MAN-MADE STRUCTURES AND ENVIRONMENTAL THREATS ON THE SERRA DA FUMAÇA MOUNTAINS - NEW CONSERVATION WARNINGS AND A SITE OF POTENTIAL ARCHAEOLOGICAL INTEREST

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Recebido em: 15/11/2024 – Aprovado em: 15/12/2024 – Publicado em: 30/12/2024
DOI: 10.18677/EnciBio_2024D13

ABSTRACT

Located on the northernmost stretch of the Chapada Diamantina plateau, the Serra da Fumaça is a mountain region mostly in the municipality of Pindobaçu, Bahia. Brazil. This region is a very important site for biodiversity and is also a *quilombo* community. However, the area has been under threat of several environmental and social impacts, including deforestation, illegal mining, and the advance of wind parks. In this scenario, one of the efforts that can be used to support conservation efforts in the region is the mapping, inventorying, and monitoring of human presence on these mountain areas, which can be done by assessing indicators of human activity based on any kind of infrastructure built on the mountain. From this perspective, this study mapped, using Google Earth, potential sites of interest that indicated human presence on the highlands of the Serra da Fumaça, and expeditions were taken to confirm the sites. In total, 11 sites were selected, of which 9 were visited. Most of the sites were fenced areas used to store cattle, a significant source of problems to water springs on the mountain. The most interesting discovery were two stone walls that, after visual analysis and reports by the population below the mountain, this study believes to be novel archaeological sites not yet recorded. However, even with this environmental and cultural potential, the Serra da Fumaça is still under severe threats, and a Conservation Unit is proposed in this study based on the drainage area of the *Rio Fumaça* river.

KEYWORDS: Archaeology; Ecology; Conservation Unit.

ESTRUTURAS FEITAS PELO HOMEM E AMEAÇAS AMBIENTAIS NA SERRA DA FUMAÇA - NOVOS ALERTAS DE CONSERVAÇÃO E UM SÍTIO DE POTENCIAL INTERESSE ARQUEOLÓGICO

RESUMO

Localizada no trecho mais ao norte do planalto da Chapada Diamantina, a Serra da Fumaça é uma região montanhosa situada majoritariamente no município de Pindobaçu, Bahia, Brasil. Esta região é um importante sítio de biodiversidade e também uma comunidade quilombola. No entanto, a área tem sido ameaçada por diversos impactos ambientais e sociais, incluindo desmatamento, mineração ilegal e o avanço de parques eólicos. Nesse cenário, um dos esforços que podem ser utilizados para apoiar a conservação na região é o mapeamento, inventário e monitoramento da presença humana nessas áreas montanhosas, o que pode ser feito por meio da avaliação de indicadores de atividade humana com base em qualquer tipo de infraestrutura construída na montanha. Sob essa perspectiva, este estudo mapeou, utilizando o Google Earth, potenciais locais de interesse que indicavam a presença humana nos planaltos da Serra da Fumaça, e expedições foram realizadas para confirmar os locais. Ao todo, 11 locais foram selecionados, dos quais 9 foram visitados. A maioria dos locais consistia em áreas cercadas utilizadas para abrigar gado, uma fonte significativa de problemas para as nascentes da montanha. A descoberta mais interessante foram dois muros de pedra que, após análise visual e relatos da população local, este estudo acredita serem novos sítios arqueológicos ainda não registrados. Contudo, mesmo com esse potencial ambiental e cultural, a Serra da Fumaça continua sob graves ameaças, e uma Unidade de Conservação é proposta neste estudo com base na área de drenagem do Rio Fumaça.

PALAVRAS-CHAVE: Arqueologia; Ecologia; Unidade de Conservação.

INTRODUCTION

The Serra da Fumaça is a mountain formation located in the northeastern Brazilian state of Bahia that spans two municipalities: Pindobaçu (which contains most of this formation) and Antônio Gonçalves (SOUSA; BAUTISTA; JARDIM, 2013). This area is included within the northernmost portion of the larger Chapada Diamantina plateau, with this northern stretch being known by several different names (e.g., Serras da Jacobina, Serras do Sertão, and Serras Jacobinas (NUNES *et al*., 2023a).

Counting on a diverse vegetation mosaic typical of an ecotone area, with typical features of three major Brazilian ecosystems (Cerrado, Atlantic Rainforest, and Caatinga), the Serra da Fumaça has been both the subject and location of several studies on different fields carried out during the last two decades, addressing the fauna (LOPES, 2010; ZACCA; BRAVO, 2012; SOUZA; BAUTISTA; JARDIM, 2013; LIMA; ZACCA, 2014), flora (GANDARA; ROQUE, 2020; SANTOS *et al*., 2022; NUNES *et al*., 2023b) and fungi (IZABEL *et al*., 2011; ALMEIDA; GUSMÃO, 2014; CONCEIÇÃO *et al*., 2016; MONTEIRO *et al*., 2017), in addition to studies on ecology and conservation (VALE, 2005; CARVALHO; RIOS; SANTOS, 2013; NUNES *et al*., 2022; SILVA; BARROS, 2023). However, despite this extensive research, the potential for biodiversity in the region remains largely underexplored.

These mountain areas are also used for different purposes by the neighboring populations, tourists, and other visitors from other locations. Nunes *et al*. (2023a) have discussed these uses from the perspective of ecosystem services, noting that the uncontrolled use of provisioning (e.g., unregulated mining, timber extraction through deforestation, compromised water springs by irrigation and cattle trampling) and cultural ecosystem services (e.g., irresponsible tourism, bonfires, and soil compaction caused by motorbikes) has affected the balance with provisioning and regulating services, which could lead to severe environmental consequences on the short, medium, and long terms (NUNES *et al*., 2023a).

Although there are different routes to access the top of the Serra da Fumaça by foot, horse or motorbike, the main trails used by tourists, miners, and local people start in the village of Lutanda, one of two neighboring villages, the other one being the village of Fumaça (VALE, 2005; CARVALHO; RIOS; SANTOS, 2013). These settlements are in an area officially recognized as *quilombo* land (also referred to in the literature as *maroon states* or *maroon communities*) (FCP, 2024a).

According to Presidential Decree No. 4,887 of November 20, 2003, *quilombo* territories are defined as areas inhabited by ethnic-racial groups with black ancestry linked to a history of resistance against racial oppression (BRASIL, 2003). These settlements, their people and lands are recognized and, to a degree, protected and supported by governmental agencies, especially the Palmares Cultural Foundation, in efforts to acknowledge their historical, environmental, and social importance (FCP, 2022). Furthermore, these communities have become synonymous with the preservation of cultural traditions and of harmony with nature. Their members, known as *quilombolas*, have learned to utilize natural resources sustainably while preserving the environment (SILVA, 2008).

The Northeast region of Brazil concentrates 68.19% of total quilombo territories in the country, with almost a million people living in these areas. Of these, almost 400,000 live in the State of Bahia (CNN BRASIL, 2020). There are only three officially recognized quilombo communities in the municipality of Pindobaçu, the area of this study, namely: Fumaça, Laginha, and Bananeiras de Santa Efigênia (FCP, 2024b). On the other hand, the municipality of Senhor do Bonfim, only 30 km far from Pindobaçu, has 17 certified quilombo communities, whereas the neighboring municipality of Antônio Gonçalves has five communities (FCP, 2024b).

However, the fact that the Serra da Fumaça is included within quilombo lands means more that the local population has, through their efforts, lived in relative coexistence and balance with nature rather than political authorities and other parties have spent sufficient efforts to participate through collaboration, training, and presence of the public sector in helping preserve and protect the local memory, biodiversity, and ecosystem services, as seen in the grave environmental problems brought to light by several different studies (CARVALHO; RIOS; SANTOS, 2013; CONCEIÇÃO, 2021; MARQUES *et al*., 2021; NUNES *et al*., 2022; SANTANA et al., 2024).

As an example, the municipal government of Pindobaçu intervened with the local environmental threats by publishing Municipal Decree no. 46, on February 9, 2023, which suspended all tourist access to the Serra da Fumaça without previous authorization, creating a 'Biological Reserve' conservation unit (one of the several types of environmental protection areas preconized by Brazilian law), and imposed the need

for guided visits with the presence of a 'monitor' registered with the municipal power (PINDOBAÇU, 2023). However, more than a year later, no concrete measures have been put into effect save for the installation of information signs and boards, with all environmental challenges exhaustively exposed before being left unattended.

As mentioned before, the environmental challenges observed on the Serra da Fumaça are many and include threats to water springs, cattle raising, deforestation, soil compaction, hunting, mining, and the construction of wind parks. Another impact is represented by the construction of infrastructure to sustain activities related to provisioning of cultural ecosystem services. Many authors have already raised alerts to the fact that infrastructure set up in wilderness areas can lead to habitat destruction and fragmentation (VAN DER REE *et al*., 2015), species mortality (FORMAN *et al*., 2003), and ecological imbalances (ASCENSÃO *et al*., 2012), causing severe negative environmental effects on wildlife populations up to several kilometers into the surrounding environment (JONGE *et al*., 2022).

In this scenario, mapping and inventorying structures and sites used for activities related to human presence on wilderness areas is essential to assist both the public sector and the local population in monitoring and implementing conservation efforts, also serving as a tool for decision-making regarding land use and eventual recovery measures (SANTOS et al., 2020; SILVA et al., 2020). This monitoring can be made using either satellite imagery from older datasets or (near) real-time footage using drones, for example. The study by López and Mulero-Pázmány (2019) has demonstrated how these techniques can be effectively employed for uses such as wildlife research and management, ecosystem monitoring, law enforcement, ecotourism, and environmental management and disaster response.

From this perspective, considering the many environmental threats to the Serra da Fumaça, its enormous significance as a quilombo territory, the officially recognized efforts to implement a conservation unit in the area, and its striking biodiversity potential, this study aimed to compile all man-made structures present on the Serra da Fumaça in order to assist in the implementation of conservation measures and seek any other features of interest for the conservation of the site.

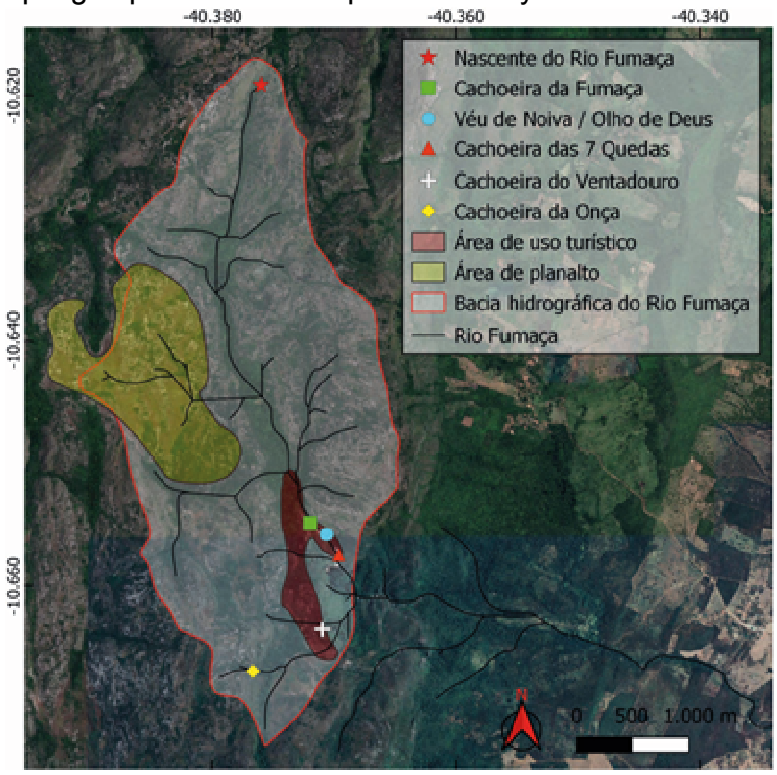
MATERIAL AND METHODS

The study was conducted on the Serra da Fumaça mountains, in an area included within the limits of the municipality of Pindobaçu, Bahia, northeastern Brazil. These mountains are part of a stretch approximately 200-km long called 'Serras Jacobinas', which corresponds to the northernmost portion of the well-known Chapada Diamantina plateau in the State of Bahia. The approximate center of the polygon considered for the sampling expeditions lies on the following coordinates: 10°38'41.34"S 40°23'4.18"W.

According to the Köppen classification, the local climate on the mountain range is classified as *Aw* (equatorial climate with dry winters), whereas the lower areas below the mountain are included in a *BSh* climate type (semi-arid with hot summers) (Rubel *et al*., 2017). The vegetation found on the mountain is formed by green patches typical of the Atlantic Rainforest ecosystem alongside rivers, wide open grasslands typical of the Cerrado, and elements of the semi-arid Caatinga (BRASIL, 2007; QUEIROZ *et al*., 2017; NEGREIROS, 2021; SANTOS NETO *et al*., 2022).

The methodology used to collect data for this study included analysis of satellite imagery from Google Earth to identify possible sites of interest, analysis and construction of contour line maps, and field expeditions to confirm and photograph the sites, when possible, which were then georeferenced and subsequently plotted on a map. The area considered for analysis was the entire terrain delimited by Nunes *et al*. (2023a) as the drainage basin of the Rio Fumaça river (Figure 1).

FIGURE 1. Reproduction of the map published by Nunes *et al*. (2023a), representing the drainage basin of the Rio Fumaça river, which corresponds to the area used for the sampling expeditions in the present study.



Source: reproduced from Nunes *et al*. (2023a).

First, Google Earth was used to sweep the area looking for any features of interest, including buildings, camping sites, fenced areas, deforestation signs, mining shacks, and any other indications of human presence that could lead to the presence of infrastructure built to support these activities. Fenced areas could be distinguished in satellite imagery by the absence of high vegetation (e.g., trees) in a polygon-shaped patch. All sites identified were then inventoried along with their geographic coordinates for the second phase of the study.

Then, the sites identified on Google Earth were visited in person to check whether they were still there, if they were still used, and to obtain pictures of these locations to support the study. The on-site photographs were taken during daytime using a Nikon® D3200 camera. Other areas that were not on the list were visited, either purposely or by accident, to verify carefully whether any other sites containing indications of continued

human presence were found. The uncharted sites eventually found were compiled with the rest of the sites visited. Two expeditions were taken to the area: one during the rainy season (December 2023) and another during the dry season (August 2024).

RESULTS AND DISCUSSION

The list of sites compiled before and after the field expeditions can be seen in Table 1. Of the 11 sites described, only site W1 (stone wall) was found after the compilation based on Google Earth imagery.

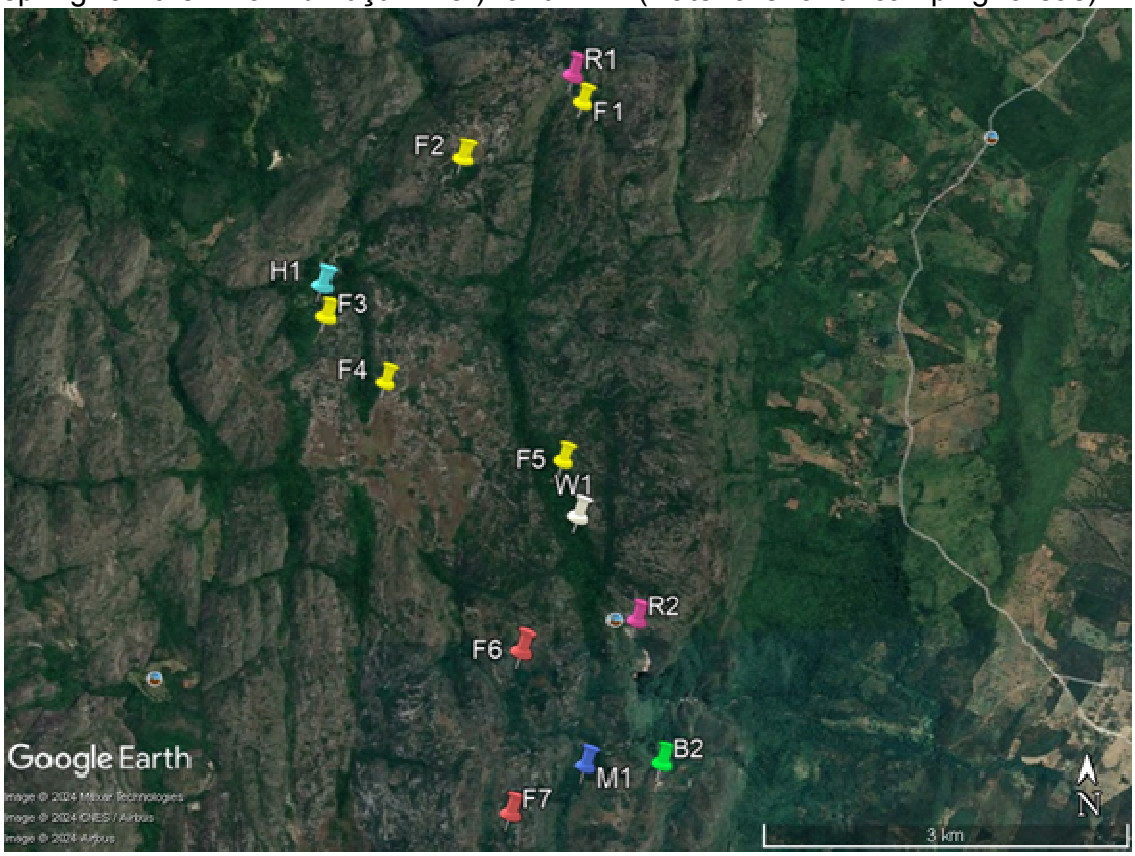
TABLE 1. Compilation of sites containing infrastructure currently or formerly used by humans on the Serra da Fumaça.

Code	Description	Coordinates
F1	Fenced area on the eastern side the northernmost spring of the *Rio Fumaça*	10° 37.192'S 40° 22.473'W
F2	Fenced area on the western side of the northernmost spring of the *Rio Fumaça*	10° 37.430'S 40° 22.978'W
F3	Fenced area on the northwestern edge of the *Rio Fumaça* drainage basin	10° 38.083'S 40° 23.559'W
F4	Fenced area to the north of the *Lago da Onça* pond	10° 38.354'S 40° 23.309'W
F5	Fenced area surrounding a large, deforested patch along the *Rio Fumaça*	10° 38.685'S 40° 22.557'W
F6	Fenced area to the west of the camping sites	10° 39.477'S 40° 22.737'W
F7	Fenced area close to the *Cachoeira da Onça* waterfall	10° 40.145'S 40° 22.782'W
H1	House built close to F3	10° 37.958'S 40° 23.580'W
W1	Stone walls found in the woods	10° 38.919'S 40° 22.495'W
B2	Chapel	10° 39.968'S 40° 22.140'W
M1	Mining shack	10° 39.970'S 40° 22.465'W

Source: the authors (2024).

Also, of the 11 sites listed on the previous table, only sites F6 and F7 could not be visited *in loco* due to accessibility issues. All other sites were visited and extensively photographed. A satellite image with all points of interest inventoried can be seen below in Figure 2:

FIGURE 2. Map of the Serra da Fumaça containing the points of interest mentioned in Table 1 plus two reference points: R1 (region of the northernmost spring of the *Rio Fumaça* river) and R2 (waterfalls and camping areas).

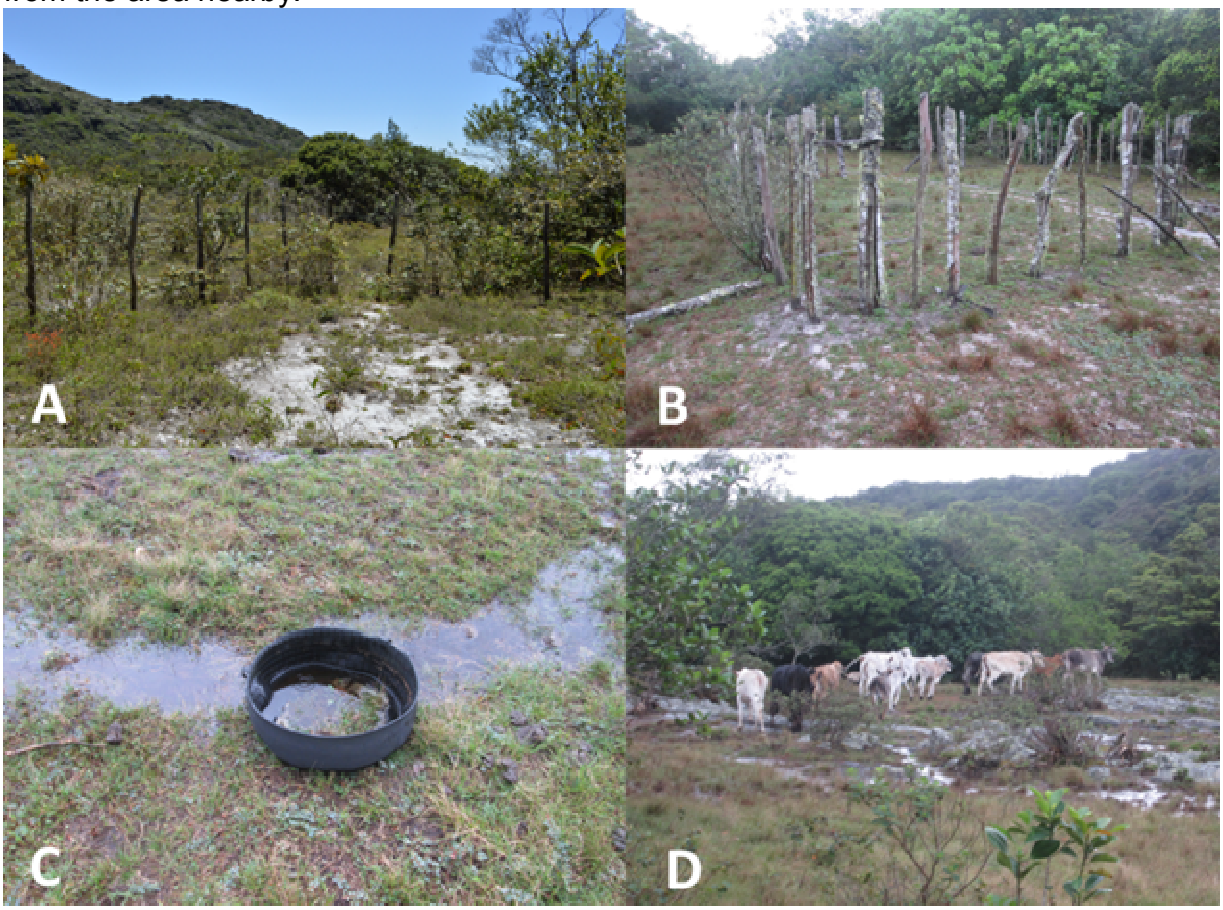


Source: Adapted from Google Earth (2024).

The first two fenced sites (F1 and F2), located close to the northernmost spring of the *Rio Fumaça* river (R1), whose drainage basin corresponded to the sampled area, can be seen below in Figure 3.

The fences represented above are not mere terrain demarcation elements. Instead, they form polygons and are closed by a gate, indicating their use to store cattle. In fact, cows, bulls, and horses can be seen roaming over the entire extent of the study area (as seen in Figure 3D), and these fenced areas are often erected by deforesting the immediate surroundings to make room for the cattle. Furthermore, the fact that there is cattle presence so near to some of the most vital springs of the *Rio Fumaça* river represents another danger to the conservation of this natural resource and all other related ecosystem services, as discussed by Nunes *et al*. (2022) in the study that discovered the springs mentioned here. In Figure 3C, there is even a half-tire used to feed cattle lying on a water spring area.

FIGURE 3 (A-B). Fenced areas close to the northernmost spring of the *Rio Fumaça* river: F1 (Figure 3A) and F2 (Figure 3B). Figures 3C and 3D are supplementary images from the area nearby.

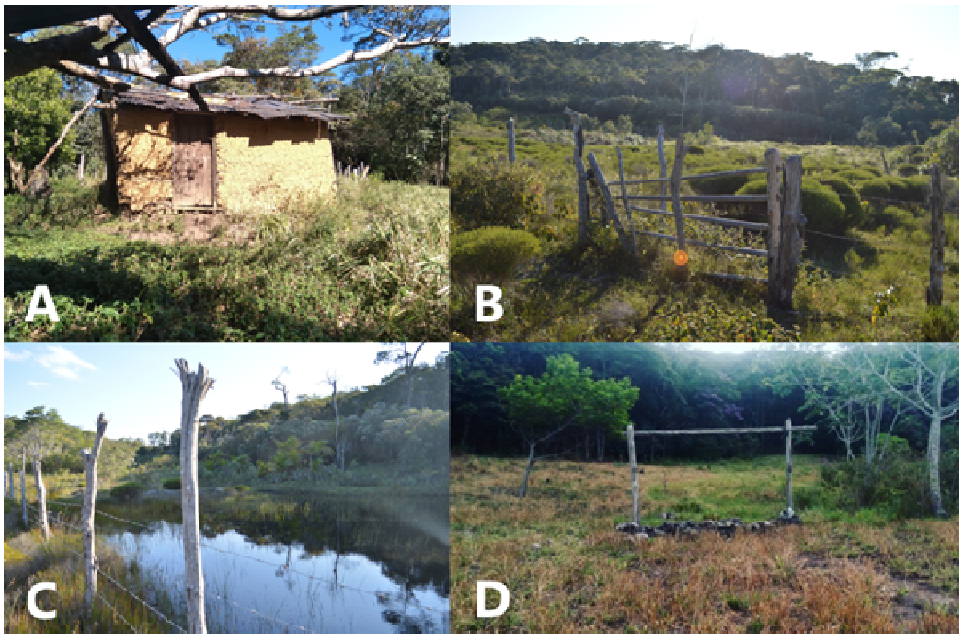


Source: the authors (2023-2024).

Other related points of interest are F3, F6, and H1, which correspond to areas used for cattle raising, keeping, and slaughter, including a house, a large, fenced area, and a pond with palm trees, as seen in Figure 4.

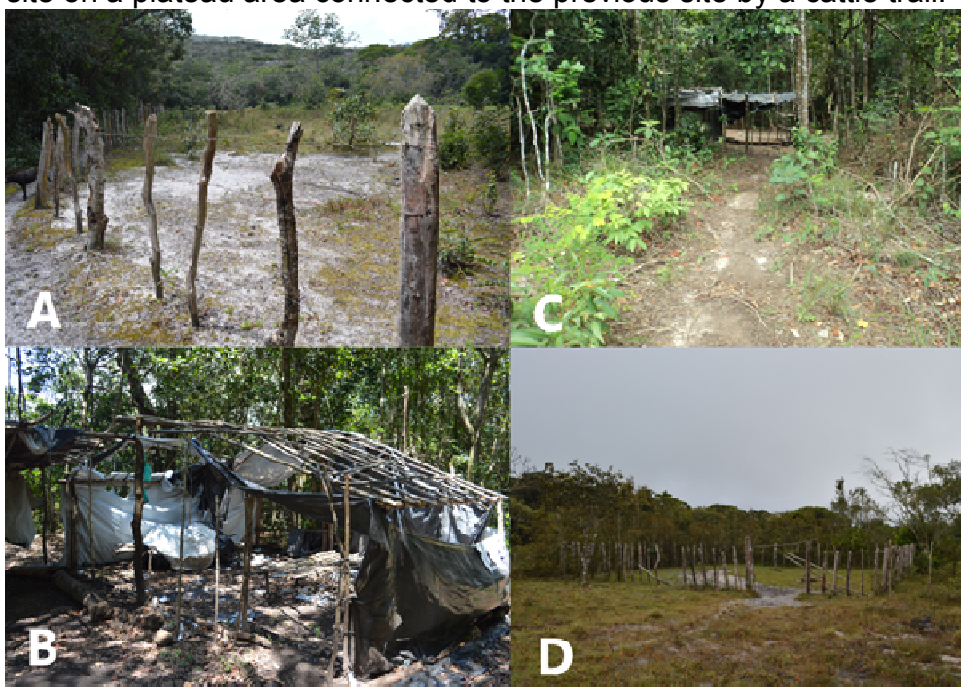
However, the largest deforested patch found on the Serra da Fumaça, measuring almost 7,000m^2, corresponds to the fenced area indicated in point F5. This area is singular because it contains not only a large, deforested segment but also an old camp-like structure with improvised wooden beds and walls covered by tarpaulin, capable of holding at least three people. This area is located close to the *Rio Fumaça* river and is connected to a plateau area seen in Figure 4D by a cattle trail. It can be inferred, therefore, that the cattle grazes on the plateau and is (or was) stored in the location (Figure 5).

FIGURE 4 (A-D). Related areas near the northwestern limit of the *Rio Fumaça* hydrographic basin. The house seen in 4A is contained within the fenced area seen in 4B and 4C. The wooden frame seen in 4D is used to dry cow hides behind the house seen in 4A.



Source: the authors (2023-2024).

Figure 5 (A-D). Some of the largest deforested, fenced areas along the *Rio Fumaça* river. The pictures seen from 5A to 5C are located on the same site. Figure 5D is a separate site on a plateau area connected to the previous site by a cattle trail.



Source: the authors (2023-2024).

Furthermore, the areas were also occasionally screened for sites that could not be seen from above, as is the case of some wooden shacks and fences under the canopy. This led to the interesting discovery of two stone walls, one of which approximately 20 meters long, in a hard-to-access area on the western bank of the *Rio Fumaça* river (site W1, Table 1), seen in Figure 6.

Figure 6 (A-C). Stone wall found on a sloped area on the west side of the *Rio Fumaça* river.

Source: the authors (2023-2024).

A first analysis of these walls could tell that these were very old structures, unlike the other areas sampled in this study. There was no disturbance in the leaf litter, there were numerous plants, even tall trees with roots intertwined with the rocks that formed the wall, and the site itself was completely isolated, not near any human or cattle trails, and with no animal trails crossing the area, attesting to its isolation. Also, the area is a slope, and the wall resembles a barricade.

After recording this site and getting down the mountain, the research team mentioned the finding and showed the pictures and videos to some elders of the village of Lutanda. Some of these people, all older than 60 years, said they recognized the walls and mentioned that the structures were already there when they were children.

Furthermore, they also attributed the construction of these walls to the *antigos* and *índios* (the ancient ones and the indigenous peoples).

Therefore, after our analysis and the reports by the local population, we believe this to be an archaeological site that is part of the *quilombo* and/or indigenous history of the area. As a result, this could be the first archaeological site to be ever recorded on the Serra da Fumaça. Specialized work by an archaeological team is essential to properly confirm this hypothesis.

The two other points visited in the expeditions were a chapel (B2, Table 1) and a mining shack (M1, Table 1), the latter found by accident on a previous occasion and already described in another study published by these authors (NUNES et al., 2022), seen in Figure 7 below. While the first is also a quite old structure, it is significantly more recent than the stone wall, with some locals claiming to have helped build the small church. As for the mining shack, it is likely one of maybe many sites where the earth is explored without authorization or legal permission, as even no mention to these activities exists in Municipal Decree no. 46, on February 9, 2023 (PINDOBAÇU, 2023).

Figure 7 (A-B). Chapel and mining shack found on the Serra da Fumaça.

Source: the authors (2023-2024).

The findings presented in this article show that not much has changed since the municipal government declared intervention in the area in early 2023. In fact, the only indication that the municipality acted on that piece of legislation are signs fixed on the camping areas, as seen below in Figure 8.

Even though the area is a *Quilombo* community, which should provide additional protection from government bodies to this region, a lot of devastation can still be seen. Figure 7C is an example of that, where a large area 10 meters from the river was deforested below the mountain, even though the Brazilian Forestry Code, established by Law. 12,651/2012, states the areas in a minimum of 30 meters from water bodies are Permanent Preservation Areas (BRASIL, 2012), where no deforestation should be allowed to occur.

Figure 8 (A-C). Informative signs and deforestation near the *Rio Fumaça* river.

Source: the authors (2023-2024).

Furthermore, the fact that what is likely an archaeological site on the *Serra da Fumaça* has been recorded only stresses how critical it is to protect this region, which is under multiple and very serious threats from all sides, including illegal mining, deforestation, deregulated camping activities, general pollution, soil compaction, and the advance of wind parks in the region. The threats to the local water springs are another cause for concern, having been the subject of several other studies, including Negreiros (2021).

CONCLUSION

There are several sites, both natural and man-made, of interest for conservation on the Serra da Fumaça, with the latter representing causes of significant concern for present and future conservation efforts. The man-made structures found there include fenced areas used to store cattle, grazing sites, camping areas, mining shacks, a house, and a chapel.

A 20-meter-long stone wall was also discovered in the middle of the forest during this research. Given the location, status of the site, and as reinforced by reports from the local population, we believe that this is a still unregistered and novel archaeological site on the Serra da Fumaça, which stresses even more the urgency and importance of establishing, with the utmost priority, a formal conservation unit in the area.

Based on the information presented in this article, we stress the need for a conservation unit to be created by considering the limits of the drainage area of the Rio

Fumaça river, as this region represents a somewhat independent stretch of the mountain formation where the Serra da Fumaça is included.

There may be other potential archaeological sites on this mountain and in neighboring others. Furthermore, this is also a registered *quilombo* area. Therefore, the authors urge the National Institute for Historical and Artistic Heritage (IPHAN) of Brazil to investigate the area with the proper resources and professionals in order to compile all the information possible before any further devastation takes place in the region.

ACKNOWLEDGMENTS

We acknowledge the support of Mirele Silva Moreira, Jadson Galdino da Silva Costa, and Bruno Cezar Silva to this research.

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