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CLASSIFICATION AND CODING OF THE CAUSES OF FOREST FIRES (CCIF): PROPOSAL FOR A HIERARCHICAL SYSTEM FOR STANDARDIZATION OF INVESTIGATIVE DATA

CLASSIFICATION AND CODING OF WILDFIRE CAUSES (CCIF): PROPOSAL FOR A HIERARCHICAL SYSTEM FOR STANDARDIZING INVESTIGATIVE DATA / CLASSIFICATION AND CODIFICATION OF LAS

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SUMMARY:

Forest fires are events of high environmental, operational and...

territorial, the investigation of which requires procedures capable of identifying and recording in a way standardized its causes. This study aimed to propose a Classification and Coding The Forest Fire Causes Management System (CCIF), as a hierarchical system designed to organize from the results of the investigations. This is applied research, of a methodological nature and Proactive in nature. The construction of the CCIF was based on the systematization and adaptation of the causes. and motivations for forest fires described by Porrero Rodríguez (2001), supplemented based on technical research references, and in the adoption of a hierarchical structure of Coding inspired by the logic of the Brazilian Disaster Classification and Coding System. (COBRADE). As a result, the CCIF was structured into four levels — Group, Subgroup, Type and Specification (GSTE) — and organized into seven groups: natural causes; use of fire in rural activities; waste, leisure and daily use; equipment, infrastructure and accidents; The classification adopts the following principle: intentional fire; undetermined cause; and reignition. The classification at the highest level of specificity supported by evidence, without presumption. of intentionality, and keeps separate the cause, the degree of determination, and the classification of event by COBRADE. The proposed structure allows converting investigative conclusions into standardized, comparable, and spatially viable categorical data, with the potential for integration into Databases and Geographic Information Systems. It is concluded that the CCIF establishes

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a structured proposal for standardizing the causes of forest fires, whose
Consolidation as a technical instrument will depend on content validation and evaluation of...
Reliability among researchers and operational application in different contexts.

Keywords: vegetation fire; fire causality; code standardization.

ABSTRACT:

Wildfires are events of high environmental, operational, and territorial complexity, whose investigation requires procedures capable of identifying and recording their causes in a standardized manner. This study aimed to propose the Classification and Coding of Wildfire Causes (CCIF), a hierarchical system designed to organize the results of investigations. This is applied research, methodological in nature and propositional in character. The construction of the CCIF was based on the systematization and adaptation of wildfire causes and motivations described by Porrero Rodríguez (2001), complemented by technical investigation references, and on the adoption of a hierarchical coding structure inspired by the logic of the Brazilian Classification and Coding of Disasters (COBRADE). As a result, the CCIF was structured into four levels — Group, Subgroup, Type, and Specification (GSTE) — and organized into seven groups: natural causes; use of fire in rural activities; waste, leisure, and everyday use; equipment, infrastructure, and accidents; intentional fire; undetermined cause; and rekindling. The classification adopts as its principle the classification at the highest level of specificity supported by the evidence, without presuming intentionality, and keeps separate the cause, the degree of determination, and the classification of the event by COBRADE. The proposal structure allows investigative conclusions to be converted into standardized, comparable, and spatially analyzable categorical data, with potential for integration into databases and Geographic Information Systems. It is concluded that the CCIF establishes a structured proposal for standardizing wildfire causes, whose consolidation as a technical instrument will depend on content validation, assessment of inter-investigator reliability, and operational application across different contexts.

Keywords: vegetation fire; fire causality; code standardization.

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1 INTRODUCTION

Forest fires are events of high environmental complexity.
operational and territorial, whose causes may be related to natural phenomena or to
different human activities. Understanding these causes is fundamental to guiding actions.
prevention, investigation and planning, since simply registering the occurrence is not
clarifies the mechanism or circumstance responsible for the ignition (SOARES; BATISTA;
NUNES, 2009; COSTA et al., 2023).

The origin and cause investigation seeks to technically reconstruct the event through...
Integrated analysis of the origin zone, starting point, propagation indicators, heat source,
ignition method, associated activity, material traces, witness statements, records
Operational and environmental conditions. Geospatial information and remote sensing products.
Remote sensing can also complement this process, especially in spatial characterization.
of the event and its effects (LENTILE et al., 2006; STURM; ACORDI, 2017; NWCG, 2023).

The diversity of ignition mechanisms makes it necessary to use categories.
capable of organizing the results of these investigations. Porrero Rodríguez (2001) systematized
causes and circumstances related to forest fires, constituting an important reference.
for its differentiation. Internationally, harmonization initiatives also
They demonstrate the relevance of standardizing the causes to increase consistency and...
comparability of records, such as the scheme adopted in the European database of
forest fires (CAMIA et al., 2013). The relevance of this distinction is evidenced by
Recent events: in the 2020 Pantanal fires, human activity was behind the
most ignitions (LIBONATI et al., 2022).

In Brazil, however, the classification of the event and the classification of its cause
They represent distinct dimensions. The Brazilian Classification and Coding of Disasters
(COBRADE) organizes adverse events and disasters through a hierarchical structure.
and codified (BRAZIL, 2012). This logic constitutes a reference for the organization
Systematic information gathering, but it does not replace the causal classification resulting from the investigation.
While COBRADE characterizes the event that occurred, a classification of causes should be developed.
To explain why the fire occurred, based on the available evidence.

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The absence of a standardized structure for coding causes can make it difficult to...
Consolidation of records from different occurrences, periods, and units.
Operational. The transformation of investigative findings into hierarchically structured categories.
Organized data can facilitate the construction of historical series, the comparison between records, and their...
Integration with databases and Geographic Information Systems. When associated with
Spatial and temporal information, and causal codes can support distribution analyses.
recurrence and territorial relationships of fires (CHUVIECO et al., 2016). In this context,
The following question arises: how to organize and code, in a hierarchical and standardized way,
the causes identified in forest fire investigations, preserving different levels
does it provide detailed information and enable its use in information systems?

Given this issue, this study aims to propose a Classification and
Forest Fire Cause Coding (CCIF), structured into Group, Subgroup, Type
and Specification (GSTE), intended for the systematization and standardization of the results of
investigations. The proposal seeks to organize the causes into hierarchical categories, establishing
Coding and framing rules, including undetermined causes and reignitions,
distinguish the cause from the degree of determination and classification of the event by COBRADE and
to establish a structure that can potentially be integrated with databases and systems of
Geographic Information.

2. THEORETICAL FOUNDATION

2.1 Investigation of the origin and cause of forest fires

Forest fire investigation is a process of technical reconstruction.
intended to identify the area of origin and, when the available evidence allows,
To establish the starting point and the cause of the ignition. This process requires an integrated analysis of the
Indicators of fire spread, fuel characteristics, topography, conditions
meteorological data, material traces, and activities carried out in the investigated area (CHANDLER et al.,
1983; PORRERO RODRÍGUEZ, 2001; NWCG, 2023).

Causal determination presupposes the progressive reduction of the area of investigation until...
identification, where possible, of the zone and point of origin where the following should be examined
elements capable of supporting the identification of the heat source, the ignition medium, and the

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Circumstances associated with the start of the fire. Information from remote sensing.
They can complement this analysis, especially in the spatial characterization of the fire and of
their effects, but they must be interpreted in conjunction with the other elements of
investigation (LENTILE et al., 2006; NWCG, 2023).

Porrero Rodríguez (2001) highlights the investigation of causes as a component
fundamental to understanding forest fires, systematizing different
circumstances related to its origin. In the Brazilian context, specific procedures of
The research has also been discussed in the specialized literature, highlighting the
need for methods capable of organizing the evidence, reconstructing the dynamics of the event and
to technically substantiate the conclusion about its cause (SOARES; BATISTA; NUNES, 2009;
PEREIRA et al., 2010; STURM; ACORDI, 2017).

Causal attribution, therefore, should not arise exclusively from the presence of
a specific activity, infrastructure, or form of land use in the vicinity of the area of
origin. The existence of pasture, agricultural activity, road, power grid, equipment or
any other circumstance potentially related to fire constitutes a contextual element.
which needs to be compared with the other available evidence and information. The cause must
to represent the interpretation technically supported by the body of evidence obtained during the investigation
(PORRERO RODRÍGUEZ, 2001; NWCG, 2023).

2.2 Classification of the causes of forest fires

Determining the cause produces information that needs to be organized in a way...
Consistent to allow comparison between occurrences and analysis of patterns. The classification
In this sense, determining the causes constitutes a complementary step to the investigation, as it converts
different causal circumstances into categories capable of being recorded and subsequently
analyzed.

The literature presents different ways of organizing the causes of fires.
forests. Porrero Rodríguez (2001) systematizes causes and circumstances associated with ignitions,
offering a conceptual basis for distinguishing natural phenomena and different modalities
of human participation. At the European level, the harmonization of the categories used in
The European Forest Fire Information System (EFFIS) demonstrates the need for compatibility.
terminologies and classification criteria to enhance the comparability of information.
originating from different territories and institutions (CAMIA et al., 2013).

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In Brazil, the importance of this organization can also be seen in studies.
on recorded causes of forest fires. Costa et al. (2023), when analyzing occurrences
in Brazilian federal conservation units, they identified different causal categories and
Records whose cause remained unknown. Records with an undetermined cause as well.
were the subject of analysis in fire investigations in Brazil (MACHADO, 2026). In the plan
Internationally, the intentional dimension of ignitions was examined in a study on fires and
arrests for the crime of forest arson in Portugal (GOMES, 2012), and official schemes of
Coding of causes has been adopted by institutions such as the Institute for Conservation of
Nature and Forests (ICNF, [n.d.]).

These results demonstrate that a classification system must be sufficiently
detailed to differentiate causal circumstances and, simultaneously, to admit situations in which
the evidence does not allow for a conclusive determination. A classification intended for
The investigation must therefore have conceptually distinct categories, reducing overlaps.
and allow for different levels of detail. This principle is particularly important.
because the quality and quantity of available evidence are not uniform across the
occurrences. Thus, the classification should allow the record to remain at a higher level.
comprehensive when there are not enough technical elements to support a more comprehensive claim.
specific.

2.3 COBRADE and the hierarchical organization of information

In Brazil, the Brazilian Classification and Coding of Disasters (COBRADE) constitutes
A reference for the organization and standardization of disaster-related records. Its
The structure uses successive hierarchical levels, allowing the representation of phenomena of
broader categories to progressively more specific categories (BRAZIL,
(2012). The hierarchical logic of COBRADE demonstrates the usefulness of classification systems.
in which different levels of detail remain related within the same
structure. This principle allows for aggregating information for general analyses and disaggregating it.
when greater specificity is needed, in addition to enabling the representation of categories.
through standardized codes.

However, classifying a fire as an event and determining its cause is still a challenge.
These correspond to conceptually distinct dimensions. COBRADE classifies the nature of
adverse event or disaster, while a classification of the causes of forest fires should

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to represent the causal circumstance technically established by the investigation. Thus, the Identifying an event does not, by itself, indicate whether its origin was related to a phenomenon. natural, rural activity, equipment, infrastructure, accident, deliberate action, reignition or if remained undetermined.

It is on this distinction that the proposal for the Classification and Coding of is based. Causes of Forest Fires (CCIF). The proposal uses the logic of The hierarchical and codified organization observed in COBRADE, but applied to an object. Specifically: the causes determined in forest fire investigations. The systems They therefore have distinct and complementary functions: COBRADE characterizes the event, While the CCIF seeks to codify the attributed cause from the investigation, maintaining both Information in separate fields.

3. MATERIALS AND METHODS

3.1 Research design

This study is characterized as applied research, of a methodological nature and of a propositional nature, aimed at developing the Classification and Coding of Causes Forest Fire Control Center (CCIF), designed as an instrument to standardize the recording of Causes identified in forest fire investigations. The development of the CCIF. It comprised three stages: (i) identification and systematization of the causes and motivations of forest fires; (ii) adaptation and organization of these categories according to criteria investigative and operational aspects applicable to the Brazilian context; and (iii) structuring a system hierarchical classification and coding. This research corresponds to the stage of The conceptual and structural construction of the CCIF does not include its external validation.

3.2 Conceptual basis and classification framework

The definition of the causes and motivations that underpinned the CCIF was based on the following reference: The main conceptual basis is the work of Porrero Rodríguez (2001). The categories presented therein were used as a starting point for identifying the circumstances related to the origin of forest fires and subsequently subjected to systematization and adaptation terminology adapted to the Brazilian context.

The analysis was supplemented by technical references regarding origin investigation and causes of forest fires, particularly the guide to determining the origin and cause of

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National Wildfire Coordinating Group (NWCG, 2023), used as support for the
Interpretation of ignition mechanisms, investigative evidence, and causal determination.
Thus, these references served a complementary function to the conceptual basis used for
the organization of causes.

For the structuring of the classification system, the following logic was adopted as a reference:
hierarchical structure of the Brazilian Classification and Coding of Disasters (COBRADE). They were
considering its organizational principles in successive levels, progressiveness of
detailed numerical identification of categories. The adoption of this logic was restricted to
classification architecture, since the two systems have distinct objects: while the
COBRADE classifies the nature of the adverse event or disaster, CCIF classifies the cause of the
Forest fire established by the investigation.

3.3 Construction and organization of categories

The causes and motivations identified in the conceptual framework were analyzed.
Comparatively, using qualitative content analysis procedures (ELO; KYNGÄS, 2008), and reorganized
according to their causal nature. Categories with meaning
Similar circumstances were grouped together, with causal mechanisms or meanings.
Distinct ones were individualized.

The construction of the categories considered five criteria: (i) relationship with the origin or
(i) reactivation of the fire; (ii) possibility of differentiation through investigative evidence;
(iii) operational applicability to the Brazilian context; (iv) usefulness for recording, analysis
statistical and spatial; and (v) reduction of redundancies and overlaps.

This procedure resulted in the organization of the causes into seven groups: Natural Causes;
Use of Fire in Rural Activities; Waste, Recreation and Daily Use; Equipment,
Infrastructure and Accidents; Intentional Fire; Undetermined Cause; and Reignition.

The structure was developed progressively, starting from the most common causal families.
comprehensive for more specific circumstances. Categories "not" were maintained.
specified" for situations where the evidence allows for the identification of a particular family.
causal, but they do not support classification at a more detailed level.

During the systematization process, the aim was to distinguish between associated activity and mechanism.
ignition and intentionality. Thus, the presence of a particular rural activity, equipment,
Infrastructure or land use does not, in isolation, constitute sufficient evidence to determine

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the cause. Similarly, the voluntary use of fire in a particular activity does not imply necessarily with the intention of causing a forest fire, the classification being as Intentional arson is contingent upon the existence of evidence to support this interpretation.

3.4 Hierarchical structure and coding rules

Based on the hierarchical logic adopted, the CCIF was structured into four levels: Group (G), Subgroup (S), Type (T) and Specification (E), represented by the code GSTE The Group This corresponds to the most comprehensive causal family; the Subgroup organizes related causes by context, activity or mechanism; the Type identifies the specific causal circumstance; and the The specification allows for additional detail when necessary. The value zero has been reserved. for general categories, not specified or without further subdivision. The maintenance of The four-position format, including the zero in the Specification position, is intentional: this The position remains reserved for future subdivisions, so the inclusion of new Specifications should not alter the length or structure of already assigned codes, preserving Comparability with historical records.

The assignment of codes was guided by the principle of maximum specificity. based on the evidence. Therefore, the classification should only advance up the hierarchy to the level technically demonstrated. When the evidence is insufficient to differentiate For specific categories, the immediately higher level or the "no" category should be used. specified" corresponding.

Intentionality should not be presumed, as per Group 5 — Intentional Fire. applicable only when there is investigative evidence to support the deliberate nature of the act. of the ignition. When it is not possible to determine the cause, Group 6 — Non-Ignition Cause — is used. Determined, although the investigative limitation responsible for the indeterminacy may be recorded. Group 7 — Reinspection is used when there is evidence linking the event to previous fire, including situations related to persistent combustion, aftermath, post-fire surveillance or reactivation.

The cause, the degree of determination of the investigation, and the eventual COBRADE code were defined as independent variables. This separation allows recording, for the same The occurrence, the nature of the event, its investigated cause, and the level of certainty of the conclusion. with no overlap between the classification systems.

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3.5 Proposal Validation

The CCIF presented in this study corresponds to a classification proposal in the phase of Development: content validation, inter-researcher reliability assessment and the application to independent series of occurrences are not part of this stage of the research. Validation plan, including expert evaluation and application testing. Independent, it is detailed in section 4.3.

3.6 Criteria for classification within the boundaries between categories

To guide the application of the CCIF in border situations, the following are established. Decision rules, which can be refined during the validation stage:

- Burning of crop residues (2.1.1.0) × Agricultural waste (3.1.2.0): the function of fire prevails and the local; the burning of crop residues in the field itself, as a tool for managing the agricultural cycle, This falls under section 2.1.1.0, while the burning of agricultural waste outside the production field, such as The disposal method falls under 3.1.2.0; when the function cannot be established, the following is used: unspecified category of the subgroup whose context is best evidenced.
- Mining: accidental ignition (4.6.2.0) × Mining: deliberate ignition (5.2.2.0): classification depends on evidence of deliberation; ignition resulting from an operational accident falls under 4.6.2.0, while the ignition is deliberately set to enable exploration or area clearing. This falls under 5.2.2.0; in the absence of evidence of deliberation, 4.6.2.0 is used, or the non-category is selected. specified corresponding.
- Agricultural purpose (5.1.x) × Land grabbing, irregular occupation or speculative appreciation of area (5.2.3.0): the discriminating axis is the purpose of ignition; the productive purpose falls under 5.1.x, while the appropriative or speculative purpose falls under 5.2.3.0; when both are Present, it is classified by the predominant motivation evidenced and, if indistinguishable, the following is used. unspecified matching category.
- Dispute over property, possession or occupation (5.3.1.0) × Retaliation/interpersonal conflict (5.5.2.0): o The discriminating axis is the object of the conflict; conflicts whose object is land fall under 5.3.1.0. while interpersonal conflicts without a demonstrated land-related object fall under 5.5.2.0.
- Destruction of evidence (5.4.1.0) × Concealment of illegal activity (5.4.2.0): 5.4.1.0 applies when the destruction of evidence constitutes the demonstrated purpose; when destruction is a means to conceal If illegal activity is identified, section 5.4.2.0 applies.

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• Management burning for pasture expansion (2.2.3.0) × Controlled burning (2.4.1.0): the axis
The distinguishing factor is the authorization regime; burning conducted under formal authorization falls under this category.
2.4.1.0, while the practice of handling without formal authorization, or where authorization is not the
In the defining context, it falls under 2.2.3.0; when the authorization status cannot be established,
The corresponding unspecified category is used.

4. RESULTS AND DISCUSSION

The main result of this study was the development of the Classification and Coding of Causes of Forest Fires (CCIF), presented in Table 1. The proposal systematizes causes and motivations related to the occurrence of forest fires in a hierarchical structure and numerically coded, allowing different causal circumstances to be recorded. in a standardized way.

The classification was constructed based on the systematization and adaptation of the causes and motivations identified in the conceptual basis adopted in the study, especially in Porrero Rodríguez (2001), subsequently reorganized according to their causal nature and their possibility of differentiation in the investigative process. The transformation of this content into A coded structure was created by adapting the hierarchical logic employed by Brazilian Classification and Coding of Disasters (COBRADE). Therefore, the contribution The CCIF code does not consist of simply reproducing the categories of the reference work or codes. from COBRADE, but in the integration between a conceptual basis of the causes of forest fires and its own classification and coding architecture.

The four-level architecture and coding rules correspond to those described in Section 3.4. The resulting structure comprises seven main groups: Natural Causes; Use of Fire in Rural Activities; Waste, Leisure and Daily Use; Equipment, Infrastructure and Accidents; Intentional Fire; Undetermined Cause; and Reignition.

Table 1 therefore constitutes the central product of this research. Its organization It makes it possible to represent the same causal family at different levels of resolution. The use of The digit zero for general categories, unspecified or without further subdivision, allows Record only the level actually achieved by the investigation, without obligating the investigator. to select a more specific category when the available elements are not sufficient. This feature also preserves positions in the structure for future expansions.

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Table 1. Classification and Coding of Forest Fire Causes (CCIF)

G	GRUPO	S	SUBGRUPO	T/E	DESCRIÇÃO DA CAUSA	CÓDIGO	SIMBOLOGIA
1	Causas Naturais	1	Causas naturais	0	Causa natural não especificada	1.1.0.0	
				1	Descarga atmosférica (raio)	1.1.1.0	
				2	Combustão espontânea natural tecnicamente comprovada	1.1.2.0	
				3	Outra causa natural comprovada	1.1.3.0	
2	Uso do Fogo em Atividades Rurais	0	Uso rural	0	Uso rural do fogo não especificado	2.0.0.0	
		1	Atividade agrícola	0	Atividade agrícola – não especificada	2.1.0.0	
				1	Queima de restos de cultura	2.1.1.0	
				2	Limpeza/preparo de área agrícola	2.1.2.0	
				3	Queima para implantação de cultivo	2.1.3.0	
				4	Queima associada à colheita	2.1.4.0	
		2	Pecuária/pastagem	0	Pecuária/pastagem – não especificada	2.2.0.0	
				1	Renovação de pastagem	2.2.1.0	
				2	Limpeza de pastagem	2.2.2.0	
				3	Queima de manejo para expansão de pastagem	2.2.3.0	
				4	Manejo pecuário com emprego do fogo	2.2.4.0	
		3	Atividade florestal	0	Atividade florestal – não especificada	2.3.0.0	
				1	Queima de resíduos florestais	2.3.1.0	
				2	Limpeza de área para atividade florestal	2.3.2.0	
				3	Outro manejo de vegetação com emprego do fogo	2.3.3.0	
		4	Manejo autorizado do fogo	0	Manejo autorizado do fogo – não especificada	2.4.0.0	
				1	Queima controlada	2.4.1.0	

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				2	Queima prescrita	2.4.2.0	
				3	Uso tradicional/adaptativo do fogo	2.4.3.0	
3	Resíduos, Lazer e Uso Cotidiano	0	Uso cotidiano	0	Uso cotidiano do fogo não especificado	3.0.0.0	
		1	Queima de resíduos	0	Queima de resíduos – não especificada	3.1.0.0	
				1	Resíduos domésticos	3.1.1.0	
				2	Resíduos agrícolas	3.1.2.0	
				3	Resíduos industriais	3.1.3.0	
				4	Resíduos de jardinagem/poda	3.1.4.0	
				5	Depósito/lixão com propagação para vegetação	3.1.5.0	
		2	Fogueiras/recreação	0	Fogueiras e atividades recreativas – não especificadas	3.2.0.0	
				1	Fogueira recreativa	3.2.1.0	
				2	Fogueira para preparo de alimentos	3.2.2.0	
				3	Acampamento	3.2.3.0	
				4	Atividade cultural/religiosa	3.2.4.0	
		3	Tabagismo	0	Tabagismo – não especificado	3.3.0.0	
				1	Cigarro ou similar descartado em área vegetada	3.3.1.0	
				2	Cigarro ou similar lançado de veículo	3.3.2.0	
		4	Apicultura	0	Apicultura – não especificada	3.4.0.0	
				1	Uso de fumigador/defumador	3.4.1.0	
				2	Outra atividade apícola com fogo	3.4.2.0	
		5	Pirotecnia	0	Pirotecnia – não especificada	3.5.0.0	
				1	Fogos de artifício	3.5.1.0	
				2	Foguetes/artefatos pirotécnicos	3.5.2.0	
		0	Geral	0	Acidente/equipamento não especificado	4.0.0.0	

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4	Equipamentos, Infraestrutura e Acidentes			1	Máquina agrícola	4.1.1.0	
				2	Máquina florestal	4.1.2.0	
				3	Equipamento de corte	4.1.3.0	
				4	Soldagem	4.1.4.0	
				5	Centelha/faísca mecânica	4.1.5.0	
		2	Veículos	0	Veículos – não especificado	4.2.0.0	
				1	Sistema de escapamento	4.2.1.0	
				2	Falha mecânica/elétrica de veículo	4.2.2.0	
				3	Acidente veicular	4.2.3.0	
				4	Veículo estacionado sobre combustível vegetal	4.2.4.0	
		3	Sistema elétrico	0	Sistema elétrico – não especificado	4.3.0.0	
				1	Contato de vegetação com rede elétrica	4.3.1.0	
				2	Rompimento de condutor	4.3.2.0	
				3	Queda/ruptura de poste ou estrutura	4.3.3.0	
				4	Curto-circuito/arco elétrico	4.3.4.0	
				5	Equipamento de geração/distribuição de energia	4.3.5.0	

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		4	Ferrovia	0	Ferrovia – não especificada	4.4.0.0	
				1	Sistema de frenagem	4.4.1.0	
				2	Operação/manutenção ferroviária	4.4.2.0	
		5	Estruturas	0	Incêndio originado em estrutura – não especificado	4.5.0.0	
				1	Residência/edificação rural	4.5.1.0	
				2	Instalação industrial	4.5.2.0	
				3	Galpão/depósito	4.5.3.0	
				4	Incêndio urbano propagado para vegetação	4.5.4.0	
		6	Atividades especiais	0	Explosivos/atividades especiais – não especificado	4.6.0.0	
				1	Explosivos	4.6.1.0	
				2	Mineração: ignição acidental	4.6.2.0	
				3	Atividade militar	4.6.3.0	
5	Incêndio Intencional	0	Geral	0	Incêndio intencional – motivação não determinada	5.0.0.0	
		1	Finalidade agropecuária	0	Finalidade agropecuária – não especificada	5.1.0.0	
				1	Ignição deliberada para limpeza de área	5.1.1.0	
				2	Ignição deliberada para conversão em pastagem	5.1.2.0	
				3	Ignição deliberada para conversão agrícola	5.1.3.0	
		2	Interesse econômico	0	Interesse econômico – não especificado	5.2.0.0	
				1	Aproveitamento de madeira queimada	5.2.1.0	
				2	Mineração: ignição deliberada para exploração ou limpeza de área	5.2.2.0	
				3	Grilagem, ocupação irregular ou valorização especulativa de área	5.2.3.0	
		3	Conflito fundiário/territorial	0	Conflito fundiário/territorial – não especificado	5.3.0.0	
				1	Disputa de propriedade, posse ou ocupação	5.3.1.0	
				2	Conflito relacionado a área protegida	5.3.2.0	
		4	Outro ilícito	0	Ocultação/facilitação de outro ilícito – não especificada	5.4.0.0	
				1	Destruição de vestígios	5.4.1.0	
				2	Ocultação de atividade ilícita	5.4.2.0	
				3	Desvio da atenção de fiscalização/segurança	5.4.3.0	

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		5	Dano deliberado	0	Vandalismo ou dano deliberado – não especificado	5.5.0.0	
				1	Vandalismo	5.5.1.0	
				2	Retaliação/conflito interpessoal	5.5.2.0	
		6	Outras motivações	0	Outra motivação intencional tecnicamente determinada	5.6.0.0	
6	Causa Não Determinada	0	Geral	0	Causa não determinada	6.0.0.0	
		1	Limitações da investigação	0	Limitação da investigação – não especificada	6.1.0.0	
				1	Ponto de início não localizado	6.1.1.0	
				2	Ponto de início localizado, mas sem evidência suficiente da causa	6.1.2.0	
				3	Evidências destruídas pelo incêndio	6.1.3.0	
				4	Evidências alteradas pelo combate/rescaldo	6.1.4.0	
				5	Local alterado antes da investigação	6.1.5.0	
				6	Investigação tardia, com perda de elementos	6.1.6.0	
				7	Hipóteses múltiplas sem diferenciação técnica	6.1.7.0	
				8	Outra limitação técnica	6.1.8.0	
7	Reignição	0	Geral	0	Reignição não especificada	7.0.0.0	
		1	Persistência de combustão	0	Persistência de combustão – não especificada	7.1.0.0	
				1	Reativação dentro do perímetro	7.1.1.0	
				2	Material combustível incandescente remanescente	7.1.2.0	
				3	Tronco/toco/raiz com combustão persistente	7.1.3.0	

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				4	Combustível subterrâneo com combustão persistente	7.1.4.0	
		2	Rescaldo	0	Reignição associada ao rescaldo – não especificada	7.2.0.0	
				1	Rescaldo não realizado	7.2.1.0	
				2	Rescaldo insuficiente	7.2.2.0	
				3	Falha na vigilância pós-incêndio	7.2.3.0	
		3	Condições ambientais favoráveis à reignição	0	Reignição favorecida por mudança ambiental	7.3.0.0	
				1	Intensificação do vento	7.3.1.0	
				2	Redução da umidade relativa	7.3.2.0	
				3	Elevação da temperatura	7.3.3.0	

Source: Prepared by the authors (2026), based on the systematization and adaptation of the causes and motivations of forest fires described by Porrero Rodríguez (2001) and the hierarchical logic of classification and coding of COBRADE.

4.2 Applicability of CCIF and integration with information systems

Transforming the causes of forest fires into hierarchical codes creates Possibilities for use that go beyond the textual record of an individual investigation. In the proposed structure, the cause becomes a standardized categorical variable, subject to change. of storage in databases, operational record systems and systems of Geographic Information Systems (GIS). This feature allows for conclusions to be drawn previously. data recorded predominantly in narrative fields can be recovered, grouped and analyzed according to uniform criteria.

The CCIF was designed to function in a complementary way to other information. related to the fire. In the same database, the event can be identified According to COBRADE; its cause can be registered using the CCIF code; the degree of determination can remain in an independent field; and attributes such as coordinates, date, area affected, Damage, land use and cover, and other characteristics may occupy specific fields. This Separation reduces the condensation of different concepts into a single code and promotes... Interoperability between systems.

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The hierarchical structure also allows for different scales of analysis. The groups can to be used in general causality analyses; the subgroups allow for the examination of sets of activities or mechanisms; and the types and specifications enable targeted analyses to particular circumstances. In this way, the same basis can support both evaluations. strategic as well as detailed operational analyses, without the need to create parallel classifications.

Linking the CCIF code to the geographic coordinates of the occurrence expands this possibility for spatial mastery. A georeferenced database can allow for cartographic representation of the causes and their joint analysis with territorial variables, such as Land use and cover, rural properties, road network, electrical infrastructure, units of conservation, indigenous lands and other spatial elements, supporting density analyses, recurrence and seasonality (CHUVIECO et al., 2016).

Standardization also creates conditions for the formation of historical series of causes. allowing future studies to investigate not only how many fires occurred, but what causes, mechanisms, or activities were associated with the occurrences and how were they The distribution has changed in space and time. The harmonization of causal categories is recognized as relevant for the comparability of forest fire records between different territories and institutions (CAMIA et al., 2013).

This potential, however, should be understood as the expected applicability of structure, and not performance already demonstrated empirically. The present study developed the classification and its coding architecture; has not yet evaluated its Operation based on national databases, historical series, or institutional information systems.

4.3 Limitations and perspectives of validation

The main limitation of the CCIF stems from its own stage of development. The classification presented constitutes a methodological proposal, the structure of which was built to starting from the systematization and adaptation of the causes and motivations identified in the conceptual basis. adopted and its organization in a hierarchical architecture inspired by the logic of COBRADE. Therefore, this study does not demonstrate, at this stage, content validity or reliability. between investigators or operational performance of the classification.

Although the systematization sought to reduce redundancies and establish limits Conceptual differences between categories, only the application of the table to real situations or cases.

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Standardized methods will allow verification of whether different researchers interpret the categories of in a consistent manner. This issue is particularly relevant at the boundaries between rural land use. fire, accidental ignitions, equipment and infrastructure, arson, unintentional cause determined and reignition.

The next step should consist of content validation by experts, including professionals with experience in fire investigation forestry, firefighting, expertise, environmental management, and research. The evaluation should examine clarity. of the denominations, relevance of the categories, scope of the causes covered, coherence hierarchical structure, operational applicability, and the existence of overlaps.

Next, it is recommended to assess inter-rater reliability by applying... Independent of the CCIF, a standardized set of occurrences is used to compare the codes. The assigned data will allow us to verify which categories show greater agreement and which They require conceptual, terminological, or hierarchical revision. The application should include cases with varying levels of evidence availability, in order to test both categories. specifics regarding the mechanisms foreseen for classification at higher levels and for cause not determined.

Brazil's territorial diversity is another relevant aspect for validation. occurrence of different biomes, production systems, forms of territorial occupation, Infrastructure and fire use regulations may reveal circumstances that are not sufficiently clear. represented in the initial version. The application of CCIF in different contexts may therefore, resulting in the inclusion of new categories, reorganization of codes, or refinement of definitions.

It will also be necessary to establish a formal version control mechanism. The inclusion or future modification of categories should, whenever possible, preserve the matching historical records and preventing the same code from being reused for to represent different causes. This procedure will be important to maintain the Temporal comparability as the CCIF is improved.

Thus, the results of this study should be interpreted as the presentation of a initial and systematized classification structure, and not as a demonstration of an instrument. definitively validated. The contribution of this step lies in the proposition of Table 1 and its coding logic, establishing a basis for the following steps to evaluate its Validity, reproducibility, and operational applicability.

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5 CONCLUSIONS

This study presented the Classification and Coding of the Causes of Forest Fires.
(CCIF) as a methodological proposal to systematize and standardize the recording of causes
identified in forest fire investigations. The classification resulted from
systematization and adaptation of the causes and motivations adopted as a conceptual basis in the study
and its organization into a hierarchical coding structure inspired by the logic of
Brazilian Classification and Coding of Disasters (COBRADE).

The resulting structure organizes the causes into four successive levels — Group,
Subgroup, Type and Specification (GSTE) — distributed into seven main groups: Causes
Natural resources; Use of fire in rural activities; Waste, recreation and daily use; Equipment,
Infrastructure and Accidents; Intentional Fire; Undetermined Cause; and Reignition. This
The organization allows for the representation of different levels of causal detail within the same...
classification structure.

The CCIF establishes as a principle that classification should only be awarded to the highest-ranking member.
level of specificity supported by the evidence from the investigation. Thus, when the
If the available elements do not allow for determining a specific circumstance, the record may
to remain in a broader or unspecified category, avoiding causal attributions.
In addition to what has been technically demonstrated. The separation between cause, degree of determination and
The classification of the event according to COBRADE also allows for the recording of distinct dimensions and
complementary aspects of the same occurrence.

Among the elements incorporated into the proposal, the differentiation between the use of stands out.
fire associated with a specific activity and deliberate ignition, the specific treatment of
reignitions and the structuring of the undetermined cause. In the latter case, the classification
It allows recording, when identifiable, the limitation that prevented causal determination.
allowing the indeterminacy itself to be subsequently analyzed as information about
the investigative process.

The proposed hierarchical coding also makes it possible to transform conclusions.
predominantly descriptive investigative studies on standardized categorical data,
potentially incorporable into databases and Geographic Information Systems. This
This feature creates conditions for future statistical, temporal, and spatial analyses of the causes.

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of forest fires, as well as for the construction of historical series and comparison between different territorial and operational contexts.

However, the results of this study correspond to the conceptual and structural construction. The CCIF classification does not depend on demonstrating its validity or operational performance. It will still need to undergo content validation by experts and application testing. independent investigations by different researchers, considering distinct causes and conditions. environmental factors, territorial contexts, and levels of evidence availability. These steps will be... necessary to assess the clarity of the categories, possible overlaps, comprehensiveness and reliability of the framework.

It can be concluded that the CCIF establishes a structured proposal for a classification language. for the causes of forest fires, with the table presented in this study as its product. central. Its initial contribution lies in the systematic organization of causes into a central structure. hierarchical and codified, capable of promoting the standardization of investigative records. Its Consolidation as a technical instrument, however, will depend on subsequent steps. Validation and operational application, from which adjustments can be made. necessary for its use in different contexts of forest fire investigation.

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