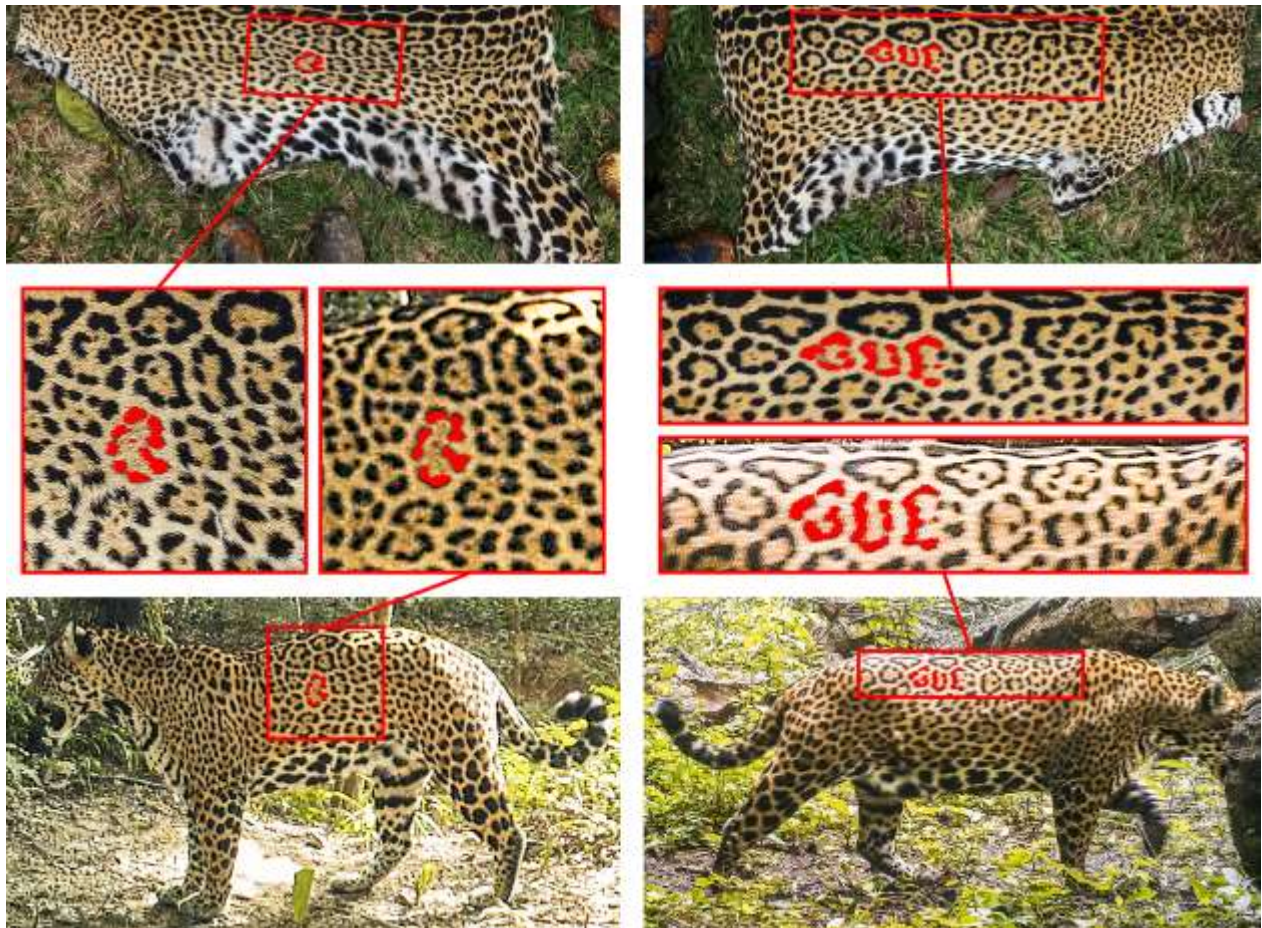


## Habitat destruction threatens jaguars in a mixed land-use region of eastern Bolivia

René Meißner, Moritz Blumer, Merlin Weiß, Maya Beukes, Gabriel Aramayo Ledezma, Yannet Condori Callisaya, José Luis Aramayo Bejarano and Martin Jansen

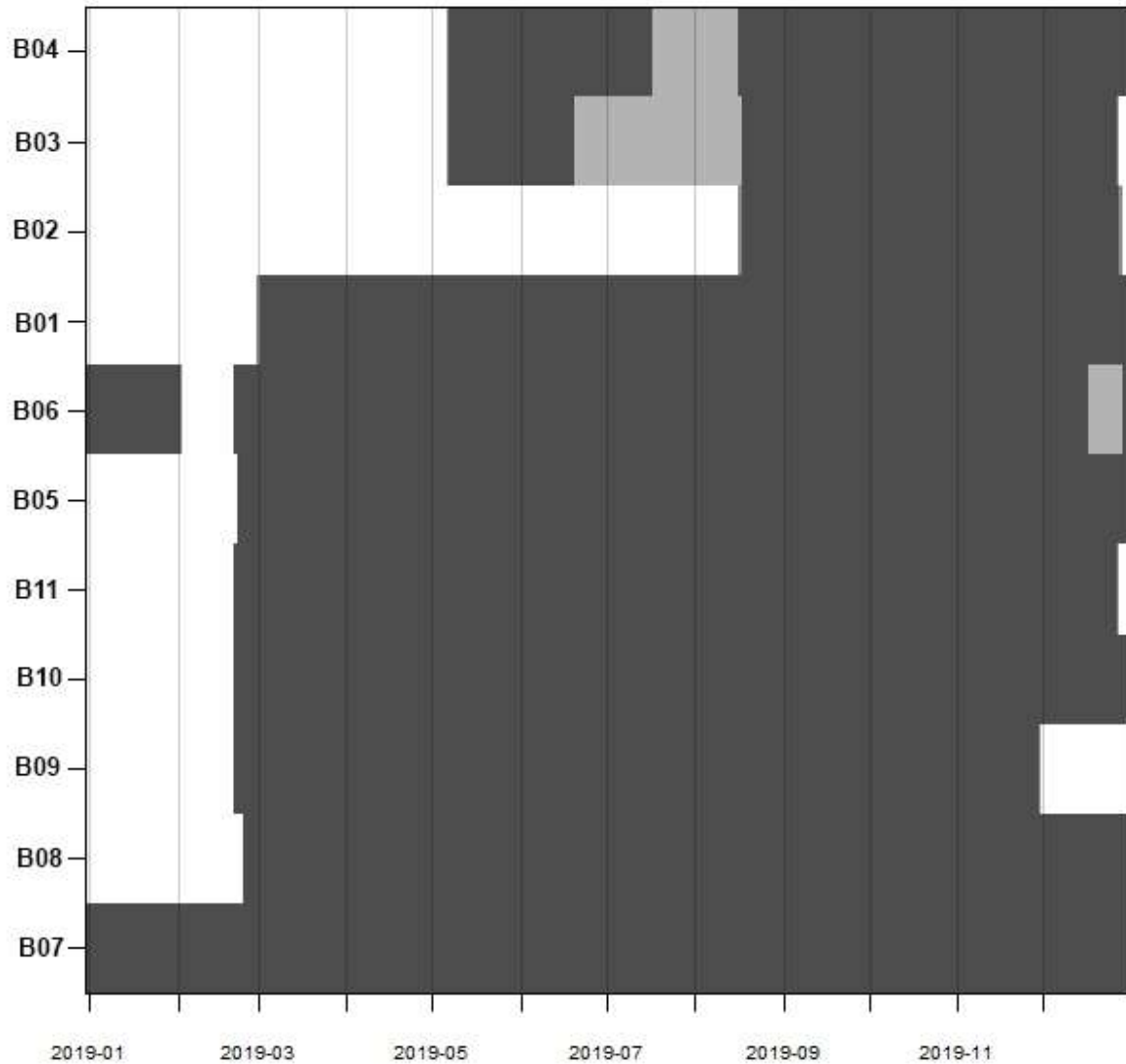
SUPPLEMENTARY PLATE 1 Matching coat color pattern of a jaguar skin found in March 2019 at a neighboring farm confirms the death of individual F-01.



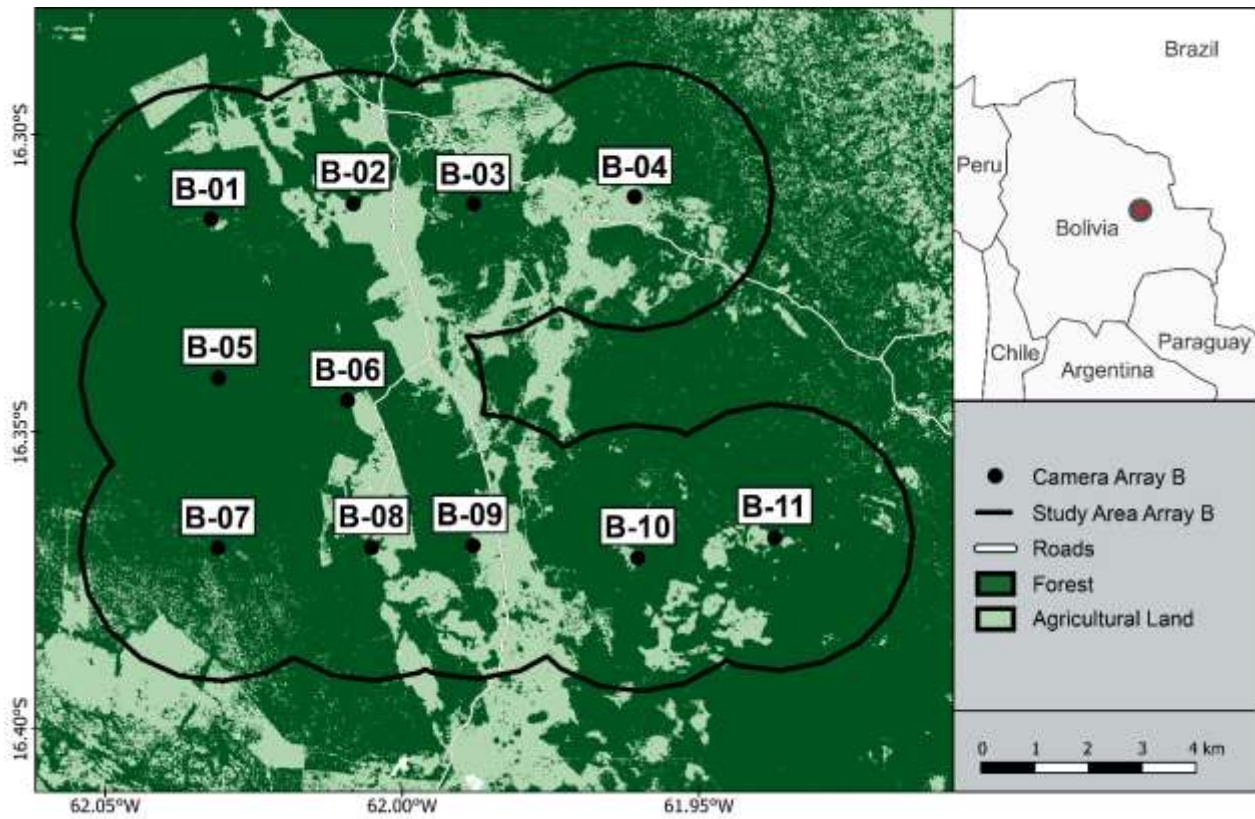
SUPPLEMENTARY PLATE 2 Documentation of a jaguar livestock predation event (photos taken a few days after the killing on 24th February 2019). (A) Overview of the deceased cow. (B) Scratch marks left behind on the back of the deceased cow. Characteristic jaguar bite marks at the forehead (C) and neck (D) of the deceased cow. Both the bite and scratch marks are characteristic for jaguars, since pumas as the only other native predator capable of killing cattle would attack the throat rather than the neck and forehead.



SUPPLEMENTARY FIG. 1 Camera trapping times of camera stations during the survey period of Camera Array B used for SECR analyses, figure showing camera station activity against time. Cameras were not consecutively active due to battery problems or problems caused by humidity. Codes indicate IDs of individual camera stations (see Fig. S-2 for location of camera stations).



SUPPLEMENTARY FIG. 2 Location of the study area in the Chiquitano region of Bolivia showing the layout of camera trap array B used for SECR analyses; 3-letter codes indicate IDs of individual camera stations.



SUPPLEMENTARY TABLE 1 Software used for the analysis.

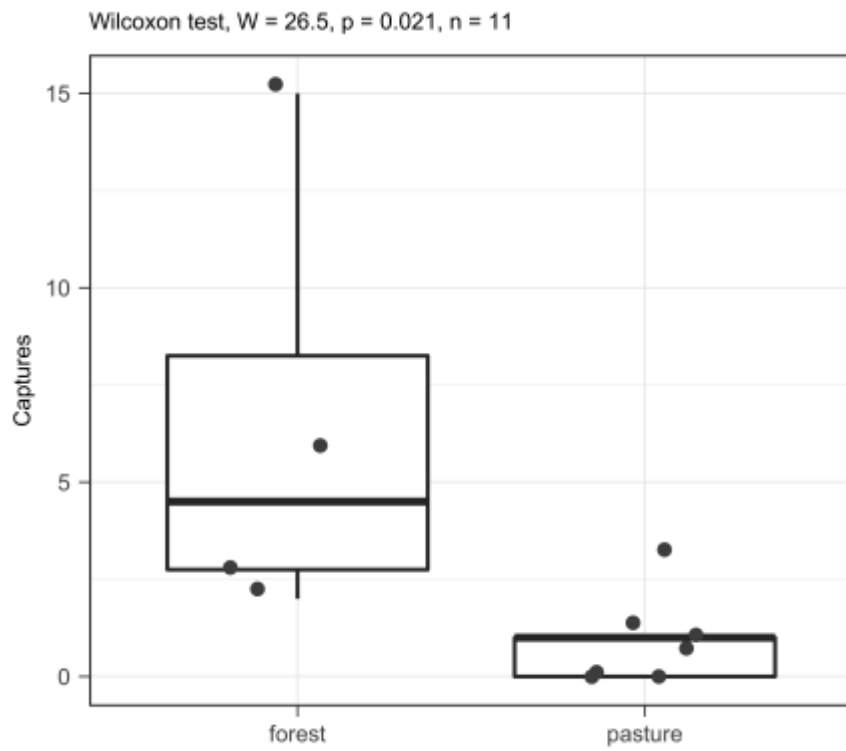
Software	Reference
activity	Rowcliffe, M. (2021) activity: <i>Animal Activity Statistics</i> . R package version 1.3.1. <a href="https://CRAN.R-project.org/package=activity">https://CRAN.R-project.org/package=activity</a> [accessed on 12.09.2022].
camtrapR	Niedballa, J., Sollmann, R., Courtiol, A. & Wilting, A. (2016) camtrapR: an R package for efficient camera trap data management. <i>Methods in Ecology and Evolution</i> , 7, 1457–1462.
amtrapRdeluxe	Niedballa, J., Courtiol, A. & Sollmann, R. (2018) camtrapRdeluxe: A R package that builds on camtrapR to provide more functionalities and flexibility. R package version 0.99.10.9999.
coin	Hothorn T., Hornik K., van de Wiel M., Zeileis A. (2006) A Lego system for conditional inference. <i>The American Statistician</i> , 60, 257–263.
data.table	Dowle, M. & Srinivasan A. (2021) data.table: Extension of `data.frame`. R package version 1.14.2. <a href="https://CRAN.R-project.org/package=data.table">https://CRAN.R-project.org/package=data.table</a> [accessed on 12.09.2022].
datarium	Kassambara, A. (2019) datarium: Data Bank for Statistical Analysis and Visualization. R package version 0.1.0. <a href="https://CRAN.R-project.org/package=datarium">https://CRAN.R-project.org/package=datarium</a> [accessed on 12.09.2022].
geosphere	Hijmans, R. J. (2021) geosphere: Spherical Trigonometry. R package version 1.5-14. <a href="https://CRAN.R-project.org/package=geosphere">https://CRAN.R-project.org/package=geosphere</a> [accessed on 12.09.2022].
ggmap	Kahle, D. & Wickham, H. (2013) ggmap: Spatial Visualization with ggplot2. <i>The R Journal</i> , 5, 144–161.
ggpubr	Kassambara, A. (2020) ggpubr: 'ggplot2' Based Publication Ready Plots. R package version 0.4.0. <a href="https://CRAN.R-project.org/package=ggpubr">https://CRAN.R-project.org/package=ggpubr</a> [accessed on 12.09.2022].
ggspatial	Dunnington, D. (2021) ggspatial: Spatial Data Framework for ggplot2. R package version 1.1.5. <a href="https://CRAN.R-project.org/package=ggspatial">https://CRAN.R-project.org/package=ggspatial</a> [accessed on 12.09.2022].
GISTools	Brunsdon, C. & Chen, H. (2014) GISTools: Some further GIS capabilities for R. R package version 0.7-4. <a href="https://CRAN.R-project.org/package=GISTools">https://CRAN.R-project.org/package=GISTools</a> [accessed on 12.09.2022].
gridExtra	Auguie, B. (2017) gridExtra: Miscellaneous Functions for "Grid" Graphics. R package version 2.3. <a href="https://CRAN.R-project.org/package=gridExtra">https://CRAN.R-project.org/package=gridExtra</a> [accessed on 12.09.2022].
lubridate	Grolemund, G. & Wickham, H. (2011). Dates and Times Made Easy with lubridate. <i>Journal of Statistical Software</i> , 40, 1–25.
pryr	Wickham, H. (2021) pryr: Tools for Computing on the Language. R package version 0.1.5. <a href="https://CRAN.R-project.org/package=pryr">https://CRAN.R-project.org/package=pryr</a> [accessed on 12.09.2022].
rstatix	Kassambara, A. (2021) rstatix: Pipe-Friendly Framework for Basic Statistical Tests. R package version 0.7.0. <a href="https://CRAN.R-project.org/package=rstatix">https://CRAN.R-project.org/package=rstatix</a> [accessed on 12.09.2022].

Software	Reference
scales	Wickham H. & Seidel, D. (2022) scales: Scale Functions for Visualization. R package version 1.2.0. <a href="https://CRAN.R-project.org/package=scales">https://CRAN.R-project.org/package=scales</a> [accessed on 12.09.2022].
scatterpie	Yu, G. (2021) scatterpie: Scatter Pie Plot. R package version 0.1.7. <a href="https://CRAN.R-project.org/package=scatterpie">https://CRAN.R-project.org/package=scatterpie</a> [accessed on 12.09.2022].
secr	Efford, M. G. (2021) secr: Spatially explicit capture-recapture models. R package version 4.4.8. <a href="https://CRAN.R-project.org/package=secr">https://CRAN.R-project.org/package=secr</a> [accessed on 12.09.2022].
sf	Pebesma, E. (2018) Simple Features for R: Standardized Support for Spatial Vector Data. <i>The R Journal</i> 10, 439–446.
sp	Pebesma, E.J. & Bivand, R.S. (2005) Classes and methods for spatial data in R. <i>R News</i> , 5.
suncalc	Thieurmel, B. & Elmarhraoui, A. (2019) suncalc: Compute Sun Position, Sunlight Phases, Moon Position and Lunar Phase. R package version 0.5.0. <a href="https://CRAN.R-project.org/package=suncalc">https://CRAN.R-project.org/package=suncalc</a> [accessed on 12.09.2022].
tidyverse	Wickham et al., (2019). Welcome to the tidyverse. <i>Journal of Open Source Software</i> , 4(43), 1686.
ExtractFramesFromVideo.py	<a href="https://github.com/MoritzBlumer/ExtractFramesFromVideo">github.com/MoritzBlumer/ExtractFramesFromVideo</a> [accessed on 16.09.2022]
QGIS	QGIS Development Team (2022). QGIS Geographic Information System. Version 10.5. Open Source Geospatial Foundation Project. <a href="http://qgis.osgeo.org">http://qgis.osgeo.org</a> .

SUPPLEMENTARY TABLE 2 Density estimates for the jaguar at the study site for all seven time slots (D= Density, CI= Confidence interval, g0= detection probability, see text for details).

<b>180-day-session</b>	<b>Value</b>	<b>Estimate</b>	<b>SEM</b>	<b>Lower CI</b>	<b>Upper CI</b>
1	D	2.996	1.690	1.069	8.394
	g0	0.041	0.017	0.018	0.090
	sigma	1741.691	399.640	1117.270	2715.088
2	D	3.463	1.925	1.252	9.577
	g0	0.038	0.016	0.017	0.086
	sigma	1763.597	431.694	1099.172	2829.654
3	D	3.352	2.141	1.065	10.551
	g0	0.02892451	0.01313455	0.01177141	0.0693195
	sigma	1838.857	515.133	1072.960	3151.464
4	D	3.567	2.576	1.002	12.697
	g0	0.008	0.004	0.003	0.024
	sigma	2316.468	848.195	1155.850	4642.489
5	D	3.066	3.618	0.491	19.125
	g0	0.007	0.005	0.002	0.028
	sigma	2622.463	1431.412	963.915	7134.769
6	D	1.319	1.860	0.170	10.251
	g0	0.013	0.009	0.004	0.047
	sigma	3137.304	1739.905	1137.006	8656.657
7	D	2.368	2.330	0.472	11.878
	g0	0.008	0.005	0.002	0.026
	sigma	3056.239	1500.168	1229.436	7597.465

SUPPLEMENTARY FIG. 3 Jaguar capture rates in relation to land-use.





SUPPLEMENTARY TABLE 3 Jaguar population density estimates from Bolivia, study area and camera polygon size. Table adapted from Maffei et al., 2011, Jędrzejewsk et al., 2018.

<b>Land use type</b>	<b>Study area (km<sup>2</sup>)</b>	<b>Polygon (km<sup>2</sup>)</b>	<b>Density ± SE (100 km<sup>2</sup>)</b>	<b>Reference</b>
protected	106	36	5.66 ± 2.33	Arispe et al., 2007
protected	137-149	49-52	5.24 ± 2.46	Maffei et al., 2003
mixed	54-142	24-53	4.23 ± 1.43	Arispe et al., 2005
protected	125-272	49-130	3.41 ± 1.21	Maffei et al., 2004
protected	153-158	48-51	2.91 ± 0.33	Romero-Muñoz 2008
mixed	139	133	2.87 ± 2.31	This study
protected	458	200	2.84 ± 1.78	Silver et al., 2004
protected	191-243	49-62	2.28 ± 0.66	Cuéllar et al., 2004
protected	309-319	100	1.92 ± 0.76	Cuéllar et al., 2003
protected	230-1068	71-434	1.13 ± 0.13	Montaño et al., 2007
mixed	34400	48-434	0.31 - 1.82	Noss et al, 2012
mixed	7431	-	1.73	Jędrzejewsk et al., 2018
protected	170	77	1.68	Wallace et al., 2003
mixed	119	43	1.6	Venegas et al., 2010
mixed	1058	434	0.94	Montaño et al., 2010

SUPPLEMENTARY TABLE 4 List of Citizen scientists that contributed to the WildLIVE!-Citizen-Science-Project (<https://wildlive.sgn.one/de/>). Only participants who agreed to publish their names are listed.

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Asztalos,	Marika
Benkert,	Philipp
Bertram,	Andrea
Breitenbach,	Klaus
Czölder,	Anja
Drescher,	Clara
Falkenhahn,	Mechthilde
Gerl,	Thomas
Götze,	Peter
Große,	Thomas
Hansen,	Simone
Intemann,	Julia
Kelch,	Andreas
Kinzelmann,	Jonas
Kirschbaum,	Philipp
König,	Alexandra
Kraus,	Lena
Künkel,	Herr/Frau
Langhoff,	Luisa
Langner,	Stephan
Leuzinger,	Lucas
Look,	Samantha
Marquaß,	Melanie
Müller,	Lilian
N. N.,	Milo
Otto,	Luisa
Ottong,	Alexandra
Pavić,	Karl

Pawliczek,	Fanny
Pfeiffer,	Jessica
Poerting, Dr. ,	Julia
Rippel,	Til Konstantin
Rolli,	Sabine
Rossol,	Daniel
Russ,	Susanne
Schäfer,	Simone
Schmitt,	Axel
Schubert,	Barbara
Schuler,	Sigrid
Simon,	David
Starostzik, Dr.,	Christine
Stratemann,	Lucas
von Ehr,	Julian
Vos,	Vincent Antoine
Wenz,	Christian
Wörner,	Elisabeth
Wulf,	Jochen
Zimmer,	Daniel

“Researcher class” 5c of the Helmholtz School, Frankfurt, Germany

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## References

- Arispe, R., Rumiz, D.I. & Venegas, C. (2005) *Second camera-trap Survey for jaguars (Panthera onca) and other mammals at San Miguelito Ranch*. Wildlife Conservation Society, Bolivia.
- Arispe, R., Rumiz, D.I. & Venegas, C. (2007) *Censo de jaguars y otros mamíferos con trampas cámara en la Concesión Forestal El Encanto*. Wildlife Conservation Society, Technical Report 173, Bolivia.
- Arispe, R., Venegas, C., Rumiz, D.I. & Noss, A. (2006) *Estudio de mamíferos con trampas cámara en estancias ganaderas al Sur de Roboré*. Wildlife Conservation Society, Technical Report 166, Bolivia.
- Cuéllar, E., Dosapei, T., Peña, R. & Noss, A.J. (2003) *Jaguar and other mammal camera trap survey Ravelo II, Ravelo field camp, Kaa-Iya del Gran Chaco National Park, 18 September–18 November 2003*. Wildlife Conservation Society, Technical Report 103, Bolivia.
- Cuéllar, E., J. Segundo, G. Castro & Noss, A.J. (2004) *Jaguar and other mammal camera trap survey Guanaco II, Guanaco field camp (20° 03′ 03″S, 62° 26′ 04″W), Kaa-Iya del Gran Chaco National Park, 18 August–18 October 2004*. Wildlife Conservation Society, Technical Report 108, Bolivia.
- Jędrzejewski, W., Robinson, H.S., Abarca, M., Zeller, K.A., Velasquez, G., Paemelaere, E.A.D., et al. (2018) Estimating large carnivore populations at global scale based on spatial predictions of density and distribution - Application to the jaguar (*Panthera onca*). *Plos ONE*, 13, e0194719.
- Maffei, L., Cuéllar, E., & Noss, A.J. (2004) One thousand jaguars (*Panthera onca*) in Bolivia's Chaco? Camera trapping in the Kaa-Iya National Park. *Journal of Zoology*, 262, 295–304
- Maffei, L., Noss, A.J., Silver, S.C. & Kelly, M.J. (2011) Abundance/density case study: Jaguars in the Americas. In *Camera traps in animal ecology* (eds A.F. O'Connell, J.D. Nichols & K.U. Karanth), pp. 11–144. Springer, Tokyo.
- Montaño, R., Maffei, L. & Noss, A.J. (2007) *Segundo muestreo con trampas cámaras de jaguares y otros mamíferos en el Campamento Palmar de las Islas y Ravelo (Diciembre 2006–Marzo 2007)*. Wildlife Conservation Society, Technical Report 185, Bolivia.
- Montaño, R., Maffei, L. & Noss, A. (2010) *Segundo muestreo con trampas cámaras de jaguares y otros mamíferos en el Campamento Palmar de las Islas y Ravelo. Diciembre 2006-Marzo 2007*. Wildlife Conservation Society, Technical Report 185, Bolivia.
- Noss, A.J., Gardner, B., Maffei, L., Cuéllar, E., Montaño, R., Romero-Muñoz, A et al. (2012) Comparison of density estimation methods for mammal populations with camera traps in the Kaa-Iya del Gran Chaco landscape. *Animal Conservation*, 15, 527–535.
- Romero-Muñoz, A. & Pérez-Zubieta, J.C. (2008) Evaluación preliminar del comercio y uso de mamíferos silvestres en el mercado La Pampa de la ciudad de Cochabamba, Bolivia. *Mastozoología neotropical*, 15, 253–259.

Rumiz, D.I., Arispe, R., Noss, A.J. & Rivero, K. (2003) *Censo de jaguares (Panthera onca) y otros mamíferos con trampas-cámara en la Estancia San Miguelito, Santa Cruz, Bolivia*. Wildlife Conservation Society, Technical Report 143, Bolivia.

Silver, S.C., Ostro, L.E, Marsh, L.K., Maffei, L., Noss, A.J., Kelly, M.J., Wallace, R.B, Gomez H, & Ayala, G (2004) The use of camera traps for estimating jaguar *Panthera onca* abundance and density using capture/recapture analysis. *Oryx*, 38, 148–154

Venegas, C., Rumiz, D.I., Angulo, S. & Rivero, K. (2010) *Censo de jaguares (Panthera onca) y otros mamíferos con trampas cámara en la propiedad Alta Vista del Bosque Seco Chiquitano*. Wildlife Conservation Society, Technical Report, Bolivia

Wallace, R.B., Gómez, H., Ayala, G. & Espinoza, F. (2003) Camera trapping for jaguar (*Panthera onca*) in the Tuichi valley, Bolivia. *Mastozoología Neotropical*, 10, 133–139.