Supplementary Information

Wildfires disproportionately affected jaguars in the Pantanal
Alan Eduardo de Barros et al.

Supplementary Note 1

Complementary analysis (Results)

Real-time fire occurrence in jaguar home ranges (HRs)

In addition to the analyses considering the impacts of fire on HRs across multiple years, we analysed real-time fire impacts on jaguar home ranges (HR) (Figs.S10-S15). This analysis considered fires that occurred within jaguar HRs only during the individual monitoring period (2008–2016 in Brazil and 2005, 2006, and 2010 in Paraguay/Bolivia; Figs.S10-S16). Our real-time investigation allowed us to find that the effects of fire were negligible in the area used by the four non-resident individuals (Fig.S11). While this might be just an anecdotal observation (given the small sample size), it may also be that fires caused more impacts on high-quality habitats within the HRs of the resident jaguars.

Relationship of the year and project region with fire occurrence

We used a two-way ANOVA to evaluate the effect of year, project region, and ID on real-time fire occurrence within jaguar HRs (during real-time monitoring) and jaguar HRs (HRs compared across all years). The interaction between year and project region on fire occurrence was the most plausible model, since it generated the smallest residuals (Table S4). However, a major limitation in the real-time analysis was the unequal distribution of jaguar HRs in space and time. Years without monitoring (2007, 2017–2020) or with sparse or clustered monitoring (2005–2006, 2008–2009, and 2016) seemed to neglect or underestimate the impact of fires on the overall jaguar HRs (Figs. S12-S15). Conversely, the main approach used here (using 48 home ranges of resident jaguars across multiple years Figs.2 and 3 in the main text) was more representative in space and time.
Additional details about the cumulative impacts in the UPRB and Pantanal (Discussion)

An assessment of the integrity risk of aquatic ecosystems identified hydroelectric power plants, urbanization, and agribusiness as the top three stressors among 13 anthropic activities impacting the Upper Paraguay River Basin (UPRB). Environmental degradation (e.g., deforestation, erosion, sewage), economic activities (e.g., agriculture, mining), and infrastructure (e.g., dams, hydroelectric power plants, waterways, gas pipelines) are associated with the demand and pressure of an increasing human population in the UPRB. These environmental damages can interfere with drainage dynamics, flood pulses, and drought extent and, consequently, impact ecological richness, biodiversity, and ecosystem services.

The Pantanal occupies 38% of the UPRB, and the water that drains into the lowlands and floods in the Pantanal comes from springs in the highlands. Thus, the removal of the vegetation cover that protects these springs in the neighbouring biomes within the UPRB (Cerrado, Amazonia, Atlantic Forest, and Chaco) impacts the drainage, water quality, and hydrological regime of the Pantanal. Deforestation, mining activities and hydroelectric power plants (total ≈ 180, 47 of them installed or in operation and 133 planned) change water quality and flow, causing erosion, river sedimentation, and reduction of outflow (up to 100% in drier years) and nutrient transport to the Pantanal floodplains. Additional problems include reduced light, which is causing a decline or disappearance of aquatic plants and photosynthetic algae, hypoxia and a consequent cascade effect, such as reduced food availability for fish and bioaccumulation of toxic mercury.

The implementation of a waterway on the Paraguay River, hydroelectric power plants, railroads, and highways have long been debated in academia, legal courts, and by stakeholders. Overwhelming evidence of negative impacts has barred or reduced the development of large enterprises, such as the construction of a 3,440 km north-south waterway from Cáceres (Brazil) to Nueva Palmira (Uruguay) and large hydroelectric power plants. However, a subterfuge often used by stakeholders in many new enterprises is to propose several small hydroelectric plants, ports, or relatively short canalization projects as low-impact alternatives, without considering their cumulative impacts. In addition, the supposed small individual impact is often used as an excuse to limit the decision-making to a smaller group of stakeholders, the so-called “tyranny of small decisions.” And the quality of many Environmental Impact assessments in Brazil lacks scientific rigor. The impact of the cumulative effects of small ventures can be only avoided by adopting a holistic perspective in a process involving scientists with relevant subject matter expertise, planners, politicians, and other social actors in-depth studies, with impartial evaluation and discussions (e.g., using a Strategic (or Integrated) Environmental Assessments (SEA) or equivalent approaches). Successful regulation based on laws and updated SEAs for the Pantanal, through a transparent and plural engagement of civil society, could bring invaluable advances for conservation and provide science-based guidance to attain sustainability. See Fig. 4 in the main text.
Supplementary Figures

**Fig. S1.** Top: Comparative histograms of yearly fire available datasets, based on MODIS satellites indicating occurrence of fire foci (**INPEfire_foci**)\(^30\), derived proportion of burned area (**FIRMS_Perc_fire_Pantanal**)\(^33,36\) and burned area based on LANDSAT satellites (**MapBiomas_fire_km2**)\(^32\). **Bottom:** The continuous lines correspond to the minimum annual river depths (minimum quotas in meters from 1985 to 2020) at six Pantanal gauge stations in the Paraguay River. The dashed lines in the same colours correspond to the respective historical medians (HM) at each station\(^33,34\). The histograms correspond to the MapBiomas 5.0\(^35\) annual wetland estimated area (ha) in the Pantanal areas of Mato Grosso (MT) and Mato Grosso do Sul (MS) from 1985 to 2019. The dashed-dotted blue line corresponds to the median annual rainfall (1967 to 2019).
Fig. S2. Spearman correlation of yearly fire data. **Upper panel:** Correlation between the proportion of burned area estimated using FIRMS\textsuperscript{31,36} fire occurrence dataset (\textit{Perc\_fire\_Pantanal}) with occurrence of fire foci (\textit{INPEfire\_foci})\textsuperscript{30} and with burned area based on LANDSAT satellites (\textit{MapBiomas\_fire\_Km}\textsuperscript{2})\textsuperscript{32} for the period between 2005-2020. **Middle panel:** Correlation between the (\textit{INPEfire\_foci})\textsuperscript{30} and (\textit{MapBiomas\_fire\_Km}\textsuperscript{2})\textsuperscript{32} for the period between 2005-2020. **Bottom panel:** Correlation between the (\textit{INPEfire\_foci})\textsuperscript{30} and (\textit{MapBiomas\_fire\_Km}\textsuperscript{2})\textsuperscript{32} for the period between 1998-2020.
Fig. S3. The continuous lines correspond to the minimum annual river depths (minimum quotas in meters from 1967 to 2020) at six Pantanal gauge stations in the Paraguay River. The dashed lines in the same colours correspond to the respective historical medians (HM) at each station\textsuperscript{33,34}. The histograms correspond to the MapBiomas 5.0\textsuperscript{35} annual wetland estimated area (ha) in the Pantanal areas of Mato Grosso (MT) and Mato Grosso do Sul (MS) from 1985 to 2019. The dashed-dotted blue line corresponds to the median annual rainfall (1967 to 2019).
Fig. S4. Hydrological conditions during the jaguar monitoring period (2005–2016) and in subsequent years. The continuous lines correspond to minimum annual river depths (minimum quotas in meters from 2005 to 2020) at six Pantanal gauge stations in the Paraguay River\textsuperscript{33,34}, and the dashed lines with the same colours correspond to the respective averaged references (average, from six stations, of medians of yearly minimums of each station during the monitoring period). The dashed-dotted line corresponds to median annual rainfall (reference 1967 to 2019)\textsuperscript{37}. The histograms correspond to the MapBiomas 5.0\textsuperscript{35} annual wetland estimated area (ha) in the Pantanal areas of Mato Grosso (MT) and Mato Grosso do Sul (MS) from 2005 to 2019. The dashed lines in the same colours correspond to the respective averages (1985 to 2019).
Fig. 5.5. Quarterly rainfall in 2020 in comparison with rainfall in the reference period (1981–2010)\textsuperscript{38}.

Fig. 5.6. Monthly rainfall per year (considering the median of 4 stations in the UPRB: Cáceres, Corumbá, Cuiabá, and Campo Grande)\textsuperscript{37}, with 2020 in red. Data acquired for 2020 was limited until October.
Fig. S7. Average monthly medians for the wet seasons (considering four stations in the UPRB: Cáceres, Corumbá, Cuiabá, and Campo Grande). Note that 28 years had estimates below the historical average, with five years (1980, 1993, 1994, 2004, 2012) having estimates more than 20% below the historical average. Data acquired for 2020 was limited until October.
Fig. S8. Annual rainfall from 2001 to 2020 in the Pantanal. Note that after 2014, accumulated rainfall often falls below the minimums (reference period 1981–2010; translated and adapted from CPTEC/INPE)\textsuperscript{38}.
Fig. S9. Water surface time series from 1985 to 2021 in the Brazilian Pantanal (MapBiomas)\textsuperscript{39}. 

Water surface time series - Pantanal

A thousand hectares

| Year | Water Surface (1000 hectares) |
|------|------------------------------|
| 1985 | 1,500                        |
| 1987 | 2,000                        |
| 1989 | 1,500                        |
| 1991 | 2,000                        |
| 1993 | 1,500                        |
| 1995 | 2,000                        |
| 1997 | 1,500                        |
| 1999 | 2,000                        |
| 2001 | 1,500                        |
| 2003 | 2,000                        |
| 2005 | 1,500                        |
| 2007 | 2,000                        |
| 2009 | 1,500                        |
| 2011 | 2,000                        |
| 2013 | 1,500                        |
| 2015 | 2,000                        |
| 2017 | 1,500                        |
| 2019 | 2,000                        |
| 2021 | 1,500                        |
Fig. S10. The left panel shows the monitoring period for GPS-collared jaguars⁴⁰. The right panel presents the yearly percentage of fire impacting jaguar HRs during the individual monitoring period in the Brazilian Pantanal.
Fig. S11. Percentage of fire occurrence matching individual jaguar areas during the monitoring period. Non-resident jaguars in Brazil (left) and resident jaguars from Paraguay/Bolivia (right). Note the low fire occurrence within the areas used by non-resident jaguars.
Fig. S12. (Left) Real-time impact with the percentage of fire occurrence matching individual jaguar areas during the GPS monitoring period. This plot includes 52 individuals from the Brazilian Pantanal (45 residents and 4 non-residents) and the Paraguayan Pantanal (3 residents). The numbers in the plot represent the number of individuals monitored each year. (Right) Projected impact of fire on areas selected as home ranges (HRs) of 48 resident individuals from 2005 to 2020. This projection allowed us to explore the impacts of fire on jaguar HRs for years in which tracking data were unavailable (as was the case for 2020) (see Table S4).
Fig. S13. Intensity of daily fire occurrence per year considering areas selected as HRs (stable jaguar priority areas) in red, and whole Pantanal in blue for the period of 2005–2020.
Fig. S14. Intensity of daily fire occurrence per year considering areas selected as HRs and whole Pantanal for the period of 2005–2020.
Fig. S15. Intensity of daily fire occurrence per year coinciding with HRs during the real time monitoring period of individuals.
Fig. S16. Resident jaguars (blue)\textsuperscript{40} from the Brazilian and Paraguayan/Bolivian Pantanal and non-residents jaguars (purple)\textsuperscript{40}. Map boundaries data sources\textsuperscript{52-54} acquired through Google Earth Engine\textsuperscript{41}.
Cattle livestock is the most abundant economic activity. It continues to increase in Pantanal areas of both states, although the number of cattle and pastures in the Cerrado has decreased (see Fig. S18). Nonetheless, agriculture was the anthropic activity with the highest percentage growth (MapBiomas data).
Fig. S18. Main anthropic activities in the Brazilian Cerrado, states of Mato Grosso (MT) and Mato Grosso do Sul (MS) (MapBiomas data\textsuperscript{35}). Cattle livestock is still the most abundant economic activity, but the area occupied by agriculture (particularly soybean plantations) is increasing\textsuperscript{35}. 
Fig S19. Creation and maintenance of protected areas in the Brazilian Pantanal and the surrounding Uplands within the Brazilian Upper Paraguay River Basin. The upper panels show the accumulated area. The bottom panel shows the accumulated numbers. IP = PAs of Integral Protection. SU = PAs of Sustainable Use. RPPNs = Private Reserves. SU = PAs that include RPPNs, Park Roads, and other categories of sustainable use. RPPNs are shown in detail, considering that almost 95% of the Pantanal are on private land. IP areas and RPPNs form most of the PAs in the Pantanal but are a minority in the Uplands. The areas have remained stable since the creation of the last PAs in the Uplands in 2011 and since the revocation of the Environmental Protected Area of Pontal dos Rios Itiquira and Corrientes in 2006, reducing the total of PAs in Pantanal by almost 20%. Adapted from Tomas et al. 2019\(^2\) and Chaves & Silva 2018\(^43\) using the following sources: MMA 2020\(^44\), IMASUL 2019\(^45\), ICMbio 2021\(^46\), ICMbio - SIMRPPN 2021\(^47\). Data used to make the charts are shown in Table S3.
Fig. S20. Percentage variation (left) and burnt area (right) of the Brazilian Pantanal. Note that farms presented the highest medians for the percentage of burnt areas, while PAs of integral protection presented the highest absolute values of burnt areas. ANOVA applied to evaluate the effect of land protection/use type categories on the percentage and amount of burnt areas found no significant difference (p > 0.05) among the category types. Reference sources: LASA, Libonati et al. Data used in the analyses are shown in Table S5.
Fig.S21. Variograms of two resident (R, left) and two non-resident (NR, right) jaguars from the Pantanal. The best-fit models are represented by the blue line and their 95% CIs. Non-resident jaguars lack a clear asymptote despite the long monitoring time, also reflected by a low number of range crossings. Numbers at the top are individual identifiers. OUF anisotropic corresponds to the best-fit model (Ornstein-Uhlenbeck-F), capturing autocorrelated locations and velocities for all R and NR jaguars shown below (see Table S6).
### Supplementary Tables

**Tab.S1.** Areas and percentages of Brazilian protected areas (PAs) in the Pantanal, Uplands, and within Paraguay River Basin (UPRB). Brazilian UPRB corresponds to the basin area in Brazil. Total UPRB corresponds to the total basin area (multiple countries), and Total PRB corresponds to the entire Paraguay River Basin (PRB).

| REGION BOUNDARY AREA | AREA km² | PA area km² | %  | number |
|-----------------------|----------|-------------|----|--------|
| Brazilian Pantanal    | 150355   | 7506        | 5.0| 31     |
| Brazilian Uplands     | 212025   | 12684       | 6.0| 42     |
| Brazilian UPRB        | 362380   | 20190       | 5.6| 73     |
| Total UPRB            | 600000   | 20190       | 3.4| 73     |
| Total PRB             | 1100000  | 20190       | 1.8| 73     |

Main sources: adapted from 2, 43-47, Brazilian Pantanal boundary (IBGE)52.

**Tab.S2.** Comparative between Brazilian PAs in 2020 and the years in which the last area changes occurred. Note that PAs in the Brazilian Pantanal have decreased by almost 20% since 2007 and have remained the same in the Uplands since 2011.

| Type of PA          | Pantanal | Uplands |
|---------------------|----------|---------|
| Year                | 2006     | 2020    | 2011   | 2020 |
| Integral Protection km² | 4491     | 4491    | 3140   | 3140 |
| Sustainable Use km² | 4842     | 3014    | 9543   | 9543 |
| Total km²           | 9333     | 7506    | 12684  | 12684 |

Main sources: adapted from 2, 43-47.
Tab. S3. Protected areas (PAs) in the Pantanal and Uplands within the Brazilian boundaries of the Upper Paraguay River Basin (UPRB). **Type:** Split Protected Area classes in Integral Protection (IP) and Sustainable use (SU). **Type II:** Split the Protected Areas of Sustainable use in additional classes (APA = Environmental Protected Area with regulated sustainable use, RPPN = Private Protected Areas with restricted use, Park Road = buffer zone of restricted use along roads).
Adapted from Tomas et al.\textsuperscript{2} and Chaves & Silva\textsuperscript{4}. Updated from\textsuperscript{4}–\textsuperscript{47} (direct links on Source).

| Type | Type II | Region       | Protected Area Name                  | Area   | Year | Modification | Source                                                                 |
| Code | Code Type | Location | Name | Area | Year | URL |
|------|-----------|----------|------|------|------|-----|
| IP   | IP        | Uplands  | PE Dom Osório Stoffel | 64.22 | 2002 | https://socioambiental.org/arp/3451 |
| IP   | IP        | Pantanal | PE do Guirá | 1102.26 | 2002 | https://socioambiental.org/pt-br/arp/3439 |
| SU   | RPPN      | Pantanal | RPPN Estância Doroché | 265.18 | 1997 | https://sistemas.icmbio.gov.br/simrppn/publico/detalhe/613/ |
| IP   | IP        | Pantanal | PE Encontro das Águas | 1089.60 | 2004 | https://socioambiental.org/pt-br/arp/4253 |
| SU   | RPPN      | Pantanal | RPPN Poleiro Grande | 165.30 | 1998 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/ |
| SU   | APA       | Pantanal | APA Pontal dos Rios Itiquira e Correntes | 2158.31 | 2007 | Chaves & Silva 2018 |
| SU   | APA       | Pantanal | APA Pontal dos Rios Itiquira e Correntes | -2158.31 | 2007 | Chaves & Silva 2018 |
| IP   | IP        | Pantanal | Monumento Natural Municipal da Serra do Pantanal | 41.60 | 2005 | https://sonora.ms.gov.br/v2/wp-content/uploads/2017/03/PLANO-DE-MANEJO_MONUMENTO-NATURAL-MUNICIPAL-DA-SERRA-DO-PANTANAL_OK.pdf |
| SU   | RPPN      | Pantanal | PN do Pantanal | 1350.00 | 1981 | https://socioambiental.org/arp/600 |
| SU   | RPPN      | Pantanal | RPPN Rumo ao Oeste | 9.90 | 2005 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/ |
| SU   | RPPN      | Pantanal | RPPN Fazenda Acurizal | 132.00 | 2007 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/ |
| SU   | RPPN      | Pantanal | RPPN Fazenda Penha | 131.00 | 1997 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/ |
| SU   | RPPN      | Pantanal | RPPN Engenheiro Eliezer Batista | 133.23 | 2008 | https://sistemas.icmbio.gov.br/simrppn/publico/detalhe/712/ |
| SU   | RPPN      | Pantanal | RPPN Santa Cecília | 88.41 | 1998 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/ |
| SU   | RPPN      | Uplands  | RPPN Cachoeiras do São Bento | 30.37 | 2010 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/ |
| IP   | IP        | Uplands  | MN Serra do Bom Jardim | 61.21 | 2003 | http://www.wikaves.com.br/wiki/areas:mona_serra_bom_jardim:inicio |
| IP   | IP        | Uplands  | PNM Templo dos Pilares | 1.06 | 2003 | http://www.semagro.ms.gov.br/wp-content/uploads/2019/01/Encarte-1_Plano-de-Manejo-PENT.pdf |
| IP   | IP        | Uplands  | PE Nascentes do Rio Taquari | 306.18 | 1999 | https://www.imasul.ms.gov.br/gestao-unidades-de-conservacao/unidades-de-conservacao-estaduais/parque-estadual-nascentes-do-rio-taquari/ |
| SU   | Park Road | Pantanal | Área de Especial Interesse Turístico (AEIT) Estrada Parque Pantanal | 68.00 | 1993 | https://www.imasul.ms.gov.br/estrada-parque-do-pantanal-2/ |
| SU   | Park Road | Pantanal | Estrada-Parque Santo Antônio de Leverger – Porto de Fora – Barão de Melgaco | 44.70 | 2000 | Chaves & Silva 2018 |
| SU   | Park Road | Pantanal | Estrada-Parque Rodovia MT 370 | 39.23 | 2000 | Chaves & Silva 2018 |
| SU   | RPPN      | Pantanal | RPPN Arara Azul | 2.04 | 2002 | https://sistemas.icmbio.gov.br/simrppn/publico/detalhe/268/ |
| SU | APA | Uplands | Pantanal | APA da Baia Negra | 54.21 | 2010 | http://www.semagro.ms.gov.br/wp-content/uploads/2019/01/Encarte-1_Plano-de-Manejo-PENT.pdf |
|----|-----|---------|----------|------------------|-------|-----|--------------------------------------------------|
| IP | IP  | Uplands | Pantanal | PNM de Piraputangas | 13.00 | 2003 | http://www.semagro.ms.gov.br/wp-content/uploads/2019/01/Encarte-1_Plano-de-Manejo-PENT.pdf |
| SU | RPPN| Uplands | Pantanal | RPPN Pauândia | 82.32 | 2002 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/ |
| SU | RPPN| Uplands | Pantanal | RPPN Fazenda Santa Helena | 42.95 | 2000 | https://sistemas.icmbio.gov.br/simrppn/publico/detalhe/622/ |
| SU | RPPN| Uplands | Pantanal | RPPN Fazendinha | 96.16 | 1994 | https://sistemas.icmbio.gov.br/simrppn/publico/detalhe/272/ |
| SU | RPPN| Uplands | Pantanal | RPPN Fazenda Alegria | 11.35 | 2008 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/ |
| SU | RPPN| Uplands | Pantanal | RPPN Fazenda Nhumirim | 8.63 | 1999 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/ |
| IP | IP  | Uplands | Pantanal | PE do Pantanal do Rio Negro | 783.03 | 2000 | https://parquesnobrasil.org/arp/2933 |
| SU | RPPN| Uplands | Pantanal | RPPN Pata da Onça (Faz. Santa Sophia) | 73.87 | 1999 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/ |
| SU | RPPN| Uplands | Pantanal | RPPN Neivo Pires I and II | 4.39 | 2001 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/ |
| SU | RPPN| Uplands | Pantanal | RPPN Estância Caiman | 56.03 | 2004 | https://sistemas.icmbio.gov.br/simrppn/publico/detalhe/253/ |
| SU | RPPN| Uplands | Pantanal | RPPN Fazenda Rio Negro | 70.00 | 2001 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/ |
| SU | APA | Uplands | Uplands | APA Sete Quedas de Rio Verde | 188.25 | 2005 | https://www.rio Verde.ms.gov.br/wp-content/uploads/2016/10/RESUMO-EXECUTIVO-APA-Sete-Quedas-de-Rio Verde.pdf |
| SU | APA | Uplands | Uplands | APA Rio Cênico Rotas Moinhoiras | 154.40 | 2000 | http://www.imasul.ms.gov.br/wp-content/uploads/2015/06/APA-Rio-C%C3%A9nico-Plano-Executivo.pdf |
| SU | RPPN| Uplands | Uplands | RPPN Duas Pedras | 1.53 | 2008 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/ |
| SU | RPPN| Uplands | Uplands | RPPN Cabeca de Lagoa | 4.31 | 2011 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/ |
| SU | RPPN| Uplands | Uplands | RPPN Vale do Bugio | 0.82 | 2003 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/ |
| SU | RPPN| Uplands | Uplands | RPPN Fazenda Lageado | 125.50 | 1990 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/ |
| SU | APA | Uplands | Uplands | APA Estrada Parque de Piraputanga | 101.08 | 2000 | https://www.imasul.ms.gov.br/wp-content/uploads/2019/08/Planilha-CNUC_paro-o-site_Atualiz.-Dez._-2018.pdf |
| SU | RPPN| Uplands | Uplands | RPPN Cara da Onça | 0.12 | 2009 | https://www.imasul.ms.gov.br/wp-content/uploads/2019/08/Planilha-CNUC_paro-o-site_Atualiz.-Dez._-2018.pdf |
| IP | IP  | Uplands | Uplands | PN da Serra da Bodoquena | 770.22 | 2000 | https://www.icmbio.gov.br/portal/unidadesdeconservacao/biomass-brasileiros/cerrado/unidades-de-conservacao-cerrado/2082-parna-da-serra-da-bodoquena |
| SU | RPPN| Uplands | Uplands | RPPN Fazenda Singapura | 4.56 | 1994 | https://sistemas.icmbio.gov.br/simrppn/publico/detalhe/251/ |
| IP | IP  | Uplands | Uplands | MN da Gruta do Lago Azul | 2.74 | 2001 | https://www.imasul.ms.gov.br/wp-content/uploads/2019/08/Planilha-CNUC_paro-o-site_Atualiz.-Dez._-2018.pdf |
| SU | RPPN| Uplands | Uplands | RPPN Rancho do Tucano | 0.30 | 2011 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/ |
| IP | IP  | Uplands | Uplands | MN do Rio Formoso | 0.18 | 2003 | https://www.imasul.ms.gov.br/wp-content/uploads/2019/08/Planilha-CNUC_paro-o-site_Atualiz.-Dez._-2018.pdf |
| SU | RPPN | Uplands | RPPN Fazenda São Pedro da Barra | 0.88 | 2003 | https://www.imasul.ms.gov.br/wp-content/uploads/2019/08/Planilha-CNUC_para-o-siteAtualiz.-Dez._-2018.pdf |
|----|------|---------|---------------------------------|------|------|---------------------------------------------------------------------------------------------------|
| SU | RPPN | Uplands | RPPN Fazenda América            | 4.01 | 1994 | https://sistemas.icmbio.gov.br/simrppn/publico/detalhe/263/                                        |
| SU | RPPN | Uplands | RPPN Fazenda São Geraldo        | 6.42 | 1999 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/                         |
| SU | RPPN | Uplands | RPPN Cabeceira do Prata         | 3.08 | 1999 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/                         |
| SU | RPPN | Uplands | RPPN Buraco das Araras          | 0.29 | 2007 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/                         |
| SU | RPPN | Uplands | RPPN Xodó do Vô Ruy             | 4.88 | 2006 | https://www.imasul.ms.gov.br/reserva-particular-do-patrimonio-natural-rppn/                         |
| SU | RPPN | Uplands | RPPN Fazenda Margarida          | 19.99| 2000 | https://sistemas.icmbio.gov.br/simrppn/publico/detalhe/266/                                        |
| SU | Park Road | Uplands | Transpantaneira | 74.29 | 1996 | Chaves & Silva 2018                                                                                   |
Tab.S4. Comparative ANOVAs considering the effect of years, location (project_region), and individuals (id) on fire occurrence within jaguar HRs during individual monitoring (monitoring time, HR in blue) or within the assumed home ranges (comparing all years, HR in red). The interaction between year and region exhibited the lowest residuals and the lowest AIC in both comparisons.

| Models                                      | Monitoring time (HR)                  | All years (HR)                   |
|---------------------------------------------|--------------------------------------|----------------------------------|
|                                             | residuals                            | AIC                              | residuals                           | AIC                              |
|                                             | df        | Mean Sq | df | ΔAIC | df        | Mean Sq | df | ΔAIC |
| * interaction <- aov(fires1 ~ year:project_region, data = HR or HR) | 63         | 108.1   | 27 | 0    | 656       | 169     | 27 | 0    |
| one.way.year <- aov(fires1 ~ year, data = HR or HR)             | 78         | 415.8   | 12 | 108.9 | 752       | 460     | 12 | 549.5 |
| one.way.local <- aov(fires1 ~ project_region, data = HR or HR)  | 82         | 561.1   | 8  | 132.0 | 761       | 586     | 8  | 1302.8 |
| two.way <- aov(fires1 ~ year + project_region, data = HR or HR) | 72         | 412.3   | 18 | 113.1 | 746       | 414     | 18 | 530.7 |
| block_ID <- aov(fires1 ~ year + project_region + id, data = HR or HR) | 71         | 414.2   | 19 | 114.2 | 745       | 414     | 19 | 532.7 |
Tab.S5. Estimates of burned areas in the Pantanal in 2020. Reference sources: (LASA, Libonati et al.).

| Region                               | Type | Burned Area 2020 (%) | Burned Area (ha) |
|--------------------------------------|------|----------------------|-----------------|
| APA Baía Negra                       | SU   | 74                   | 45000           |
| ESEC de Taipam                       | IP   | 40                   | 4700            |
| PARNA do Pantanal Matogrossense      | IP   | 100                  | 136100          |
| Parque Municipal de Piraputangas     | IP   | 0                    | 0               |
| PE Encontro das Águas                | IP   | 86                   | 93300           |
| PE do Guirá                          | IP   | 43                   | 45300           |
| PE do Pantanal do Rio Negro          | IP   | 10                   | 8200            |
| RPPN Acurizal                        | SU   | 85                   | 10400           |
| RPPN Arara Azul                      | SU   | 90                   | 1900            |
| RPPN Dorocê                          | SU   | 84                   | 22600           |
| RPPN Estância Caiman                 | SU   | 0                    | 0               |
| RPPN Fazenda Nhumirim                | SU   | 0                    | 0               |
| RPPN Fazenda Paculândia              | SU   | 58                   | 4800            |
| RPPN Fazenda Rio Negro               | SU   | 0                    | 0               |
| RPPN Fazenda Santa Cecília II        | SU   | 29                   | 2600            |
| RPPN Fazenda Santa Sofia             | SU   | 0                    | 0               |
| RPPN Fazendinha                      | SU   | 0                    | 0               |
| RPPN Jubran                          | SU   | 78                   | 26300           |
| RPPN Neivo Pires                     | SU   | 0                    | 0               |
| RPPN Penha                           | SU   | 100                  | 12900           |
| RPPN Pioneira do Rio Piquiri         | SU   | 0                    | 0               |
| RPPN Poleiro Grande                  | SU   | 68                   | 11200           |
| RPPN Reserva Natural Eng. Eliezer Batista | SU | 84 | 10600       |
| RPPN Rumo ao Oeste                   | SU   | 60                   | 600             |
| Landmark                  | Code | Unit | Price  |
|--------------------------|------|------|--------|
| RPPN Sesc Pantanal       | SU   | 90   | 78800  |
| TI Baía dos Guató        | TI   | 94   | 18100  |
| TI Cachoeirinha          | TI   | 2    | 600    |
| TI Guató                 | TI   | 61   | 900    |
| TI Kadiwéu               | TI   | 46   | 248000 |
| TI Perigara              | TI   | 86   | 9300   |
| TI Taunay/Ipegue         | TI   | 18   | 6000   |
| TI Tereza Cristina       | TI   | 86   | 25000  |
| Fazenda Jatobazinho      | Farms| 89   | 300    |
| Fazenda Morro Alegre     | Farms| 85   | 1200   |
| Fazenda Porto Jofre      | Farms| 98   | 41500  |
| Fazenda Santa Rosa       | Farms| 64   | 100    |
| Fazenda Santa Tereza     | Farms| 75   | 44800  |
| Fazenda São Bento        | Farms| 68   | 18800  |
| Fazenda São Gonçalo      | Farms| 100  | 300    |
| Fazenda Vale do Paraíso  | Farms| 81   | 200    |
## Tab.S6. Model selection and home range output used for status classification in combination with variograms (ctmm)\textsuperscript{50,51}.

| N | data id | DOF | $τ_p$ (days) | $τ_s$ (h) | duration (months) | model | status | Total points | start | end         | HR (km\(^2\)) | area CI (km\(^2\)) | project | country |
|---|---------|-----|--------------|----------|------------------|-------|--------|--------------|-------|-------------|-------------|------------------|----------|---------|
| 1 | 13      | 68.9| 3.4          | 0.3      | 8.8              | OUF_{ani} | R       | 5039         | 07-12-14 | 24-08-15    | 52.8        | (41.1 - 66)       | Taïama   | Brazil   |
| 2 | 15      | 17.5| 3.9          | 0.5      | 2.6              | OUF_{ani} | R       | 1257         | 19-10-13 | 03-01-14    | 352.5       | (206.95 - 536.09) | Oncafari | Brazil   |
| 3 | 18      | 26.0| 4.7          | 0.4      | 4.6              | OUF_{ani} | R       | 2305         | 29-11-14 | 13-04-15    | 126.8       | (82.79 - 180.03)  | Taïama   | Brazil   |
| 4 | 19      | 53.6| 0.9          | 0.3      | 2.5              | OUF_{ani} | R       | 741          | 30-10-11 | 11-01-12    | 40.2        | (30.18 - 51.68)   | Oncafari | Brazil   |
| 5 | 22      | 22.0| 10.0         | 0.2      | 8.5              | OUF_{ani} | R       | 4709         | 11-09-14 | 21-05-15    | 114.0       | (71.38 - 166.35)  | Taïama   | Brazil   |
| 6 | 25      | 102.5| 1.6         | 0.2      | 35.3             | OUF_{ani} | R       | 3074         | 22-10-12 | 30-08-15    | 46.2        | (37.69 - 55.56)   | Oncafari | Brazil   |
| 7 | 27      | 57.7| 3.7          | NA       | 39.3             | OUF_{ani} | R       | 559          | 21-09-10 | 24-11-13    | 51.2        | (38.87 - 65.27)   | Panthera2 | Brazil   |
| 8 | 28      | 40.5| 2.1          | NA       | 3.3              | OU_{ani}  | R       | 205          | 08-07-10 | 13-10-10    | 33.2        | (23.77 - 44.17)   | Panthera1 | Brazil   |
| 9 | 29      | 27.0| 1.7          | 2.8      | 2.8              | OUF_{ani} | R       | 67           | 08-07-11 | 30-09-11    | 43.3        | (28.55 - 61.15)   | Panthera1 | Brazil   |
| 10| 30      | 123.1| 2.9         | NA       | 13.6             | OU_{iso}  | R       | 581          | 13-10-11 | 19-11-12    | 60.8        | (50.57 - 72.05)   | Panthera2 | Brazil   |
| 11| 31      | 33.2| 2.2          | NA       | 3.5              | OU_{ani}  | R       | 103          | 21-10-13 | 01-02-14    | 31.7        | (21.84 - 43.33)   | Panthera2 | Brazil   |
| 12| 32      | 92.8| 1.3          | NA       | 6.1              | OU_{ani}  | R       | 240          | 15-10-12 | 12-04-13    | 100.0       | (80.7 - 121.36)   | Panthera2 | Brazil   |
| 13| 33      | 26.6| 2.9          | NA       | 3.4              | OU_{ani}  | R       | 133          | 22-10-13 | 29-01-14    | 88.8        | (58.33 - 125.62)  | Panthera2 | Brazil   |
| 14| 41      | 61.0| 3.8          | 0.3      | 8.6              | OUF_{ani} | R       | 4951         | 05-12-14 | 17-08-15    | 25.5        | (19.53 - 32.33)   | Taïama   | Brazil   |
| 15| 52      | 6.5 | 3.6          | 0.3      | 0.9              | OUF_{ani} | R       | 615          | 27-11-14 | 25-12-14    | 21.7        | (8.34 - 41.33)    | Taïama   | Brazil   |
| 16| 53      | 24.9| 6.1          | NA       | 37.9             | OU_{ani}  | R       | 299          | 20-09-10 | 13-10-13    | 348.6       | (225.27 - 498.39) | Panthera2 | Brazil   |
| 17| 54      | 7.3 | 5.1          | 1.6      | 1.5              | OUF_{ani} | R       | 128          | 12-07-10 | 26-08-10    | 36.1        | (14.79 - 66.72)   | Panthera1 | Brazil   |
| 18| 55      | 38.3| 1.9          | NA       | 4.2              | OU_{ani}  | R       | 141          | 26-06-11 | 28-10-11    | 91.8        | (65.04 - 123.03)  | Panthera2 | Brazil   |
| 19| 56      | 28.1| 2.3          | 1.4      | 3.0              | OUF_{ani} | R       | 109          | 08-07-11 | 04-10-11    | 72.6        | (48.29 - 101.88)  | Panthera1 | Brazil   |
| 20| 59      | 118.0| 2.5        | 1.9      | 27.1             | OUF_{ani} | R       | 434          | 15-10-11 | 23-12-13    | 241.3       | (199.72 - 286.72) | Panthera2 | Brazil   |
| 21| 60      | 235.5| 1.2       | NA       | 12.8             | OUF_{ani} | R       | 705          | 10-10-12 | 23-10-13    | 88.4        | (77.42 - 99.98)   | Panthera2 | Brazil   |
| 22| 61      | 8.6 | 7.0          | 2.3      | 2.4              | OUF_{ani} | R       | 109          | 18-06-13 | 28-08-13    | 343.9       | (153.75 - 609.23) | Panthera2 | Brazil   |
| 23| 68      | 14.0| 3.0          | 0.4      | 1.8              | OUF_{ani} | R       | 996          | 01-11-11 | 23-12-11    | 242.9       | (132.71 - 385.72) | Oncafari | Brazil   |
| 24| 69      | 63.9| 3.0          | 0.3      | 6.7              | OUF_{ani} | R       | 3304         | 27-10-13 | 13-05-14    | 156.6       | (120.55 - 197.23) | Oncafari | Brazil   |
| 25| 79      | 42.9| 2.8          | 0.4      | 4.3              | OUF_{ani} | R       | 2202         | 19-04-15 | 25-08-15    | 68.9        | (49.81 - 90.93)   | Oncafari | Brazil   |
| 26| 84      | 114.2| 2.3        | 0.3      | 9.3              | OUF_{ani} | R       | 4643         | 21-04-13 | 21-01-14    | 70.4        | (58.05 - 83.84)   | Oncafari | Brazil   |
| ID | Individual (ID) | Region | DOF | OUF | DOF | OUF | Resident | Latitude | Longitude | Date of Birth | Date of Death | Area (km²) | Note |
|----|----------------|--------|-----|-----|-----|-----|----------|-----------|------------|---------------|---------------|------------|-------|
| 27 | 86 | 26.4 | 3.0 | 0.3 | 3.0 | OUF | R | 1324 | 22-10-13 | 17-01-14 | 166.3 | (108.97 - 235.44) | Oncafari | Brazil |
| 28 | 87 | 35.2 | 0.6 | 0.3 | 1.2 | OUF | R | 398 | 15-05-12 | 18-06-12 | 37.4 | (26.05 - 50.65) | Oncafari | Brazil |
| 29 | 88 | 18.7 | 8.8 | NA | 6.6 | OUF | R | 1289 | 08-10-13 | 20-04-14 | 80.2 | (48.1 - 120.48) | Taíama | Brazil |
| 30 | 91 | 48.3 | 0.7 | 1.8 | 13.1 | OUF | R | 85 | 01-01-11 | 24-01-12 | 66.8 | (49.33 - 86.96) | Taíama | Brazil |
| 31 | 92 | 81.6 | 0.2 | NA | 25.3 | OUF | R | 95 | 01-01-11 | 18-01-13 | 130.8 | (103.97 - 160.67) | Taíama | Brazil |
| 32 | 101 | 79.5 | 2.1 | 1.2 | 7.3 | OUF | R | 404 | 26-08-15 | 29-03-16 | 302.1 | (239.34 - 371.98) | RioNero | Brazil |
| 33 | 104 | 15.4 | 3.3 | 0.6 | 10.4 | OUF | R | 134 | 22-08-15 | 23-06-16 | 481.7 | (272.14 - 749.97) | RioNero | Brazil |
| 34 | 105 | 180.2 | 2.4 | NA | 16.1 | OUF | R | 2111 | 05-07-08 | 22-10-09 | 105.2 | (90.43 - 121.15) | SaoBento | Brazil |
| 35 | 106 | 48.2 | 1.0 | 1.5 | 25.9 | OUF | R | 227 | 24-09-09 | 29-10-11 | 244.4 | (180.32 - 318.01) | SaoBento | Brazil |
| 36 | 107 | 19.9 | 3.8 | 0.8 | 4.5 | OUF | R | 287 | 30-07-08 | 08-12-08 | 124.8 | (76.11 - 185.43) | SaoBento | Brazil |
| 37 | 108 | 72.3 | 1.3 | 0.3 | 3.5 | OUF | R | 481 | 25-07-08 | 06-11-08 | 142.8 | (111.77 - 177.54) | SaoBento | Brazil |
| 38 | 109 | 69.6 | 0.6 | NA | 2.7 | OUF | R | 165 | 04-08-08 | 22-10-08 | 55.0 | (42.86 - 68.68) | SaoBento | Brazil |
| 39 | 110 | 53.9 | 1.1 | NA | 3.4 | OUF | R | 166 | 02-02-10 | 13-05-10 | 265.8 | (199.62 - 341.33) | SaoBento | Brazil |
| 40 | 111 | 104.4 | 4.5 | NA | 34.3 | OUF | R | 1757 | 17-07-08 | 26-04-11 | 58.4 | (47.73 - 70.11) | SaoBento | Brazil |
| 41 | 112 | 9.5 | 7.5 | NA | 3.0 | OUF | R | 202 | 16-07-08 | 13-10-08 | 119.1 | (55.93 - 205.82) | SaoBento | Brazil |
| 42 | 113 | 151.9 | 1.2 | NA | 11.5 | OUF | R | 707 | 11-08-08 | 15-07-09 | 40.6 | (34.4 - 47.31) | SaoBento | Brazil |
| 43 | 115 | 58.0 | 3.9 | 0.9 | 8.9 | OUF | R | 952 | 20-06-08 | 10-03-09 | 123.8 | (94.02 - 157.67) | SaoBento | Brazil |
| 44 | 116 | 9.0 | 18.3 | 0.4 | 6.4 | OUF | R | 3340 | 11-10-15 | 18-04-16 | 282.0 | (129.18 - 493.57) | Taíama | Brazil |
| 45 | 117 | 25.2 | 4.5 | 0.4 | 4.3 | OUF | R | 2820 | 11-10-15 | 14-02-16 | 47.8 | (30.95 - 68.13) | Taíama | Brazil |
| 46 | 12 | 4.0 | 32.7 | 0.4 | 4.6 | OUF | NR | 2681 | 05-12-14 | 18-04-15 | 619.7 | (169.85 - 1355.38) | Taíama | Brazil |
| 47 | 23 | 3.3 | 8.6 | 0.2 | 0.9 | OUF | NR | 572 | 01-09-14 | 26-09-14 | 44.8 | (10.23 - 104.34) | Taíama | Brazil |
| 48 | 81 | 9.45* | 52.7 | 0.4 | 20.0 | OUF | NR | 10617 | 15-10-13 | 29-05-15 | 591.1 | (276.34 - 1023.36) | Taíama | Brazil |
| 49 | 102 | 4.6 | 12.2 | 1.1 | 1.9 | OUF | NR | 151 | 29-03-16 | 23-05-16 | 567.4 | (172.2 - 1193.86) | RioNero | Brazil |
| 50 | 51 | 47.6 | 3.6 | 1.4 | 6.5 | OUF | R | 727 | 05-06-10 | 14-12-10 | 535.7 | (394.46 - 698.22) | PantPy | Paraguay |
| 51 | 74 | 98.6 | 2.6 | NA | 9.1 | OUF | R | 1300 | 09-08-05 | 06-05-06 | 75.4 | (61.24 - 90.97) | PantPy | Paraguay |
| 52 | 75 | 74.7 | 4.4 | 1.1 | 12.7 | OUF | R | 1694 | 09-08-05 | 18-08-06 | 115.9 | (91.13 - 143.64) | PantPy | Paraguay |

N = individual id, data id = correspondent id in Morato et al. datapaper⁴⁰, DOF_{max} = effective number of range crossings, OUF_{ani} = anisotropic Ornstein-Uhlenbeck-F model, OUF_{iso} = isotropic Ornstein-Uhlenbeck-F model, R = resident jaguars, NR = non-resident jaguars. PantPy = Paraguayan Pantanal. Note that all non-resident jaguars had DOF area < 5, except for individual 81 (which had the largest amount of tracking locations in the dataset); however, observation of the variograms showed that this individual is a non-resident (see Fig.521).
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