

# Current Status and Dynamics of Illegal Wildlife Hunting in the Sao La Nature Reserve Thua Thien Hue, Viet Nam

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## ABSTRACT

Although substantial support has been from the government and local authorities to reduce dependence on forest resources, hunting wildlife for food and selling it to increase income remains relatively common in remote and mountainous communities in Thua Thien Hue province. This study aims to assess the situation and fluctuations in wildlife hunting in the Thua Thien Hue Saola Nature Reserve. The research utilizes a combination of household interviews, group discussions, expert interviews, as well as inheriting results from biodiversity monitoring surveys, data from camera trap systems, and more to evaluate the level of dependence on forest resources, the changes in wildlife hunting activities, and the correlation between areas rich in wildlife resources and the wildlife trapping systems used by local communities in the buffer zones of the Thua Thien Hue Saola Nature Reserve, located in the Nam Dong and A Luoi districts of Thua Thien Hue province. The study reveals a decreasing dependence on forest resources among local communities, the areas where they commonly set traps for wildlife, and the changes in these practices over time. It also identifies priority areas for wildlife resource protection and management activities and issues that need attention in community awareness-raising and educational outreach. It underscores the potential and importance of developing livelihood models for local people to reduce their dependence on forest resources and wildlife exploitation, offering inspiration and motivation for positive change.

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RK conceptualize and supervised the study. TNQT collected data, wrote and formatted the manuscript. IM conceptualized, analyzed and reviewed the manuscript.

## Key words

Forest resources, Wildlife hunting, Biodiversity monitoring, Camera trap, Wildlife resource protection, Wildlife exploitation

## INTRODUCTION

Non-sustainable hunting has decimated tropical forests worldwide (Benítez-López *et al.*, 2017, 2019; Harrison *et al.*, 2016). Moreover, the loss of forest fauna puts certain ecological services connected to human well-being at risk (Lacher *et al.*, 2019). Since, large vertebrates carry out ecological tasks that are essential to preserving healthy tropical ecosystems (Krause and Tilker, 2022). Regardless of increased protected area coverage and site-based conservation initiatives, certain locations have experienced significant reductions in animal and avian

species (Tilker *et al.*, 2024). Evidence-based conservation practices are growing in order to reduce wild meat hunting. Distinct livelihood opportunities are offered by non-governmental organizations (NGOs) in central and west Africa. However, time duration and financial capacity impact short-term grants, making it difficult to achieve goals. Moreover, projects seldom include conditions and penalties, which might cause the alternatives to be supplementary rather than replacement activities (Wicander and Coad, 2018). Vietnam, home to over 7,000 marine invertebrates and 10,500 terrestrial species (Loung, 2022), is both a wildlife consumer and a key transit hub in the transnational wildlife trade (Van Asch, 2017). Regardless of initiatives to combat degradation of biodiversity, Viet Nam is facing substantial biodiversity devastation. According to recent IUCN and WWF reports, 38% of fish, 24% of amphibians, 21% of mammals, 6.5% of birds, 19% of reptiles, and 2.5% of plants are considered endangered species (WWF, 2021; IUCN, 2023). Quang and Noriko (2008), investigates the execution of Vietnam's forest policy, which assigns forest land to individual families for administration and expansion. Local residents in the community violated the forest allocation policy

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by freely lending and borrowing forestland for cropping, regardless of their wealth, land availability, or legal status. In 2016, the Wildlife Justice Commission (WJC) held an open session at the Peace Palace in Hague to investigate wildlife smuggling in Nhi Khe commune (Covert, 2016). Vietnam remains a significant local transportation center for IWT operations (Loung, 2022). Vietnam prohibits the shooting, trapping, and snaring of animals; however, this practice is nevertheless common and is seen to represent the most significant risk to many species (Macmillan and Nguyen, 2014). According to 2017 data, there were 1,352 recorded violations related to wildlife, including 65.2% involving trade and advertisement, 21.1% involving illegal captivity, and 1.61% involving wildlife hunting. A total of 829 cases were reported via a hotline by citizens, marking a 29% increase compared to 2016 (WWF, 2017). Of these, 399 cases were resolved, with a success rate of 48%, a 6% increase from 2016. This increase in the success rate of resolving cases is a positive sign of progress, offering hope for the future of wildlife protection in Vietnam. Wildlife protection violations were most frequent in Ho Chi Minh City, Vung Tau, and Hanoi (EVN, 2017).

The Thua Thien Hue Saola Nature Reserve spans two districts, Nam Dong and A Luoi. The buffer zone of the Thua Thien Hue Saola Nature Reserve covers five communes and is home to approximately 12,000 people across 2,766 households. Most residents live in the northwest and southeast regions of the buffer zone. Snare hunting, primarily using wire snares, continues to pose the greatest threat to biodiversity in the Thua Thien Hue Saola Nature Reserve (USAID, 2018; WWF, 2023). Some previously known species have not been recorded in recent surveys, possibly because they have disappeared or are nearly extinct. These species include (1) extensive and medium-sized carnivores (tiger, clouded leopard, dhole, wild cats, and sun bear) and (2) large ungulates (large-antlered muntjac) (WWF, 2017). While some individuals of these species may still exist within the landscape, they cannot sustain viable populations. Current data suggests that these species are either extinct or functionally extinct (no longer play a significant ecological role). The environmental consequences of the disappearance of these species through cascading effects have not been studied in this area. However, studies from other tropical ecosystems indicate that the absence of apex predators or large ungulates can have severe ecological repercussions (Terborgh *et al.*, 2001).

Non-selective snares are a leading source of animal reductions in tropical forests. Snares are inexpensive, simple to install in large quantities, and very successful in trapping terrestrial vertebrate species (Gray *et al.*, 2021). Current investigation has shown that snare-driven

elimination poses a serious risk to ground-dwelling animals and birds in Africa (Bi *et al.*, 2017) and Asia (Belecky and Gray, 2020; Groenenberg *et al.*, 2023). Snaring is still a serious and persistent issue, and it has been particularly devastating in Southeast Asia, where it has drastically decreased biodiversity in numerous protected areas (Gray *et al.*, 2021). The large-scale use of wire snares throughout the landscape and in Southeast Asia has been highlighted in numerous reports (Gray *et al.*, 2017, 2018; Minh and Tuan, 2018). During the six years of the WWF CarBi project, from 2011 to 2017, over 100,000 snares were removed from the Thua Thien Hue Saola and Quang Nam Saola Nature Reserves (WWF, 2017). The presence of snares has significantly decreased due to intensified patrols and law enforcement activities, likely reducing the negative impact on trap-sensitive species. However, the level of snare hunting remains high in the forest, and despite continuous patrol efforts, a substantial number of snares are still being dismantled by patrol teams annually. In recent years, despite extensive efforts by the Nature Reserve and the international community to control illegal wildlife hunting, various types of snares, ranging from simple to complex, persist in many areas and are considered a significant threat to the decline of wild mammal populations. Many rare species face a high risk of extinction, including the Saola a species found only in central Vietnam and southern Laos. Viollaz *et al.* (2021) investigated snare poaching in three Vietnamese protected areas utilizing crime script analysis with the goal of enhancing community-based crime prevention tactics. The study analyses criminal scripts for three different types of poachers across nine phases of the poaching process. The report provided comprehensive insights into the procedures involved in poaching, from preparation to selling the catch. These findings highlight several preventative intervention areas to address different forms of poaching. Our study did not use criminal script analysis to comprehensively evaluate the standard features of poaching operations. Incorporating criminal script analysis in future studies may provide a more organized comprehension of the trafficking and assist in determining particular intervention areas for preventative initiatives.

This study aims to compile and assess the current status of wildlife hunting activities in the Thua Thien Hue Saola Nature Reserve during the 2017-2022 period and propose policy and technical solutions to minimize wildlife hunting in the study area.

Despite government efforts, hunting wildlife for food and income remains prevalent in remote areas, this study (i) assesses the dependency on forest resources, changes in hunting practices, and the areas with significant wildlife traps. (ii) highlights a decreasing trend in forest dependency among locals, which is crucial for wildlife conservation

efforts, although illegal hunting is still common; (iii) identifies priority areas for wildlife protection and management, especially zones where wildlife traps are concentrated and (iv) suggests improving local awareness and developing sustainable livelihood models to reduce the reliance on forest resources and wildlife hunting.

The main objectives are to (1) determine the level of dependence on forest resources and the current state of wildlife trapping systems residents; (2) identify shifts in methods and techniques of snaring, the types of snares used by locals in response to changes in policies and enforcement measures by forestry law agencies; (3) establish the correlation between the number of snares, the areas where they are set, and the distribution of target wildlife species; and (4) develop and propose management and conservation solutions for wildlife.

## MATERIALS AND METHODS

### *Study area*

The research was conducted in two communes, Huong Nguyen and A Roang, in A Luoi district, and two communes, Thuong Quang and Thuong Long, in Nam Dong district.

### *Data collection and study subjects*

The study subjects include residents and professional hunters specializing in wildlife trapping system and hunting wild animals. Saola Nature Reserve and Forest Protection Forces staff were interviewed and participated in discussions to document outcomes and information during patrols and snare removal operations. Secondary data were collected, including socioeconomic information and the natural conditions of the Huong Nguyen and A Roang communes in the A Luoi district and the Thuong Long and Thuong Quang communes in the Nam Dong district. Over the past five years, data on forest management and protection efforts in the Saola Nature Reserve were reviewed, along with biodiversity monitoring surveys, management plans, conservation needs assessments from the Saola Nature Reserve, and activity reports from the CarBi project in Thua Thien Hue. Data from the SMART (spatial monitoring and reporting tool) system was used for patrol and biodiversity monitoring system in the Saola Nature Reserve, and information from books, newspapers, and published materials was also utilized.

Interviews were conducted with 30 residents/hunters per village, and group discussions were held with four groups per commune (10 people per group). Forest rangers and protection staff were interviewed to understand traditional and current hunting methods, comparing them with field observations on locations, techniques, snares,

and target species.

### *Patrol and forest protection data collection*

Patrol and forest protection data were collected on-site using GIS and the SMART system to record all instances of illegal snares set in the forest, including the compartment, time of detection, coordinates, snare type, quantity, condition, and handling measures. This was combined with biodiversity monitoring survey data collected from camera traps in the study area during the same period.

### *Statistical analysis*

The collected data were classified and processed using Microsoft Excel 2021 to create descriptive statistical tables and charts for the research content. All patrol information was updated in the SMART system, where the data structure had been established to support updating wildlife snare-related information. The data fields were digitized and represented on maps using specialized GIS software.

## RESULTS AND DISCUSSION

The present study was conducted to evaluate the trends and present scenario of illegal hunting for wildlife in Thua Thien Hue, Vietnam's Sao La Nature Reserve. The study shows that local communities in the research area continue to rely on forest resources and exert significant pressure on forest resources through wildlife hunting for consumption and sale. Living in dependence on the forest has been a long-standing practice and tradition of the local communities in the study area. All daily activities, from improving meals to making a living, rely heavily on the forest. Although the government has implemented various support policies, and local authorities have introduced poverty alleviation programs for buffer zone households, the illegal exploitation of forest resources has not been effectively curtailed. Buffer zones safeguard the natural integrity of forests and support community development. The empirical investigation of the Chu Yang Sing National Park in Vietnam examines how ethnic minorities' local livelihoods affect the long-term sustainability of buffer zones. The result revealed that Ethnic minorities mostly rely on gathering forest products for a living, and many continue to live below the national average. Furthermore, their unregulated exploitation had a severe influence on the biodiversity of the national park, leading to a negative impact on the livelihoods of residents (Phuong *et al.*, 2019). Interviews with households and group discussions in the study area revealed that the forest is still regarded as a communal asset, and all villagers feel entitled to exploit

**Table I. Status of hunting and utilization of certain wildlife species in the region.**

| Species                       | Hunting season<br>(months of the year) | Target | Method     | Usage |      | Status |
|-------------------------------|----------------------------------------|--------|------------|-------|------|--------|
|                               |                                        |        |            | Food  | Sale |        |
| <i>Muntiacus</i> sp.          | Rainy season                           | Male   | Trap       | ✓     | ✓    | +      |
| <i>Nycticebus</i> spp.        | Year-round                             | Male   | Shot       | ✓     | ✓    | +      |
| <i>Capricornis</i> spp.       | Rainy Season                           | Male   | Shot, trap | ✓     | ✓    | ++     |
| <i>Varanus</i> spp.           | 5 - 6                                  | Male   | Shot, trap | ✓     | ✓    | ++     |
| <i>Gekko gekko</i>            | Year-round                             | Male   | Shot       |       |      | ++     |
| Testudines                    | 11 - 4                                 | Male   | Trap       | ✓     | ✓    | +      |
| <i>Macaca</i> spp.            | Rainy Season                           | Male   | Trap       | ✓     | ✓    | ++     |
| <i>Mustela</i> spp, Sciuridae | Year-round                             | Male   | Trap       | ✓     | ✓    | +++    |
| <i>Muntjacs</i>               | Rainy Season                           | Male   | Trap       | ✓     | ✓    | ++     |
| <i>Gallus</i> spp.            | Year-round                             | Male   | Trap       | ✓     | ✓    | ++     |
| <i>Sus scrofa</i>             | Rainy Season                           | Male   | Trap       | ✓     | ✓    | +++    |
| Serpentes                     | Year-round                             | Male   | Shot       |       | ✓    | +      |
| <i>Python</i> spp.            | Year-round                             | Male   | Shot       | ✓     | ✓    | ++     |

+++; abundant; ++, moderate; +, scarce.

and use it to address food shortages and increase their income. Table I shows the present scenario of hunting and exploitation of wildlife in the region.

Our findings are consistent with the study conducted by Minh and Tuan (2018) on illegal hunting in Phong Dien Nature Reserve (also located in Thua Thien Hue) emphasizes the cultural drivers of hunting, suggesting that hunting is deeply ingrained in the traditions of local communities. Wildlife trapping and hunting remain rampant and uncontrollable. The direct cause of this issue lies in the people's habitual reliance on nature, as hunting and gathering are nearly instinctual. Moreover, wildlife products are considered high-end and expensive food and medicinal items, further incentivizing local people to engage in wildlife hunting.

The division of labor among household members is relatively straightforward regarding gender roles. Women typically handle tasks related to farming and collecting non-timber forest products. In contrast, men engage in more labor-intensive activities, such as hunting and logging, to generate cash income for the family. Most households possess tools for hunting and trapping wildlife. Wildlife trade remains largely unregulated, with wild animals becoming commodities in specialty restaurants in towns and cities. Local people hunt when they need food or require cash during festive seasons or the lean months before harvest. Nyaupane and Poudel (2011), also revealed that poverty and starvation are the primary drivers causing excessive consumption and destruction of

natural resources.

Household surveys indicate that the average per capita income in the study area is low, at approximately 12.075 million VND per year. Of this, revenue from agriculture accounts for 74.1%, income from forestry production 3.7%, income from hunting and collecting non-timber forest products 7%, and other sources 15.2%. These results demonstrate a significant reduction in dependence on forest resources compared to previous studies in the area (Thang *et al.*, 2010). From 2017 to 2022, the Thua Thien Hue Saola Nature Reserve conducted 694 patrols and trap removals (an average of 11.5 patrols per month) with more than 17,618 labor days, covering over 31,480 kilometers of patrol routes. Table II summarizes the number of traps detected and removed over the years.

**Table II. Number of types of trap detected and removed from 2017 – 2022.**

| Type of trap                  | Quantity (units) |
|-------------------------------|------------------|
| Snare with fence              | 16,733           |
| Snare without fence           | 19,053           |
| Large snare (heavy-duty wire) | 20,707           |
| Small snare (light wire)      | 7,350            |
| Clamp trap                    | 225              |

The statistical table of the different types of traps shows that 64,068 traps were removed, of which 28,057

were leg-hold traps (both large and small), accounting for 43.79% of the total traps removed. This was followed by wire traps without fences, with 19,053 traps accounting for 29.73%, wire traps with fences, with 16,733 traps accounting for 26.11%; and clamp traps, with 225 traps. These figures indicate that local people's impact on forest resources remains substantial. [Gray et al. \(2018\)](#) highlighted the wildlife snaring crisis across Southeast Asia, focusing on Laos, Cambodia, and Vietnam. They noted that snaring is a leading cause of the decline of the wildlife population in Southeast Asia, including Vietnam. The Sao La study supports these findings by showing that snaring remains widespread and destructive despite removing over 100,000 traps.

From 2020 to 2022, many forestry policies were issued and implemented, significantly enhancing state management responsibilities for forestry from the central to local levels. These policies also played a significant role in livelihood support activities and in raising public awareness, which has partly changed the perceptions and responsibilities of local people regarding forest management, protection, and biodiversity conservation. Consequently, in the Sao La Nature Reserve, Thua Thien Hue, there have been changes in wildlife trapping systems by local people. Specifically: Through comparing the distribution maps of traps between these two periods, it can be observed that the primary trapping areas have shifted and contracted closer to the Ho Chi Minh road, focusing on subzones 345, 351, 352, 353, and the boundary between subzones 353 and 404, 405 ([Fig. 1](#)).

The total number of traps removed from these areas reached 7,943, accounting for over 58.3% of the traps removed during 2021-2022. These areas are easily accessible for local people, thus reducing the time spent in the forest and avoiding detection and apprehension by forest protection forces. The analysis of data from the study area shows that the timing of trap placement by local people has not changed significantly over the years. Traps are primarily set during the rainy season, while fewer traps are observed and removed during the dry season ([Fig. 2](#)).

During the survey in the Sao La Nature Reserve, Thua Thien Hue, using randomly placed camera traps, 16 species were recorded in Subzone 405, 6 in Subzone 404, and 10 in Subzone 352. To better understand the biodiversity in the study area, the research has modeled the distribution of wildlife species on a map. For the scope of this study, wildlife was divided into two groups: medium and large animals (e.g., monkeys, muntjacs, goats, wild boars, bears, deer) and small animals (e.g., weasel, martens, rodents, turtles, pangolins). The camera traps most frequently captured monkeys, goats, and wild boars among these. During patrols, forest protection staff record sightings

of species on pre-prepared patrol sheets (including information such as the location's coordinates, species, and number of individuals). This data is then entered into the forest patrol monitoring system. The results show that the highest number of sightings and individual animals were concentrated in subzones 350, 351, 352, 353, 404, and 405, with wild boars, goats, muntjacs, and bears being the most frequently observed species ([Table III](#)).

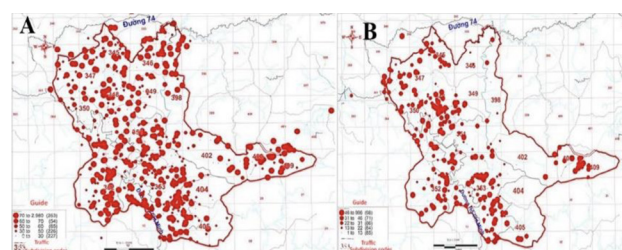


Fig. 1. Trap distribution by local people. A, 2018-2020 period; B, 2021-2022 period.

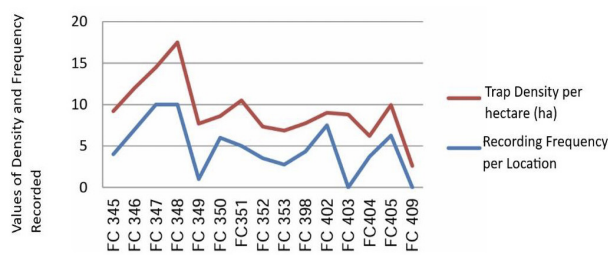
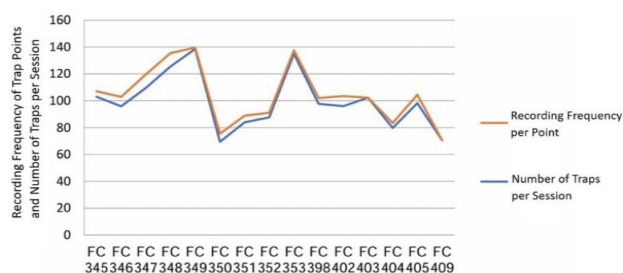


Fig. 2. Wildlife trap numbers by months from 2017- 2022 indicate that trap deployment is concentrated from January to March, gradually decreasing from April to September, with a peak occurring annually from October to December.

The research analyzed the number of traps based on trap density per unit area across subzones from 2017 to 2022 to evaluate the relationship between trapping areas and wildlife distribution. The study also analyzed, synthesized, and modeled the distribution and frequency of trap placement on a map, comparing this data with wildlife survey data using the frequency index of species recorded at specific locations. Based on this comparison, the research presents conclusions and evaluations. The results comparing the relationship between trapping areas and wildlife distribution show a close relationship between areas with a high number of traps and areas with high wildlife frequency. Specifically, areas with higher trap density also had higher wildlife recording frequency ([Fig. 3](#)).

**Table III. Wildlife sightings during patrols.**

| Scientific name                                                                                                                                  | Subdivi-<br>sion | Number of re-<br>corded locations | Total individ-<br>uals recorded |
|--------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----------------------------------|---------------------------------|
| <i>Sus scrofa</i> , <i>Helarctos malayanus</i> / <i>Ursus thibetanus</i> , <i>Muntiacus</i> sp.                                                  | 345              | 5                                 | 14                              |
| <i>S. scrofa</i> , <i>H. malayanus</i> / <i>U. thibetanus</i>                                                                                    | 346              | 9                                 | 30                              |
| <i>S. scrofa</i> , <i>H. malayanus</i> / <i>U. thibetanus</i>                                                                                    | 347              | 8                                 | 25                              |
| <i>S. scrofa</i> , <i>H. malayanus</i> / <i>U. thibetanus</i>                                                                                    | 348              | 8                                 | 18                              |
| <i>S. scrofa</i> , <i>H. malayanus</i> / <i>U. thibetanus</i>                                                                                    | 349              | 10                                | 22                              |
| <i>H. malayanus</i> / <i>U. thibetanus</i> , <i>Muntiacus</i> sp., <i>Capricornis milneedwardsii</i> , <i>S. scrofa</i>                          | 350              | 15                                | 47                              |
| <i>H. malayanus</i> / <i>U. thibetanus</i> , <i>Muntiacus</i> sp., <i>C. milneedwardsii</i> , <i>S. scrofa</i> , <i>Prionailurus bengalensis</i> | 351              | 32                                | 59                              |
| <i>H. malayanus</i> / <i>U. thibetanus</i> , <i>Muntiacus</i> sp., <i>C. milneedwardsii</i> , <i>S. scrofa</i>                                   | 352              | 21                                | 45                              |
| <i>H. malayanus</i> / <i>U. thibetanus</i> , <i>Muntiacus</i> sp., <i>C. milneedwardsii</i> , <i>S. scrofa</i> , <i>P. bengalensis</i>           | 353              | 21                                | 32                              |
| <i>Muntiacus</i> sp., <i>Capricornis milneedwardsii</i> , <i>S. scrofa</i>                                                                       | 398              | 6                                 | 17                              |
| <i>S. scrofa</i>                                                                                                                                 | 402              | 4                                 | 24                              |
| <i>S. scrofa</i> , <i>Muntiacus</i> sp.                                                                                                          | 403              | 5                                 | 12                              |
| <i>H. malayanus</i> / <i>U. thibetanus</i> , <i>Muntiacus</i> sp., <i>S. scrofa</i>                                                              | 404              | 14                                | 34                              |
| <i>H. malayanus</i> / <i>U. thibetanus</i> , <i>Muntiacus</i> sp., <i>Rusa unicolor</i> , <i>S. scrofa</i>                                       | 405              | 39                                | 74                              |
| <i>Helarctos malayanus</i> / <i>Ursus thibetanus</i>                                                                                             | 409              | 2                                 | 4                               |

**Fig. 3.** Comparison of the relationship between trap locations and wildlife distribution**Fig. 4.** Comparison of the relationship between trap locations and wildlife distribution using two indices: wildlife sighting frequency per camera trap point and number of traps per patrol.

To assess this relationship more accurately, we conducted further analysis using the number of traps

recorded during patrols in the subzones and the frequency of wildlife sightings at specific camera trap locations shown in Figure 4.

Comparing wildlife sighting frequency per camera trap point and the number of traps per patrol shows a clear relationship between trapping areas and wildlife distribution. Specifically, in subzones with a high number of traps per patrol, such as subzones 348, 347, 402, 346, 405, 351, 398, and 404, the frequency of wildlife sightings per camera trap point was also correspondingly high. Van Asch (2017) spotlighted the wildlife crime in Vietnam, Van Asch explored the role of international cooperation in combating wildlife trade and poaching. Although the Sao La study does not explicitly discuss international wildlife crime, it indirectly touches on the issue by highlighting that wildlife species such as the Sao La are highly prized in the illegal wildlife trade, both nationally and internationally. This aligns with Van Asch's recommendation for greater international cooperation to address transnational wildlife crime, suggesting that local enforcement alone may not be sufficient to tackle the issue. Overall, the findings of the Sao La study align with broader research on illegal wildlife hunting and conservation in Southeast Asia. It highlights similar challenges, such as the persistence of the illicit hunting despite government interventions, the need for livelihood diversification, and the crucial role of community engagement in reducing hunting pressure.

## CONCLUSION

The study meticulously examines the wildlife reliance and illicit hunting in Thua Thien Hue's Sao La Nature Reserve between 2017 and 2022. Local communities in the Sao La Nature Reserve buffer zones have steadily reduced their dependence on forest assets. Nevertheless, illegal hunting is still a frequent means for people to obtain food and additional revenue, particularly for those who live in isolated places with few other economic opportunities. The greater number of traps set during the rainy season indicates a peak hunting season, owing to both wildlife availability and activity. This implies that a seasonal strategy for law enforcement would be advantageous, with heightened patrols during these active times to target the spike in trapping activities. Community involvement, stringent enforcement, and sustainable alternatives are necessary to make long-lasting improvements to the animal conservation environment in the area. Addressing illegal hunting demands, altering socioeconomic systems, and honoring local customs is necessary to establish a conservation paradigm that is both successful and egalitarian. We advocate implementing sustainable livelihood programs, including communities in biodiversity monitoring surveys, and expanding environmental education campaigns. Strengthening law enforcement in partnership with local communities and creating long-term monitoring methods are vital for attaining sustainable conservation goals.

## DECLARATIONS

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### Funding

The study received no external funds.

### IRB approval

This study was approved by the Experimental Animal Management and Ethics Committee of Northeast Forestry University 2024/020. Their guidance ensured that our research adhered to the highest ethical standards.

### Ethical consideration for community engagement

This study complies with ethical standards and rules while interacting with the research communities. Informed

consent was acquired from all participants to ensure they were completely aware of the goal, scope, and possible implications of the research.

### Statement of conflict of interest

The authors have declared no conflict of interest.

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