



# Assessment and Causes of Degradation in a Montane Cloud Forest, Granma, Cuba Evaluación y causas de la degradación de un bosque pluvial de montaña en Granma, Cuba

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## ABSTRACT

Forest degradation in tropical regions is a topic of concern due to its implications for climate and biodiversity. The objective of this research is to assess degradation and its causes in a montane cloud forest. The study was conducted in the La Platica Ecological Community within Turquino National Park (PNT), located in the west-central zone of the Sierra Maestra, Granma Province, Cuba. A land cover and use analysis was performed using remote sensing data. The primary causes of degradation affecting the area were evaluated through a survey administered to 20 experts, and 6 forest threats were assessed using a five-level Likert scale. It was demonstrated that, between 1985 and 2014, forest degradation occurred mainly due to agricultural activities. The inter-expert agreement analysis, using global and weighted Fleiss's kappa, revealed disagreement among experts in evaluating the degree of impact, but with a tendency to cluster into adjacent categories when weighting the distances between ratings (weighted Kappa). Selective logging and fuelwood extraction, forest fires, and irregular forest management practices were ranked as the highest-category threats. The most significant correlations, calculated using Kendall's tau, corresponded to a positive association between extreme weather events and forest fires, and an inverse relationship between management irregularities and forest fragmentation. This underscores the need for an integrated approach when evaluating causes of forest degradation.

**Keywords:** Forest Degradation; Forest management; Forest Threats; Kappa Statistic; Remote Sensing.

## RESUMEN

La degradación de los bosques forestales en zonas tropicales es un tema de atención por sus implicaciones en el clima y la biodiversidad. El objetivo de esta investigación fue evaluar las causas de la degradación de un bosque pluvial de montaña en Granma, Cuba. El estudio se desarrolló en la Comunidad Ecológica La Plática del Parque Nacional Turquino (PNT), en la zona centro-occidental de la Sierra Maestra, en la provincia de Granma, Cuba. Se realizó un análisis de cobertura y uso del suelo con datos de teledetección. Se evaluaron las principales causas de degradación que afectan la zona a través de una encuesta aplicada a 20 expertos, y se evaluaron seis amenazas forestales en una escala Likert de cinco niveles. Quedó demostrado que, entre 1985 y 2014, se produjo degradación del bosque debido a actividades agrícolas. El análisis de concordancia entre expertos, mediante kappa de Fleiss global y ponderado, demostró desacuerdo entre los expertos para evaluar el grado de afectación, pero con tendencia a agruparse en categorías adyacentes al ponderar las distancias entre calificaciones (kappa ponderado). La tala selectiva y extracción de leña, los incendios forestales y las irregularidades en el manejo del bosque fueron calificadas como las amenazas de mayor categoría. Las correlaciones significativas más importantes, calculadas por Kendall, correspondieron a la asociación positiva entre eventos meteorológicos extremos e incendios forestales, y la relación inversa entre irregularidades en el manejo y la fragmentación forestal. Esto evidencia la necesidad de un enfoque integrado al evaluar las causas.

**Palabras claves:** Degradación Forestal; Amenazas Forestales; Teledetección; Estadístico kappa.

## INTRODUCTION

Forest degradation is defined as a process that fundamentally alters a forest without necessarily reducing its area or its definition as such. Forest degradation and deforestation can be closely correlated, yet they essentially differ in their definitions and impacts on ecosystem services (Vásquez-Grandón *et al.* 2018).

Deforestation results from the loss or conversion of forests to alternative land uses, whereas degradation maintains forest cover but compromises its quality and functionality. Furthermore, it is worth highlighting that forest degradation often leads to deforestation in tropical regions (Gerwing, 2002; Vancutsem *et al.* 2021), underscoring the importance of an early study to prevent complete forest loss.

Natural forests worldwide have undergone unprecedented deforestation in the second half of the twentieth century. From 1990 to 2020, the world lost 178 million hectares of forests, an area equivalent to the size of Libya (FAO, 2020).

In particular, forest degradation poses a significant environmental, social, and economic problem in developing countries (Muttaqin *et al.* 2019). However, it is a challenging issue to prevent and assess. Degradation is subject to different evaluations and perceptions by various stakeholders, who pursue diverse objectives.

Cuba experienced a progressive process of deforestation and forest degradation due to strong anthropogenic influence for the development of the naval industry, sugarcane, and coffee cultivation, which reduced forested area to 14.0% of the national territory. This led to 14.0% of the flora being composed of extinct or endangered species (Sosa *et al.* 2013).

In the Turquino National Park, located in the Sierra Maestra in eastern Cuba, a National Protected Area with unique biological and geological characteristics, unparalleled natural value worldwide, and a high level of endemism, very few scientific studies have been conducted.

The creation of the Turquino National Park in 1980, through the enactment of Law N° 27 of the Asamblea Nacional del Poder Popular (1980), was a direct response to the urgent need to conserve the montane ecosystems of the Sierra Maestra, which were already showing signs of environmental pressure. The main threats identified at the time included forest fragmentation caused by agricultural activities in lower areas, wildfires in transitional zones between humid forest and pine woodland, selective logging and firewood extraction, as well as pressure on ecologically valuable endemic species such as the Cuban nightingale, and various orchids. The designation of the area as a protected zone aimed to safeguard regional biodiversity, preserve Pico Turquino—the highest elevation in Cuba—and ensure the conservation of the natural and historical-cultural heritage associated with this emblematic mountainous region.

Through satellite imagery, the behavior of the forest cover index in the mountainous massif has been evaluated, where the desired progress has not been achieved, as recovered and degraded areas are observed (Sosa *et al.* 2013).

In this context, the objective of this research was to assess the causes of degradation of a mountain rainforest in Granma, Cuba in the La Platica Zonal Conservation Unit, Granma, Cuba.

## MATERIALS AND METHODS

The Ecological Community La Platica is located within the homonymous Zonal Conservation Unit (UZC). Its geometric center has geographical coordinates N20°00'46.74"; W76°53'27.93" (Figure 1). Both the UZC and its geometric center belong to the Turquino National Park (PNT), situated in the central-western zone of the Sierra Maestra.

The PNT includes areas from the municipalities of Bartolomé Masó Márquez (Granma Province) and Guamá (Santiago de Cuba Province). It borders to the north and east with sectors of the Conservation Area (APC) "Batalla de Santo Domingo" (Bartolomé Masó Márquez municipality). To the east and west, it adjoins zones of the Silvicultural Unit of the Guamá municipality. To the south, its boundary is the Caribbean Sea. It covers an area of 23,210 hectares (Pontius *et al.* 2004).

The terrain features an irregular mountainous topography with slopes ranging from 10° - 30° at the center to up to 50°, and an average altitude above 850 meters. Andesitic rocks predominate. The soil types found are Pardo without carbonates, reddish-brown fersiallitic, skeletal, yellowish ferrallitic, leached red ferrallitic, and yellow ferrallitic (Hernández *et al.* 2015).

According to the Köppen-Geiger climate classification, the area is influenced by a temperate rainy climate (Cf): warm temperate with rainfall throughout the year (Peel *et al.* 2007). It is a montane rainforest without deciduous elements, although it may present deciduous occurrences, with an abundance of epiphytes; it develops in areas with high precipitation levels; with the presence of shrubs, herbaceous plants, and climbing plants (Pontius *et al.* 2004; Challenger *et al.* 2009).

This vegetation formation results in an evergreen forest that can reach up to 30 meters in height, with two well-defined tree strata and a shrub stratum (Bisse, 1988). The presence of typical elements of secondary vegetation stands out, indicating a clear deterioration of the balanced community composition (Hernández, 2017).

La Platica, as an administrative structure of the Turquino National Park, exhibits some of the facilities and emblematic sites of the struggles for independence from the last century, with a small rural settlement.

A land cover analysis was conducted following the methodology of Lillesand & Kiefer (1994), based on remote sensing data,

land cover and land use classification, accuracy assessment, and change detection. This procedure accuracy analysis is based on statistical methods to validate classification and analytical results; it also incorporates confusion matrices, kappa coefficient analysis, and field sampling data collected between 2016 and 2021. The

applied accuracy criteria distinguish the research findings from the limitations identified by GOF-C-GOLD (2016), Herold *et al.* (2011); and DeFries *et al.* (2007), which highlight the shortcomings of remote sensing methodologies for studying forest degradation, though not necessarily for deforestation.

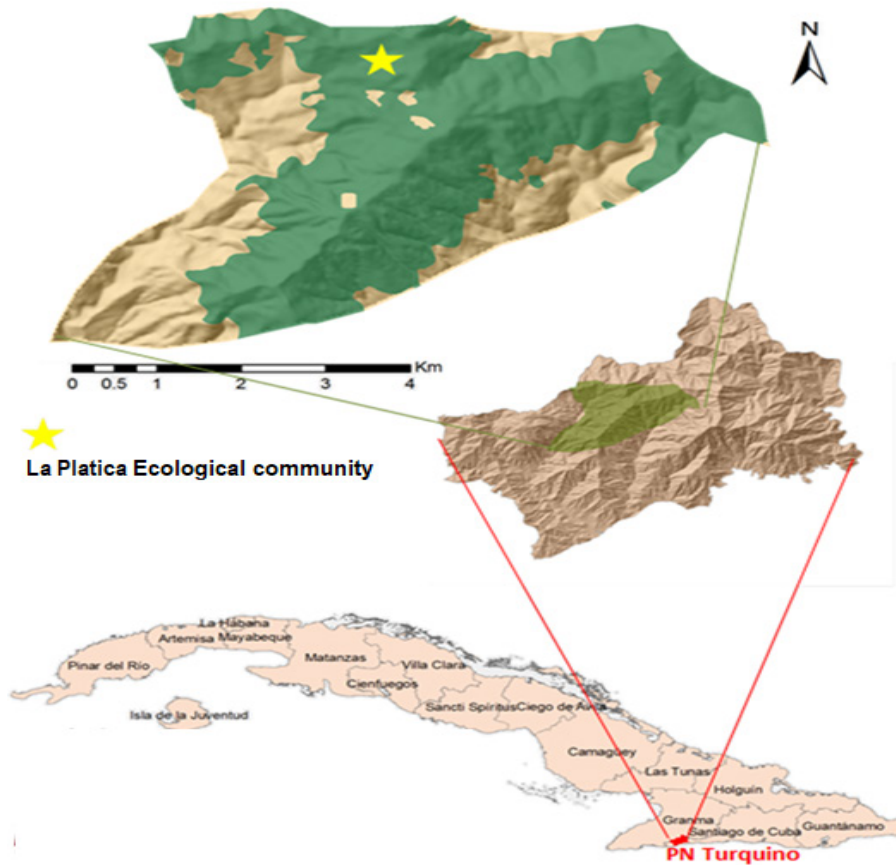


Figure 1. Map of the physical location of the study area in La Platica Ecological Reserve, Turquino National Park, Granma province, Cuba.

For the remote sensing analysis, five satellite images were used: LT05\_012046\_19840416, LT05\_012046\_19850113, LT05\_012046\_19850505, LE07\_012046\_20140121, and LE07\_012046\_20140513, all with cloud coverage of less than 1%. To mitigate information gaps caused by clouds and shadows, temporal fusion with images from nearby dates was implemented. Digital processing was performed using ERDAS IMAGINE 2022 (v16.7.0) and ArcGIS 10.2 (Esri, 2013), applying geometric, atmospheric, and topographic corrections to ensure data accuracy.

Given that the study area covered a portion of the scene, an Area of Interest (AOI) was generated using a pre-existing vector file. This clipping procedure, based on Congalton & Green (2019), allowed for the exclusive extraction of final products corresponding to the analysis zone, optimizing spatial and thematic information management.

To evaluate the leading causes of degradation affecting the area, an inter-observer reliability study was implemented to assess the level of agreement among 20 experts in evaluating the impact of 6 main forest threats. Participants, selected through intentional sampling based on

their recognized professional trajectory in forest management and knowledge of the area, conducted independent evaluations using a five-point Likert scale with the following levels or categories: 1 Null, 2 Low, 3 Medium, 4 High, and 5 Very High.

The threats assessed, which generate data categories different from those derived through remote sensing analysis, refer to processes that exhibit a direct cause-effect relationship with the previously cited data. This integration of datasets underscores the relevance, within the scope of this manuscript, of employing remote sensing for prospecting forest degradation, in alignment with Sánchez-Díaz (2018).

The causes evaluated under expert criteria included: selective logging and firewood extraction, invasion of exotic species, management and governance irregularities, extreme meteorological events, fragmentation, and forest fires. To ensure consistency in the understanding of these threats, each expert was provided with a standardized form containing a brief conceptual description of each threat, thereby establishing a common methodological foundation for evaluations, and mitigating bias.

The global Fleiss's kappa was calculated using the Fleiss's kappa (1971) function from the irr package, a statistical measure that allows for the evaluation of agreement among multiple observers beyond chance when categorizing multiple subjects. This coefficient is interpreted according to the criteria established by Landis & Koch (1977), where values  $\leq 0$  indicate poor agreement; 0.01-0.20 slight; 0.21-0.40 fair; 0.41-0.60 moderate; 0.61-0.80 substantial; and 0.81-1.00 almost perfect agreement.

For each category, specific statistics such as conditional probability (proportion of category use), kappa value per category, standard error, Z statistic, p-value, and 95.0% confidence interval were calculated. The weighted Fleiss's kappa with quadratic weights was determined to consider the magnitude of differences between categories, assigning decreasing weights to larger disagreements.

Additionally, measures of central tendency (mean) and dispersion (standard deviation and coefficient of variation) were calculated for each cause, classifying them according to the Likert scale category to which their mean value was closest, while to evaluate the association between causes, Kendall's correlation coefficient ( $\tau$ ), a non-parametric method suitable for ordinal data, was applied.

All statistical processing was performed using R software version 4.5.1 (R Core Team, 2024).

## RESULTS AND DISCUSSION

The changes in land cover quantified by remote sensing images (Figure 2) estimated for the years 1985 and 2014 detected changes in land cover and land use types during the analyzed period. The observed changes between land cover classes differed in the periods studied.

In 1985, five years after the PNT was established, according to the processed satellite image, approximately 85.0% of the area was covered by forests, sparse and shrub forests constituted 8.6%, while clearings occupied 7.4%. The forest shows signs of degradation, as evidenced in the 1985 Landsat image, apparently resulting from the productive economic activities of the APC operating there. The focus on coffee production (*Coffea arabica* L.) led to the removal of forest fragments to turn them into coffee plantations.

Along with this, subsistence agricultural lands expanded alongside a growing population, from mid-1985 to the early 1990s. Community-related small livestock, coupled with unsustainable grazing practices, also contributed to forest degradation. The selective and illegal use of commercial forest species, under an enrichment plan, became the final factor encouraging and preventing the mitigation of degradation.

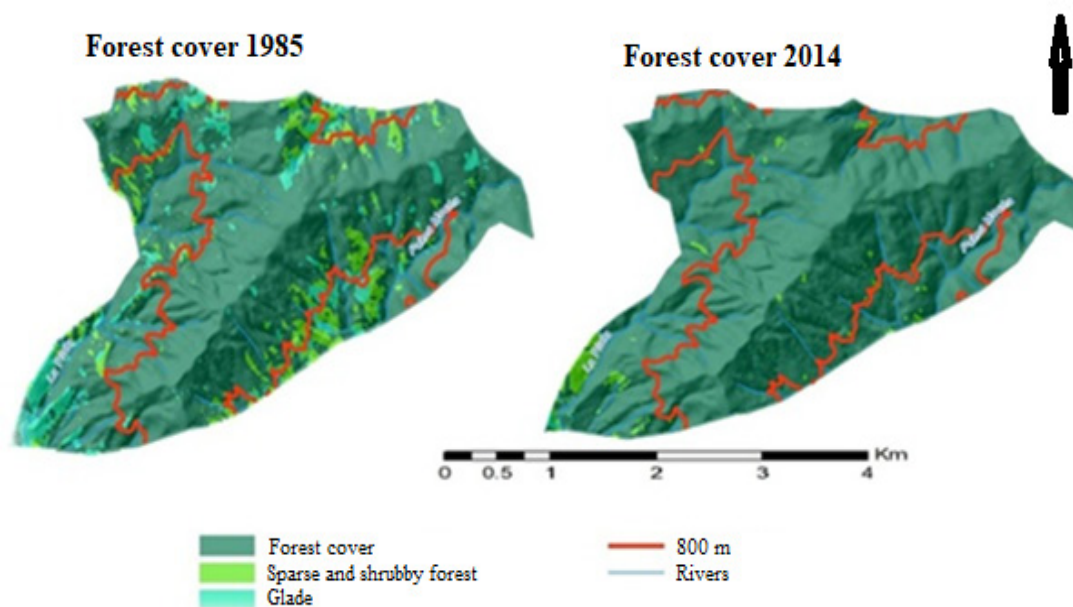


Figure 2. Land cover maps based on the classification of remote sensing images of the study area in La Plata for the years 1985 and 2014.

On the other hand, there is no record of the extent to which the existing forest was modified, or which species were used, elements that hinder understanding the degradation process. In a study on forest degradation in tropical dry forests of Enciso, Santander, Colombia, Gómez-Pacheco *et al.* (2025) demonstrated that 60.71% of the relics show low conservation due to agricultural activities, with structural homogenization and biodiversity loss linked to human pressure and unsustainable soil management affecting its quality (Zeraatpisheha *et al.* 2020).

### Analysis of land use change through coverage percentages

From 1985 to 2014, based on the results of land use change analysis, it can be inferred that, due to the strict conservation policy of the PNT, the study area has gradually recovered from a spatial perspective. In 2014, forest cover reached 97.5%, indicating an increase of 12.5%. Regarding sparse and shrub forests in 2014, they accounted for only 2.3%, a decrease of 6.3%.

These results differ from those obtained by Zanetti *et al.* (2017) in central Veracruz (Mexico). In that study, after a period of slight increase in forest area in previous decades, it strongly decreased from 1990 onwards.

The forest degradation observed in PNT, through aerospace remote sensing reveals patterns of fragmentation and selective logging consistent with high-altitude tropical ecosystems. In contrast, San Juan del Monte in Veracruz, Mexico, exhibits degradation linked to land-use change and invasive species within temperate pine-oak forests. Both cases demonstrate the utility of satellite-based monitoring for detecting spatially explicit threats. However, local

governance and restoration strategies differ significantly, influencing the pace and visibility of ecological recovery.

### Main forest threats through agreement analysis

The results of the agreement analysis using Fleiss's kappa (Table 1) showed moderate agreement among the 20 experts who evaluated 6 forest threats. The overall kappa ( $\kappa = 0.319$ ,  $p < 0.001$ ) indicates reasonable agreement, superior to that expected by chance, according to Landis Koch (1977). Although this result ( $z = 18.1$ ,  $p < 0.001$ ) confirms considerable consensus, evaluations show persistent variability.

Table 1. Results of the agreement analysis using Fleiss's kappa index according to the impact category of the assessed forest threats.

Category	Cond. Probab.	Kappa	SE	Z	Sig.	Lower CI	Upper CI
1 (Null)	0.017	-0.015	0.03	-0.515	0.607	-0.073	0.043
2 (Low)	0.108	-0.095	0.03	-3.203	0.001	-0.153	-0.037
3 (Medium)	0.300	-0.156	0.03	-5.266	<0.001	-0.214	-0.098
4 (High)	0.217	-0.194	0.03	-6.537	<0.001	-0.252	-0.136
5 (Very high)	0.358	-0.167	0.03	-5.635	<0.001	-0.225	-0.109

The analysis by categories reveals a systematic disagreement pattern in all categories except null. The most used categories (Medium, with 30.0%, and Very High, with 35.8%) exhibit the lowest kappa values ( $K = -0.156$  and  $K = -0.167$ , respectively), indicating significant disagreement ( $p < 0.001$ ). In contrast, the null category does not show significant disagreement ( $p = 0.607$ ), probably due to its scarce use (1.7% of the total).

The null category exhibited a conditional probability of 0.017, indicating its use in only 1.7% of all evaluations. The kappa value (-0.015) suggests marginally lower agreement than expected by chance, though very close to zero. The lack of statistical significance ( $p = 0.607$ ) confirms that the observed disagreement is not systematic, but attributable to chance. Additionally, the 95.0% confidence interval (-0.073 to 0.043) includes zero, statistically demonstrating insufficient evidence to establish systematic agreement or disagreement in this category.

The scarce application of this category reflects tacit agreement among evaluators, as no considered threat has a null effect on the studied forest ecosystem. The absence of significant disagreements indicates that experts agree that even seemingly insignificant disturbances generate some impact. This finding supports the principle that forests are complex systems where any modification can have important ecological consequences.

The low category reached a conditional probability of 0.108, applied in 10.8% of evaluations. The kappa (-0.095) indicates agreement

below that expected by chance ( $p = 0.001$ ), evidencing systematic disagreement. The confidence interval (-0.153 to -0.037), negative and excluding zero, confirms this disagreement in classifying threats as having low impact.

The medium category obtained the second-highest conditional probability (0.300), applied in 30.0% of evaluations. The kappa (-0.156) indicates agreement below that expected by chance ( $p < 0.001$ ), revealing systematic disagreement. The confidence interval (-0.214 to -0.098), negative and wide, confirms consistent disagreement in classifying threats as having medium impact.

This category is crucial for forest management, as medium-impact threats represent optimal points for effective and economical interventions. Disagreement among experts could lead to inadequate or delayed management. For example, some classify forest fragmentation as medium based on structural metrics, while others consider it high due to its functional effects on biodiversity. This may be due to disciplinary differences (landscape ecology vs. communities) or experiences in forests with variable sensitivity to fragmentation. The lack of consensus can result in inconsistent preventive measures.

The high category obtained a conditional probability of 0.217, applied in 21.7% of evaluations. Its kappa (-0.194) is the most negative value, indicating the greatest systematic disagreement. The high statistical significance ( $p < 0.001$ ) and the confidence interval (-0.252 to -0.136), negative and wide, confirm pronounced and consistent disagreement.

Disagreement requires constant monitoring, as high-impact threats demand immediate actions and priority resource allocation. This disagreement may originate from differences in the perception of immediate severity versus long-term effects. For example, selective logging may be classified as high for its structural effects or as very high for its cascading impacts on biodiversity.

The very high category shows the highest conditional probability (0.358), applied in 35.8% of evaluations. The kappa (-0.167) reveals agreement below that expected by chance, with high statistical significance ( $p < 0.001$ ). The confidence interval (-0.225 to -0.109), negative and wide, confirms the existence of systematic disagreement, though lower compared to that observed in the high category.

Overall, systematic disagreement is identified in all categories except null. The high and very high categories exhibit the highest levels of disagreement, indicating difficulties in reaching consensus on severe impacts. Even in the very high category, disagreement persists, affecting classification accuracy.

From a forest management perspective, this disagreement is highly significant for managing urgent threats. The absence of consensus, particularly in high-risk categories, can result in inadequate management or inefficient resource allocation, a circumstance of special relevance in the context of climate change.

Disagreements in intermediate categories (medium and high) suggest differences in classification thresholds due to divergent experiences or disciplinary approaches. For this, objective and standardized criteria based on quantitative indicators and protocols applicable in different forest contexts are required.

The weighted Fleiss's kappa analysis ( $\kappa = 0.680$ ) reveals substantial agreement (Table 2), considering differences between ratings. Although experts do not accurately coincide, they tend to group in adjacent categories. The high observed agreement in relation to the expected one indicates optimized consensus when weighting distances between ratings.

Table 2. Weighted (quadratic) Fleiss's kappa estimates and 95% confidence intervals for inter-rater agreement on the impact category assigned to each assessed forest threat.

Statistical	Value
Weighted kappa	0.680
Weighted observed agreement (Po)	0.952
Weighted expected agreement (Pe)	0.850

Srivastava (2025) analyzed forest degradation in Dehradun (India) during the 2000–2023 period using Landsat and MODIS satellite data. He used the kappa statistic and confusion matrices to verify an accuracy of 94.0%, allowing for a robust statistical measure of agreement between the classification obtained and observed reality. This method corrects the agreement expected by chance and helps improve the analysis validity.

Table 3 shows descriptive statistics for the analyzed causes of forest degradation, whose impact degree was established by a Likert scale. Selective logging and firewood extraction had the highest average score, followed by forest fires and irregularities in forest management, all in the very high classification and with the lowest values of the coefficient of variation. Extreme weather events had the lowest score and the highest variation, classified as medium.

Table 3. Descriptive statistics and Likert-scale classification of the drivers of forest degradation, evaluated by 20 experts in La Platica Ecological Reserve, Turquino National Park, 1985–2014.

Cause	Mean	SD	CV (%)	Category
1. Selective logging and firewood extraction	4.84	0.37	7.74	Very high
2. Invasion of exotic species	2.80	0.40	14.66	Medium
3. Management irregularities	4.55	0.50	11.22	Very high
4. Extreme meteorological events	2.85	0.93	32.75	Medium
5. Forest fragmentation	3.00	0.79	26.49	Medium
6. Forest fires	4.75	0.44	9.35	Very high

Selective logging in tropical forests modifies canopy architecture, resulting in reduced light capture and negatively impacting biodiversity. Additionally, it decreases efficiency in the organic carbon respiration cycle, leading to a net loss of carbon in forests (Riutta *et al.* 2021). This practice alters ecological structures and biogeochemical processes; effects associated with changes in the stability of organic soil (Qin *et al.* 2024).

A study conducted in Dehradun, India, revealed that forest fires caused the loss of 650 hectares of tree cover between 2001 and 2023, emitting 430 kilotons (kt) of CO<sub>2</sub>. Average annual emissions reached 18.7 kt of CO<sub>2</sub>, highlighting their significant impact on atmospheric concentrations (Srivastava, 2025).

Low coefficients of variation (CV) for selective logging and fires (very high agreement level among experts) indicate high consistency in their perception as critical threats. The high CV for extreme weather events (medium agreement level) reflects uncertainty, perhaps due to their spatiotemporal variability. The results identify selective logging, fires, and inadequate forest management as the

main threats (low CV, very high agreement level), with average ratings between 4-5 (scale 1-5), confirming their criticality.

Inadequate forest management causes severe environmental and social consequences, such as deforestation, degradation, and resource conflicts. Conversely, effective community management, with balanced relationships between state and community, promotes conservation, local empowerment, and sustainable development (Arts *et al.* 2023).

**Correlation analysis**

Kendall’s correlation analysis identified seven statistically significant associations between causes (Figure 3), ordered from highest to lowest absolute coefficient value. The correlation with the highest coefficient was the positive association between extreme weather events and forest fires, followed by the negative relationship between management irregularities and forest fragmentation.

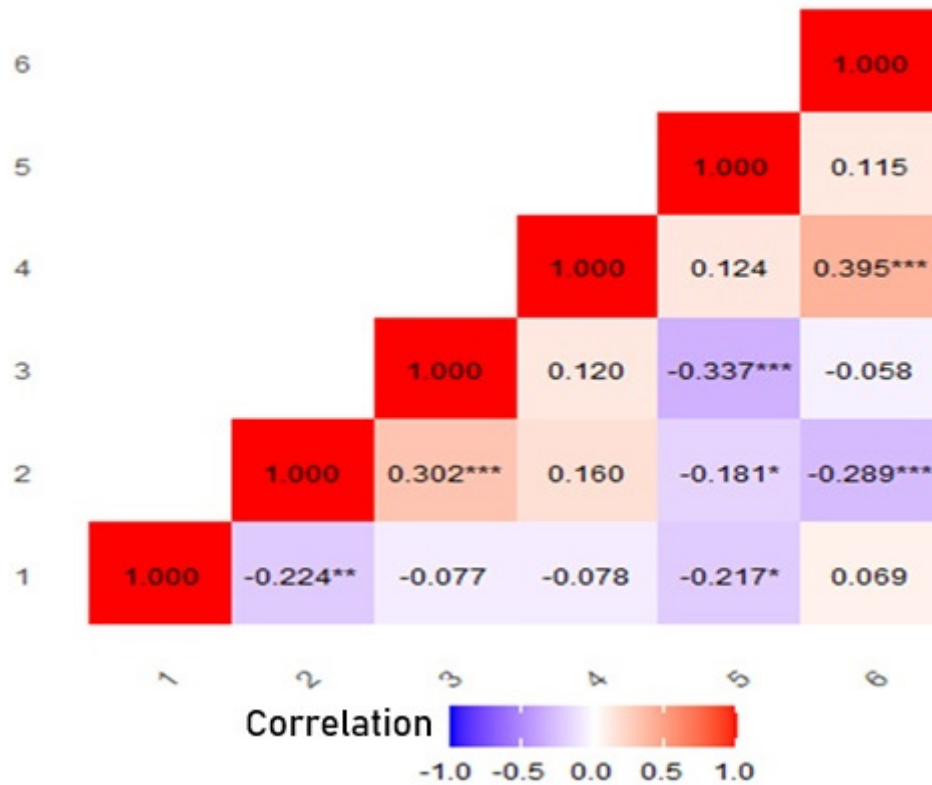


Figure 3. Kendall’s partial correlation matrix among the 6 causes surveyed using a heat map with its corresponding scale. The numbers on the X and Y axes are in the same order as the causes in Table 3. The correlation coefficient value appears in each grid. \*, \*\*, \*\*\* indicate significant differences for p values lower than 0.05; 0.01 and 0.001, respectively.

A positive correlation between the invasion of exotic species and management irregularities was found, followed by the negative association between the invasion of exotic species and forest fires. In descending order, a negative correlation between selective logging and the invasion of exotic species was identified, followed by the negative relationship between selective logging and forest fragmentation.

The weakest significant correlation was the negative association between the invasion of exotic species and forest fragmentation. The remaining correlations analyzed between different causes of forest degradation did not show statistical significance.

The negative association between the invasion of exotic species (medium) and forest fires (very high) is particularly interesting, as it could indicate that frequent fires create less favorable conditions for the establishment of certain invasive species, or that experts perceive that these threats operate in different ecological contexts. These findings underscore the complexity of interactions between multiple forest degradation factors and the need for integrated management approaches that consider both direct threats and their synergies.

The results have important practical implications for forest ecosystem management, such as improving expert consensus, prioritizing consensual threats, focusing on extreme categories, managing uncertainty, and the importance of weighted agreement among experts.

**Improving expert consensus:** The highest global kappa ( $\kappa = 0.319$ ) suggests improved consensus among experts, perhaps due to greater shared experience or better understanding of forest threats. This greater agreement facilitates decision-making based on expert knowledge.

**Prioritizing consensual threats:** Threats with greater agreement (such as selective logging, management irregularities, and forest fires) should be prioritized in management strategies, as they represent universally recognized problems with well-documented impacts.

**Focusing on extreme categories:** The greater use of “high” and “very high” categories (21.7% and 35.8%, respectively) suggests that experts perceive forest threats as serious problems. This justifies the implementation of robust and preventive management measures.

**Managing uncertainty:** Variability in threat evaluations, such as extreme weather events and fragmentation, suggests that management strategies should incorporate adaptive approaches that consider this uncertainty. This includes continuous monitoring, periodic evaluations, flexibility in interventions, and implementation of quantitative evaluation methodologies.

**Importance of weighted agreement:** The high weighted kappa ( $\kappa = 0.680$ ) indicates that, although differences exist in accurate ratings, experts tend to agree on the general magnitude of threats. This provides a solid basis for decision-making in forest management, especially when considering relative differences between categories.

It is recommended to complement these expert evaluations with quantitative monitoring data and the introduction of indicators to improve evaluation accuracy and adapt management strategies to specific local conditions.

These results are consistent with the assessment proposed by Bustamante *et al.* (2016) when they state that processes such as anthropogenic fires, selective logging, or overexploitation of a resource are the most commonly reported direct causes of forest degradation (Budiharta *et al.* 2014).

Forest degradation in the Congo is primarily caused by the expansion of commercial and subsistence agriculture, mining, infrastructure development, and urban expansion, which, together with armed conflicts, negatively affect forest condition (Shapiro *et al.* 2021).

The results demonstrated that from 1985 to 2014, a degradation process occurred in the forest largely due to the promotion of agricultural productions, especially coffee production.

The principal threats and causes of degradation of a montane moist forest in the La Platica Zonal Conservation Unit, Granma, Cuba, in descending order of importance as evaluated by experts, are selective logging and firewood extraction, forest fires, and forest management and governance irregularities. The rest, although considered to have a lesser impact, include the invasion of exotic species, extreme weather events, and forest fragmentation, but all should be methodologically monitored from an integrated approach.

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