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Fatores que influenciam o uso do hábitat do gato-maracajá (*Leopardus wiedii*) em uma área de várzea da Amazônia central

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RESUMO

Diversas atividades humanas têm criado e acentuado ameaças à fauna no mundo todo, inclusive em áreas consideradas remotas e pristinas. Para ajudar a mitigar esse cenário, informações sobre a distribuição das espécies e suas relações com os hábitats tornam-se úteis. A investigação de parâmetros populacionais dinâmicos permite identificar e quantificar possíveis oscilações em uma população. Essas informações permitem melhores predições acerca das tendências ecológicas futuras, subsidiando ações de conservação baseadas em ciência. Os carnívoros são importantes para as comunidades biológicas, regulando a densidade das populações de presas e de competidores. Apesar de a maioria dos carnívoros serem espécies pequenas, estes são os menos estudados, logo, menos conhecidos. De maneira geral, aspectos ecológicos desse grupo, especialmente dos felinos, tornam os carnívoros sensíveis às influências antropogênicas. O gato-maracajá (*Leopardus wiedii*) é um felino neotropical ecologicamente pouco conhecido e globalmente classificado como quase ameaçado. Possivelmente o gato com a maior habilidade escansorial, a espécie é fortemente dependente de florestas, e tem como principais ameaças a perda e a fragmentação dos hábitats. A Amazônia é altamente relevante para a conservação do gato-maracajá, que parece exercer função ecológica excepcional em planícies inundáveis de várzea, os ecossistemas mais ameaçados deste bioma. Em vista disso, investigamos a dinâmica do uso do hábitat do gato-maracajá na maior área protegida dedicada à conservação de várzea na Amazônia brasileira. Através do uso de armadilhas fotográficas e de modelos hierárquicos de ocupação dinâmica, testamos as hipóteses de que o uso do hábitat do gato-maracajá é influenciado por variáveis ambientais (bióticas e abióticas) e antropogênicas. De nossas hipóteses, a influência antropogênica foi a única para a qual encontramos indícios de relação com uso do hábitat do gato-maracajá. Contrariamente às nossas predições, a ocupação inicial da espécie foi negativamente relacionada à distância das comunidades humanas. Para esta mesma covariável, encontramos indícios de relação positiva com as probabilidades de colonização e de extinção do gato-maracajá. A espécie parece usar áreas com maior influência antropogênica mais intensamente e regularmente. Já em áreas afastadas das comunidades parece haver uma elevadaalternância (“turnover”) nos hábitats utilizados. Esse padrão possivelmente é resultado da influência antropogênica, a qual estaria afetando a competição interespecífica e/ou a disponibilidade de presas para o gato-maracajá. Nenhum dos parâmetros avaliados variou em função do ano, indicando a estabilidade da área estudada em relação ao uso do hábitat da espécie. Nosso trabalho foi o primeiro dedicado a investigar a ecologia do gato-maracajá em áreas de várzea, gerando informações inéditas sobre sua dinâmica de uso do hábitat. Essas informações são cruciais para prever tendências futuras que a espécie irá enfrentar nesses ecossistemas peculiares e relevantes para a conservação de incontáveis outros táxons. Esperamos ter contribuído para que a gestão das várzeas, importantes tanto para as comunidades tradicionais locais como também para a humanidade, seja cada vez mais baseada em evidências científicas.

Palavras-chave: felinos, armadilhas fotográficas, ocupação dinâmica, “multi-season”, “turnover”, influência antropogênica.

INTRODUÇÃO GERAL

O rápido avanço das áreas utilizadas pelos humanos, com as inerentes supressão ou descaracterização dos habitats naturais, é atualmente uma das maiores ameaças enfrentadas pela fauna no mundo inteiro (BARLOW et al., 2016; BROOK; SODHI; BRADSHAW, 2008; TILMAN et al., 1994; VETTER et al., 2011). O surgimento relativamente recente de expressões como “Extinções do Antropoceno”, “Floresta vazia” e “Defaunação” são apenas alguns exemplos que evidenciam a pressão antropogênica e o nível de ameaça que a fauna, de maneira geral, tem enfrentado (DIRZO et al., 2014; REDFORD, 1992). Os efeitos negativos dos impactos antropogênicos sobre os animais são observados até mesmo em áreas do Planeta consideradas remotas, como por exemplo, no interior da Amazônia. Nesta região, além da expansão das áreas utilizadas para agricultura e pecuária tradicionais, do aumento em número e tamanho das comunidades humanas, (GOULDING; SMITH; MAHAR, 1996; REDFORD, 1992), o número de represas para a geração de energia hidrelétrica também cresce e é motivo de preocupação (FEARNSIDE, 2014; LEES et al., 2016; LATRUBESSE et al., 2017). Além disso, as mudanças climáticas e o aquecimento global tendem a, durante as próximas décadas, alterar aspectos da flora ao redor do Planeta (FINLAYSON et al., 2019; HANSEN et al., 2013). Esses processos apresentam potencial de afetar negativamente organismos de uma imensa variedade filogenética (ANTUNES et al., 2016; BENCHIMOL; VENTICINQUE, 2014; DA SILVA et al., 2018; DE RESENDE et al., 2019; EMER; VENTICINQUE; FONSECA, 2013; FINLAYSON et al., 2019; PAROLIN; WITTMANN; FERREIRA, 2013; REDFORD, 1992; RIPPLE et al., 2017; SANTOS et al., 2018; SIVARAMAN, 2019).

Dentre as ações que são necessárias para a mitigação das ameaças perpetradas pelas atividades humanas sobre a fauna está a geração de informações sobre a distribuição das espécies e suas relações com o hábitat. Entre as abordagens utilizadas para a obtenção dessas informações, as que avaliam parâmetros populacionais dinâmicos são capazes de demonstrar, por exemplo, a alternância dos hábitats utilizados, também chamados de “turnovers”. Por isso, essas abordagens são mais indicadas para auxiliar na predição de tendências futuras nas distribuições e nas relações espécie-hábitat (GREEN; PAVLACKY JR; GEORGE, 2019; YACKULIC et al., 2015). Essas análises expandem nosso conhecimento ecológico e são úteis para o monitoramento e a elaboração de ações de conservação, através da tomada de decisões baseadas em evidências (GUISAN et al., 2013). Entender os fatores que determinam que dada espécie ocupe determinado hábitat é útil, por exemplo, para prever e lidar melhor com processos associados a espécies invasoras, apontar entre potenciais áreas qual o destino mais adequado para a translocação de indivíduos de espécies ameaçadas, auxiliar na seleção de áreas prioritárias para a conservação *in situ*, entre outras aplicações (GUISAN et al., 2013; NEWBOLD; EADIE, 2004).

Um grupo de espécies para o qual a obtenção de informações referentes à utilização do hábitat é apontada como relevante são os carnívoros. As espécies da ordem Carnivora apresentam elevada importância ecológica para a estrutura e funcionalidade das comunidades biológicas que compõem, exercendo função reguladora sobre a densidade das espécies de presas e de competidores (TERBORGH et al., 2001; ROEMER; GOMPPER; VAN VALKENBURGH, 2009; RIPPLE et al., 2014). Entre os carnívoros, a maioria das espécies é composta por animais de pequeno e médio portes (<15 kg) (COLINVAUX, 1980; ROEMER; GOMPPER; VAN VALKENBURGH, 2009). Na família Felidae, por exemplo, 60% das espécies são gatos pequenos (<6,5 kg) (NOWELL; JACKSON, 1996; SUNQUIST; SUNQUIST, 2002). No entanto, a maioria dos estudos sobre carnívoros foca em espécies de grande porte. Como consequência, há uma carência de informações ecológicas básicas disponíveis para muitas espécies de carnívoros neotropicais de pequeno porte, inclusive sobre suas distribuições e relações espécie-hábitat. De maneira geral, os carnívoros, e especialmente os felinos, apresentam extensas áreas de vida, elevadas demandas energéticas, baixas taxas de recrutamento, densidades populacionais naturalmente baixas, e muitas vezes enfrentam conflitos sociais com humanos, aspectos ecológicos que fazem com que essas espécies sejam, de forma geral, sensíveis às transformações antrópicas (CROOKS et al., 2011; NOWELL; JACKSON, 1996; SUNQUIST; SUNQUIST, 2002).

Uma espécie de pequeno porte que se enquadra nesses contextos de escassez de informações ecológicas e de potencial de ameaça é o gato-maracajá (*Leopardus wiedii*). Esse felino neotropical se distribui atualmente do norte do Uruguai e da Argentina até o norte do México, e é globalmente classificado como quase ameaçado (DE OLIVEIRA et al., 2015; SUNQUIST; SUNQUIST, 2002). No Brasil, o gato-maracajá está na lista oficial de espécies ameaçadas (MMA, 2003) e é considerado vulnerável pela mais recente revisão da situação da espécie (TORTATO et al., 2013). A dieta do gato-maracajá parece variar ao longo de sua ampla distribuição geográfica, mas de maneira geral é baseada em médios e pequenos mamíferos, pequenas aves, e, em menor grau, por pequenos répteis e presas maiores (BIANCHI et al., 2011; NAGY-REIS et al., 2019; SEIBERT et al., 2015). O gato-maracajá pertence à linhagem da jaguatirica, apresenta pelagem pintada e pesa em média cerca de 3,3 kg, com leve tendência de os machos serem mais pesados que as fêmeas (DE OLIVEIRA, 1998; DE OLIVEIRA et al., 2015). A espécie apresenta uma longa cauda que facilita a distribuição de seu peso corporal e permite um maior equilíbrio e agilidade, e principalmente, patas posteriores capazes de realizar um giro de 180°, permitindo com que seja uma das raras espécies no Planeta a conseguir descer as árvores com a cabeça para baixo. Por essas e outras características, o gato-maracajá possivelmente seja o felino mais bem adaptado ao hábito escansorial. Apesar disso, seus deslocamentos são principalmente pelo chão (SUNQUIST; SUNQUIST, 2002; TORTATO et al., 2013). Trata-se de uma espécie de hábitos marcadamente noturnos, solitários, elusivos e tímidos (DE OLIVEIRA, 1998; DI BITETTI et al., 2010; SUNQUIST; SUNQUIST, 2002). As áreas de vida reportadas para esse felino variam de 0,72 a 21,85 km^2 e as densidades populacionais de 1 a 81 indivíduos/100 km^2 (CARVAJAL-VILLARREAL et al., 2012; DE OLIVEIRA et al., 2015; KASPER; SCHNEIDER; DE OLIVEIRA, 2016; PÉREZ-IRINEO; SANTOS-MORENO; HERNÁNDEZ-SÁNCHEZ, 2017).

O gato-maracajá até chega a ser observado em áreas fragmentadas e perturbadas (DE OLIVEIRA, 1998; KASPER; SCHNEIDER; DE OLIVEIRA, 2016), porém, em função do intenso hábito arborícola, essa espécie é apontada como um dos felinos neotropicais com maior dependência de altos graus de cobertura florestal, o que o qualifica como especialmente sensível ao desmatamento (NOWELL; JACKSON, 1996; SUNQUIST; SUNQUIST, 2002). Assim como outros felinos neotropicais, o gato-maracajá foi bastante explorado comercialmente no passado, principalmente pelas suas peles, que eram utilizadas para a produção de vestimentas de luxo. Além das peles, outras partes dos corpos desses animais eram vendidas principalmente como ornamentos e souvenires (ANTUNES; SHEPARD JUNIOR; VENTICINQUE, 2014; NOWELL; JACKSON, 1996; REDFORD, 1992). Até 1980, o abate comercial foi possivelmente a principal ameaça enfrentada pelo gato-maracajá, que chegou a estar entre os quatro felinos pintados mais intensamente explorados. Desde então, essa pressão diminuiu, e em 1989 o gato-maracajá entrou para o Apêndice I da Convenção sobre o Comércio Internacional de Espécies Ameaçadas (CITES), sendo então declarado “em perigo” (ANTUNES; SHEPARD JUNIOR; VENTICINQUE, 2014; NOWELL; JACKSON, 1996; SUNQUIST; SUNQUIST, 2002). Atualmente, as principais ameaças enfrentadas pelo gato-maracajá são a perda e a fragmentação dos hábitats, mas também a caça direta, atropelamentos, e doenças transmitidas por animais domésticos (DE OLIVEIRA et al., 2015; TORTATO et al., 2013). Por estas e outras ameaças foi estimada para a espécie uma redução populacional de 10% entre os anos de 2013 e 2028 (TORTATO et al., 2013).

Para o gato-maracajá, a Amazônia é apontada como altamente relevante para sua conservação (DE OLIVEIRA et al., 2015; NOWELL; JACKSON, 1996). Esse bioma representa um refúgio onde inúmeras espécies neotropicais mantêm populações abundantes e amplamente distribuídas (WITTMANN; JUNK, 2016). Cerca de 2,6% da Amazônia é constituída por planícies inundadas sazonalmente por rios que drenam em suas origens áreas próximas aos Andes (HAUGAASEN; PERES, 2005; VILLAMIZAR et al., 2020). As características geoquímicas dos leitos desses rios a montante tornam suas águas ricas em sedimento e nutrientes, e por causa de seu aspecto são então chamados de rios de “águas-brancas” (PRANCE, 1979; VILLAMIZAR et al., 2020). As florestas situadas nessas planícies alagadas por “águas-brancas” são chamadas de várzeas, e são sujeitas a um regime de inundação anual monomodal conhecido como “pulso de inundação” (JUNK; BAYLEY; SPARKS, 1989; WITTMANN; SCHÖNGART; JUNK, 2010). O pulso de inundação da bacia do rio Solimões/Amazonas é o principal fator a determinar os processos bióticos e abióticos nas várzeas, as quais podem se expandir lateralmente por várias dezenas de quilômetros em ambos os lados do rio principal (JUNK et al., 2012; WITTMANN; SCHÖNGART; JUNK, 2010; VILLAMIZAR et al., 2020).

Entre as florestas de planícies alagadas do mundo inteiro, a várzea é a que apresenta a maior riqueza de espécies, além de peculiaridades como uma pronunciada taxa de retenção de carbono e uma acelerada dinâmica hidro-geomorfológica (MELACK et al., 2009; RICHEY et al., 2002;WITTMANN; JUNK; PIEDADE, 2004; WITTMANN et al., 2006). Um número crescente de estudos indica haver destacada importância das várzeas amazônicas para populações de um grande número de espécies de animais, várias delas ameaçadas, e especialmente para aquelas com estratégias para lidar com longos períodos de inundação, como hábitos aquáticos ou escansoriais (PAIM et al., 2013; RAMALHO et al., 2021; TORRALVO; BOTERO-ARIAS; MAGNUSSON, 2017). Apesar de esse contexto sugerir que as várzeas amazônicas sejam áreas de especial relevância para o gato-maracajá, nunca um estudo foi realizado nestas áreas exclusivamente para investigar aspectos ecológicos da espécie. A facilidade logística proporcionada pelo amplo e ramificado sistema de cursos fluviais e a elevada produtividade das várzeas fazem com que a maior parte da população humana da Amazônia viva associada a esses ambientes (GOULDING; SMITH; MAHAR, 1996; WITTMANN; JUNK, 2016). Grande quantidade da madeira, das frutas e verduras, da proteína animal oriunda da pecuária, da caça e da pesca, e inúmeros outros recursos consumidos nas comunidades ribeirinhas e nos centros urbanos regionais são provenientes da várzea. Isso pode representar ameaças à conservação desses ecossistemas e espécies associadas, tornando investigações sobre os efeitos de variáveis ambientais e antropogênicas sobre a biodiversidade da várzea ainda mais urgentes (GOULDING; SMITH; MAHAR, 1996; JUNK et al., 2012; WITTMANN; JUNK, 2016).

Uma área altamente relevante para a conservação de ecossistemas de várzea é a Reserva de Desenvolvimento Sustentável Mamirauá (RDSM). Esta unidade de conservação possui 1.240.000 ha exclusivamente cobertos por várzea, sendo a maior área protegida brasileira dedicada à conservação de áreas úmidas. Localizada na Amazônia central, estado do Amazonas, a RDSM foi a primeira de sua categoria decretada no Brasil. Ela compõe, juntamente com a vizinha Reserva de Desenvolvimento Sustentável Amanã e o Parque Nacional do Jaúparte do Corredor Central da Amazônia, uma área contígua com cerca de 6.500.000 ha de áreas protegidas (QUEIROZ, 2005). A várzea da RDSM permanece alagada durante quatro a cinco meses ao ano, por uma inundação que varia verticalmente de 10 a 15 m (FERREIRA-FERREIRA et al., 2014; RAMALHO et al., 2009). A estação seca se estende de setembro a novembro e a cheia de maio a julho (RAMALHO et al., 2009). O clima local é tropical úmido com médias de temperatura mensal de 26°C e precipitação anual de 2.373 mm, com maior parte da precipitação ocorrendo entre dezembro e maio (AYRES, 1993). A RDSM pode ser considerada uma imensa ilha cercada pelo canal Auatí-Paraná e pelos rios Japurá e Solimões/Amazonas, e é severamente influenciada pelo pulso de inundação do rio Solimões/Amazonas (IDSM, 2014; QUEIROZ, 2005).

As inundações periódicas aparentemente afetam a assembleia de carnívoros da região. Na RDSM, essa assembleia é composta apenas pela onça-pintada (*Panthera onca*), pelo gato-maracajá, e pelo quati (*Nausa nasua*) (ALVARENGA et al., 2018; obs. pess.), espécies capazes de lidar com o alagamento recorrente da área. Na ausência de outros carnívoros, essas três espécies possivelmente têm elevada relevância para a cadeia trófica local, ao exercerem com exclusividade a regulação das populações das espécies de presas (ROEMER; GOMPPER; VAN VALKENBURGH, 2009). Perturbações nas relações interespecíficas podem se propagar pela teia trófica em uma cascata de eventos (RIPPLE; BESCHTA, 2012). Oscilações nas populações de carnívoros podem influenciar até mesmo os produtores primários, com efeitos, por exemplo, na dispersão de plantas (DIRZO et al., 2014). Excepcionalmente, na RDSM o gato-maracajá pode ter um papel semelhante ao de uma “espécie chave” (PAINE, 1969; RIPPLE; BESCHTA, 2012). Portanto nessas áreas, ameaças ao gato-maracajá poderiam até mesmo influenciar os serviços e as funções ecossistêmicas, com potenciais impactos negativos na segurança alimentar e na qualidade de vida das cerca de 207 comunidades tradicionais e aproximadamente 11.532 pessoas que vivem ou utilizam a área da RDSM principalmente para pesca e agricultura familiar (MOURA et al., 2016). Comunidades neste contexto dependem dos recursos naturais e serviços ecossistêmicos não apenas para subsistir, como também para manter e perpetuar sua cultura e modos de vida, fortemente associados à natureza que os cerca (DIRZO et al., 2014; REDFORD, 1992).

Em uma escala maior, a Amazônia é um dos biomas brasileiros mais importantes para a regulação de processos continentais e até mesmo globais, como o clima. Os serviços ecossistêmicos fornecidos pelas áreas úmidas amazônicas combinadas provavelmente é um dos maiores do mundo (WITTMANN; JUNK, 2016). Portanto, para que esses ecossistemas sigam funcionais, fornecendo serviços ecológicos vitais não só para as comunidades locais como também para toda a humanidade, é imprescindível que seja garantida a conservação da sua biodiversidade, incluindo o gato-maracajá (WITTMANN; JUNK, 2016).

Dentre as prioridades apontadas para a conservação do gato-maracajá, estão estudos sobre parâmetros ecológicos, como relações de uso do hábitat (DE OLIVEIRA et al., 2015). Diferentes coberturas do solo, incluindo as distintas fitofisionomias (WANG et al., 2019), as distâncias de corpos d’água e de ocupações humanas (TAN et al., 2017) são alguns dos fatores capazes de determinar o uso do hábitat por felinos (SOLLMANN et al., 2012). Entender como essas variáveis influenciam uma espécie ameaçada e carente de informações ecológicas é essencial para planejar estratégias visando sua conservação, especialmente em uma área relevante para suas populações (TAN et al., 2017).

Um aspecto que demanda atenção na avaliação do seu uso do hábitat é que o gato-maracajá, assim como muitos outros organismos, apresenta detecção imperfeita (HARMSEN; SAVILLE; FOSTER, 2021). É possível que durante as amostragens sejamos incapazes de registrá-lo em um determinado local mesmo quando ele na realidade está presente (TYRE et al., 2003). Se os componentes metodológicos e ambientais que influenciam a probabilidade de detecção das espécies não forem considerados, as estimativas geradas podem ser bastante distantes da realidade (MACKENZIE; BAILEY, 2004). Porém, com uma análise de dados selecionada e conduzida de forma apropriada, é sim possível estimar diferentes parâmetros populacionais até mesmo para táxons de detecção imperfeita (MACKENZIE et al., 2002; TYRE et al., 2003). Uma abordagem que permite contornar os vieses oriundos desses insucessos em detectar organismos mesmo quando eles estão presentes (probabilidade de detecção <1), tendo inclusive sido chamada de “estimativa dos falsos negativos”, é a modelagem de ocupação, um procedimento relativamente novo proposto por Mackenzie et al. (2002).

Uma das variações da modelagem de ocupação, conhecida como “multi-season”, permite estimar os parâmetros da dinâmica da ocupação de espécies (MACKENZIE et al., 2006). Obtendo informações de detecção/não detecção da espécie alvo em várias estações de amostragem durante várias ocasiões amostrais, é possível estimar a probabilidade de detecção (p, probabilidade de detectar a espécie em um local onde ela está presente). Essa estimativa, por sua vez, nos permite estimar a probabilidade de não detectar a espécie quando ela está de fato presente (MACKENZIE et al., 2002; TYRE et al., 2003). Usando essa probabilidade de detecção estimada, é então possível estimar a probabilidade de ocupação inicial (ψ_i, psi_i, probabilidade de um local ser ocupado pela espécie na primeira de uma série de amostragens/temporadas/anos), a probabilidade de colonização (γ, gama, probabilidade de um local desocupado na temporada anterior tornar-se ocupado pela espécie na temporada seguinte), e a probabilidade de extinção (ε, epsilon, probabilidade de um local anteriormente ocupado se tornar desocupado pela espécie na temporada seguinte) (MACKENZIE et al., 2006). É esperado que fatores ambientais e antropogênicos influenciem cada um desses quatro parâmetros da dinâmica da ocupação. Assumindo que não há mudanças no estado de ocupação ao longo das ocasiões amostrais de uma mesma temporada, mas possivelmente apenas entre as temporadas (premissa de "ocupação fechada" durante cada temporada), é possível então estimar a ocupação inicial e modelar variações espaciais e temporais nas probabilidades de detecção, colonização e extinção em resposta a covariáveis locais ou metodológicas (MACKENZIE et al., 2006). Desta forma, a abordagem "multi-season" permite então identificar os fatores mais importantes para cada um dos parâmetros da dinâmica da ocupação das espécies, gerando informação sobre relações espécie-habitat até mesmo para táxons difíceis de serem detectados (COMLEY et al., 2020; JOHNSON, 1980; MACKENZIE; NICHOLS, 2004; PIÉDALLU et al., 2017; SALOM-PÉREZ et al., 2021; WANG et al., 2019).

Assim como para vários outros organismos, as densidades populacionais naturalmente baixas, o comportamento noturno e elusivo, e o hábito florestal fazem com que o gato-maracajá tenha não apenas detecção imperfeita, mas também uma probabilidade de detecção especialmente reduzida (ROCHA et al., 2015; HARMSEN; SAVILLE; FOSTER, 2021; SUNQUIST; SUNQUIST, 2002). A pequena quantidade de registros de alguns táxons pode inclusive ser um limitante para a realização de várias análises (HARMSEN; SAVILLE; FOSTER, 2021). Em função disso, o uso de métodos não invasivos, como as armadilhas fotográficas, praticamente tornou-se o procedimento padrão para investigações sobre esses grupos (KARANTH; CHELLAM, 2009; SUNARTO et al., 2013). Esta técnica representa uma excelente alternativa para obter registros de espécies com baixa probabilidade de detecção, sendo por vezes associado ao uso de atrativos para tentar gerar uma quantidade ainda maior de registros (O'BRIEN, 2011; ROCHA et al., 2015; SEBASTIÁN-GONZÁLEZ et al., 2020). Antigamente, as armadilhas fotográficas chegaram a ser construídas artesanalmente, improvisando o uso de componentes fabricados para outras finalidades em um mesmo dispositivo (KUCERA; BARRETT, 2011). Atualmente, há equipamentos disponíveis construídos com a exclusiva finalidade de detectar animais em ambientes naturais, inclusive com um número relativamente grande de fabricantes e de diversos países. Geralmente, as atuais armadilhas fotográficas possuem componentes sensíveis à diferença de temperatura em movimento, muitas vezes "sensores infravermelhos passivos", os quais quando excitados ativam uma máquina fotográfica interna (SWANN; KAWANISHI; PALMER, 2011).

Dentre incontáveis outras vantagens, nas armadilhas fotográficas atuais os antigos "flashes" foram substituídos por tecnologias que permitem visualização noturna sem espantar muitos dos animais (ROVERO; ZIMMERMANN, 2016).Em estudos que possuem uma espécie focal, várias outras espécies também são registradas. Além disso, as armadilhas podem ser configuradas para operar 24 h por dia e funcionam em quase todas as condições climáticas e meteorológicas, reduzindo bastante o desgaste humano em vários tipos de levantamento. De maneira geral, os modelos mais recentes apresentam considerável autonomia, dependendo do equipamento e das baterias utilizadas podem operar por vários meses sem manutenção. Isso também diminui o empenho humano e financeiro necessário para um esforço amostral equiparável; apesar de o investimento inicial por vezes ser desencorajador, considerando em longo prazo os demais custos envolvidos ao utilizar outras técnicas de amostragem, o armadilhamento fotográfico inúmeras vezes é mais acessível e permite um maior número de registros (ROVERO; ZIMMERMANN, 2016; SILVEIRA; JACOMO; DINIZ-FILHO, 2003). Por esses e outros motivos, em investigações sobre distribuição e relações espécie-hábitat de táxons difíceis de detectar, a associação do uso de armadilhas fotográficas à modelagem de ocupação dinâmica tem se mostrado um método bem-sucedido (COMLEY et al., 2020; HARMSEN; SAVILLE; FOSTER, 2021).

Considerando todo esse cenário apresentado, nosso principal objetivo com este estudo foi avaliar como variáveis ambientais e antropogênicas influenciam o uso do hábitat do gato-maracajá em uma área de várzea da Amazônia central brasileira. Para isso, utilizamos dados coletados com armadilhas fotográficas e analisados através de modelos hierárquicos de ocupação dinâmica. Nossos objetivos específicos foram: 1) investigar como a detecção do gato-maracajá é influenciada pelo esforço amostral (HARMSEN; SAVILLE; FOSTER, 2021), pelo uso de atrativo de cheiro (SEBASTIÁN-GONZÁLEZ et al., 2020), e se varia temporalmente (VITEKERE et al., 2020); 2) avaliar quais fatores ambientais afetam o uso do hábitat pelo gato-maracajá, incluindo variáveis bióticas, particularmente a disponibilidade de diferentes fitofisionomias na área de estudo (CERESA et al., 2020; MASSARA et al., 2017), e variáveis abióticas, como elevação (OBERSOLER et al., 2020; VITEKERE et al., 2020) e presença de corpos d'água (TAN et al., 2017; WANG et al., 2019); e finalmente 3) avaliar a influência de variáveis antropogênicas no uso do hábitat do gato-maracajá.

Especificamente, testamos as hipóteses de que a detecção da espécie é positivamente relacionada ao esforço amostral (MUNARI; KELLER; VENTICINQUE, 2011) e ao uso do atrativo de cheiro (ROCHA; RAMALHO; MAGNUSSON, 2016), e que não apresenta variação temporal (GERBER; KARPANTY; KELLY, 2011; WANG et al., 2019). Também testamos as hipóteses de que o uso do hábitat do gato-maracajá na área de estudo é positivamente relacionado à vegetação florestal densa e de baixa altura (HODGE, 2014; TORTATO et al., 2013) e à proximidade da água (WANG et al., 2019), negativamente relacionado à elevação e à influência antropogênica (DE OLIVEIRA et al., 2015), e que não variaria durante o estudo. Nossas predições são detalhadamente descritas na Tabela S1.

A compreensão de como as variáveis ambientais, bióticas e abióticas, bem como as variáveis antropogênicas influenciam o uso do hábitat do gato-maracajá pode fornecer informações úteis para o entendimento de quais são as ameaças locais à espécie. Essa compreensão pode permitir uma melhor previsão de como a espécie será afetada por futuras influências negativas, ajudando a estabelecer critérios para a seleção de áreas prioritárias para sua conservação (DE OLIVEIRA et al., 2015; GUISAN et al., 2013). Avaliar essa aparente importância das áreas de várzea para o gato-maracajá pode ser fundamental para novas diretrizes de conservação da espécie (NEWBOLD; EADIE,

2004; RITCHIE; JOHNSON, 2009; ROEMER; GOMPPER; VAN VALKENBURGH, 2009).

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CAPÍTULO 1

Factors influencing the margay (*Leopardus wiedii*) habitat use in a várzea area of the central Amazonia

ABSTRACT

Different human activities have created and accentuated threats to the fauna worldwide, including in remote areas still considered to be pristine. To help to mitigate this scenario, information on the species distribution and their habitats relationships become useful. The investigation of vital rates through dynamic parameters allows the identification and quantification of turnovers. This knowledge allows better predictions about future ecological trends, supporting science-based conservation actions. Carnivores are important for biological communities, regulating prey and competitor population densities. Although the majority of carnivores are small species, these are the least studied ones, and therefore, the least known. Ecological traits of this group, especially felids, make carnivores, in general, sensitive to anthropogenic influences. The margay (*Leopardus wiedii*) is a neotropical small cat ecologically little known and globally considered Near Threatened. Possibly the felid with the greatest scansorial ability, the species is heavily forest dependent, and faces as main threats habitats loss and fragmentation. Amazonia is highly relevant for the margay conservation, which seems to have an exceptional ecological function in várzea floodplains, the most threatened ecosystems in this biome. In view of this, we investigated the margay habitat use dynamics in the largest protected area dedicated to the várzea conservation in the Brazilian Amazonia. Through the use of camera traps and hierarchical occupancy models, we tested the hypotheses that the margay habitat use is influenced by biotic and abiotic environmental covariates, as well as by anthropogenic covariates. The anthropogenic influence hypotheses was the only one for which we found some evidence of relationship with the margay habitat use. Contrary to our predictions, the species initial occupancy was negatively related to the distance to human settlements. For this same covariate, we found clues of a positive relationship with the margay colonization and extinction probabilities. The species seems to use areas with higher anthropogenic influence more intensively and regularly. In areas further to the settlements, there seems to be a high turnover in the habitats used. Possibly the anthropogenic influence is interfering in the interspecific competition and/or in the margay' prey availability. None of the parameters we evaluated varied according to the year, indicating stability of the studied area in relation to the species' habitat use. Our study was the first dedicated to investigate the margay ecology in the várzea, generating inedit information about its habitat use dynamics.This knowledge is crucial to predict future trends that the species will face in these peculiar and relevant ecosystems for countless other taxa conservation. We hope to have contributed to a increasingly scientific-based várzea management, favoring the ecological function maintenance of these remarkable ecosystems for the traditional local communities, as well as for the humanity.

Keywords: felids, camera traps, dynamic occupancy, multi-season, turnover, anthropogenic influence.

INTRODUCTION

The expansion of the areas used by humans and the consequent suppression or degradation of natural habitats is currently one of the major threats faced by the biodiversity worldwide (BARLOW et al., 2016; BROOK; SODHI; BRADSHAW, 2008; TILMAN et al., 1994; VETTER et al., 2011). This scenario is observed even in areas of the planet considered remote, as, for instance, those located in the core of Amazonia, where the expansion of traditionalagriculture and livestock areas, human settlements (GOULDING; SMITH; MAHAR, 1996) and hydroelectric damare all increasing (FEARNSIDE, 2014; LEES et al., 2016; LATRUBESSE et al., 2017). In addition to these local drivers, ongoing global changes tend to modify aspects of flora around the planet over the next decades (FINLAYSON et al., 2019; HANSEN et al., 2013). These processes might negatively affect many organisms representing an immense phylogenetic variety (ANTUNES et al., 2016; BENCHIMOL; VENTICINQUE, 2014; DA SILVA et al., 2018; DE RESENDE et al., 2019; EMER; VENTICINQUE; FONSECA, 2013; FINLAYSON et al., 2019; PAROLIN; WITTMANN; FERREIRA, 2013; RIPPLE et al., 2017; SANTOS et al., 2018; SIVARAMAN, 2019). To help mitigating this issue, obtain information on species distribution and habitat associations pose as necessary to expand our ecological knowledge and therefore support the development of management actions (GUISAN et al., 2013). Understanding the environmental and anthropogenic variables that influence species occurrence is particularly useful in the selection of priority areas for conservation(NEWBOLD; EADIE, 2004). Whenever possible, the elucidation of occupancy rate parameters through dynamic modeling is preferable to static parameters, as it might provide a broader perspective on the population status by revealing temporal trends and turnovers, making it an important tool for ecological monitoring and management (GREEN; PAVLACKY JR; GEORGE, 2019; YACKULIC et al., 2015).

Understanding ecological temporal trends is highly relevant for the conservation of wild mammals, especially those groups that are of great conservation concern, such as many carnivores. Currently 38.5% of the 296 species of the Carnivora order are near threatened, threatened or extinct in the wild (IUCN, 2021). This is of particular concern because carnivores have great ecological importance in the biological communities, exerting a regulatory function on the abundance of prey and competitors' populations (RIPPLE et al., 2014; TERBORGH et al., 2001). Although most of the carnivores comprise small and midsized species (<15 kg), the majority of the scientific literature has focused on larger and more charismatic ones. This bias results in gaps in the basic ecological knowledge of the smaller species, such as on species distributions and species-habitat associations (ROEMER; GOMPPER; VAN VALKENBURGH, 2009). Ecological traits of these species, such as small litter size and naturally low densities, make carnivores particularly sensitive to anthropogenic disturbances (CROOKS et al., 2011).

The margay (*Leopardus wiedii*) is a small carnivore that faces scarcity of ecological information and a myriad of anthropogenic threats. This neotropical felid, with distribution from Uruguay and northern Argentina to northern Mexico, is globally classified as Near Threatened (DE OLIVEIRA et al., 2015), and in Brazil is listed as Vulnerable (MMA, 2003). Due to its strong arboreal habits, the margay is especially sensitive to deforestation and forest degradation, being habitat loss and fragmentation its main threats, but also suffering from direct killing and diseases transmitted by domestic animals (TORTATO et al., 2013). Moreover, the margay's nocturnal, arboreal, and secretive behavior makes it difficult to acquire sufficient data to conduct complex studies on the species. Not surprisingly, there are few available studies focusing on this wild cat (DE OLIVEIRA, 1998; HARMSEN; SAVILLE; FOSTER, 2021; SUNQUIST; SUNQUIST, 2002; SUNQUIST; SUNQUIST, 2014).

Amazonia is considered highly relevant for the margay conservation (DE OLIVEIRA et al., 2015; NOWELL; JACKSON, 1996). This biome represents a refuge where numerous neotropical species maintain healthy and widely distributed populations (WITTMANN; JUNK, 2016). About 2.6% of the Amazonia is constituted by forested plains seasonally flooded by the sediment- and nutrient-rich "white waters", during the flood pulse of the Amazon River basin (HAUGAASEN; PERES, 2005; JUNK; BAYLEY; SPARKS, 1989, VILLAMIZAR et al., 2020). These floodplains, locally known as 'várzeas', have a high carbon storage and a fast hydro-geomorphological dynamics (MELACK et al., 2009; RICHEY et al., 2002;WITTMANN; JUNK; PIEDADE, 2004). Additionally, the várzeas are crucial habitats for populations of many threatened species, particularly those with adaptations to deal with long periods of flooding, such as aquatic and arboreal abilities (PAIM et al., 2013; RAMALHO et al., 2021; TORRALVO; BOTERO-ARIAS; MAGNUSSON, 2017). Although this context strongly suggests that the várzeas are areas of special relevance for the margay, there are no studies on the ecology of the species in such ecosystems. Because of the high primary productivity and the logistical advantages provided by the numerous rivers and water channels, most of the human population that lives in the Amazonia is associated to these floodplains (GOULDING; SMITH.; MAHAR, 1996). This human occupation and usage can represent a threat to these ecosystems and all associated species, making assessments about the effects of environmental and anthropogenic variables on the várzea' biodiversity an urgent conservation issue (JUNK et al., 2011; JUNK et al., 2012; WITTMANN; JUNK; PIEDADE, 2004).

Ecological studies investigating habitat use associations are among the conservation research priorities for the margay (DE OLIVEIRA et al., 2015). The habitat use by wild felids may be affected by several factors (SOLLMANN et al., 2012), such as differences in land covers (including phyto-physiognomies; HORN et al., 2020; WANG et al., 2019), elevation (VITEKERE et al., 2020; WANG et al., 2019), proximity of water bodies, and distance to human settlements (MARINHO et al., 2017; TAN et al., 2017). Understanding how these biotic and abiotic environmental covariates, as well as anthropogenic covariates influence the margay habitat use can provide useful information to unveil which are the mainlocal threats to this species. This knowledge allows a better predicting of how the margay will be affected by future negative influences, helping to establish criteria for the selection of priority areas for his conservation (DE OLIVEIRA et al., 2015; GUISAN et al., 2013). Understanding this apparent relevance of várzea areas for a threatened species that lacks ecological information, as the margay, is essential to accurately assess the species conservation status and plan for future conservation strategies, and may be fundamental for new species conservation guidelines (NEWBOLD; EADIE, 2004; RITCHIE; JOHNSON, 2009; ROEMER; GOMPPER; VAN VALKENBURGH, 2009).

Wild felids generally occur at naturally low densities, have nocturnal habits, and elusive behaviors (SUNQUIST; SUNQUIST, 2002). Therefore, the use of non-invasive methods, such as camera trapping, has become the standard procedure to investigate habitat use association, sometimes accompanied by lures to try to increase the number of records (KARANTH; CHELLAM, 2009; SEBASTIÁN-GONZÁLEZ et al., 2020). Many studies applied this sampling method combined with hierarchical occupancy modeling accounting for imperfect detection, to successfully investigate the effect of different variables on species-habitat associations of mammals (COMLEY et al., 2020; HARMSEN; SAVILLE; FOSTER, 2021; O'CONNELL; BAILEY, 2011; ROVERO; SPITALE, 2016). In this study, we used this approach to evaluate how environmental and anthropogenic variables influence the margay habitat use in a várzea area in central Brazilian Amazonia. Specifically, we intend to: 1) evaluate possible effects of sampling effort (HARMSEN; SAVILLE; FOSTER, 2021), use of scent lure (SEBASTIÁN-GONZÁLEZ et al., 2020), and seasonal variation (VITEKERE et al., 2020) on the detection of the margay; 2) investigate how the margay habitat use is influenced by the availability of different phyto-physiognomies in our study area (CERESA et al., 2020; MASSARA et al., 2017); 3) assess how the margay habitat use is influenced by abiotic environmental factors, such as elevation (OBERSOLER et al., 2020; VITEKERE et al., 2020) and presence of water bodies (TAN et al., 2017; WANG et al., 2019); and finally 4) evaluate the influence of human presence, using as proxies of anthropogenic influence the proximity of human settlements (HORN et al., 2020; MARINHO et al. , 2017) and the proximity of large water bodies.

We tested the hypotheses that species detection is positively related to both the sampling effort (MUNARI; KELLER; VENTICINQUE, 2011) and the use of scent lure (ROCHA; RAMALHO; MAGNUSSON, 2016). Although we did not expect strong temporal variation in detection, we tested it in a way to account for temporal effects not covered by the other detection covariates(GERBER; KARPANTY; KELLY, 2011; WANG et al., 2019). We also tested the hypotheses that the habitat use by the margay is positively related to dense and low-height forest vegetation (HODGE, 2014; TORTATO et al., 2013) and to the proximity of water (WANG et al., 2019), negatively related to the elevation and to the anthropogenic influences (DE OLIVEIRA et al., 2015), and do not vary during the study. Our predictions are described in detail in Table S1.

MATERIAL AND METHODS

Study area

We performed surveys in the Mamirauá Sustainable Development Reserve (hereafter, MSDR). This is the largest (1,124,000 ha) protected area dedicated to wetlands conservation in Brazil and consists entirely of várzea (FERREIRA-FERREIRA et al., 2014). MSDR is located in Central Amazonia, between the Japurá and Solimões/Amazonas rivers interflow, and is classified as category VI by IUCN (DUDLEY, 2008) (Fig.1). Annually subject to a flooding that varies vertically from 10 to 15 m, the MSDR remains flooded for 4 to 5 months per year (FERREIRA-FERREIRA et al., 2014; RAMALHO et al., 2009). The highest water level usually occurs between May and July, whereas the lowest water season between September and November (RAMALHO et al., 2009). The local climate is tropical humid with monthly temperature averages of 26°C and annual precipitation of 2,373 mm, with most of the precipitation occurring between December and May (AYRES, 1993). The MSDR presents an altitudinal variation that gradually decreases from west to east, from 89 to 7 m above sea level (IDSM, 2014). The elevation determines the intensity of the aquatic period influence over the aquatic-terrestrial areas, representing one of the most important factors influencing local biological processes (JUNK et al., 2012; WITTMANN; SCHÖNGART; JUNK, 2010; VILLAMIZAR et al., 2020). Approximately 11,500 people (207 human settlements) live or use the area, mainly for fishing and familiar agriculture (MOURA et al., 2016).

The MSDR vegetation consists of four major phyto-physiognomies that naturally form a complex and fragmented mosaic (AYRES, 1993; FERREIRA-FERREIRA et al., 2014; WITTMANN; SCHÖNGART; JUNK, 2010). The ‘High várzea’ has high canopy (30-35 m, emergent trees up to 45 m) (WITTMANN; SCHÖNGART; JUNK, 2010), absent or undeveloped understory, and its vegetation is more similar to the non-flooded forests (i.e. *terra firme*, tall forest associated to well-drained soils not exposed to flooding). High várzeas are in the upper areas, which remain flooded by 2 to 4 months per year at a depth ranging from 1 to 2.5 m (AYRES, 1993; WITTMANN; SCHÖNGART; JUNK, 2010). The ‘Low várzea’ exhibits smaller trees, more developed understory and occurs in areas that remains flooded for 4 to 6 months a year, at a depth of 2.5 to 5 m (AYRES, 1993). Chavascals are swampy areas that occupy poorly drained depressions that constituted water bodies’ beds in the hydro-geomorphological past, with vegetation composed by low trees and high presence of shrubs and lianas. Chavascals are located in areas that are flooded for 6 to 8 months a year, 5 to 7 m deep (AYRES, 1993; JUNK et al., 2012; WITTMANN; SCHÖNGART; JUNK, 2010). In addition to these forest formations, the várzea Fields are composed of grasses and shrubs (macrophytes) located in the lowest lands at the margin of water bodies, and therefore, are the areas that endure the longest flooding duration (FERREIRA-FERREIRA et al., 2014; WITTMANN; SCHÖNGART; JUNK, 2010).

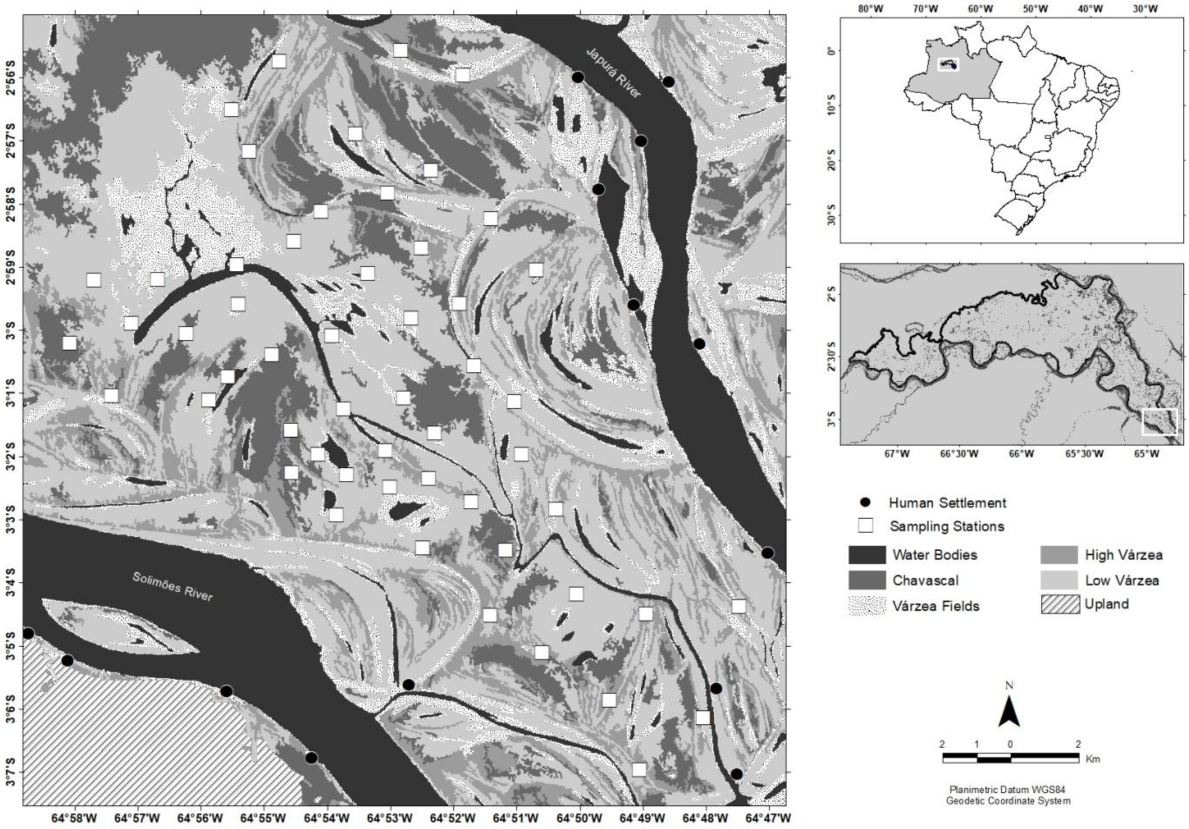

Figure 1: Mamirauá Sustainable Development Reserve and the study area localizations.

Data collection

We conducted surveys around the Mamirauá lake, at the south-eastern portion of the MSDR (centroid" 2°59'54" S, 64°55'28" W) (Fig.1). We implemented an average of 49 (min. 47; max. 54) camera trap stations per year, from 2013 to 2019, in an area of about 214.55 km² (Minimum Convex Polygon) (Fig.1; Table 1). Using the complex waterways available in the region, we systematically distributed the stations maintaining a mean distance of 1.58 km (min. 0.87; max. 2.73) between neighboring stations. We collected the data between September and January of seven consecutive years, with an average of 95.86 (min. 87; max. 118) sampling days per year (Table 1), and an average of 42.66 (min. 0; max. 57) sampling days per station per year. Due to logistical constraints, in each year, we divided the sampling grid into two "sampling blocks" (ROVERO et al., 2013), the first block operated continuously during the first half of the sampling period. Then, the cameras were immediately relocated to the second "sampling block" locations, for the second half of the sampling period. The two blocks covered roughly the same area, rather than adjacent to each other, in a chess board design. Although we aimed to survey margays, sampling design was originally designed for a jaguar (*Panthera onca*) population dynamic study.

Each sampling station consisted of a pair of camera traps (model PC800 HyperFire Professional Semi-Covert IR, Reconyx Inc., Holmen, Wisconsin) set to operate 24 h a day and to take one photo per second while the animals remained in front of the camera. We deployed the camera traps facing each other, approximately 4 m apart, at a height of about 30 cm above ground. Before installation, we removed the vegetation in front of the cameras that could hinder the animals' visualization and increase false triggers. In 2013 and 2014 we used scent lures in all sampling stations, renewing them and performing the camera traps maintainanceevery 14 days. From 2015 to 2019, we placed lures in half of the stations in each sampling block (randomly), but did not renew the lures nor performed camera traps maintainanceduring the sampling period.The lure was a mix of canned sardines and eggs, which were packed it in a poorly ventilated can attached to the ground, in the center of the station, being unavailable for consumption by the animals (ROCHA; RAMALHO; MAGNUSSON, 2016).Our sampling design was in accordance with what is recommended as appropriate for the dynamic occupancy analysis framework (MACKENZIE et al., 2006; O'CONNELL; BAILEY, 2011).

Table 1: Sampling year (Year), number of stations implemented (Stations), number of days of data collection (Duration), sampling effort (Effort, number of sampling stations*number of operation days), number of margay detections (Records), margay detection rate (Det. rate, detections/100 station*days), number of margay records in the collapsed capture history used to build the models (Records analysis), number of sampling stations where margays were detected (Stations detected) and margay naïve occupancy (Naïve occu., number of stations that detected margays/total number of sampling stations).

Year	**Stations**	**Duration**	**Effort**	**Records**	**Det. rate**	**Records analysis**	**Stations detected**	**Naïve occu.**
2013	48	87	1,968	24	1.22	24	19	0.40
2014	47	93	2,036	36	1.77	29	21	0.45
2015	54	76	1,914	36	1.88	29	21	0.39
2016	48	98	2,205	29	1.32	22	17	0.35
2017	49	118	2,738	29	1.06	27	21	0.43
2018	50	103	2,385	23	0.96	22	20	0.40
2019	49	96	2,278	32	1.40	31	23	0.47

Covariate extraction

Based on the literature, we evaluated the influence of three variables on the margay detection probability: 1- the number of days each sampling station operated during each visit (sampling occasion), to consider the effect of the sampling effort (HARMSEN; SAVILLE; FOSTER, 2021; TAN et al., 2017; WANG et al., 2019); 2- the presence of scent lure in the sampling stations at each year, to test the influence of the lures (SUNARTO et al., 2013; THORN et al., 2009; ZIMMERMANN; FORESTI, 2016), and; 3- the year as a factor to assess whether the detection probability varied among years, considering possible effects of environmental conditions (e.g. meteorological, river water level) that we did not measure directly in the different years (HAMEL et al., 2013; JACKSON; FAHRIG, 2015, VITEKERE et al., 2020) (Table 2; Table S2).

We carefully selected several site covariates to assess their influence on margay habitat use: the elevation above the sea level (hereafter, elevation; OBERSOLER et al., 2020; VITEKERE et al., 2020), distance to the nearest human settlement (hereafter, settlement) (MARINHO et al., 2017; WANG et al., 2019) and to the nearest permanent water body (TAN et al., 2017; WANG et al., 2019), and the amount of area of different land covers, including water surface, High várzea, Low várzea and Chavascal (CERESA et al., 2020; HODGE, 2014; HORN et al., 2020; MASSARA et al., 2017) (Table 2). Elevation data was obtained directly from SRTM imagery (JARVIS et al., 2008), human settlement locations from the Geographic Database of the Mamirauá Sustainable Development Institute. Land cover mapping was performed during a previous study conducted in our study area through Synthetic Aperture Radar (SAR) remote sensing (FERREIRA-FERREIRA et al., 2014).

The study area was divided into four land cover classes, following Ferreira-Ferreira et al. (2014): (1) Permanent Water, (2) High várzea, (3), Low várzea, and (4) Chavascal. The class Permanent Water represents perennial water surfaces such as rivers, channels and lakes that do not run dry even during the driest months (FERREIRA-FERREIRA et al., 2014). We did not implement sampling stations in várzea Fields because margays are notably forest dwellers (DE OLIVEIRA, 1998; HORN et al., 2020; SUNQUIST; SUNQUIST, 2002), and therefore we did not evaluate the várzea Fields influence in the species occupancy.

Acknowledging that species’ responses to environmental conditions are scale-dependent, we tested the potential influence of the site covariates from a scale smaller than the smallest home range reported for the species (0.72 km^2 to females; 1 km^2 considering both sexes), up to a scale about four times larger than the largest home range reported for the species (21.85 km^2) (CARVAJAL-VILLARREAL et al., 2012; DE OLIVEIRA et al., 2015; HORN et al., 2020; JACKSON; FAHRIG, 2015; KASPER; SCHNEIDER; OLIVEIRA, 2016; MAYOR et al., 2009; MCGARIGAL et al., 2016). In this way, we extracted spatial covariates within circular buffers of 250, 500, 1000, 2000 and 5000 m radii around each sample station (ROCHA et al., 2020). For the covariates that represent distance to features (distance to settlements, or to water bodies), we first created a 30x30 m resolution cost raster map and calculated the mean of pixel values within buffers (TAN et al., 2017; ROCHA et al., 2020). We conducted all spatial data processing in Quantum GIS (QGIS) v. 2.18.9 (QGIS DEVELOPMENT

TEAM, 2017). For the complete description of variables see Table S2 and Table S3 in supporting information.

Table 2: Covariates included in the models. Covariates' identification label (ID); covariate description, and the dynamic occupancy model parameters that each covariate was tested for. Detection probability (p), initial occupancy probability (Ψi), colonization probability (γ), and extinction probability (ε), and expected relationship between the parameter and the covariates (negative (-), non-directional effect (0), or positive (+)).

Covariate	**ID**	**Description**	**Tested parameters and effects**			
			p	**Ψ_i**	**γ**	**ε**
Effort	Eff	Number of days each sampling station was active on each collapsed sampling occasion.	+			
Scent lure	Scl	Absence or presence of the scent lure in each sampling station in each year.	+			
Year	Yea	Year of the sampling.	0		0	0
Elevation	Ele	Average elevation in 30 m^2 pixels in 250, 500, 1,000, 2,000 and 5,000 m radii circular buffers around the sampling stations (meters above sea level).		-		
Distance to settlement	Set	Average distance to the nearest human settlement in 30 m^2 pixels in 250, 500, 1,000, 2,000 and 5,000 m radii circular buffers around the sampling stations (meters).		+	+	-
Distance to water body	Hid	Average distance to the nearest permanent water body in 30 m^2 pixels in 250, 500, 1,000, 2,000 and 5,000 m radii circular buffers around the sampling stations (meters).		-	-	+
Water area	Wat	Quantity of area occupied by water in 30 m^2 pixels in 250, 500, 1,000, 2,000 and 5,000 m radii circular buffers around the sampling stations (square meters).		-		+
High várzea area	Hiv	Quantity of area occupied by High várzea in 30 m^2 pixels in 250, 500, 1,000, 2,000 and 5,000 m radii circular buffers around the sampling stations (square meters).		-		
Low várzea area	Lov	Quantity of area occupied by Low várzea in 30 m^2 pixels in 250, 500, 1,000, 2,000 and 5,000 m radii circular buffers around the sampling stations (square meters).		+		
Chavascal area	Cha	Quantity of area occupied by Chavascal in 30 m^2 pixels in 250, 500, 1,000, 2,000 and 5,000 m radii circular buffers around the sampling stations (square meters).		+	+	

Data analysis

We used hierarchical “single-species” “multi-season” occupancy models in a maximum likelihood framework (BURNHAM; ANDERSON, 2002; MACKENZIE et al., 2002; TYRE et al., 2003) to investigate margay’s habitat associations in our study area. This approach allows estimating dynamic occupancy parameters of a given species, while accounting for imperfect detection (i.e., when detection probability is <1). Non-detection of a certain species at a given site can result from its real absence or sampling failure to detect when the species is in fact present (MACKENZIE et al., 2002; TYRE et al., 2003). By obtaining detection/non-detection information of the target species at multiple sampling sites at multiple sampling occasions, it is possible to estimate detection probability (p, probability of detecting the species in a site when it is present), which in turn, allows us to estimate the probability of not detecting the species when it is in fact present (MACKENZIE et al., 2002; TYRE et al., 2003). Using the detection probability, the model estimates the initial occupancy probability (ψ_i, psi_i, probability of a site being occupied by the species in the first of a series of survey/season/year), the colonization probability (γ, gamma, probability of an unoccupied site in the previous season become occupied by the species in the following season), and the extinction probability (ε, epsilon, probability of a previously occupied site becoming unoccupied by the species in the next season) (MACKENZIE et al., 2006).

Environmental and anthropogenic features are expected to influence each of these four dynamic occupancy parameters. Assuming that there are no changes in the occupancy state along the visits of the same season, but possibly only between seasons (assumption of “closed occupancy” during each season), it is possible to estimate the initial occupancy and to model spatial and temporal variations in the detection, colonization and extinction probabilities in response to survey and site covariates (MACKENZIE et al., 2006). This approach allows us to identify the most important drivers of each of the species dynamic occupancy parameter, and inform about the species-habitat relationship (MACKENZIE et al., 2002; MACKENZIE et al., 2006; TYRE et al., 2003). Thus, in this study, the occupancy parameters should not be seen strictly as the probabilities of presence, arrival or vacancy of a given site by margays, but as an investigation of the species’ habitats requirements and use intensity, as well as any possible occupancy trend in our research sites during the length of this study (COMLEY et al., 2020; JOHNSON, 1980; MACKENZIE; NICHOLS, 2004; PIÉDALLU et al., 2017; SALOM-PÉREZ et al., 2021; WANG et al., 2019).

We based our hypotheses and predictions on perceptions acquired several years of field research in the study area, and from the literature (BIANCHI et al., 2011; DE OLIVEIRA, 1998; HORN et al., 2020; SUNQUIST; SUNQUIST, 2002; TAN et al., 2017) (Table S1). To test them, we built dynamic occupancy models including environmental and anthropogenic covariates, which were evaluated using “theoretic information criteria” approach. In this approach, models representing different meaningful hypothesis are compared and ranked. Biological conclusions are drawn from the best performing models (BURNHAM; ANDERSON, 2002; MACKENZIE et al., 2006). To rank the candidate model, we used AIC values (Akaike Information Criterion) (BURNHAM; ANDERSON, 2002), which is a relative score based on models' maximum likelihood that favors parsimony by penalizing models with more parameters. Due to our relatively small sample size, we used the AICc, as recommended by Burnham and Anderson (2002). The same authors advocate that models with ΔAICc<7 may also have "considerably support" of evidence, not only the model with the lowest AICc value. Models that did not converge or fail to reasonably estimate standard errors were discarded from analysis (COMLEY et al., 2020; KENNEDY et al., 2011; LONG et al., 2011).

In multi-season occupancy models, each survey (different yearly samplings in this study) is named "primary occasion" (HARMSEN; SAVILLE; FOSTER, 2021; MACKENZIE et al., 2006). Each primary occasion is divided in several "secondary occasions", where a detection/non-detection data is inferred. Multi-season models assume no changes in species occupancy (closure) within a primary occasion but allow changes on occupancy between them (ROTA et al., 2009; WANG et al., 2019). To create margay's detection history, we generated a site-by-day table with ones (1) representing detections and zeros (0) representing non-detections (MACKENZIE et al., 2002). Aiming at higher temporal independence between the detections and a greater general detection probability, which favors the models' convergence, we collapsed 11 days detection/non-detection information into a single occasion, which represented our secondary occasions (COMLEY et al., 2020; DILLON; KELLY, 2007; OTIS et al., 1978). Therefore, if the species was detected at least once at a given site during a 11-day period, it was counted as detected for this period (secondary occasion). We selected this sampling occasion duration as it represents an optimum compromise between reducing non-detections (zeros in the capture history table) while not discarding detections (ones in the capture history table). Collapsing capture history is a standard procedure in occupancy analysis (TAN et al., 2017; WANG et al., 2019). To facilitate general model convergence and computational efficiency, we centered and scaled all continuous quantitative covariates (COMLEY et al., 2020; LONG et al., 2011; TACK et al., 2019).

We modeled the margay dynamic occupancy in a stepwise procedure of four stages. We first tested the effect of different covariates on the species detection probability, then on the initial occupancy probability, and finally on the colonization and extinction probabilities (COMLEY et al., 2020; DUGGER; ANTHONY; ANDREWS, 2011; HAMEL et al., 2013; LEE; BOND, 2015). In each step, we ranked univariate models for that parameter using the top model from the previous selecting stage (DUGGER; ANTHONY; ANDREWS, 2011; HAMEL et al., 2013; WANG et al., 2019). In all stages, we also included the null model (no covariates included) in the comparisons as a baseline (CERESA et al., 2020).

To test the influences of the sampling effort (MUNARI; KELLER; VENTICINQUE, 2011; SALOM-PÉREZ et al., 2021), presence of scent lure (GERBER; KARPANTY; KELLY, 2011; SEBASTIÁN-GONZÁLEZ et al., 2020), and the year (JACKSON; FAHRIG, 2015, VITEKERE et al., 2020) on the margay detection probability, we built univariate and additive multivariate models with combinations of these three covariates (HAMEL et al., 2013; KENNEDY et al., 2011).

We used the "multi-scale optimization" (MCGARIGAL et al., 2016) to select the best scale for each spatial covariate tested on the initial occupancy, colonization, and extinction probabilities (ROCHA et al., 2020) (Table 2). We extracted each site covariate in five different buffer sizes centered at our camera trap sites. We then selected the best buffer size for each covariate by ranking univariate models for a given parameter (COMLEY et al., 2020; LONG et al., 2011). By inspecting their AICc's, if none of the univariate models performed better than the null model, that covariate was not included in the next modeling steps (BURNHAM; ANDERSON, 2002; HAMEL et al., 2013; MACKENZIE et al., 2006). We performed Pearson's correlation test between all individual covariates selected in their best buffer sizes and, when correlation was strong (|r|>0.60), the covariate with the best performance (lowest AICc) was retained to the next modeling selection stage (SALOM-PÉREZ et al., 2021; TACK et al., 2019; VITEKERE et al., 2020). Then we built additive multivariate models with combinations of the selected individual covariates (in their best buffer size) (SALOM-PÉREZ et al., 2021). The covariates we tested in each parameter are found in Table 2, detailed descriptions in the supporting information Table S2 and Table S3. All the models we built and the results of their comparisons are available in supporting information Table S4.

To assess the fit of the final model to our data, we ran the "goodness off fit" test for dynamic occupancy as proposed by MacKenzie and Bailey (2004), with 999 simulations (COMLEY et al., 2020; HARMSEN; SAVILLE; FOSTER, 2021; MACKENZIE et al., 2006). We performed all analyzes in the open-source statistical programming environment "R version 4.0.3" (R CORE TEAM, 2020) using the packages "unmarked version 1.0.1" (FISKE; CHANDLER, 2011) and "AICcmodavg version 2.3-1" (MAZEROLLE, 2020).

RESULTS

With a sampling effort of 15,524 trap*day over seven surveys, we obtained 209 margay independent records, resulting in an average detection rate of 1.35 records/100 trap*days. After processing the data, 184 independent margay records remained in the collapsed capture history used in our analysis (Table 1). On average, we employed a sampling effort of 2,217.71 trap*day and obtained 29.86 margay records per survey (mean 95.86 days), with a detection rate ranging from 0.96 (in 2018) to 1.88 records/100 trap*day (in 2015), and naïve occupancy varying from 0.35 (2016) to 0.47 (2019) (Table 1). Margays were detected at least once at 48 of the 54 sampling stations consistently deployed across the entire multi-year surveys (Table 1).

Among the models we tested for the detection probability, the model that considered exclusively the influence of the sampling effort (m_psi(.)_g(.)_e(.)_p(Eff)) had the best performance, surpassing both the other univariate models (with only scent lure effect or year effect), as well as the multivariate and the null models. The selected model indicated a positive relationship between the probability of detecting a margay and the sampling effort, so that each additional day of a sampling increases in 0.03 the probability of detecting the species in a given occasion (Table 3; Fig.2; Fig.6).

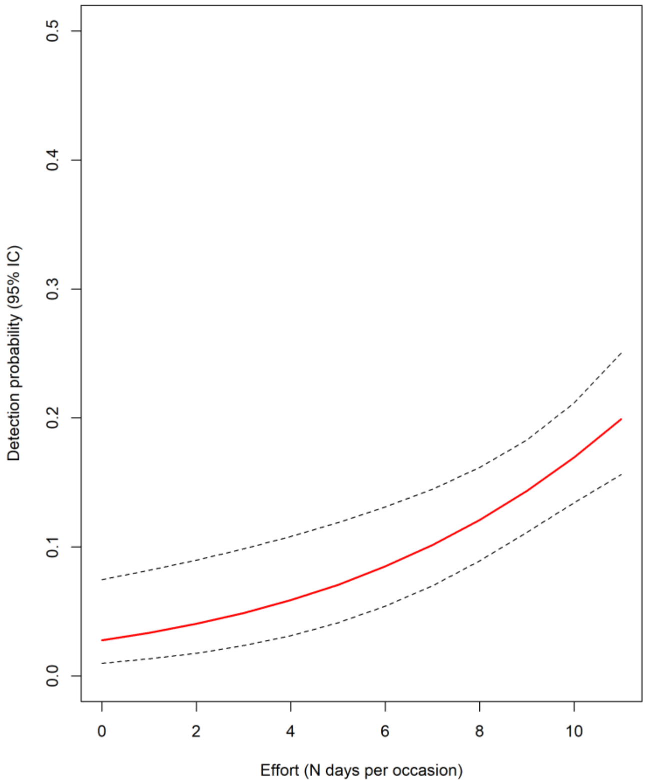

Figure 2: Estimated relationship between the probability of detecting a margay and the sampling effort.

In the univariate models tested for the margay initial occupancy, distance to settlement, amount of Low várzea area and amount of Chavascal area outperformed the null model. Both settlement and Low várzea had their best performance with the 5000 m buffer, while Chavascal with the 2000 m buffer. However, when carefullyinspected, Low várzea (m_psi(Lov5000)_g(.)_e(.)_p(Eff)) and Chavascal (m_psi(Cha2000)_g(.)_e(.)_p(Eff) and m_psi(Set5000Cha2000)_g(.)_e(.)_p(Eff)) showed initial occupancy models with unrealistic estimates (Table S4), indicating lack of model convergence, and were therefore discarded. Considering only top ranked models with reliable estimates (DUGGER; ANTHONY; ANDREWS, 2011), the best initial occupancy model included exclusively the covariate human settlement within a circular buffer of 5000 m, with a negative effect on the margay initial occupancy (Table 3; Fig.3; Fig.6).

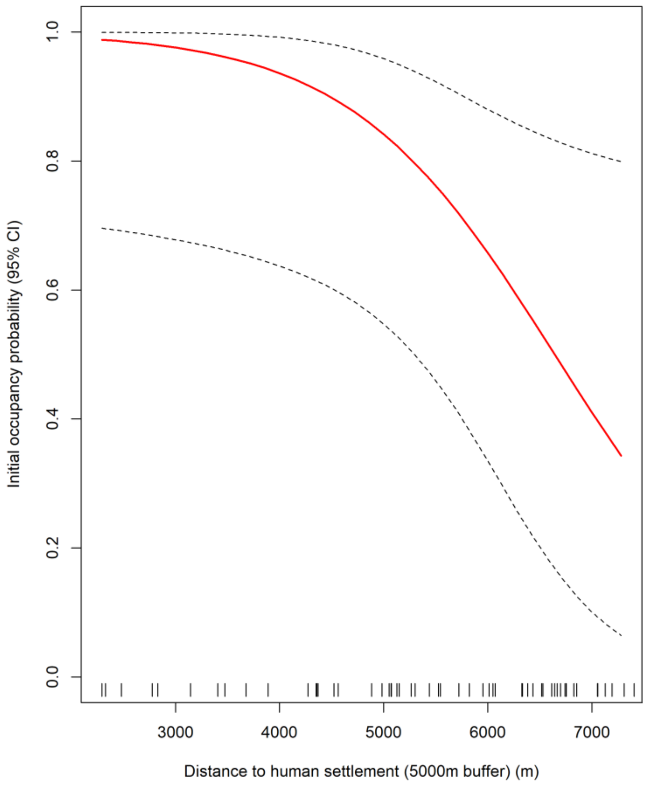

Figure 3: Estimated relationship between the margay initial occupancy probability and the distance to the nearest settlement.

For the evaluation of factors affecting margay colonization probability, the only univariate model that outperformed the null model was the one with the distance to the settlement in the 250 m buffer, which affected positively the colonization probabilityof this wild cat (Table 3; Fig.4; Fig.6).

Table 3: Untransformed (natural scale) estimates for intercepts and slopes of covariates effects (β), and standard errors (S.E.) on detection, initial occupancy, colonization, and extinction probabilities parameters. Covariates are sampling effort (Eff), and distance to the nearest human settlement within circular buffers of 250 (Set250) and 5000 m radii (Set5000).

	β	**S.E.**
Detection		
Intercept	-3.56	0.53
Eff	0.20	0.05
Initial occupancy		
Intercept	1.29	0.69
Set5000	-1.45	0.71
Colonization		
Intercept	-2.35	1.06
Set250	2.44	1.40
Extinction		
Intercept	-2.17	0.64
Set5000	1.67	0.59

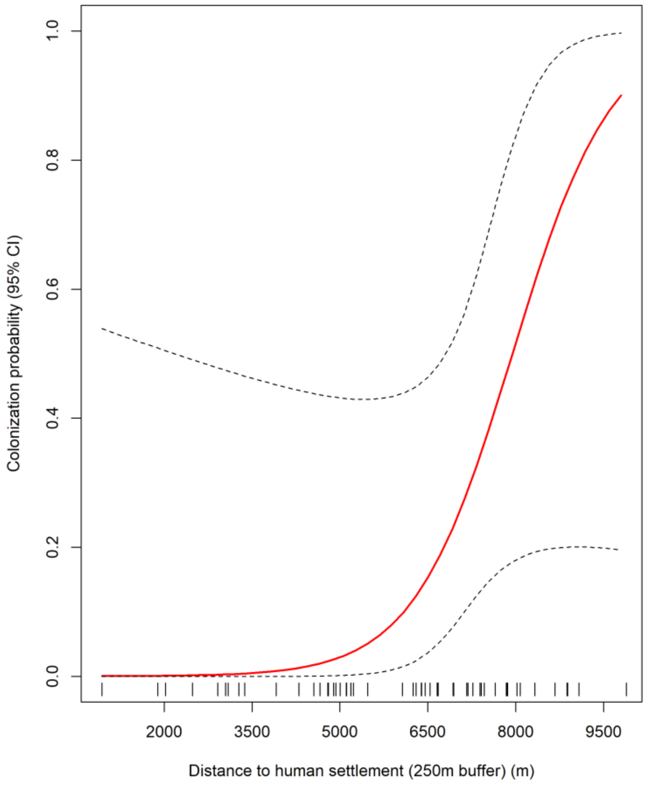

Figure 4: Estimated relationship between the margay colonization probability and the distance to the nearest settlement.

Among the univariate models tested for the extinction probability, the site covariates distance to the settlement, distance to the water body and amount of water area outperformed the null model. Both settlement and water area had their best performance with the 5000 m buffer, while distance to the water with the 1000, the 250, and the 500 m buffers. However, when carefullyinspected, the threetop ranked distance to the water models showed unrealistic estimates and were discarded (Table S4). We did not find a strong correlation between the Set5000, Hid250 and Wat5000 covariates (Table S4). Among the null, the univariate and multivariate extinction models composed by these three site covariates, the best ranked was the one that included exclusively the covariate distance to the settlement within a circular buffer of 5000 m, with a positive effect on the margay extinction probability (Table 3; Table 4; Fig.5; Fig.6).

Table 4: Model comparison to select the extinction probability model in the fourth and final step of our modeling procedure, using the models selected in the previous stages. Parameters are detection (p), initial occupancy (psi), colonization (g), and extinction (e) probabilities. Covariates are effort (Eff), distance to the human settlement (Set), distance to the water body (Hid), water area (Wat), and the null model (.). Evaluated covariates were in 250, 500 and 5000 m radii circular buffers around the sampling stations. Models were compared by their number of parameters (K), by the Akaike Information Criteria corrected for small sample sizes (AICc), their AICc difference in relation to the top ranked model (ΔAICc), AICc weights (AICcWt), AICc cumulative weights (Cum.Wt), and their Log Likelihood (LL).

Model	**K**	**AICc**	**ΔAICc**	**AICcWt**	**Cum.Wt**	**LL**
m_psi(Set5000)_g(Set250)_e(Set5000)_p(Eff)	8	676.89	0	0.28	0.28	-328.84
m_psi(Set5000)_g(Set250)_e(Set5000Hid500)_p(Eff)	9	678.11	1.23	0.15	0.42	-328.01
m_psi(Set5000)_g(Set250)_e(Set5000Wat5000)_p(Eff)	9	678	1.59	0.12	0.55	-328.19
m_psi(Set5000)_g(Set250)_e(Hid500Wat5000)_p(Eff)	9	679.26	2	0.08	0.63	-328.59
m_psi(Set5000)_g(Set250)_e(Set5000Hid500Wat5000)_p(Eff)	10	679.37	2.49	0.08	0.71	-327.13
m_psi(Set5000)_g(.)_e(Set5000)_p(Eff)	7	679.56	2.68	0.07	0.78	-331.57
m_psi(Set5000)_g(.)_e(Hid500Wat5000)_p(Eff)	8	679.99	3.1	0.06	0.84	-330.39
m_psi(Set5000)_g(.)_e(Set5000Hid500)_p(Eff)	8	680.84	3.96	0.04	0.88	-330.82
m_psi(Set5000)_g(.)_e(Set5000Wat5000)_p(Eff)	8	681.47	4.58	0.03	0.91	-331.13
m_psi(Set5000)_g(Set250)_e(Hid500)_p(Eff)	8	681.91	5.02	0.02	0.93	-331.35
m_psi(Set5000)_g(.)_e(Set5000Hid500Wat5000)_p(Eff)	9	683.01	6.12	0.01	0.94	-330.46
m_psi(Set5000)_g(Set250)_e(Wat5000)_p(Eff)	8	683.01	6.13	0.01	0.96	-331.91
m_psi(Set5000)_g(.)_e(Hid500)_p(Eff)	7	683.19	6.3	0.01	0.97	-333.38
m_psi(Set5000)_g(Set250)_e(.)_p(Eff)	7	683.22	6.33	0.01	0.98	-333.39
m_psi(Set5000)_g(.)_e(.)_p(Eff)	6	683.4	6.51	0.01	0.99	-334.81
m_psi(Set5000)_g(.)_e(Wat5000)_p(Eff)	7	683.72	6.83	0.01	1	-333.64

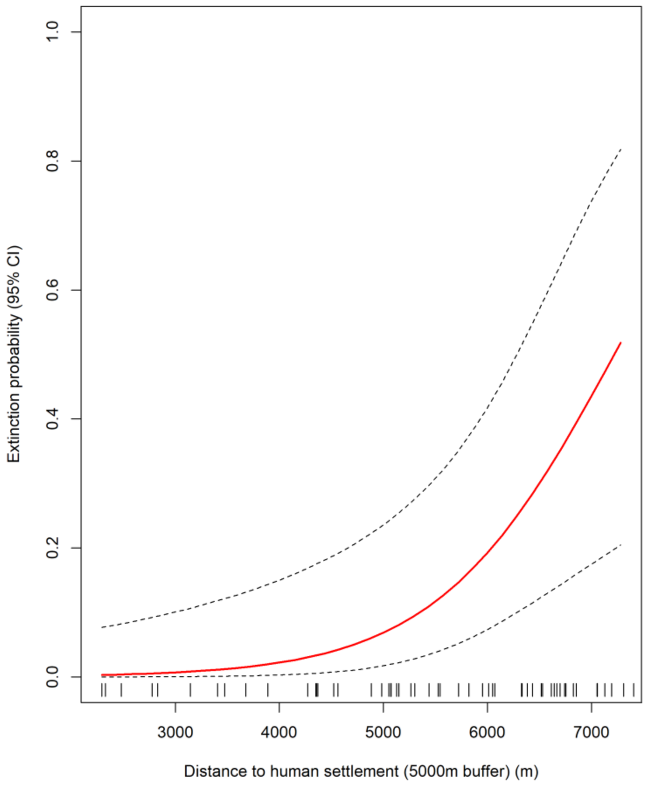

Figure 5: Estimated relationship between the margay extinction probability and the distance to the nearest settlement.

Our final model indicated that, in the study area, the sampling effort is positively related to the margay detection probability, and that the distance to the nearest human settlement is negatively related to the initial occupancy probability, positively to the colonization probability, and positively related to the extinction probability.

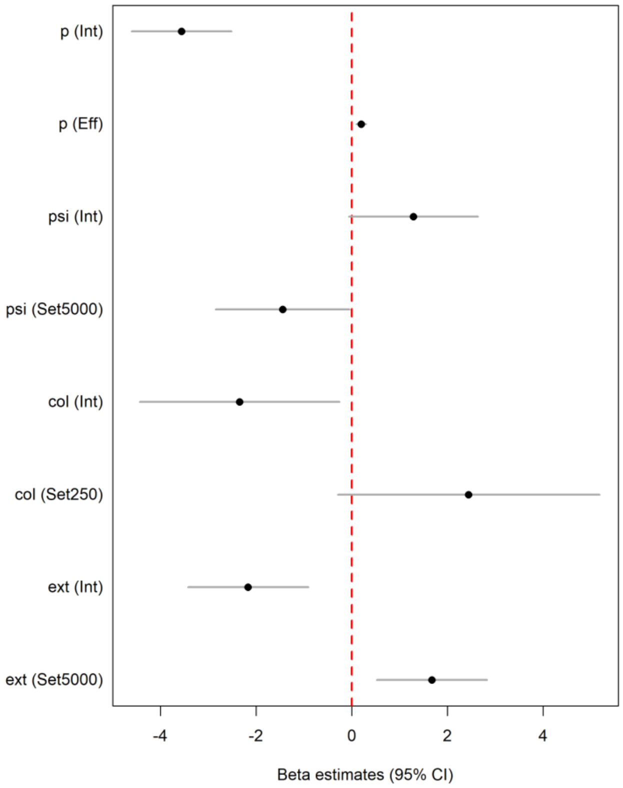

Figure 6: Untransformed (natural scale) estimates and 95% confidence intervals for intercepts (Int) and slopes of covariates effects (Betas) on detection (p), initial occupancy (psi), colonization (col), and extinction (ext) probabilities parameters. Covariates are sampling effort (Eff), and distance to the nearest human settlement within circular buffers of 250 (Set250) and 5000 m radii (Set5000).

For the margay dynamic occupancy in our studied area, the final model fitted well to our data (p=0.64). This model included the effects of the sampling effort on the detection probability, the distance to the settlement within 5000 m buffer on the initial occupancy and extinction probabilities, and the distance do the settlement within 250 m buffer on the colonization probability. We found a little sub-dispersion of our data in relation to the model (c-hat=0.65) (MACKENZIE et al., 2006). We estimated for all pooled sampling stations an average margay initial occupancy probability of 0.68 (Table 5).

Table 5: Naïve and estimated margay occupancy (ψ) probabilities for each survey.

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Naïve	0.40	0.45	0.39	0.35	0.43	0.40	0.47
ψ	0.68	0.67	0.67	0.67	0.67	0.67	0.67

DISCUSSION

In this study, we used data from a consecutive seven-year camera trap survey to investigate environmental and anthropogenic effects on the margay habitat use dynamics within a protected area in the central Amazonia.We revealed that the estimated occupancy was higher than the naïveoccupancy recorded in any of the years, indicating the expected imperfect detection of this keystone felid species(CALVERT et al., 2018; MARINHO et al., 2017; SALOM -PÉREZ et al., 2021; TAN et al., 2017; WANG et al., 2019). The influence of human presence, using as proxy of anthropogenic influence the proximity of human settlements, was the main driver of the margay dynamic occupancy, affecting the initial occupancy, colonization and extinction probabilities. Furthermore, we found no evidence of temporal variation in any of the evaluated margay dynamic occupancy parameters, demonstrating the stability of their habitat use dynamics in the várzeaof the Mamirauá Reserve.

Although the methodological component of our hierarchical model was not the main interest of this study, there are some results worth discussing. Our results indicate, as hypothesized, that the margay detection in the study area was positively related to sampling effort. This is not surprising, as it has long been known that in most cases, the number of detections of a target species follows the amount of effort used to detect it (HARMSEN; SAVILLE; FOSTER, 2021; OTIS et al., 1978; WANG et al., 2019). For instance, in the mid-southern Belize, the number of margay detections was found to be positively related to trap effort, with a mean rate of about one extra detection every 100 station*days(HARMSEN; SAVILLE; FOSTER, 2021).The difference we found between the naïveand the modeled occupancy reinforces that, only with a good understanding of the methodological component it is possible to access a good ecological component of the model (ROYLE; NICHOLS, 2003; MACKENZIE; BAILEY, 2004), generally the main objective of the studies.

Differently from our prediction, we did not find influence of the scent lure on the margay detection. Possibly this reflects the elusive and cautious behavior of the species (DE OLIVEIRA, 1998), the not-so-refined smell sense of the felids (KITCHENER; VAN VALKENBURGH; YAMAGUCHI, 2010), and the short-range effectivity of the scent of the lure. In fact, by packing the lure content in poorly vented container, but inaccessible for consumption, our main objective was not to attract or to change the course of felids naturally passing nearby the station, which could bias our data.Our main intention with the scent lure was to make individuals staying longer in front of the cameras, providing a higher number and better quality of photos. In an investigation on the effect of the scent lure in an adjacent area to the ours, Rocha et al. (2016) found that predators were not influenced by the lure and that some prey species avoided it. Therefore, considering the extra field effort, the use of scent lures might not add any advantage to the sampling design and even harm it. For future studies, a careful evaluation of the effect of scent lures on target species is recommended before the survey, possibly through some controlled experiment or pilot sampling.

As hypothesized, we did not observe influence of the sampling year on the methodological neither on the ecological component of our study. This means that at least during the period we collected the data, there were no significant temporal variations to cause changes in the detection or in the margay habitat use. We expected this consistency because we were unaware of a cause, environmental or anthropogenic, with the potential to alter during our samplings the parameters investigated. Therefore, like Eaton et al. (2014), which indicated that the relative environmental stability probably led to stability in the dynamic occupancy of a lagomorph (Lower Keys marsh rabbit, *Sylvilagus palustris hefneri*), we conclude that the RDSM seems to be a stable area in relation to the margay habitat use.

We found evidence that the margay uses more intensively areas with higher anthropogenic influence, measured using the distance to the nearest settlement. This pattern was contrary to our initial hypothesis, as we expected a negative effect of anthropogenic influence. There are a number of possible explanations for this unexpected pattern, which can even act synergistically. Two explanations, however, seem to be more likely. One possible reason for this relationship could be interspecific competition release. Larger carnivores, which are known to exert a negative influence on smaller carnivores, face higher persecution by humans and therefore might be negatively affected by settlements (CARUSO et al., 2016; DE OLIVEIRA et al., 2010; CROOKS; SOULÉ, 1999). The only other felid with established population in our study area is the jaguar (ALVARENGA et al., 2018; pers. obs.). This species is frequently seen close to human settlements, but the real effects of human presence on the jaguar are unclear. This large felid not rarely preys upon domestic animals, sometimes within the settlements (pers. obs.), and dozens of jaguars are killed every year in Mamirauá Reserve (RAMALHO, 2012). Despite that, jaguars did not seem to have their space use influenced by human settlements in RDSM (MONTANARIN, 2020). In addition to the margay and the jaguar, the only other carnivore established in the sampled area is the coati (*Nasua nasua*) (ALVARENGA et al., 2018; pers. obs.). Despite coatis seems to have a diet based on other items than those mostly consumed by the margaythroughout its geographical ranges, possibly in várzea they compete for prey to some degree (ALVES-COSTA; DA FONSECA; CHRISTÓFARO, 2004; GOMPPER; DECKER, 1998; ROCHA-MENDES et al., 2010). However, coatis are gregarious and not as furtive, cautious and agile as the margay, which can make coatis more harmed due to anthropogenic influences, as, for example, domestic dogs. Therefore, it is possible that jaguars and coatis face greater negative anthropogenic effects than margays, unbalancing interspecific relationships, and releasing margays competitively.

A second possible reason for the positive relationship between the margay habitat use and settlements could be a higher prey availability for the margay in areas closer to human settlements.The shelter found in structures built by humans, the food provided by agriculture and livestock, even on a small scale, and the disposal of wastes are just some direct ways in which various species can be favored by settlements (FARIAS; KITTLEIN, 2008; LÓPEZ-BAO et al., 2019; NEWSOME et al., 2014).

Among the organisms traditionally benefited by this interaction, several appear as prey items most explored by the margay, such as small mammals, birds, and reptiles (NAGY-REIS et al., 2019; SEIBERT et al., 2015).Several studies suggest that anthropogenic interference can influence carnivore species through food availability (CARUSO et al., 2016; GRAVES et al., 2021; SÉVÊQUE et al., 2020). In an upland *terra firme* area adjacent to our study site, margay occupancy responded to the availability of potential prey. Some of these prey species were positively and others negatively associated with traditional familiar agriculture (ILHA, 2016). In addition, human influence can negatively affect diurnal species with higher intensity, changing the community composition and increasing the prevalence of nocturnal species by reducing the fraction of diurnal species in biological communities close to the settlements (ABRAHAMS; PERES; COSTA, 2017). This could consequently increase the relative prey availability for margays in its period of highest activity, directly benefiting its occurrence. In addition, most of the animal protein obtained locally for human consumption in RDSM comes from fishing (MOURA et al., 2016), so that the margay and some potential prey species (e.g. Tinamidae, Cracidae) do not face the negative pressure from hunting, often observed in other contexts to be more severe close to the settlements (ABRAHAMS; PERES; COSTA, 2017).

Other studies have shown the tolerance of carnivore species to anthropogenic stressors. For instance, Graves et al. (2021) indicated that in the southern Atlantic Forest, carnivores with medium and smallbody sizes, such as the margay, were more tolerant to anthropogenic influence (measured using multiple covariates simultaneously) than the larger species.Horn et al. (2020) found higher margay densities in areas with less anthropogenic influence, and intermediate densities of the species associated with intermediate levels of human interference, suggesting the reduction in the vegetation cover for human land use as the main cause. Other studies have shown that anthropogenic interference negatively influenced both the ocelot (*Leopardus pardalis*) (MASSARA et al., 2017) and the margay through domestic dogs, for example (CASSANO; BARLOW; PARDINI, 2014).Sévêque et al. (2020) in a broad review demonstrated that the carnivores' responses to anthropogenic influences can be highly varied. We believe that one aspect that must certainly be considered is the nature and the intensity of the human pressure, which depends on both, technical and practical (e.g. familiar or high-tech, high-impact agriculture), as well as on cultural and social aspects (e.g. species can be seen as enemy or charismatic) (DRESSEL; SANDSTRÖM; ERICSSON, 2015).

Distance to settlements was also the only covariate relevant to the margay occupancy dynamic parameters (extinction and colonization). However, in the case of the colonization probability, our inferences were limited and should be carefully considered, as the confidence intervals overlapped zero (Fig.6) (DUGGER; ANTHONY; ANDREWS, 2011; MARINHO et al., 2017; WANG et al., 2019). As predicted, the colonization probability was positively related to distance to settlements. However, contrary to our prediction, extinction probability was also positively related to this same covariate. Although it might seem counterintuitive, this pattern has already been found in various taxa, including birds (GREEN; PAVLACKY JR; GEORGE, 2019), small mammals (RODHOUSE et al., 2018), lagomorphs (EATON et al., 2014), and other carnivores (FIDINO; SIMONIS; MAGLE, 2019).High colonization and extinction probabilities concomitantly, indicate that there is a high "turnover", i.e., a shift in habitats used. In our study area, margay habitat use is higher and constant across surveys at sites nearer to settlements. However, sites located further from settlements tend to be less used and more likely to vary its use intensity by margays across seasons. Possibly, the cause for this scenario is that the anthropogenic influence increases the quality and/or quantity of food resources for margay, as well as makes their availabilitymore constant. It is likely that in more pristine and distant to settlements habitats, margay's prey availability is influenced by a number of factors, which varies in time, causing greater fluctuations in the margay's food availability. However, in areas closer to the settlements, the anthropogenic influence, relatively stable over the time, would be the major influence on the preys consumed by margays, causing less temporal variation in the food resources explored by the species.Among the other studies that also found colonization and extinction probabilities related in the same direction to the same covariate, Eaton et al. (2014) suggest that in that case, a high turnover occurs in high-quality habitats, often exposed to temporallyirregular disturbances. Adjacent and less advantageous habitats for their studied species would act as refuges that, immediately after local extinctions in the best habitat, would provide migrant individuals searching for better conditions and resources, causing a higher turnover in the most advantageous habitats. Yet we believe in our case, the higher turnover was in the low-quality habitats. Possibly the dominant individual margays would settle and use territories with higher anthropogenic influence, more advantageous. The inferior competitors would be fated to use areas with less anthropogenic influence and with heterogeneous resources over the space and/or the time, resulting in a higher habitat use turnover in the most pristine and further from settlements areas.

The aforementioned advantages found by the margay nearer the settlements probably are, to some extent, beneficial for the species. There are, however, potential risks. Generally, positive relationships between covariates and species' biological/ecological parameters are interpreted as favorable to the conservation of these organisms. However, higher population densities, for example, are sometimes found in habitats that, in the long term, are harmful to these populations (PURCELL; VERNER, 1998; SCHLAEPFER; RUNGE; SHERMAN, 2002). Possibly the major feature of the anthropogenic induced environmental changes is the high velocity they occur. Occasionally, these changes alter the cues used by organisms to select their habitats. In other situations, fast environmental changes modify the habitats themselves, but remaining the old stimuli individuals used to select it (SCHLAEPFER; RUNGE; SHERMAN, 2002). As a result, individuals show equal or even greater preference for less favorable habitats, even though higher quality habitats are available. These less-favorable habitats eventually will negatively affect the populations, creating a “ecological trap” or “evolutionary trap” (DWERNYCHUK; BOAG, 1972; GATES;

GYSEL, 1978).The trap's severity depends both on the degree of the change in the habitat attractiveness, as well as on how harmful the less favorable habitat will be for the organisms choosing it (ROBERTSON; HUTTO, 2006). However, the consequences can be quite negatives, including local population extinctions (BATTIN, 2004).It is likely that margays were using more intensively areas with higher anthropogenic influence, even though more pristine habitats were available. For the adequate testing of this 'ecological trap' hypothesis, however, it would be necessary to demonstrate reduced individuals' fitness in margays from habitats nearest to the settlements. In addition, we believe that main potential risk of the margays' proximity to the settlements in RDSM is a high exposure to pathogen transmission by domestic animals (CLEAVELAND et al., 2006; FILONI, 2006; TORTATO et al., 2013). The negative consequences of an epidemic disease could take years to manifest, therefore not being easily detected on a short-term basis.

Ecological traps have some analogies with the dynamics of meta-populations and the source-sink system (BATTIN, 2004; PULLIAM, 1988). Regarding this, despite possibly creating a ecological trap for the margay, the small number, extent and the reduced impacts of the RDSM settlements (MOURA et al., 2016; pers. obs.) probably does not represent a major threat to its population. Because of the high conservation status of most our study area, the sink sites would have minimal effect in relation to the source areas in a significant space-time perspective. Despite raising the timid possibility that the margay is being an ecological trap victim, reasons such as the logistical difficulties imposed by our study area and the spatial and temporal scales necessary to prove it (HALE; SWEARER, 2016) make this exciting task tremendously challenging.

We observe that due to the large size of the area and the limited number of settlements in it, few of our sampling stations were located really close to these settlements, most of them being above 2000 m away from any settlement (the closest was 550 m, Euclidean distance). Although the location of settlements in this study was represented by a point vector (that have zero dimensions, therefore you can measure neither length or area of this objects), settlements are a rather complex and dynamic feature. In fact, it is virtually impossible to draw a boundary to settlement, as area of use of its settlers can go far beyond the cluster of houses and might change in response to different spatial and time variables. We assumed local people behave foraging settlement-centered (ABRAHAMS; PERES; COSTA, 2017), so anthropogenic influence is the highest and centered in our point vector, decreasing further away from the settlements. Therefore, even though we do not have survey units closer than 500 m to any settlement, we believe that most of our sites were within the influence of settlements, analogous to what some studies on hunting call "catchment area" (JEROZOLIMSKI; PERES, 2003). Nevertheless, our results should be taken with caution, keeping in mind that when we refer to closer to a settlement, we do not mean to say on top of it. We believe that the consistency with which the same covariate appeared in the top models for the habitat use and its dynamic parameters, and especially the ecological and empirical coherence, indicate that the anthropogenic influence is an important covariate for the margay in várzea areas of the central Amazonia.

We found no evidence that the margay habitat use is directly influenced by elevation. In várzea areas, the elevation is important by determining the flooding period to which the aquatic-terrestrial transition zone is subjected and, consequently, the distribution of several species and countless biological processes (JUNK et al., 2012; WITTMANN; SCHÖNGART; JUNK, 2010; VILLAMIZAR et al., 2020). We believe, however, that the altitudinal gradient we sampled probably presented a very low variation, (range 32-50 m; Table S3). This variation seemed not to be enough for revealing some influence on the species occupancy. Altitudinal variation has already been shown to affect the dynamic occupancy of three carnivore species (including two felids) even more than anthropogenic influence but along a wider altitudinal range (between 1,300 and 1,700 m a.s.l; VITEKERE et al., 2020). A narrow elevation range (22.56–241.34 m a.s.l.) was considered to explain a positive but weak relation between elevation and habitat use by the ocelot in mid-southern Brazilian Amazonia (WANG et al., 2019). Therefore, it is possible that on a broader geographical scale, with higher variation and wider range, elevation might have an effect on margay occupancy, even in várzea areas.

In this study, we did not find evidence that proximity to or amount of water influence margay' habitat use and dynamics. These results demonstrate that, in our study area, the margay uses habitats near large water bodies in the same intensity that areas where there are no water bodies in the vicinity. In fact, our entire study area is an island surrounded by two large rivers and with many lakes and channels spread thru. Therefore, except during the peak of the dry season, when the rainfall and river are at their lowest levels, there is plenty of water in the landscape. Distance to the water did not seem to affect margay population density in the Atlantic Forest in Brazil (HORN et al., 2020). Proximity to water was relevant, however to other small felids in dryer habitats. For instance, Tirelli et al. (2019) found that the Geoffroy cat (*Leopardus geoffroyi*) selects areas closest to the water bodies in the Pampa biome. We believe that the similarity of the results found in the rainforests of Amazonia and Atlantic Forest, and the contrast with the findings in the arid Pampa, indicates that the distance to the water probably becomes more relevant for these small felids at a more severe restriction on this resource availability.

Another limitation we face is the seasonably pronounced transformation caused by the flood pulse in our study area every year (FERREIRA-FERREIRA et al., 2014; JUNK; BAYLEY; SPARKS, 1989; RAMALHO et al., 2009). The selection of certain resources and/or habitats by a given species may depend on their availability in space and time (CUSHMAN et al., 2011; CUSHMAN; SHIRK; LANDGUTH, 2013).Habitat association found by studies during the dry season does not necessarily hold for the flooding season. Thus, our inferences must be restricted to the whole period of drought and part of the receding and rising water periods, not including necessarily high water level periods.

None of the phyto-physiognomies we tested as a covariate was important to explain variation in the margay habitat use and its dynamics in our study area. These results did not corroborate our hypotheses related to the vegetation influence on the margay. This felid is notoriously reported as a forest dweller (ESPINOSA et al., 2018; HODGE, 2014; HORN et al., 2020) and all the physiognomies we evaluated are habitats with high degrees of forest cover. We believe that, at least in our study area, the species does not distinguish between the contrasting aspects of the phyto-physiognomies we evaluated, for example, the canopy height, the presence or how developed is the understory.Alvarenga et al. (2018) showed that in the RDSM, the presence and the amount of Chavascal, for example, influenced the composition of mammal species, which apparently avoided using areas with longer flooding regimes. Probably the margay occupancy in other non-forested habitats (e.g. areas of bare soil and várzea Fields) is reduced when compared to the forest physiognomies we evaluated here and, if included as covariates, would have revealed a different result. However, we did not sample these habitats, limiting our inferences regarding the margay habitat use in these areas.

In this study, we evaluated both elevation and distance to water, and neither appear to be relevant to the margay occurrence. Both these factors, however, are considered by the local people to select the settlement sites in our study area. Generally, they seek higher areas, so their homes remain above the water during most of the flooding season, but at the margins of the main rivers and channels for water supply and logistical reasons (as fluvial transportation is the only way to get around). Our results reinforce the hypothesis that margay habitat use is being influenced by anthropogenic effects *per se* and not indirectly by other environmental covariates related to settlement locations.

As next steps to fill important gaps in the ecological knowledge about the margay in várzea areas of the Amazonia, we suggest the generation of robust population density estimates on a multi-year time frame, providing better evidence about the population trends by which the species is going through (DI BITETTI et al., 2008; KARANTH et al., 2006; TORTATO et al., 2013). In addition, physical contention to collect biological samples and implement telemetry transmitters, while challenging and financially costly, would help to take a huge step towards elucidating the real impact of human settlements to the margay.It would thus be possible to assess its epidemiological profile and confirm whether there is occurring the introduction of allochthonous pathogens in the local population of the species through the domestic animals (MURRAY et al., 1999; SCOTT, 1988; SMITH; SAX; LAFFERTY, 2006). The movement ecology, on the other hand, would expand our understanding of the margay spatial dynamics in these areas, and could indicate species-habitat relations impossible to assess through the methods we used in this study (BURT, 1943; FALCONI et al., 2015; GINÉ et al., 2015; TIRELLI et al., 2018; TURCHIN, 1991). These next steps would demonstrate with higher robustness the conservation status of these margay populations, and would help to understand if really there are ecological traps for the species in the várzeas of the Amazonia.

Only through occupancy rate parameters it is possible to demonstrate turnovers, which makes them better than static occupancy to identify source and sink areas, as well as to predict future trends in the species' occurrence patterns (GREEN; PAVLACKY JR; GEORGE, 2019; SCHLAEPFER; RUNGE; SHERMAN, 2002; YACKULIC et al., 2015). We used data from a consecutive seven-year camera trap survey to investigate environmental and anthropogenic effects on the margay habitat use dynamics. This unique dataset allowed us to use a multi-season occupancy modeling to investigate the species-habitat relationships. This is the first time such analytical framework is used in a margays study. Our results indicate that anthropogenic influence is a major element for the margay habitat use dynamics in our study area. This is particularly concerning, as human and margay populations are forced to share the same areas. Added to this, the National Action Plan for the Conservation of Small Felids in Brazil (ICMBio/CENAP, 2021) prioritizes investigations about anthropogenic influence on small felids populations. This demonstrates the importance of our study so that the next decisions aiming the margay and other carnivores conservation can be better informed and, principally, science based.

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SUPPORTING INFORMATION

Table S1: Parameters and covariates tested evaluating the margay dynamic habitat use in a várzea area of the central Amazonia, the expected relation between the parameter and the covariate, rationale why we formulated the prediction, and related studies.

Parameter	Covariate	Relation	Rationale	References
Detection	Effort	Positive	The greater is the sampling effort, higher would be the probability of recording the species.	KENNEDY et al., 2011; MUNARI; KELLER; VENTICINQUE, 2011; SALOM-PÉREZ et al., 2021
Detection	Scent lure	Positive	The scent lure would attract margays to the sample station.	GERBER; KARPANTY; KELLY, 2011; ROCHA; RAMALHO; MAGNUSSON, 2016;SEBASTIÁN-GONZÁLEZ et al., 2020
Detection	Year	Non-directional effect	Although there were no potential causes to strong temporal variation in the margay detection, we tested the year as a factor in a way to account for temporal effects not covered by the other detection covariates (e.g. meteorological, river	GERBER; KARPANTY; KELLY, 2011; HAMEL et al.,

			water level).	2013; JACKSON; FAHRIG, 2015, VITEKERE et al., 2020
Occupancy	Elevation	Negative	Higher areas tend to have a forest with taller trees and an absent/less dense understory. Therefore, in these areas there would be less availabilityof margay's preys, which would also face higher difficulty in foraging and in doing its vertical movements.	OBERSOLER et al., 2020; VITEKERE et al., 2020
Occupancy	Distance to settlement	Positive	Areas farther from human settlements probably are exposed to less anthropogenic influences, and potentially lead margays to use these areas more frequently.	MARINHO et al., 2017; WANG et al., 2019
Occupancy	Distance to water body	Negative	Areas farther from water bodies are likely to retain lower prey availability, potentially leading margays to visit these areas less frequently.	TAN et al., 2017; WANG et al., 2019
Occupancy	Water area	Negative	Larger water bodies are more used by humans, higher anthropogenic influences would have negative effects on the occupancy of margays.	
Occupancy	High várzea area	Negative	Considering that taller trees and absent/less dense understory layer is found in this phyto-physiognomy, there would be less availabilityof margay's preys. Also, this same vegetation features could hamper the margay' ambush strategy for predation, and hinder its vertical movements. Lower occurrence of margays is expected to occur.	
Occupancy	Low várzea area	Positive	The merely intermediate height of the trees and the present/denser understory would retain intermediate margay's prey availability, and facilitate its vertical	

			movements. Therefore, the species possibly use these habitats frequently.	
Occupancy	Chavascal area	Positive	Low trees height and well-developed understory would favor a high margay’s prey availability, in addition to facilitating its ambush strategy to predate and its vertical movements, favoring intense use by the species.	
Colonization	Distance to settlement	Positive	Areas farther from human settlements probably are exposed to less anthropogenic influences, and potentially lead margay to starts to use these areas more frequently.	
Colonization	Distance to water body	Negative	Probably there is lower margay’s prey availability in areas farther from water bodies and so, the species would tend to start to use these habitats less frequently.	
Colonization	Chavascal area	Positive	Low trees height and well-developed understory would favor a high margay’s prey availability, in addition to facilitating its ambush strategy to predate and its vertical movements. The species would start to use these habitats more frequently.	
Colonization	Year	Non-directional effect	Although there were no potential causes to strong temporal variation in the margay colonization, we tested the year as a factor in a way to account for temporal effects not covered by the other colonization covariates (e.g. meteorological, river water level).	
Extinction	Distance to settlement	Negative	Areas farther from human settlements probably are exposed to lower anthropogenic influences, and potentially lead margay to stops to use these areas less frequently.	
Extinction	Distance to water body	Positive	Probably there is lower margay’s prey availability in areas farther from water bodies and so, the species would tend to stop to use these habitats more	

			frequently.	
Extinction	Water area	Positive	Larger water bodies are more used by humans, higher anthropogenic influences would lead margay to stop to use these habitats more frequently.	
Extinction	Year	Non-directional effect	Although there were no potential causes to strong temporal variation in the margay extinction, we tested the year as a factor in a way to account for temporal effects not covered by the other extinction covariates (e.g. meteorological, river water level).	

Table S2: Description of the covariates included in the models. Cov. ID = covariates' identification label; Type = type of covariate data; Values = range or covariate central tendency measures (minimum; mean; maximum); and the dynamic occupancy model parameters that each covariate was tested for. Detection probability (p), initial occupancy probability (Ψi), colonization probability (γ), and extinction probability (ε); and expected relationship between the parameter and the covariates (negative (-), non-directional effect (0), or positive (+)).

Covariate	**Cov. ID**	**Type**	**Values**	**Description**	**Tested parameters and effects**			
					p	Ψi	**γ**	**ε**
Effort	Eff	Quantitative discrete	0 to 11	Number of days each sampling station was active on each collapsed sampling occasion.	+			
Scent lure	Scl	Binary	0 or 1	Absence or presence of the scent lure in each sampling station in each year.	+			
Year	Yea	Categorical ordinal	2013 to 2019	Year of the sampling.	0		0	0
Elevation in 250 m buffer	Ele250	Quantitative continuous	32.45; 43.32; 49.5	Average elevation in 30 m^2 pixels in 250 m radii circular buffers around the sampling stations (meters above sea level).		-		
Elevation in 500 m buffer	Ele500	Quantitative continuous	34.01; 43.14; 48.56	Average elevation in 30 m^2 pixels in 500 m radii circular buffers around the sampling stations (meters above sea level).		-		
Elevation in 1000 m buffer	Ele1000	Quantitative continuous	35.14; 43.18;	Average elevation in 30 m^2 pixels in 1000 m radii circular buffers around the sampling stations (meters above sea level).		-		

			48.09					
Elevation in 2000 m buffer	Ele2000	Quantitative continuous	37.19; 43.13; 46.76	Average elevation in 30 m^2 pixels in 2000 m radii circular buffers around the sampling stations (meters above sea level).		-		
Elevation in 5000 m buffer	Ele5000	Quantitative continuous	40.59; 42.95; 44.72	Average elevation in 30 m^2 pixels in 5000 m radii circular buffers around the sampling stations (meters above sea level).		-		
Distance to settlement in 250 m buffer	Set250	Quantitative continuous	940.15; 5963.67; 9886.15	Average distance to the nearest human settlement in 30 m^2pixels in 250 m radii circular buffers around the sampling stations (meters).		+	+	-
Distance to settlement in 500 m buffer	Set500	Quantitative continuous	963.35; 5955.88; 9836.06	Average distance to the nearest human settlement in 30 m^2pixels in 500 m radii circular buffers around the sampling stations (meters).		+	+	-
Distance to settlement in 1000 m buffer	Set1000	Quantitative continuous	1020.27; 5925.29; 9624.62	Average distance to the nearest human settlement in 30 m^2pixels in 1000 m radii circular buffers around the sampling stations (meters).		+	+	-
Distance to settlement in 2000 m buffer	Set2000	Quantitative continuous	1221.74; 5835.64; 9086.73	Average distance to the nearest human settlement in 30 m^2pixels in 2000 m radii circular buffers around the sampling stations (meters).		+	+	-
Distance to settlement in 5000 m buffer	Set5000	Quantitative continuous	2295.54; 5374.66; 7405.79	Average distance to the nearest human settlement in 30 m^2pixels in 5000 m radii circular buffers around the sampling stations (meters).		+	+	-
Distance to water body in 250 m buffer	Hid250	Quantitative continuous	22.19; 315.56; 1377.11	Average distance to the nearest permanent water body in 30 m^2 pixels in 250 m radii circular buffers around the sampling stations (meters).		-	-	+

Distance to water body in 500 m buffer	Hid500	Quantitative continuous	45.21; 323.5; 1296.25	Average distance to the nearest permanent water body in 30 m^2 pixels in 500 m radii circular buffers around the sampling stations (meters).		-	-	+
Distance to water body in 1000 m buffer	Hid1000	Quantitative continuous	74.63; 342.03; 1106.2	Average distance to the nearest permanent water body in 30 m^2 pixels in 1000 m radii circular buffers around the sampling stations (meters).		-	-	+
Distance to water body in 2000 m buffer	Hid2000	Quantitative continuous	155.45; 362.98; 712.78	Average distance to the nearest permanent water body in 30 m^2 pixels in 2000 m radii circular buffers around the sampling stations (meters).		-	-	+
Distance to water body in 5000 m buffer	Hid5000	Quantitative continuous	145.41; 335.85; 635.53	Average distance to the nearest permanent water body in 30 m^2 pixels in 5000 m radii circular buffers around the sampling stations (meters).		-	-	+
Water area in 250 m buffer	Wat250	Quantitative continuous	0; 5209.76; 83918	Amount of area occupied by permanent free water surfaces in 30 m^2pixels in 250 m radii circular buffers around the sampling stations (square meters).		-		+
Water area in 500 m buffer	Wat500	Quantitative continuous	0; 33329.46; 311865	Amount of area occupied by permanent free water surfaces in 30 m^2pixels in 500 m radii circular buffers around the sampling stations (square meters).		-		+
Water area in 1000 m buffer	Wat1000	Quantitative continuous	0; 147781.7; 610080	Amount of area occupied by permanent free water surfaces in 30 m^2pixels in 1000 m radii circular buffers around the sampling stations (square meters).		-		+
Water area in 2000 m buffer	Wat2000	Quantitative continuous	37256; 628934.1; 1780419	Amount of area occupied by permanent free water surfaces in 30 m^2pixels in 2000 m radii circular buffers around the sampling stations (square meters).		-		+

Water area in 5000 m buffer	Wat5000	Quantitative continuous	2551951; 5663257; 16089402	Amount of area occupied by permanent free water surfaces in 30 m^2pixels in 5000 m radii circular buffers around the sampling stations (square meters).		-		+
High várzea area in 250 m buffer	Hiv250	Quantitative continuous	0; 32769; 164479	Amount of area occupied by High várzea in 30 m^2pixels in 250 m radii circular buffers around the sampling stations (square meters).		-		
High várzea area in 500 m buffer	Hiv500	Quantitative continuous	0; 123187.1; 470469	Amount of area occupied by High várzea in 30 m^2pixels in 500 m radii circular buffers around the sampling stations (square meters).		-		
High várzea area in 1000 m buffer	Hiv1000	Quantitative continuous	0; 497047.3; 1469582	Amount of area occupied by High várzea in 30 m^2pixels in 1000 m radii circular buffers around the sampling stations (square meters).		-		
High várzea area in 2000 m buffer	Hiv2000	Quantitative continuous	52255; 1917696; 4518212	Amount of area occupied by High várzea in 30 m^2pixels in 2000 m radii circular buffers around the sampling stations (square meters).		-		
High várzea area in 5000 m buffer	Hiv5000	Quantitative continuous	7049737; 11923377; 18379588	Amount of area occupied by High várzea in 30 m^2pixels in 5000 m radii circular buffers around the sampling stations (square meters).		-		
Low várzea area in 250 m buffer	Lov250	Quantitative continuous	0; 114838.1; 195545	Amount of area occupied by Low várzea in 30 m^2pixels in 250 m radii circular buffers around the sampling stations (square meters).		+		
Low várzea area in 500 m buffer	Lov500	Quantitative continuous	133; 444266.9; 775129	Amount of area occupied by Low várzea in 30 m^2pixels in 500 m radii circular buffers around the sampling stations (square meters).		+		

Low várzea area in 1000 m buffer	Lov1000	Quantitative continuous	589434; 1701874; 2861840	Amount of area occupied by Low várzea in 30 m^{2}pixels in 1000 m radii circular buffers around the sampling stations (square meters).		+		
Low várzea area in 2000 m buffer	Lov2000	Quantitative continuous	3228622; 6527200; 9014509	Amount of area occupied by Low várzea in 30 m^{2}pixels in 2000 m radii circular buffers around the sampling stations (square meters).		+		
Low várzea area in 5000 m buffer	Lov5000	Quantitative continuous	25448545; 39186560; 46761408	Amount of area occupied by Low várzea in 30 m^{2}pixels in 5000 m radii circular buffers around the sampling stations (square meters).		+		
Chavascal area in 250 m buffer	Cha250	Quantitative continuous	0; 22212.06; 141015	Amount of area occupied by Chavascal in 30 m^{2}pixels in 250 m radii circular buffers around the sampling stations (square meters).		+	+	
Chavascal area in 500 m buffer	Cha500	Quantitative continuous	0; 99838.8; 547601	Amount of area occupied by Chavascal in 30 m^{2}pixels in 500 m radii circular buffers around the sampling stations (square meters).		+	+	
Chavascal area in 1000 m buffer	Cha1000	Quantitative continuous	0; 491667.5; 1820154	Amount of area occupied by Chavascal in 30 m^{2}pixels in 1000 m radii circular buffers around the sampling stations (square meters).		+	+	
Chavascal area in 2000 m buffer	Cha2000	Quantitative continuous	23918; 2243315; 6006607	Amount of area occupied by Chavascal in 30 m^{2}pixels in 2000 m radii circular buffers around the sampling stations (square meters).		+	+	
Chavascal area in 5000 m buffer	Cha5000	Quantitative continuous	4388281; 12256928; 25727851	Amount of area occupied by Chavascal in 30 m^{2}pixels in 5000 m radii circular buffers around the sampling stations (square meters).		+	+	

Table S3: Central tendency measures (Mean, standard deviation (St. Dev.), Minimum (Min), quartiles (Pctl) and maximum (Max)) of the spatial covariates (elevation above the sea level (Ele), distance to the nearest human settlement (Set), distance to the nearest water body (Hid), amount of water area (Wat), amount of High várzea area (Hiv), amount of Low várzea area (Lov) and amount of Chavascal area (Cha)) evaluated in different buffer sizes (250, 500, 1000, 2000 and 5000 m radii circular buffers around the sampling stations). Distances are in meters and areas in squared meters.

Covariate	**Mean**	**St. Dev.**	**Min**	**Pctl(25)**	**Pctl(75)**	**Max**
Ele250	43.321	3.470	32.455	41.027	45.635	49.500
Ele500	43.137	3.085	34.011	40.912	45.298	48.564
Ele1000	43.185	2.624	35.137	41.626	45.320	48.087
Ele2000	43.126	2.114	37.190	41.986	44.608	46.756
Ele5000	42.953	1.063	40.591	42.284	43.858	44.715
Set250	5,963.665	2,061.141	940.146	4,796.735	7,452.550	9,886.150
Set500	5,955.875	2,049.851	963.354	4,752.023	7,455.861	9,836.059
Set1000	5,925.292	2,015.265	1,020.271	4,675.897	7,449.553	9,624.620
Set2000	5,835.643	1,924.104	1,221.741	4,720.589	7,356.166	9,086.733
Set5000	5,374.664	1,424.644	2,295.541	4,407.985	6,593.424	7,405.794

Hid250	315.557	300.499	22.191	76.846	421.879	1,377.110
Hid500	323.495	267.095	45.206	126.703	396.296	1,296.254
Hid1000	342.033	198.498	74.632	228.209	389.740	1,106.205
Hid2000	362.976	127.717	155.454	265.366	459.482	712.781
Hid5000	335.853	92.838	145.407	280.496	384.818	635.533
Wat250	5,209.759	15,484.630	0	0	0	83,918
Wat500	33,329.460	61,707.020	0	0	42,859	311,865
Wat1000	147,781.700	158,466.500	0	14,086.8	223,898	610,080
Wat2000	628,934.100	416,512.900	37,256	309,258	877,689.8	1,780,419
Wat5000	5,663,257.000	3,309,692.000	2,551,951	3,635,454	6,424,676.0	16,089,402
Hiv250	32,769.000	40,327.050	0	0	50,572.2	164,479
Hiv500	123,187.100	128,489.700	0	2,946.5	237,110.5	470,469
Hiv1000	497,047.300	352,032.800	0	285,972.2	712,755	1,469,582
Hiv2000	1,917,696.000	955,358.800	52,255	1,289,007	2,591,104.0	4,518,212
Hiv5000	11,923,377.000	2,596,548.000	7,049,737	9,939,724.0	13,330,548.0	18,379,588
Lov250	114,838.100	52,738.580	0	74,033.8	154,253.5	195,545

Lov500	444,266.900	172,004.800	133	320,468.5	560,398.8	775,129
Lov1000	1,701,874.000	540,781.200	589,434	1,358,326	2,092,477.0	2,861,840
Lov2000	6,527,200.000	1,278,168.000	3,228,622	6,003,337.0	7,416,679.0	9,014,509
Lov5000	39,186,560.000	4,830,061.000	25,448,545	37,706,107	42,286,230.0	46,761,408
Cha250	22,212.060	39,935.530	0	0	26,768	141,015
Cha500	99,838.800	147,868.600	0	0	147,318	547,601
Cha1000	491,667.500	495,812.500	0	57,263.8	772,319.8	1,820,154
Cha2000	2,243,315.000	1,342,580.000	23,918	1,300,436	3,222,360.0	6,006,607
Cha5000	12,256,928.000	4,194,345.000	4,388,281	9,059,666	13,796,774.0	25,727,851

Table S4: Built models and his comparisons along the stepwise to investigate the margay habitat use in a várzea area in central Amazonia. Parameters are detection (p), initial occupancy (psi), colonization (g), and extinction (e) probabilities. Covariates are effort (Eff), scent lure (Scl), year (Yea), elevation (Ele), distance to the human settlement (Set), distance to the water body (Hid), water area (Wat), High várzea area (Hiv), Low várzea area (Lov), Chavascal area (Cha), and the null model (.). Covariates were tested in 250, 500, 1000, 2000 and 5000 m radii circular buffers around the sampling stations. Models were characterized by their number of parameters (K), by the Akaike Information Criteria corrected for small sample sizes (AICc), the AICc difference in relation to the top ranked model (ΔAICc), AICc weights (AICcWt), AICc cumulative weights (Cum.Wt), and their Log Likelihood (LL).

1a - UNIVARIATE AND MULTIVARIATE MODELS TESTED FOR THE DETECTION PROBABILITY

m_psi(.)_g(.)_e(.)_p(.)
m_psi(.)_g(.)_e(.)_p(Eff)
m_psi(.)_g(.)_e(.)_p(Scl)
m_psi(.)_g(.)_e(.)_p(Yea)
m_psi(.)_g(.)_e(.)_p(EffScl)
m_psi(.)_g(.)_e(.)_p(EffYea)
m_psi(.)_g(.)_e(.)_p(SclYea)
m_psi(.)_g(.)_e(.)_p(EffSclYea)

1b - Performance of uni and multivariate models tested for detection probability

	K	AICc	ΔAICc	AICcWt	Cum.Wt	LL
m_psi(.)_g(.)_e(.)_p(Eff)	5	683.66	0	0.76	0.76	-336.21
m_psi(.)_g(.)_e(.)_p(EffScl)	6	685.97	2.31	0.24	1	-336.09
m_psi(.)_g(.)_e(.)_p(EffYea)	11	695.6	11.93	0	1	-333.65
m_psi(.)_g(.)_e(.)_p(EffSclYea)	12	698.72	15.06	0	1	-333.56

m_psi(.)_g(.)_e(.)_p(.)	4	699.27	15.61	0	1	-345.23
m_psi(.)_g(.)_e(.)_p(Scl)	5	701.61	17.95	0	1	-345.18
m_psi(.)_g(.)_e(.)_p(Yea)	10	711.37	27.71	0	1	-343.13
m_psi(.)_g(.)_e(.)_p(SclYea)	11	714.46	30.8	0	1	-343.09

2.1 – UNIVARIATE MODELS TESTED FOR INITIAL OCCUPANCY PROBABILITY

2.1.1a – Test of the covariate elevation in univariate models for the initial occupancy probability

m_psi(.)_g(.)_e(.)_p(Eff)
m_psi(Ele250)_g(.)_e(.)_p(Eff)
m_psi(Ele500)_g(.)_e(.)_p(Eff)
m_psi(Ele1000)_g(.)_e(.)_p(Eff)
m_psi(Ele2000)_g(.)_e(.)_p(Eff)
m_psi(Ele5000)_g(.)_e(.)_p(Eff)

2.1.1b - Performance of the covariate elevation in univariate models for the initial occupancy probability

	K	**AICc**	**ΔAICc**	**AICcWt**	**Cum.Wt**	**LL**
m_psi(.)_g(.)_e(.)_p(Eff)	5	683.66	0	0.38	0.38	-336.21
m_psi(Ele5000)_g(.)_e(.)_p(Eff)	6	685.83	2.17	0.13	0.51	-336.02
m_psi(Ele500)_g(.)_e(.)_p(Eff)	6	685.86	2.2	0.13	0.64	-336.04
m_psi(Ele250)_g(.)_e(.)_p(Eff)	6	685.92	2.26	0.12	0.77	-336.07
m_psi(Ele1000)_g(.)_e(.)_p(Eff)	6	685.94	2.28	0.12	0.89	-336.08
m_psi(Ele2000)_g(.)_e(.)_p(Eff)	6	686.14	2.48	0.11	1	-336.18

2.1.2a – Test of the covariate distance to the human settlement in univariate models for the initial occupancy probability

m_psi(.)_g(.)_e(.)_p(Eff)
m_psi(Set250)_g(.)_e(.)_p(Eff)
m_psi(Set500)_g(.)_e(.)_p(Eff)
m_psi(Set1000)_g(.)_e(.)_p(Eff)
m_psi(Set2000)_g(.)_e(.)_p(Eff)
m_psi(Set5000)_g(.)_e(.)_p(Eff)

2.1.2b - Performance of the covariate distance to the human settlement in univariate models for the initial occupancy probability

	K	AICc	ΔAICc	AICcWt	Cum.Wt	LL
m_psi(Set5000)_g(.)_e(.)_p(Eff)	6	683.4	0	0.21	0.21	-334.81
m_psi(Set2000)_g(.)_e(.)_p(Eff)	6	683.63	0.23	0.18	0.39	-334.92
m_psi(.)_g(.)_e(.)_p(Eff)	5	683.66	0.26	0.18	0.57	-336.21
m_psi(Set1000)_g(.)_e(.)_p(Eff)	6	684	0.6	0.15	0.72	-335.1
m_psi(Set500)_g(.)_e(.)_p(Eff)	6	684.12	0.72	0.14	0.86	-335.17
m_psi(Set250)_g(.)_e(.)_p(Eff)	6	684.2	0.8	0.14	1	-335.21

2.1.3a - Test of the covariate distance to the water body in univariate models for the initial occupancy probability

m_psi(.)_g(.)_e(.)_p(Eff)
m_psi(Hid250)_g(.)_e(.)_p(Eff)
m_psi(Hid500)_g(.)_e(.)_p(Eff)
m_psi(Hid1000)_g(.)_e(.)_p(Eff)
m_psi(Hid2000)_g(.)_e(.)_p(Eff)
m_psi(Hid5000)_g(.)_e(.)_p(Eff)

2.1.3b - Performance of the covariate distance to the water body in univariate models for the initial occupancy probability

	K	AICc	ΔAICc	AICcWt	Cum.Wt	LL
m_psi(.)_g(.)_e(.)_p(Eff)	5	683.66	0	0.35	0.35	-336.21
m_psi(Hid250)_g(.)_e(.)_p(Eff)	6	685.31	1.65	0.15	0.51	-335.76
m_psi(Hid500)_g(.)_e(.)_p(Eff)	6	685.43	1.76	0.15	0.65	-335.82
m_psi(Hid1000)_g(.)_e(.)_p(Eff)	6	685.76	2.1	0.12	0.78	-335.99
m_psi(Hid2000)_g(.)_e(.)_p(Eff)	6	685.95	2.29	0.11	0.89	-336.08
m_psi(Hid5000)_g(.)_e(.)_p(Eff)	6	686.01	2.35	0.11	1	-336.11

2.1.4a - Test of the covariate water area in univariate models for the initial occupancy probability

m_psi(.)_g(.)_e(.)_p(Eff)
m_psi(Wat250)_g(.)_e(.)_p(Eff)
m_psi(Wat500)_g(.)_e(.)_p(Eff)
m_psi(Wat1000)_g(.)_e(.)_p(Eff)
m_psi(Wat2000)_g(.)_e(.)_p(Eff)
m_psi(Wat5000)_g(.)_e(.)_p(Eff)

2.1.4b - Performance of the covariate water area in univariate models for the initial occupancy probability

	K	AICc	ΔAICc	AICcWt	Cum.Wt	LL
m_psi(.)_g(.)_e(.)_p(Eff)	5	683.66	0	0.34	0.34	-336.21
m_psi(Wat500)_g(.)_e(.)_p(Eff)	6	685.18	1.52	0.16	0.5	-335.7
m_psi(Wat5000)_g(.)_e(.)_p(Eff)	6	685.49	1.83	0.14	0.64	-335.85
m_psi(Wat1000)_g(.)_e(.)_p(Eff)	6	685.57	1.9	0.13	0.77	-335.89
m_psi(Wat2000)_g(.)_e(.)_p(Eff)	6	685.66	2	0.13	0.9	-335.94
m_psi(Wat250)_g(.)_e(.)_p(Eff)	6	686.03	2.37	0.1	1	-336.12

2.1.5a - Test of the covariate <u>High várzea</u> in univariate models for the initial occupancy probability

m_psi(.)_g(.)_e(.)_p(Eff)
m_psi(Hiv250)_g(.)_e(.)_p(Eff)
m_psi(Hiv500)_g(.)_e(.)_p(Eff)
m_psi(Hiv1000)_g(.)_e(.)_p(Eff)
m_psi(Hiv2000)_g(.)_e(.)_p(Eff)
m_psi(Hiv5000)_g(.)_e(.)_p(Eff))

2.1.5b - Performance of the covariate <u>High várzea</u> in univariate models for the initial occupancy probability

	K	AICc	ΔAICc	AICcWt	Cum.Wt	LL
m_psi(.)_g(.)_e(.)_p(Eff)	5	683.66	0	0.3	0.3	-336.21
m_psi(Hiv1000)_g(.)_e(.)_p(Eff)	6	684.49	0.83	0.2	0.5	-335.35
m_psi(Hiv500)_g(.)_e(.)_p(Eff)	6	684.65	0.99	0.18	0.68	-335.43
m_psi(Hiv250)_g(.)_e(.)_p(Eff)	6	685.23	1.57	0.14	0.82	-335.72
m_psi(Hiv2000)_g(.)_e(.)_p(Eff)	6	685.88	2.22	0.1	0.91	-336.05
m_psi(Hiv5000)_g(.)_e(.)_p(Eff)	6	686.15	2.49	0.09	1	-336.18

2.1.6a - Test of the covariate <u>Low várzea</u> in univariate models for the initial occupancy probability

m_psi(.)_g(.)_e(.)_p(Eff)
m_psi(Lov250)_g(.)_e(.)_p(Eff)
m_psi(Lov500)_g(.)_e(.)_p(Eff)
m_psi(Lov1000)_g(.)_e(.)_p(Eff)
m_psi(Lov2000)_g(.)_e(.)_p(Eff)

m_psi(Lov5000)_g(.)_e(.)_p(Eff)

2.1.6b - Performance of the covariate Low várzea in univariate models for the initial occupancy probability

	K	AICc	ΔAICc	AICcWt	Cum.Wt	LL
m_psi(Lov5000)_g(.)_e(.)_p(Eff) *	6	681.43	0	0.49	0.49	-333.82
m_psi(.)_g(.)_e(.)_p(Eff)	5	683.66	2.23	0.16	0.65	-336.21
m_psi(Lov250)_g(.)_e(.)_p(Eff)	6	683.67	2.24	0.16	0.81	-334.94
m_psi(Lov2000)_g(.)_e(.)_p(Eff)	6	684.51	3.08	0.1	0.91	-335.36
m_psi(Lov1000)_g(.)_e(.)_p(Eff)	6	686.16	4.73	0.05	0.96	-336.19
m_psi(Lov500)_g(.)_e(.)_p(Eff)	6	686.3	4.87	0.04	1	-336.26

* psi Lov5000 95% C.I. -354.60; 302.78

2.1.7a - Test of the covariate Chavascal in univariate models for the initial occupancy probability

m_psi(.)_g(.)_e(.)_p(Eff)
m_psi(Cha250)_g(.)_e(.)_p(Eff)
m_psi(Cha500)_g(.)_e(.)_p(Eff)
m_psi(Cha1000)_g(.)_e(.)_p(Eff)
m_psi(Cha2000)_g(.)_e(.)_p(Eff)
m_psi(Cha5000)_g(.)_e(.)_p(Eff)

2.1.7b - Performance of the covariate Chavascal in univariate models for the initial occupancy probability

	K	AICc	ΔAICc	AICcWt	Cum.Wt	LL
m_psi(Cha2000)_g(.)_e(.)_p(Eff)	6	681.62	0	0.49	0.49	-333.92
m_psi(.)_g(.)_e(.)_p(Eff)	5	683.66	2.04	0.18	0.67	-336.21

m_psi(Cha1000)_g(.)_e(.)_p(Eff)	6	684.86	3.23	0.1	0.77	-335.54
m_psi(Cha250)_g(.)_e(.)_p(Eff)	6	684.88	3.25	0.1	0.87	-335.54
m_psi(Cha500)_g(.)_e(.)_p(Eff)	6	685.18	3.55	0.08	0.95	-335.69
m_psi(Cha5000)_g(.)_e(.)_p(Eff)	6	686.19	4.56	0.05	1	-336.2

2.2 - Correlation test between covariates selected for the initial occupancy probability

	Set5000	Cha2000
Set5000	1	-0.01
Cha2000	-0.01	1

2.3a - UNI AND MULTIVARIATE MODELS TESTED FOR THE INITIAL OCCUPANCY PROBABILITY

m_psi(.)_g(.)_e(.)_p(Eff)
m_psi(Set5000)_g(.)_e(.)_p(Eff)
m_psi(Cha2000)_g(.)_e(.)_p(Eff),
m_psi(Set5000Cha2000)_g(.)_e(.)_p(Eff)

2.3b - Performance of the uni and multivariate models tested for initial occupancy probability

	K	**AICc**	**ΔAICc**	**AICcWt**	**Cum.Wt**	**LL**
m_psi(Cha2000)_g(.)_e(.)_p(Eff) **	6	681.62	0	0.38	0.38	-333.92
m_psi(Set5000Cha2000)_g(.)_e(.)_p(Eff) ***	7	681.92	0.3	0.33	0.71	-332.74
m_psi(Set5000)_g(.)_e(.)_p(Eff)	6	683.40	1.78	0.16	0.86	-334.81
m_psi(.)_g(.)_e(.)_p(Eff)	5	683.66	2.04	0.14	1	-336.21

** psi Cha2000 95% C.I. -6.19; 0.95
*** psi Cha2000 95% C.I. -6.96; 1.49

3.1 - UNIVARIATE MODELS TESTED FOR COLONIZATION PROBABILITY

3.1.1a - Test of the covariate distance to the human settlement in univariate models for the colonization probability

m_psi(Set5000)_g(.)_e(.)_p(Eff)
m_psi(Set5000)_g(Set250)_e(.)_p(Eff)
m_psi(Set5000)_g(Set500)_e(.)_p(Eff)
m_psi(Set5000)_g(Set1000)_e(.)_p(Eff)
m_psi(Set5000)_g(Set2000)_e(.)_p(Eff)
m_psi(Set5000)_g(Set5000)_e(.)_p(Eff)

3.1.1b – Performance of the covariate distance to the human settlement in univariate models for the colonization probability

	K	AICc	ΔAICc	AICcWt	Cum.Wt	LL
m_psi(Set5000)_g(Set250)_e(.)_p(Eff)	7	683.22	0	0.22	0.22	-333.39
m_psi(Set5000)_g(Set500)_e(.)_p(Eff)	7	683.32	0.1	0.21	0.42	-333.44
m_psi(Set5000)_g(.)_e(.)_p(Eff)	6	683.40	0.18	0.2	0.62	-334.81
m_psi(Set5000)_g(Set1000)_e(.)_p(Eff)	7	683.54	0.32	0.18	0.81	-333.55
m_psi(Set5000)_g(Set2000)_e(.)_p(Eff)	7	684.54	1.31	0.11	0.92	-334.05
m_psi(Set5000)_g(Set5000)_e(.)_p(Eff)	7	685.18	1.96	0.08	1	-334.37

3.1.2a - Test of the covariate distance to the water body in univariate models for the colonization probability

m_psi(Set5000)_g(.)_e(.)_p(Eff)
m_psi(Set5000)_g(Hid250)_e(.)_p(Eff)
m_psi(Set5000)_g(Hid500)_e(.)_p(Eff)
m_psi(Set5000)_g(Hid1000)_e(.)_p(Eff)

m_psi(Set5000)_g(Hid2000)_e(.)_p(Eff)
m_psi(Set5000)_g(Hid5000)_e(.)_p(Eff)

3.1.2b - Performance of the covariate distance to the water body in univariate models for the colonization probability

	K	**AICc**	**ΔAICc**	**AICcWt**	**Cum.Wt**	**LL**
m_psi(Set5000)_g(.)_e(.)_p(Eff)	6	683.40	0	0.4	0.4	-334.81
m_psi(Set5000)_g(Hid5000)_e(.)_p(Eff)	7	684.87	1.47	0.19	0.6	-334.22
m_psi(Set5000)_g(Hid2000)_e(.)_p(Eff)	7	685.67	2.27	0.13	0.73	-334.62
m_psi(Set5000)_g(Hid250)_e(.)_p(Eff)	7	685.96	2.56	0.11	0.84	-334.76
m_psi(Set5000)_g(Hid500)_e(.)_p(Eff)	7	685.99	2.59	0.11	0.95	-334.78
m_psi(Set5000)_g(Hid1000)_e(.)_p(Eff)	7	687.48	4.08	0.05	1	-335.52

3.1.3a - Test of the covariate Chavascal in univariate models for the colonization probability

m_psi(Set5000)_g(.)_e(.)_p(Eff)
m_psi(Set5000)_g(Cha250)_e(.)_p(Eff)
m_psi(Set5000)_g(Cha500)_e(.)_p(Eff)
m_psi(Set5000)_g(Cha1000)_e(.)_p(Eff)
m_psi(Set5000)_g(Cha2000)_e(.)_p(Eff)
m_psi(Set5000)_g(Cha5000)_e(.)_p(Eff)

3.1.3b - Performance of the covariate Chavascal in univariate models for the colonization probability

	K	**AICc**	**ΔAICc**	**AICcWt**	**Cum.Wt**	**LL**
m_psi(Set5000)_g(.)_e(.)_p(Eff)	6	683.40	0	0.37	0.37	-334.81
m_psi(Set5000)_g(Cha2000)_e(.)_p(Eff)	7	684.75	1.35	0.19	0.56	-334.16
m_psi(Set5000)_g(Cha1000)_e(.)_p(Eff)	7	685.45	2.05	0.13	0.69	-334.51

m_psi(Set5000)_g(Cha250)_e(.)_p(Eff)	7	685.95	2.55	0.1	0.8	-334.76
m_psi(Set5000)_g(Cha500)_e(.)_p(Eff)	7	685.97	2.57	0.1	0.9	-334.77
m_psi(Set5000)_g(Cha5000)_e(.)_p(Eff)	7	686.04	2.64	0.1	1	-334.8

3.1.4a - Test of the covariate year in univariate models for the colonization probability

m_psi(Set5000)_g(.)_e(.)_p(Eff)
m_psi(Set5000)_g(Yea)_e(.)_p(Eff)

3.1.4b - Performance of the covariate year in univariate models for the colonization probability

	K	**AICc**	**ΔAICc**	**AICcWt**	**Cum.Wt**	**LL**
m_psi(Set5000)_g(.)_e(.)_p(Eff)	6	683.4	0	0.99	0.99	-334.81
m_psi(Set5000)_g(Yea)_e(.)_p(Eff)	11	692.4	9	0.01	1	-332.06

3.2 - Correlation test between covariates selected for the colonization probability

Only one covariate selected

3.3 - UNI AND MULTIVARIATE MODELS TESTED FOR THE COLONIZATION PROBABILITY

m_psi(Set5000)_g(Set250)_e(.)_p(Eff)

4.1 - UNIVARIATE MODELS TESTED FOR EXTINCTION PROBABILITY

4.1.1a - Test of the covariate distance to the human settlement in univariate models for the extinction probability

m_psi(Set5000)_g(.)_e(.)_p(Eff)
m_psi(Set5000)_g(.)_e(Set250)_p(Eff)

m_psi(Set5000)_g(.)_e(Set500)_p(Eff)
m_psi(Set5000)_g(.)_e(Set1000)_p(Eff)
m_psi(Set5000)_g(.)_e(Set2000)_p(Eff)
m_psi(Set5000)_g(.)_e(Set5000)_p(Eff)
m_psi(Set5000)_g(Set250)_e(.)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Set250)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Set500)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Set1000)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Set2000)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Set5000)_p(Eff)

4.1.1b - Performance of the covariate <u>distance to the human settlement</u> in univariate models for the extinction probability

	K	**AICc**	**ΔAICc**	**AICcWt**	**Cum.Wt**	**LL**
m_psi(Set5000)_g(Set250)_e(Set5000)_p(Eff)	8	676.89	0	0.2	0.2	-328.84
m_psi(Set5000)_g(Set250)_e(Set2000)_p(Eff)	8	677.34	0.46	0.16	0.36	-329.07
m_psi(Set5000)_g(Set250)_e(Set1000)_p(Eff)	8	677.63	0.75	0.14	0.5	-329.22
m_psi(Set5000)_g(Set250)_e(Set500)_p(Eff)	8	677.65	0.76	0.14	0.64	-329.23
m_psi(Set5000)_g(Set250)_e(Set250)_p(Eff)	8	677.71	0.82	0.13	0.77	-329.25
m_psi(Set5000)_g(.)_e(Set5000)_p(Eff)	7	679.56	2.68	0.05	0.82	-331.57
m_psi(Set5000)_g(.)_e(Set2000)_p(Eff)	7	679.91	3.02	0.04	0.87	-331.74
m_psi(Set5000)_g(.)_e(Set1000)_p(Eff)	7	680.18	3.29	0.04	0.91	-331.87
m_psi(Set5000)_g(.)_e(Set500)_p(Eff)	7	680.21	3.32	0.04	0.95	-331.89
m_psi(Set5000)_g(.)_e(Set250)_p(Eff)	7	680.25	3.36	0.04	0.98	-331.91
m_psi(Set5000)_g(Set250)_e(.)_p(Eff)	7	683.22	6.33	0.01	0.99	-333.39
m_psi(Set5000)_g(.)_e(.)_p(Eff)	6	683.4	6.51	0.01	1	-334.81

4.1.2a - Test of the covariate <u>distance to the water body</u> in univariate models for the extinction probability

m_psi(Set5000)_g(.)_e(.)_p(Eff)
m_psi(Set5000)_g(.)_e(Hid250)_p(Eff)
m_psi(Set5000)_g(.)_e(Hid500)_p(Eff)
m_psi(Set5000)_g(.)_e(Hid1000)_p(Eff)
m_psi(Set5000)_g(.)_e(Hid2000)_p(Eff)
m_psi(Set5000)_g(.)_e(Hid5000)_p(Eff)
m_psi(Set5000)_g(Set250)_e(.)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Hid250)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Hid500)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Hid1000)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Hid2000)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Hid5000)_p(Eff)

4.1.2b - Performance of the covariate distance to the water body in univariate models for the extinction probability

	K	AICc	ΔAICc	AICcWt	Cum.Wt	LL
m_psi(Set5000)_g(.)_e(Hid1000)_p(Eff) ****	7	681.6	0	0.2	0.2	-332.58
m_psi(Set5000)_g(Set250)_e(Hid250)_p(Eff) *****	8	681.89	0.29	0.17	0.37	-331.34
m_psi(Set5000)_g(Set250)_e(Hid500)_p(Eff) ******	8	681.91	0.3	0.17	0.55	-331.35
m_psi(Set5000)_g(.)_e(Hid500)_p(Eff)	7	683.19	1.58	0.09	0.64	-333.38
m_psi(Set5000)_g(Set250)_e(.)_p(Eff)	7	683.22	1.62	0.09	0.73	-333.39
m_psi(Set5000)_g(.)_e(Hid250)_p(Eff)	7	683.35	1.75	0.08	0.81	-333.46
m_psi(Set5000)_g(.)_e(.)_p(Eff)	6	683.4	1.8	0.08	0.89	-334.81
m_psi(Set5000)_g(Set250)_e(Hid1000)_p(Eff)	8	684.23	2.62	0.05	0.95	-332.51
m_psi(Set5000)_g(.)_e(Hid2000)_p(Eff)	7	684.69	3.09	0.04	0.99	-334.13
m_psi(Set5000)_g(Set250)_e(Hid2000)_p(Eff)	8	688.78	7.17	0.01	1	-334.79

m_psi(Set5000)_g(Set250)_e(Hid5000)_p(Eff)	8	690.27	8.67	0	1	-335.53
m_psi(Set5000)_g(.)_e(Hid5000)_p(Eff)	7	690.56	8.96	0	1	-337.06

****epsilon Hid1000 95% C.I. -6.94 ; 21.27
*****epsilon Hid250 95% C.I. -30.89 ; 45.92
******epsilon Hid500 95% C.I. -21.39 ; 35.57

4.1.3a - Test of the covariate water area in univariate models for the extinction probability

m_psi(Set5000)_g(.)_e(.)_p(Eff)
m_psi(Set5000)_g(.)_e(Wat250)_p(Eff)
m_psi(Set5000)_g(.)_e(Wat500)_p(Eff)
m_psi(Set5000)_g(.)_e(Wat1000)_p(Eff)
m_psi(Set5000)_g(.)_e(Wat2000)_p(Eff)
m_psi(Set5000)_g(.)_e(Wat5000)_p(Eff)
m_psi(Set5000)_g(Set250)_e(.)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Wat250)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Wat500)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Wat1000)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Wat2000)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Wat5000)_p(Eff)

4.1.3b - Performance of the covariate water area in univariate models for the extinction probability

	K	**AICc**	**ΔAICc**	**AICcWt**	**Cum.Wt**	**LL**
m_psi(Set5000)_g(Set250)_e(Wat5000)_p(Eff)	8	683.01	0	0.14	0.14	-331.91
m_psi(Set5000)_g(Set250)_e(.)_p(Eff)	7	683.22	0.21	0.13	0.27	-333.39

m_psi(Set5000)_g(.)_e(.)_p(Eff)	6	683.4	0.39	0.12	0.38	-334.81
m_psi(Set5000)_g(.)_e(Wat5000)_p(Eff)	7	683.72	0.7	0.1	0.48	-333.64
m_psi(Set5000)_g(Set250)_e(Wat250)_p(Eff)	8	683.81	0.8	0.09	0.58	-332.31
m_psi(Set5000)_g(.)_e(Wat1000)_p(Eff)	7	683.92	0.91	0.09	0.67	-333.74
m_psi(Set5000)_g(Set250)_e(Wat2000)_p(Eff)	8	684.44	1.42	0.07	0.74	-332.62
m_psi(Set5000)_g(Set250)_e(Wat1000)_p(Eff)	8	684.66	1.65	0.06	0.8	-332.73
m_psi(Set5000)_g(.)_e(Wat250)_p(Eff)	7	684.76	1.75	0.06	0.86	-334.16
m_psi(Set5000)_g(.)_e(Wat2000)_p(Eff)	7	685.03	2.02	0.05	0.91	-334.3
m_psi(Set5000)_g(Set250)_e(Wat500)_p(Eff)	8	685.11	2.1	0.05	0.96	-332.96
m_psi(Set5000)_g(.)_e(Wat500)_p(Eff)	7	685.52	2.51	0.04	1	-334.54

4.1.4a - Test of the covariate year in univariate models for the extinction probability

m_psi(Set5000)_g(.)_e(.)_p(Eff)
m_psi(Set5000)_g(.)_e(Yea)_p(Eff)
m_psi(Set5000)_g(Set250)_e(.)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Yea)_p(Eff)

4.1.4b - Performance of the covariate year in univariate models for the extinction probability

	K	**AICc**	**ΔAICc**	**AICcWt**	**Cum.Wt**	**LL**
m_psi(Set5000)_g(Set250)_e(.)_p(Eff)	7	683.22	0	0.52	0.52	-333.39
m_psi(Set5000)_g(.)_e(.)_p(Eff)	6	683.4	0.18	0.47	0.99	-334.81
m_psi(Set5000)_g(.)_e(Yea)_p(Eff)	11	692	9.11	0.01	1	-332.02
m_psi(Set5000)_g(Set250)_e(Yea)_p(Eff)	12	695.29	12	0	1	-331.84

4.2 - Correlation test between covariates selected for the extinction probability

	Set5000	Hid500	Wat5000
Set5000	1	0.12	-0.45
Hid500	0.12	1	-0.14
Wat5000	-0.45	-0.14	1

4.3a - UNI AND MULTIVARIATE MODELS TESTED FOR THE EXTINCTION PROBABILITY

m_psi(Set5000)_g(.)_e(.)_p(Eff)
m_psi(Set5000)_g(.)_e(Set5000)_p(Eff)
m_psi(Set5000)_g(.)_e(Hid500)_p(Eff)
m_psi(Set5000)_g(.)_e(Wat5000)_p(Eff)
m_psi(Set5000)_g(.)_e(Set5000Hid500)_p(Eff)
m_psi(Set5000)_g(.)_e(Set5000Wat5000)_p(Eff)
m_psi(Set5000)_g(.)_e(Hid500Wat5000)_p(Eff)
m_psi(Set5000)_g(.)_e(Set5000Hid500Wat5000)_p(Eff)
m_psi(Set5000)_g(Set250)_e(.)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Set5000)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Hid500)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Wat5000)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Set5000Hid500)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Set5000Wat5000)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Hid500Wat5000)_p(Eff)
m_psi(Set5000)_g(Set250)_e(Set5000Hid500Wat5000)_p(Eff)

4.3b - Performance of the uni and multivariate models tested for extinction probability

	K	**AICc**	**ΔAICc**	**AICcWt**	**Cum.Wt**	**LL**
m_psi(Set5000)_g(Set250)_e(Set5000)_p(Eff)	8	676.89	0	0.28	0.28	-328.84

m_psi(Set5000)_g(Set250)_e(Set5000Hid500)_p(Eff)	9	678.11	1.23	0.15	0.42	-328.01
m_psi(Set5000)_g(Set250)_e(Set5000Wat5000)_p(Eff)	9	678	1.59	0.12	0.55	-328.19
m_psi(Set5000)_g(Set250)_e(Hid500Wat5000)_p(Eff)	9	679.26	2	0.08	0.63	-328.59
m_psi(Set5000)_g(Set250)_e(Set5000Hid500Wat5000)_p(Eff)	10	679.37	2.49	0.08	0.71	-327.13
m_psi(Set5000)_g(.)_e(Set5000)_p(Eff)	7	679.56	2.68	0.07	0.78	-331.57
m_psi(Set5000)_g(.)_e(Hid500Wat5000)_p(Eff)	8	679.99	3.1	0.06	0.84	-330.39
m_psi(Set5000)_g(.)_e(Set5000Hid500)_p(Eff)	8	680.84	3.96	0.04	0.88	-330.82
m_psi(Set5000)_g(.)_e(Set5000Wat5000)_p(Eff)	8	681.47	4.58	0.03	0.91	-331.13
m_psi(Set5000)_g(Set250)_e(Hid500)_p(Eff)	8	681.91	5.02	0.02	0.93	-331.35
m_psi(Set5000)_g(.)_e(Set5000Hid500Wat5000)_p(Eff)	9	683.01	6.12	0.01	0.94	-330.46
m_psi(Set5000)_g(Set250)_e(Wat5000)_p(Eff)	8	683.01	6.13	0.01	0.96	-331.91
m_psi(Set5000)_g(.)_e(Hid500)_p(Eff)	7	683.19	6.3	0.01	0.97	-333.38
m_psi(Set5000)_g(Set250)_e(.)_p(Eff)	7	683.22	6.33	0.01	0.98	-333.39
m_psi(Set5000)_g(.)_e(.)_p(Eff)	6	683.4	6.51	0.01	0.99	-334.81
m_psi(Set5000)_g(.)_e(Wat5000)_p(Eff)	7	683.72	6.83	0.01	1	-333.64

* Top models that showed unrealistic estimates, discarded from the analysis.

CONSIDERAÇÕES FINAIS

Nosso trabalho foi o primeiro dedicado a investigar a ecologia do gato-maracajá nas planícies inundáveis de várzea da Amazônia, gerando informações inéditas sobre a espécie. Utilizamos um conjunto de dados único, coletado utilizando armadilhas fotográficas durante sete anos consecutivos. Nossos dados nos permitiram utilizar modelos de ocupação “multi-season” para avaliar relações espécie-hábitat. Esta é a primeira vez que tal abordagem analítica é utilizada para estudar o gato-maracajá. Através de modelos hierárquicos de ocupação dinâmica avaliamos a influência de variáveis ambientais e antropogênicas na dinâmica de uso do hábitat da espécie. A distância das comunidades humanas foi a única das covariáveis testadas para a qual encontramos indícios de relação com uso do hábitat do gato-maracajá. Nossos principais resultados indicam que, na várzea da Amazônia central, a influência antropogênica é o principal fator a influenciar o uso do hábitat da espécie. Em nossa área de estudo, a distância das comunidades humanas foi negativamente relacionada à ocupação inicial do gato-maracajá, e positivamente relacionada à suas probabilidades de colonização e de extinção. A espécie parece usar mais intensa e regularmente áreas com maior influência antropogênica. Já em áreas mais afastadas das comunidades humanas parece haver maior alternância nos hábitats utilizados pelo gato-maracajá. Sugerimos que possivelmente a influência antropogênica esteja interferindo nas relações interespecíficas, aliviando a competição enfrentada, e/ou favorecendo uma maior disponibilidade de presas para o gato-maracajá. Não encontramos evidência de relação do ano da amostragem com nenhum dos parâmetros avaliados, indicando a estabilidade de nossa área de estudo, pelo menos em relação ao uso do hábitat do gato-maracajá. Geramos com este trabalho informações cruciais para previsões robustas de tendências futuras que a espécie irá enfrentar nas planícies inundáveis de várzea da Amazônia. Essas áreas são relevantes para a conservação de elevada diversidade biológica e cultural humana. Esperamos que nosso trabalho contribua para que a gestão das várzeas, importantes tanto para as comunidades tradicionais locais como também para a humanidade, seja cada vez mais baseada em evidências científicas.