Predicted distribution and habitat loss for the Endangered black-faced black spider monkey *Ateles chamek* in the Amazon

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SUPPLEMENTARY TABLE 1 Records of *Ateles chamek* used in the species distribution modelling.

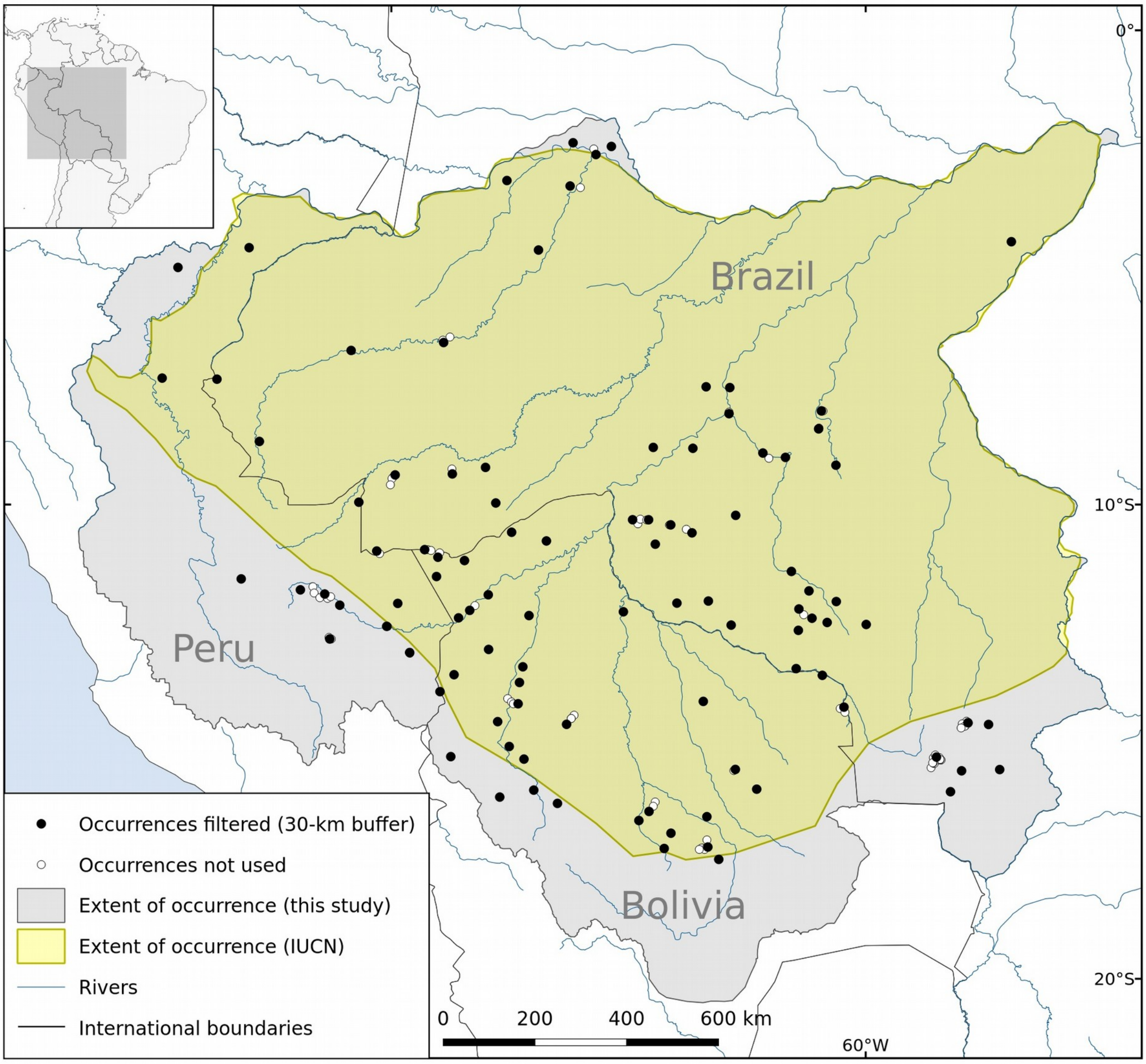
Country	Longitude	Latitude	Locality	Type of record	Year	Source
Bolivia	-63.35000	-16.58000	15 km north of Santa Rosa, Santa Cruz	Preserved specimen	1996	Anderson (1997)
Bolivia	-68.35000	-12.23000	Chivé, Pando	Preserved specimen	1996	Anderson (1997)
Bolivia	-67.23000	-13.42000	Desierto, Beni	Preserved specimen	1996	Anderson (1997)
Bolivia	-69.02000	-11.11000	Mucden, Pando	Preserved specimen	1996	Anderson (1997)
Bolivia	-60.46000	-14.27000	Precalmbrio road, Santa Cruz	Preserved specimen	1996	Anderson (1997)
Bolivia	-67.33000	-14.20000	Puerto Salinas, Beni	Preserved specimen	1996	Anderson (1997)
Bolivia	-65.11000	-12.26000	Rio Mamore, Beni	Preserved specimen	1996	Anderson (1997)
Bolivia	-68.46000	-11.18000	Rio Nareuda, Pando	Preserved specimen	1996	Anderson (1997)
Bolivia	-63.33000	-17.22000	Rio Palometa, Santa Cruz	Preserved specimen	1996	Anderson (1997)
Bolivia	-66.50000	-16.30000	San Antonio rio Cotacajes, Cochabamba	Preserved specimen	1996	Anderson (1997)
Bolivia	-67.10000	-12.34000	Santa Ana de Madidi, La Paz	Preserved specimen	1996	Anderson (1997)
Bolivia	-63.10000	-17.48000	Santa Cruz de la Sierra, Santa Cruz	Preserved specimen	1996	Anderson (1997)
Bolivia	-67.00000	-16.02000	Santa Helena, Cochabamba	Preserved specimen	1996	Anderson (1997)
Bolivia	-62.30000	-16.00000	Totaitu, Santa Cruz	Preserved specimen	1996	Anderson (1997)
Bolivia	-64.57000	-16.47000	Yuqui camp, Santa Cruz	Preserved specimen	1996	Anderson (1997)
Bolivia	-69.30000	-10.95000	Buena Vista, Pando	Report	1997	Buchanan-Smith et al. (2000)
Bolivia	-69.05000	-11.51667	Ponton, Pando	Report	1997	Buchanan-Smith et al. (2000)

Country	Longitude	Latitude	Locality	Type of record	Year	Source
Bolivia	-67.46667	-10.58333	Santa Rosa, Pando	Report	1997	Buchanan-Smith et al. (2000)
Bolivia	-66.30833	-14.63333	Estacion Biologica del Beni, Beni	Sighting	1991	Garcia and Tarifa (1988)
Bolivia	-66.73300	-10.76700	Pando	Sighting	1992	GBIF.org (2015)
Bolivia	-67.51667	-15.10000	Pilon Lajas Biosphere Reserve, La Paz	Machine observation	1998	GBIF.org (2015)
Bolivia	-68.74884	-15.31429	Ayata, La Paz	Sighting	2007	Marcos and Teran (2013)
Bolivia	-63.42602	-14.14989	Baures, Beni	Sighting	2007	Marcos and Teran (2013)
Bolivia	-64.78355	-16.66083	Chimore, Cochabamba	Sighting	2007	Marcos and Teran (2013)
Bolivia	-68.68000	-13.58667	Ixiamas, La Paz	Sighting	2007	Marcos and Teran (2013)
Bolivia	-67.95134	-13.05344	Ixiamas, La Paz	Sighting	2007	Marcos and Teran (2013)
Bolivia	-67.76050	-14.57656	Madidi Reserve, La Paz	Sighting	2007	Marcos and Teran (2013)
Bolivia	-67.20601	-15.36632	Palos Blancos, La Paz	Sighting	2007	Marcos and Teran (2013)
Bolivia	-67.30080	-13.75030	Reyes, Beni	Sighting	2007	Marcos and Teran (2013)
Bolivia	-64.10788	-16.92791	Yapacani, Santa Cruz	Sighting	2007	Marcos and Teran (2013)
Bolivia	-68.58550	-12.38839	Chive, Pando	Sighting	2003	Porter (2006)
Bolivia	-67.71667	-16.16667	Tunquini Biological Station, La Paz	Sighting	2001	Quevedo et al. (2008)
Bolivia	-67.95861	-11.90139	Ixiamas, La Paz	Sighting	1998	Rumiz and Maglianesi (2001)
Bolivia	-64.25000	-17.25000	Carrasco National Park, Cochabamba	Sighting	1997	Rumiz et al. (1998)
Bolivia	-60.91667	-13.60000	Noel Kempff National Park, Santa Cruz	Sighting	1992	Wallace et al. (1998)
Bolivia	-62.75000	-15.58333	Rios Blanco y Negro Wildlife Reserve, Santa Cruz	Sighting	1993	Wallace et al. (2000)
Brazil	-62.83833	-12.54083	Guapore Biological Reserve, Rondonia	Sighting	2013	Alves (2013)
Brazil	-63.64556	-8.81306	Samuel Ecological Station, Rondonia	Sighting	2004	Bonavigo and Messias (2005)
Brazil	-69.92164	-9.37481	Chandless State Park, Acre	Sighting	2013	Borges (2014)

Country	Longitude	Latitude	Locality	Type of record	Year	Source
Brazil	-56.93139	-4.45778	Tapajos National Park, Para	Sighting	1979	Branch (1983); George et al. (1988)
Brazil	-73.67778	-7.35639	Parque Nacional Serra do Divisor, Acre	Bone	1997	Calouro (1999)
Brazil	-68.01694	-9.21639	Floresta Estadual do Antimary, Acre	Sighting	1991	Calouro (2005)
Brazil	-63.36667	-7.51667	Ipixuna River, Labrea, Amazonas	Report	1990	Ferrari and Lopes (1992)
Brazil	-62.88333	-8.08333	Jiparana River, left bank, Rondonia	Sighting	1990	Ferrari and Lopes (1992)
Brazil	-62.86667	-7.53333	Lago dos Reis, Itaituba, Amazonas	Report	1990	Ferrari and Lopes (1992)
Brazil	-61.42222	-12.65139	Fazenda 4 Maravilhas, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-61.41056	-12.20139	Fazenda Arara Azul, RO492, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-61.69417	-9.00528	Fazenda do Domingo, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-64.11194	-10.42806	Fazenda do Sr Dias, BR421, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-63.31917	-12.03361	Fazenda do Sr Geraldo, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-64.57889	-10.32000	Fazenda do SrAntonio, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-61.56833	-11.40944	Fazenda Mariana, BR364, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-62.74306	-10.22694	Fazenda Nova Vida, BR364, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-59.99139	-12.52778	Fazenda Olga, RO174, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-61.46833	-13.45861	Fazenda Sao Paulo, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-64.91667	-10.31917	Guajara Mirim State Park, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-62.16972	-8.91278	Jiparana River, right bank, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-61.13444	-12.39611	Pequeno K48, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-64.43778	-10.83472	RESEX Rio Ouro Preto, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-60.81500	-12.48556	RO391, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-61.19778	-11.82000	Sitio do Sr Alirio, BR364, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)

Country	Longitude	Latitude	Locality	Type of record	Year	Source
Brazil	-63.66417	-10.59611	Sitio do Sr Jreuter, BR421, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-63.98222	-12.07722	Sitio do Sr Noel, BR429, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-60.62250	-12.04417	UHE Rondon II, Rio Comemoracao, Rondonia	Sighting	1998	Iwanaga and Ferrari (2002)
Brazil	-68.71639	-9.35414	Rio Iaco e Riozinho do Rola, Acre	Sighting	1989	Martins (1993)
Brazil	-68.90003	-6.58336	Jurua River Altamira	Sighting	1992	Peres (1997)
Brazil	-70.84981	-6.75033	Jurua River Condor	Sighting	1992	Peres (1997)
Brazil	-72.78371	-8.66907	Jurua River Porongaba	Sighting	1992	Peres (1997)
Brazil	-66.89998	-4.63331	Jurua River Riozinho	Sighting	1992	Peres (1997)
Brazil	-66.23335	-3.28371	Jurua River Vira Volta	Sighting	1992	Peres (1997)
Brazil	-66.17132	-2.37218	Reserva Mamiraua, Amazonas	Preserved specimen	2013	Rabelo et al. (2014)
Brazil	-65.36333	-2.44944	Reserva Mamiraua, Amazonas	Sighting	2013	Rabelo et al. (2014)
Brazil	-65.68889	-2.62028	Reserva Mamiraua, Amazonas	Sighting	2013	Rabelo et al. (2014)
Brazil	-57.84667	-14.59806	Bozetti, Mato Grosso	Sighting	2016	Santos-Filho et al. (2017)
Brazil	-57.98111	-15.61278	Curvelandia, Mato Grosso	Sighting	2016	Santos-Filho et al. (2017)
Brazil	-57.41250	-14.63583	File do Boi, Mato Grosso	Sighting	2016	Santos-Filho et al. (2017)
Brazil	-58.21480	-16.05375	Icaroma, Mato Grosso	Sighting	2016	Santos-Filho et al. (2017)
Brazil	-58.51139	-15.32389	Roberta, Mato Grosso	Sighting	2016	Santos-Filho et al. (2017)
Brazil	-57.17806	-15.58639	Serra das Araras, Mato Grosso	Sighting	2016	Santos-Filho et al. (2017)
Brazil	-67.80000	-9.96667	Bairro Centro, Rio Acre, Acre	Sighting	1995	speciesLink.org (2015)
Brazil	-70.30972	-10.97917	Estacao Ecologica Rio Acre, Acre	Sighting	1988	speciesLink.org (2015)
Brazil	-60.63000	-9.17000	Aripuana, Mato Grosso	Preserved specimen	2014	This study
Brazil	-67.56556	-3.16806	Jutai-Solimoes Ecological Station, Amazonas	Sighting	2014	This study

Country	Longitude	Latitude	Locality	Type of record	Year	Source
Brazil	-60.93662	-8.02497	Parque Nacional dos Campos Amazonicos, Amazonas	Sighting	2016	This study
Brazil	-60.99509	-8.40370	Parque Nacional dos Campos Amazonicos, Amazonas	Sighting	2016	This study
Brazil	-64.48076	-8.79485	Parque Nacional Mapinguari, Amazonas	Sighting	2017	This study
Peru	-73.00000	-4.58333	TamshiyacuTahuayo Communal Reserve, Loreto	Sighting	1995	Aquino (1998)
Peru	-74.50000	-5.00000	Reserva Nacional Pacaya Samiria, Loreto	Sighting	2005	Aquino and Bodmer (2006)
Peru	-74.83333	-7.33333	Sierras de Contamana, Loreto	Sighting	2004	Aquino et al. (2005)
Peru	-73.16667	-11.56685	Lower Urubamba River, Cuzco	Sighting	2008	Aquino et al. (2013)
Peru	-71.08910	-12.12140	Cocha Juarez Manu Lodge, Madre de Dios	Vocalization	2005	Macaulay Library (2016)
Peru	-70.10000	-12.56667	Los Amigos field station, Madre de Dios	Sighting	1991	Macaulay Library (2016)
Peru	-71.91914	-11.79787	Yomybato, Madre de Dios	Sighting	2006	Endo et al. (2010)
Peru	-69.86667	-12.08333	Las Piedras Biodiversity Station, Madre de Dios	Sighting	2009	Lee et al. (2010)
Peru	-68.97610	-13.94360	San Fermin, Callao	Sighting	2009	Pacheco et al. (2011)
Peru	-71.30000	-12.83333	Salvacion, Madre de Dios	Sighting	2002	Palminteri et al. (2011)
Peru	-69.61639	-13.11917	Tambopata Research Center, Madre de Dios	Sighting	2008	Rosin and Swamy (2013)
Peru	-70.68675	-9.94946	Rio La Novia, Alto Purus, Ucayali	Sighting	2015	Ruelas et al. (2016)
Peru	-71.40586	-11.88608	Manu National Park, Madre de Dios	Sighting	1982	Terborgh et al. (1984)



SUPPLEMENTARY FIG. 1 Location of all 172 records gathered in this study. We controlled for the sampling bias in the intensity of points by randomly removing duplicate records within a 30-km radius (unfilled circles). Filled circles are the resulting 99 occurrences used in the modelling process. Descriptions of all records are in Supplementary Table 1.

SUPPLEMENTARY TABLE 2 Selected variables expected to influence the distribution of the black-faced black spider monkey. Variables used in the final model are in bold.

	Variable	Source
Climatic	Annual Mean Temperature	Hijmans et al. (2005)
	Temperature Seasonality (standard deviation*100)	Hijmans et al. (2005)
	Max. Temperature of Warmest Month	Hijmans et al. (2005)
	Min. Temperature of Coldest Month	Hijmans et al. (2005)
	Annual Precipitation	Hijmans et al. (2005)
	Precipitation Seasonality (Coefficient of Variation)	Hijmans et al. (2005)
	Precipitation of Wettest Quarter	Hijmans et al. (2005)
	Precipitation of Driest Quarter	Hijmans et al. (2005)
	Annual Potential Evapo-Transpiration	CGIAR-CSI (2008)
	Aridity Index	CGIAR-CSI (2008)
Edaphic	Cation Exchance Capacity – topsoil (soil fertility)	FAO (2007)
	Organic Carbon % – topsoil	FAO (2007)
Topographic	Elevation (SRTM)	Jarvis et al. (2008)
	Flooded areas (ALOS PALSAR)	VERTEX (2018)
	Compound Topographic Index HYDRO1K	Earth Explorer (2018)
	Height Above Nearest Drainage - 100	DPI-INPE (2018)
Vegetation	Tree Cover %	Hansen et al. (2013)
	Net Primary Productivity	NEO (2018)
	Leaf Area Index	NEO (2018)

SUPPLEMENTARY TABLE 3 Pair-wise matrix of correlation coefficients between environmental variables. Correlation coefficients ≥ |0.80| are shown in bold.

	Temp$_{annual}$	Temp$_{season}$	Temp$_{max}$	Temp$_{min}$	Prec$_{annual}$	Prec$_{season}$	Prec$_{wet}$	Prec$_{dry}$	CEC*	Tree%*	AI	Altitude	HAND	CTI	LAI	NPP	COrg*	PET
Temp$_{season}$	-0.39																	
Temp$_{max}$	**0.96**	-0.25																
Temp$_{min}$	**0.96**	-0.54	**0.86**															
Prec$_{annual}$	0.58	-0.65	0.43	0.68														
Prec$_{season}$	-0.49	0.5	-0.28	-0.64	-0.65													
Prec$_{wet}$	0.51	-0.52	0.45	0.54	**0.89**	-0.26												
Prec$_{dry}$	0.35	-0.41	0.14	0.51	0.74	**-0.9**	0.4											
CEC*	-0.51	0.23	-0.55	-0.45	-0.3	0.05	-0.39	0.02										
Tree%*	0.68	-0.49	0.63	0.69	0.57	-0.47	0.49	0.34	-0.45									
AI	0.43	-0.63	0.25	0.57	**0.98**	-0.66	**0.84**	0.78	-0.21	0.47								
Altitude	**-0.99**	0.38	**-0.95**	**-0.94**	-0.58	0.45	-0.53	-0.32	0.57	-0.69	-0.43							
HAND	-0.75	0.25	-0.73	-0.71	-0.45	0.29	-0.42	-0.22	0.56	-0.48	-0.34	**0.8**						
CTI	0.6	-0.32	0.51	0.63	0.42	-0.45	0.29	0.37	-0.38	0.36	0.37	-0.62	-0.64					
LAI	0.63	-0.62	0.51	0.71	0.69	-0.6	0.56	0.5	-0.32	**0.84**	0.63	-0.62	-0.4	0.38				
NPP	0.21	-0.04	0.16	0.22	0.26	-0.4	0.16	0.34	0.18	0.38	0.22	-0.17	0.04	-0.07	0.47			
COrg*	-0.2	-0.25	-0.26	-0.1	0.21	-0.17	0.17	0.23	0.52	0.08	0.27	0.24	0.39	-0.25	0.29	0.36		
PET	**0.81**	-0.15	**0.91**	0.66	0.25	-0.11	0.32	-0.04	-0.49	0.55	0.04	**-0.81**	-0.58	0.34	0.37	0.19	-0.27	
Flood	0.48	-0.46	0.35	0.57	0.54	-0.6	0.35	0.53	-0.16	0.68	0.52	-0.44	-0.18	0.31	**0.85**	0.38	0.34	0.19

Temp$_{annual}$, mean annual temperature; Temp$_{season}$, temperature seasonality; Temp$_{max}$, maximum temperature of warmest month; Temp$_{min}$, minimum temperature of coldest month; Prec$_{annual}$, mean annual precipitation; Prec$_{season}$, precipitation seasonality; Prec$_{wet}$, precipitation of wettest quarter; Prec$_{dry}$, precipitation of driest quarter; CEC, cation exchange capacity; Tree%, % tree cover; AI, aridity index; HAND, height above nearest drainage; CTI, compound topographic index (wetness index); LAI, leaf area index; NPP, net primary productivity; COrg, % organic carbon in topsoil; PET, annual potential evapo-transpiration; Flood, flooded areas.

SUPPLEMENTARY MATERIAL 1 Maxent modelling procedure.

Environmental variables preparation

We chose 19 environmental variables that we would expect a priori to influence species distribution (Supplementary Table 2). The chosen variables had an original resolution of c. 1 km, which was reprojected to 10-km resolution. We used this scale of analysis because: (1) the species has a wide range extent, and using a fine scale would demand a computer with high processing capacity; (2) this species is known to have long daily journeys and large home ranges, so the scale of analysis matches the species' ecology; and (3) this scale of analysis provides data that are compatible with the scale of data that decision makers usually take into account when developing environmental conservation policies, i.e. the landscape scale (Monjeau, 2010). We performed a pair-wise correlation between variables to remove collinear predictors. After running preliminary models we also excluded unimportant variables that were decreasing the model gain and reducing model performance.

Model parameterization and evaluation

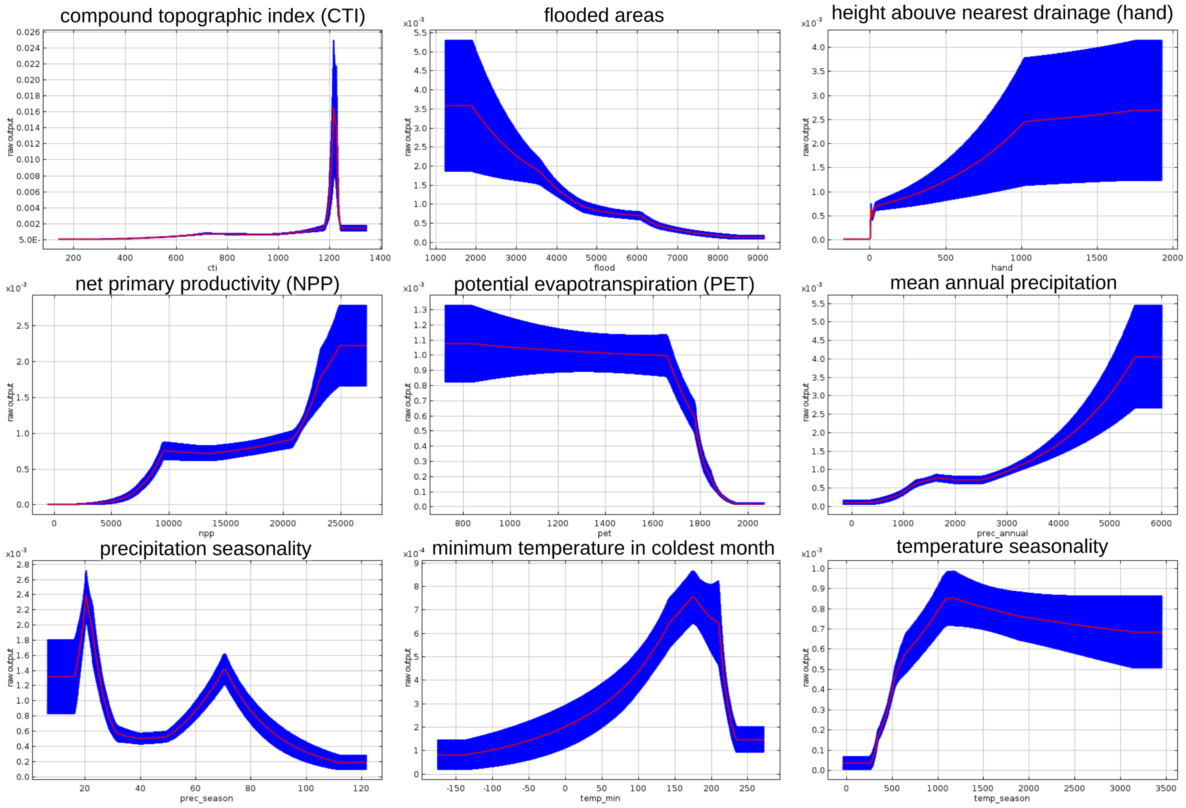
Here we present the detailed methods and summary of the results of 10-fold cross-validation for our modelling procedure, using *dismo 1.1-4* and *Maxent 3.4.0* in *R. 3.3.3* (R Core Team, 2016). We used the *ENMevaluate* function of *ENMeval* (Muscarella et al., 2014) to evaluate best model parametrization among all combinations of L, Q, LQ, H, LQP and LQH features, and regularization multiplier coefficients of 0.5–4.0 (at 0.5 intervals). We chose the best model parametrization according to the highest area under the curve (AUC) of testing data. Model final parameterization was set on hinge features, which uses complex response curves, and a regularization multiplier of 0.5, which generates a more restricted (or conservative) prediction, using the cross-validate replicate type with 10 replicates.

We transformed the continuous prediction of cumulative output into a binary prediction by setting a threshold above which we considered that the species is present (i.e. area of occupancy, sensu IUCN, 2012). To accomplish this task, we found the threshold value by finding on the receiver operating characteristic (ROC) curve the threshold at which sensitivity (i.e. proportion of correctly predicted presences) and specificity (i.e. proportion of correctly predicted absences) have equal values. The advantage of this threshold is that it does not favour either sensitivity or specificity, which is appropriate to assign areas with caution where the species is actually present. Accuracy of binary prediction was measured by the True Skill Statistic (TSS) (Allouche et al., 2006). TSS is calculated from sensitivity and specificity (TSS = Sensitivity + Specificity − 1), and it ranges from −1 to +1; values close to +1 indicate accurate predictions and values equal to/smaller than zero are no better than random predictions.

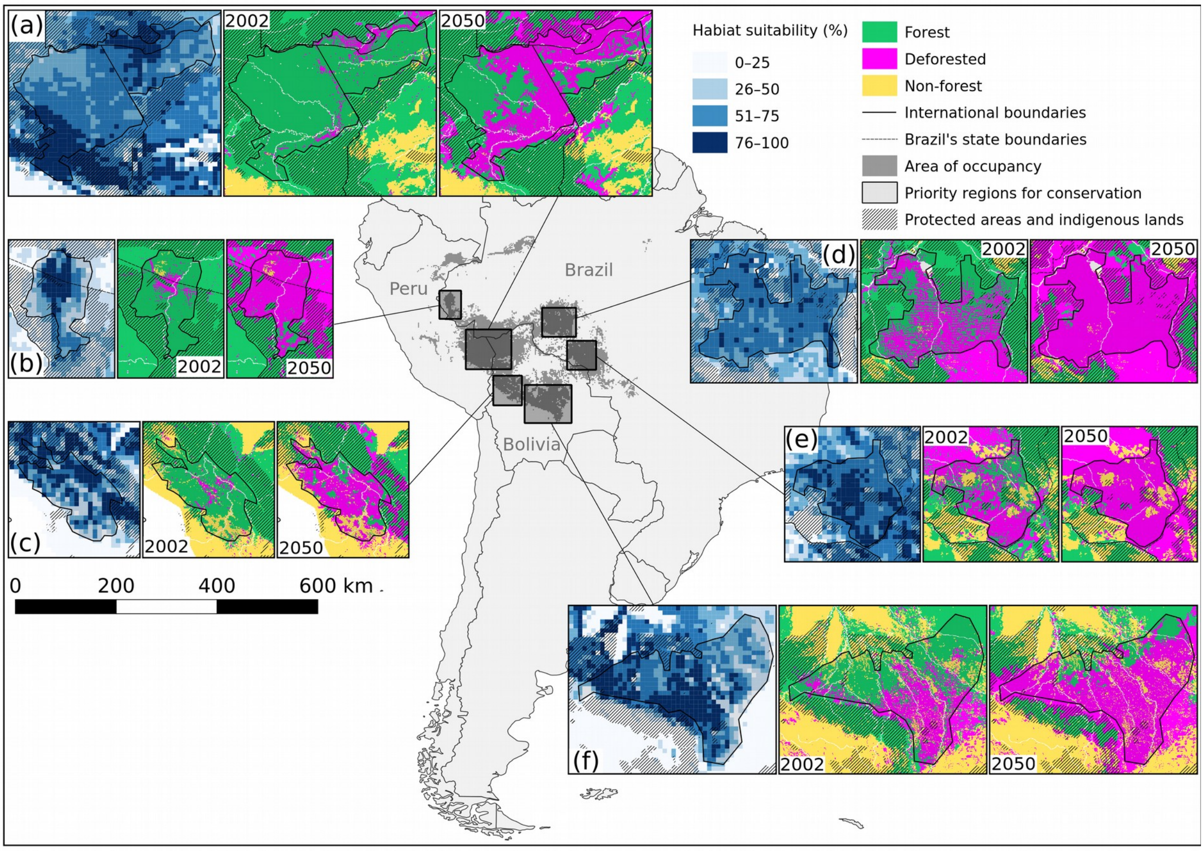
The model parametrization that we used allowed us to fit a model that is conservative in predicting species' area of occupancy (Merow et al., 2013). This is especially important when the aim is to appropriately target priority areas for the conservation of species, i.e. areas where the species is really present and where the invested conservation efforts will be more likely to be effective.

SUPPLEMENTARY TABLE 4 Estimates of relative contributions of the environmental variables to the Maxent model. The percent contribution represents how much the variable contributes to the regularized gain of the model in all iterations. For the permutation importance, the model performance is re-evaluated after the values of the variable on training presence and background data are randomly permuted. Values shown are mean values over replicate runs.

Variable	Percent contribution	Permutation importance
Temperature seasonality	23.7	16
Net primary productivity	21.1	17.6
Annual potential evapo-transpiration	12.3	17.4
Annual precipitation	10.9	2.4
Compound topographic index (wetness)	9.6	12.6
Height above nearest drainage	8	10.7
Precipitation seasonality	6.5	7.4
Flooded areas	6.3	8.6
Minimum temperature of coldest month	1.6	7.2



SUPPLEMENTARY FIG. 2 Maxent prediction response curves for environmental variables. The curves show how the predicted probability of presence changes as each environmental variable varies, keeping all other variables constant at their mean sample value (i.e. the marginal effect of each variable). Red lines are the mean response of the 10 replicates and blue is the mean ± SD. cti, compound topographic index (wetness index); flood, flooded areas; hand, height above nearest drainage; npp, net primary productivity; pet, annual potential evapo-transpiration; prec_annual, annual precipitation; prec_season, precipitation seasonality; temp_min, minimum temperature of coldest month; temp_season, temperature seasonality.



SUPPLEMENTARY FIG. 3 Priority regions for the conservation of *A. chamek* in the Amazon, with habitat suitability for the species, forest cover in 2002, and predicted forest cover in 2050 according to the business-as-usual scenario of deforestation. Proposed regions for expanding the protected area network: (a) Assis Brasil (includes international borders between Peru, Bolivia and Brazil); (b) Cruzeiro (Brazil); and (c) La Paz (Bolivia). Human-modified regions for landscape planning, management and/or restoration: (d) Porto Velho (Rondônia state, Brazil); (e) Vilhena (Rondônia state, Brazil); and (f) Santa Cruz (includes Santa Cruz and Cochabamba departments, Bolivia). Data on deforestation scenarios are from Soares-Filho et al. (2013).

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