688	2%
ser	*Apostolepis lineata* Cope, 1887	1	PG	326	326	4	Guimarães-Roncador	18860	10225	7544	2%
ser	*Apostolepis vittata* Cope, 1887	1	PG	326	326	4	Guimarães-Roncador	18860	10225	7544	2%
liz	*Manciola guaporicola* Dunn & Piatt, 1935	6	RC ; PA ; PE ; PCa ; PG ; EA	9492	6733	4	Guimarães-Roncador	245735	89901	98294	3%
liz	*Stenocercus sinesaccus** Torres-Carjaval, 2005	3	PG ; PE ; EI	3813	2004	4	Guimarães-Roncador	95387	43903	38155	2%
ser	*Apostolepis dimidiata* Jan, 1862	1	Pci	316	316	5	Espinhaço	14250	8127	7268	2%
liz	*Eurolophosaurus nanuzae* Rodrigues, 1981	2	PSV ; Pci	1558	316	5	Espinhaço	16705	9026	8520	2%
liz	*Gymnodactylus guttulatus* Vanzolini, 1982	2	PSV ; Pci	1558	1555	5	Espinhaço	31644	18566	16138	5%
liz	*Placosoma cipoense* Cunha, 1966	1	Pci	316	1450	5	Espinhaço	17026	12598	8683	9%
liz	*Rhachisaurus brachylepis* Dixon, 1974	1	Pci	316	316	5	Espinhaço	14631	8201	7462	2%
ser	*Tantilla boipiranga* Sawaya & Sazima, 2003	1	Pci	316	316	5	Espinhaço	30468	13425	15539	1%

liz	*Tropidurus montanus* Rodrigues, 1987	3	PCi ; PSV ; PGV	3867	1726	5	Espinhaço	87476	46906	44613	2%
amp	*Amphisbaena miringoera* Vanzolini, 1971	1	PA	5555	1736	6	Araguaia	12482	9931	5617	14%
amp	*Amphisbaena silvestrii* Boulenger, 1902	3	PA ; PG ; PE	2301	3409	6	Araguaia	213693	92112	96162	2%
ser	*Apostolepis serrana* Lema & Renner, 2006	0	-	-	-	6	Araguaia	20709	7425	9319	0%
ser	*Atractus albuquerquei* Cunha & Nascimento, 1983	3	PE ; PCV ; EA	2301	2246	6	Araguaia	129798	54385	58409	2%
liz	*Tropidurus insulanus* Rodrigues, 1987	0	-	-	-	6	Araguaia	2330	761	1049	0%
amp	*Amphisbaena mensae* Castro-Mello, 2000	3	RC ; PB ; PCV	2352	1106	7	Central Plateau	95267	41055	59066	1%
ser	*Apostolepis albicollaris* Lema, 2002	3	RC ; PB ; PCV	2352	812	7	Central Plateau	132584	42478	82202	1%
ser	*Apostolepis cerradoensis* Lema, 2003	1	PCV	648	389	7	Central Plateau	18439	12808	11432	2%
ser	*Apostolepis nelsonjorgei* Lema & Renner, 2004	3	PNP ; ET ; PCV	14962	7046	7	Central Plateau	85067	59372	52742	8%

Appendix S4 Number of Cerrado endemic species that qualify for different International Union for the conservation of Nature (IUCN) categories: (1) on the IUCN Red List in 2013, under a business as usual (BAU) scenario, and under a governance (GOV) scenario, under category A4c; (2) when uncertainty in species' generation length is incorporated (2010-2030 years) with maximum generation length (MGL), under category A4c and (3) when uncertainty in species' responses to fragmentation is corrected for habitat (CFH), under category A4c, (4) Considering both A and B IUCN categories and correcting for species' responses to fragmentation according to habitat (CFH).

	(1)IUCN Red List			**(2) Incorporating uncertainty in generation length**		**(3)Incorporating uncertainty in population responses to fragmentation depending upon habitat type**		**(4) A and B IUCN categories coupled with CFH**	
	2014 Red List Category	**Revised category (BAU)**	**Revised category (GOV)**	**Revised category (MGL, BAU)**	**Revised category (MGL, GOV)**	**Revised category (CFH, BAU)**	**Revised category (CFH, GOV)**	**Revised Category (CFH, BAU)**	**Revised Category (CFH, GOV)**
NA	**93**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
DD	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
LC	**3**	**23**	**24**	**13**	**16**	**26**	**25**	**15**	**16**
NT	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
VU	**3**	**41**	**35**	**26**	**37**	**55**	**37**	**63**	**43**
EN	**0**	**33**	**40**	**46**	**34**	**17**	**38**	**20**	**40**
CR	**0**	**7**	**5**	**19**	**17**	**6**	**4**	**7**	**5**
Thr.	**3**	**81**	**80**	**91**	**88**	**78**	**79**	**90**	**88**
% thr.	**2.85%**	**77.14%**	**76.19%**	**86.67%**	**83.81%**	**74.29%**	**75.24%**	**85.71%**	**83.80%**