Emergency and Disaster Reports

ISSN 2340-9932 Vol 13, Num 1, 2026

Monographic issue

Wildfire Risk Assessment and Mitigation Measures for Rural Housing in Central Chile: Evidence from the Maule Region

University of Oviedo – Department of Medicine
Unit for Research in Emergency and Disaster

Letter from the editor

The Emergency and Disaster Reports is a journal edited by the Unit for Research in Emergency and Disaster of the Department of Medicine of the University of Oviedo aimed to introduce research papers, monographic reviews and technical reports related to the fields of Medicine and Public Health in the contexts of emergency and disaster. Both situations are events that can deeply affect the health, the economy, the environment and the development of the affected populations.

The topics covered by the journal include a wide range of issues related to the different dimensions of the phenomena of emergency and disaster, ranging from the study of the risk factors, patterns of frequency and distribution, characteristics, impacts, prevention, preparedness, mitigation, response, humanitarian aid, standards of intervention, operative research, recovery, rehabilitation, resilience and policies, strategies and actions to address these phenomena from a risk reduction approach. In the last thirty years has been substantial progress in the above-mentioned areas in part thanks to a better scientific knowledge of the subject. The aim of the journal is to contribute to this progress facilitating the dissemination of the results of research in this field.

This monographic issue explores the wildfire risk and proposes mitigation measures for rural housing in Central Chile, Maule Region.

Prof. Pedro Arcos

Editor, *Emergency and Disaster Reports*
Unit for Research in Emergency and Disaster
Department of Medicine. University of Oviedo
Campus del Cristo 33006 Oviedo –Spain
www.uniovi.net/uied

ORIGINAL RESEARCH

Wildfire Risk Assessment and Mitigation Measures for Rural Housing in Central Chile: Evidence from the Maule Region

Rodrigo Missiacos Aliaga, Pedro Arcos González.

ABSTRACT

Background

Wildfires represent one of the most recurrent and destructive hazards in Chile, particularly in rural areas and in the wildland–urban interface. Climate change, prolonged drought, and the predominantly anthropogenic origin of these events have increased their frequency, severity, and complexity, generating significant risks for rural populations and their housing.

The rural localities of Quilico and Los Coipos, in the municipality of Hualañe, and Los Treiles, in the municipality of Río Claro, in the Maule Region, exhibit territorial and construction characteristics that heighten their vulnerability to wildfires. These localities are situated within urban–rural interface zones, where residential dwellings, combustible vegetation, and limitations in critical infrastructure—such as water supply, communications, and evacuation routes—converge.

Objective

To propose prevention and mitigation measures for the localities under study, based on wildfire risk assessments using the methodology of the British Columbia Forest Service (Canada), as adapted by the Chilean Wood Corporation.

Methods

The study employed a methodology adapted by the Chilean Wood Corporation (CORMA), based on the *Wildfire Risk Meter* developed by the British Columbia Forest Service, aimed at assessing wildfire risk in rural housing. The methodology was applied to a sample of 30 dwellings, randomly selected from the localities of Quilico and Los Coipos (Hualañe municipality) and Los Treiles (Río Claro municipality).

The assessment considered variables including: Housing construction materials; Exterior area maintenance and fuel management practices; Location of dwellings relative to surrounding vegetation; Availability of water and tools for initial response; Accessibility to the dwellings; Availability of communication systems; Knowledge and understanding of evacuation procedures during major or complex emergencies. The data obtained enabled the classification of dwellings according to risk levels and the identification of gaps in existing prevention and mitigation measures.

Results

The assessment of 30 rural dwellings indicated that 73.3% were classified as low wildfire risk, 20% as medium risk, and 6.6% as high or extreme risk. The most significant gaps were associated with fuel accumulation, limited water availability, inadequate access routes, and insufficient household and community preparedness.

Conclusions

Based on the identified risk levels, prevention and mitigation measures were proposed across different levels of intervention. These measures include strengthening household preparedness, enhancing local organization through community participation, and implementing territorial-level actions aimed at reducing wildfire risk.

Key proposed measures include improving water availability for first responders and for the refilling of aircraft involved in wildfire protection programs, both governmental and private. In addition, community training initiatives are recommended, along with physical mitigation measures such as the construction of firebreaks, the application of preventive silviculture practices, and land-use planning as critical tools to reduce exposure and vulnerability to wildfires.

Keywords: Wildfires; Disaster Risk Management; Vulnerability; Emergency Preparedness; Exposure; Risk; Capacity; Risk Reduction; Wildland–Urban Interface; Chile.

INTRODUCTION

Chile is recurrently affected by multiple hazards of natural and anthropogenic origin, including earthquakes, tsunamis, mass movements, volcanic eruptions, and—most notably—wildfires. Among these threats, wildfires exhibit the highest frequency nationwide and often escalate into major or complex emergencies. It is therefore essential to clearly understand the concept of a wildfire. According to the definition provided by the National Forestry Corporation (Corporación Nacional Forestal, CONAF), the country's technical authority in this field, a wildfire is defined as a fire that, regardless of its origin and posing danger or damage to people, property, or the environment, spreads uncontrollably across rural land through woody, shrubby, or herbaceous vegetation, whether living or dead (1). In other words, it is an unjustified and uncontrolled fire in which vegetation constitutes the fuel and which, as it spreads, may destroy everything encountered along its advancing front.

Despite this definition, CONAF reports that 99.7% of wildfires are caused by anthropogenic factors, such as negligence in the handling of heat sources, agricultural practices, or deliberate actions driven by diverse motivations, including criminal intent. During the 2020–2021 season, a total of 7,101 wildfires were recorded nationwide; of these, 725 occurred in the Maule Region, including 13 incidents specifically in the municipality of Hualañe (2). These events affected a total area of 11.7 hectares, of which 2.01 hectares corresponded to plantations and 9.69 hectares to natural vegetation. By comparison, during the 2019–2020 season, 39 wildfires were recorded in the same municipality, affecting a total area of 223.13 hectares (3).

Data provided by reports from the United Nations indicate that climate change has increased average temperatures by approximately 1.5°C, along with a loss of nearly 40% of annual precipitation in Chile (3). Consequently, wildfires have preliminarily become more resistant to control, as reflected in CONAF statistics (2). This situation suggests that factors such as prolonged drought, reduced precipitation, and the effective concentration of the four seasons into two—summer and winter—have become additional variables influencing wildfire behavior, alongside temperature, wind speed, fine dead fuel moisture, and low relative humidity (4).

This hazard unquestionably affects the population every year, resulting in loss of human life, damage to property and critical infrastructure, and broader consequences such as environmental degradation and pollution. The development of a wildfire emergency not only entails the deployment of resources by CONAF, but also reflects the institutional mandate established under Supreme Decree No. 733/82 (Article 1), which defines wildfire protection as a regular and fundamental responsibility of the Ministry of Agriculture, exercised through CONAF as part of its mission to protect forest resources in Chile(5).

Nevertheless, public policies, prevention programs, mitigation investments, and other actions implemented in the country are secondary to what may be considered the most critical element: the preparedness of authorities, infrastructure, and the immediate residential environment, coupled with direct support for households in emergency preparedness. Such preparedness—both intrinsic and extrinsic—enhances capacity while reducing vulnerability, thereby lowering overall risk (7).

Accordingly, the purpose of this study is to evaluate housing exposed to wildfire hazards using the methodology of the British Columbia Forest Service, as adapted by the Chilean Wood Corporation (CORMA). The assessment is conducted in the communities of Quilico and Los Coipos, in the municipality of Hualañe, and the locality of Los Treiles, in the municipality of Río Claro, Maule Region, Chile, with the objective of proposing prevention and mitigation measures aimed at reducing community-level wildfire risk.

The impact on the population generates losses not only in terms of human life, but also material, environmental, economic, and social assets, making this issue a major concern for residents of the localities under study. Furthermore, according to assessments by municipal emergency management officers in Hualañe and Río Claro, these dwellings lack formal hazard evaluations and risk diagnoses. As a result, there is an underlying potential risk that may increase significantly in the event of partial damage or total destruction caused by wildfires in the study areas.

This situation is compounded by the fact that emergency personnel—also referred to as first responders—experience long response times when reaching the study areas, limiting their ability to promptly address incidents and protect people and critical infrastructure. Consequently, housing characteristics, geographic location, construction materials, available surrounding fuel, and silvicultural management of vegetation around dwellings are key factors in delaying fire spread and allowing sufficient time for the arrival of suppression resources (8,9). This is particularly relevant in wildland–urban interface zones and rural areas.

At present, community capacity development—including the identification of local human and material resources for emergency preparedness at the household level and within disaster risk management frameworks—constitutes an essential component of prevention. Community organization for planning and developing local emergency plans, together with knowledge acquisition through preparedness activities, is vital for effective response to wildfire incidents (10,11). Moreover, these measures form a foundational basis for household-level response to a wide range of emergencies that may affect the locality.

When prioritized toward safeguarding human life, property, and the environment, and combined with mitigation actions, they further contribute to reducing the overall risk faced by populations exposed to wildfire hazards.

MATERIALS AND METHODS

Study population

The population of interest comprised households permanently residing in three rural localities in south-central Chile: Quilico (Hualañe municipality), located approximately 21 km from the town of Hualañe via Route J-80; Los Coipos (Hualañe municipality), approximately 30 km from Hualañe via Route J-60, Los Coipos junction, and Route J-70-I; and Los Treiles (Río Claro municipality), approximately 32 km from Cumpeo via Route K-245 and then Route K-235 toward the El Bolsico sector. The unit of analysis was the rural dwelling and its immediate surroundings, understood as the wildland–urban interface where conditions of exposure and vulnerability to wildfires are manifested.

Wildfire risk assessment methodology

The Wildfire Risk Meter methodology developed by the British Columbia Forest Service and adapted by the Chilean Wood Corporation (CORMA) was applied to estimate the risk of damage or total loss of dwellings due to wildfires(12). The instrument includes Side A (Hazards), which scores variables related to location, construction characteristics, and environmental conditions (vegetation type, fuel continuity, slope, and access), assigning higher scores to higher levels of risk. Risk interpretation is organized into four categories: Low (19–28), Moderate (29–37), High (38–65), and Extreme (≥66), each associated with graduated improvement recommendations. Side B (Mitigation) deducts points from the total score based on the presence and quality of hazard-reduction measures (firebreaks, fuel management, roof and eave maintenance, defensible space distances, signage, and accessibility), yielding a net wildfire risk score for each dwelling(12).

Study design

The study was structured in six sequential stages:
(a) geographic and demographic characterization of each locality;
(b) coordination and information sharing with local authorities of the Hualañe and Río Claro municipalities;
(c) definition of the sample and selection of dwellings;
(d) briefing sessions with local leaders (neighborhood association presidents) for operational and logistical validation;
(e) application of the instrument, risk analysis, and interpretation of results at both dwelling and locality levels; and
(f) formulation of prevention and mitigation measures at household and community scales.

Ethical considerations

Honesty and transparency in document preparation, compliance with legal standards, and responsible management of potential conflicts were ensured, promoting collaboration and advisory support to households. Considerations of gender equality and socioeconomic structure were incorporated, while data confidentiality was safeguarded and information was used exclusively for prevention purposes and for strengthening household and community self-protection.

Study type and data management

This was a descriptive study based on the compilation of quantitative data at the dwelling level. Records were systematized in a spreadsheet, where net wildfire risk scores were calculated and each household was classified into risk strata. The analysis characterized the distribution of risk and the proportion of households within each category, providing inputs for prioritizing mitigation interventions.

Sample size and sampling

The target population consisted of families residing in rural dwellings that met the inclusion criteria. A sample of 30 dwellings was assessed, defined through simple random probabilistic sampling. The sample size considered an estimation error of E = 0.05 and a 95% confidence level (Z value), with the expected proportion p defined in accordance with the methodology.

Sample size estimation was guided by the expression $N = p(1 - p)[Z/E]^2$, applicable to finite populations under the study assumptions (13). Inclusion and exclusion criteria were restricted to residential dwellings (excluding other types of infrastructure), and the CORMA-adapted risk assessment instrument was applied in a standardized manner.

Interpretation and outputs

Interpretation was conducted using the Risk Meter tables, classifying each dwelling according to its risk threshold and generating specific and cumulative recommendations by locality. The results support a package of prevention and mitigation measures aimed at managing low- and mid-level fuels (gardens, hedges, firewood, weeds), cleaning roofs and eaves, establishing defensible space distances from auxiliary structures and vegetation, improving access and signage for emergency response, and promoting community education on self-protection practices.

At the community level, the study proposes prioritizing areas with higher concentrations of high and extreme risk, coordinating with authorities on fuel-continuity reduction works, and implementing targeted campaigns during high-risk

seasons.

Overall, the approach integrates field-based assessment, objective risk classification, and scalable mitigation proposals, providing evidence to strengthen the resilience of rural housing to wildfires in Quilico, Los Coipos, and Los Treiles.

RESULTS

The Wildfire Risk Evaluator (CORMA/Risk Meter methodology) was applied to 30 rural dwellings distributed across three localities: Quilico (n = 13), Los Coipos (n = 8), and Los Treiles (n = 9). At the overall level, the final classification showed that 22 dwellings (73.3%) were classified as low risk, 6 (20.0%) as moderate risk, 1 (3.3%) as high risk, and 1 (3.3%) as extreme risk. These percentages are derived from a direct count of the total sample and may differ slightly from previously rounded approximations.

Results by locality

Quilico (Hualañe, n = 13).

The risk distribution was highly favorable: 92.3% of dwellings were classified as low risk and 7.7% as moderate risk, with no cases in the high or extreme categories. The average final score was 11 (Low), reflecting adequate site conditions and/or effective mitigation measures. This profile suggests an environment with relatively controlled fuel continuity and exposure, together with sound household-level practices.

Los Coipos (Hualañe, n = 8).

Results were also positive, with 87.5% of dwellings classified as low risk and 12.5% as moderate risk, and no presence of high or extreme risk. The average final score was likewise 11 (Low), indicating a pattern similar to Quilico, characterized by low net exposure resulting from the balance between hazards and mitigation.

Los Treiles (Río Claro, n = 9).

This locality exhibited the most demanding situation: 33.3% of dwellings were classified as low risk, 44.4% as moderate risk, 11.1% as high risk, and 11.1% as extreme risk. The average final score was 22 (Moderate). One extreme case (final score = 44) was identified, associated with high hazard levels (e.g., fuel continuity, slopes, and access constraints) combined with insufficient mitigation, along with one high-risk case (34 points). Overall, this locality shows a higher concentration of exposure and/or deficits in hazard-reduction measures within part of its housing stock.

Comparative synthesis

Predominance of low risk in Quilico and Los Coipos, with identical average final scores (11, Low category). Greater heterogeneity and the presence of critical cases in Los Treiles (average score 22, Moderate category), which concentrates the only extreme and the only high-risk dwellings in the study. Overall distribution (n = 30): Low 73.3%; Moderate 20.0%; High 3.3%; Extreme 3.3%.

Operational interpretation

The results support prioritizing mitigation interventions in Los Treiles, particularly for dwellings classified as high and extreme risk, with emphasis on fuel management, improvements in access and defensible space distances, and strengthening household-level self-protection practices. In Quilico and Los Coipos, maintaining and disseminating good practices emerges as an effective strategy to sustain the current low-risk profile.

DISCUSSION

The results indicate that assessing community capacity cannot be limited solely to levels of preparedness or the evaluation of physical infrastructure. It is also necessary to assess training and knowledge regarding the hazard itself, including appropriate response actions, siting decisions, and—most critically—the recognition of risks surrounding dwellings. In this context, feedback derived from post-emergency management processes should be systematically incorporated into improvement strategies and into Municipal Disaster Risk Management Plans, as field-based assessments are essential for understanding community dynamics, particularly in light of the growing trend of population movement from large urban centers toward rural areas in different regions.

Similarly, surveys addressing underlying territorial risk factors conducted nationwide by the former National Emergency Office (ONEMI), now the National Service for Disaster Prevention and Response (SENAPRED), are aligned with disaster risk reduction scenarios that emphasize medium- and long-term horizons. These approaches focus on land-use planning with inclusive perspectives and coordinated emergency response mechanisms, which should be preliminarily incorporated into Municipal Disaster Risk Reduction Plans as part of the identified challenges. A key objective is to strengthen a preventive culture within communities, thereby reducing, at least in part, the impacts generated by wildfire-related emergencies in the areas assessed in this study (10).

It is important to highlight that, based on engagement with neighborhood associations in the localities of Quilico, Los Coipos, and Los Treiles, residents have received training from municipal authorities on emergency preparedness related to wildfires.

Considering that these communities have previously been affected by such events, this training represents an opportunity to consolidate resilience and reinforce learned values and practices.

However, it is equally important that these experiences are communicated to the highest municipal authorities through city council members and in coordination with the Municipal Council of Civil Society (Consejo de la Sociedad Civil, COSOC). Established under Law No. 20,500 on Associations and Citizen Participation in Public Management, COSOC constitutes a consultative mechanism for citizen participation and plays a key role in integrating community-based learning into local governance(14).

In the case of Los Treiles, located in the municipality of Río Claro, the locality has been affected by a wildfire that placed residential dwellings at risk. This finding is consistent with the information collected through the surveys, particularly regarding construction materials, where respondents reported materials that are no longer commonly used, such as fiber-cement sheets or fonolas. This underscores the need to update this survey item to better reflect current construction practices.

With respect to risk reduction and mitigation measures, the survey item addressing water supply for firefighting operations should be reformulated to better align with the national context, taking into account the dimensions and technical requirements of firefighting vehicles and equipment, as defined by minimum operational standards. These considerations were consistently identified across 100% of the surveys conducted.

Finally, the analysis of the methodology not only highlights opportunities for improving the risk assessment process itself, but also suggests a complementary outcome: the development of a broader disaster risk management evaluator. Such an instrument would integrate knowledge on preparedness, mitigation, and lessons learned, drawing on methodologies such as AIDEP and ACCEDER (15). This enhanced evaluator would generate more comprehensive data to support improved disaster risk management actions by municipalities and by the Municipal System for Disaster Prevention and Response.
The documented increase in wildfires affecting natural forest and forest plantations in Chile underscores the need to strengthen prevention and mitigation strategies (16).

CONCLUSIONS

Based on the field visit conducted—which was preliminary in nature and informed initially by professional observation as a forest engineer—the expected findings suggest that a portion of the sampled population has received some form of emergency training. However, such training has not been explicitly captured by the applied methodology, as residents generally lack clear information regarding the level of wildfire risk to which

their homes are exposed, the potential damage that may occur, and the simple measures that can effectively protect both their dwellings and family units.

The results of the housing assessment indicate that 6.7% of the surveyed dwellings fall within the moderate to extreme risk categories. In light of these findings, and considering the information provided by the Quilico community included in the sample, a set of prevention measures is proposed, prioritizing household-level self-protection. These measures emphasize community training through targeted wildfire prevention programs aimed at strengthening family preparedness.

Furthermore, survey results show that 73.3% and 20.0% of the assessed dwellings are classified as low and moderate risk, respectively. These households have been continuously trained by various emergency management stakeholders, including municipal authorities, CONAF, the regional branch of SENAPRED, Community Prevention Networks, and private forestry companies such as ARAUCO and MININCO, among other organizations cooperating in disaster risk management specifically related to wildfires.

Despite this ongoing capacity-building, these communities face a high probability of being affected by wildfire-related emergencies due to their territorial context. Recurrent exposure to such threats has heightened concern among residents but has also fostered significant resilience. Consequently, community receptiveness to preparedness initiatives increases following direct exposure to hazards, enabling prevention and mitigation information disseminated by technical agencies such as CONAF and coordinating bodies such as SENAPRED to be assimilated more rapidly.

In conclusion, the low-risk category identified in this study is closely associated with households that have received training or possess prior knowledge of programs designed to protect homes from wildfires. This finding underscores the critical role of continuous education, risk communication, and community engagement in reducing vulnerability and sustaining low wildfire risk levels in rural settings.

REFERENCES

1. Chile, Ministerio de Agricultura. Decreto Ley N.º 701, de 1974, que somete los terrenos forestales a las disposiciones que señala. Publicado en el Diario Oficial el 28 de octubre de 1974. Santiago de Chile: Biblioteca del Congreso Nacional de Chile. Disponible en: Ley Chile, Decreto Ley N.º 701.

2. Díaz-Hormazábal, I., & González, M. E. (2016). Análisis espacio - temporal de incendios forestales en la región del Maule, Chile. Bosque (Valdivia), 37(1), 147-158.

3. De Incendios Forestales, S. D. P. PLAN REGIONAL DE PREVENCIÓN CONTRA INCENDIOS FORESTALES.

4. El Mercurio, S. A. P. (2021). Informe ONU señala que calentamiento global se acelera con consecuencias" sin precedentes": Temperatura aumentaría 1, 5ºC al 2030| Emol. com.

5. Cartes Carrasco, R. A., & Marelic Rokov, B. (2015). Los incendios forestales frente al derecho chileno.

6. González, M. E., Lara, A., Urrutia, R., & Bosnich, J. (2011). Cambio climático y su impacto potencial en la ocurrencia de incendios forestales en la zona centro-sur de Chile (33º-42º S). *Bosque (Valdivia)*, *32*(3), 215-219.

7. Ortiz, R. (2012). Gestión del riesgo de desastres en Chile. *Recuperado el*, *22*.

8. Alvarado Ojeda, A., Haltenhoff Duarte, H., Katelman Villirillo, T., & Rojo Almarza, A. (2015). ¿Cómo preparo mi casa y entorno frente a los incendios forestales?: manual de Prevención de Incendios Forestales.

9. Haltenhoff, H. (2006). Silvicultura preventiva. Silvicultura para la prevención de incendios forestales en plantaciones forestales. CL. 38 p. Corporación Nacional Forestal. (Manual de Trabajo 452). Consultado: 22 jul2008.

10. Oficina Nacional de Emergencia ONEMI, (2022). Guía para la implementación Plan Comunal para la Reducción del Riesgo de Desastres.

11. Servicio Nacional de Prevención y Respuesta ante Desastres (2021). Guía para la Realización de ejercicios de simulaciones.

12. Stephen, W. T. (2001). Consideraciones para la aplicación del Sistema Canadiense de Evaluación de Peligro de Incendios Forestales (CFFDRS) en Argentina. Servicio Forestal Canadiense. Centro Forestal del Pacífico. Recursos Naturales Canadá. Manuscrito. BC Ministry of Forests. *British Columbia Canada–Ref*, (14020-90), 02.https://www.bcn.cl/siit/nuestropais/region7

13. Cochran, W. G. (1977). *Sampling techniques* (3rd ed.). John Wiley & Sons.

14. Chile. *Ley N.º 20.500 sobre Asociaciones y Participación Ciudadana en la Gestión Pública*. Diario Oficial de la República de Chile, 16 de febrero de 2011. Biblioteca del Congreso Nacional de Chile.

15. Oficina Nacional de Emergencia del Ministerio del Interior y Seguridad Pública. *Plan Integral de Seguridad Escolar: metodologías AIDEP y ACCEDER*. ONEMI.

16. Peña-Fernández, E., & Valenzuela-Palma, L. (2004, April). Incremento de los incendios forestales en bosques naturales y plantaciones forestales en Chile. In *Memorias del segundo simposio internacional sobre políticas, planificación y economía de los programas de protección contra incendios forestales: Una visión global* (pp. 595-612).