https://doi.org/10.22478/ufpb.1981-1268.2023v17n2.65378

Environmental perception from rural residents and specialists in a biodiversity hotspot

Heitor C. Sousa[1*], Guarino R. Colli[2], Adriana Malvasio[1]

1 Universidade Federal do Tocantins – UFT, Quadra 109 Norte Av. NS-15, ALCNO-14, Plano Diretor Norte, CEP: 77001-090, Palmas, Tocantins, Brasil
2 Universidade de Brasília – UnB, Departamento de Zoologia, Instituto de Ciências Biológicas, Avenida L4 Norte, Asa Norte, CEP: 70910-900, Brasília, Distrito Federal, Brasil
*Corresponding author: heitor.sousa@uft.edu.br

Received 2 January 2023.
Accepted 11 July 2023.
Published 31 August 2023.

Abstract - Humanity is experiencing an environmental crisis, threatening biodiversity and itself. Knowing the environmental perception of social actors in threatened ecosystems can be critical for making decisions and planning more effective conservation actions. We investigated the positive and negative environmental perceptions of the Cerrado, a biodiversity hotspot, from 48 rural residents and 49 environmental specialists (n = 97). We used semiautomated content analysis methods to explore differences in word and topic associations used by each group. As expected, we found differences in the vocabulary used by rural residents and specialists' environmental perceptions of the Cerrado. However, only positive perceptions of the Cerrado presented different topics between groups. Rural residents tend to have a more utilitarian and anthropocentric perception of the Cerrado, emphasizing edible fruits and scenic beauties. In contrast, specialists stressed the importance of biodiversity and ecosystem services in the region, such as water supply and tourism, in regional, national, and global contexts. Public policies and environmental education activities are essential to demystify misperceptions about the Cerrado and to increase society's awareness of the conservation of this highly threatened region.

Keywords: Content analysis. Cerrado. Deforestation. Ecosystem services. Social actors. Attitudes. Social conservation. Environmental changes. Environmental education.

Percepção ambiental de residentes rurais e especialistas ambientais em um *hotspot* de biodiversidade

Resumo - A humanidade está vivendo uma crise ambiental, que ameaça a biodiversidade e a si mesma. Conhecer a percepção ambiental dos atores sociais em ecossistemas ameaçados pode ser crítico para tomar decisões e planejar ações conservacionistas mais efetivas. Nesse estudo, investigamos as percepções ambientais positivas e negativas de 48 residentes rurais e 49 especialistas ambientais (n = 97) em frente ao Cerrado, um *hotspot* de biodiversidade. Utilizamos métodos de análises de conteúdo semiautomáticas para explorar as diferenças nas associações de palavras e tópicos utilizados por cada

grupo. Como esperado, encontramos diferenças no vocabulário utilizado na percepção ambiental do Cerrado pelos residentes rurais e ambientalistas. No entanto, somente as percepções positivas do Cerrado apresentaram tópicos diferentes entre os grupos. Residentes rurais tendem a ter uma percepção mais utilitarista e antropocêntrica do Cerrado, enfatizando frutas comestíveis e beleza cênica; enquanto ambientalistas enfatizam mais a importância de serviços ecossistêmicos da região, como a provisão de água e turismo, em contextos regional, nacional e global. Políticas públicas e atividades de educação ambiental são importantes para desmistificar algumas percepções equivocadas que algumas pessoas ainda possuem em relação ao Cerrado e para sensibilizar e conscientizar a sociedade para a conservação dessa região tão ameaçada.

Palavras-chave: Análise de conteúdo. Cerrado. Desmatamento. Serviços ecossistêmicos. Atores sociais. Atitudes. Conservação social. Mudanças ambientais. Educação ambiental.

Percepción ambiental de los residentes rurales y especialistas ambientales en un *hotspot* de biodiversidad

Resumen - La humanidad está experimentando una crisis ambiental, amenazando la biodiversidad y a sí misma. Conocer la percepción ambiental de los actores sociales en ecosistemas amenazados puede ser fundamental para tomar decisiones y planificar acciones de conservación más efectivas. En este estudio, investigamos las percepciones ambientales positivas y negativas de 48 residentes rurales y 49 especialistas ambientales (n = 97) frente al Cerrado, un punto crítico de biodiversidad. Utilizamos métodos de análisis de contenido semiautomáticos para explorar las diferencias en las asociaciones de palabras y temas utilizadas por cada grupo. Como era de esperar, encontramos diferencias en el vocabulario utilizado en la percepción ambiental del Cerrado por los residentes rurales y ambientalistas. Sin embargo, solo las percepciones positivas del Cerrado presentaron diferentes temas entre los grupos. Los residentes rurales tienden a tener una percepción más utilitaria y antropocéntrica del Cerrado, enfatizando la fruta comestible y la belleza escénica; mientras que los ambientalistas enfatizan más la importancia de los servicios ecosistémicos en la región, como el suministro de agua y el turismo, en contextos regionales, nacionales y globales. Las políticas públicas y las actividades de educación ambiental son importantes para desmitificar algunas percepciones erróneas que algunas personas aún tienen en relación con el Cerrado y para sensibilizar y concienciar a la sociedad sobre la conservación de esta región altamente amenazada.

Palabras chave: Análisis de contenido. Cerrado. Deforestación. Servicios de ecosistema. Actores sociales. Actitudes. Conservación social. Cambios ambientales. Educación ambiental.

Introduction

The world has already surpassed many safe biophysical limits for humanity, and biodiversity loss has suffered the most significant change (Johan et al. 2009; Rockström et al. 2009). Land use is the

primary driver of this change, especially in biodiversity hotspots (Newbold et al. 2016). By decreasing native vegetation areas, agriculture mechanization and global population growth have accelerated the rate of biodiversity loss (Aycrigg et al. 2022; Beckmann et al. 2019; Bellard et al. 2014). Extinction rates are as high as when other mass extinctions occurred on Earth, posing challenges to biodiversity conservation and the resilience of socio-ecological systems (Cardinale et al. 2018; Ceballos et al. 2020; Dirzo et al. 2014). The loss of biodiversity brings to discussion not only practical issues related to ecosystem services provided to society and other cascading ecological effects but also ethical ones in our daily practices and long-term actions, policies, and plans that contrapose the biodiversity conservation (Ducarme et al. 2020; Kopnina 2016; Vucetich et al. 2021).

Despite substantial advances in conservation since the 80s (raised concerns about environmental problems), many negative trends are no different than before or are even worse (Chazdon 2019; Macura et al. 2015; Schleicher et al. 2019). Some argue that this failure is partly due to the dichotomy created between humans and nature (Adams et al. 2019; Fitzgerald and Stronza 2009; Sutherland et al. 2009). For instance, one of the most effective conservation practices is the creation of protected areas to exclude human presence in certain regions (Dinerstein et al. 2017; Kopnina 2016). Thus, it is increasingly necessary to consider in environmental evaluations the socioeconomic activities and other human dimensions (*e.g.*, psychology, cultural traditions, politics, and governance) to mitigate negative impacts and increase the efficiency and effectiveness of biodiversity conservation (Tilman et al. 2017). The success of conservation actions depends on the local people and how they live and build their social constructs (Bennett and Roth 2015; Bennett et al. 2016).

Studies on environmental perception aim to provide a systematic and scientific understanding of the "internal" view (from the local human community) to supplement the more traditional and "external" scientific approach (Whyte 1977). This internal view is critical for sustainability and biological conservation in biodiversity hotspots, where social and environmental conflicts arise and lead to socio-ecological crises (Zhao et al. 2022). Therefore, understanding human perceptions, motivations, predispositions, preferences, and attitudes may help to formulate more effective conservationist educational policies, actions, and awareness programs to convince people to collaborate and participate (Bennett 2016; Bennett et al. 2016; Cortés-Capano et al. 2020).

The Brazilian savannas (Cerrado) comprise the second largest ecoregion in South America with more than 2,000,000 km^2 of geographical area and possess a highly heterogenous environment shaped by complex interactions between vegetation, terrain, soil, and fire (Eiten 1972; Françoso et al. 2019; Furley 1999). The Cerrado is one of the most diverse savannas in the world and has high endemism levels (Furley 1999; Klink and Machado 2005). However, the increase in croplands and pastures threatens its biodiversity (Colli et al. 2020); therefore, it is considered a global biodiversity conservation hotspot (Mittermeier et al. 1998; Myers et al. 2000). Converting native vegetation to crops and pastures increases average surface temperatures and reduces the water recycled to the atmosphere, disrupting many ecosystem functions and services, such as the provision of water to other basins (Alencar et al. 2020; Bustamante et al. 2016; Rodrigues et al. 2022; Schüler and Bustamante 2022). In this study, we investigated the differences in the perceptions between rural people and environmental specialists towards the Cerrado savannas. We used automated content analysis and statistical modeling to assess differences in positive and negative perceptions between these two groups. We explored the discourses in light of the main psychological and social drivers to advance our knowledge about the tradeoffs and conflicts in conserving this world's biodiversity hotspot.

Material and Methods

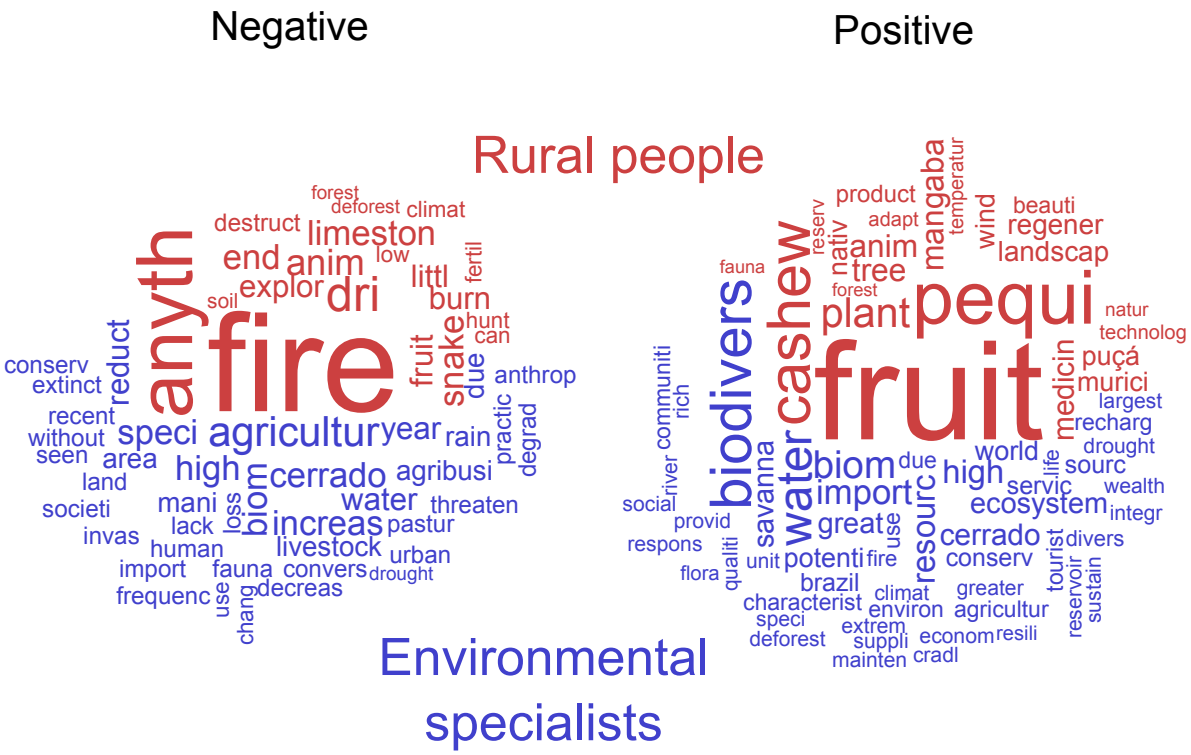
This study is part of a broader project aiming to investigate the perceptions and attitudes towards fire use and management, biodiversity conservation, climate change, and sustainable development in the Cerrado savannas. We built two different questionnaires for rural residents and environmental specialists. We used the questionnaires to survey, in person, rural residents in Palmas municipality, Tocantins, Brazil. For the selection of interviewees, we excluded rural properties exclusive for leisure purposes or without permanent residents. We recorded the audio in the interviews (when allowed) and helped them read the questions. We asked 548 environmental specialists to answer an online questionnaire through Google Forms. We contacted researchers involved with Cerrado conservation (mainly ecologists), agents, and technicians from state and federal environmental agencies, including managers of protected areas using their publicly available e-mails on the internet. We only considered environmental agencies located inside the Cerrado distribution (see Appendix 1 for a summary of the environmental specialists contacted). We gave the participants to sign a term of consent signed by the researchers before answering the questions. The in-person surveys usually took more time (~20-30 min) than online questionnaires (~15-20 min) because we had to verbalize and explain the questions more thoroughly. We conducted surveys and questionnaires using the Portuguese language. We asked open questions about their positive and negative perceptions of Cerrado. Later, we asked for other socio-economical information, precisely about their educational level, monthly income, age, gender identification, years of current work (only for specialists) or living in rural areas (only for rural people), and property size. The levels and descriptions of each question are in Appendix 2. By the end of the surveys, which occurred between July and August 2021, we surveyed 48 rural residents, and 49 environmental specialists answered the questionnaires (a total of 97 participants).

In this study, we used a quanti-qualitative approach, since we quantified the words used by the groups, applied statistical analyses, and interpreted them qualitatively enlightened by a conservation and socioenvironmental perspective. We used the package quanteda to make automated content analyses on the open answers by the participants (Benoit et al. 2018). First, we used the Google Translate Service to translate the text of the answers into English. For each question (positive and negative aspects about Cerrado), we created a corpus and a document-feature matrix (DFM). In our pre-processing routine, we removed from the DFMs the punctuation, numbers, and stopwords; selected words longer than two characters; and used the default stemming algorithm. Then, we counted for each DFM the most frequent features (words after the stemming process) from each group (rural people and environmental specialists) and built network matrices of co-occurrent features used by each person (Butts 2008). Afterward, we fitted Bernoulli Naïve Bayes (NB) models to rate the best features that classify each group (rural people and environmental specialists) (Jurafsky and Martin 2018; Manning et al. 2008). We used confusion matrix classification with 1,000 repeated k-fold cross validation and McNemar's tests to assess model accuracy. We also built structural topic models (STMs) using the package stm to test whether the groups' topics differed (Roberts et al. 2019). The STM is a semiautomated coding technique that draws on recent developments in machine learning-based analysis of textual data (Roberts et al. 2016; Roberts et al. 2014). In the results' section, when the feature (stemmed word) is not a complete word, we show the feature (stemmed word) and the word associated.

Results

In the open questions about Cerrado's negative aspects, rural people and environmental specialists cited the word "fire" more often (19 and 12 interviewees, respectively). Some rural interviewees (7) could not indicate anything as negative in the Cerrado ("anyth—anything"), and others cited the dry conditions (4 people, "dri—dry"). Words associated with "deforestation" were present in both groups but were the second most cited by environmental specialists, together with the word "agriculture" (both cited by seven interviewees, Figure 1). Regarding Cerrado's positive aspects, most rural interviewees mentioned fruits (25 people) and their names ("pequi—the fruit of *Caryocar brasiliense*"—by 12 and "cashew—the fruit of *Anacardium humile*"—by nine people). At the same time, the most cited features by the environmental specialists were "biodivers—biodiversity -," "water," and "biom—biome" (26, 18, and 10 people, respectively).

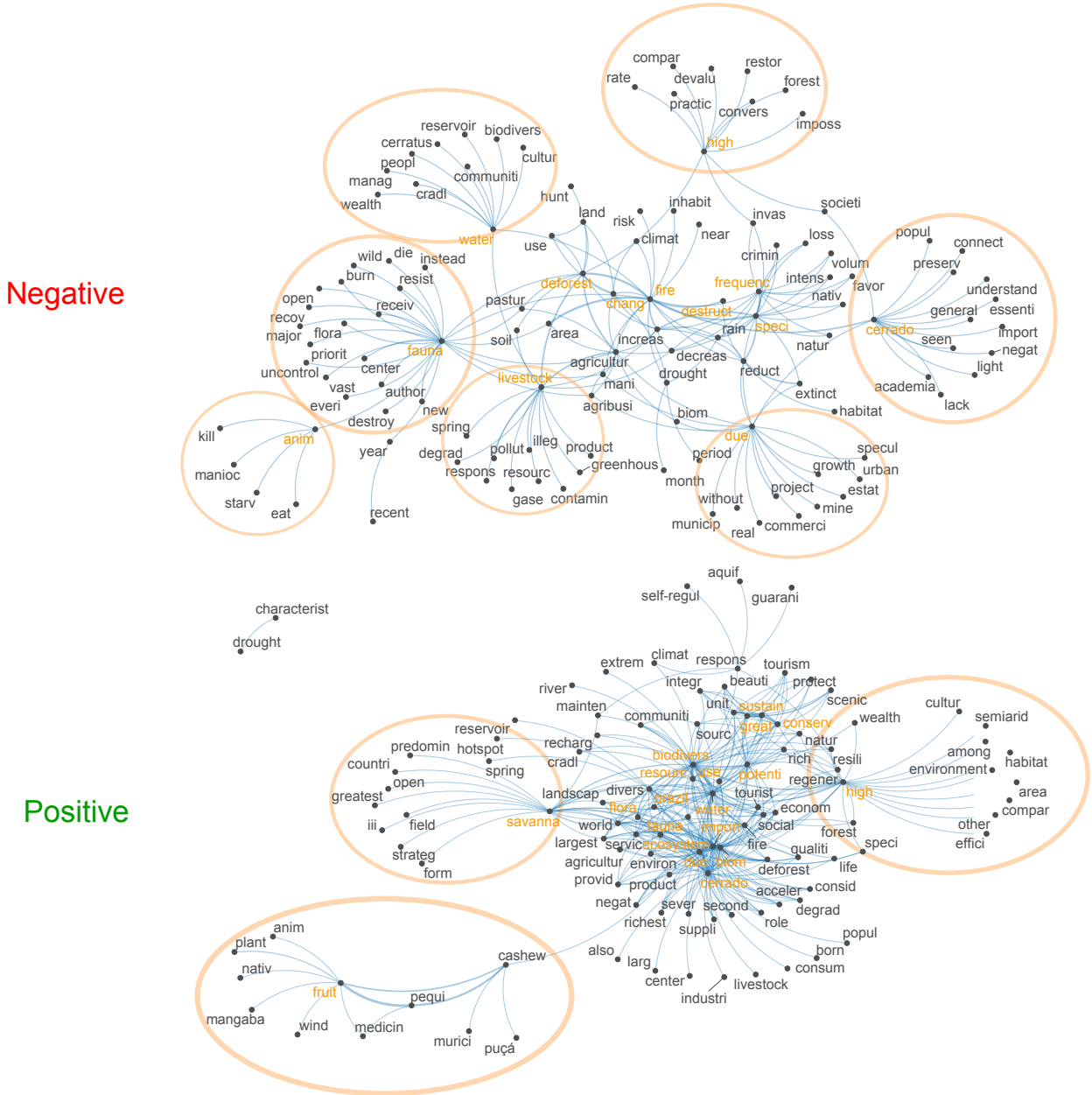
Figure 1. Word clouds of the Cerrado's perceptions from rural people (red) and environmental specialists (blue) in Brazil.



The network analysis indicated that the negative perceptions were richer in topics than the positive ones (Figure 2). The negative perceptions' central features were fire, deforestation, destruction, changes, frequency, and species (losses). Peripherally, we noted some impacts of fire and land use, such as livestock, and how they affect the water resources and the fauna. Interestingly, there was a cluster of features (centered in the feature "due") that were related to the socioeconomic system, such as "project," "specul—speculation," "urban," "growth," and "mine." We also noticed a cluster related to a pessimistic view (centered in the feature "high"), highlighting the features "imposs—impossible," "rate," "devalu—devalue," "convers—conversion," and "restor—restore"; and a disconnection between the importance of Cerrado with the population (centered in the feature "cerrado"). Regarding the positive

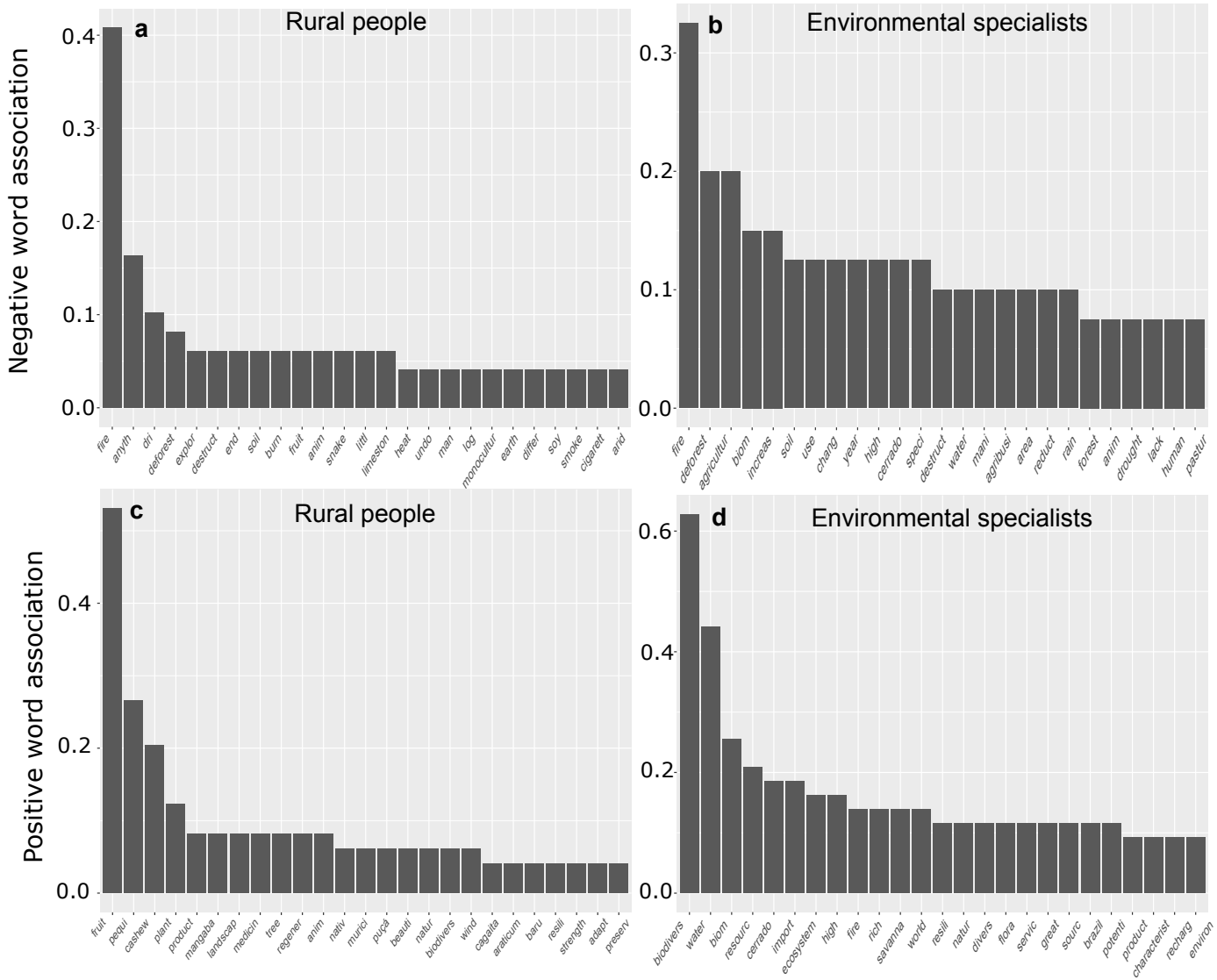
perceptions, the network analyses revealed a utilitarian point of view of resources (features "water," "resourc—resource," "use," "tourist") and highlighted the importance of the ecosystem, biodiversity, fauna, and flora. There were links between these features with national and world relevance, such as the features "Brazil," "savanna," and "countri—country". Peripherally, there was a cluster of fruits consumed by people (centered in the features "fruit," "pequi," and "cashew") and another related to specific characteristics, such as the high capacity of regeneration and resilience, the high diversity of cultures, environments, and habitats (features linked with "high").

Figure 2. Network of co-occurrent features (post-processed words) of the Cerrado's perceptions from rural people and environmental specialists in Brazil.



The Naïve Bayes models successfully classified the groups (rural people and environmental specialists) based on the features used in negative (classification error rate = 0.823, 95% CI = 0.726 - 0.898, $P < 0.001$) and positive perceptions (classification error rate = 0.901, 95% CI = 0.829 - 0.960, $P = 0.013$). However, the models had poor predictive accuracy for some negative (39.47%) and positive (19.51%) perceptions from environmental specialists. Features associated with deforestation and land use occurred in both groups. However, rural interviewees used more words related to the dry conditions in Cerrado, while specialists used more technical terms, such as "agriculture," "biome," and "species". Rural interviewees used more positive words associated with fruits or direct uses. In contrast, environmental specialists often used the biodiversity, water resources, and regional/national/global importance of the biome and ecosystem. Both groups also cited some resilient characteristics to fires and droughts (Figure 3).

Figure 3. Word associations with rural people and environmental specialists of Cerrado's perceptions from rural people and environmental specialists in Brazil predicted by Bernoulli Naïve Bayes models.



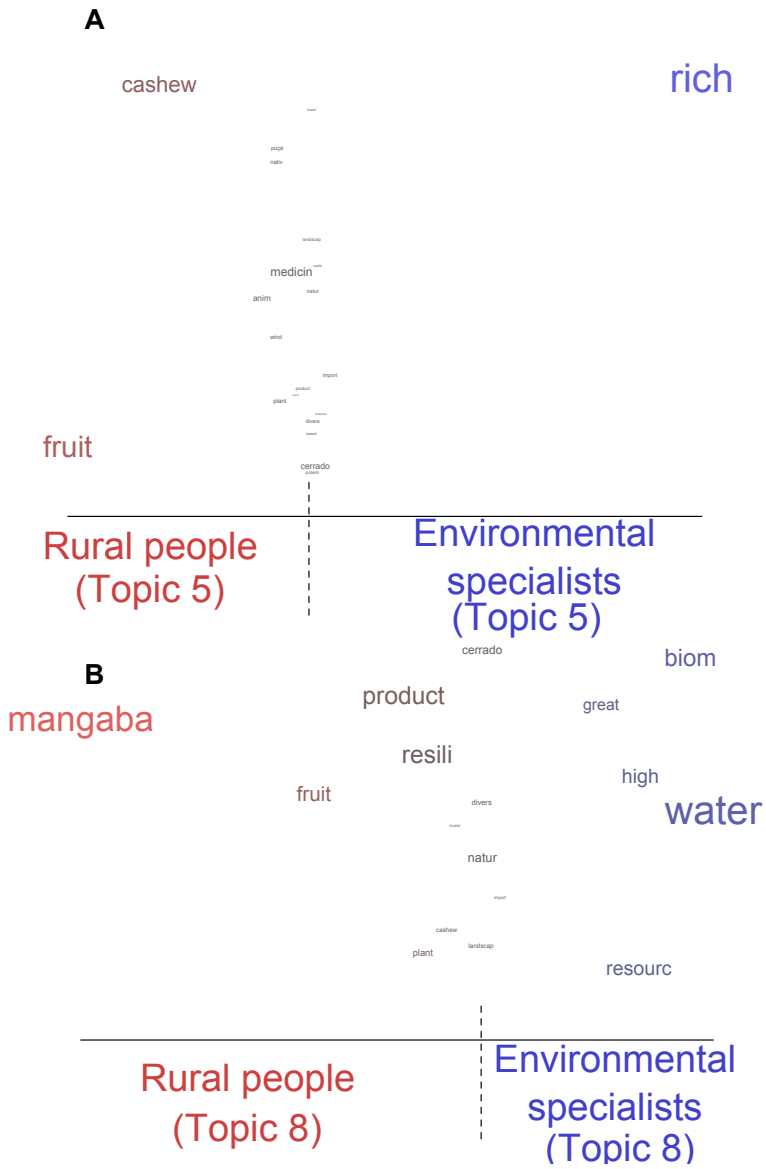
The STMs identified 13 topics related to negative perceptions and eight topics related to positive perceptions (Table 1). We found no significant differences in the words' prevalence among the topics in the negative perceptions. However, two topics differed in words' prevalence in the positive perceptions. In topic 5, rural people cited more fruits (fruit and cashew), while environmental specialists emphasized the richness of species. In topic 8, rural people again mentioned fruits (fruit and "mangaba"—the fruit of *Hancornia speciosa*) but also resilience and products. At the same time, environmental specialists cited the high quantity of resources ("resourc—resource" and water) in the biome (Figure 4).

Table 1. Topics identified by structural topic models related to Cerrado's negative and positive perceptions from rural people and environmental specialists in Brazil and respective tests in words' prevalence in each topic. We highlighted with bold letters the topics with significant differences between the groups.

Negative perception topics	**t**	***P***
Topic 1: arid, low	-0.884	0.380
Topic 2: event	0.387	0.700
Topic 3: extrem—extreme	0.439	0.662
Topic 4: soy, differ, earth, heat, end, deforest, agrosilvopastor—agrosilvopastoral, sprawl, practic—practice, suppress, veget—vegetation, devalu—devalue, compar—compare(d)	0.113	0.910
Topic 5: legal	0.312	0.756
Topic 6: especi—especially, fuel, june, octob—October, peak, tocantin—Tocantins, drought, monocultur—monoculture	-0.226	0.822
Topic 7: protect	0.210	0.834
Topic 8: inhabit, near, risk, suffer, area, destruct, last, run, weather, cigarett—cigarette, temperatur—temperature, work	-0.288	0.774
Topic 9: cerrado, academia, connect, essenti—essential, general, light, negat—negative, mechan—mechanic, plantat—plantation, limeston—limestone, fire	-0.656	0.514
Topic 10: be, consequ—consequence, desertif, —desertification food, savann—savanna, regul—regulation, specif—specific, eat, kill, manioc, starv—starve, snake	0.001	1.000
Topic 11: acid, assist, technic, correct, cost, livestock, aluminum, concentr—concentration	-0.220	0.826
Topic 12: fauna, author, center, destroy, die, everi—every, flora, better, explor—explore	-0.238	0.812
Topic 13: reduct—reduction, advanc—advance, extens—extensive, influenc—influence, occurr—occurrence, origin	0.774	0.441
Positive perception topics	**t**	***P***
Topic 1: biodivers—biodiversity, hold, pequi	-0.046	0.963
Topic 2: biodivers—biodiversity, lack, pequi	-0.117	0.907

Topic 3: biodivers—biodiversity, longer, pequi	-0.346	0.730
Topic 4: clear, rain, thunder, comfort, place, vantag—vantage, advantag—advantage, savanna, ecosystem, import, world, cerrado, birthplac—birthplace, regul—regulate	1.534	0.129
Topic 5: cashew, wind, nativ—native, puçá, anim—animal, rich, asset, bio, input, lot	**-2.118**	**0.037**
Topic 6: regrowth, post, burn, fast, abil—ability, mani—manipulate, power, fire, flora, resist	0.186	0.853
Topic 7: biodivers—biodiversity, shade, pequi	-0.232	0.817
Topic 8: mangaba, resourc—resource, biom—biome, great, high, water, compar—compare(d), effici—efficient	**2.270**	**0.026**

Figure 4. Word's prevalence from topics five and eight identified by Structural Topic Models related to Cerrado's positive perceptions in Brazil. The size and color of words are proportional to the word's prevalence in each group.



Discussion

In this study, we used semiautomated content analyses to explore the differences between rural people and environmental specialists in their perceptions of the Cerrado. Despite their different vocabularies, as indicated by the NB models, the topics related to Cerrado's negative perceptions did not vary between the groups. However, the positive perceptions were strikingly different between the groups. Rural people tended to perceive more practical benefits, mainly edible fruits. At the same time, environmental specialists cited various ecosystem services (also utilitarian) and emphasized the importance of biodiversity and water resources. It is interesting to notice the dichotomy in Cerrado's water perception. Despite specialists highlighting the high quantity of water resources and the importance of vegetation for the water cycle (Klink et al. 2020; Latrubesse et al. 2019), rural people perceived an environment with water scarcity because of the highly seasonal rainfall. This difference may derive from the distinct demands between urban and rural areas. First, urban areas have more planned and established water supply than rural areas (Garfì et al. 2011; Green et al. 2017). Second, agriculture and livestock demand much more water quantity than urban people (Chaplin-Kramer et al. 2019). Therefore, rural people tend to suffer more from rain seasonality than urban people. However, misplaced perceptions about water scarcity in Cerrado may come from deeper-rooted information through formal and informal education in the early ages of life (Bizerril 2004).

In their negative perceptions, rural residents and environmental specialists identified the main threats to Cerrado conservation, such as deforestation and fires. Although fire is a natural factor in open savannas like Cerrado, humans intensify fire regimes by changing their seasonal patterns (Bowman et al. 2011; Bowman et al. 2020; Enright and Thomas 2008; Fidelis et al. 2018). Humans use fire for various reasons, such as resprouting pastures, hunting, and clearing trails and surroundings (Bowman et al. 2020; Mistry et al. 2005; Pivello 2011). However, fire is also linked to deforestation because it is used to clear native vegetation for other land uses (Cochrane and Barber 2009; Moreira de Araújo et al. 2012; Ward et al. 1992). Therefore, rural people and environmentalists perceive fire negatively despite its function in maintaining the structure of the Cerrado vegetation. The use of fire is prohibited (permitted only in exceptional cases in protected areas and private areas, with special licenses) in Brazil, and it is negatively associated with destruction and sterile environments after the passage of fire in the media and by governmental agencies (Moura et al. 2019). This scenario of criminalization in the use of fire may drive this negative perception in people. However, some participants (rural people and specialists) acknowledged Cerrado's regenerative and resilient characteristics in an optimistic view. Thus, converging these perceptions into policies and regulations is increasingly necessary to build more sustainable fire regimes (Bowman et al. 2013; Pivello et al. 2021; Roos et al. 2014).

One crucial result we found is the lack of positive perceptions about Cerrado's fauna by the rural residents. Cerrado has one of the most biodiverse and unique faunas in the world (Azevedo et al. 2016; Cardoso Da Silva and Bates 2002), but it is undervalued compared to forested regions, such as the Amazon and Atlantic rainforests (Lahsen et al. 2016; Overbeck et al. 2015). This pattern is a trend in many open ecosystems worldwide (Buisson et al. 2020; Lehmann and Parr 2016). Again, this misperception may derive from early education and a preference by the media towards forests, in general (Bizerril 2004). Rural people also mentioned (venomous) snakes and other animals as negative characteristics because of possible accidents and crop losses, reinforcing the negative perception of animals (Olson and Pilliod 2022; Pooley et al. 2021; Whitehouse-Tedd et al. 2021). However, some

people linked these human-animal interactions with deforestation (habitat loss), attributed to farmers and landowners. This perception agrees with other studies which measured increased human-animal interactions in more anthropized areas (Pooley et al. 2021).

Our results also reveal the causes of the environmental changes the participants perceived to occur in Cerrado. Some people cited livestock, agriculture, mines, urban growth, land speculation, and commerce as some drivers of these changes. Some interviewees also linked to governmental responsibilities, mainly the states and municipalities, to increase surveillance and regulatory actions. Therefore, the participants perceive there are direct and indirect responsibilities for the environmental changes, with the socioeconomic and political systems dictating many farming and environmental policies and regulations in Cerrado. Environmental specialists' negative discourse on agriculture also emphasizes the need to identify the real responsibilities to achieve environmental justice (Esteves et al. 2012; Kopnina 2016; 2018). The leading cause of deforestation in the Cerrado savannas nowadays is the large-scale agribusiness (also cited by the environmentalists) that produces grains as an international commodity to export to other countries (Aragão et al. 2022; De Alban et al. 2021; Dobrovolski et al. 2011; Metzger et al. 2019). Thus, blaming agriculture may create injustices for small, local, or more sustainable farmers (Iverson et al. 2019; Perfecto and Vandermeer 2008; Pinheiro and Hunt 2020).

We also identified environmental specialists' concerns to mention Cerrado's importance on regional, national, and global scales. They highlighted many ecosystem services provided by the Cerrado, such as water resources, tourism, and by-products (Resende et al. 2019; Resende et al. 2017). However, rural people probably lacked this knowledge (Bizerril 2004; Ferreira and Freire 2009; Lahsen et al. 2016) and cited more quotidian uses of Cerrado biodiversity, mainly edible fruits (Silva et al. 2017). The perceptions of rural people also reveal an anthropocentric and utilitarian view of Cerrado's qualities. These results emphasize the need to increase the public's knowledge of the large-scale importance of Cerrado and the ethical concerns to conserve the unique (endemic) species in formal education and through the media and environmental education activities (Bizerril 2004; Gomes et al. 2019; Lima and Bastos 2019). Emotions make a significant part of people's perceptions and attitudes (Gosal et al. 2018; Iared et al. 2017; Pooley et al. 2021), so if more people were sensitized to conserve the Cerrado, we could expect higher participation and mobilization by society to make conservation more effective.

Conclusion

To our knowledge, this is the first study comparing rural residents' perceptions with environmental specialists in a biodiversity hotspot. We found a knowledge gap between academia and society about Cerrado's positive qualities. The environmental specialists also identified this gap and highlighted the lack of connection between the population and Cerrado's importance. Knowing and understanding these gaps is essential to plan and elaborate policies, regulations, and actions of environmental education transversally in schools, protected areas, and institutions (Christie et al. 2020; Cortés-Capano et al. 2020; Dobrovolski et al. 2018). We must demystify the perception of an arid region and poor in terms of resources and biodiversity if we aim to increase society's participation and awareness of Cerrado conservation (Bizerril 2004). We found that the avenue to value resilience and its diversity in formal and informal education may be critical to change these perceptions and attitudes (Zmigrod et al. 2021). Academia may also be essential in advocating these issues in outreach activities and social

and professional media (Steger et al. 2021). These results and recommendations may apply to other neglected open ecosystems worldwide, where social conflicts and different tradeoffs in conservation planning are common (Adams et al. 2017; Kiatkoski Kim et al. 2021; Kremen and Merenlender 2018). We expect educators, researchers, and stakeholders from all disciplines to read this message and act to promote changes if we want future generations to know the intrinsic values of the Cerrado, not only from books and past narratives.

Acknowledgments

HCS thanks the drivers Geremias, João Batista, Marcos, and the tremendous support from Raquel Acácio for performing the surveys. We thank the Tocantins Federal University for supporting and providing transport for the surveys in the rural areas. HCS thanks the scholarship from Coordination of Superior Level Staff Improvement (CAPES) [grant number 88887.484511/2020-00]. All authors thank the valuable contributions to the study development from the professors of the Environmental Sciences Post-Graduation Program (PPGCIAMB) and the interviewees for participating in the study.

Authors' contributions: HCS - Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Visualization, Writing–Original draft preparation, Writing–Review and Editing; GRC - Software, Supervision, Validation, Writing–Review and Editing; AM - Funding acquisition, Resources, Supervision, Writing–Review and Editing.

Ethical approval: All procedures performed in this study involving human participants were in accordance with the ethical standards and legislation of the Research Ethics Committees (CEP) from the Federal University of Tocantins (Universidade Federal do Tocantins – UFT) and National Research Ethics Commission (Comissão Nacional de Ética em Pesquisa – CONEP). The protocol of the Ethical Appreciation Presentation Certificate (Certificado de Apresentação de Apreciação Ética – CAAE) has the number 45041921.6.0000.5519 and the approval recommendation document has the number 4.799.043. Informed consent was obtained from all individual participants included in the study.

Data availability: R code and data can be accessed at https://github.com/HeitorCSousa/CerradoPerception/tree/main. Funding: Scholarship from Coordination of Superior Level Staff Improvement (CAPES) [grant number 88887.484511/2020-00].

Conflict of Interests: The authors declare that they have no conflict of interest.

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