# Nakai-Nam Theun National Park Biodiversity Research and Monitoring 5-year Strategy 2024-2028



SYSTEMATIC CAMERA-TRAP SURVEYS

SPECIES/TOPIC-SPECIFIC RESEARCH AND MONITORING
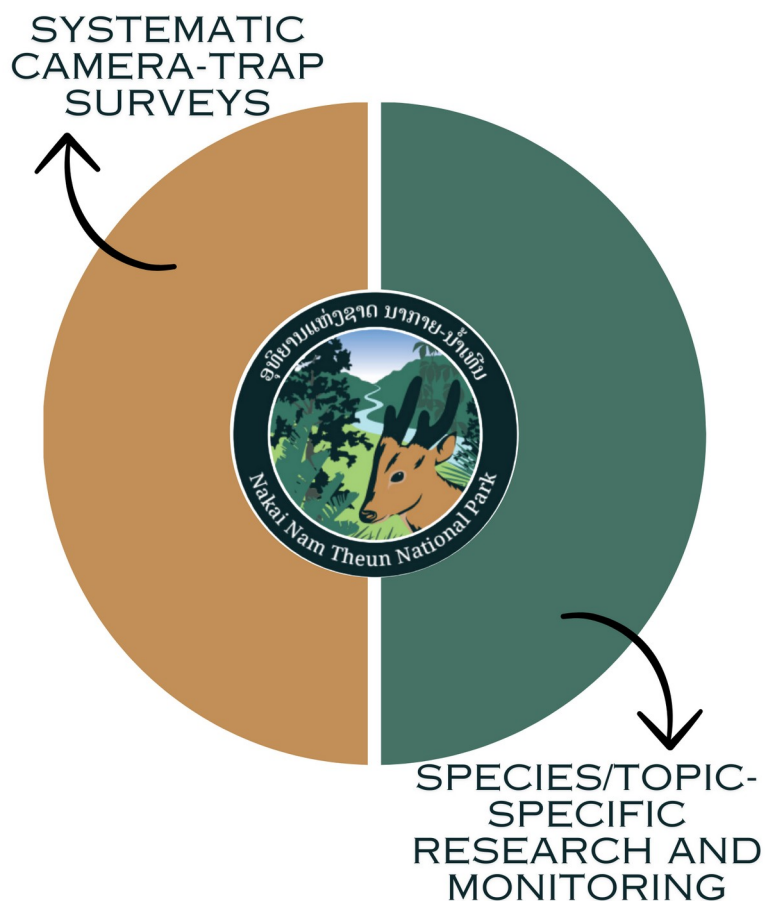
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June 2024

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# Introduction to the document

The Nakai-Nam Theun National Park (NNT NP) including the watershed area of the Nam Theun 2 Hydropower Project was established in 2019 under Decree 36/PM. The Nakai Nam Theun National Park Management Division is responsible for the management of the NNT NP and must conform to the Social and Environmental Management Framework and Operational Plan version 4 (SEMFOP4) for the period 2022-2026 (NNT NP, 2022). As described in the SEMFOP4, the vision for the NNT NP is that, "***the Nakai Nam Theun National Park is managed to effectively protect its biodiversity values, maintain and enhance its natural ecosystems, protect its rivers and soils and to improve the livelihood of the inhabitants of the NP and PIZ villages who rely on its resources***". To achieve this vision, the SEMFOP 4 sets the following biodiversity target for the NNT NP: ***Conserve viable populations of Annamite endemics and other nationally and internationally threatened (but non-endemic) species in the NT2 Watershed focusing on three biodiversity priority zones (Thong Kacheng/Upper Nam Mon area, Nam Chea area, and Thong khuang/Thong Xet area).***

Therefore, NNT NP must have a strategy for its biodiversity research and monitoring unit in order to monitor and study the population of target species.

This document describes the NNT NP's Biodiversity Research and Monitoring Strategy for the period 2024-2028. It succeeds the one developed for the period 2018-2022 (O'Kelly, 2018).

This strategy document was developed with the following approach:

- Review of previous research projects, findings, status and gaps on biodiversity in NNT NP
- Literature review of key documents guiding the management of NNT NP to ensure this strategy is in line with the SEMFOP 4, the Law Enforcement Strategy of NNT NP, recommendations from the Independent Monitoring Agency, the IUCN Green List status application process.
- Consultations with key researchers and experts with previous knowledge and experience with NNT NP and/or with plans to implement future research project on biodiversity in the National Park
- Consultation and review of the first draft of the strategy by NNT NP managers

# Objectives of the Strategy

The Biodiversity research and Monitoring Strategy will guide the National Park managers to develop annual work plans for the Biodiversity Research and Monitoring Unit to reach the following two objectives:

- **Objective 1:** By the end of 2028, all Annamite endemic species occurring in NNT NP have been monitored over time within biodiversity priority zones of the national park and population trends (abundance indices) are established in order to assess the impact of conservation interventions by NNT NP on these species
- **Objective 2:** By the end of 2028, some other species (and species group) nationally and internationally threatened and of conservation value have been surveyed/studied to advance knowledge on the biodiversity of NNT NP and contribute to raise its profile as a biodiversity hotspot
- **Objective 3:** Within the next five years (2024-2028), adapt management, conservation interventions and develop future research projects based on the results of Objectives 1 and 2

# Strategy operation approach

To best put this strategy document in operation on the ground, key stakeholders should commit to the following responsibilities:

**Responsibility of Nakai-Nam Theun National Park Management Division:**
- Develop Annual Work Plans and Budget Plans based on this strategy
- Identify and support research partners to develop an improved understanding of the population size and distribution of wildlife species within the NP
- Develop with national and local government partners (MAF, DOF, MOFA) guidelines describing the process for external partners wishing to implement a project in Nakai-Nam Theun National Park (including a condition to include fees for NNT NP re-invested for conservation in NNT NP and/or support of Lao students)
- Promote Nakai-Nam Theun National Park at the National and International level to attract future potential donors and researchers/institutions
- Facilitate research undertaken by well qualified research professionals and institutions in the expansion of knowledge on all forms of biota within the NP
- Provide funding for at least part of the field work for projects implementation (as agreed with external partners
- Coordinate project field work implementation and permission process for external partners when applicable
- Data management and database of all research project/programmes implemented in NNT NP

**Responsibility of external technical partners (e.g. research institutions, researchers etc.):**
- Lead on projects technical development, design, implementation, international coordination and administration
- Provide technical funding for projects implementation (fund raising and fund management are operated by external partners themselves)
- Provide capacity building to NNT NP staff and local partners including villagers for the implementation of projects
- Report to NNT NP and partners on main findings of the projects
- Provide educative resources based on research/project results that are easily accessible to various audience and that can be disseminated to all NNT NP staff (notably to the outreach section responsible to transfer back and disseminate these knowledge to local communities and local partners)

This strategy document should be made available publicly to attract researchers, institutions and donors for future research and monitoring projects in Nakai-Nam Theun National Park.

The projects listed in this 2024-2028 Strategy are dependent of external partners' availability, interest and own constraints.

Capacity building for the Nakai-Nam Theun National Park staff in charge of over-seeing research in NNT NP should focus on networking, communication, administration, coordination and institutionalised process of working with external partners.

Explore the potential to merge the research section of NNT NP with the NTPC/IRD's International Center for Environemental Research in Nakai (Centre International de Recherche Environementale de Nakai – CIREN).

# Brief overview of previous biodiversity in the Annamite region and in Nakai-Nam Theun National Park

## The Annamite Mountains

Southeast Asia (i.e. Brunei, Cambodia, Indonesia, Lao People's Democratic Republic [hereafter, Lao PDR], Malaysia, Myanmar, the Philippines, Singapore, Timor-Leste, Thailand, and Viet Nam) has an impressively high degree of endemism of animal and plant species due to its unique geological history. The 'Indo-Burma Hotspot' (comprising Cambodia, Lao PDR, Myanmar, Thailand, Viet Nam and parts of southern China) is ranked in the top 10 global hotspots for irreplaceability and in the top five for threats (Mittermeier et al. 2004; Conservation International, 2011) (Figure 1). This hotspot contains the third highest number of vertebrate species and one of the highest levels of vertebrate endemism in the world. Biological survey effort across the region and over time has been uneven, meaning that many startling discoveries were not made until the 1980s-2000s.

Various explorations in the 1990s penetrated areas poorly covered before and resulted in remarkable discoveries of large mammal species new to science, specifically concentrated within the Annamite Mountains (Figure 1). The Annamite Mountains extend from northern Viet Nam along the border with Lao PDR and south into southern Viet Nam (Figure 1). The new species discoveries included several large mammals such as Saola *Pseudoryx nghetinhensis*, Large-antlered Muntjac *Muntiacus vuquangensis*, Annamite Muntjac *M. truongsonensis* and Annamite Striped Rabbit *Nesolagus timminsi*. Another remarkable scientific discovery was the Kha-nyou *Laonastes aenigmamus,* a large rodent discovered and restricted to the limestone habitat of Lao PDR and Viet Nam, identified as the only surviving member of the otherwise extinct rodent family Diatomyidae (Dawson et al., 2014). In addition, numerous reptiles and amphibians endemic to the Annamite Mountains have been described to science including Marble Pygmy Narrow-Mouth Frog *Nanohyla marmorata*, Truongson Bug-eyed Frog *Theloderma truongsonense*, Andrea's Keelback *Hebius andreae*, Annam Keelback *Hebius annamensis*, Three-scaled Lance-headed Pitviper *Protobothrops sieversorum*, Truongson Pitviper *Trimeresurus truongsonensis*. Likewise, several Annamite endemic bird species include Annamite Crested Argus *Rheinardia ocellata*, Grey-crowned Crocias *Laniellus langbianis*, Edwards's Pheasant *Lophura edwardsi*, Indochinese Wren Babbler *Napothera danjoui*, Bare-faced Bulbul *Nok hualon,* Coral-billed Ground Cuckoo *Carpococcyx renauldi*.

The Annamite Mountains range is therefore recognised as a priority for biodiversity conservation by the 'WWF Global 200 Ecoregions' (Olson and Dinerstein, 2002). The region has a complex geological history; successive periods of sedimentation over millions of years formed an enlarged stable block of complex geological forms, including ancient rocks, limestone karst, and volcanic regions. The Annamite Mountains range forms an important barrier between Viet Nam's moist uplands and the drier monsoon ranges of Lao PDR, resulting in divergent weather patterns across the range. It is believed that the Annamite Mountains have provided stable refugia for plant and

animal species during climatic glaciations of the Pleistocene era, which are likely to have resulted in speciation and the high level of endemism observed today in this region.



# Nakai-Nam Theun National Park

## Biodiversity

Nakai – Nam Theun National Park (4500 km$^2$), including two corridors with two other neighbouring protected areas (Figure 1), is located in east central Lao PDR along the international border with Viet Nam. Nakai – Nam Theun National Park is one of the largest remaining contiguous areas of mostly primary forest in Indo-Burma and hosts numerous rare, endemic and highly threatened species. It falls in the heart of one of the richest regions of biodiversity and endemism in Southeast Asia and is one of the identified 'Key Biodiversity Areas' within the Indo-Burma biodiversity hotspot (Tordoff et al., 2012). In Lao PDR, Nakai – Nam Theun is ranked as one of the most important areas for biodiversity conservation at the national and global levels. Although (as for every other large, complex, natural area in Indo-Burma) there is no comprehensive biodiversity census for the area, early surveys have identified at least 92 mammal species, 403 bird species, 29 reptile species, 69 fish species, 25 amphibian species, and 917 species of Non-Timber Forest Products. Since then, biodiversity research in the area has essentially focused on mammals as part of monitoring programs implemented by the national park authority and partners (Coudrat, 2020).

While Nakai – Nam Theun has received relatively more conservation attention than other protected areas within the Annamite Mountains, a large knowledge gap remains. Much is unknown about the diversity and/or the current conservation status of most fish, reptiles, amphibians, birds, invertebrates, fungi and flora. Surveys of these taxa would undoubtedly result in the discovery of many species new to science, of which many would likely be endemic to the Annamites or even to a small part of them.

## Ecosystems, habitat and weather patterns

Nakai – Nam Theun National Park remains more forested than does most of the rest of the Annamite Mountains, still containing 88% of its original forest cover. The area encompasses a variety of different forest types for the diversity of species found in the areas. The most common forest type is dry evergreen forest found between 500 to 1800 m above sea level (a.s.l.). Other more localised forest types include the semi-evergreen/pine forest, wet evergreen forest close to the Viet Nam border over 600 m a.s.l., and upper montane forest at the highest elevations from 1800 m a.s.l. (Timmins and Evans, 1996). Elevation in the area ranges from *ca.* 500 m to 2300 m a.s.l. Measured annual precipitation ranges from 1865–2620 mm but may be considerably higher in some of the wettest areas. Monthly mean temperatures range 14–24°C, with annual extremes of 4 to 32 °C. The area typically experiences four seasons based on average monthly rainfall and temperatures: a cold dry season in December– February, a warm dry season in March–May, a warm wet season in June– September, and a further warm dry season in October–November. This variety in forest types, topography and seasonal patterns explain its diversity in flora and fauna.

## Flora

From the limited botanical surveys conducted within the Annamite Mountains, plant biodiversity is exceptionally rich, comprising notably recent discoveries of new species of orchids and other endemic species of conifers (Coffman, 2021). However, the flora of Lao PDR remains one of the least studied in the region (Newman et al., 2007), consistent with the paucity of botanical work that has been conducted in Nakai – Nam Theun National Park. The most comprehensive botanical surveys conducted in the area date from specimens collected between 2004 and 2007 (Newman et al., 2007b) which resulted in 614 identified species (in 527 genera and 143 families). The authors of the work and compilers of the documents recognize that '*this is only a small fraction of the number of species that are present'* (Newman et al., 2007: 1) but this preliminary work identified 34 species that are of at least national conservation concern (Thomas et al., 2007).

One of the most remarkable discoveries of a rare species of tree took place in the area in 2007 during biodiversity surveys as part of the environmental impact assessment of the Nam Theun 2 hydropower project (Dersu & associates, 2008). The Asian Swamp Cypress (*Glyptostrobus pensilis*) was found: the largest and only known old growth population anywhere in the world and the first population known in Lao PDR. The species, classified as Critically Endangered by the IUCN Red List of Threatened Species, is a conifer native to China, Viet Nam and Lao PDR but most of its current global population has been extirpated with the only remaining trees in semi-natural setting known occurring in Viet Nam (fewer than 200 trees, which do not produce viable seeds), and the only remaining old-growth forests are those of 600 trees (minus 200 cut down in 2016) found in Lao PDR (Coffman, 2021). The entire population of Asian Swamp Cypress known in Lao PDR is within the Nakai Nam Theun National Park, excepting one small stand just to the northwest. This makes the area a priority for the global conservation of this species. However, between 2008 and 2016, already approximately 62% of the old growth trees (i.e. trees estimated to be between 500 and 1000 years old) documented in the Nakai – Nam Theun catchment have already been lost: in 2008, the reservoir inundated several hundred trees and in 2016, 200 were logged down for the timber trade (Coffman, 2021). To this day fewer than 420 trees are documented within the national park.

In 2017, a satellite imagery analysis of NNT NP showed that the park is primarily covered with forest (87.9%). Evergreen forests cover the majority of the NP, including almost the entirety of the TPZ (93.3%). The forest loss rate over the 2012-2017 period was 499 ha/year (Ferrand and Moore, 2018).

## Fauna

Many of the characteristic and remarkable rare and locally endemic faunal species of the Annamite Mountains are found in the Nakai – Nam Theun National Park, including the Saola, Large-antlered Muntjac, Roosevelts'-group muntjac(s) (a group which comprises several species, includes the Annamite Muntjac, which are difficult to tell apart) and Annamite Stripped Rabbit. In addition, a large number of Globally Threatened (i.e. Vulnerable [VU], Endangered [EN] and Critically Endangered [CR]) and Near Threatened (NT) species (as listed in the IUCN Red List of Threatened Species; IUCN 2020) and/or locally endemic mammals were recorded in Nakai – Nam Theun National Park, though some are likely to have gone extinct in the past two-three decades (Coudrat, 2022).

NNT NP has notably been distinguished as an important area for the conservation of small carnivores (Coudrat et al., 2014), Eurasian and Asian small-clawed otters (Coudrat et al., 2022; Appendix 2), red-shanked douc (Coudrat et al., 2012; Coudrat et al., 2013), macaques (Coudrat & Nekaris, 2013), Northern and Southern white-cheeked gibbons (Coudrat et al., 2015; Coudrat et al., *submitted*), muntjacs (Ioannis et al., 2021; Appendix 2), elephants (Ahlering et al., 2011). Recent research on the elephant population in Nakai District shows that following the Nam Theun 2 dam completion, there was a major increase in Human-Elephant Conflict locally and the creation of new, serious, and persistent Human-Elephant Conflict problems as far as 100 km away (Budd et al., 2023). An on-going research (as of 2024) will provide information on the elephant population size, movement patterns and genetic diversity (Coudrat, 2023c).

Recent camera-trap surveys notably shows that NNT NP holds globally important populations of two Annamite endemics, Owston's civet and the large-antlered muntjac (*Muntiacus vuquangensis*). Both of these threatened endemics have become extirpated across much of their historic range, with the large-antlered muntjac now approaching global extinction, and NNT NP maybe one of their best hopes for long term survival. The diversity and detection rates of several other species recorded by camera-traps in recent years in NNT NP also shows that the faunal community in NNT NP appears to be much less defaunated than other Annamite forests that have been surveyed in recent years.

Previous research on fish diversities and fisheries have been conducted, mostly focusing on the Nam Theun Reservoir and Nam Theun River (Gillet et al., 2018). Recent research shows that the largest global population of Endangered Wolf Barb *Luciocyprinus striolatus* (Paa Kang) and best chance for long-term survival is found in NNT NP (Coudrat, 2023b; Appendix 2).

Less recent information is available on reptiles, amphibians and birds; however, several species known to occur in Nakai – Nam Theun National Park are Globally Threatened and of global, regional and/or national conservation significance (Thewlis et al. 1998; Robichaud and Stuart, 1999; Stuart et al., 2010; Stuart et al., 2011; Timmins & Evans, 1996).

# Threats and justification for the Strategy

Southeast Asia has long been identified as being the region of the world with the highest biodiversity extinction risk and this pattern is observed throughout Laos and in Nakai – Nam Theun (Coudrat, 2022). Across mainland Southeast Asia, by far the most imminent threat to large vertebrates (defined here as vertebrates over and above the size of a domestic cat) is the large-scale

overhunting of large wildlife, and principally with the use of snares (Harrison et al., 2016; Gray et al., 2017). This has led to selective defaunation (i.e. extinction of larger vertebrate species) in many forested areas in the region, many of which are legally protected, yet failing to protect biodiversity within (Tilker et al., 2019).

Because of this widespread and intensive snaring, within the Nakai – Nam Theun National Park, some mammal species have declined significantly including most cats and some other small carnivores. Other species have already been extirpated such as Tiger, Leopard, Clouded Leopard, Dhole, Gaur, Banteng and Rhinoceros. Some of these species were lost in as short as a decade (Gray et al., 2017). Without control over this large-scale and pervasive commercially-oriented hunting practice, the most hunting-sensitive and most sought-for species could face national park-wide extinction in the near future (e.g. Saola, Large-antlered Muntjac, Sambar, Greater Hog Badger, Binturong, Owston's Civet, some primates, cats other than Leopard Cat *Prionailurus bengalensis*, otters, pangolins and turtles).

It is therefore imperative to adopt a conservation strategy for NNT NP that includes sites prioritization where most of the resources for protection (e.g. anti-poaching patrol and law enforcement) are directed and where biodiversity is systematically monitored to assess the effectiveness of conservation interventions to protect biodiversity.

# List of previous work to build on for this Biodiversity Research and monitoring strategy 2024-2028

This strategies builds on previous major biodiversity research that were implemented in the past few years in NNT NP, as presented in the following table

| Project/program | Year of coverage of study / year of implementation | Project leaders and technical partners | Reference documents |
|---|---|---|---|
| Wildlife surveys | 1996-2008 | Wildlife Conservation Society (WCS); Dersu & Associates | Timmins, 1996; Timmins & Evans; 1996; Duckworth, 1998; Robichaud & Stuart, 1999; Johnson et al., 2005; Johnson & Johnston, 2007; Dersu & Associates; 2008; |
| Fish surveys, fisheries monitoring, aquatic diversity and water quality of Nam Theun 2 Reservoir | 1996-2016 | Nam Theun 2 Power Company | NTPC, internal fisheries monitoring database; Kottelat, 1996; Kottelat, 1998; Kottelat, 2016; Cottet et al., 2016; Cottet & Visser, 2017; Chanudet et al., 2016; Chanudet et al., 2012; Descloux et al., 2016a; Descloux et al., 2016b; Gillet et al., 2018 |
| Genetic diversity, social structure, | 2004-2006 | WCS | Ahlering et al., 2011; Hedges et al., 2013 |

| | | | |
|---|---|---|---|
| and conservation value of the elephants of the Nakai Plateau, Lao PDR, based on non-invasive sampling | | | |
| Effects of a hydropower project on a high-value Asian elephant population | 2004-2019 | University of Missouri; WCS | McWilliam et al., 2010; Budd et al., 2023 |
| Research on the Critically Endangered *Glyptostrobus pensilis* Mai Hing Sam | 2007-2019 | Dr. Gretchen Coffman | Coffman et al., 2021 |
| Botanical surveys | 2004-2007 | Darwin Initiative Project; National University of Laos; Royal Botanical Garden of Edinburgh | Thomas et al., 2007; Newman et al., 2007 |
| Forest cover change 2012-2017 | 2012-2017 | Forest Carbon | Ferrand & Moore, 2018 |
| Systematic camera-trapping for ground-dwelling animal populations monitoring | 2018-2019: Baseline 2020: replicate 1 2022-2023: replicate 2 | Association Anoulak; Leipniz Institute for Zoo and Wildlife Research (IZW) | Coudrat, C.N.Z. 2019; Coudrat, C.N.Z. 2020; Coudrat, C.N.Z. 2023a (Appendix 1); Alexiou et al., 2021 (Appendix 2); Alexiou et al., *submitted* (Appendix 1) |
| Otter survey for species identification | 2019-2020 | Association Anoulak | Coudrat et al., 2022 (Appendix 2) |
| White-cheeked Gibbon species distribution in the Annamite Mountains of Laos | 2016-2023 | Association Anoulak; Czech Republic University of Life Science | Coudrat et al., *Submitted* (Appendix 2) |
| Gibbon survey methods development | 2020—ongoing | Association Anoulak; Centre for Research into Ecological and Environmental Modelling (CREEM), University of St | *On-going research* |

| | | Andrews in Scotland; Rainforest Connection. | |
|---|---|---|---|
| Study of the distribution and conservation status of Endangered *Luciocyprinus striolatus* (Paa Kang) | 2022-2023 | Association Anoulak; FISHBIO | Coudrat, 2023b (Appendix 2) |
| Survey of the population of Endangered Asian Elephant (*Elephas maximus*) in Nakai District and surrounding areas | 2022-2024 | Association Anoulak; IRD; Royal Zoological Society of Scotland; CNRS-France | *On-going research* Coudrat, 2023c |
| ONENAKAI pilot project | 2022-2023 | Institut Francais de Recherche pour le Developement (IRD)-Lao program | Locatelli, 2023 |

# Indicators

## Definition

An indicator species is a species or group of species chosen as an indicator of, or proxy for, the state of an ecosystem or of a certain process within that ecosystem.

Species or groups of species which are suitable as indicators of management effectiveness must meet the following criteria:

- They are vulnerable to key threats to wildlife, in particular hunting.
- They have the potential to respond to effective management interventions (i.e. a reduction in hunting brought about by increased law enforcement efforts)
- They are not so rare that it is impossible to collect sufficient data to monitor trends
- They can be monitored with cost-effective and reliable methods providing information on population status (abundance indices)

## List of selected indicator species or group of species for Nakai-Nam Theun National Park and research/monitoring approach

| Indicator | Research/monitoring strategy |
|---|---|
| Species of national and global importance (including endemics to the Annamite Mountains):<br>• Large-antlered Muntjac – *Muntiacus vuquangensis*<br>• Roosevelts'-group Muntjac(s) – *Muntiacus cf. rooseveltorum*<br>• Sambar – *Rusa unicolor*<br>• Mainland Serow – *Capricornis sumatraensis*<br>• Stump-tailed Macaque – *Macaca arctoides*<br>• Northern Pig-tailed Macaque – *Macaca leonina*<br>• Assamese Macaque – *Macaca assamensis* | • Ground camera-traps (every 3-5 years) |

| | |
|---|---|
| <ul><li>Owston's Civet – *Chrotogale owstoni*</li><li>Greater Hog Badger – *Arctonyx collaris*</li><li>Binturong – *Arctictis binturong*</li><li>Sun Bear – *Helarctos malayanus*</li><li>Asiatic Black Bear – *Ursus thibetanus*</li><li>Annamite striped rabbit – *Nesolagus timminsi*</li><li>Sunda Pangolin – *Manis javanica*</li></ul> | |
| Species consumed for food by indigenous communities (allowed under national law): <ul><li>Wild pig – *Sus scrofa*</li><li>Northern Red Muntjac – *Muntiacus vaginalis*</li><li>East Asian Porcupine – *Hystrix brachyura*</li><li>Asiatic Brush-tailed Porcupine – *Atherurus macrourus*</li><li>Large Indian Civet – *Viverra zibetha*</li><li>Masked Palm Civet – *Paguma larvata*</li><li>Crab-eating Mongoose – *Herpestes urva*</li><li>Common Palm Civet – *Paradoxurus hermaphroditus*</li><li>Yellow-throated Marten – *Martes flavigula*</li></ul> | <ul><li>Ground camera-traps (every 3-5 years)</li></ul> |
| Elephants | <ul><li>Wild Elephant conservation Unit</li><li>DNA-based dung surveys (every 10 years)</li><li>Salt-licks refurbishing</li><li>Selected individuals GPS collaring</li></ul> |
| Large-antlered muntjac | <ul><li>Ecological study with GPS collaring</li></ul> |
| Saola | <ul><li>Dung-based DNA test</li><li>Sniffer dog tracking</li><li>Targeted camera-trapping</li></ul> |
| White-cheeked Gibbons | <ul><li>Automated recorders (every 5 years)</li></ul> |
| Wolf Barb *L. striolatus* (*Paa Kang*) (and fish populations) | <ul><li>Fish tagging and villagers logbooks</li><li>Fish Conservation Zones monitoring</li></ul> |
| Asian Swamp Cypress *G. pensilis* (*Mai Hing Sam*) | <ul><li>Community-based restoration programme</li><li>Habitat and ecological study to support restoration program</li><li>Monitoring known stands (monitor potential death and identify potential causes)</li><li>Pathogen prevention protocols as part of tourist visits to the stands</li></ul> |
| Non-Timber Forest Products of conservation concern: <ul><li>Orchid species</li><li>Tree turmeric Kheua Haem *Coscinium fenestratum*</li><li>Other species of NTFPs: with potential value chain</li></ul> | <ul><li>Field surveys by experts (species checklist)</li><li>Assessment of resources (abundance; distribution)</li></ul> |

| | |
|---|---|
| for alternative income and with medicinal purpose | • Assessment of threats<br>• Study sustainable off-take rate<br>• Recommend conservation interventions (regulations) |
| Forest cover (% of NNT NP area covered by different categories of forest and non-forest land and forest loss rate/year) | • Satellite imagery analysis |
| Other poorly studied species-groups, e.g. reptiles, amphibians; flora; birds; insects; fish | • Field surveys by experts |
| Social Science Research on Biodiversity Conservation and Community Livelihoods | • Local communities interviews<br>• Community-based conservation programs linked to biodiversity that can generate income (eg. ecotourism, NTFP value chain etc.) |
| One Health Program (Human-Animal-Environment interface) | • Next-generation sequencing diagnostic testing between humans, domestic animals and wildlife<br>• Database and monitoring of flora and fauna biodiversity as well soil and water quality |
| Rescued animals post release tracking | • Soft release and post release tracking with radio collars |

# Long-term systematic camera-trapping for ground-dwelling animal populations monitoring

**Rationale:** The current conservation status of several globally threatened species remains unknown in Nakai-Nam Theun. In addition, in order to evaluate the management efforts (especially patrol efforts) being implemented it is critical to obtain baseline population estimates of key indicator species and monitor their populations trend over time

**Project 2024-2028:**
Within the next 5 years the systematic camera-trapping survey replicate should be conducted:
- Over the dry season of 2026-2027
- Over the dry season of 2028-2031

The exact same survey design, protocol and data management and analysis as previous surveys should be employed (see below).

## Summary of past systematic camera-trap surveys 2018-2023

Between 2018-2022, systematic camera-trap wildlife monitoring surveys were implemented in the three identified Biodiversity Priority Zones of the national park:
- The base line survey was conducted in 2018-2019

- The first survey replicate was conducted in 2020
- The second survey replicate was conducted in 2022-2023

Each systematic camera-trapping survey was planned with a robust wildlife monitoring protocol across the three biodiversity management zones in Nakai-Nam Theun NP during the dry seasons (October to May), using a grid-based approach, with individual camera-trap station spaced approximately 2.5 km apart, and a total of up to **134** stations (35 in Nam Chae, 50 in Thong Khacheng, and 50 in Thong Khouang), with two cameras per station (Figure 1) (see detailed protocol below).

Note: Prior to 2018, camera-trapping baseline surveys were conducted in Nakai Nam Theun NP between 2005 and 2007 under the technical advice of the Wildlife Conservation Society, though due to few captures of indicator species, the precision of the occupancy estimates were poor; in addition there was no systematic repeats of the survey due to a lack of capacity of park staff (O'Kelly et al. 2018b; Johnson and Johnston, 2007).
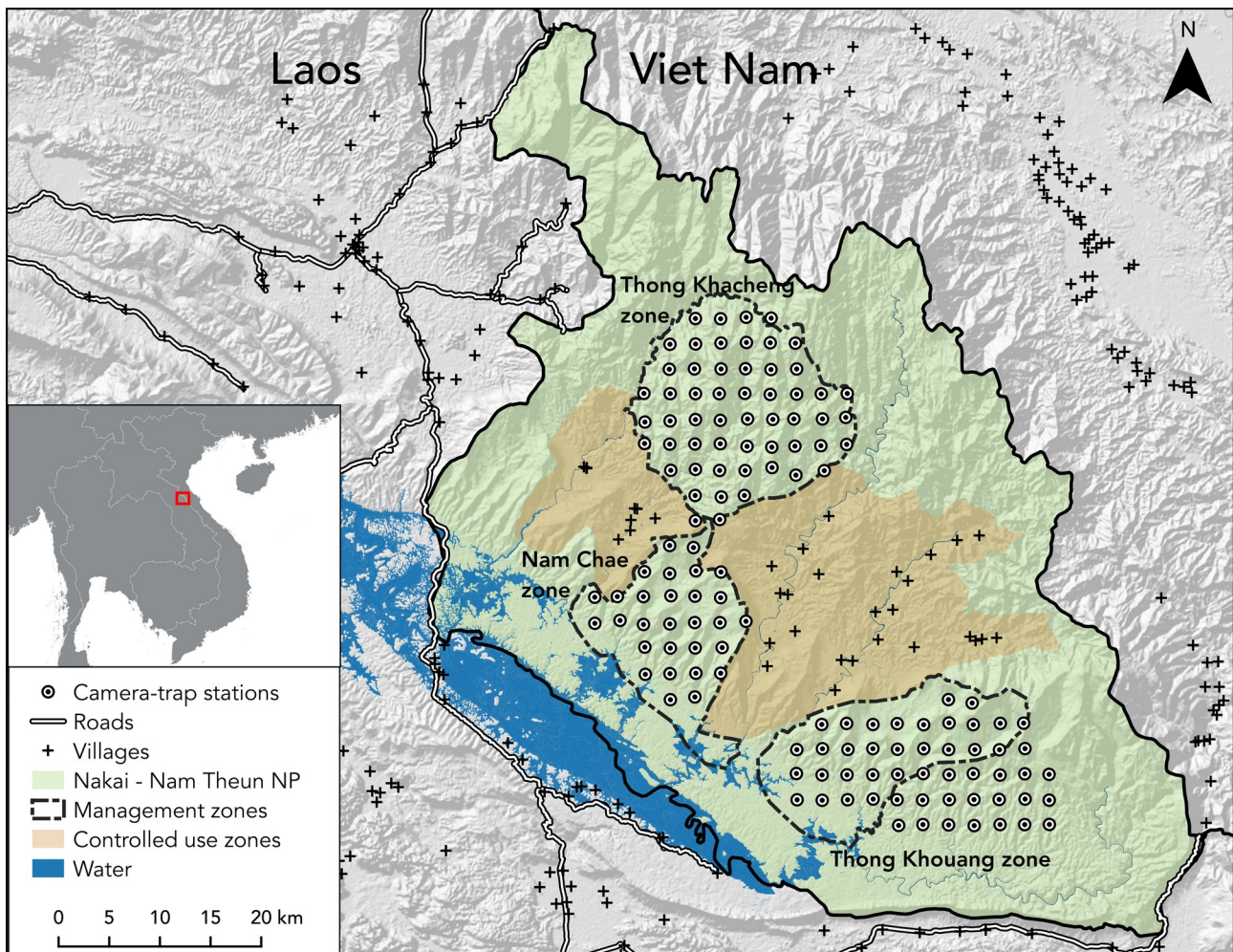


**Figure 1**: Systematic camera-trap survey design implemented in Nakai-Nam Theun National Park between 2018 and 2023 (to be replicated in the next 3 years).

The following table presents findings (species detections at camera-trap stations) from surveys in 2018-2019, 2020 and 2022-2023:

| # taxa identifed | species | IUCN Red List of Threatened Species category (2023) | 2018-2019 | 2020 | 2022-2023 |
|---|---|---|---|---|---|
| | | | n stations | n stations | n stations |
| **Pangolin(s) Manis** | | | | | |
| 1 | Sunda Pangolin – *Manis javanica* | CR | 6 | 11 | 25 |
| **Rabbits** | | | | | |
| 2 | Annamite striped rabbit – *Nesolagus timminsi* | EN | 0 | 1 | 2 |
| **Small carnivores** | | | | | |
| 3 | Binturong – *Arctictis binturong* | VU | 2 | 4 | 2 |
| 4 | Common Palm Civet – *Paradoxurus hermaphroditus* | LC | 76 | 80 | 57 |
| 5 | Crab-eating Mongoose – *Herpestes urva* | LC | 50 | 67 | 51 |
| - | Ferret badger(s) – *Melogale* | LC | 98 | 86 | 87 |
| 6 | Greater Hog Badger – *Arctonyx collaris* | VU | 4 | 37 | 24 |
| 7 | Large Indian Civet – *Viverra zibetha* | LC | 7 | 18 | 12 |
| 8 | Masked Palm Civet – *Paguma larvata* | LC | 76 | 78 | 77 |
| 9 | Owston's Civet – *Chrotogale owstoni* | EN | 24 | 24 | 16 |
| 10 | Spotted Linsang – *Prionodon pardicolor* | LC | 20 | 20 | 22 |
| - | Weasel(s) – *Mustela* | - | 20 | 16 | 19 |
| 11 | Yellow-throated Marten – *Martes flavigula* | LC | 74 | 91 | 80 |
| **Cats** | | | | | |
| 12 | Leopard Cat – *Prionailurus bengalensis* | LC | 8 | 9 | 28 |
| **Primates** | | | | | |
| 13 | White-cheeked gibbon(s) – *Nomascus siki/leucogenys* | CR | 1 | 1 | 0 |
| 14 | Hatinh Langur – *Trachypithecus hatinhensis* | EN | 1 | 1 | 2 |
| 15 | Red-shanked Douc – *Pygathrix nemaeus* | CR | 5 | 4 | 7 |
| 16 | Assamese Macaque – *Macaca assamensis* | NT | 63 | 82 | 80 |
| 17 | Northern Pig-tailed Macaque – *Macaca leonina* | VU | 42 | 43 | 44 |
| 18 | Rhesus Macaque – *Macaca mulatta* | LC | 6 | 17 | 15 |
| 19 | Stump-tailed Macaque – *Macaca arctoides* | VU | 29 | 27 | 35 |
| - | Unidentified macaque(s) – *Macaca* | - | 10 | 35 | 25 |
| 20 | Bengal Slow Loris – *Nycticebus bengalensis* | EN | 0 | 0 | 1 |
| 21 | Pygmy Slow Loris – *Nycticebus pygmaeus* | EN | 0 | 0 | 1 |
| **Bears** | | | | | |
| 22 | Sun Bear – *Helarctos malayanus* | VU | 12 | 6 | 18 |
| 23 | Asiatic Black Bear – *Ursus thibetanus* | VU | 1 | 1 | 0 |
| - | Unidentified Bear | VU | 1 | 0 | 1 |
| **Ungulates** | | | | | |
| 24 | Large-antlered Muntjac – *Muntiacus vuquangensis* | CR | 64 | 90 | 86 |
| 25 | Northern Red Muntjac – *Muntiacus vaginalis* | LC | 49 | 65 | 58 |
| 26 | Roosevelts'-group Muntjac(s) – *Muntiacus cf. rooseveltorum* | DD | 29 | 38 | 34 |
| - | Unidentified muntjac(s) – *Muntiacus* | - | 66 | 78 | 64 |
| 27 | Lesser Oriental Chevrotain – *Tragulus kanchil* | LC | 11 | 11 | 17 |
| 28 | Sambar – *Rusa unicolor* | VU | 10 | 8 | 20 |
| 29 | Mainland Serow – *Capricornis sumatraensis* | VU | 35 | 33 | 38 |
| 30 | Wild Pig – *Sus scrofa* | LC | 68 | 107 | 64 |
| **Elephant** | | | | | |
| 31 | Asian Elephant – *Elephas maximus* | EN | 0 | 1 | 1 |
| **Porcupines** | | | | | |
| 32 | Asiatic Brush-tailed Porcupine – *Atherurus macrourus* | LC | 32 | 30 | 32 |
| 33 | East Asian Porcupine – *Hystrix brachyura* | LC | 23 | 39 | 43 |
| **Squirrels** | | | | | |
| 34 | Black Giant Squirrel – *Ratufa bicolor* | NT | 4 | 3 | 3 |
| 35 | Giant Flying Squirrel – *Petaurista* | - | 0 | 0 | 1 |
| **Ground birds** | | | | | |
| - | Partridge(s) | - | 26 | 25 | 54 |
| 36 | Red Junglefowl – *Gallus gallus* | LC | 26 | 37 | 44 |
| 37 | Silver Pheasant – *Lophura nycthemera* | LC | 33 | 50 | 41 |
| 38 | Grey Peacock-pheasant – *Polyplectron bicalcaratum* | LC | 25 | 22 | 18 |
| 39 | Coral-billed Ground-cuckoo – *Carpococcyx renauldi* | VU | 0 | 1 | 0 |

Additional data analysis (community-based occupancy models) will allow to assess population trends since 2018 and inform law enforcement strategy (this research is on-going, led by Association Anoulak, with expected reports by early 2025).

These previous surveys highlighted the conservation importance of NNT NP for biodiversity conservation in the Annamites and demonstrates the utility of using camera-trapping and multi-species occupancy modelling approaches to establish robust baselines for the monitoring of mammal communities in tropical protected areas. Analysis of the results (for ground-dwelling species recorded on camera-traps) testifies of the species richness of the three Biodiversity Priority Zones (Nam Chae, Thongkouang, Thongkhacheng) (Figure 2).
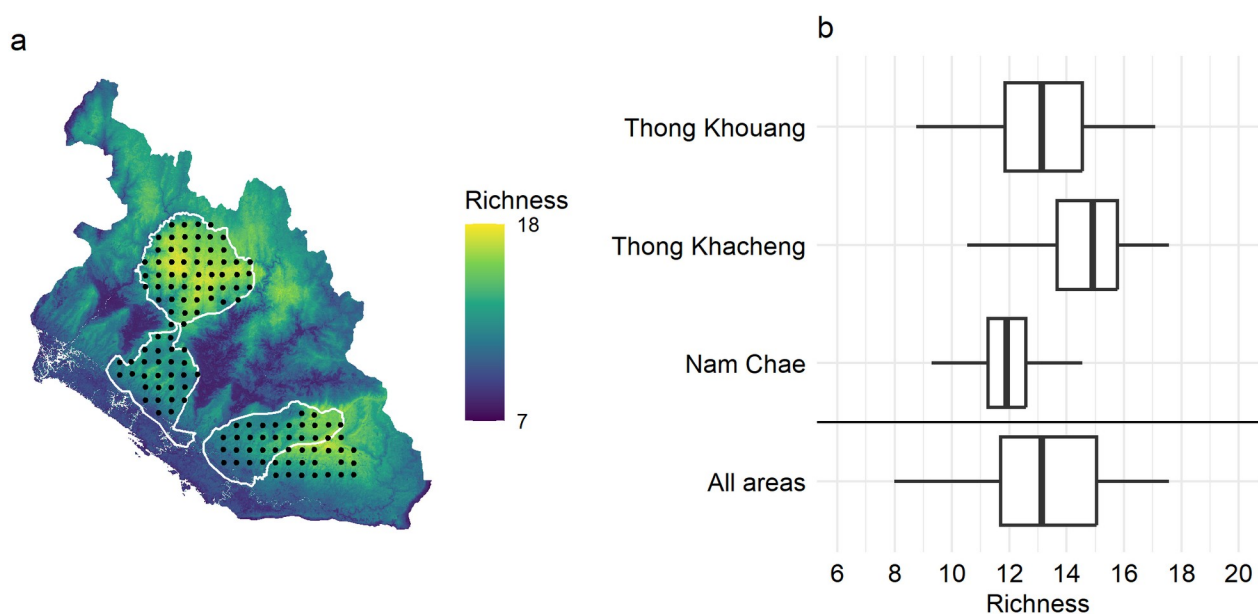


**Figure 2:** Species richness in NNT NP for the selected species. Points indicate camera-trapping stations and white lines show the three biodiversity management zones (a). Box plots showing species richness across the three zones (b). Mean ± SD predicted species richness in the three management zones was 14.85 ± 1.59 (Zone 1-Thong Khacheng), 13.46 ± 1.67 (Zone 2-Thong Kouang), 12.04 ± 1.1 (Zone 3-Nam Chae), with an average of 13.49 ± 2.05.

## Survey design and data collection protocols

The Nakai – Nam Theun National Park is divided into management zones including three Biodiversity Priority Zones (BPZs) (Figure 1) that were delineated based on their conservation importance at the national and/or global levels and past (and current) threat analysis (from past biological and threat records and from expert knowledge). The three zones combined cover approximately 700 km2:

- **BPZ1: THONGKHACHENG Zone**: Highest priority area as highest biodiversity values. This is an area of high elevation which may still hold the last remaining individuals of Saola. This area is believed to have experienced relatively low levels of snaring and other forms of hunting due to its remoteness and inaccessibility.

- **BPZ2: NAM CHAE Zone**: This is a lower elevation area of mixed broadleaf and coniferous forest. This zone has experienced some level of wildlife hunting but mainly with non-commercially driven snaring (i.e. mainly for local consumption) and the use of guns (hand-made guns or AK-47).
- **BPZ3: THONGKOUANG Zone**: The habitat and biodiversity values of this area are similar to BPZ2 but due to ease of access from Vietnam, hunting pressure has been much more severe in this area. Populations of key species have already been severely depleted in this zone.

As part of the Law Enforcement Strategy (O'Kelly et al., 2018b) for NNT NP, foot forest patrols should focus solely on these zones to control illegal activities and avoid wildlife populations to decrease any further. To evaluate these patrol efforts in these zones, the Biodiversity Research and Monitoring Strategy includes the monitoring of wildlife in these three BPZs using occupancy-based camera-trap survey method to estimate the probability that a species is present at a site and the percentage of area occupied by a species.

The survey design for the camera-trapping implemented in NNT NP follows the rationale and protocols developed by the Leibniz Institute for Zoo and Wildlife Research (IZW) (Abrams et al., 2018), with whom we collaborate for this project.

The approach developed by IZW has the main objective to estimate trends in animal populations (monitoring) over time and across landscapes as part of management plans. These estimations are based on the combination of camera-trap data with advanced statistical modeling techniques to estimate the occurrence of a species (with 'occupancy models') used as an index of species abundance.

Several aspects are therefore taken in consideration:
- Apply a survey design that accounts for imperfect detectability of species through repeated detection/non-detection of species over a certain time frame and across a landscape representative (e.g. habitats) of the area of interest.
- An occupancy model requires that camera-trap stations are independent (i.e. animals should not be photographed at multiple camera-trap stations; MacKenzie et al., 2002): this requires the spacing between camera-traps to be larger than the home range diameter of the species of interest. IZW's survey design uses a 2.5 km spacing, which ensured spatial independence of all but a few species (e.g. large carnivores, wild pigs). A systematic survey design is therefore used.
- An occupancy model requires that animal populations do not change within the sampling period (e.g. through births and deaths or immigration and emigration; MacKenzie et al., 2002; Rota et al., 2009). IZW's sampling period is for between 60 to 120 days (depending on landscapes and logistics associated).
- Maximize the detection of a maximum of species of interest (e.g. priority species of conservation concern) at the local level: 2 non-independent cameras are set-up at each survey station to increase detectability of species. The final location and placement of camera-traps are key components of the survey and are implemented at the local level by teams that are familiar with the landscape surveyed.
- Placement of cameras should take in consideration height, angle and target zone: cameras are placed between 20 to 40 cm above the ground to capture large, medium, and small mammals; camera-traps should be angled so that the target zone is parallel with the ground; camera-traps are located approximately 3 m from the target zone.
- Camera-trap model and specifics: detections will vary greatly between camera models and their specifics (e.g. picture trigger speed; picture trigger recovery; detection range and angle; field of view; flash type; battery life etc.). The model chosen will depend on budget available. The picture trigger speed should be the shortest possible to maximize picture

records. The camera-trap model(s) used should be included as a covariate in the detection probability during analysis.

# Data processing and analysis

Species identifications should be processed by and/or under the supervision of technical partners. The management and data visualization should be processed with software R using package CamtrapR and other R packages necessary and QGIS. In addition, cameras for which date and time configuration is faulty, the metadata stamps should be systematically modified with the software EXIF Date Changer after cross checking the date and time of set-up from the field data forms and the photos metadata, and therefore calculating the date/time shift required.

For consistency, the overall data management and analysis workflow should be as follow:
1. Input all set-up and retrieval data into Master Excel database
2. Prepare with CamtrapR package the station folders before loading data from cameras
3. Load all raw images from each camera to each corresponding folder
4. Check and systematically record date and time of the photos' metadata to verify if they are correct based on actual first date of set-up
5. Modify all incorrect date and time stamps on metadata of photos (using software EXIF Date Changer)
6. Check and systematically record date of last photo taken (for survey effort reporting)
7. Process all raw images in CamtrapR to copy and rename each image from each station and camera with format StationID__CameraID_Date[yyyy-mm-dd]_Time[hh:mm].JPG
8. Prepare species folders for species identification (with CamtrapR)
9. Species identification process (*First stage* implemented by field team leaders)
10. Species identification process (*Second stage* of identification cross checked by technical experts)
11. Dataset backup
12. Processing dataset with CamtrapR *version 2.2.0* (or older) to produce survey reports for each survey zone
13. Produce species distribution maps in QGIS
14. Data reformatting for visualization, presentation and reporting

The taxonomy base source should follow the current IUCN Red List of Threatened Species (www.iucnredlist.org).

# Species/topic-specific research programs, surveys and/or monitoring

## Asian Elephant

**Rationale:** One of the largest elephant populations of Laos is in NNT NP and surrounding areas. In 2008, the Nam Theun 2 hydroelectric dam resulted in the flooding of a large part of the resident elephant population's habitat. Prior to the impoundment, the population was estimated at 132 elephants, likely the largest and genetically most diverse in Laos at the time. But it was suggested that the elephant population would be affected and disperse due to the habitat loss. Since the impoundment, elephants have moved closer to villages and human-elephant conflicts have increased across a wide region, spanning several provinces. The size of the elephant population has not been systematically monitored. In 2022, Association Anoulak initiated a study of the current status, genetic diversity and movement patterns of the elephant population (expected results end of 2024). These information will provide updated baseline for the resident elephant population and inform future elephant conservation plans in Nakai.

**Project 2024-2028:**
- Elephant population monitoring: Given the life cycle of elephant, a new monitoring of the population should be planned in approximately 10 years time (~2034)
- Monitoring the use of artificial salt-licks by elephants and other animals with camera-traps
- Wild Elephant Conservation Unit (WECU): The main goals of a WECU are to improve habitat protection by identifying wild elephants' core habitat and providing a constant protection presence to address threats such as poaching, hunting, and encroachment across elephant's prime habitat. Once this core habitat is identified, monitoring of the populations through camera trapping, fecal sample collection for DNA analysis, visual assessments (when possible and safe) can all help provide clarity on the populations present. Having dedicated WECUs for NNT NP ensures species-specific information and lays the foundations for more evidence-based conservation programs capable of responding to localised threats and contexts. Field data collected by the WECU provides some estimates of elephant abundance (no rigorous density estimates), size, and demographics through monitoring patrols and camera trapping. These data will inform NNT NP critically needed information on elephant area use, distribution, and age to rapidly respond to human-elephant conflicts (HEC) in the area. Information on elephant population and its movement can be applied to the plan for elephant population conservation through ecotourism in order to reduce HEC in the future. These data can in turn contribute to ecotourism tours development to observe wild elephants
- GPS collaring has the potential to fill information gaps on elephant movement and critical habitat needs. Movement tracking via GPS collars has been identified as a top priority by the government under Task One, Program Five in the National Elephant Action Plan (NEAP 2022). Tracking individual elephant movements across the key sites in Laos could accelerate filling knowledge gaps, help limit damage from HEC, and aid the government in developing land-use plans designed to help reduce and manage human-elephant conflict in the future and provide critical data to complement the WECUs field work across Laos.

## Saola

**Rationale:** The Saola is a bovid species, the only one in its genus *Pseudoryx*, and one of the most remarkable mammal discoveries of the twentieth century. It was first discovered by scientists in Viet Nam and subsequently in Lao PDR from its typical horns found in village houses (Vu Van Dung et al., 1993). The species is endemic to the Annamite Mountains with an extremely restricted global range. Within the Annamite Mountains, this bovid has an even more specific habitat association

with wet evergreen forest (which is characterised by no marked dry season) (Timmins et al., 2020). Its global population was greatly reduced in the past few decades due to habitat loss and indiscriminate trade-driven snare hunting (Tilker et al., 2017). The Saola is extremely elusive: it has never been directly observed in the wild by biologists, has been recorded from camera-trap photographs only five times since 1998 and from a few freshly killed or newly captured individuals. Today, it is one of the rarest large mammals in the world with an estimated global population of up to 100 individuals (Tilker et al., 2017). Saola has been confirmed in the past from Nakai – Nam Theun National Park, but it is unclear if the species still occurs there. Given the dire global conservation status of the Saola, any remaining large forested site within the Annamite Mountains represent a potential site to save the species from extinction, including Nakai – Nam Theun NP.

**Project 2024-2028**:
Future research and intervention on Saola in NNT NP can include:
- Targeted camera-trap surveys
- Targeted patrol units (including training)
- Dung DNA identification field kit use in the field at targeted site (including training of villagers and rangers on use and reporting)
- Deployment of sniffing dog teams for Saola tracking
- Any other detection methods to inform future site-based and saola-specific conservation interventions by NNT NP staff

# Large-antlered Muntjac

**Rationale**: The Large-antlered Muntjac was named by scientists in 1994 in Viet Nam (Do Tuoc et al., 1994). Since the discovery of this new species of a large mammal, there has unfortunately been no project specifically focusing on its conservation. The Large-antlered Muntjac is native to Lao PDR and Viet Nam (and possibly, but only marginally, to Cambodia, though this has never been proven). It is largely restricted to the low to mid-elevations of the Annamite Mountains and adjacent plains and hill ranges. The global population is now scattered in isolated populations. In Viet Nam, populations are now mostly small and many have recently faced local extinction. Populations have declined due to commercial and subsistence wildlife hunting and the considerable reduction in suitable habitat (Timmins et al., 2016a). The largest global population is known to occur in Lao PDR, including in Nakai – Nam Theun National Park where it is one of the most frequently recorded ground mammal species from the on-going systematic wildlife monitoring program (Coudrat, 2020).

**Project 2024-2028:**
Future research specifically on the Large-antlered Muntjac in NNT NP include:
- Use satellite telemetry of collared muntjacs to study their movement in the habitat, understand behavioural ecology and vulnerability to snares. This will inform in situ conservation strategies
- Feasibility study for a long-term captive breeding program for the species

# Otter populations monitoring

**Rationale:** The distribution of Asian-ranged otter species remains very little known. In Laos, three species have been confirmed to occur: Asian Small-clawed Otter Aonyx cinereus, Smooth-coated Otter Lutrogale perspicillata and Eurasian Otter Lutra lutra. Given the global conservation status of these three species – with declining populations throughout their range due to a continuous loss of habitat, decreasing number of their prey and hunting for the pet trade and pelt trade – information is urgently needed on their distribution, habitat use and local threats in order to adopt species-specific and site-based management and conservation strategies. Nakai – Nam Theun National Park is of

regional importance for otter conservation. In 2019-2020, Association Anoulak in collaboration with Conservation Ecology Program, King Mongkut's University of Technology Thonburi conducted a baseline otter fecal DNA surveys based on mitochondrial DNA (mtDNA) to identify species, assess the occurrence, and map the spatial distribution of genetic diversity and evolutionary relationships of otter populations from Nakai-Nam Theun National Park in the Annamite Mountains of Lao PDR.

The main findings show that:
- Two species identified in Nakai-Nam Theun National Park:
  - Asian small-clawed otter *Aonyx cinereus* (7 samples, 12.5% of samples; one haplotype was detected: ACLA01, not detected previously in Asia)
  - Eurasian otter *Lutra lutra* (49 samples, 87.5% of samples; Three haplotypes were detected: LLLA01, LLLA02, LLLA03, not detected previously in Asia)
- Nakai – Nam Theun NP retains healthy populations of *Lutra lutra* and *Aonyx cinereus* and is considered a priority site for regional otter conservation

**Project 2024-2028:**
Previous otter fecal survey conducted in 2019-2020 provides the first baseline reference for the species presence as well as genetic diversity in NNT NP, where such surveys should be repeated in the future over wider areas and habitats.

In addition to maternal mtDNA diversity, biparental markers with high mutation rate like microsatellite loci or genome-wide single nucleotide polymorphisms (SNPs) are needed to determine with a much higher level of reliability both spatial structure and genetic diversity of the study populations.

Future surveys should be developed under a design framework that allows abundance estimates (eg. occupancy models) for long-term monitoring of populations. Surveys can be combined with other methods such as camera-trapping and fecal detection/non-detection and identify the most cost-effective methodology.

# White-cheeked Gibbons

**Rationale**: Gibbons are some of the most threatened primates in the world, due to habitat loss, illegal pet trade, and hunting for food and traditional medicine. All twenty species of gibbons are threatened with extinction on the IUCN Red List of Threatened Species: five are Critically Endangered, fourteen are Endangered, and one is Vulnerable. Effective conservation measures and actions to mitigate threats to gibbon populations require accurate and precise estimates of their abundance, distribution, and population trends. However reliable survey methods are lacking. Gibbons are challenging to see but easy to hear, so the best way to detect them is to listen to them. Traditional methods to survey gibbons with human listeners and triangulation have produced unreliable estimates of population densities. Digital recorders that estimate directions to calls (which are essential for precise estimation of density) are therefore needed to contribute to gibbon population monitoring and conservation planning across their range. Since 2020, Association Anoulak initiated a collaborative project with acoustic engineers and statisticians from St. Andrew University to develop a new hardware and software technology that will be completed in the coming years.

**Project 2024-2028**:
The aim of the project is to develop new digital recorders that estimate directions to sound accurately to improve density and abundance estimation, using acoustic spatial capture-recapture methods. The recorders' hardware (called TReX) are developed by acoustic engineer Dr. Mark Johnson and his team. The software are developed by statisticians Dr. Cornelia Oedekoven and Dr.

David Borchers and their team. The first prototype was tested in Laos in January 2024. Within the period 2024-2028, follow-up testing and deployment in NNT NP to estimate the gibbon population will be conducted.

## Wolf Barb (*Paa Kang*) and other fish species populations

**Rationale**: Endangered Wolf Barb *Luciocyprinus striolatus,* known locally as *Paa Kang* is a species of cyprinid native to parts of Laos and China. The species is believed to be already extinct from China, which make Laos the only country to protect the species. The distribution of the species in Laos remains little known, as well as the threats it faces where the species has been confirmed. There are currently only two locations in the country where the species has been recorded: Nam Pak river, a tributary of the Nam Ou river in Oudomxay Province, northern Laos; and Nam Kading/Nam Theun river, a tributary of the Mekong river, in Khammouan Province, central Laos. In 2022-2023, FISHBIO and Association Anoulak collaborated to implement a pilot project to understand the distribution, life cycle, and threats of *L. striolatus* in Nakai-Nam Theun National Park and develop future conservation plans. The main findings show that:

- *L. striolatus* is under threat at all locations in Laos: Nam Pak in Oudomxay Province, Xay Champhone in Bolikhamxay Province and Nakai-Nam Theun National Park in Khammouan Province
- Nakai-Nam Theun National Park represents the best location in the world for the long-term conservation of the species

**Project 2024-2028:**

Based on the pilot project conducted in 2022-2023, follow-up activities for the protection and conservation of wolfbarb in NNT NP are as follows:

- Set up community-based Fish Conservation Zones within the national park targeted for wolfbarb and other globally/nationaly important fish populations such as *Tor alter, Scaphongathops theunensis,* and *Poropuntius carinatus*
- Conduct a follow-up study to understand the species' reproductive cycle in Nakai-Nam Theun, including the identification of key locations of reproduction and spawning.
- If possible, avoid the practice of catch-and-release sport fishing in Nakai-Nam Theun National Park, as this park represents the best location in the world for the long-term conservation of the species.
- If sport fishing is unavoidable, conduct an impact assessment and define appropriate regulations prior to authorising and promoting this practice in the park.
- Develop community-based ecotourism to observe the species in its natural habitat. Any ecotourism projects must directly benefit the local communities and ensure their involvement in the protection of the species, notably through community-based Fish Conservation Zones.
- Conduct awareness-raising for local authorities and local communities on the conservation value of the species.

## Reptiles and amphibians surveys

**Rationale**: The Annamites have long been recognised as an important region of herpetological diversity in Indochina (Orlov and Ananjeva 2007; Bain and Hurley 2011). The Annamites Mountains range includes three biogeographic regions of herpetofaunal diversity: the Northern, Central, and Southern Annamites (Bain and Hurley, 2011; Poyarkov et al., 2021). Reptiles and amphibians are poikilothermic animals and have lower activity ranges than other vertebrates which make them particularly at risk from anthropogenic impacts (e.g. habitat loss, capture for illegal

trade and consumption). Characterising the diversity of herpethofauna and identifying main threats in NNT NP will inform future conservation plans for these species. In addition, herpethological-surveys in NNT NP has the potential to result in several new species described to science.

**Project 2024-2028:** Conduct surveys of the amphibians, reptiles in Nakai – Nam Theun National Park to produce comprehensive inventories (including potential discoveries of new species). Preliminary surveys of the diversity of amphibians and reptiles will focus on taxonomic, biogeographic and ecological aspects. The findings of preliminary surveys will provide a first overview of the diversity of the herpetofauna species at the survey site in order to develop more comprehensive plans for further surveys, covering additional habitats and survey locations in NNT NP. Surveys will provide knowledge on the diversity and status of herpetofauna species combining morphological, biogeographic and ecological data to inform conservation plans and advance scientific knowledge.

# Non-Timber Forest Product Species

**Rationale**: Non-timber forest products (NTFPs) encompass a wide array of goods derived from forests, excluding conventional timber and wood-based products. They play a crucial role in the livelihoods of rural and indigenous communities in Nakai-Nam Theun National Park, contributing to income generation, food security, cultural preservation, and biodiversity conservation. Several species of NTFPs in NNT NP have been collected and used for the traditional livelihoods of local communities. But many species are also collected for the national and international trade-driven high and increasing demand. Sustainable management practices including regulations and law enforcement are essential to ensure the long-term viability of NTFPs while safeguarding forest ecosystems and supporting local communities. In addition, exploring alternative ways how some species of NTFPs can be sustainably collected to generate income can contribute to the long-term conservation, management and livelihoods of local communities. In Nakai-Nam Theun National Park, information (conservation status, threats, distribution) is lacking for all NTFPs species preventing the development of sustainable management plans for the most threatened species. Continued research, innovation, and collaboration are needed to address existing challenges and capitalise on the potential of NTFPs for sustainable development.

## Orchids

**Rationale:**The orchid trade in Southeast Asia is significant, with the region being a major hub for orchid cultivation, production, and export. Orchids are popular ornamental plants, and the trade involves both legal and illegal activities. The illegal orchid trade poses a threat to the biodiversity of orchid species in Laos. Unregulated harvesting can lead to the depletion of wild populations, particularly for rare or endangered species. Orchids are protected under international conventions such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). However, illegal trade often occurs due to inadequate enforcement, lack of resources, and challenges in monitoring. Nakai-Nam Theun NP holds several species of orchids, including many species being collected illegally. Orchid-specific surveys have not been implemented in NNT NP preventing the development of conservation interventions for most threatened species.

**Project 2024-2028:**
Future research in NNT NP should focus on:
- Assessment of trade and collection dynamic of orchid species at target sites (Thaphaibanh cluster), including characterise supply and demand dynamic (volumes, value paid to harvesters, resell to middle-men etc.) and supply chain routes to/from target sites
- Produce a checklist of orchid species at the target site
  ○ Highlight connections between orchid diversity and threats

- ◦ Identify traded species from the checklist and how this might evolve overtime (the checklist is important to be used to inform future conservation management: is there species that are going extinct over time which leads to switching demand/collection on other species?)
  - ◦ Ex-situ collection at orchid nursery for taxonomic identification when this is not possible in the field
- Research the potential and feasibility of ex-situ cultivation of most threatened species

## Tree turmeric Kheua Haem *Coscinium fenestratum*

**Rationale:** Kheua Haem *Coscinium fenestratum* (Goetgh.) Colebr. / Menispermaceae commonly known as tree turmeric or golden thread, is a creeping and climbing vine species found in the forests of Southeast Asia. It belongs to the Menispermaceae family. The species has a long history of traditional medicinal use. Various parts of the plant, including its stem and roots, are processed to obtain major bioactive alkaloids, i.e., berberine, palmatine, magnoflorine extract that is used in various medicinal purpose. It is valued for its anti-inflammatory, anti-diabetic, anti-microbial, and antioxidant properties. In traditional medicine, it's used to treat various ailments such as fever, diabetes, skin diseases, digestive disorders, and rheumatism. Besides, the stem and root of KheuaHaem are processed to obtain an extract that is used to treat wounds, dysentery and the after-effects of childbirth. The berberine extracted from KheuaHaem is a popular medicine for diarrhoea and intestinal parasites. It displays significant microbiological activity against bacteria, fungi, yeast, viruses and worms, and also anti-cancer, and hepatis properties. Chipped stems are used to make a yellow dye, resembling turmeric. Kheua Haem faces threats due to over-exploitation for its medicinal properties. The high and increasing demand for its stems and roots has led to depletion of wild populations. Conservation efforts are necessary to protect its natural habitats and ensure sustainable harvesting practices to prevent over-exploitation. Kheua Haem is classified under the Prohibition Category I under the National Law, meaning its collection is prohibited. However in the past decade the increasing demand from international traders have driven its over-exploitation across the national park.

**Projects 2024-2028:**
Future research in NNT NP should include:
- Surveys for assessment of species abundance at target sites within the national park and its distribution
- Review current regulations and law enforcement practices in the national park to develop and or revise regulations and disseminate them
- Research the ecology of the species to provide information on off-take rates and sustainable harvesting practices
- Research the potential and feasibility of ex-situ cultivation
- Research the potential and feasibility of sustainable value chain for the species

## Other NTFPs species

Several other NTFP species traditionally used and/or harvested for (illegal and legal) trade should be studied to address the challenges associated with NTFP extraction and utilisation including for:
- Community-Based Management: Empowering local communities and indigenous groups to manage NTFPs sustainably through participatory decision-making, traditional knowledge integration, and equitable benefit-sharing mechanisms
- Market Development: Facilitating value chain development, market linkages, and market-based incentives to enhance the economic viability of NTFPs and improve the livelihoods of harvesters

- Research and Education: Investing in research, capacity building, and knowledge dissemination initiatives to improve understanding of NTFP ecology, management practices, market dynamics, and socio-economic impacts

## Asian Swamp Cypress *Glyptostrobus pensilis* Mai Hing Sam

**Rationale:** The Critically Endangered *Glyptostrobus pensilis*, also known as the Asian swamp cypress or *Mai Hing Sam* in Lao, once widespread across southern China, Vietnam and Laos, has declined over the past century, primarily due to habitat conversion, illegal logging, and hydroelectric development. With an estimated total population of less than 1,000 mature individuals globally of which about 400 are in the NNT NP, the species is on the brink of extinction. Recent discoveries in Laos, particularly in the Nakai Nam Theun area, have highlighted the region's importance for the species' survival.

Ecotourism can play a part in bringing money to NNT NP but it is critical that we develop best practices for visiting the stand of endangered tree species around the park. Long-lived conifer species like *G. pensilis* are known to be particularly susceptible to pathogen attacks.

**Project 2024-2028:**
Future research project for the conservation of Mai Hing Sam in NNT NP should have the following objectives:
1. To survey the existing *Glyptostrobus pensilis* population near Ban Nahao, documenting live and dead trees, their diameter at breast height (DBH), and assessing their health
2. Feasibility Study for Restoration: To evaluate the feasibility of re initiating a restoration project led by NTPC from 2015-2022 for *Glyptostrobus pensilis* in Nakai, including documenting protocols for collecting seeds, propagation, planting techniques and locating sites to plant
3. Pathogen Research Recommendation: To identify research methods and recommend researchers at the National University of Lao or Research Institutes in Lao capable of investigating and addressing pathogen issues affecting the *Glyptostrobus pensilis* population in Nakai. Recommend a management plan for controlling pathogens (especially where tree stands are regularly visited by tourists upper Nam Xot)

## Forest cover analysis

**Rationale:** Climate models within the Nakai-Nam Theun watershed provide strong evidence that climate change will significantly impact biological and socio-economic conditions in the medium and longer terms. Climate change adaptation strategies were therefore integrated in the SEMFOP 4, and future versions. One of the strategies listed is the protection of forest cover and the maintenance of large blocks of forest. Forest cover is therefore one of the indicators to monitor to assess conservation intervention in NNT NP. In 2017, a baseline satellite imagery analysis of NNT NP showed that the park is primarily covered with forest (87.9%). Evergreen forests cover the majority of the NP, including almost the entirety of the Total Protection Zone (93.3%). The forest loss rate over the 2012-2017 period was 499 ha/year (Ferrand and Moore, 2018).

**Project 2024-2028**: Conduct a satellite imagery analysis of forest cover, forest land cover (forest type categorisation) and forest loss rate.

# Social Science Research on Biodiversity Conservation and Community Livelihoods

**Rationale:** Biodiversity conservation is critical for maintaining ecosystem services that support human well-being. However, conservation efforts can have complex socio-economic impacts on local communities. This research aims to explore the intersection of biodiversity conservation and community livelihoods, focusing on how conservation policies influence social and economic aspects of local populations and how community engagement can enhance conservation outcomes.

**Project 2024-2028:**

1. Assess the Socio-Economic Impacts of the National Park's Conservation Interventions and Management Plans:
   - Evaluate how different conservation strategies (e.g., protected areas, community-based conservation) affect local economies and livelihoods.
   - Identify both positive and negative socio-economic outcomes for communities involved in or affected by conservation efforts.
2. Understand Community Perceptions and Involvement:
   - Investigate local communities' perceptions of biodiversity conservation and their attitudes towards various conservation initiatives.
   - Examine the role of traditional ecological knowledge in conservation practices and its integration into modern conservation strategies.
3. Develop Strategies for Community-Based Conservation:
   - Propose frameworks for community-based conservation that balance ecological goals with socio-economic benefits for local populations (including ecotourism, NTFP value chain etc.)
   - Identify best practices for involving communities in conservation planning and implementation to ensure sustainable outcomes.

# One Health Program

**Rationale:** Emerging zoonotic diseases are a serious threat to public health and animal conservation. Humans have always shared habitats with wild and domestic animals, but the dynamics of their relationships have changed. Development activities such as roads, dams, and other infrastructure projects can drive encroachment and fragmentation of wildlife habitat, block migration routes, and facilitate poaching of wild animals. The Nakai Plateau underwent major habitat transformation following the construction of the NT2 hydroelectric dam in April 2008. As a consequence, people, domestic and wild animals live in increasing spatial proximity to each other. This is leading to an increasing exposure of pathogens for the animals and the human population. Establishing a long-term prevention, diagnostic and monitoring centre for the prevention of Emerging Diseases at the Human-Animal-Environment interface in Nakai is therefore key to implement. Data on flora and fauna biodiversity as well soil and water quality are also going to be collected in these areas.

**Project 2024-2028:**

Projects on zoonotic disease prevention in Nakai District will create a sustainable research, diagnosis and training platform on Emerging Diseases at the Human-Animal-Environment interface with expert multidisciplinary teams able to:
• Rapidly identify emerging zoonotic diseases
• Develop, validate and evaluate new prevention, diagnostic and monitoring tools
• Address knowledge gaps by acting as a central node in Southeast Asia for researchers and graduate students

Methodologies employed will include:
• The characterisation, at the molecular level, emerging zoonotic viruses, by implementing next-generation sequencing platforms and diagnostic testing between both human and veterinary laboratories.
• The identification and characterisation of the zoonotic sources of viruses and the route of introduction to the human population, including the possible role of intermediate hosts
• The research of the processes and mechanisms that may lead to a cross-species transmission event, and global spread by investigating both the virus diversity and evolution in an animal reservoir, the interactions between animals, their environment, and humans, and the factors (viral, ecological and social) contributing to efficient human to human transmission

In 2024, the International Center for Environemental Research in Nakai (Centre International de Recherche Environementale de Nakai - CIREN) was established in 2024 for this purpose under an agreement between Nam Theun 2 Power Company (NTPC) and Institut de Recherche pour le Development (IRD). CIREN is also a platform which aim is to provide a link between satellite data and field data, not only for monitoring changes in the environment and associated risks, but also as for students training and research teams capable of extracting the most relevant information. They are essential for validating products derived from the analysis of multi-spectral data from the Sentinel 1 and 2 earth observation satellites. These space-based products cover a wide range of applications, including the mapping of vegetation cover, soil surface moisture and river and lake water quality. Coupled with the characterisation of genetic diversity and the epidemiology of pathogens circulating in these monitored areas, this observatory will be a valuable tool not only for land-use planning but also for warning of the emergence of diseases.

## Rescued animals release program

**Rationale:** Rescuing and releasing animals back into the wild has been a crucial aspect of conservation efforts worldwide for several endangered species. However, ensuring the success of such releases requires diligent monitoring and tracking to assess the animals' post-release behaviours, habitat usage, and overall survival. One effective method for monitoring released animals is through the use of radio/GPS collars and other technology such as targeted fine-scale camera-trapping, which provide valuable insights into their movements and interactions within their natural environment, thereby assessing success rates of rescued animal release programs.

**Project 2024-2028:**
Future potential releases in NNT NP of rescued animals from rescue centres in Laos, if applicable, should include when feasible (in terms of logistics, and resources available), post-release programs with the use of targeted-individual monitoring to better understand habitat utilisation, survival rates, ecological behaviour and contribute to adaptive management and public engagement and education. Release of animals into wild habitat will follow state-of the-art international guidelines to ensure the best possible outcomes.

# Suggested 5-year plan timeline based on proposed research and monitoring projects

*[[[tentative: To be confirmed with each technical partner, based on available resources]]]*

|  | 2024 | 2025 | 2026 | 2027 | 2028 |
|---|---|---|---|---|---|
| Ground camera-traps (every 3-5 years) |  |  |  |  |  |

| | | | | | |
|---|---|---|---|---|---|
| Elephants | ▓ | ▓ | ▓ | ▓ | ▓ |
| Large-antlered muntjac (ecology) | | | ▓ | ▓ | |
| Saola | | | ▓ | | |
| Otter populations monitoring | | | ▓ | | |
| White-cheeked Gibbons | | | ▓ | | |
| Wolf Barb *L. striolatus* (Paa Kang) (and other key fish populations) | ▓ | ▓ | ▓ | ▓ | ▓ |
| Asian Swamp Cypress *G. pensilis* (Mai Hing Sam) | ▓ | ▓ | ▓ | ▓ | ▓ |
| Non-Timber Forest Products research: - Orchid species | ▓ | | | | |
| - Keua Haem | ▓ | | | | |
| - Other NTFPs (including those used in handicraft confection: bamboo, rattan, pandan) | ▓ | | | | |
| Forest Cover | | | | | ▓ |
| Other poorly studied species-groups, e.g. reptiles, amphibians; flora; birds; insects; fish | | ▓ | | ▓ | |
| Social Science Research on Biodiversity Conservation and Community Livelihoods | ▓ | | | | |
| One Health Program | | ▓ | ▓ | ▓ | ▓ |
| Rescued animals post release tracking | | | | ▓ | ▓ |
| Capacity building (for each research project implemented) | ▓ | ▓ | ▓ | ▓ | ▓ |

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# Appendices

## Appendix 1: Final reports on three previous systematic camera-trapping in NNT NP

**1.a -** Coudrat, C. N. Z. (2019). *Camera-Trap Surveys in Nakai – Nam Theun National Park for Wildlife Population Monitoring Report for Surveys Conducted in 2018-2019*. A report to Nakai-Nam Theun National Park. Association Anoulak, Lao PDR.

**1.b -** Coudrat, C. N. Z. (2020). *Camera-Trap Surveys in Nakai – Nam Theun National Park for Wildlife Population Monitoring Report for Surveys Conducted in 2020*. A report to Nakai-Nam Theun National Park. Association Anoulak, Lao PDR.

**1.c -** Coudrat, C. N. Z. (2023). *Camera-Trap Surveys in Nakai – Nam Theun National Park for Wildlife Population Monitoring Report for Surveys Conducted in 2022-2023*. A report to Nakai-Nam Theun National Park. Association Anoulak, Lao PDR.

## Appendix 2: Posters of previous research implemented by Association Anoulak and partners

**2.a -** The Annamite Mountains - A Biodiverse Ecosystem at Risk A Case Study in Nakai – Nam Theun National Park, Lao P.D.R

**2.b -** Wildlife Monitoring in Nakai-Nam Theun NP 2018-2023

**2.c -** Multi-species occupancy modeling of ground-dwelling mammals in central Laos a case study for monitoring in tropical forests

**2.d -** Camera-trapping reveals new insights in the ecology of three sympatric muntjacs in an overhunted biodiversity hotspot

**2.e -** Taxonomic status of otter species in Nakai-Nam Theun National Park, Lao PDR, based on DNA evidence

**2.f -** Biological Research, Threat Analysis, and Conservation Activities for Endangered Luciocyprinus striolatus (Paa Kang) in Nakai – Nam Theun National Park

**2.g -** New Insights in the Distribution of The Southern White-Cheeked Gibbon Nomascus siki and The Northern White-Cheeked Gibbon Nomascus leucogenys in Central Lao PDR

## Appendix 3: Strategy Power Point/PDF Presentation
## Appendix 4: Strategy Poster