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Posts Supporting Anti-Environmental Policy in Brazil are Shared More on Social Media

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Abstract

Weakening environmental laws supported by disinformation are currently of concern in Brazil. An example of disinformation is the case of the "firefighter cattle". Supporters of this idea believe that by consuming organic mass, cattle decrease the risk of fire in natural ecosystems. This statement was cited by a member of the Bolsonaro government in response to the unprecedented 2020 fires in the Pantanal, as well as in support of a new law that enables extensive livestock in protected areas of this biome. By suggesting that grazing benefits the ecosystem, the "firefighter cattle" argument supports the interests of agribusiness. However, it ignores the real costs of livestock production on biodiversity. We analysed the social repercussion of the "firefighter cattle" by analysing public reactions to YouTube, Facebook, and Google News posts. These videos and articles and the responses to them either agreed or disagreed with the "firefighter cattle". Supportive posts were shared more on social media and triggered more interactions than critical posts. Even though many netizens disagreed with the idea of "firefighter cattle", it has gone viral, and was used as a tool to strengthen anti-environmental policies. We advocate that government institutions should use resources and guidelines provided by the scientific community to raise awareness. These materials include international reports produced by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the Intergovernmental Panel on Climate Change (IPCC). We need to curb pseudoscience and misinformation in political discourse, avoiding misconceptions that threaten natural resources and confuse global society.

Keywords Brazil · Deforestation · Environmentalism · Fake news · Grazing · Pantanal

Introduction

When governments implement policies, public interest, as well as collective needs must be protected. Safeguarding nature is one of these collective needs, as functioning ecosystems are necessary to maintain human well-being. Nevertheless, economic demands are often incompatible with nature protection (Otero et al. 2020), therefore many nations have neglected environmental commitments or even acted against them (Ari and Sari 2017; Ward et al. 2019; Mao et al. 2020). Politicised decision-making, along with the intentional dissemination of disinformation, confuse

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citizens and discredit science (Betsch 2017; O'Connor and Weatherall 2019). Disinformation content is usually based on manufactured provocations, in some cases a harmful relativism that affects public opinion, usually consisting of some kind of fake news sustained by denialist scientists and used by governments (Rajão et al. 2022). The use of disinformation campaigns, such as those that discredit global warming, provides an opportunity to maintain or create environmentally harmful policies (Hansson 2020), because these statements exculpate the effects of actions more prone to economic development. In the United States, a nation that occupies a crucial position against climate change, denialist attacks have delayed effective actions (Farrell et al. 2019). Moreover, disinformation campaigns can profoundly affect actions by the government (Farrell, McConnell, and Brulle 2019). Reaffirming the truth and controlling the resulting chaos can prove difficult and need to be addressed at multiple scales (Farrell et al. 2019).

Brazil recently experienced a disinformation campaigning, when on October 9, 2020, the Minister of Agriculture commented on the increased incidence of the 2020 fires in the Brazilian Pantanal in a public hearing (Garcia et al. 2021). This hearing was later reported by the mainstream media (e.g., the YouTube channels of UOL and Poder360, and the portal G1 of Rede Globo). A crucial statement in the hearing and in the subsequent media reports was that increasing livestock production would decrease fire damage (Jornal Hoje 2020). This assumption was based on the fact that the grass consumed by cattle reduces the amount of dry organic mass (fuel), an empirical observation reported by EMBRAPA (Brazilian Agricultural Research Corporation) scientists since the 1980s (Pott and Pott 2004). In the following days, the "firefighter cattle" (or *boi bombeiro* in Portuguese), the name given to this belief by the Minister of Agriculture, was endorsed by the president Jair Bolsonaro and surprisingly by the Minister of Environment (Revista Globo Rural 2020). The same argument has been used to support a recently approved law (PL 561/2022) to expand livestock production in protected areas of Pantanal (Observa-MT 2021).

Brazil is a megadiverse nation (Mittermeier et al. 1997) with many fragile ecosystems under historical and current anthropic pressure (Dean 1996; Coelho et al. 2020; Silva Junior et al. 2021). Certain large biomes, such as Amazonia, Cerrado and Pantanal have complex natural landscapes and high species diversity, which play important ecological functions in the maintenance of life on the planet (Klink and Machado 2005; Junk et al. 2006; Silman 2007; Pott et al. 2011; Funk 2012). Given the continental size of Brazil, harmful environmental policies at the state or national level may also affect climate and biodiversity conservation at the global scale (Gallardo and Bond 2011; Fearnside 2016; Issberner and Léna 2016).

While the idea of the "firefighter cattle" is based on empirical facts, the discourse, as it was used, completely ignores the fact that extensive livestock production is associated with habitat destruction and the production of methane, a powerful greenhouse gas (Berndt and Tomkins 2013). These collateral effects cause enormous ecological damage that drives global warming, thereby ironically worsening droughts and expanding the magnitude of fires in natural ecosystems (Trenberth et al. 2014; Kelly et al. 2020). The current government has shown explicit actions to dismantle important environmental laws (Abessa et al. 2019; Barbosa et al. 2021; Ruggeri and Forti 2021). Before taking office, Jair Bolsonaro had announced the desire to merge the Ministry of the Environment as a secretariat into the Ministry of Agriculture (Oeco 2021). Even though he was unsuccessful, the current Minister of Environment has been linked to the Brazilian Rural Society (Fünfgeld 2021), creating a clear conflict of interest.

The reconstruction of environmental policies by the Brazilian National Congress has been affected by disinformation propagated by certain scientists, who deny deforestation is happening and proclaim that agriculture is a powerful ally to forest conservation (Vacchiano et al. 2019; Rajão et al. 2022). Part of this community of denialist scientists is clearly committed to Bolsonaro. An example is Dr Evaristo de Miranda, who was part of Bolsonaro's transition team (Rajão et al. 2022). Disinformation produced by Dr Miranda is based on manufacturing uncertainty, misusing scientific credentials, and disregarding scientific literature (Rajão et al. 2022). All of these strategies have been used to weaken environmental law enforcement, all convenient to oligarchs involved with agribusiness (Rajão et al. 2022; Esteves 2021).

In Brazil, pro-government groups habitually accuse the mainstream media (offline journals and most popular television channels) of distorting facts or reporting content selectively, i.e., only including news that support the narrative of the opposition (Latin America Reports 2019). Therefore, in this study, we aim to quantify the repercussions of the idea of the "firefighter cattle" in society, as a case study of assessing the level of social agreement with regard to current environmental policies in Brazil. Supporting the idea of the "firefighter cattle" indicates an anti-environmental position. Anti-environmental discourse is known to trigger moral and emotional reactions, and consequently to capture attention (Brady et al. 2020). Therefore, here we hypothesised that posts in favour of the "firefighter cattle" would trigger more engagement (interactions and shares) with posts (articles and videos) on social media. We also discuss the implications of our findings from a national and global perspective.

Materials and Methods

In order to assess the public opinion with regard to the idea of "firefighter cattle", we analysed posts on Google News,

YouTube and Facebook, which are routinely used for political discussions in Brazil. We chose Google News, as it is a major news aggregator service that congregates several popular and traditional news media and also has a high visibility in Brazil (Cobos 2022). On Google News, we evaluated the use of information provided by scientists for each article, deciding if the content was based on interviews or citations of peer-reviewed scientific articles. We also obtained data from YouTube and Facebook to assess the representation of the idea of the "firefighter cattle" in social media. On Facebook we only accessed publicly available posts, without joining closed groups. We chose YouTube and Facebook platforms because they offered longer texts and videos enabling a more detailed picture of the content compared to Twitter, Instagram and other social networking and microblogging sites. Furthermore, at the time of data collection, we attempted to download data from Twitter and Instagram via the APIs of these websites, but we were only getting partial data. This is explained by the data sharing policy adopted by these platforms. After this attempt, we also considered downloading data manually, however, posts can be deleted. As the subject is complex and has caused politicised discussions, we were afraid that not tracking the interactions shortly after the launch of the subject, obtaining data later would not have yielded complete coverage. Nevertheless, we checked the most common visual representation of the subject on Twitter, repeating the search using the term *boi bombeiro* on 10 December, 2020 and counting the frequency with which each image appeared.

We searched the platforms between 15 November and 10 December, 2020 for the term *boi bombeiro*. We analysed all material available and stopped data compilation when new posts on the topic were no longer identified on any of the three platforms. Two of the researchers independently classified the position of 51 Google News articles, 47 YouTube videos and 34 Facebook posts about the "firefighter cattle" as in favour, against or neutral. In case of disagreement with regard to the position, the post was discussed with other members of the author team, and decisions were based on the most common opinion among the members. We classified the position of the posts based on the tone and the message of the content, looking for statements or terms of approval or disapproval with regard to the idea of the "firefighter cattle". We counted the number of shares and comments of each post. The comments on the posts were also classified as in favour, against or neutral in relation to the idea of the "firefighter cattle". This classification was based on the response or reaction of netizens, characterising the post as disagreement, agreement, or simply repeating the statement of the original post. Based on personal judgement of our research team, we also classified the tone of each comment as serious, joking, sarcastic, or unknown. In case the position or the tone of the post was not obvious, it was discussed among the authors and if we did not reach consensus, the item was classified as "unknown".

To visualise interaction patterns among profiles within online communities, we constructed network charts for posts using the *igraph* package (Csardi and Nepusz 2006) in R version 4.0.2 (R Core Development Team 2020). We only used posts that joined over 20 profiles and separated them based on their position towards the "firefighter cattle", as well as towards the point of view of the post they were reacting to. Through these network charts, we mapped interactions by identifying 2188 profiles that reacted to the original post and to other responses. The edges in the network represent each commentary when a profile reacts to another. For this analysis, we maintained the anonymity of the netizens by replacing profile names by codes (performed by an independent researcher). In order to describe the complexity and structure of each topology, we calculated the following network metrics: [1] nodes, i.e., the number of profiles in that particular online community, [2] edges, i.e., the number of interactions among nodes, [3] density, i.e., the proportion of observed edges from all possible edges in the network, [4] reciprocity, i.e., the proportion of reciprocated ties, [5] diameter, i.e., the length of the shortest path between two nodes, and [6] mean degree. i.e., the average number of ties. After checking for statistical assumptions, we used a generalised linear model to test whether the number of nodes and position towards the "firefighter cattle" affected the number of interactions in the network. We used a *Quasi Poisson* model to solve over-dispersion in our data (Pardo 2020; Abdulkabir et al. 2015).

Bots are automated agents operating via text without human intervention in online communities (Gorwa and Guilbeault 2020). While studying bots on Facebook is notoriously difficult, due to the limitations of the publicly available API, we searched for reactions from bots on the posts by identifying repeated text made by the same profile and comments that included links to websites.

Results

On Google News we found more critical publications (31) than in favour (6) or neutral (14) posts about the "firefighter cattle". The 664 public comments on Google News articles were against (599) or neutral (65). In general, the media reported expert opinion (mentioning declarations or documents), mostly featuring botanists and ecologists, who in general expressed opinions against the idea of the "firefighter cattle". While expert opinion was included in the news, comments in favour of the idea of the "firefighter cattle" were usually focused on the idea that removing vegetation by cattle grazing would reduce the incidence of

fire in the Pantanal. However, public commentaries in support of the idea of "firefighter cattle" lacked a perception that increasing cattle production may result in more transformed land, habitat destruction, deforestation and increase greenhouse gas emission. On YouTube, critical videos represented 51.1%, while those in favour added up to 31.9%. Neutral and those responses that we could not classify represented 14.9 and 2.1%, respectively. Critical comments to YouTube posts represented 50.5%, while comments in favour of the "firefighting cattle" represented 18.8%. YouTube comments that we could not classify represented 22.4% of the 1230 comments on this planform, while neutral comments were only 8.3%. Among comments that in supported of the idea of the "firefighter cattle", we found examples, such as: "What specialist would argue that removing dry vegetation would not decrease the chance of fire?" and "Denying that where cattle are grazing there is a drastic reduction of fire is an astronomical stupidity".

The 34 Facebook posts (three in favour, 23 against and eight neutral in relation to the "firefighter cattle") were shared 2378 times (2127 related to posts in favour, 204 against and 47 neutral). Networks of online communities with more nodes (profiles) had more edges (interactions), and posts in favour of the idea of the "firefighter cattle" had more interactions than those against (Fig. 1; results of the GLM are presented in the Table 1).

The online communities based on posts in favour of the "firefighter cattle" had more interactions (edges) than predicted by the model, while online communities based on posts against of the "firefighter cattle" had less interactions than predicted by the model (Fig. 1). This indicates that the posts in favour, which elicited more discussion and argumentations, composed more complex online communities, with a higher mean degree (Table 2).

While there were more posts against the idea of the "firefighter cattle", the network of in favour posts contained more profiles. The highest density (proportions of interactions with regards the number of profiles) and reciprocity (number of interactive ties) values were linked to a network based on a neutral post in the Facebook (for instance "fp17" in Fig. 2).

On all platforms, there were more public comments against the idea of the "firefighter cattle" than supporting it (Fig. 2). However, more than 27% of the disagreeing comments were ironic or joking (Fig. 3a).

Profiles supporting the idea of the "firefighter cattle" represented 30% of all profiles, while profiles with neutral and opposing points of view represented 20% and 50% of the profiles, respectively. We identified 22 profiles as possible bots. These profiles commented the same text repeatedly under different posts. The comments from three of these profiles included links. There were more interactive networks with higher density and reciprocity on Facebook than on YouTube and Google News. On the other hand, YouTube had the largest online communities. On Twitter, we found 13 cases of the idea of the "firefighter cattle" illustrated by the picture of a toy ox wearing firefighter clothes (Fig. 3b) among 66 other pictures (all appearing fewer times) that were related to the subject.

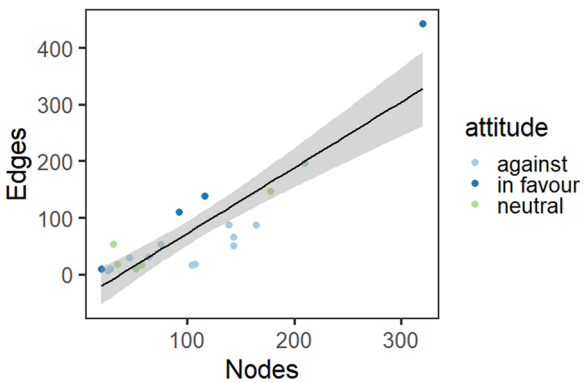

Fig. 1 The effect of the number of nodes on the number of edges in online community networks and the attitude of the posts with regard to the firefighter cattle

Discussion

Environmental issues in Brazil have a history of promoting online social debates among Brazilian netizens (Silva 2021). In this context, public comments on the "firefighter cattle" were potentially affected by polarised opinions in a political scenario. Based on the content of the analysed material (articles, videos and posts) we can conclude that most experts agreed that the idea of the "firefighter cattle" should not be brought up during the discussion of uncontrolled fires in the Pantanal. Several key pieces of evidence support this point of view. First, cattle herds and the ranches supporting them have multiplied and expanded over the past 14 years in the Pantanal (Alho et al. 2019; Mapbiomas 2019). According to the idea of the "firefighter cattle", this was supposed to reduce and not increase the number and

Table 1 Results of the generalised linear model (dispersion parameter for *quasipoisson* family taken to be 15.83318) for the effects of the number of nodes and attitude with regard to the firefighting cattle (FFC) on number of edges in online communities' networks

Variables	Estimate	Std. Error	*z* value	*P* value
Model Intercept	2.931	0.220547	13.294	9.54e-11
Nodes	0.009	0.001183	7.603	5.02e-07
In favour of FFC	0.441	0.247233	1.783	0.09
Neutral to FFC	0.179	0.299877	0.596	0.558

Null deviance = 1867.9 on 21 degrees of freedom; and Residual deviance = 303.5 on 18 degrees of freedom

Table 2 Network metrics of each online community with more than 20 profiles related to the posts on firefighter cattle in YouTube, Facebook, and Google News

Post ID	Attitude	Nodes	Edges	Density	Reciprocity	Diameter	Mean degree
YouTube							
yv14	Against	26	6	0.0092308	0	2	0.2307692
yv1	Neutral	57	17	0.0053258	0.3529412	3	0.2982456
yv4	Against	64	31	0.0076885	0.3225806	5	0.484375
yv10	Against	139	88	0.0045876	0.4090909	10	0.6330935
yv3	Against	104	16	0.0014937	0.25	3	0.1538462
yv2	Against	210	196	0.0044657	0.2244898	7	0.9333333
yv7	Neutral	35	18	0.0151261	0.4444444	3	0.5142857
yv6	In favour	178	147	0.0046657	0.3809524	8	0.8258427
yv9	In favour	20	10	0.0263158	0.4	3	0.5
yv34	Against	143	66	0.0032503	0.3030303	5	0.4615385
yv31	Neutral	178	147	0.0046658	0.3809524	8	0.8258427
yv8	Against	164	87	0.0032545	0.2068966	4	0.5304878
yv13	Against	107	18	0.0015871	0.2222222	3	0.1682243
yv22	In favour	320	443	0.0043397	0.2934537	16	1.384375
Facebook							
fp5	In favour	116	138	0.0103448	0.2898551	6	1.189655
fp10	In favour	92	110	0.0131390	0.2909091	7	1.195652
fp17	Neutral	31	53	0.0569893	0.6037736	7	1.709677
Google News							
gr1	Against	75	54	0.0097297	0.3703704	6	0.72
gr6	Against	28	9	0.0119048	0	2	0.3214286
gr8	Neutral	52	10	0.0037707	0	1	0.1923077
gr19	Against	143	50	0.0024623	0.04	3	0.3496503
gr25	Against	46	30	0.0144928	0.0666667	3	0.6521739

severity of fire events as time progressed. Second, in 2019–2020 the Pantanal experienced one of the harshest droughts in the last 49 years (Marengo et al. 2021), presumably driven by climate change (Garcia et al. 2021). Third, historical spatial analyses show the extent of modification of natural landscapes of the Pantanal in the last 30 years (Souza Jr et al. 2020). A considerable part of this modification was the conversion of native vegetation into "improved" pasture, which harbours several invasive alien plant species (Garcia et al. 2021). This landscape transformation changed the dynamic of pasture management by producers, leading to the use of controlled fire and other ways to remove vegetation. Applying this strategy in the wrong (dry) season may trigger uncontrolled fires fuelled by the accumulation of large amounts of dry organic mass over the soil (Garcia et al. 2021). Finally, fire prevention actions by fire brigades, as well as the budget of firefighter agencies have suffered substantial reductions (Garcia et al. 2021). All of these evidences show that the tragic megafires of 2020 in the Pantanal resulted from a complex interaction of local and global factors as opposed to the low number (or lack) of cattle consuming organic mass. Nevertheless, the media aimed at livestock producers reported the topic highlighting livestock production as beneficial to the environment (Canal Rural 2020). This interpretation is based on a biased analysis presented by the Brazilian Ministry of Economy (Ministério da Economia 2020) and describes a negative correlation between the number of cattle and the number of fires by municipality in the Pantanal and other biomes. Even controlling for the size of the municipality, the data are misleading, since these municipalities have different vegetation types that are not equally prone to fire and some municipalities that have large areas outside the Pantanal were included as a whole (i.e., heads of cattle and fire data).

The high rate of sharing of posts in favour to the "firefighter cattle" in social media and the position of the supporters of the current government indicate that Brazil is not on track for Target 1 of the Convention on Biological Diversity (CBD 2020). Evidently, this is because of the lack of mainstreaming of biodiversity, as public awareness on biodiversity values, conservation and sustainability is still very limited. On the other hand, engineered controversies further weaken environmental laws (Rajão et al. 2022). Defending the idea of the "firefighter cattle" creates a misconception that the villain is actually a hero, thereby supporting agribusinesses to expand their frontiers, aligned

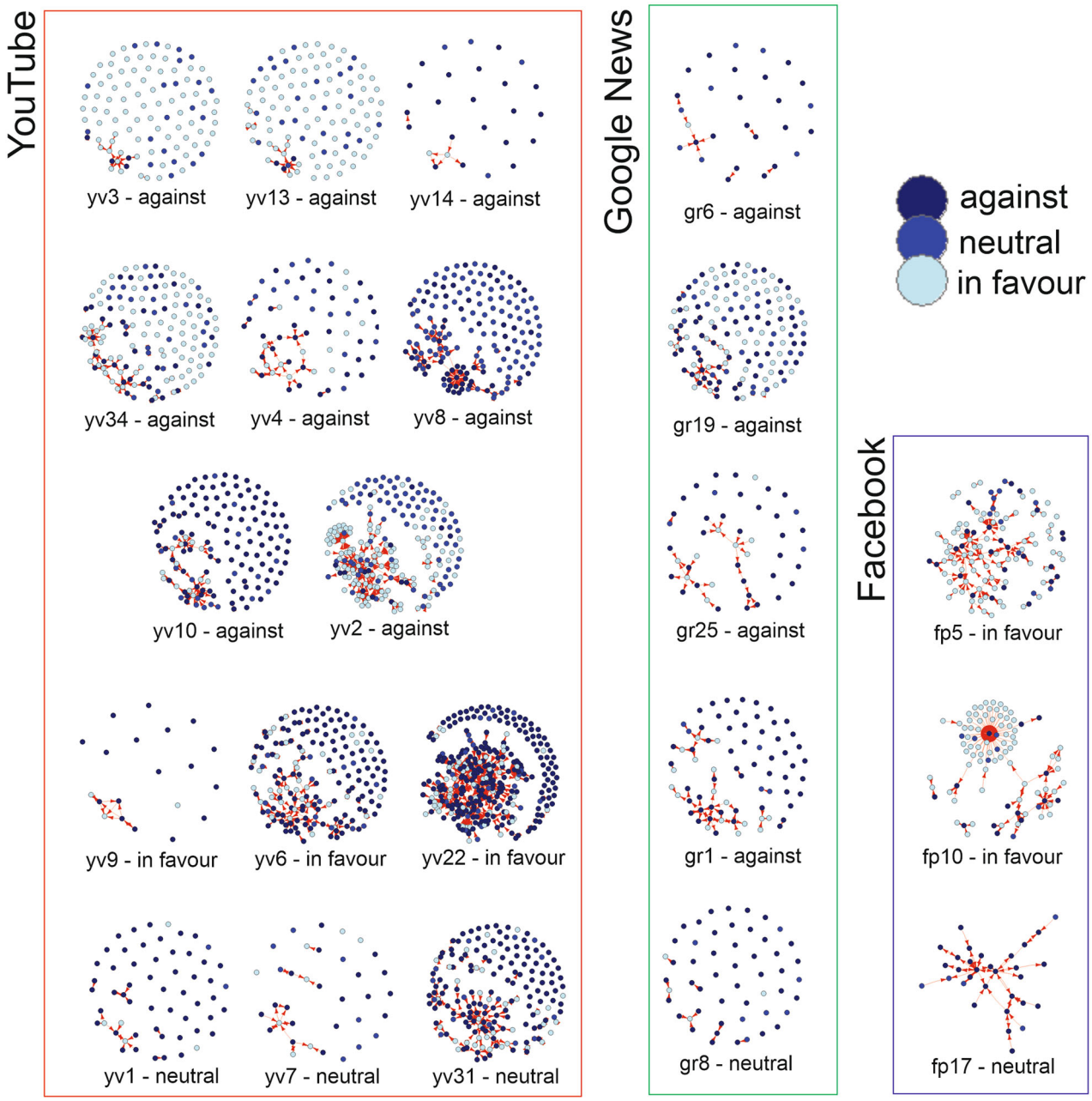

Fig. 2 Online community networks on YouTube, Google News and Facebook ordered by the attitude with regard to the firefighting cattle (against, neutral or in favour) and the average degree of complexity

with the interest of large landholders (Ferrante and Fearnside 2019). Our findings give an insight into the current political scenario and question the ability of the Brazilian government to fulfil international environmental commitments to decrease deforestation and increase ecosystem restoration as proclaimed by the United Nations (Strassburg et al. 2020).

Livestock grazing is a major cause of deforestation and habitat loss (Barona et al. 2010), not to mention the production of at least 14.5% of all anthropogenic greenhouse gas emissions worldwide (FAO 2022). In addition to the substantial impact on climate, grazing of native vegetation diminishes genetic and species diversity (Coelho et al. 2020), accelerating biodiversity loss. People supporting the idea of the "firefighter cattle" deny these issues by pretending the subject is irrelevant, likely because their scepticism is conveniently related to their profit or they are blindly following a particular ideology.

Since 1934, Brazil has been considered to be strongly oriented towards economic development (Drummond and

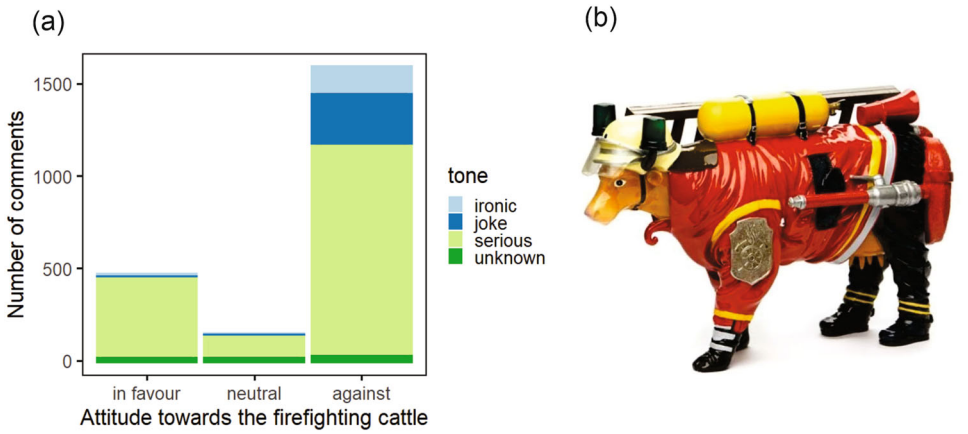

Fig. 3 The number of public comments accessed on YouTube, Facebook and Google News with regard to the firefighting cattle by tone (**a**), and the most common figure illustrating the subject on Twitter (**b**) *Figure available at https://www.pinterest.ch/pin/400187116859126508/

Barros-Platiau 2006; Ioris and Ioris 2013). The current government further prioritised economic gains over environmental protection (Ferrante and Fearnside 2019; Pereira et al. 2019; Forti, Rossi-Santos, and Nunes 2021). Starting in 2018, when Jair Bolsonaro has taken office as the president of Brazil, new policies has relaxed environmental licenses and pesticide use regulation in favour of economic activities (Barbosa, Alves, and Grelle 2021; Atwoli et al. 2021). President Bolsonaro has repeatedly declared that environmental issues were secondary to economic interests (CNN Brasil 2021; Canal UOL 2021). In addition, this new policy perspective intensified the conflict with indigenous peoples over suspending protected area designation of new lands in the Amazon. The justification for this action was that changing land categories can allow agricultural and mining activities within protected areas (Abessa, Famá, and Buruaem 2019). Intensive livestock farming in Brazil has increased substantially between 2000 and 2014 (Zalles et al. 2019). In addition, people have left rural areas for large cities, making it possible for agribusiness to expand (Gerhard, Hoelscher, and Wilson 2016). In 2000, the rate of urbanisation in Brazil was 81.2%, which increased to 84.7% by 2015 (Instituto Brasileiro de Geografia e Estatística 2015). In spite of the new Brazilian Forest Code (Law no. 12.651 of 2012), over 10,000 km^2 have been clear-cut in 2019, just within the Amazon (Silva Junior et al. 2021). Since then, the Cerrado and other biomes have also been seriously affected (Silva Junior et al. 2021; Bezerra et al. 2022). The pace of deforestation in Brazil is not only concerning considering the loss of traditional cultures and biodiversity, including cultivars, but also threatens ecosystem services, such as carbon storage (Crouzeilles et al. 2017; Coelho et al. 2020). Decreased carbon storage affects society globally by intensifying climate change (Lal 2004; Hui et al. 2017). Ironically, in some circumstances the current government have used social media to blame external entities, such as NGOs for illegal extraction of natural resources in the Amazonia (Silva 2021).

Based on 1094 profiles disagreeing with the idea of the "firefighter cattle" (50% of all active profiles in the social media), we assume that a considerable portion of the Brazilian society that is active on social media clearly distrusts the current government with regard to the issue of the "firefighter cattle". However, posts that supported the idea of the "firefighter cattle" were shared more and received more interactions than critical posts, as generally seen in the case of fake news (Da Empoli 2019; Vosoughi et al. 2018). This is very concerning, as sharing content without added text can be interpreted as supporting an idea (Goldenberg and Gross 2020), an evidence that the idea of the "firefighter cattle" is influential among netizens. Anti-environmental discourse, as a negative political situation, triggers emotional and moral reactions (Schöne et al. 2021; Silva 2021). We suggest that this is likely the reason for the "firefighter cattle" idea becoming viral. We also noticed that online communities, particularly on Facebook, that apparently advocated for the "firefighter cattle" were less isolated and received more negative reactions than posts against it. This also supports the idea that pseudoscience spreads more through non-formal communication, since most mainstream media reported the topic using a critical perspective, and there were no comments in favour of the "firefighter cattle" in response to Google News articles. One alternative view is that many shares of posts in favour of the "firefighter cattle", especially on Facebook, were addressed by bots, also called of crawlers or spiders. These web bots are programmed to deliver specific and bulk-indexed contents (AlDayel and Magdy 2022). Bots may occasionally spread controversial content, including hateful posts (Luceri et al. 2019). Although most profiles were probably real people and not computer algorithms, the political debate on social media was likely affected by broadcast bots, which potentially spread repeated messages among different online communities. Coincidence or not, almost two years after the idea of the "firefighter cattle" has gone viral on social media, a new law (PL 561/2022) for allowing livestock production in protected areas of the Pantanal has been approved (Assembleia Legislativa do Estado de Mato Grosso 2021).

Combating disinformation with regard to environmental policies should be a priority for democratic nations (Bartlett 2019). We recognise that is not easy for citizens to judge the reliability of the information circling on social media. Therefore, government institutions should be equipped with resources and guides provided by the scientific community containing scientifically based information that they could share. Public policies can be oriented by international reports produced by a team of scientists, such as the IPBES (https://ipbes.net/) for issues related to biodiversity and ecosystem function, or IPCC (https://www.ipcc.ch/) for decision-making with regard to climate change. Whenever possible, official communications should be accompanied by accessible materials based on these reports. This information can guide citizens and provide clear criteria for decision making about the reliability of online information.

Economic policies should be compatible with nature protection and conservation, even under neoliberalist governments, and should not be led exclusively by business interests. Brazil needs to increase investment in education, scientific inclusion and strong public policies promoting societal engagement in environmental protection, especially among young people (Massarani et al. 2021). Campaigns promoting the long-term value of biodiversity and the sustained use of preserved natural resources for human well-being should be among the central objectives of governments in Brazil and other megadiverse countries. More investment is needed with regard to computational mechanisms, such as artificial intelligence that can recognise potential manipulative information (Bounegru et al. 2018; Kar et al. 2022). By identifying fake news circling on social media, we can raise awareness of the lack of adherence to scientific knowledge, while maintaining the freedom of expressing one's opinion. People are free to follow their ideology, but they deserve to known that some pieces of information are potentially manufactured misconceptions. Facilitating access to science and investing in actions to eliminate political polarisation must also be part of the government's agenda. We advocate national authorities to present an agenda that is aligned with the best available environmental science and to create robust mechanisms against the dissemination of fake news. The first step of this process should be stopping the creation and broadcasting of false information. Otherwise, anti-environmental policies supported by disinformation will have fatal consequences for biodiversity and climate not only in Brazil, but globally.

Conclusions

The lack of cattle is not a reliable explanation of the origin of the unprecedented fires in Pantanal during 2020, and increasing livestock numbers could have made the situation even worse. In general, supporting the idea of the "firefighter cattle" represents an anti-environmental perspective, spreading the unscientific statement that livestock grazing benefits natural ecosystems in Brazil. The idea of the "firefighter cattle" can support harmful policies (e.g., PL 561/2022). Here we showed that the idea of the "firefighter cattle" has spread mainly through posts that were in favour of it. These posts also received more interactions in debates that were more political than scientific. Most mainstream media handled the topic from a critical perspective, usually conveying the opinion of experts supported by scientific publications. In fact, profiles that were pro-firefighter cattle did not post comments on Google News articles, but shared in-favour content and commented on the topic on social media platforms (i.e., YouTube and Facebook). Here we presented quantitatively and qualitatively the repercussions of a disinformation created by the current Brazilian government in order to support an economic development discourse. Our results raise serious concerns, which demand more effort to curb the use of pseudoscience in political speech in Brazil and worldwide.

Data Availability

Raw data are available at https://zenodo.org/record/4906347#.YL4ot_lKhPY.

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Author Contributions LRF conceived the ideas, designed methodology, analysed the data and led the writing of the manuscript. JKS conceived the ideas and contributed to writing. MLOT, DCB, DFM, DS collected the data. JS revised the manuscript. All authors gave final approval for publication.

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Compliance with Ethical Standards

Conflict of Interest The authors declare no competing interests.

Ethics Approval We declare all ethical guidelines were met.

References

Abdulkabir M, Udokang AE, Tunde RS, Kemi BL (2015) An empirical study of generalized linear model for count data. J Appl Comput Math 4:253. https://doi.org/10.4172/2168-9679.1000253

Abessa D, Famá A, Buruaem L (2019) The systematic dismantling of Brazilian environmental laws risks losses on all fronts. Nat Ecol Evol 3:510–511. https://doi.org/10.1038/s41559-019-0855-9

AlDayel A, Magdy W (2022) Characterizing the role of bots' in polarized stance on social media. Soc Netw Anal Min 12:30. https://doi.org/10.1007/s13278-022-00858-z

Alho CJR, Simone BM, Benites M, Andrade BS, Sepúlveda JJ (2019) Threats to the biodiversity of the Brazilian Pantanal due to land use and occupation. Ambient Soc 22:e01891. https://doi.org/10.1590/1809-4422asoc201701891vu2019L3AO

Ari I, Sari R (2017) Differentiation of developed and developing countries for the Paris Agreement. Energy Strategy Rev 18:175–182. https://doi.org/10.1016/j.esr.2017.09.016

Assembleia Legislativa do Estado de Mato Grosso (2021) Deputados aprovam projeto que altera política de proteção da bacia pantaneira. https://www.al.mt.gov.br/midia/texto/deputados-aprovam-projeto-que-altera-politica-de-protecao-da-bacia-pantaneira/visualizar. Accessed 31 Mar 2021

Atwoli L, Baqui AH, Benfield T, Bosurgi R, Godlee F, Hancocks S, Horton R, Laybourn-Langton L, Monteiro CA, Norman I, Patrick K, Praities N, Rikkert MGMO, Rubin EJ, Sahni P, Smith R, Talley NJ, Turale S, Vázquez D (2021) Call for emergency action to limit global temperature increases, restore biodiversity, and protect health. J Health Popul Nutr 40:1–4. https://doi.org/10.1093/nutrit/nuab067

Barbosa LG, Alves MAS, Grelle CEV (2021) Actions against sustainability: dismantling of the environmental policies in Brazil. Land Use Policy 104:105384. https://doi.org/10.1016/j.landusepol.2021.105384

Barona E, Ramankutty N, Hyman G, Coomes OT (2010) The role of pasture and soybean in deforestation of the Brazilian Amazon. Environmental Research Letters 5:024002. https://doi.org/10.1088/1748-9326/5/2/024002

Bartlett J (2019) The people vs tech: how the internet is killing democracy (and how we save it). Ebury Press, London.

Berndt A, Tomkins NW (2013) Measurement and mitigation of methane emissions from beef cattle in tropical grazing systems: a perspective from Australia and Brazil. Animal 7:363–372. https://doi.org/10.1017/S1751731113000670

Betsch C (2017) Advocating for vaccination in a climate of science denial. Nat Microbiol 2:17106. https://doi.org/10.1038/nmicrobiol.2017.106

Bezerra FGS, de Toledo PM, von Randow C, de Aguiar APD, Lima PVPS, dos Anjos LJS, Bezerra KRA (2022) Spatio-temporal analysis of dynamics and future scenarios of anthropic pressure on biomes in Brazil. Ecol Indic 137:108749. https://doi.org/10.1016/j.ecolind.2022.108749

Bounegru L, Gray J, Venturini T, Mauri M (2018) A field guide to" fake news" and other information disorders: a collection of recipes for those who love to cook with digital methods. Public Data Lab, Amsterdam. https://doi.org/10.2139/ssrn.3097666

Brady WJ, Gantman AP, Bavel JJV (2020) Attentional capture helps explain why moral and emotional content go viral. J Exp Psychol Gen 149:746. https://doi.org/10.1037/xge0000673

Canal Rural (2020) Boi bombeiro: estudo aponta que quanto maior o rebanho, menor incidência de focos de incêndio. https://www.canalrural.com.br/noticias/pecuaria/boi/boi-bombeiro-maior-rebanho-menor-incendio/ Accessed 29 March.

Canal UOL (2021). Bolsonaro sobre meio ambiente: 'Entre uma perereca e nossa vida, a gente fica com a nossa vida'. https://www.youtube.com/watch?app=desktop&v=otiKlygCSe4. Accessed 1 April.

CBD (2020) https://www.cbd.int/sp/targets/

CNN Brasil (2021) 'É preciso mudar a legislação ambiental, diz Bolsonaro. https://www.cnnbrasil.com.br/politica/e-preciso-mudar-a-legislacao-ambiental-diz-bolsonaro/. Accessed 1 April.

Cobos TL (2022) Origin and weight of news media outlets indexed on Google News: an exploration of the editions from Brazil, Colombia, and Mexico. Braz Journalism Res 17:28–63. https://doi.org/10.25200/BJR.v17n1.2021.1331

Coelho AJP, Magnago LFS, Matos FAR, Mota NM, Diniz ES, Alves Meira-Neto JAA (2020) Effects of anthropogenic disturbances on biodiversity and biomass stock of Cerrado, the Brazilian savanna. Biodivers Conserv 29:3151–3168. https://doi.org/10.1007/s10531-020-02013-6

Crouzeilles R, Feltran-Barbieri R, Ferreira MS, Strassburg BBN (2017) Hard times for the Brazilian environment. Nat Ecol Evol 1:1213. https://doi.org/10.1038/s41559-017-0303-7

Csardi G, Nepusz T (2006) The igraph software package for complex network research. InterJournal, Complex Systems, 1695. https://igraph.org.

Da Empoli G (2019) Os engenheiros do caos: como as fake news, as teorias da conspiração e os algoritmos estão sendo utilizados para disseminar ódio, medo e influenciar eleições. Vestígio Editora, São Paulo.

Dean W (1996) *A ferro e fogo: a história e a devastação da Mata Atlântica brasileira*. São Paulo, Companhia das Letras, 484 pp.

Drummond J, Barros-Platiau AF (2006) Brazilian environmental laws and policies, 1934–2002: a critical overview. Law Policy 28:83–108. https://doi.org/10.1111/j.1467-9930.2005.00218.x

Esteves B (2021) O fabulador oculto: a trajetória e os métodos de Evaristo de Miranda, o ideólogo da política ambiental de Bolsonaro. In: Revista Piauí, 174. https://piaui.folha.uol.com.br/materia/o-fabulador-oculto/.

FAO (2022) 'https://www.fao.org/news/story/en/item/197623/icode/#:~:text=By%20the%20numbers%3A%20GHG%20emissions,of%20all%20anthropogenic%20GHG%20emissions.'

Farrell J, McConnell K, Brulle R (2019) Evidence-based strategies to combat scientific misinformation. Nat Clim Change 9:191–195. https://doi.org/10.1038/s41558-018-0368-6

Fearnside PM (2016) Brazilian politics threaten environmental policies. Science 353:746–748. https://doi.org/10.1126/science.aag025

Ferrante L, Fearnside PM (2019) Brazil's new president and 'ruralists' threaten Amazonia's environment, traditional peoples and the global climate. Environ Conserv 46:261–263. https://doi.org/10.1017/S0376892919000213

Forti LR, Rossi-Santos M, Nunes JACC (2021) Assess before changing Brazil's shipping policy. Science 372:139. https://doi.org/10.1126/science.abh36

Fünfgeld A (2021) "Brazil must be back!" – but real climate action is possible only after bolsonaro. GIGA Focus Latin America, 6. https://nbn-resolving.org/urn:nbn:de:0168-ssoar-76295-4

Funk WC, Caminer M, Ron SR (2012) High levels of cryptic species diversity uncovered in Amazonian frogs. Proc R Soc Lond B: Biol Sci 279:1806–1814. https://doi.org/10.1098/rspb.2011.1653

Gallardo ALCF, Bond A (2011) Capturing the implications of land use change in Brazil through environmental assessment: time for a strategic approach. Environ Impact Assess Rev 31:261–270. https://doi.org/10.1016/j.eiar.2010.06.002

Garcia LC, Szabo JK, de Oliveira Roque F, de Matos Martins Pereira A, Nunes da Cunha C, Damasceno-Júnior GA, Morato RG, Tomas WM, Libonati R, Ribeiro DB (2021) Record-breaking wildfires in the world's largest continuous tropical wetland: Integrative fire management is urgently needed for both biodiversity and humans. J Environ Manag 293:112870. https://doi.org/10.1016/j.jenvman.2021.112870

Gerhard U, Hoelscher M, Wilson D (2016) Inequalities in creative cities: issues, approaches, comparisons. Springer, New York.

Goldenberg A, Gross JJ (2020) Digital emotion contagion. Trends Cogn Sci 24:316–328. https://doi.org/10.1016/j.tics.2020.01.009

Gorwa R, Guilbeault D (2020) Unpacking the social media bot: a typology to guide research and policy. Policy Internet 12:225–248. https://doi.org/10.1002/poi3.184

Hansson SO (2020) Social constructionism and climate science denial. Eur J Philos Sci 10:37. https://doi.org/10.1007/s13194-020-00305-w

Hui D, Deng Q, Tian H, Luo Y (2017) *Climate change and carbon sequestration in forest ecosystems*. Handbook of climate change mitigation and adaptation, 1–40. https://doi.org/10.1007/978-1-4614-6431-0_13-2

Instituto Brasileiro de Geografia e Estatística (2015) 'População Rural e Urbana, https://educa.ibge.gov.br/jovens/conheca-o-brasil/populacao/18313-populacao-rural-e-urbana.html. Accessed 25 March.

Ioris RR, Ioris AAR (2013) Assessing development and the idea of development in the 1950s in Brazil. Rev Econ Polit 33:411–426. https://doi.org/10.1590/S0101-31572013000300003

Issberner L-R, Léna P (eds.) (2016). Brazil in the anthropocene: conflicts between predatory development and environmental policies. Taylor & Francis, Abingdon

Jornal Hoje (2020) Por que a teoria do "boi bombeiro" no Pantanal, citada pela ministra da Agricultura, é mito, https://g1.globo.com/natureza/noticia/2020/09/17/ambientalistas-explicam-por-que-boi-bombeiro-e-reservas-incendiarias-no-pantanal-citados-porsalles-sao-mito.ghtml. Accessed 29 March

Junk WJ, Nunes da Cunha C, Wantzen KM, Petermann P, Strüssmann C, Marques MI, Adis J (2006) Biodiversity and its conservation in the Pantanal of Mato Grosso, Brazil. Aquat Sci 68:278–309. https://doi.org/10.1007/s00027-006-0851-4

Kar P, Xue Z, Ardakani SP, Kwong CF (2022). Are fake images bothering you on social network? Let us detect them using recurrent neural network. IEEE Trans Comput Soc Syst. https://doi.org/10.1109/TCSS.2022.3159709

Kelly LT, Giljohann KM, Duane A, Aquilué N, Archibald S, Batllori E, Bennett AF, Buckland ST, Canelles Q, Clarke MF, Fortin M-J, Hermoso V, Herrando S, Keane RE, Lake FK, McCarthy MA, Morán-Ordóñez A, Parr CL, Pausas JG, Penman TD, Regos A, Rumpff L, Santos JL, Smith AL, Syphard AD, Tingley MW, Brotons L (2020) Fire and biodiversity in the Anthropocene. Science 370:eabb0355. https://doi.org/10.1126/science.abb0355

Klink CA, Machado RB (2005) Conservation of the Brazilian Cerrado. Conserv Biol 19:707–713. https://doi.org/10.1111/j.1523-1739.2005.00702.x

Lal R (2004) Soil carbon sequestration to mitigate climate change. Geoderma 123(1–2):1–22. https://doi.org/10.1016/j.geoderma.2004.01.032

Latin America Reports (2019) Bolsonaro's weaponized social media. https://latinamericareports.com/bolsonaros-weaponized-social-media/1342/. Accessed 1 April.

Luceri L, Deb A, Badawy A, Ferrara E (2019) "Red bots do it better: comparative analysis of social bot partisan behavior." In: Companion Proceedings of the 2019 World Wide Web Conference (WWW '19 Companion), May 13–17, 2019, San Francisco, CA, USA. ACM, New York, NY, USA, 6 pages. https://doi.org/10.1145/3308560.3316735.

Mao WX, Wang WP, Sun HF (2020) Optimization path for overcoming barriers in China's environmental protection institutional system. J Clean Prod 251:119712. https://doi.org/10.1016/j.jclepro.2019.119712

Mapbiomas (2019) https://mapbiomas.org/.

Marengo JA, Cunha AP, Cuartas LA, Deusdara Leal KR, Broedel E, Seluchi ME, Michelin CM, De Praga Baião CF, Ângulo EC, Almeida EK, Kazmierczak ML, Mateus NPA, Silva RC, Bender F (2021) Extreme drought in the Brazilian Pantanal in 2019–2020: characterization, causes, and impacts. Front Water 3:13. https://doi.org/10.3389/frwa.2021.639204

Massarani L, Castelfranchi Y, Mendes I, Fagundes VO, Moreira I (2021) Science in society: what young Brazilians think about S&T. An Acad Bras Ciênc 93:e20200204. https://doi.org/10.1590/0001-3765202120200204

Mittermeier RA, Robles-Gil P, Mittermeier CG (eds.) (1997) *Megadiversity: Earth's biologically wealthiest nations*. CEMEX, Agrupación Serra Madre, S.C., Mexico.

Ministério da Economia (2020) Correlação entre a densidade do rebanho bovino e a incidência de focos de incêndio por área. https://direitoambiental.com/correlacao-entre-a-densidade-do-rebanho-bovino-e-a-incidencia-de-focos-de-incendio-por-area/. Accessed 29 March.

O'Connor C, Weatherall JO (2019) The misinformation age: how false beliefs spread. Yale University Press, London.

Observa-MT (2021) Observatório Socioambiental de Mato Grosso - Entenda porque o PL 561 representa retrocesso na proteção ao Pantanal. https://observamt.org.br/noticia/entenda-porque-o-pl-561-representa-retrocesso-na-protecao-ao-pantanal/. Accessed 29 Mar 2021.

Oeco (2021) Bolsonaro pode rever extinção do Ministério do Meio Ambiente. https://oeco.org.br/noticias/bolsonaro-pode-rever-extincao-do-ministerio-do-meio-ambiente/. Accessed 31 Mar 2021

Otero I, Farrell KN, Pueyo S, Kallis G, Kehoe L, Haberl H, Plutzar C, Hobson P, García-Márquez J, Rodríguez-Labajos B, Martin J-L, Erb K-H, Schindler S, Nielsen J, Skorin T, Settele J, Essl F, Gómez-Baggethun E, Brotons L, Rabitsch W, Schneider F, Pe'er G (2020) Biodiversity policy beyond economic growth. Conserv Lett 13:e12713. https://doi.org/10.1111/conl.12713

Pardo S (2020). Generalized linear models. In: Statistical analysis of empirical data. Springer, Cham

Pereira, de Area Leão EJ, Ferreira PJS, de Santana Ribeiro LC, Carvalho TS, de Barros Pereira HB (2019) Policy in Brazil (2016–2019) threaten conservation of the Amazon rainforest. Environ Sci Policy 100:8–12. https://doi.org/10.1016/j.envsci.2019.06.001

Pott A, Oliveira AKM, Damasceno-Junior GA, Silva JSV (2011) Plant diversity of the Pantanal wetland. Braz J Biol 71:265–273. https://doi.org/10.1590/S1519-69842011000200005

Pott A, Pott VJ (2004) Features and conservation of the Brazilian Pantanal wetland. Wetl Ecol Manag 12:547–552. https://doi.org/10.1007/s11273-005-1754-1

R Core Development Team (2020) R: a language and environment for statistical computing. Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/

Rajão R, Nobre AD, Cunha ELTP, Duarte TR, Marcolino C, Soares-Filho B, Sparovek G, Rodrigues RR, Valera C, Bustamante M, Nobre C, Santos de Lima L (2022) The risk of fake controversies for Brazilian environmental policies. Biol Conserv 266:109447. https://doi.org/10.1016/j.biocon.2021.109447

Revista Globo Rural (2020) Bolsonaro volta a defender uso do "boi-bombeiro" para reduzir queimadas no Pantanal, https://globorural.globo.com/Noticias/Sustentabilidade/noticia/2020/11/bolsonaro-volta-defender-uso-do-boi-bombeiro-para-reduzir-queimadas-nopantanal.html. Accessed 29 March.

Ruggeri J, Forti LR (2021) Trade resolution further threatens Brazil's amphibians. Nature 593(7860):510. https://doi.org/10.1038/d41586-021-01412-1

Schöne JP, Parkinson B, Goldenberg A (2021) Negativity spreads more than positivity on twitter after both positive and negative political situations. Affect Sci 2:379–390. https://doi.org/10.1007/s42761-021-00057-7

Silman MR (2007) Plant species diversity in Amazonian forests. In: Tropical rainforest responses to climatic change. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-48842-2_10

Silva HM (2021) Wildfires and Brazilian irrationality on social networks. Ethics Sci Environ Politics 21:11–15. https://doi.org/10.3354/esep00194

Silva Junior, Celso HL, Alvarado ST, Celentano D, Rousseau GX, Hernández LM, Ferraz TM, Silva FB, de Melo MH, Rodrigues TC, Viegas JC, Souza UD (2021) Northeast Brazil's imperiled Cerrado. Science 372:139–140. https://doi.org/10.1126/science.abg0556

Silva Junior, Celso HL, Pessôa ACM, Carvalho NS, Reis JBC, Anderson LO, Aragão LEOC (2021) The Brazilian Amazon

deforestation rate in 2020 is the greatest of the decade. Nat Ecol Evol 5:144–145. https://doi.org/10.1038/s41559-020-01368-x

Souza JR, Carlos M, Shimbo JZ, Rosa MR, Parente LL, Alencar AA, Rudorff BFT, Hasenack H, Matsumoto M, Ferreira LG, Souza-Filho PWM, de Oliveira SW, Rocha WF, Fonseca AV, Marques CB, Diniz CG, Costa D, Monteiro D, Rosa ER, Vélez-Martin E, Weber EJ, Lenti FEB, Paternost FF, Pareyn FGC, Siqueira JV, Viera JL, Ferreira Neto LC, Saraiva MM, Sales MH, Salgado MPG, Vasconcelos R, Galano S, Mesquita VV, Azevedo T (2020) Reconstructing three decades of land use and land cover changes in Brazilian biomes with landsat archive and earth engine. Remote Sens 12:2735. https://doi.org/10.3390/rs12172735

Strassburg, Bernardo BN, Iribarrem A, Beyer HL, Cordeiro CL, Crouzeilles R, Jakovac CC, Junqueira AB, Lacerda E, Latawiec AE, Balmford A, Brooks TM (2020) Global priority areas for ecosystem restoration. Nature 586:724–729. https://doi.org/10.1038/s41586-020-2784-9

Trenberth KE, Dai A, van der Schrier G, Jones PD, Barichivich J, Briffa KR, Sheffield J (2014) Global warming and changes in drought. Nat Clim Change 4:17–22. https://doi.org/10.1038/nclimate2067

Vacchiano MC, Santos JWMC, Angeoletto F, Silva NM (2019) Do data support claims that Brazil leads the world in environmental preservation?. Environ Conserv 46:118–120. https://doi.org/10.1017/S0376892918000371

Vosoughi S, Roy D, Aral S (2018) The spread of true and false news online. Science 359:1146–1151. https://doi.org/10.1126/science.aap9

Ward, MS, Simmonds JS, Reside AE, Watson JEM, Rhodes JR, Possingham HP, Trezise JA, Fletcher R, File L, Taylor M (2019) Lots of loss with little scrutiny: the attrition of habitat critical for threatened species in Australia. Conserv Sci Pract: e117. https://doi.org/10.1111/csp2.117

Zalles V, Hansen MC, Potapov PV, Stehman SV, Tyukavina A, Pickens A, Song X-P, Adusei B, Okpa C, Aguilar R (2019) Near doubling of Brazil's intensive row crop area since 2000. Proc Natl Acad Sci USA 116:428–435. https://doi.org/10.1073/pnas.1810301115