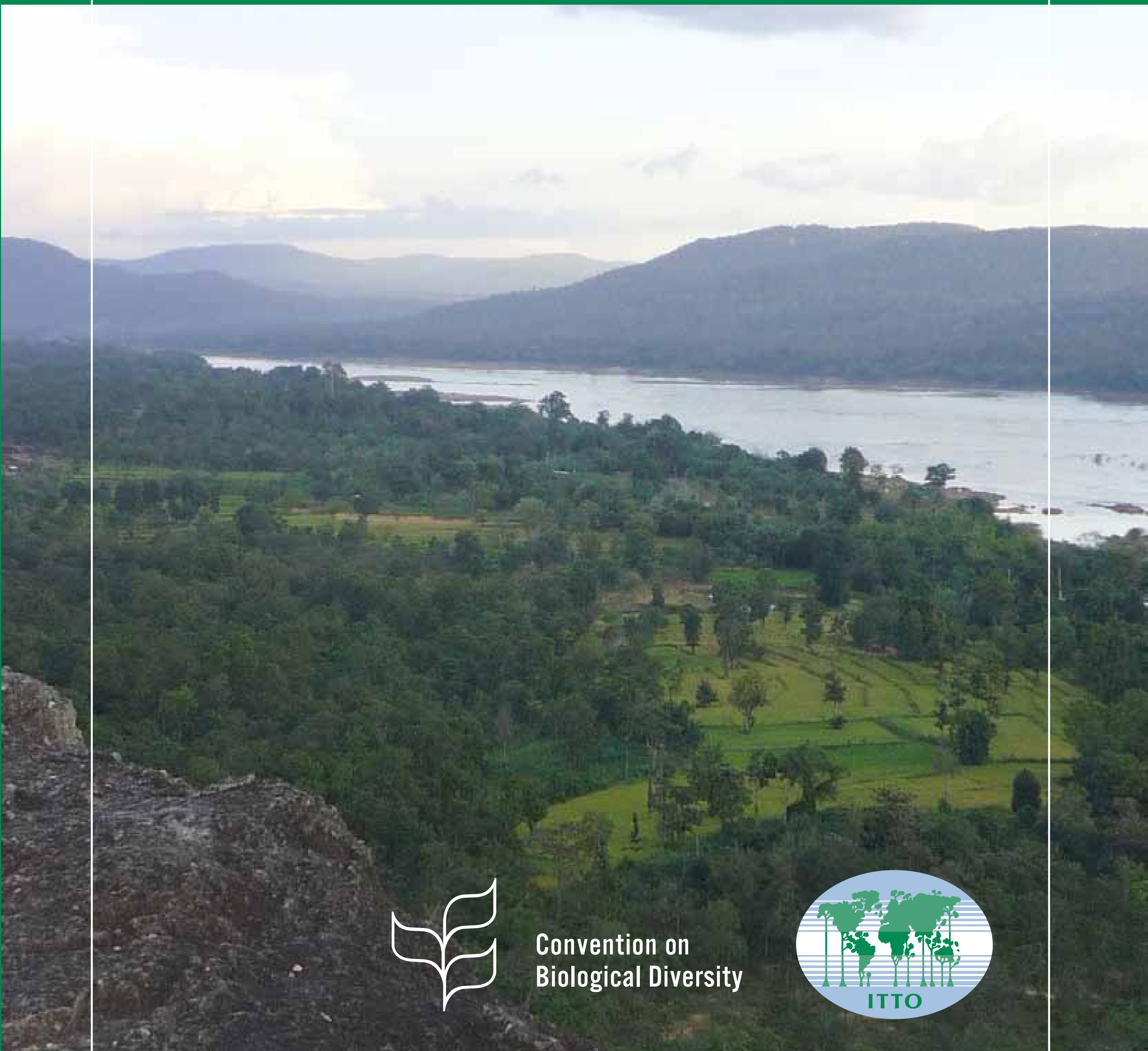
TECHNICAL SERIES

46

THE BRIGHT GREEN HOTSPOT

Outcomes of the Emerald Triangle Protected Forests Complex project, 2000–2016

NOVEMBER 2017



Convention on Biological Diversity

ITTO

INTERNATIONAL TROPICAL TIMBER ORGANIZATION

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Preferred citation: ITTO & CBD Secretariat 2017. *The bright green hotspot: outcomes of the Emerald Triangle Protected Forests Complex project, 2000–2016.* ITTO Technical Series No. 46. International Tropical Timber Organization (ITTO), Yokohama, Japan and Convention on Biological Diversity (CBD) Secretariat, Montreal, Canada.

The International Tropical Timber Organization (ITTO) is an intergovernmental organization promoting the conservation and sustainable management, use and trade of tropical forest resources. Its members represent the bulk of the world's tropical forests and of the global tropical timber trade. ITTO develops internationally agreed policy documents to promote sustainable forest management and forest conservation and assists tropical member countries to adapt such policies to local circumstances and to implement them in the field through projects. In addition, ITTO collects, analyzes and disseminates data on the production and trade of tropical timber and funds projects and other actions aimed at developing sustainable forest industries at both the community and industrial scales. Since it became operational in 1987, ITTO has funded more than 1000 projects, pre-projects and activities valued at more than US$400 million. All projects are funded by voluntary contributions, the major donors to date being the governments of Japan and the United States of America.

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ISBN 978-4-86507-034-7

Front-cover photo: A view of the Mekong River in the Emerald Triangle Protected Forests Complex. Credit: N. Bhumpakphan/Kasetsart University, Thailand.

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FOREWORD

The Emerald Triangle Protected Forests Complex comprises a group of protected areas and reserves shared by Cambodia, the Lao People's Democratic Republic (Lao PDR) and Thailand. It is one of the largest remaining tracts of intact natural forests in Southeast Asia and a vitally important biodiversity conservation landscape. The Emerald Triangle provides habitat for the critically endangered giant ibis, three species of critically endangered vultures, and other endangered animals such as the Asian elephant, Indochinese tiger, fishing cat and white-winged duck. The area is also home to many people, whose cultures are deeply attached to the environment and whose livelihoods are highly dependent on natural resources.

There is no doubting the sociocultural and conservation importance of the Emerald Triangle, but its effective management has been compromised over the years by, among other things, a lack of transboundary coordination and transnational and internal conflicts. In 2000, ITTO funded a project designed to encourage greater cooperation between Cambodia, Lao PDR and Thailand in the management of the Emerald Triangle. Today, more than 18 years later, the project's third phase has been completed.

Since 2011, the project has been part of the Joint ITTO/Convention on Biological Diversity (CBD) Collaborative Initiative for Tropical Forest Biodiversity, a programme designed to enhance biodiversity conservation in tropical forests with the direct participation of local stakeholders and to address the main drivers of biodiversity loss in tropical forests. The Initiative strives to achieve the common objectives of the ITTO Strategic Action Plan 2013–2018 and the CBD's Strategic Plan for Biodiversity 2011–2020, especially its forest-related Aichi Biodiversity Targets. The contribution of the project thereby addresses several CBD programmatic activities, including forest biodiversity, protected areas, ecosystem and forest restoration, genetic resources, and sustainable wildlife management.

This report, written by local and international experts with strong credentials and vast experience on the ground in the Emerald Triangle, sets out the findings and results arising from the many activities conducted under the project and shows the benefits of a collaborative approach to research and implementation. The list of achievements is impressive: for example, the project has promoted leadership among national staff involved in the planning, decision-making and coordination of project activities. As a result, there is now more local capacity in land-use and development planning and project management. In addition, coordination among agencies (within and between governments) has been institutionalized, and local people, who have participated strongly in the project, have several new options for their livelihoods through integrated conservation and development programmes. Independent management plans for the protected areas in Cambodia and Thailand are being implemented, representing an important regional advance.

Many challenges remain in ensuring the sustainability of the Emerald Triangle, protecting its biodiversity, improving law enforcement and ensuring that local communities prosper. Nevertheless, the project and its many national and local partners are making commendable progress in this fascinating and vital area. This report is an important milestone in this ongoing work, and we thank the authors for their dedication in producing it.

Gerhard Dieterle
ITTO Executive Director

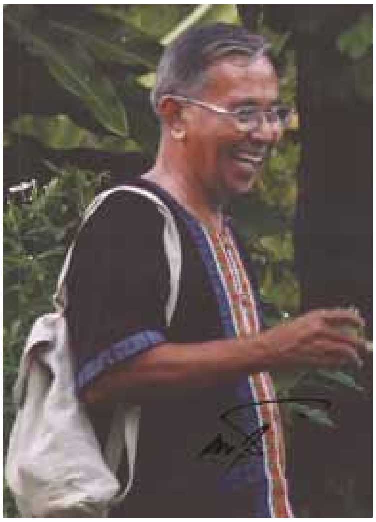
Cristiana Paşca Palmer
CBD Executive Secretary

ACKNOWLEDGEMENTS

This publication, which presents efforts to promote cooperation in transboundary conservation between Thailand, Cambodia and the Lao People's Democratic Republic, was made possible by the long-term support of donors and many partners. Financial support was provided by the United States of America, Switzerland and Japan in the project's first phase, Switzerland in its second phase and Japan in its third phase. The two executing agencies—the Royal Forest Department of Thailand and Cambodia's Forestry Administration—have shown great dedication to the conservation of globally outstanding biological diversity in an area with a history of considerable cross-border strife and increasing human impacts. In particular, the project would not have been completed without the dedicated efforts of the project teams in the two organizations. In conducting biodiversity research in the Emerald Triangle Protected Forests Complex, we gratefully acknowledge the technical cooperation provided by the Faculty of Forestry at Kasetsart University and the Department of National Parks, Wildlife and Plant Conservation in Thailand; the Faculty of Forestry at the Royal University of Agriculture in Cambodia; the Faculty of Agriculture and Forestry at Champasak University in Lao PDR; and the Mekong River Commission. We also thank the Japan International Cooperation Agency for its fruitful technical support and administrative assistance through a grant agreement in the project's third phase.

Ensuring the longevity of development initiatives—especially those that span international boundaries—is often difficult. We are grateful for the production of this publication, and we expect that it will assist in scaling up the conservation and sustainable management of the Emerald Triangle Protected Forests Complex between the three countries.

Our special thanks go to Alastair Sarre for his indispensable editing, Steven Johnson, Assistant Director of ITTO's Trade and Industry Division, for his overall guidance, and Takeshi Goto, former Assistant Director of ITTO's Forest Management Division, for his encouragement. Finally, we express our deep appreciation to the various park managers, protected-forest managers, field staff and other stakeholders engaged in the Emerald Triangle Protected Forests Complex for their important contributions to the realization of project objectives on the ground.



Kamol Wisupakan

Finally, we are sad to report that Mr Kamol Wisupakan (pictured left) passed away in February 2017. Kamol was a great source of enthusiasm and an outstanding leader of ITTO projects in the Emerald Triangle, and he worked hard to increase transboundary biodiversity cooperation there. His contributions will always be remembered.

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ACRONYMS AND ABBREVIATIONS

AEC	ASEAN Economic Community 2015
AUC	area under curve
CBD	Convention on Biological Diversity
COP	Conference of the Parties
dbh	diameter at breast height
DKPPA	Dong Khanthung Provincial Protected Area
ETPFC	Emerald Triangle Protected Forests Complex
GIS	geographic information system
GPS	global positioning system
ICDP	integrated conservation and development pilot
ITTO	International Tropical Timber Organization
IUCN	International Union for Conservation of Nature
Lao PDR	Lao People's Democratic Republic
LU/LC	land-use/land-cover
MOU	memorandum of understanding
NGO	non-governmental organization
PPFC	Pha Taem Protected Forest Complex
PVPF	Preah Vihear Protected Forest for Plant and Wildlife Genetic Resources Conservation
REDD+	The term used to refer to the efforts of countries to reduce greenhouse gas emissions from deforestation and forest degradation and to enhance forest carbon stocks through forest conservation and the sustainable management of forests

1 THE EMERALD TRIANGLE PROTECTED FORESTS COMPLEX PROJECT, 2000–2016

Ian D. Thompson and Hwan-Ok Ma

The Emerald Triangle Protected Forests Complex (ETPFC) project began in 2000 between Cambodia, the Lao People's Democratic Republic (Lao PDR) and Thailand in an effort to develop a common transboundary management framework for a large group of protected areas along borders shared by these countries. The protected areas existed before the project, but there was little national-level management and no transboundary management planning at a large landscape scale. As described below and in the chapters that follow, the vision for the area is to implement a comprehensive management plan for a large complex of transboundary protected areas with a view to conserving some of the world's most important biodiversity in an area with a history of considerable strife and increasing human impacts.

In the framework of the 2010 International Year of Biodiversity and the 2011 International Year of Forests, the secretariats of the International Tropical Timber Organization (ITTO) and the Convention on Biological Diversity (CBD) signed a memorandum of understanding (MOU) to strengthen collaboration in the pursuit of their common objectives of conserving and sustainably managing tropical forest resources. The MOU was renewed with a joint signing by the two secretariats at the 2014 CBD Conference of the Parties (CBD COP 12), held in the Republic of Korea. The main objective of the Joint ITTO/CBD Collaborative Initiative for Tropical Forest Biodiversity ("ITTO–CBD Collaborative Initiative") is to enhance biodiversity conservation in tropical forests with the direct participation of local stakeholders, addressing the two main drivers of biodiversity loss in tropical forests: deforestation and forest degradation. More specifically, the ITTO–CBD Collaborative Initiative supports ITTO producer member countries in reducing the loss of biodiversity through the implementation of the CBD Programme of Work on Forest Biodiversity, focusing on the common objectives of the CBD's Strategic Plan for Biodiversity 2011–2020 and Aichi Targets (specifically targets 5, 7, 11 and 15), and the ITTO Action Plan.

ITTO has long promoted the application of sustainable forest management in its tropical member countries, including those in Southeast Asia. ITTO has developed guiding documents to assist forest managers in conducting sustainable forest management while protecting biodiversity, including guidelines for conserving endangered species. The CBD advocates the careful management of forests through its Programme of Work on Forest Biodiversity and of protected areas under the Plan of Work on Protected Areas. The CBD encourages the use of an ecosystem approach to land management, which in cases such as the ETPFC means developing cross-border relations to manage larger landscapes. Further, projects such as the one described in this publication help countries in implementing the CBD, providing international assistance to support actions that otherwise might not be accomplished.

This publication presents a collection of work conducted in the ETPFC by Thailand (the Royal Forestry Department) and Cambodia (the Forestry Administration), with additional participation by Lao PDR (through Champasak University). The ITTO–CBD Collaborative Initiative became involved in Phase 3 of the project after 2010, although ITTO has been involved since 2000. The vision of the project is that: "by 2030, Cambodia, Lao PDR and Thailand will have established a common cooperative framework for the conservation and sustainable management of the ETPFC in order to strengthen the protection of the transboundary habitats of wide-ranging wildlife species and will endeavour to maintain the viability and ecological integrity of the forest ecosystems and increase its land-use and climate-change adaptation capability to transform the ETPFC into an international symbol of transboundary biodiversity conservation". Ultimately, the success or failure of the ITTO–CBD project will be strongly influenced by the willingness of the three neighbour countries to work together for conservation, despite a recent history of turmoil and mistrust.

Transboundary conservation

There is increasing recognition globally of the importance of biodiversity to human welfare through the linkages between biodiversity and ecosystem services (Parrotta et al. 2012). Numerous studies now link biodiversity to forest resilience and ecosystem functioning, including carbon sequestration (Thompson et al. 2009). Biodiversity continues to decline for many reasons, however, including overexploitation, habitat loss and degradation (including fragmentation), pollution, and climate change (CBD 2014).

Under the CBD Strategic Plan for Biodiversity 2011–2020, which was agreed at CBD COP 10 in 2010, nations will work towards having 17% of their land areas in formally protected areas (Aichi Target 11). Protected areas play a key role in the protection and conservation of biodiversity and are usually the cornerstone of national conservation policies and agendas, but they are often too small to contain functioning ecosystems (Terborgh 1999). Transboundary areas often feature shared watersheds, for example, and the ranges of migratory species frequently cross international borders. The ecology of forests does not end at international boundaries; sometimes, therefore, protected areas must span international borders if they are to function properly. In such cases, a combined multinational management approach is required to maintain intact ecosystems over large landscapes, to sustain the ecosystem services provided, and to maintain the genetic connectivity of species. How well this works depends on the capacity to develop management plans that span two or more nations for adjoining protected areas, which in turn is partly dependent on the willingness of those countries to cooperate on this. Difficulties in cooperation can arise for many reasons, reflecting national priorities, historical land uses, and the history of relations between nations. International politics is an influential condition for transboundary protected areas; there were 169 transboundary protected areas in 2007 (Lysenko et al. 2007), but very few of those have achieved any form of integrated ecosystem management across borders. Most transboundary protected areas involve only consultation or irregular meetings between the involved countries (Zbicz 2008).

Based on an assessment of many transboundary protected areas, Wells (2003) suggested that the following key issues need to be considered: unclear objectives; insufficient emphasis on enforcement; a need to involve communities directly in decision-making; capacity constraints in government; and a failure to identify and mitigate key threats. The top-down imposition of conservation will not work without clear bottom-up participation, not only by nations but also by the many stakeholders affected, including local people living near or in protected areas. A key to success is to recognize what does and does not work in protected areas and to be prepared to manage adaptively as the planning process moves forward. Regardless, transboundary protected-area development is an essential tool in the protection of intact ecosystems. An important role for international organizations is to help facilitate and fund cooperative transboundary protected-area management and to provide conservation advice and capacity where required.

The Emerald Triangle Protected Forests Complex

The ETPFC comprises a group of protected areas and reserves (Table 1.1, Figure 1.1) totalling 483 695 hectares, shared by Cambodia, Lao PDR and Thailand along 317 km of international borders. The ETPFC is part of the Southeastern Indochina Dry Evergreen Forest ecoregion; it supports dry evergreen forest, mixed deciduous forest, deciduous dipterocarp forest, plantations (mostly rubber), and second-growth forests, with 207 known tree species. Mean annual rainfall is 1560–1840 mm, which falls mostly between June and September during tropical monsoons, and the average day temperature is 33 °C. The general topography of the ETPFC on the Thailand side is mountainous and sloping gently towards the southeast. The terrain in the Cambodian and Lao PDR components is generally flatter, but it is rugged along the Mekong River; parts of the forested areas are inundated in the wet season. It is estimated that about two-thirds of the original forest of the Southeastern Indochina Dry Evergreen Forest ecoregion has been cleared or seriously degraded (Wikramanayake et al. 2000), but a few large forest blocks remain. A study on land-use change in the ecoregion between 2002 and 2008 indicated that deforestation was continuing, mostly outside protected areas.

The Pha Taem Protected Forest Complex (PPFC) is the term given to that part of the Emerald Triangle in Thailand; it comprises three national parks and two wildlife sanctuaries. Assuming a continuation of current land-use trends, the forest cover of the PPFC landscape will decrease from 46% in 2008 to 37% by 2030 unless strict protection measures are enforced (Trisurat et al. 2010). The primary cause of deforestation in Thailand in the past several decades has been encroachment for agriculture and agroforestry, especially rubber plantations that have been established in response to increasing demand in international markets. Rubber plantations have expanded in the area at an average annual rate of 35%.

The Preah Vihear Protected Forest for Plant and Wildlife Genetic Resources Conservation (PVPF) in Cambodia contains one of the largest intact blocks of natural dry deciduous forest on the Asian mainland; it is located on flat topography that rises toward Thailand to the west. The primary causes of forest degradation and land-use change there have varied over time, but the most important have been clearing for agriculture (e.g. rice paddies, cash crops and fruit-tree orchards) by local communities in and around the PVPF. Small-scale illegal logging by villagers for domestic use and the repair of local bridges and community buildings has also been prevalent. Another important driver of land-use change in Cambodia has been road construction to stimulate economic development along the border with Thailand and Lao PDR, including through the PVPF. Such construction has resulted in not only forest degradation but also habitat fragmentation, which hinders the movement of wildlife. The development of roads is likely to increase forest clearing for rice fields and lead to illegal land encroachment.

In Lao PDR, the Phou Xiang Thong National Protected Area is the only national-level protected area in the Emerald Triangle region. There is, however, a provincial-level protected area, the Dong Khanthung Provincial Protected Area (DKPPA), which is not officially part of the ETPFC but which confers conservation value to the Complex. Moreover, a military reserve—the Laos Border Protection Forest—is designated for Lao military security and has no official conservation function; nevertheless it presently serves as an important wildlife corridor (see Chapter 3).

The ETPFC is located in the Indo-Burma biodiversity hotspot, one of the world's most important centres of biodiversity (Myers et al. 2000). It is probably the most important site globally for the critically endangered giant ibis, as well as the most important site in Southeast Asia for three species of critically endangered vultures. The ETPFC also has important populations of the Asian elephant, banteng, Siamese Eld's deer, fishing cat, dhole, and white-winged duck, all of which are endangered. Other threatened species that occur in the area are the gaur, Bengal slow loris, northern pig-tailed macaque, sun bear, green peafowl and sarus crane. The primary biodiversity value of the ETPFC resides in its populations and unique assemblages of large mammals and waterbirds. The area sustains more than 100 mammal species, about 250 species of birds, 60 species of reptiles, more than 50 species of amphibians, and an estimated 12 000–15 000 plants. Table 1.2 lists some of the most endangered and charismatic animal species known to occur (or to have occurred) in the ETPFC.

Table 1.1: Protected areas of the ETPFC among Cambodia, Lao PDR and Thailand

Reserve	Area (ha)
Pha Taem Protected Forest Complex (Thailand)	
Pha Taem National Park	35 316
Kaeng Tana National Park	8 462
Phu Jong-Na Yoi National Park	69 738
Yot Dom Wildlife Sanctuary	23 593
Bun Thrik-Yot Mon Wildlife Sanctuary (Thailand)	36 586
Subtotal (Pha Taem Protected Forest Complex)	*173 695*
Phou Xiang Thong National Protected Area (Lao PDR)	120 000
Preah Vihear Protected Forest (Cambodia)	190 000
Total	**483 695**
Dong Khanthung Provincial Protected Area[a]	*170 000*
	653 695[b]

Notes: [a] not officially part of the ETPFC; [b] total area if Dong Khanthung Provincial Protected Area is included.

Pha Taem National Park

Pha Taem was established as Thailand's 74th national park on 31 December 1991 in the Khong Chiam and Si Mueang Mai amphoes (districts) of Ubon Ratchathani Province. About 27% of its border is connected to the Mae Khong (Mekong) River and 73% is adjacent to villages. The potential effect of local communities on the park, therefore, is ranked the highest among all protected areas in the Complex.

Kaeng Tana National Park

Kaeng Tana in the Khong Chiam and Phibun Mangsahan districts, Ubon Ratchathani Province, became Thailand's 33rd national park on 13 June 1981. About 52% of the park boundary is adjacent to local communities and 48% lies along national boundaries, including the Mekong River to the north and a mountain ridge to the east.

Phu Jong-Na Yoi National Park

Phu Jong-Na Yoi was declared Thailand's 53rd national park on 1 June 1987; it overlaps the Bun Thrik, Na Chaluai and Nam Yuen districts in Ubon Ratchathani Province. To the north is the Bun Thrik-Yot Mon Wildlife Sanctuary, to the south is Yot Dom, and to the east is Lao PDR.

Yot Dom Wildlife Sanctuary

Yot Dom was established as Thailand's 13th wildlife sanctuary on 11 October 1977 in Nam Yuen district in Ubon Ratchathani Province. To the west of the sanctuary at its periphery is the Cambodian border and to the east it adjoins the Phu Jong-Na Yoi National Park. About 29 km or 33% of the sanctuary's boundary is connected with agricultural areas and human settlements.

Bun Thrik-Yot Mon Wildlife Sanctuary

Thailand's Bun Thrik-Yot Mon is a new wildlife sanctuary in the PPFC. It is located to the north of the Phu Jong-Na Yoi National Park and adjoins Phu Jong-Na Yoi National Park; to its east is the Laotian border and to its west are agricultural areas and human settlements.

Preah Vihear Protected Forest

Cambodia's PVPF was established in 2002. It lies on the border with Lao PDR to the north and Thailand to the west; importantly, it forms a large protected-area complex with Yot Dom and Phu Jong-Na Yoi in Thailand and the DKPPA in Lao PDR. The southern border is largely agricultural, although settlements are sparse.

Phou Xiang Thong National Protected Area

The Phou Xiang Thong National Protected Area in Lao PDR became a forest reserve in 1993. It is bordered across the Mekong River by Thailand's Pha Taem National Park and, to the east, by a highway and several villages. This is Lao PDR's only protected area on the Mekong River.

Dong Khanthung Provincial Protected Area

Given its location and large size (about 170 000 hectares), the DKPPA in Lao PDR (Figure 1.1) has obvious importance for regional conservation and forest landscape connectivity. Its status is provincial, and although it has been nominated as a national protection forest for border and watershed protection, the Government of Lao PDR has not officially considered it as part of the ETPFC. Nevertheless, the ETPFC project did survey wildlife distributions within it during Phase 3 (see Chapter 3).

Characteristics of the main forest types

As described in reports by Choon (2004) and Cambodia's Forestry Administration (2009), there are three main forest types in the ETPFC: dry evergreen, deciduous dipterocarp, and mixed deciduous.

Dry evergreen forest is characterized by deep soils with high moisture content, very rare fires, and a multistorey canopy. The most important family in the canopy is Dipterocarpaceae, mainly *Anisoptera costata*, *Dipterocarpus costatus*, *Shorea henryana* and *S. roxburghii*, all reaching up to 40 m in height. The secondary canopy, usually 10–25 m in height, is more diverse; dominant species include *Aglaia porifera*, *A. pyramidata*, *Aphanamixis polystachya*, *Carallia brachiata*, *Dalbergia cochinchinensis*, *Diospyros ferrea*, *D. malabarica*, *D. variegata*, *Garcinia merguensis*, *Hydnocarpus anthelminthica*, *H. ilicifolia*, *Knema furfuracea, K. linifolia*, *Memecylon ovatum*, *Miliusa velutina*, *Millettia atropurpurea*, *Mitrephora vandiflora*, *Nephelium hypoleucum*, *Picrasma javanica*, *Polyalthia viridis*, *Pterospermum acerifolium*, *Suregada multiflora*, *Vatica odorata* and *Walsura trichostemon*.

Pioneer trees such as *Trema orientalis* quickly invade forest gaps. Beneath these trees is a shrub layer, but the forest floor is usually so thickly shaded that plant foliage is sparse there, giving the forest an open aspect and making it easy to traverse. The ground is covered by only a thin layer of leaf litter, and the rapid recycling of dead plant matter means there is no humus in the soils.

Deciduous dipterocarp forests (dry or moist) are located on laterite soils with often-shallow depth to bedrock. Most tree species shed leaves in the dry season. The forest is relatively open and dominated by species in the family Dipterocarpaceae,

Table 1.2: Rare, endangered and other important animal species mentioned in this publication and thought to occur or to have occurred in the ETPFC

Common name	Scientific name	Conservation status[a]
Mammals		
Asiatic black bear	*Ursus thibetanus*	Vulnerable
Asian elephant	*Elephas maximus*	Endangered
Asian two-horned rhinoceros	*Dicerorhinus sumatrensis*	Critically endangered
Banteng	*Bos javanicus*	Endangered
Bengal slow loris	*Nycticebus bengalensis*	Vulnerable
Chinese serow	*Capricornis milneedwardsii*	Near threatened
Common barking deer	*Muntiacus vaginalis*	Least concern
Dhole	*Cuon alpinus*	Endangered
Fishing cat	*Prionailurus viverrinus*	Vulnerable
Gaur	*Bos gaurus*	Vulnerable
Golden jackal	*Canis aureus*	Least concern
Indochinese lutong	*Trachypithecus germaini*	Endangered
Indochinese tiger	*Panthera tigris corbetti*	Endangered (*Panthera tigris*)
Irrawaddy dolphin	*Orcaella brevirostris*	Vulnerable
Kouprey	*Bos sauveli*	Critically endangered
Leopard	*Panthera pardus*	Vulnerable
Lesser mouse deer	*Tragulus kanchil*	Least concern
Lesser one-horned rhinoceros	*Rhinoceros sondaicus*	Critically endangered
Northern pig-tailed macaque	*Macaca leonina*	Vulnerable
Pileated gibbon	*Hylobates pileatus*	Endangered
Sambar deer	*Rusa unicolor*	Vulnerable
Siamese Eld's deer	*Rucervus eldii siamensis*	Endangered (*Rucervus eldii*)
Sumatran/southern serow	*Capricornis sumatraensis*	Vulnerable
Sun bear	*Helarctos malayanus*	Vulnerable
Wild boar	*Sus scrofa*	Least concern
Water buffalo	*Bubalus bubalis*	Not yet assessed
Yellow-cheeked gibbon	*Nomascus gabriellae*	Endangered
Birds		
Asian woolly-necked stork	*Ciconia episcopus*	Vulnerable
Black-capped bulbul	*Pycnonotus melanicterus*	Least concern
Black-necked stork	*Ephippiorhynchus asiaticus*	Near threatened
Brahminy kite	*Haliastur indus*	Least concern
Garganey	*Anas querquedula*	Least concern
Giant ibis	*Pseudibis gigantea*	Critically endangered
Greater adjutant stork	*Leptoptilos dubius*	Endangered
Greater coucal	*Centropus sinensis*	Least concern
Green peafowl	*Pavo muticus*	Endangered
Grey-headed fish-eagle	*Ichthyophaga ichthyaetus*	Not yet assessed
King vulture	*Sarcoramphus papa*	Least concern
Lesser adjutant stork	*Leptoptilos javanicus*	Vulnerable
Long-billed vulture	*Gyps indicus*	Critically endangered
Red-headed vulture	*Sarcogyps calvus*	Critically endangered
Red jungle fowl	*Gallus gallus*	Least concern
Sarus crane	*Grus antigone*	Vulnerable
Siamese fireback	*Lophura diardi*	Least concern
Slender-billed vulture	*Gyps tenuirostris*	Critically endangered
Spot-billed pelican	*Pelecanus philippensis*	Near threatened
White-rumped vulture	*Gyps bengalensis*	Critically endangered
White-winged duck	*Asarcornis scutulata*	Endangered
Fish		
Bronze featherback	*Notopterus notopterus*	Least concern
Clown featherback	*Chitala ornata*	Least concern

Common name	Scientific name	Conservation status[a]
Goldfin tinfoil barb	*Hypsibarbus malcolmi*	Least concern
Jullien's golden carp	*Probabus jullieni*	Endangered
Mekong giant catfish	*Pangasianodon gigas*	Critically endangered
Pa do/Giant snakehead fish	*Channa micropeltes*	Least concern
Pa khan yaeng hin	*Leiocassis spp.*	Data deficient (*Leiocassis longirostris*)
Pa mark phang/Mekong herring	*Tenualosa thibaudeaui*	Vulnerable
Pa nam ngeuan	*Micronema bleekeri*	Not yet assessed
Serpent-head fish	*Channa striata*	Least concern
Amphibians		
Blunt-headed burrowing frog	*Glyphoglossus molossus*	Near threatened
Dark-sided froglet	*Microhyla heymonsi*	Least concern
House tree frog	*Polypedates leucomystax*	Least concern
Indochinese box turtle	*Cuora galbinifrons*	Critically endangered
Malayan snail-eating turtle	*Malayemys subtrijuga*	Vulnerable
Marsh frog	*Fejervarya limnocharis*	Least concern
Reptiles		
Indochinese rat snake	*Ptyas korros*	Not yet assessed
King cobra	*Ophiophagus hannah*	Vulnerable
Reticulated python	*Python reticulatus*	Not yet assessed
Siamese crocodile	*Crocodylus siamensis*	Critically endangered
Tree monitor	*Varanus bengalensis nebulosus*	Not yet assessed
Water monitor	*Varanus salvator*	Least concern

Note: [a] according to the IUCN Red List, February 2017.

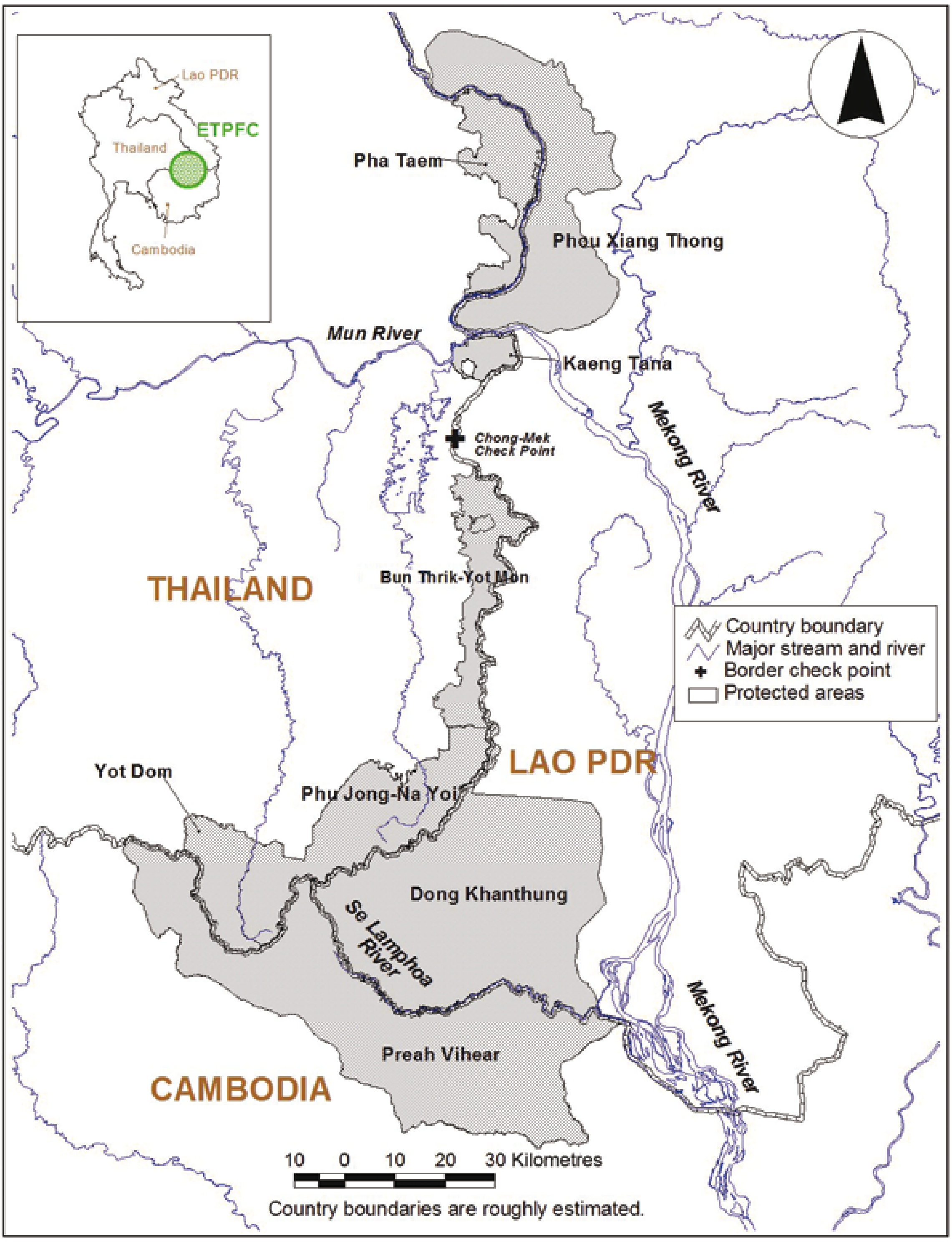
such as *Dipterocarpus intricatus, D. obtusifolius, D. tuberculatus, Shorea henryana, S. obtusa, S. roxburghii* and *S. siamensis*, reaching up to 30 m in height. The second canopy layer has a height range of 10–20 m and the dominant species are *Canarium subulatum, Dalbergia oliveri, Diospyros castanea, Gardenia sootepensis, Hymenodictyon excelsum, Millettia leucantha, Mitragyna brunonis, Morinda coreia, M. elliptica, Phyllanthus emblica, Rothmania wittii* and *Sindora siamensis*. Forest fire is a characteristic feature of this forest type, and it strongly affects species composition, forest structure and regeneration.

Mixed deciduous forests have a leafless period in the dry season. The top canopy has a height range of 20–30 m, with dominant tree species including *Bombax anceps, Canarium subulatum, Dialium cochinchinense, Irvingia malayana, Lagerstroemia calyculata, Pterocarpus macrocarpus, Terminalia nigrovenulosa, Vitex peduncularis* and *Xylia xylocarpa* var. *kerrii*. Bamboos are characteristic of these forests but are not dense. The secondary canopy has a height range of 10–20 m and features the following dominant species: *Canarium subulatum, Dalbergia oliveri, Diospyros castanea, Gardenia sootepensis, Hymenodictyon excelsum, Millettia leucantha, Mitragyna brunonis, Morinda coreia, M. elliptica, Phyllanthus emblica, Rothmannia wittii* and *Sindora siamensis*. Forest fire is a characteristic feature of this forest type, and it strongly affects species composition, forest structure and regeneration.

Local communities

More than 80 villages are situated within 3 km of the boundaries of the PPFC in Thailand, with a total estimated population of about 89 000. The livelihood choices of local people often have an impact on biodiversity conservation through forest encroachment for unsustainable agricultural practices, the introduction of cattle and buffaloes into protected areas, and wildlife poaching. Agriculture is the primary occupation of the majority of local households (70%), followed by fishing (10% of households). The average annual household income of local communities is US$1070, which is only about one-third that in Ubon Ratchathani city. Sixty-four percent of the local population believes that their incomes are insufficient to cover expenses for food and basic services (Tanakajana 2003). Less than half (40%) of the local adult population received a primary-school education, and only 30% received a secondary-school education. Four communities inside the Pha Taem National Park were there long before the

Figure 1.1: Location of the ITTO–CBD project area and protected areas in Cambodia, Lao PDR and Thailand



establishment of the park. There are no substantive reports of conflicts between local people and park rangers because local people have agreed to curtail their shifting cultivation.

In most of these communities, people depend largely on the protected areas for their livelihoods, which may be a threat to biodiversity because parts of the protected areas are used for agriculture, grazing livestock, woodcutting, hunting and collecting plant products. This resource dependence is an obstacle to creating and promoting sustainable programmes to integrate community development into protected-area management. To some degree, conflict exists between the local need to use resources inside the protected areas and the management requirements of protected-area agencies in every area of the PPFC; a recent socioeconomic survey showed that the majority of local people were indifferent to protected-area management.

In Cambodia, Preah Vihear Province is sparsely populated, with about 130 000 primarily poor, rural residents. Living in or adjacent to the PVPF are 3042 families with a collective population of 14 189 people. Until 1998, this area was accessible primarily only by air, large areas were still insecure, and most roads were mined. The low population density in the project area (< 8 people/km^2) is due mainly to the inaccessibility that results from flooding during the wet season, the lack of water in the dry season, poor roads and the lack of other infrastructure such as water supply, and the relatively small area of land suitable for intensive agriculture (although some irrigated agriculture is practised in areas that are inundated in the rainy season). As a consequence, the province generally has not benefited to the same extent as elsewhere from the country's economic development. The province has seven districts, of which four are cut off in the wet season by the flooding Steung Sen River. There is a military establishment in the area, including within the PVPF, with associated hunting and forest harvesting.

Why develop a transboundary project in the Emerald Triangle?

The Emerald Triangle is globally important because of the rich biodiversity it supports in forests, marshes and rivers. Habitats essential for most wildlife species, especially large mammals and endangered birds, have been afforded inadequate protection in the Emerald Triangle in the past, despite the existence of several large protected areas. Due to the highly seasonal nature of the environment, key species are dependent on certain limited resources, including permanent water bodies and upland forest patches, which tend to be small, localized and especially vulnerable to disturbances, including fragmentation. The crucial conservation problem in the Emerald Triangle is the inadequate protection of the transboundary habitats of protected wide-ranging wildlife species, which can have negative impacts on their populations and which poses an increased threat to ecosystem functioning at the landscape level.

There is a significant gap between Thailand and its neighbouring countries in the extent and availability of skills for managing protected areas. Cambodia and especially Lao PDR lack the capacity to manage and plan biodiversity conservation effectively at all levels. Protected-area staff—at the central level but particularly at local levels—have limited access to training, their management budgets are often constrained, and there are few rangers in the field. These obstacles reduce the effectiveness of patrolling and law enforcement and enable forest encroachment, poaching, and the illegal trade of wildlife via protected areas. Border disputes between Cambodia and Thailand, which have occurred irregularly over the years, pose another challenge to transboundary conservation in the area by heightening political tensions and interrupting efforts at trinational collaboration in policymaking.

Most communities in the Emerald Triangle live below the poverty line and rely on natural resources for their subsistence. This is one reason for wildlife poaching and illegal logging (the latter especially for rosewood, *Dalbergia cochinchinensis*, which has been reported in all three countries). The primary impetus for poaching, for example, is demand for bushmeat, which is an important source of protein in rural households (Trisurat 2003a, 2003b).

There is an active trade in wildlife and animal parts taken from the forest reserves, highlighting the need to protect corridors and habitats for migrating wildlife species and to control the illegal hunting of animals and the trade of plants collected in protected areas. The illegal trade of wild animals and plants has been observed at border checkpoints between Thailand and Lao PDR.

Local people who collect edible plants often burn areas of dry dipterocarp forests to stimulate the growth of young shoots, and the application of scientific research is essential for raising local awareness of the relationships between forest fire and the sustainable management of deciduous tropical forests. There is a lack of accurate, up-to-date information on the status of biodiversity, and the magnitude and significance of degradation due to the trade of animals and plants or their parts is unknown. These problems are likely to persist in the Emerald Triangle because local people have been using forest resources for many generations. One way for the ITTO–CBD project to address the issue is to develop alternative activities whereby local people can supplement their incomes while implementing strict protection measures and proper land-use planning (Trisurat 2007).

Given the importance of the area for large mammal and avian conservation in Southeast Asia, the ITTO–CBD project was established as a mechanism to assist the three countries in transboundary cooperation to accomplish large-scale landscape management and maintain regional biodiversity. Much of the work carried out by the project is intended to address local socioeconomic concerns in the knowledge that this will also have direct benefits for conservation and the functioning of the protected areas.

Project objectives

The ITTO–CBD project was established with three main objectives:

1) To strengthen cooperation between Cambodia, Lao PDR and Thailand on biodiversity conservation in their respective transboundary conservation areas.
2) To enhance protection measures and monitoring of the biological resources along trinational borders.
3) To strengthen the involvement of local communities and stakeholders to ensure the sustainable use and management of natural resources in both enclave communities and buffer zones.

Project design and phases

Under the project, transboundary conservation was perceived as a process that would be conducted in several stages. The project began before the establishment of the ITTO–CBD Collaborative Initiative but was placed under it as an excellent fit from many perspectives. In the initial phase, Thailand took the initiative to make cross-border contact with authorities in Cambodia and Lao PDR for the exchange of information on opportunities for and the goals of cooperation, transboundary issues, and the management process. A framework for dialogue and the exchange of views and information on transboundary conservation was established to create conditions for the implementation of a joint programme. This framework comprised:

- Tripartite commissions of government officials and protected-area managers, whose task was to help pave the way for trinational cooperation in transboundary biodiversity conservation.
- Joint taskforces composed of protected-area staff for the exchange of views and information through meetings, mutual visits, joint expeditions and patrols, and joint proposals for the modalities of transboundary cooperation in management planning, research, and the implementation of international conventions, etc.

In Phase 1, which took place from 2000 to 2003, the project was directed toward management planning in Thailand and developing international cooperation. The focus was on establishing an effective organizational and management system for the PPFC in Thailand; data collection; the installation of an information system and database; initiating a planning process; initiating contacts with conservation authorities in Cambodia and Lao PDR; and establishing fora for the trinational exchange of information on transboundary biodiversity conservation.

The first phase, therefore, emphasized the establishment of organizational and management systems and laying the foundations of an ecosystem-based management approach. With the transboundary dimension, the Thai project team assessed how best to cooperate with the conservation and management agencies of neighbouring countries so as to agree on modalities for applying optimal management across the national boundaries, with concerted actions on all sides of the borders for collaboration in planning and implementing research and conservation-related activities. Among the project's most important long-term objectives was to initiate the development of an overall management plan—including an action plan—that would put in place a strategy for transboundary biodiversity conservation.

On completion of the first phase of the project, the governments of Cambodia and Thailand received additional funding from ITTO to enable them to implement a second phase in which they could address the threats and challenges that impeded the effective management of the ETPFC, including the following:

- Lao PDR had been reluctant to nominate an area for inclusion in the ETPFC.
- Forests in the ETPFC buffer zone were being encroached.
- Cattle grazing and forest fires associated with local herders were occurring in and around the protected areas.
- Protected-area staff at the central and local levels had little or no access to training, management budgets were very small, and there were few park rangers or facilities on the ground, especially in protected areas.
- Thousands of landmines that had been laid along the borders between Cambodia, Lao PDR and Thailand in the early 1980s had not been cleared. Thailand (with assistance from Norway) and Cambodia (with the assistance of several international donors) have since begun demining the area, but the task requires considerable funding and the mines still constitute a major threat to researchers and park rangers conducting biodiversity surveys and patrols. As a result, surveys and patrols continue to require collaboration with the military.

Lessons learned in Phase 1 informed the development of Phase 2, the aim of which was to put in place a working management plan for the implementation of biodiversity conservation measures. These included initial collaborative trinational transboundary activities in areas that were jointly identified in Phase 1; the initiation of a long-term scientific research programme; the development of buffer-zone activities for villages adjacent to the ETPFC; human resource development; ecotourism development; and the strengthening of trinational exchange mechanisms. Phase 2 was planned originally for 2002–2005 but was delayed because of issues around the wording of the agreement; it was eventually carried out from 2008 to 2010. By its completion, conditions in the project area and among surrounding communities had improved considerably, providing the basis for the continuation of transboundary cooperation in implementing conservation activities. Specifically, the following had been achieved:

- Networks had been established between protected areas and local communities.
- A framework for transboundary cooperation between Cambodia and Thailand had been established.
- An information service for reaching out to communities had been developed.
- Cooperation among relevant agencies had been strengthened for the achievement of mutual objectives.
- Protected areas were less encroached.
- The economic status of local communities had improved, with increased incomes.
- Local communities involved in buffer-zone management had increased their understanding of alternative income-generating opportunities; resource managers had been provided with more reliable information for decision-making; park rangers had increased their understanding of conservation management planning; and the Cambodian and Thai people had collectively benefited from less encroachment and fewer other forest crimes in the protected areas.

A formal project evaluation at the end of Phase 2 identified the following challenges:

- Trinational ownership of the transboundary coordination process was still lacking, in large part because Lao PDR remained reluctant to join.
- There was a lack of an explicit vision for the overall project.
- Information and capacity weaknesses persisted, making implementation difficult.
- Transboundary issues continued to be sensitive.
- Emerging issues included the development of the economic zone, an improved highway, border tensions, and the permanent settlement of new families in areas contiguous with the PVPF.

- Concerns remained about the long-term sustainability of activities, should external funding be removed (ITTO 2010).
- An overall strategic plan and action plan was still lacking for the ETPFC at the end of Phase 2, although full management plans had been prepared for the PPFC and the PVPF.

Overview of this report

Chapters 2–8 of this report provide details of the wildlife and forest monitoring and research conducted under the ITTO–CBD project from 2000 to the end of Phase 3 in 2016, as well as the work carried out to enhance the livelihoods of local people. Chapter 9 discusses these accomplishments, identifies the lessons learned as a result of the project, and makes recommendations for policymakers and managers considering developing transboundary conservation projects elsewhere.

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2 FORECASTING LAND-USE CHANGE IN THE EMERALD TRIANGLE PROTECTED FORESTS COMPLEX

Yongyut Trisurat

The ETPFC, situated along the trinational borders between Cambodia, Lao PDR and Thailand, is the largest extensive intact block of the Southeastern Indochina Dry Evergreen Forests ecoregion in the Greater Mekong Subregion. Wikramanayake et al. (2000) reported that only one-third of the original habitat still remained in this ecoregion, which is recognized globally as outstanding for providing important habitats for many endemic species of large vertebrates (Office of Environmental Center 2005). Bhumpakphan (2015), Cambodia's Forestry Administration (2009) and Round (1998) indicated that more than 50 threatened species occur in the ETPFC, including the Asian elephant, banteng, Siamese Eld's deer and Siamese crocodile.[1] These wide-ranging species inhabit and seasonally migrate across the trinational boundaries of this area because of its heterogeneous topographic patterns and variations in seasonal hydrological conditions (Trisurat 2009; Bhumpakphan 2015).

According to Galt et al. (2000), there are dissimilarities among the three countries in conservation efforts and human capacity. Cambodia and Lao PDR have more extensive intact natural forests and biodiversity than Thailand, but they lack sufficient human capacity and resources to effectively maintain that biodiversity. In contrast, Thailand has assigned more forestry officials and park rangers and has greater facilities to manage and protect biological resources in its protected areas and the remaining forests in the buffer zones. Forested landscape configurations and biodiversity in Thailand are less intact than those of Lao PDR or Cambodia, however (Trisurat 2007). Moreover, a recent study of land-use change between 2002 and 2008 (Trisurat 2009) indicated that deforestation was continuing in the buffer zones near protected areas in the entire ETPFC due to the expansion of rubber plantations in Thailand, unsustainable logging in Lao PDR, and a land allocation programme for military purposes in Cambodia (Forestry Administration 2009). In addition, wildlife poaching for bushmeat and its illegal trade across the trinational borders has been reported (Bhumpakphan 2015). These issues are overlaid by external constraints associated with the limited participation of Lao PDR in project activities and border disputes between Cambodia and Thailand, which reduce the effective level of transboundary cooperation (Kalyawongsa and Hort 2010).

Therefore, the long-term persistence of species with transboundary ranges in the ETPFC depends primarily on a conservation partnership among the three countries and between park rangers and local people to maintain the integrity of wildlife habitats and to reduce anthropogenic pressures in the protected areas and buffer zones. To address some of these issues, Thailand initiated a management planning process for the PPFC in 2000 in the context of transboundary biodiversity conservation with Cambodia and Lao PDR, with the support of an ITTO project (Kalyawongsa and Hort 2010), which later developed into the ITTO–CBD project (see Chapter 1).

This chapter focuses on land-use change in the ETPFC, which is generally recognized as an important aspect of wildlife habitat because it alters the availability of food and cover (McComb 2008). Deforestation causes significant effects on wildlife distributions and populations, including the direct loss of species (Sodhi et al. 2004; Corlett 2012). Deforestation and forest degradation result in reduced habitat availability, habitat fragmentation, reduced patch size and core area, and the isolation of suitable habitat patches (MacDonald 2003). Trisurat et al. (2010) indicated that land-use change, including habitat fragmentation due to deforestation and degradation, would reduce the mean abundances of original species relative to their abundances in the primary forests of northern Thailand.

1 Table 1.2 provides the scientific names and conservation status of these and other fauna species.

Various models have been developed to forecast future land use. For example, Markov Chain models have been used as land-use models that employ previous land-use trends to predict future land uses. These models cannot display land-use patterns, however, and nor can they incorporate preference locations, land demands or spatial policies (Pontius et al. 2008). Cellular automata can be used to enhance traditional Markov Chain models by showing spatial patterns of future land use (Baker 1989). Recently, the Dyna-CLUE ("Conversion of Land Use and its Effects") model was developed to assess future land uses (Verburg and Overmars 2009). This is a spatially explicit model applicable at all spatial scales, and it can be used in policy support tools and participatory approaches.

This chapter presents and assesses the rate of land-use/land-cover (LU/LC) change in recent years in the ETPFC and defines narrative land-use scenarios for forecasting land-use patterns across the ETPFC through a participatory approach.

Methods

Study area

The study area comprises the ETPFC as well as remaining forest in the buffer zones and other land-use types located within the rectangular extent shown in Figure 2.1. The total area, including buffer zones, is approximately 2 580 000 hectares. The general topography of Thailand's PPFC is mountainous and sloping gently towards the southeast. In contrast, the terrain in Cambodia and Lao PDR is flat, with parts of the lowland areas flooding during the wet monsoon season.

Land-use change modelling

The LU/LC change modelling conducted in the study had two main components: the detection of land-use change, and the forecasting of land-use change (Figure 2.2).

Land-use/land-cover change detection

The detection of LU/LC change, and the quantification of the rate of change, involved three steps:

1) *Generalize past land-use maps*: The Mekong River Commission Secretariat provided the project with a land-use map for 2003. The original 14 land classes, with a resolution of 250 m, were generalized into nine classes for effective modelling (Verburg and Overmars 2009) at a landscape scale: i) evergreen forests (moist evergreen forest, dry evergreen forest, and hill evergreen forest); ii) mixed deciduous forest; iii) dry deciduous forest; iv) forest plantation; v) rubber plantation; vi) arable land[2] (rice paddy, cash crop and oil palm); vii) settlement and infrastructure; viii) bare soil and rock outcrop; and ix) water.

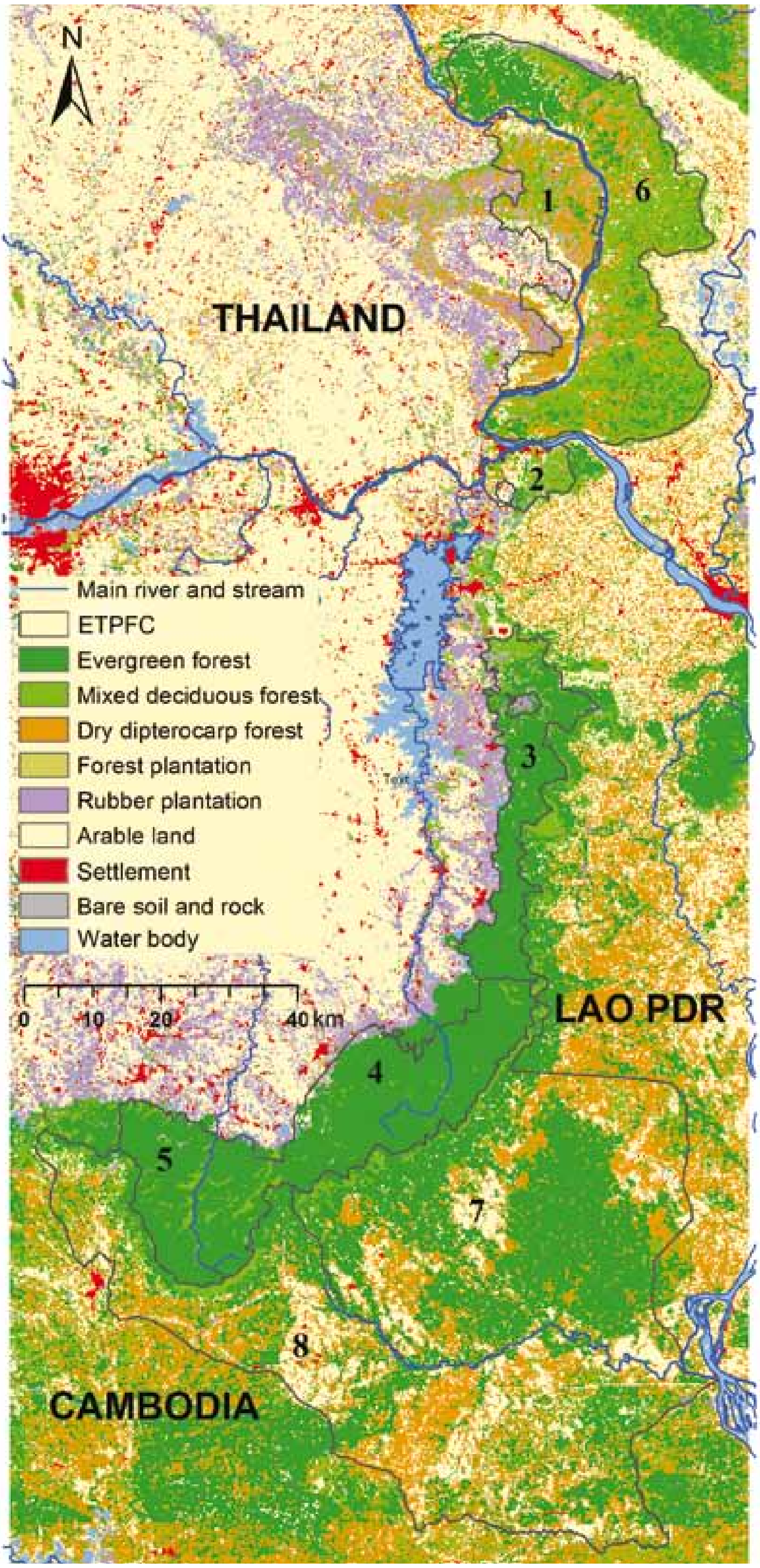
2) *Interpret land-use map*: The land-use map for 2013 was interpreted visually from Landsat-8 TM imagery. A sub-scene of satellite images (path/row 126/49, dated 8 October 2013, and path/row 126/50, dated 26 October 2013) was extracted and projected to the UTM [Universal Transverse Mercator] coordinate system WGS 1983 Zone 48 using ERDAS Imagine software. A false colour composite image (band combination 4 5 3—RGB) was produced and visually interpreted using an onscreen digitizing technique based on tone, shape, size, pattern, texture, shadow and feature association (Lillesand et al. 2004). Key image features of nine land-use types were sampled according to the image signatures during fieldwork in the PPFC in Thailand and the PVPF in Cambodia, as reference data.

   The accuracy of the interpreted land-use map was assessed using contingency table analysis. Omission and commission errors for each land-use class, overall accuracy, and the kappa statistic (a measure of map accuracy) were calculated (Jensen 1996). A number of interpreted samples were chosen using stratified random sampling. There were 238 sample locations for the arable land land-use type, 38 for rubber plantations, 14 for forest plantations, 43 for dry dipterocarp forests, 42 for mixed deciduous forests, 61 for dry evergreen forests, 54 for settlements, and 19 for "other classes". These interpreted land-use types were compared with observed land-use types to estimate map accuracy.

3) *Assessing the rate of land-use change*: The average rate of land-use change was calculated by dividing the difference in the area of the past and current "extent of land use by the past

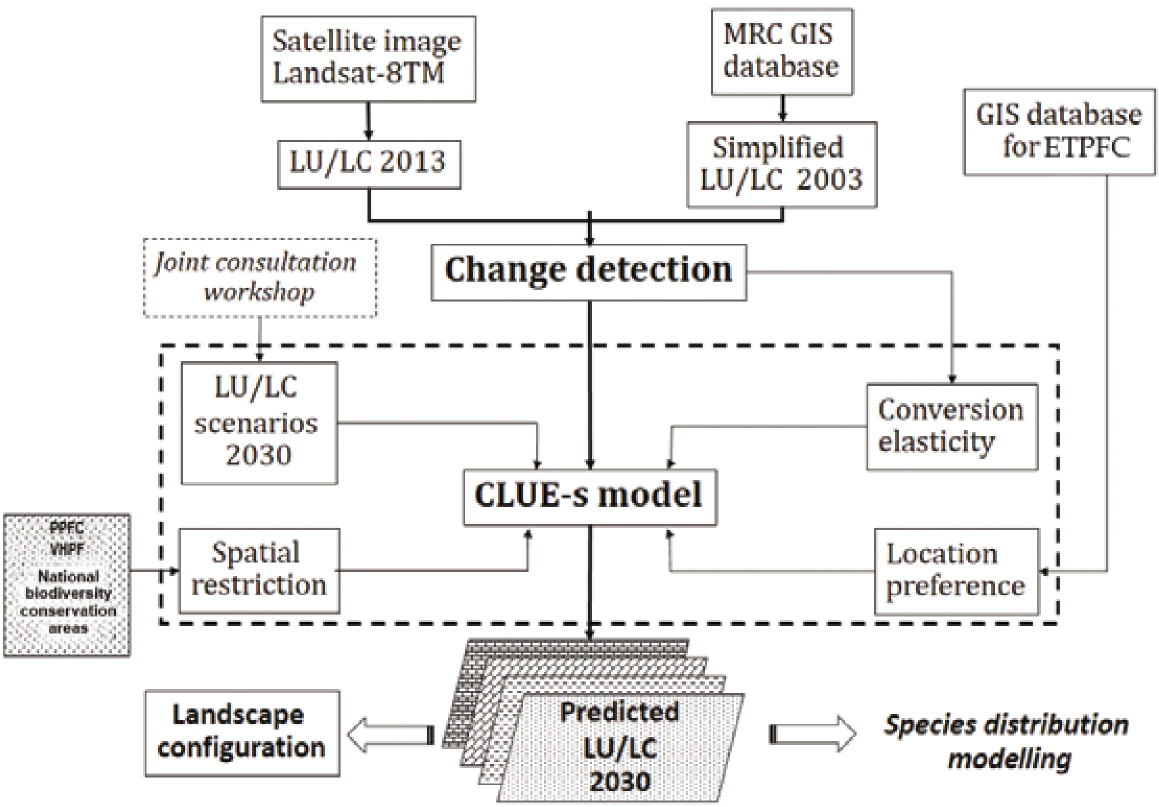
2 Note that "arable land" is defined here as the area of land placed under crops.

Figure 2.1: Land use in the ETPFC, 2013



Notes: 1 = Pha Taem National Park; 2 = Kaeng Tana National Park; 3 = Bun Thrik-Yot Mon Wildlife Sanctuary; 4 = Phu Jong-Na Yoi National Park; 5 = Yot Dom Wildlife Sanctuary; 6 = Phou Xiang Thong National Protected Area; 7 = Dong Khanthung Provincial Protected Area; 8 = Preah Vihear Protected Forest for the Conservation of Genetic Resources of Plants and Wildlife.

Figure 2.2: The main steps in land-use/land-cover change detection and prediction, ETPFC



extent. In addition, the annual rate of change was determined by using the deforestation rate (DR) equation from year P (start) to year N (end year) (Trisurat 2009), as below:

$$DR\,(\%) = -\left[1 - \left(\frac{LUyearN}{LUyearP}\right)^{1/t}\right] x100$$

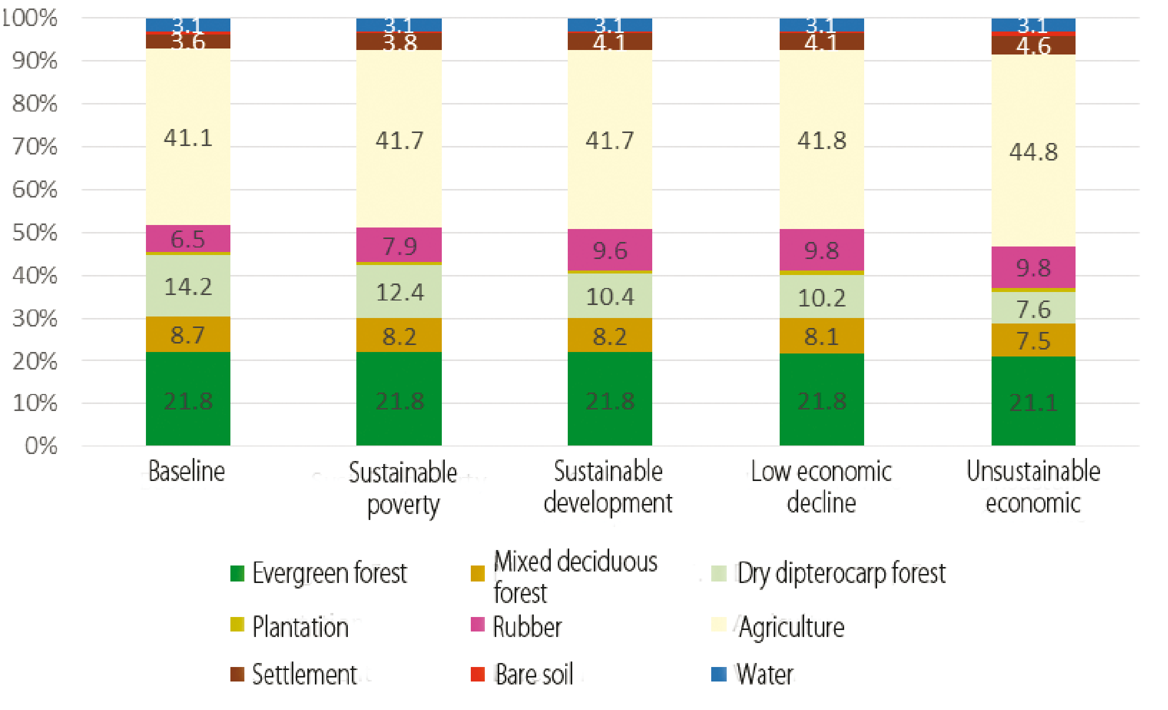
where
DR = annual rate of change
N = land use of end year
P = land use of start year
t = time period; t2 – t1 (10 years)

Forecasting land-use change

The study used the Dyna-CLUE model to predict land-use change because it is able to incorporate inputs from multiple stakeholders and present land-use patterns derived from different scenarios. The Dyna-CLUE model requires four inputs to allocate future land-use patterns: 1) land-use requirements; 2) location characteristics; 3) spatial policies and restrictions; and 4) land-use-type-specific conversion settings (Verburg and Overmars 2009). These were obtained through three main steps:

1) *Land-use requirements and restriction policies*: 50 stakeholders from the three participating countries attending a joint training workshop on geographic information system (GIS) modelling for forest land-use planning jointly defined land demands and requirements. These stakeholders comprised the superintendents of protected areas, government officials, non-governmental organization (NGO) representatives, and university lecturers. Using a two-dimensional matrix (Van der Heijden 1996), they identified population growth as an important factor and economic growth due to the "ASEAN Economic Community 2015" (AEC) scheme as a crucial uncertainty in driving four land-use scenarios for the period from 2003 to 2030. Figure 2.3 presents the aggregate values of land-use types; the narrative scenarios were as described below.

Figure 2.3: The proportion of each land-use type under four scenarios in 2030



Scenarios:

i. **Low economic decline and localized resource degradation, or business as usual**. This scenario assumes the continuation of the land conversion observed in recent years (2003–2013) based on recent land-use monitoring in the PPFC, where only limited encroachment was observed inside the protected areas (Protected Areas Region 9, personal communication, 2014). Therefore, this scenario defines the PPFC as a restriction area.

ii. **Unsustainable economic development and serious resource degradation.** Continuously rising rubber prices and high population growth stimulate a huge land transformation from forest and bare soil to rubber plantations and arable lands (paddy field and economic crops), respectively.

iii. **Sustainable poverty and stable resources.** The rate of land conversion is reduced due to low population growth and the delay of the AEC scheme. This scenario also anticipates the effective protection of remaining forests in all protected areas in three countries.

iv. **Sustainable development and limited resource degradation.** A relatively low land conversion rate applies to rubber plantations, and there is limited forest encroachment for agriculture outside protected areas and production forest in the DKPPA.

2) *Location preferences*: The Dyna-CLUE model determines the suitable location of each land-use class based on a logistic regression model (Verburg and Veldkamp 2004), which defines the relationship between the occurrence of a particular land-use type and physical and socioeconomic conditions (explanatory variables).

The physical factors entered into the logistic model were altitude; slope; aspect; distance to available water; annual rainfall; rainfall in wettest quarter; rainfall in driest quarter; and soil characteristics. The socioeconomic factors influencing land-use change were distance to district; population density; and distance to main road. Topographic variables were gathered from the Advanced Space Thermal Emission and Reflection Radiometer online archive.[3] Road and stream networks and

3 http://asterweb.jpl.nasa.gov/data.asp

district location were updated from topographic maps at a scale of 1:50 000 and Landsat-8 TM images. Rainfall variables of 1-km resolution were downloaded from the World Climate Database[4], and soil data and population density were obtained from the Mekong River Commission Secretariat. A pixel resolution of 250 m, similar to the original LU/LC map from 2003, was used for all spatial analyses. The accuracy of logistic regression models for determining suitable locations for each land-use class was evaluated using the "receiver operating characteristic" (Hosmer and Lemeshow 2000).

3) *Land-use type-specific conversion settings*: Land-use elasticity refers to the reversibility of land-use change. Generally, land-use types with high capital investment cannot easily be converted to other uses as long as there is high demand. Land-use elasticities range from 0 (easy conversion) to 1 (irreversible change) (Verburg and Veldkamp 2004). In this study, elasticity values were obtained from the probability transition matrix of land-use changes between 2003 and 2013, which was developed from the sequential series of satellite imagery. Water-body and settlement and infrastructure classes were assigned as permanent. According to Sahunalu et al. (1993), a minimum of ten years was defined to transform from reforestation to a forest class and 20 years was specified for succession from abandoned agriculture back to forest cover.

Results and discussion

Land-use change between 2003 and 2013

The classification matrix (Table 2.1) shows that all sample points for evergreen forest, water bodies and human settlements and infrastructure were correctly classified. The accuracy of interpreted arable land was 98%, and bare soil was 89%. Five sample locations of arable land were misclassified as dry dipterocarp forest, perhaps because some small trees or shrubs remained in new paddy fields, particularly on the northern plain of Cambodia. Seven locations of dry dipterocarp forest, or 15% of the total sample points, were interpreted as mixed deciduous forest due to the similarity in the image signatures of these two classes. The overall accuracy for the interpreted land-use map in 2013 was 94% and the kappa statistic value was 0.91, which was ranked as high (Jensen 1996).

4 www.worldclim.org/download

In 2003, **evergreen forest** covered 21.36% of the study area; by 2013, this had increased slightly, to 21.71% (Table 2.2). The apparent increase may have been because 2013 was a wetter-than-average year, with the result that some dense mixed deciduous forest and flooded dry dipterocarp forest pixels in the DKPPA (seven samples; see Table 2.1) were misclassified as evergreen forest. Approximately 60% of the total evergreen forest was inside protected areas, particularly in Phu Jong-Na Yoi, Yot Dom and the core area of the DKPPA.

Mixed deciduous forest is dominant in Phou Xiang Thong, Pha Taem, Kaeng Tana and along the escarpment between Thailand and Lao PDR. It covered 9.49% of the study area in 2003 and 8.77% in 2013, representing a decline in this forest type of 7.68% over the decade (0.80% per year; Table 2.2). The deforestation rate was much lower inside the protected areas than in the ETPFC landscape as a whole, due to protection measures.

Dry dipterocarp forest is predominant in Pha Taem, Kaeng Tana, the PVPF and the DKPPA, which have shallow and lateritic soils. Approximately 30% of dry dipterocarp forest (166 000 hectares) was lost between 2003 and 2013 (Table 2.2), and large-scale forest conversion was observed inside the PVPF and Phou Xiang Thong and in the buffer zones. This finding is consistent with forest-cover monitoring in the PVPF, as reported by Sobon et al. (2014), and with land-use monitoring in the PPFC and buffer zones (Trisurat 2009).

Although a relatively new cultivation practice in the ETPFC, rubber plantations have increased rapidly in the last decade in the PPFC and they have expanded into Cambodia and Lao PDR. Rubber plantations covered 3.31% of the study area in 2003, but this had nearly doubled to 6.35% by 2013. The annual increase (6.75%) was the highest of the nine land-use classes and reflects the increase in rubber prices over the decade. Most plantations were in the buffer zone of the PPFC.

Arable land (paddy fields, cash crops and oil palm) covered about 37% of the study area in 2003; by 2013 this had increased to 41%. Arable land increased greatly inside the PVPF (Table 2.2) because of Cambodia's land allocation programme for the military (Forestry Administration 2009). The areas of bare soil and rock outcrops, water bodies and settlements were stable over the decade.

Projected land use/land cover in 2030

Table 2.3 shows the explanatory factors and coefficients that determine site suitability, as derived from the logistic regression models of eight land-use classes. Water bodies were not evaluated because this class was treated as stable in all demand scenarios (Figure 2.3). The various driving factors affected different LU/LC types. For example, altitude, slope, annual rainfall, and distance from city and stream, as well as access by road, were all positively correlated with remaining evergreen forest. In contrast, arable land was predicted at low attitudes, close to streams and settlements, with fertile soil, and accessible from main roads. Aspect was an important factor only for rubber plantations (Table 2.3).

The predicted models were strongest for evergreen forest and settlements (area under curve [AUC] >0.9), excellent for forest plantations, rubber plantations and arable land (0.8≤ AUC <0.9), and acceptable for mixed deciduous forest, dry dipterocarp forest and bare soil and rock outcrops (0.7≤ AUC <0.8). The gradient of the goodness-of-fit of logistic regression models showed agreement with the accuracy assessment of the classified land-use map (Table 2.1).

Figure 2.4 shows the predicted land-use changes derived from the Dyna-CLUE models relative to the current land-use map, under four scenarios.

1) The model predicted future deforestation for arable land in the buffer zones of the PPFC and areas close to the Chong-Mekong border checkpoint under the *low economic decline and localized resource degradation* ("business as usual") scenario. In addition, a substantial amount of forest cover inside Phou Xiang Thong and to the north of the DKPPA would be converted to rubber plantations and agriculture. Forest cover was predicted to decline from 44% of the study area in 2013 to 38% in 2030.

2) A large area of mixed deciduous and dry dipterocarp forest would be converted to rubber plantations and arable land under the *unsustainable economic development and serious resource degradation* scenario. The area of rubber plantations would increase by 50% from the current level. In addition, the Dyna-CLUE model predicted that new arable land would be created in the west of the PVPF because of unsustainable land-use and land-allocation programmes (Sobon et al. 2014). Forest cover would decline by 9% to only 35% of the landscape by 2030.

3) The *sustainable poverty and stable resources scenario* assumed low population growth and a continuation of recent land-use trends and predicted limited deforestation (58 500 hectares) between 2013 and 2030. A small amount of land conversion to agriculture and rubber plantation was predicted outside all protected areas.

4) Finally, the land-use patterns predicted in the *sustainable development and limited resource degradation* scenario were similar to those in the business-as-usual scenario. High deforestation was suggested in the north of the DKPPA and to the west of the PPFC, but only limited areas of deforestation were predicted in all protected areas. Overall, forest cover would decline from 44% in 2013 to 39% in 2030.

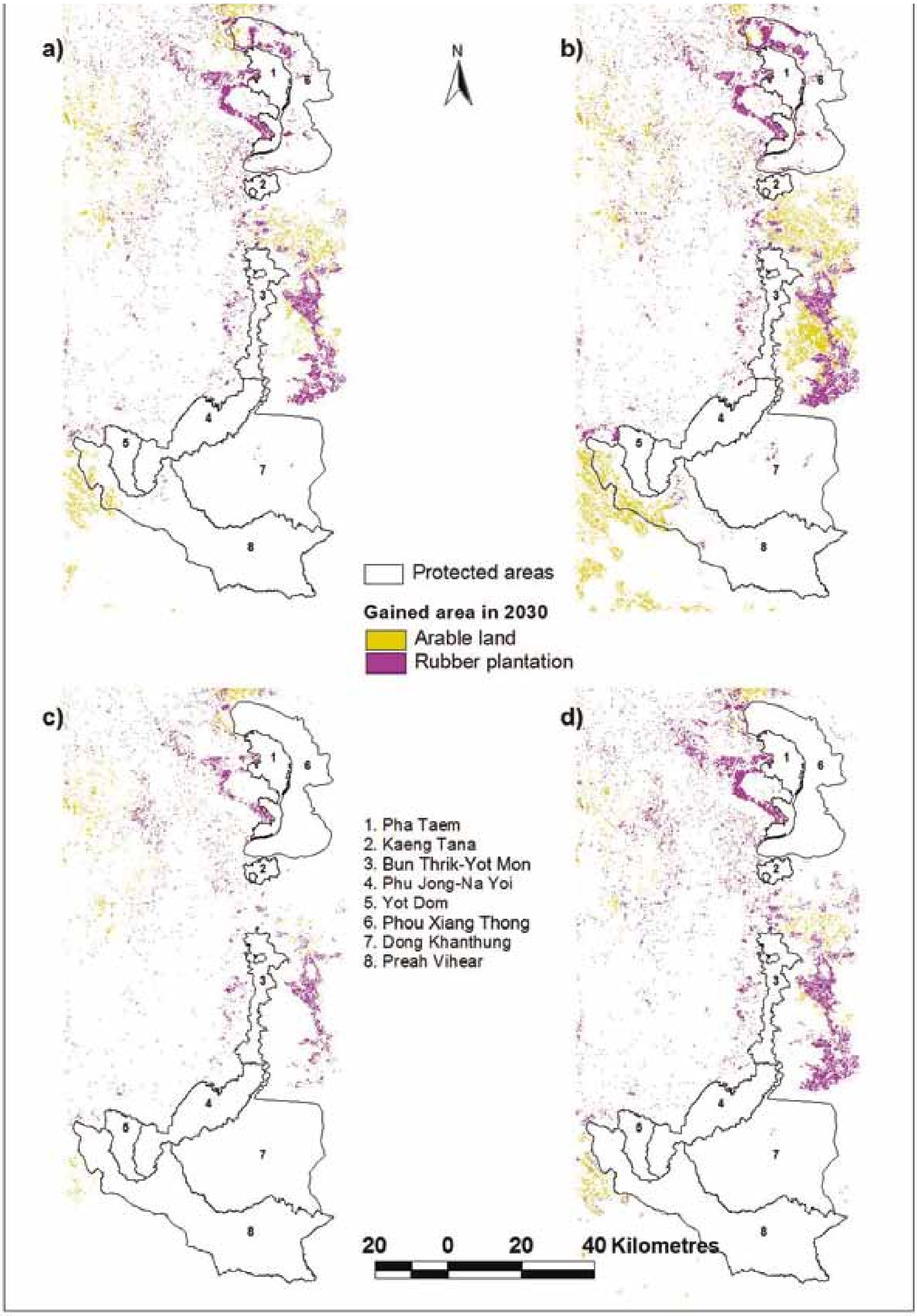
Potential effects of land-use changes on transboundary biodiversity

Land-use conversion as a result of human activities not only decreases forest cover, which is habitat for many wildlife species, it also results in habitat fragmentation, shrinking patch size, and reduced core area (Turner et al. 2001; MacDonald 2003; Trisurat and Duengkae 2011). All these factors have a degrading effect on the habitats of large wildlife species (Lynam 2010).

The consequences of land-use conversion are clear for dry dipterocarp forests, for which the total forest area was predicted to decrease from 356 900 hectares in 2013 to less than 200 000 hectares in 2030 under the *unsustainable economic development and serious resource degradation* scenario. Evergreen forest is less threatened because it is situated either in protected areas or on steep slopes, which are difficult to access (Trisurat 2007).

The loss of lowland deciduous forests in Cambodia and Lao PDR would have negative impacts on some threatened or endangered wildlife species, such as Siamese Eld's deer, giant ibis, sarus crane, Asian elephant, banteng and gaur, which are currently found in these areas. Lowland dry dipterocarp forests in the DKPPA (Round 1998) and the PVPF support more wildlife species in greater abundance

Figure 2.4: Predicted new areas of arable land and rubber plantations in 2030 based on four scenarios: a) low economic decline and localized resource degradation ("business as usual"); b) unsustainable economic development and serious resource degradation; c) sustainable poverty and stable resources; and d) sustainable development and limited resource degradation



than do evergreen forests (Round 1998; Forestry Administration 2009). Therefore, the destruction of lowland forests would reduce the integrity of habitats used by many of these wide-ranging species and threaten the population viability of transboundary species in the ETPFC landscape.

Conclusion

The LU/LC assessment for the period 2003–2013 suggests that dry dipterocarp forests are under threaten in the ETPFC. Approximately 30% of its area has already been converted to agriculture and rubber plantations, especially in the buffer zones of the PPFC. Population growth and the economic transition in the region due to the AEC scheme are the key driving factors for a predicted transformation in land-use patterns by 2030.

Under the *sustainable poverty and stable resources* scenario, there will be a small expansion of rubber plantations and arable land, and all protected areas will be secured from future land-use change. Limited deforestation in the buffer zones of the PPFC and in Lao PDR is indicated under the *low economic decline and localized resource degradation* scenario. The *unsustainable economic development and serious resource degradation* scenario forecasts a greater expansion of arable land and rubber plantations. In addition, substantial conversion of dry dipterocarp forest in the PVPF is expected as the result of a land allocation programme for the military and infrastructure development for tourism. Based on a decline in the price of rubber due to oversupply and a stable economy, the *low economic decline and localized resource degradation* (business as usual) scenario is the most likely of the four scenarios.

The forecast changes in land use derived from this research depend on land demands by multiple stakeholders in the three countries and on the characteristics of each land-use type. Although there are some limitations (e.g. the spatial resolution of assessment) and uncertainties about future socioeconomic conditions in the models and scenarios, the outputs provide useful information to assist policymakers and stakeholders in the three participating countries in collaborating proactively to prevent future deforestation in high-risk areas and important wildlife habitats.

Table 2.1: Contingency table resulting from field validation

	LU/LC class	**Interpreted class (no. of samples)**											
		Arable land	**Rubber plantation**	**Plantation**	**Bare soil**	**Dry dipterocarp forest**	**Mixed dipterocarp forest**	**Evergreen forest**	**Water**	**Settlement and infrastructure**	**Total**	**Producer accuracy (%)**	**Omission error (%)**
Known class	Arable land	224				5					229	98	2
	Rubber plantation	7	35	1							43	81	19
	Plantation		3	13							16	81	19
	Bare soil				8					1	9	89	11
	Dry dipterocarp forest	7				38	2				47	81	-3
	Mixed deciduous forest						40	7			47	85	15
	Evergreen forest							54			54	100	0
	Water								10		10	100	0
	Settlement & infrastructure									53	53	100	0
	Total	**238**	**38**	**14**	**8**	**43**	**42**	**61**	**10**	**54**	**508**		
	User accuracy (%)	94	92	93	100	88	95	89	100	98	94		
	Commission error (%)	6	8	7	0	12	5	11	0	2			

Table 2.2: Land-use classes in 2003 and 2013 in the ETPFC

Land-use type	2003		2013		Area change (ha)	Change (%)	
	ha	%	ha	%		10 yrs	Annual
Evergreen forest	552 112	21.36	561 104	21.71	+8 992	+1.63	+0.16
Mixed deciduous forest	245 412	9.49	226 573	8.77	-18 839	-7.68	-0.80
Dry dipterocarp forest	540 687	20.92	374 337	14.48	-166 350	-30.77	-3.61
Forest plantation	9 850	0.38	13 475	0.52	+3 625	+36.80	+3.18
Rubber plantation	85 456	3.31	164 225	6.35	+78 769	+92.18	+6.75
Arable land	965 087	37.34	1 058 836	40.96	+93 749	+9.71	+0.93
Settlement	77 700	3.01	80 365	3.11	+2 665	+3.43	+0.34
Bare soil & rock outcrop	25 549	0.99	23 293	0.90	-2 256	-8.83	-0.92
Water body	83 050	3.21	82 697	3.20	-353	-0.43	-0.04
Total (ETPFC)	**2 584 903**	**100**	**2 584 903**	**100**	**0**	**0**	**0**

Table 2.3: Beta values of significant location factors for regression models related to each land-use type

Variables	Evergreen forest	Mixed deciduous forest	Dry dipterocarp forest	Plantation	Rubber	Arable land	Settlement	Bare soil
DEM (m)	0.002	ns	-0.013	0.015	0.011	-0.003	0.003	0.007
Slope (%)	ns	0.103	ns	-0.096	-0.118	-0.120	ns	-0.035
Aspect	ns	ns	ns	ns	0.001	ns	ns	ns
Population density (person/km^2)	-0.039	-0.001	< -0.001	-0.001	-0.001	< -0.001	0.002	ns
Annual rainfall (mm)	0.009	-0.006	-0.003	0.019	-0.006	-0.007	0.008	-0.015
Rainfall in the wettest quarter (mm)	-0.007	0.008	0.007	-0.023	0.008	0.006	-0.011	0.016
Rainfall in the driest quarter (mm)	-0.045	0.152	0.290	-0.384	-0.179	-0.102	-0.122	ns
Distance to road (m)	< 0.001	8.9E-05	5.7E-05	-0.001	-0.001	-0.0003	-0.003	< -0.001
Distance to stream (m)	8E-05	0.6E-05	5.1E-05	< -0.001	-0.001	< -0.001	< -0.001	ns
Distance to city	3.8E-05	-0.3.2E-05	1.1E-05	ns	ns	1.6E-05	-3.0E-05	-3.4E-05
Acrisol soil	3.222	0.437	2.332	0.763	0.667	1.590	-0.366	0.744
Arenosol soil	1.503	ns	1.311	0.735	ns	2.174	-0.513	ns
Cambisol/plinthosol soil	3.503	0.572	2.446	ns	-1.594	1.383	-0.628	ns
Ferralsol soil	3.554	ns	Ns	-1.836	0.834	1.161	ns	ns
Gleysol/fluvisol soil	2.168	0.929	1.916	ns	ns	1.836	-1.161	ns
Leptosol soil	4.786	ns	2.099	ns	ns	1.933	ns	ns
Lixixol soil	2.893	ns	ns	ns	1.664	1.673	ns	ns
Luvisol/solonetz soil	2.495	ns	3.001	ns	-2.447	1.777	ns	ns
Slope complex	2.475	ns	4.245	ns	1.736	ns	-0.740	2.222
Rock	3.660	ns	3.512	-3.355	-1.326	Ns	-1.718	0.997
Constant	-11.252	-0.232	-8.307	-5.176	4.120	7.532	1.489	8.008
AUC	0.902	0.758	0.767	0.837	0.802	0.815	0.903	0.797

Notes: AUC = area under curve; DEM = digital elevation model; ns = not statistically significant.

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3 WILDLIFE MANAGEMENT AND TRAVEL CORRIDORS

Naris Bhumpakphan and Thanet Buakaew

The ETPFC between Cambodia, Lao PDR and Thailand supports a very rich fauna of unique and key species. One of these—the kouprey—was last seen in 1970 and its horn trophies can still be found in three villages near the ETPFC; it is possibly extinct, and 50 other species are endangered. Several are endangered or critically endangered, including the Asian elephant, gaur, banteng, greater adjutant stork, giant ibis, Siamese crocodile and several species of vulture.[1] The total area of the ETPFC—483 695 hectares (with five reserves in Thailand and one each in Cambodia and Lao PDR)—is probably large enough for the long-term survival of these unique wildlife species, assuming proper cooperative management, thereby serving science as well as the livelihoods of the local people (Round 1998; Forestry Administration 2009; Bhumpakphan 2004, 2015).

Wildlife recovery activities for endangered and critically endangered species are under consideration or implementation in Thailand, such as for the Siamese crocodile. Wild elephants, with a total population of only about 50 individuals in the ETPFC, cause conflicts by damaging the crops and properties of local people, hence presenting a challenge for their protection (Bhumpakphan 2015). A key part of the ITTO–CBD project (see Chapter 1) is to develop recommendations and management plans to achieve conservation goals for the rare and endangered landscape-scale wildlife species in the transboundary area.

For most of the large animal species in the ETPFC, few data exist on their distributions, abundances and movements. Yet data on these species are essential for long-term planning and the effective management of the ETPFC among the three countries. Therefore, a study of wildlife resources in the Laotian and Thai parts of the ETPFC was conducted in 2013–2014, with the objectives of providing a better understanding of the diversity of wildlife species; determining the key landscape-scale species and their distributions in the two countries; and understanding the threats to fauna in the transboundary area and how these can be minimized. Key landscape-level wildlife species include the Asian elephant, gaur, banteng, sambar, common barking deer, Chinese serow, and the large stork and vulture species. An overall objective of the ITTO–CBD project is to ensure that these species can move freely between Cambodia, Lao PDR and Thailand. For migratory species, it is necessary to consider habitats for breeding and foraging as well as travel corridors among the countries.

Study areas

The wildlife study was conducted in the Pha Taem National Park, the Kaeng Tana National Park, the Bun Thrik-Yot Mon Wildlife Sanctuary, the Phu Jong-Na Yoi National Park and the Yot Dom Wildlife Sanctuary in Ubon Ratchathani Province, Thailand (combined, these five reserves comprise Thailand's PPFC, which covers 173 695 hectares; see Chapter 1); and, in Lao PDR, in the Phou Xiang Thong National Protected Area (71 800 hectares) in Salavanh and Champasak provinces and the DKPPA (not officially part of the ETPFC—see Chapter 1), which covers 182 800 hectares in Champasak Province. Chapter 2 provides details of land uses and land-use changes that affect (or may affect, in the future) wildlife species in the ETPFC. Chapter 4 reports on a survey conducted in Cambodia's PVPF, and a more detailed recent survey of the DKPPA is discussed in Chapter 5.

Before widespread land-use change, large mammals could roam for foraging and breeding across a large landscape between Cambodia, Lao PDR and Thailand. Today, however, the populations of these species are fragmented due to habitat change and disturbances caused by the people who now dominate the landscape. On the Thai side, the ETPFC reserves are mostly narrow and mountainous and constitute largely unsuitable habitats for many large mammal species, and those in Lao PDR (the Phou Xiang Thong National Protected Area and the DKPPA) and Cambodia (the PVPF, at 170 000 hectares) provide much of the remaining suitable habitat. A large population of wild elephants is isolated in the Bun Thrik-Yot Mon Wildlife Sanctuary by surrounding unsuitable

1 Table 1.2 provides the scientific names and conservation status of these and other fauna species.

habitat and human disturbance areas; it requires more habitat and safe corridors to enable southward movement to larger reserves, such as the DKPPA and the PVPF (Figure 1.1).

Methods

Data collection

In the five PPFC reserves in Thailand, wildlife surveys consisted of direct and indirect counts, including roadside counts, track and other sign identification, and camera traps, updating previous work by Bhumpakphan (2004). The DKPPA was surveyed using the same techniques. Data for the Phou Xiang Thong National Protected Area were obtained from Duckworth et al. (1999). In addition, local markets and some villages in Lao PDR and Thailand were visited to obtain information on local uses of wildlife for subsistence and trade. Direct surveys and observations of landscape wildlife were conducted along the border of the Bun Thrik-Yot Mon Wildlife Sanctuary, the Laos Border Protection Forest[2], the Phu Jong-Na Yoi National Park and the DKPPA. Most of the survey activities in the DKPPA were supported by Champasak University's Wildlife Study Team, led by Dr Phonesavanh Thepphasoulithone.

The steep, high Dongrek Mountain Range between Phu Jong-Na Yoi and the DKPPA, Yot Dom and the PVPF is a barrier to large terrestrial mammals, such as Asian elephant, gaur, banteng and (in the past) kouprey. Possible focal points for large mammal movements through lowlands and valleys on the borders between Thailand and Lao PDR and Thailand and Cambodia were checked, and all sightings were located using a global positioning system (GPS).

Human–elephant conflicts are a known problem near the Bun Thrik-Yot Mon Wildlife Sanctuary. Due to the narrow shape of this mountainous habitat "island" and its lack of sufficient forage and water resources in the dry season, elephants are forced to move out of the reserve and into nearby agricultural areas and water pools. Direct observations were conducted at the conflict sites near and in the core area of the Bun Thrik-Yot Mon Wildlife Sanctuary. Data on the frequency of damage and the sites where losses were incurred were collected in January 2015 at a meeting with stakeholders comprising local people, forestry officials and ITTO staff.

An old trophy of a kouprey cow found at Ban Kaedon village near the Yot Dom Wildlife Sanctuary. Photo: N. Bhumpakphan

All survey data were mapped to assess the movements (by season), migration corridors used, and distributions of key landscape species. This was the first such investigation conducted transnationally in the ETPFC.

Results and discussion

Wildlife species richness

In the Thai part of the ETPFC and the Phou Xiang Thong National Protected Area and the DKPPA in Lao PDR, 695 invertebrate species, 96 mammals, 288 birds, 81 reptiles, 30 amphibians, and at least 101 freshwater fish species were identified (Table 3.1). Key wildlife species in Thailand included the Asian elephant, gaur, sambar, Indochinese tiger, green peafowl, white-winged duck, Siamese fireback and Siamese crocodile.

The two reserves in Lao PDR mostly supported the same species as in Thailand, but with a few additional species, including the yellow-cheeked gibbon in the Phou Xiang Thong National Protected Area and the Siamese Eld's deer, sarus crane, giant ibis, lesser adjutant stork and Asian

2 The Laos Border Protection Forest is not part of the ETPFC project; its main function is for border security, but it also serves as an important ecological corridor and habitat for large mammals and primates, facilitating their movement between the Bun Thrik-Yot Mon Wildlife Sanctuary, the DKPPA and the PVPF.

Table 3.1: Numbers of vertebrate wildlife species found in the various reserves of the ETPFC between Lao PDR and Thailand

Faunal type	Total	Thailand PPFC					Lao PDR	
		Pha Taem	Kaeng Tana	Bun Thrik	Phu Jong	Yot Dom	Phou Xiang	DKPPA
Mammal	**96**	32	51	45	78	85	30	24
Bird	**288**	72	131	113	180	259	23	32
Reptile	**81**	34	56	38	72	71	15	22
Amphibian	**30**	15	22	16	21	28	7	8
Fish	**101**	52	70	24	55	73	52	37
Total	**596**	**205**	**330**	**236**	**406**	**516**	**127**	**123**

woolly-necked stork in the DKPPA. Cambodia's Forestry Administration (2009) reported that all these species also occur in the PVPF.

Threats to wildlife and habitat

Threats to wildlife in the ETPFC include the following:

- Wildlife poaching for subsistence and trade, which occurs in all reserves in both Lao PDR and Thailand. Bushmeat was found at Chong Ta-U in Lao PDR and Chong Arn Ma in Cambodia.
- The collection of non-timber forest products by local villagers who live near reserves.
- Grazing by livestock, including domestic buffalo and cattle, in all reserves, where they increase ecological competition and could spread diseases to wild ungulates.
- The illegal cutting of valuable rosewood (*Dalbergia cochinchinensis*) timber in the Phu Jong-Na Yoi National Park and the Yot Dom Wildlife Sanctuary.
- Forest land encroachment at the boundary of the PPFC and inside the DKPPA.
- Land mines, which are scattered along the borders of Cambodia, Lao PDR and Thailand.

All these issues need to be addressed within each country through law enforcement, regular patrolling systems, and the removal of landmines.

Mitigation of human–elephant conflicts

The elephant population in the ETPFC consists of around 50 individuals in three subpopulations: a population of 40–45 animals in the Bun Thrik-Yot Mon Wildlife Sanctuary in Thailand and the Lao Border Protection Forest (Bhumpakphan 2015), and two small populations—one, in the DKPPA, with just three individuals (Inpaeng Daungvongsa, personal communication, 2014), and one, in the PVPF, with five individuals (C. Dany, personal communication, 2014).

In the Thai reserves, wild elephants roam throughout the Bun Thrik-Yot Mon Wildlife Sanctuary to the upper area of the Phu Jong-Na Yoi National Park. Elephants have damaged crops and destroyed people's properties locally there, from 1998 to the present. Agricultural crops and a good water supply from seven large reservoirs in lowland areas along the western part of these reserves provide food and water resources for wild elephants during the dry season. At least ten villages along the western boundary of the Bun Thrik-Yot Mon Wildlife Sanctuary (e.g. Ban Pa Mai, Ban Nong Rue, Kaeng Si-kot, Ban Palan Chai and Nong Kob) informed the survey team that they lose rice, cassava, corn, bananas, jackfruit and coconuts to elephants each year. Most of these cases of damage are in the village of Ban Pa Yaa-ka in the north of the reserve (yellow enclosed area in Figure 3.1). Ban Pa Yaa-ka village is an enclave in the wildlife sanctuary; it is located in a flat area that has recently been converted to agriculture and a large reservoir and should have been included in the original reserve. In October 2014, elephants destroyed some of the rice production in Bun Thrik district in Thailand and, as a result, compensatory payments were made to four farmer groups.

Of the 40–45 elephants, ten range between the Bun Thrik-Yot Mon Wildlife Sanctuary and the Laos Border Protection Forest, which includes rice paddy fields in Muong Soukhouma district in Lao PDR. The elephants form a herd and travel beyond the Laos Border Protection Forest during the harvest season in late October to November to feed in the

Wild elephant herd with calf at Pa Yaa-ka village, Bun Thrik-Yot Mon Wildlife Sanctuary. Photo: Thanet Buakaew

rice paddies. These crop raids in Lao PDR happen every year before the animals return to Thailand.

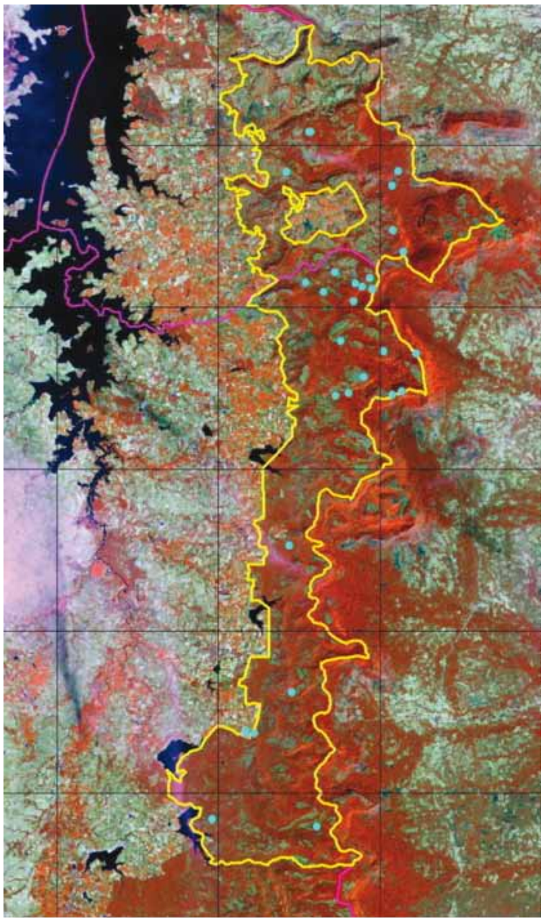
The range of wild elephants in the Bun Thrik-Yot Mon Wildlife Sanctuary and the Laos Border Protection Forest includes the dry evergreen forests along the eastern boundary of Bun Thrik-Yot. This strip of forest provides escape cover for wildlife, including elephants, bovids, sambar and tigers, and it also acts as a corridor to the DKPPA.

The question of how to mitigate human–elephant conflicts has been discussed in informal meetings over many years, the most recent of which was at the Bun Thrik-Yot Mon Wildlife Sanctuary attended by 60 local people living near the wildlife sanctuary. No resolution has been reached, however, other than the payment of compensation to farmers whose property is damaged; such payments are obtained from the "Elephant Food Fund" maintained by Thailand's Department of National Parks, Wildlife and Plant Conservation.

Seasonal movements of wildlife

Laotian and Thai people living on the Mekong River confirm that most of the large mammals in the ETPFC, including elephant, gaur, banteng, tiger and sambar, cross the border. There is a supporting record in the form of a prehistoric cave painting, estimated to be up to 3000 years old, at Pha Taem Cliffs above the western bank of the Mekong River (see photo next page). This painting depicts humans, the Mekong giant catfish, smaller fish, turtles painted in red, and two swimming elephants (a cow and calf) and a fish, suggesting that prehistoric people saw elephants swimming

Figure 3.1: The distribution of wild elephants in the Bun Thrik-Yot Mon Wildlife Sanctuary



Source: Wichit Jiramongkolkan

across the Mekong River between Phou Xiang Thong and Pha Taem.

The PPFC is located in the Khong Chiam district of Thailand's Ubon Ratchathani Province. The name "Khong Chiam" is derived from "klong a-jiang", in which "klong" means "herd" and "a-jiang" is a native name for elephant; thus, the full name means "herd of elephants". In the past, herds of wild elephants undoubtedly moved freely along the Mun River in Thailand and the Mekong River before humans arrived and dominated in these areas.

Two wild elephant herds of 5 and 12 individuals, and an individual gaur, were recently reported crossing the Mekong River between Lao PDR and Thailand at the Phu Wau Wildlife Sanctuary and Bolykamxai in Lao PDR (Ronglarp Sukmasuang, personal communication, 2014).

The ETPFC can be considered to be composed of two main groups of reserve complexes: the upper ETPFC, and the lower ETPFC. The upper ETPFC contains three reserves: the Pha Taem National Park, the Kaeng Tana National Park and the Phou Xiang Thong National Protected Area. There is no forested connection between the Pha Taem and Kaeng Tana national parks in Thailand because the intervening land has been converted to agriculture and rubber plantations. Forested habitats in the upper ETPFC are separated from the lower ETPFC reserves by a highway running from Sirinthorn district in Thailand to the Chong Mek International Border Crossing at Wang Tao village in Lao PDR. Moreover, several villages and their agricultural lands dominant a large part of the area. Because of the considerable extent of forest clearing, large mammals no longer move through this area. Elephants and other large mammals have been extirpated in the area on the Thai side, although bovids, tigers and others continue to exist in the Phou Xiang Thong National Protected Area. The last known elephant in Phou Xiang Thong died in 2012, leaving none in that reserve.

In the upper ETPFC, the Mekong River forms the international border between Lao PDR and Thailand, which does not constrain wildlife movement for foraging. Combined, the Phou Xiang Thong National Protected Area in Lao PDR and the Pha Taem National Park and Kaeng Tana National Park in Thailand provide a larger range for wildlife species than they would otherwise have if they were restricted to one of these reserves, especially the small Kaeng Tana National Park.

Many records for large mammals come from Ban Pak La village, where sambar, common barking deer and wild boar from the Phou Xiang Thong National Protected Area are reported to cross the Mekong River to the Pha Taem National Park. There was no record of gaur in the Pha Taem National Park, however, until November 2014, when gaur from Phou Xiang Thong moved across the river to forage in the Pha Taem National Park near Dong Na village. The head villager photographed an adult bull, and he informed the chief of Pha Taem National Park in order to protect this large animal. Track identification in the area indicated that there was a gaur herd with at least three individuals. No further information on this herd was obtained, however, and it is likely that the animals returned unseen to the Phou Xiang Thong National Protected Area. There are records of bovids and a single tiger moving between the Bun Thrik-Yot Mon Wildlife Sanctuary and the Laos Border Protection Forest; the Phu Jong-Na Yoi National Park and the DKPPA; and the Phu Jong-Na Yoi National Park and the PVPF.

Prehistoric cave painting at Pha Taem Cliff in Pha Taem National Park showing two elephants swimming with small fish and the Mekong giant catfish. Photo: Thanet Baukaew

A male gaur photographed at Dong Na village near Pha Taem National Park in November 2014.

The lower ETPFC is larger than the upper ETPFC, and there are good records of large mammal movements between Cambodia, Lao PDR and Thailand via routes that avoid the steep cliffs of the Dongrek Mountain Range (Table 3.2). Most elephant routes are known to be located between the Bun Thrik-Yot Mon Wildlife Sanctuary and the Laos Border Protection Forest, while the northernmost area of the Phu Jong-Na Yoi National Park and the DKPPA are known routes for tigers and wild bovids.

Banteng track found at the Phu Jong-Na Yoi National Park near the Lao PDR border and the DKPPA

Wildlife corridors

According to survey data, large mammals move through specific habitats: for example across rivers and through riparian habitats from reserve to reserve, and through valleys between highland and lowland habitats. Human activities in areas near to or in the ten potential travel corridors listed in Table 3.3 should be minimized to reduce disturbances to large mammals, and these areas should be fully protected to ensure that the animals are able to move through them (Figure 3.2).

Table 3.2: Large mammal movements among the transboundary reserves in the ETPFC

Species	Upper ETPFC	Lower ETPFC				
	PT – PX – KN	BT – BF	PJ – DK	PJ – PV	DK – PV	YD – PV
Asian elephant	In the past	X	-	-	X	-
Gaur	X	-	X	-	X	-
Banteng	-	X	X	-	X	-
Chinese serow	?	X	X	?	X	X
Sambar	X	X	X	X	X	-
Common barking deer	X	X	X	X	X	X
Wild boar	X	X	X	X	X	X
Tiger	-	X	X	-	-	-
Asiatic black bear	-	X	X	-	-	-
Indochinese lutong	-	-	X	-	X	X
Pileated gibbon	Not found	-	X	X	-	?

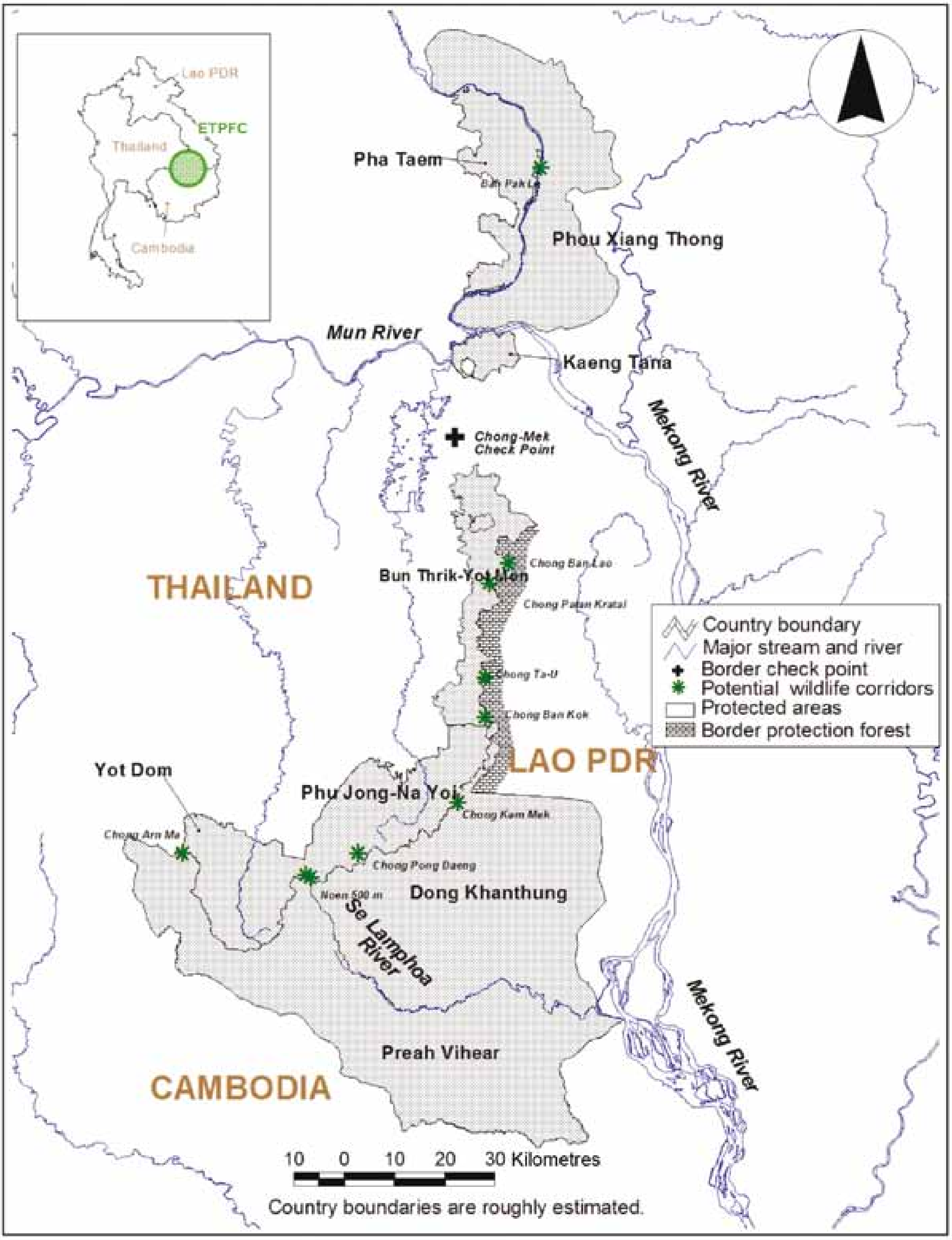
Notes: Thailand: PT = Pha Taem, KN = Kaeng Tana, BT = Bun Thrik-Yot Mon, PJ = Phu Jong-Na Yoi, YD = Yot Dom. Lao PDR: PX = Phou Xiang Thong, DK = DKPPA, BF = Laos Border Protection Forest. Cambodia: PV = PVPF. Wildlife movement: X = present movement; - = no report; ? = likely but without confirmation. See Table 1.2 for the scientific names and conservation status of these and other fauna species.

Table 3.3: Ten potential travel routes of large mammal movements among the three countries in the ETPFC

Place name	UTM coordination		Reserves	Countries	Human activities	Wildlife movement
	Northing	Easting				
Ban Pak La	1726633	567931	PT/PX	Lao PDR/Thailand	Villagers	Rarely possible
Chong Palan Kratai	1644131	557708	BT/BF	Lao PDR/Thailand	Few	Possible
Chong Ban Lao	1648110	561521	BT/BF	Lao PDR/Thailand	No	Very possible
Chong Ta-U	1625273	556882	BT/BF	Lao PDR/Thailand	Market	Rarely possible
Chong Ban Kok	1617437	556949	PJ/DK	Lao PDR/Thailand	Few	Possible
Chong Kam Mek	1600552	551427	PJ/DK	Lao PDR/Thailand	Few	Possible
Chong Pong Daeng	1590475	531653	PJ/DK	Lao PDR/Thailand	Few	Possible
Emerald Triangle	1585406	522288	PJ/DK/PV	Cambodia/Lao PDR/ Thailand	Military	Possible
Noen 500 m Hill	1586155	521218	PJ/PV	Cambodia/Thailand	No	Rarely possible
Chong Arn Ma	1590511	496777	YD/PV	Cambodia/Thailand	Market	Not possible

Notes: Thailand: PT = Pha Taem, BT = Bun Thrik-Yot Mon, PJ = Phu Jong-Na Yoi, YD = Yot Dom. Lao PDR: PX = Phou Xiang Thong, DK = DKPPA, BF = Laos Border Protection Forest.

Figure 3.2: Location of ten potential wildlife corridors between the three countries in the ETPFC



Pha Taem National Park and Phou Xiang Thong National Protected Area. Large mammals, including sambar, common barking deer, wild boar and gaur, cross the Mekong River at narrow sites with rocky rapids in the dry season when the water level is lowest in the area between Ban Pak La, Ban Khan Tha Kwein and Ban Khum villages in Thailand. There are no records of movements of large wildlife between the Phou Xiang Thong National Protected Area and the Kaeng Tana National Park. Eight transit sites between Lao PDR and Thailand should be designated for monitoring and the collection of long-term data. In this area, a lack of planning, the development of roads, and the increasing number of houses, fences, livestock pens in Ban Pak La village on the Thai side and villages in Lao PDR appear to have effectively blocked the movement of large wildlife. If this is the case, urgent planning to protect the area and ensure proper land-use development is needed to provide for the movement of large wildlife in the future.

Ban Khum village between the Pha Taem National Park and the Phou Xiang Thong National Protected Area. Photo: Naris Bhumpakphan

Phu Jong-Na Yoi National Park connects to the steep slopes and lowlands of the DKPPA. Photo: Naris Bhumpakphan

Bun Thrik-Yot Mon Wildlife Sanctuary and Laos Border Protection Forest. The wildlife routes are used mainly by elephants, with a few records of wild bovids—mostly banteng herds that come to forage on Phu Foi Lom Mountain in the rainy season. A few Chinese serows are found on the transboundary mountain ridges. Chong Pralan Kratai, Chong Ban Lao village and Chong Ta-U are target corridor sites between the two countries. The Laos Border Protection Forest is designated only for Lao military security, not biodiversity conservation, and there is no certainty that its habitats and corridors will be maintained. This strip of dry evergreen forest, which runs from north to south parallel to the Bun Thrik-Yot Mon Wildlife Sanctuary, acts as a wildlife corridor connecting the northern part of the Bun Thrik-Yot Mon Wildlife Sanctuary and the DKPPA in the south. Elephant herds visit rice paddies in the Soukhouma district on the outer eastern part of the Laos Border Protection Forest. They cannot easily move further south to the DKPPA (where there are large flat, lowland areas that could support a large population of elephants) because Lao farmers shoot them or drive them back to Thailand. In some years, a team of mahouts with domesticated elephants from Buaong Kiet-Ngong village in Dong Xe Pian in Champasak is used to chase wild elephants out of the paddy fields.

Phu Jong-Na Yoi National Park and the DKPPA. The adjoining border has a steep slope and is unsuitable for the movement of wild elephants. Tracks and scats of gaur, banteng and tigers are reported each year, however, at three locations—Chong Kam Mek, Chong Pong Daeng and Chong Bok—on the border with Lao PDR in the rainy season. Gaur and banteng forage for a short time in these transit areas and then move to the DKPPA. Primates, including the pileated gibbon, Indochinese lutong and northern pig-tailed macaque, move freely between the two transboundary reserves using dry evergreen forests as cover in these transit areas. Chinese serow in the DKPPA sometimes move up to rock outcrop habitats to sun themselves and graze in high areas of Phu Jong.

Phu Jong-Na Yoi National Park and Yot Dom Wildlife Sanctuary with PVPF. Wild elephants and gaur once occurred in these areas but were extirpated by about 1986 during the Khmer civil war (Kotmongkhon 1997). The last record of a wild elephant in Phu Jong-Na Yoi National Park was in

1986, and there have been no known recent large mammal movements in these transboundary areas. Primates inhabit dry evergreen forests at higher elevations in the Thailand reserves, which connect to mixed deciduous forest on the high mountain slopes of Cambodia. Noen 500 m Hill on the border between Phu Jong-Na Yoi National Park and the PVPF could be suitable as a corridor for large mammals, but a Cambodian settlement site called Dechochey Hunsen village was established there recently, effectively rendering the site impassable to large animals. At Chong Arn Ma, where there is now a local border market on the Cambodian side, increasing human activities make it unlikely that large mammals will use this area to transit between the two countries. A few elephants from the Bun Thrik-Yot Mon Wildlife Sanctuary roam and forage in the northern part of Phu Jong-Na Yoi National Park, normally returning to the Bun Thrik-Yot Mon Wildlife Sanctuary.

DKPPA and PVPF. The DKPPA is close to the PVPF, separated by the Xe Lamphao River. Protecting riparian and riverine habitats along the Xe Lamphao River is important for large mammals, especially in an area in the middle section of the river, where the habitat has the highest suitability (Trisurat 2015). If protected, the area will continue to provide a travel corridor for wildlife moving between the PVPF and the DKPPA; in particular, subpopulations of Siamese Eld's deer, sambar, wild bovids (gaur and banteng) and elephants can move between the two reserves, thus ensuring genetic connectivity. If the habitats in the transit areas are removed and replaced by agricultural lands, however, wildlife movement would cease and the two reserves would become isolated.

Noen 500 m Hill on the border of Phu Jong-Na Yoi National Park and the PVPF. Photo: Naris Bhumpakphan

Xe Lamphao River—the border between the DKPPA in Lao PDR and the PVPF in Cambodia (right-hand side). Photo: Inpaeng Daungvongsa

Conclusion and recommendations

Solving the human–elephant conflict in Lao PDR and Thailand and securing the remaining movement corridors should be management priorities; both are necessary for the conservation of elephants and other large wildlife in the ETPFC. There are three subpopulations of elephants: 40–45 animals in the Bun Thrik-Yot Mon Wildlife Sanctuary in Thailand and the Laos Border Protection Forest; three individuals in the DKPPA; and five individuals in the PVPF. Consideration should be given to enabling connectivity to support the movement of the larger wild elephant subpopulation further south to the DKPPA and the PVPF. As it is now, the large subpopulation cannot move south of the Laos Border Protection Forest because it is driven back to Thailand to protect crops in Champasak Province.

An important priority is to design an ecological corridor between the Bun Thrik-Yot Mon Wildlife Sanctuary and the Laos Border Protection Forest; the latter provides a travel route for elephants and wild bovids between Lao PDR and Thailand. Other wildlife species will benefit from the management of elephants as an umbrella species to protect landscape-scale habitats and travel routes. The other sites mentioned above are also important as wildlife corridors to enhance connectivity in the ETPFC.

Future work in Cambodia, Lao PDR and Thailand should be to strengthen the protection of wildlife and reserves and to increase collaborative research and data-sharing to provide a better understanding of the ecology and movements of large mammal fauna. Based on the results of wildlife habitat modelling (Trisurat 2015, see Chapter 6) and knowledge of key wildlife species distributions in the PVPF (Chapter 4), an overview of suitable habitats can be provided for many landscape wildlife species in the ETPFC. The management of landscape wildlife species should be a focus, including for Asian elephant, banteng, Siamese Eld's deer, pileated gibbon, giant ibis, and greater and lesser adjutant storks. Recovery programmes for specific species should be planned and implemented, using the Siamese Crocodile Recovery Project in the Yot Dom Wildlife Sanctuary as a model (Youngprapakorn et al. 2015). Strategic planning for the conservation of transboundary landscape mammals and large birds needs to be developed and implemented soon if these large mammal species are to survive.

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4 THE DISTRIBUTION OF LANDSCAPE WILDLIFE SPECIES IN THE PREAH VIHEAR PROTECTED FOREST

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This chapter provides descriptions of the current distributions of landscape wildlife species in the PVPF in Cambodia, part of the ETPFC. Located in northern Cambodia and bordering Thailand and Lao PDR, the PVPF supports a high level of biodiversity associated with seasonally dry dipterocarp forests. The area has been surveyed for important wildlife species since 1998 (in collaboration with the Cat Action Treasury); here we report a summary of that information supplemented with the results of studies conducted under the ITTO–CBD project (see Chapter 1), as well as other projects in which related wildlife data have been compiled. The distributional data resulting from the studies and presented here were made available to Kasetsart University for the habitat modelling presented in Chapter 6.

A path to effective transboundary biodiversity conservation

The production of the maps depicting the current distributions of landscape wildlife species in the PVPF presented here represents the completion of several initial steps of a process contributing to the ITTO–CBD project's transboundary biodiversity conservation objective. In the conceptual structure for the path to conservation (Figure 4.1), the three countries—Cambodia, Lao PDR and Thailand—continue to manage their parts of the ETPFC autonomously, sharing information and data and collaborating to develop a single transboundary management framework to conserve regional biodiversity.

Identification of landscape wildlife species

The initial step in the process to distinguish landscape wildlife species was to determine the weighting given to the following factors: the relative frequency of occurrence of individual wide-ranging species in and around the PVPF; the social and economic importance of each species to local communities and relative to their regional, national and international distributions; and the extent to which each species is an indicator of biodiversity in the area.

Those criteria resulted in the initial selection of eleven mammal, ten avian and one reptile landscape wildlife species in the PVPF (Table 4.1). Comparable criteria resulted in the selection of 17 and 18 landscape wildlife species in the PPFC and the DKPPA, respectively (Bhumpakphan 2015). Of the 22 landscape wildlife species selected in the PVPF, ten of the eleven mammals—Asian elephant, banteng, tiger, gaur, pileated gibbon, sambar, Sumatran (southern) serow, leopard, golden jackal and wild boar—as well as three of the ten birds (green peafowl, white-winged duck and Siamese fireback) and the single reptile, the Siamese crocodile, were classified as landscape wildlife species present in each of the three countries of the ETPFC. In this chapter we present the distributions of those 14 landscape wildlife species in the PVPF as a way of expediting species-specific distributional comparisons among the three countries.

The next step in the process was (and continues to be) to determine the distribution of the selected landscape wildlife species in the ETPFC. A series of maps was developed with known species distributions for each country based on various data sources. Here we specifically discuss those data collected for the PVPF. The initial information on the distributions of landscape wildlife species in and around the PVPF was incorporated into the 2010–2014 management plan (Forestry Administration 2009) to inform the decision-making process. The updated distributions will be used in the revised 2015–2020 management plan for the PVPF. Comparable information was incorporated into the management plan for the PPFC in Thailand, but similar data have not yet been used to inform decision-making in the DKPPA in Lao PDR.

The remaining steps in the process are the most challenging because they require increased

Figure 4.1: The path to effective transboundary biodiversity conservation

Identification of landscape wildlife species

↓

Distribution of landscape wildlife species in individual countries

↓

Incorporation of the distributions of landscape wildlife species in the management plans of each country

↓

Merging of the distributions of landscape wildlife species across the ETPFC

↓

Incorporation of the distributions of landscape wildlife species into a common management framework for transboundary biodiversity conservation in the ETPFC

↓

Transboundary biodiversity conservation achieved in the ETPFC between Cambodia, Lao PDR and Thailand

Table 4.1: Landscape wildlife species selected in the PVPF

Mammals
Asian elephant*
Banteng*
Siamese Eld's deer
Tiger*
Gaur*
Pileated gibbon*
Sambar deer*
Sumatran (southern) serow*
Leopard*
Golden jackal*
Wild boar*
Birds
Giant ibis
White-rumped vulture
Greater adjutant stork
Green peafowl*
White-winged duck*
Sarus crane
Lesser adjutant stork
Black-necked stork
King vulture
Siamese fireback*
Reptile
Siamese crocodile*

*Notes: * denotes species present in each of the three countries. Table 1.2 provides the scientific names and conservation status of these and other fauna species.*

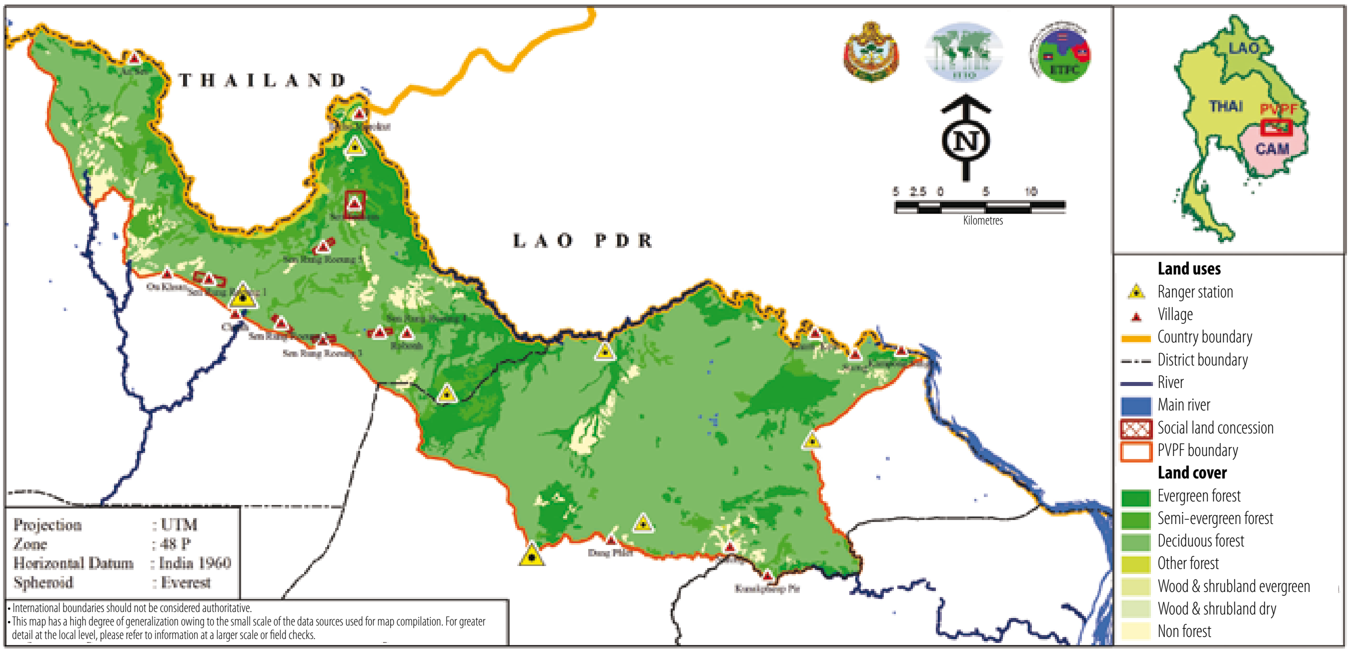
cooperation and coordination, not only among resource managers involved in addressing technical matters but also among regional and national governments. The success of these collaborative efforts will ultimately result in the adoption of a common management framework with shared actions to be applied across the ETPFC to conserve biodiversity.

The Preah Vihear Protected Forest

The PVPF is located between 13°51'19" and 14°25'01"north latitude and 104°51'42"and 105°47'04" east longitude (Figure 4.2). It has a land surface of 190 027 hectares dominated by forests of three principal types (evergreen, semi-evergreen, and deciduous); dry dipterocarp deciduous forests accounted for more than 65% of land cover in the most recent assessment (2010). The forest area of the PVPF declined by about 2% between 2002 and 2010, although the area of evergreen forest increased and, overall, forest continues to account for more than 95% of land cover (Table 4.2).

The PVPF is situated in a lowland area crossed by the steep Dongrek Mountain Range along the border with Thailand in the northwest, which results in a gradually decreasing slope toward the southeast. The highest altitude is 766 m and

Figure 4.2: Location of the PVPF, Cambodia



the lowest is 66 m. The climate is dry tropical monsoonal, with most precipitation occurring from April to October. The average annual rainfall is more than 1500 mm; the daily average temperature is 33 °C.

The PVPF was established on 30 July 2002 and forms part of the Indo-Burma Biodiversity Hotspot, which is one of 35 designated global biodiversity hotspots (Critical Ecosystem Partnership Fund 2015). It contains the most extensive remaining contiguous natural forest in a unique landscape; it is of exceptional global importance for biodiversity in Southeast Asia; and it is one of nine "biodiversity corridors" in the Greater Mekong Subregion. The diversity of plant communities forms a mosaic of ecosystems that provides habitats for many threatened and endangered wildlife species. The PVPF is probably the most important site worldwide for the critically endangered giant ibis and the most important site in Southeast Asia for three critically endangered vultures: the white-rumped vulture, slender-billed (or long-billed) vulture, and red-headed vulture. The area also has important populations of Asian elephant, banteng, Siamese Eld's deer, fishing cat, dhole and white-winged duck, all of which are endangered or vulnerable. Other vulnerable species include gaur, northern pig-tailed macaque, green peafowl and sarus crane. Table 4.1 lists the landscape wildlife species selected in the PVPF and adjacent countries.

Cambodia's Forestry Administration (formerly the Department of Forestry and Wildlife) has conducted several biodiversity surveys in the PVPF in cooperation with the Cat Action Treasury (an NGO concerned with felids) from 1998 to 2005, with the Wildlife Conservation Society from 1999, and in Phase 2 (2008–2010) and Phase 3 (2012–2016) of the ITTO–CBD project. Those surveys have documented the presence of a fauna that is probably unique in Southeast Asia for large mammal and bird species in dry dipterocarp forests and other habitats, many of which are in rapid decline elsewhere in the region. At least 57 mammal species, 255 bird species and 58 reptile species have been documented in the PVPF. The fauna in the PVPF is representative of a large proportion of the species extant in Cambodia (Table 4.3). Several animal species that formerly occurred in the PVPF have gone extinct, however, including the Asian two-horned rhinoceros, the lesser one-horned rhinoceros, which was last observed in the 1930s, and the kouprey and wild water buffalo, both of which had apparently been extirpated by 1964.

Table 4.2: Forest-cover change in the PVPF, 2002 to 2010

Forest type	Forest cover				Change	
	2002		2010		2002–2010	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Evergreen forest	33 586.37	17.7	35 673.9	18.8	2 087.5	1.10
Semi-evergreen forest	18 511.64	9.7	18 188.9	9.57	-322.7	-0.17
Deciduous forest	130 949.20	68.9	125 004.0	65.8	-5 945.2	-3.13
Other forest	2 455.85	1.29	2,283.9	1.20	-171.96	-0.09
Total forest area	**185 503.06**	**97.6**	**181 150.7**	**95.3**	**-4 352.3**	**-2.29**
Non-forest	4 523.95	2.4	8 876.3	4.67	-4 352.3	2.29
Total area	**190 027**	**100**	**190 027**	**100**		

Table 4.3: Numbers of wildlife species reported countrywide in Cambodia and in the PVPF in 2010 and 2014

Class	No. of known species in Cambodia, 2010 and 2014	No. of species (relative % in the PVPF), 2014
Mammals	125, 135	> 57 (42%)
Birds	540, 635	> 255 (40%)
Reptiles	73, 95	58 (61%)
Amphibians	62, 65	No formal study conducted
Insects	> 400	No formal study conducted

Methods

Baseline information

Baseline information on the distribution of mammal and avian landscape wildlife species in the PVPF was accumulated from various data sources, including:

- Ground surveys conducted with NGOs through the Wildlife Protection Office (now the Department of Wildlife and Biodiversity) in the Forestry Administration. The Wildlife Protection Office incorporated individual observations of species into a GIS and output maps. These maps were used in the 2010–2014 management plan for the PVPF.
- Literature reviews and specialized wildlife guidebooks—particularly *A Guide to the Mammals of Cambodia* (Men et al. 2008)—that provide overviews of wildlife species distributions in Cambodia.

Data collection

Distributional data on landscape wildlife species were updated in Phase 3 of the ITTO–CBD project by establishing 40 2–3 km transect lines that passed through the various wildlife habitats of the PVPF and its buffer areas in the Chhaep and Choam Khsant districts. Ten of those transect lines were established between the villages of Kakheuk and Prey Prah Rokar; ten were established between Kakheuk and Kbal Damrey; and 20 others were established in the core zone of the PVPF in the Nam Sam area. The lines were traversed 2–4 times per month by 2–5 ITTO–CBD project staff, assisted by undergraduate students at the Royal University of Agriculture and Prek Leap National College of Agriculture, who were supervised and supported by the project. Information was also obtained from camera traps used to detect wildlife species in the PVPF under a complementary project initiated in 2013. The camera project was supported by the Japan International Cooperation Agency and implemented by the Wildlife Conservation Society. The 70 cameras were moved to various locations periodically, ultimately covering about 35 000 hectares of the PVPF.

Evidence of the presence of wildlife species included the following signs and direct observations:

- *Mammals (excluding bats)*: spotlighting, tracks, scats, hair snags and photographs from remote cameras for mammals.
- *Birds*: irregular morning and evening observations conducted by project field staff and opportunistic visual sightings for birds.

- *Reptiles*: searches by rock-rolling, tree-bark removal and the displacement of fallen timber, as well as opportunistic sightings.

The data were verified using:

- Wildlife guidebooks and checklists to reference animal ranges and corroborate identifications.
- Wildlife guidebooks and checklists to confirm the identification of the species in photographs from camera traps.
- Planned consultations with local villagers during community livelihood pilot project activities, in which the wildlife guidebooks and checklists were used to confirm and update the presence of wildlife species near the villages. These consultations were designed to provide a sample of 90 household interviews in the following villages in the PVPF: O Chunh, Robunh, Trapeang Prey, Sen Dekchas, Kbal Dam Rey and Sen Rung Reung (3–4 villages), as well as in the Nam Sam area.

Distributions and related information on the 14 selected landscape wildlife species in the PVPF are reported below by mammal, avian and reptile species and presented in the order of each species' assessment status in the IUCN Red List. The scientific names of species are provided in Table 1.2.

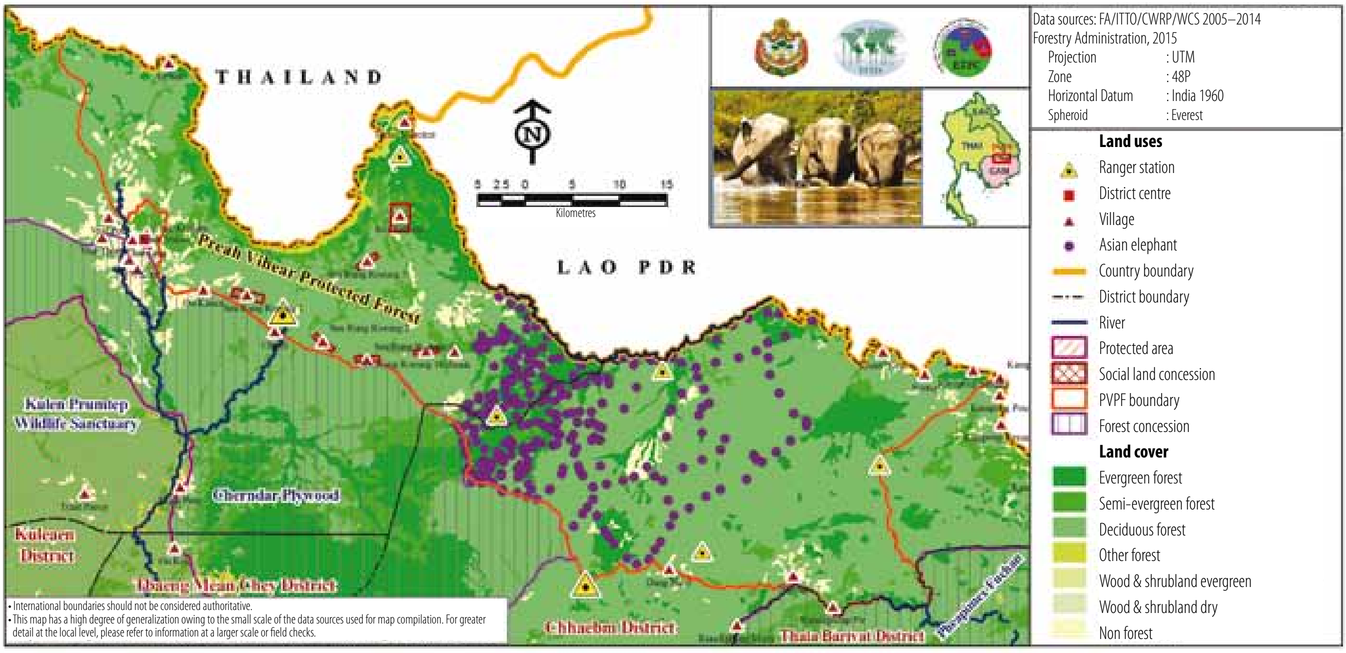
Photo: Phnom Tamao Wildlife Rescue Centre/Forestry Authority/Wildlife Alliance

Mammals

Asian elephant

There are numerous records of Asian elephant as a year-round resident in the PVPF (Figure 4.3), although the number of individuals now (five) is considerably fewer than in the Thailand–Lao PDR part of the ETPFC, where there are approximately 50 (see Chapter 3). Considering that the habitats in areas adjoining the PVPF are similar to those within its boundaries, it is likely that these elephants cross the international border into Lao PDR. The elephant population in the PVPF may have been connected previously to that in the Kulen Promtep Wildlife Sanctuary through Cherndar Plywood's suspended forest concession, but there is no evidence to suggest that elephants still move into that area. The range of the herd may have changed in recent years, perhaps as the result of hunting and other disturbances, but surveys and patrolling efforts vary across years and available meteorological information is insufficient to assess the effects of rainfall on movements of the Asian elephant.

Figure 4.3: Distribution of Asian elephant in and near the PVPF



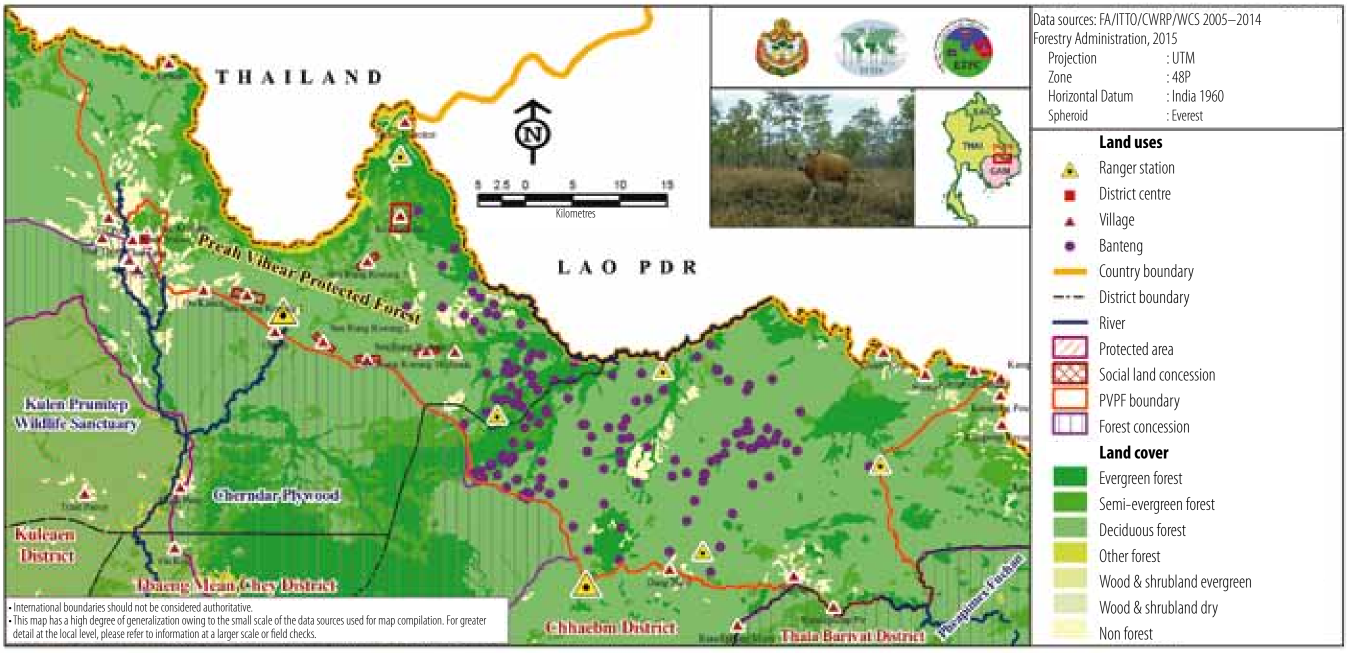
Note: Only a very few individuals account for all records.

Banteng

Banteng are widespread in the PVPF and the area of Cherndar Plywood's suspended forest concession (Figure 4.4). The species is observed relatively frequently by means of camera traps, tracks and direct observation. Banteng generally prefer more open forest than gaur, and this might be the case in the PVPF. Insufficient information is available on abundance, but the PVPF is almost certainly of international importance in supporting efforts to conserve this species. The banteng has disappeared from most of the rest of its range in Southeast Asia and it mainly survives in the northern and eastern plains of Cambodia. Fragmented populations occur in only limited areas elsewhere. Enforcement actions to control hunting and reduce deforestation are the most important safeguards for protecting remaining banteng in the ETPFC.

Photo: Forestry Authority/Wildlife Conservation Society

Figure 4.4: Distribution of banteng in and near the PVPF

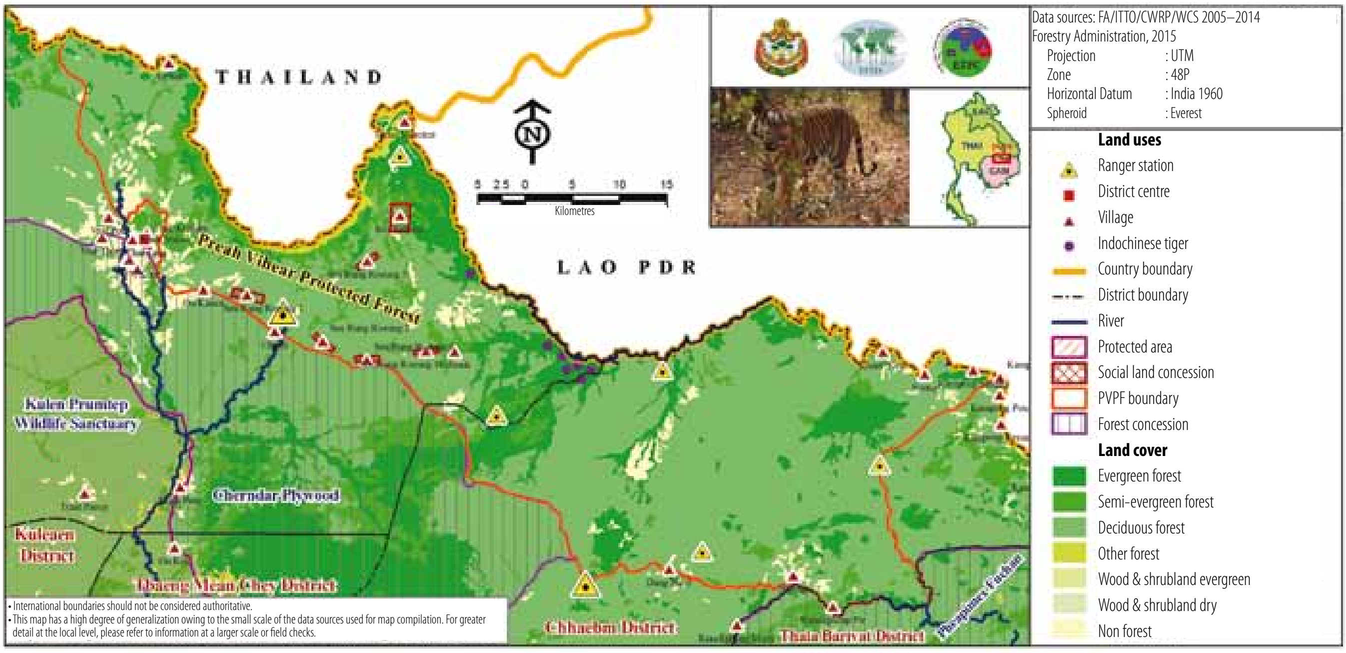


Indochinese tiger

Photo: Chheang Dany

As recently as the 1980s and 1990s, the Indochinese tiger was considered widespread in the region, but “vast areas of Southeast Asia [were] recently found to be void of tigers and depleted of prey by hunters” (IUCN 2015). In the PVPF, there have been no confirmed observations of tigers since 2005 (Cambodia Wildlife Ranger Program 2002; Wildlife Conservation Society 2008; Forestry Administration 2014; Figure 4.5). Government estimates of national populations in the tiger range states exceed (in total) 350 (Thailand—200; Myanmar—85; Cambodia—20; Viet Nam—20; and Lao PDR—17), but those estimates are mostly speculative, and the number of tigers in confirmed, protected populations in these countries is considered to be substantially lower (202) and mostly in Thailand (185). There is no evidence of breeding tigers in either Cambodia or Viet Nam. Myanmar has only one potentially viable population, and Lao PDR has a single confirmed population of fewer than 20 mature individuals.

Figure 4.5: Distribution of Indochinese tigers in and near the PVPF



Note: The most recent sightings were in 2005.

Gaur

Gaur are most common in the central part of the PVPF and in the area of the suspended Cherndar Plywood forest concession, where they inhabit the evergreen, semi-evergreen and riverine forests that are most abundant in those areas (Figure 4.6). Gaur have been recorded relatively frequently in annual large mammal surveys in the PVPF, although the data do not allow population estimates. Gaur have a wider global distribution than banteng but may be even more threatened in Southeast Asia and have disappeared from much of their former range. The population of gaur in the PVPF is interconnected with other sites on the northern and eastern plains of Cambodia and, as a result, the PVPF is considered to be of international importance for the conservation of this species.

Photo: Forestry Authority/Wildlife Conservation Society

Figure 4.6: Distribution of gaur in and near the PVPF

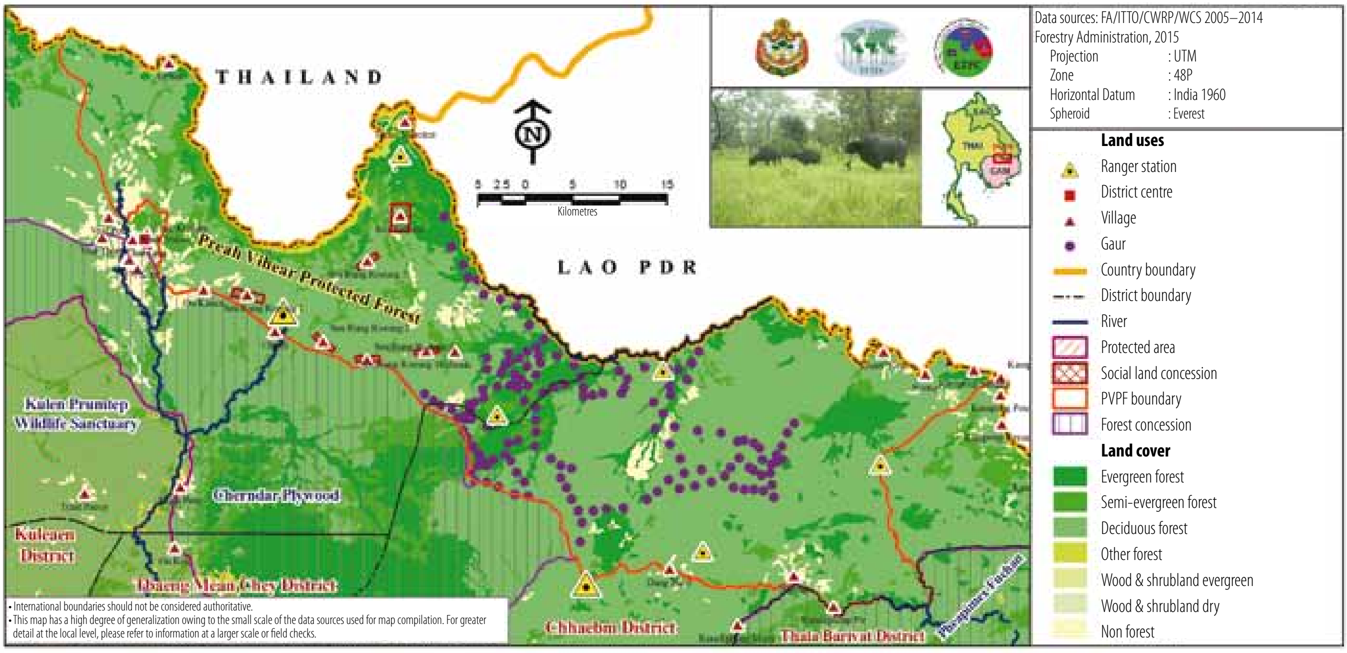
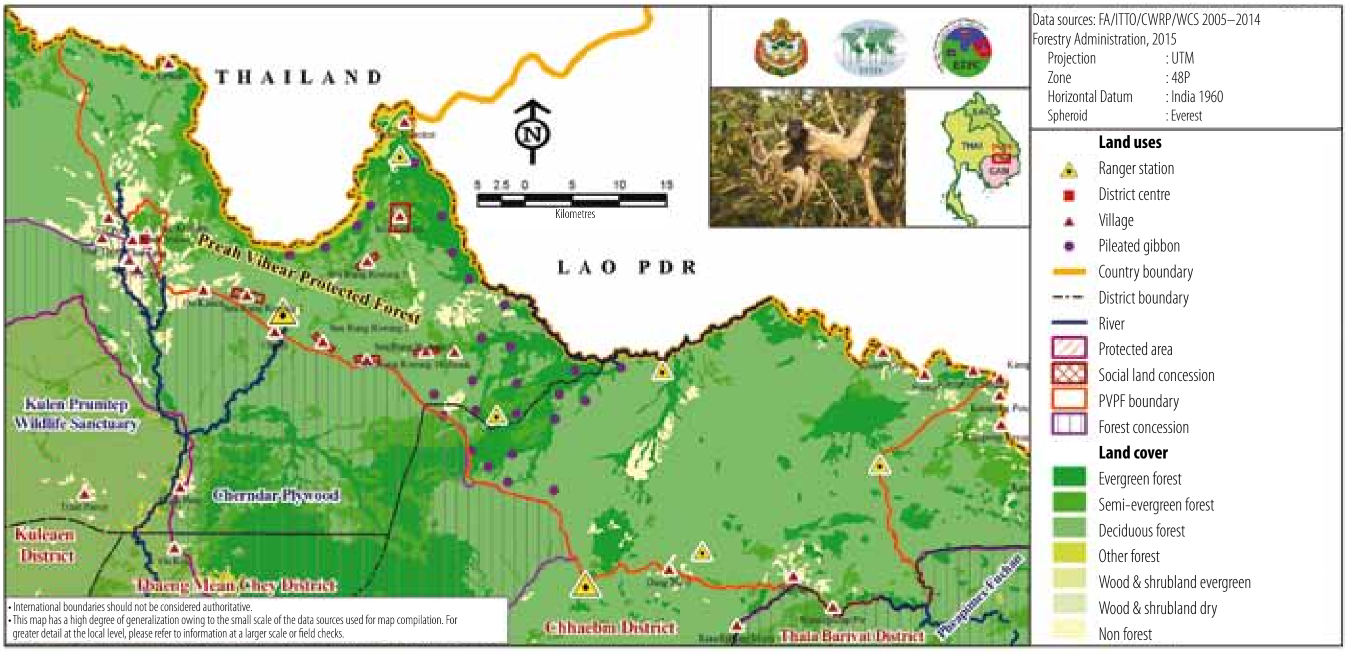


Photo: Phnom Tamao Wildlife Rescue Centre/Forestry Authority/ Wildlife Alliance

Pileated gibbon

The distribution of the pileated gibbon is restricted to forests in southeastern Thailand and Cambodia that extend to the Mekong River (Brockelman 1975; Brockelman and Gittins 1984; Marshall and Sugardjito 1986; Figure 4.7). Its range, therefore, is relatively small, and it is decreasing as the area of forest declines. If deforestation trends continue, it is probable that pileated gibbons will be confined to protected forests. The species is distributed widely across the PVPF, inhabiting areas of evergreen and mixed deciduous–evergreen forest (Wildlife Conservation Society 2008), and the relatively intact nature of those forests underpins the importance of the PVPF to the conservation of this species. Moreover, the habitat provided by the ETPFC is enhanced by the connectivity between the PVPF and the adjacent Yot Dom Wildlife Sanctuary and Phu Jong-Na Yoi National Park in Thailand, where small populations of pileated gibbons have also been reported.

Figure 4.7: Distribution of pileated gibbon in and near the PVPF

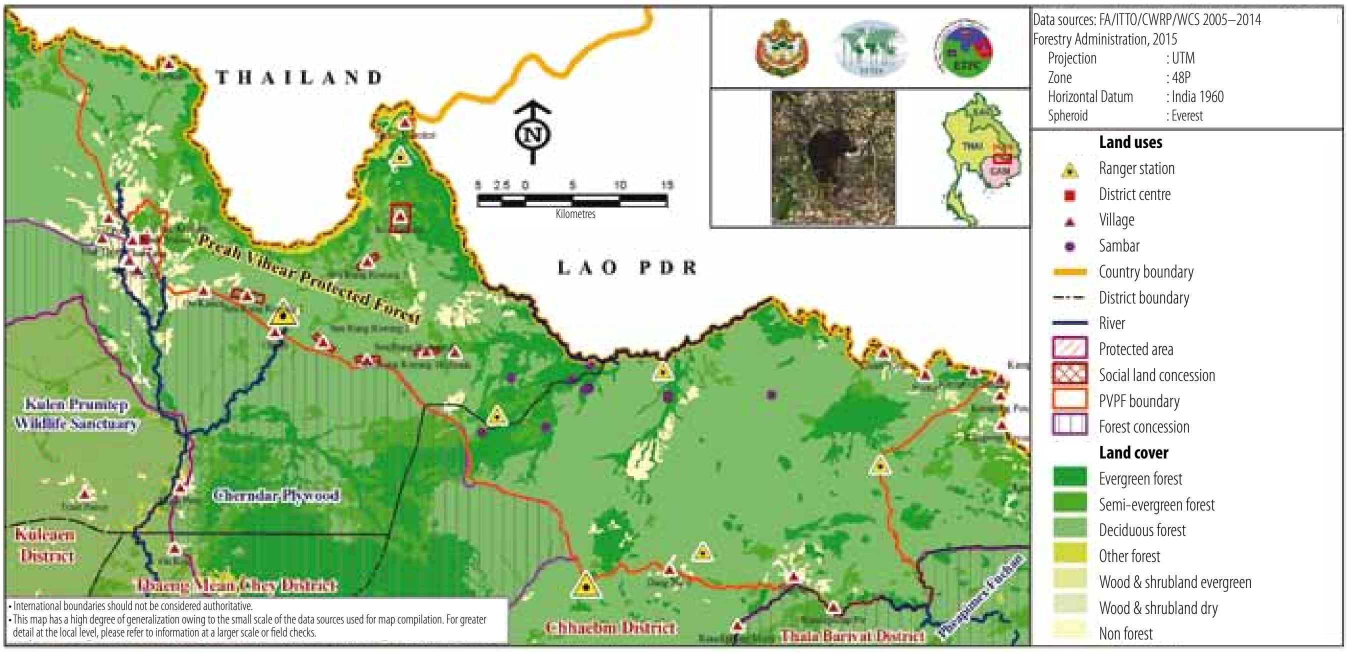


Sambar

The distribution of sambar, which extends east from India and Sri Lanka along the southern Himalayas to Taiwan Province of China and south into Bangladesh and throughout mainland Southeast Asia and Borneo and Sumatra, is highly fragmented. In Cambodia, Sambar are relatively common in some areas but entirely absent from others. This fragmentation appears to be correlated primarily with hunting pressure. In the PVPF, Sambar are common and have been recorded in most habitats (Figure 4.8). Recent studies have affirmed, however, that although the species was widespread at the time of the wildlife assessment conducted in 2008, numbers have declined since, especially on the eastern plains (IUCN 2015).

Photo: Pech Ravin

Figure 4.8: Distribution of sambar in and near the PVPF

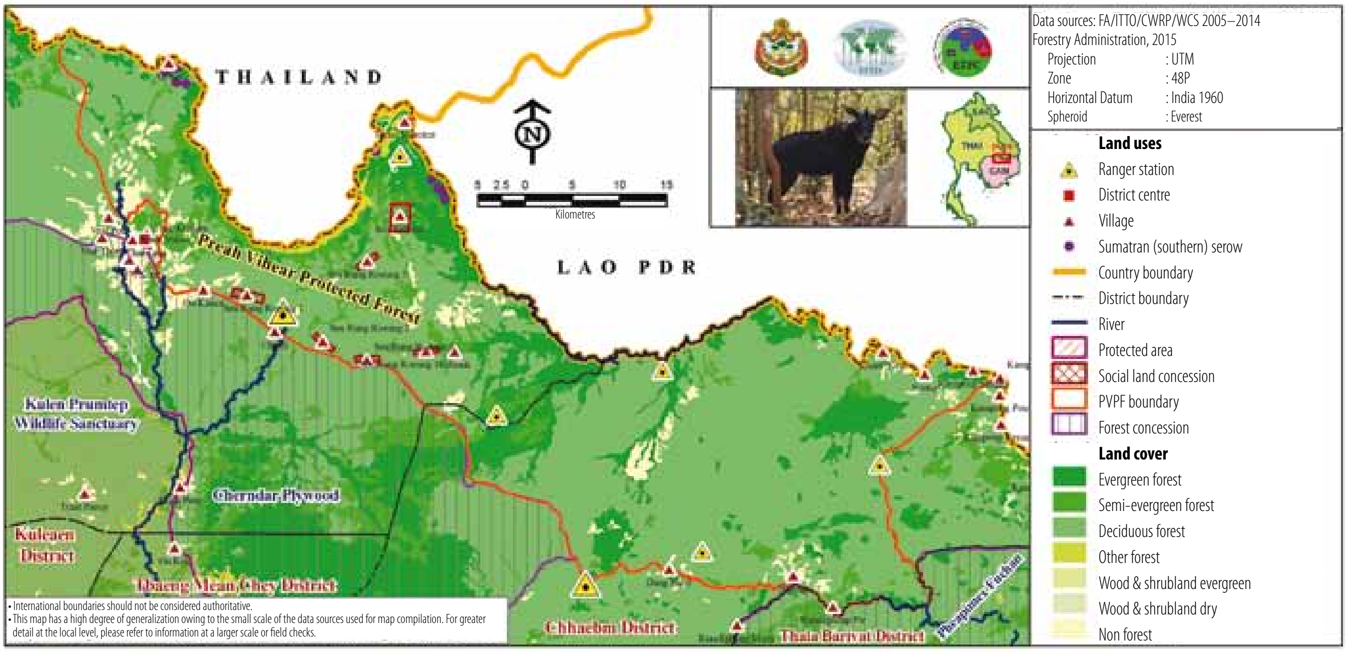


Sumatran (southern) serow

The Sumatran (southern) serow is a species of goat-antelope native to mountain forests in Cambodia, Indonesia, Malaysia and Thailand. Very little information is available on this solitary, nocturnal species, including its population status (Figure 4.9). It occupies seasonal ranges and uses well-marked trails that often run along the ridges of steep hills covered by both primary and secondary forests. The principal threats to the Sumatran (southern) serow are hunting and, to a lesser extent, habitat loss, although the species is considered to tolerate environments that are moderately degraded. The Sumatran (southern) serow is relatively well protected in Cambodia compared with the other range states in Southeast Asia, where populations have been declining.

Photo: Pech Ravin

Figure 4.9: Distribution of Sumatran (southern) serow in and near the PVPF



Leopard

Leopards are widely distributed in the PVPF (Figure 4.10); there are many records of the species in the dry dipterocarp forest in the southeast of the reserve (Wildlife Conservation Society 2008), as well as in the evergreen forest in the mid-central portion of it. The species has a distribution ranging from Africa to East Asia, but it is disappearing in some areas due to habitat loss, increased hunting, and declining numbers of prey species. In Cambodia, the number of leopards recorded in camera traps has been increasing in the dry forests of the eastern plains (World Wide Fund for Nature 2015). Those areas, as well as the large comparable areas of habitat with adequate prey species in the PVPF, are of considerable significance for the long-term survival of the leopard in Southeast Asia.

Photo: Chheang Dany

Figure 4.10: Distribution of the leopard in and near the PVPF

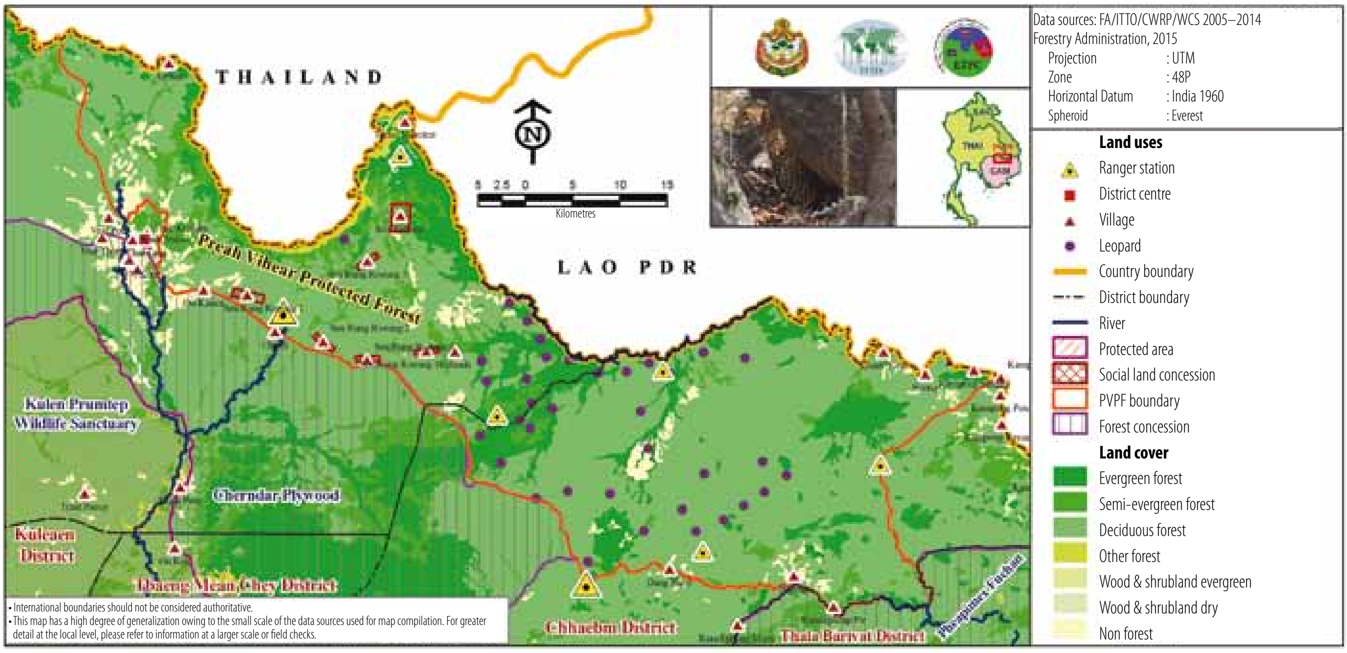
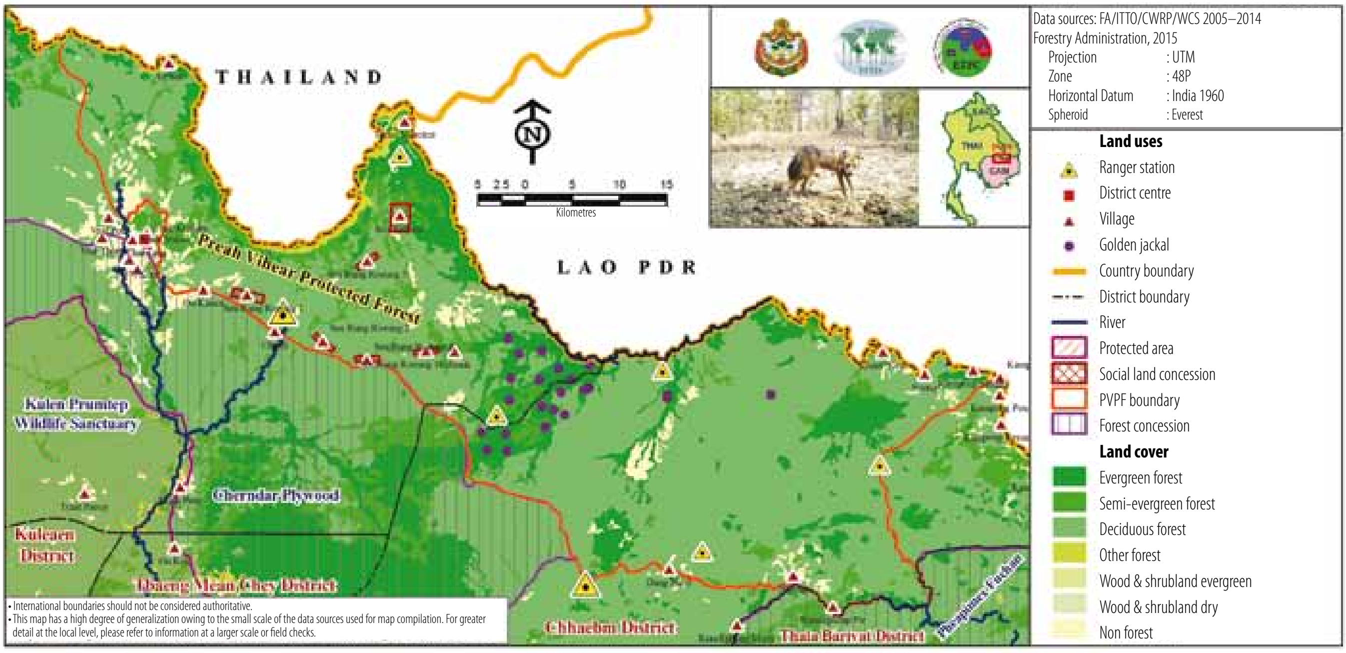


Photo: Forestry Authority/Wildlife Conservation Society

Golden jackal

The golden jackal is widespread and common throughout its range in Asia, Africa and southeastern Europe, and it is the most frequently recorded large carnivore in the PVPF (Cambodia Wildlife Ranger Program 2002; Wildlife Conservation Society 2008; Figure 4.11). Its tolerance of dry habitats and its omnivorous diet enable it to survive in a range of habitats, although tropical dry and moist deciduous forests—where deer are its primary prey—are considered its optimal habitats.

Figure 4.11: Distribution of golden jackal in and near the PVPF



Wild boar

The wild boar is widespread in most habitats in Cambodia, and it is the most frequently recorded mammal in the PVPF (Figure 4.12). The wild boar has one of the widest geographic distributions of any terrestrial mammal worldwide, and its range has greatly expanded because of human activities. The species now occurs in a wild or scarcely modified wild form on every continent except Antarctica, as well as on many oceanic islands. The PVPF is particularly important for wild boar because it constitutes a large area of high-quality habitat. Wild boar is commonly hunted by villagers in and around the PVPF, as well as throughout its range in Cambodia, primarily as subsistence food.

Photo: Forestry Authority/Wildlife Conservation Society

Figure 4.12: Distribution of wild boar in and near the PVPF

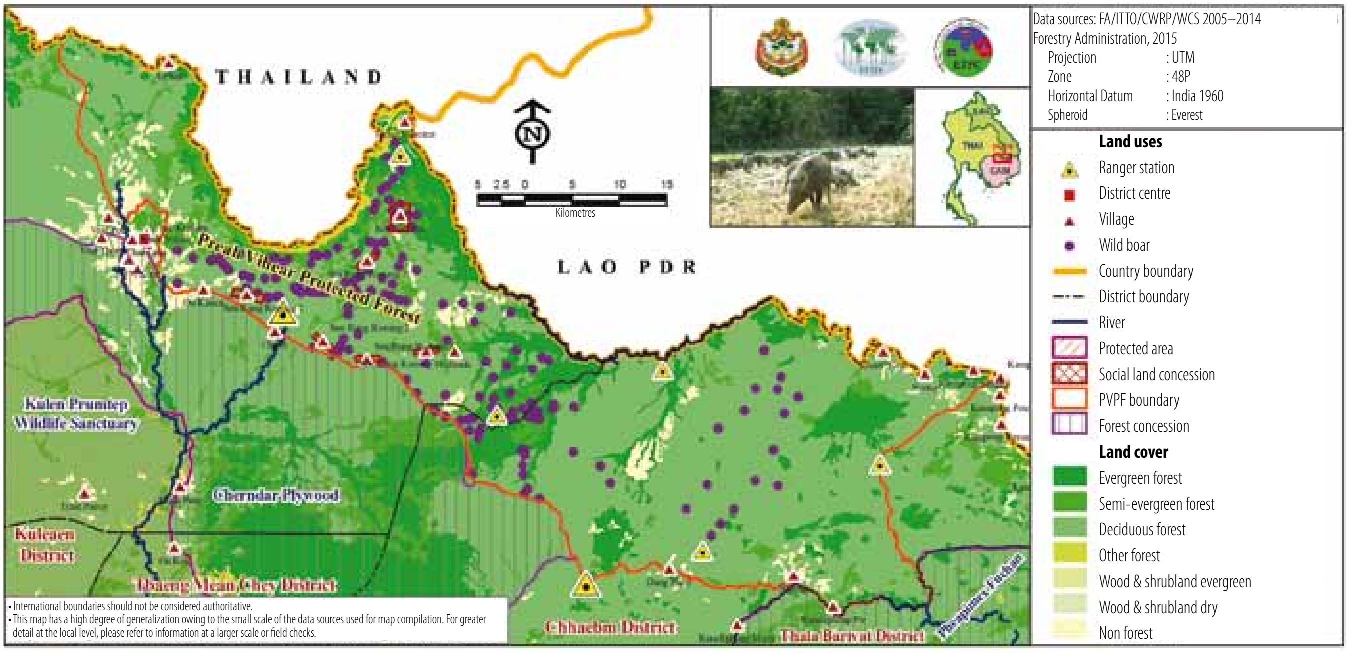


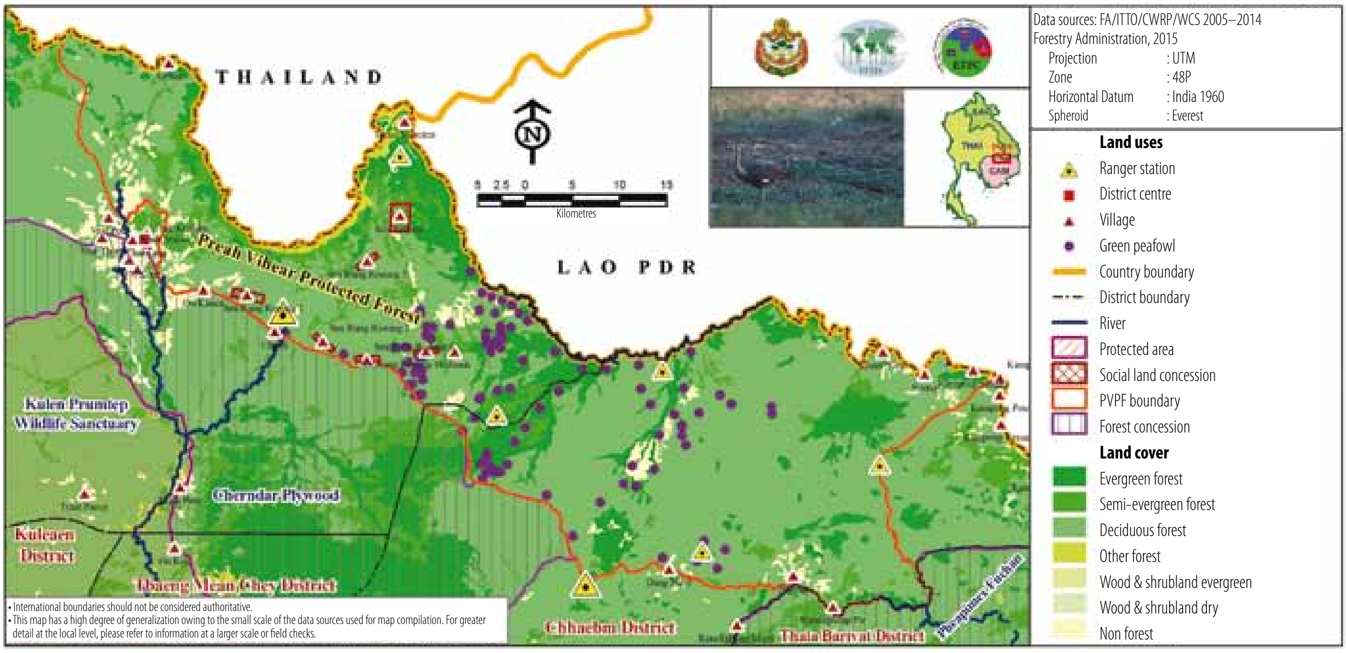
Photo: Kim Sobon

Birds

Green peafowl

Green peafowl have been recorded south and west of Kahkeuk station and in the catchment of the O'Kapok "trapeang", or wet-season stream, in the mid-central part of the PVPF (Figure 4.13). The species is thought to prefer undisturbed dry dipterocarp forest near streams and wetlands, and those areas may constitute its most suitable habitat. Elsewhere in its range, green peafowl numbers are declining rapidly, and the only remaining large populations are believed to be in northern and eastern Cambodia and west-central Viet Nam. The PVPF is considered of international significance for the long-term survival of the species. Its most serious threats are habitat degradation—often through fragmentation—and hunting, which is exacerbated by increased access.

Figure 4.13: Distribution of green peafowl in and near the PVPF



White-winged duck

The white-winged duck has been observed in a small number of sites in riverine forests near Roboinh village, Kahkeuk station (at the O Koki and O Kapok trapeangs) and in the suspended Cherndar Plywood forest concession (Figure 4.14). The species has experienced a precipitous decline in Asia of at least 95% of its original population, and it has been extirpated in some countries as a result of egg-collecting, the destruction of riverine habitats, deforestation and hunting (Green 1993) and has not recovered (Birdlife International 2015a). The white-winged duck prefers dense forest with permanent pools or rivers and low levels of disturbance for nesting. The global population of the white-winged duck, which is a popular species for bird-watching, is highly fragmented; its only large remaining populations are in Cambodia and Myanmar, indicating the international significance of the PVPF for the conservation of this species.

Photo: Forestry Authority/Wildlife Conservation Society

Figure 4.14: Distribution of white-winged duck in and near the PVPF

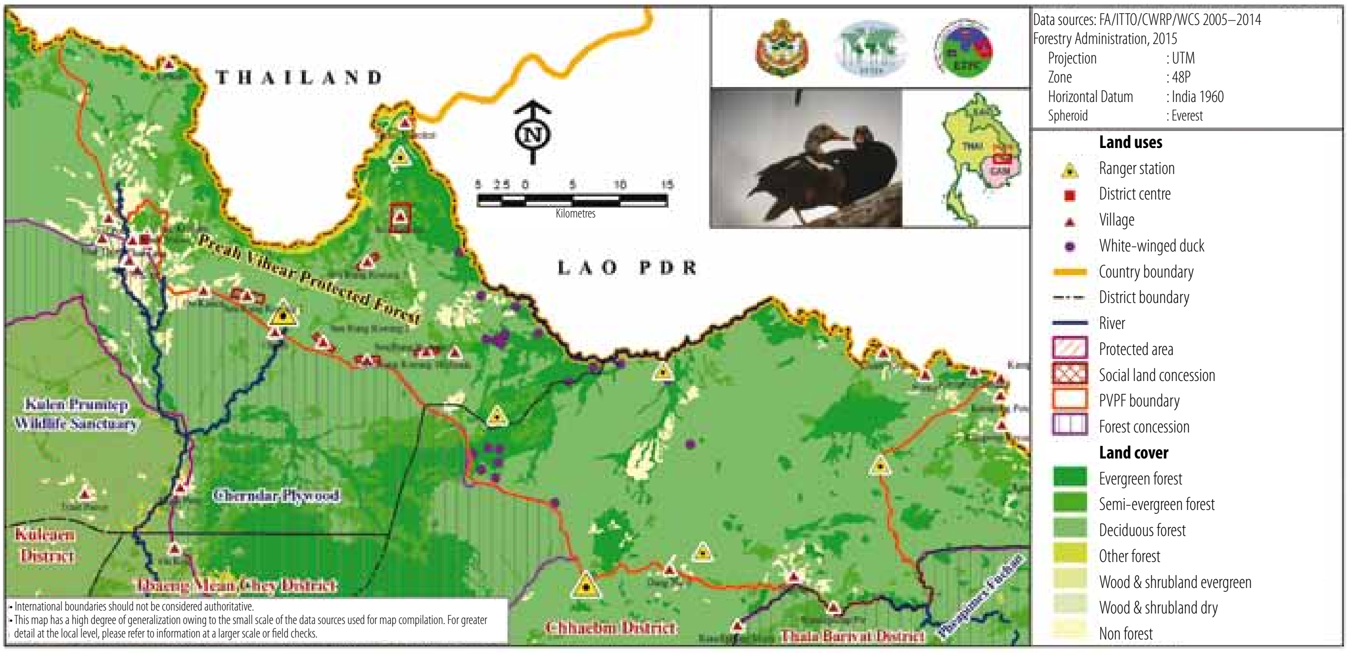
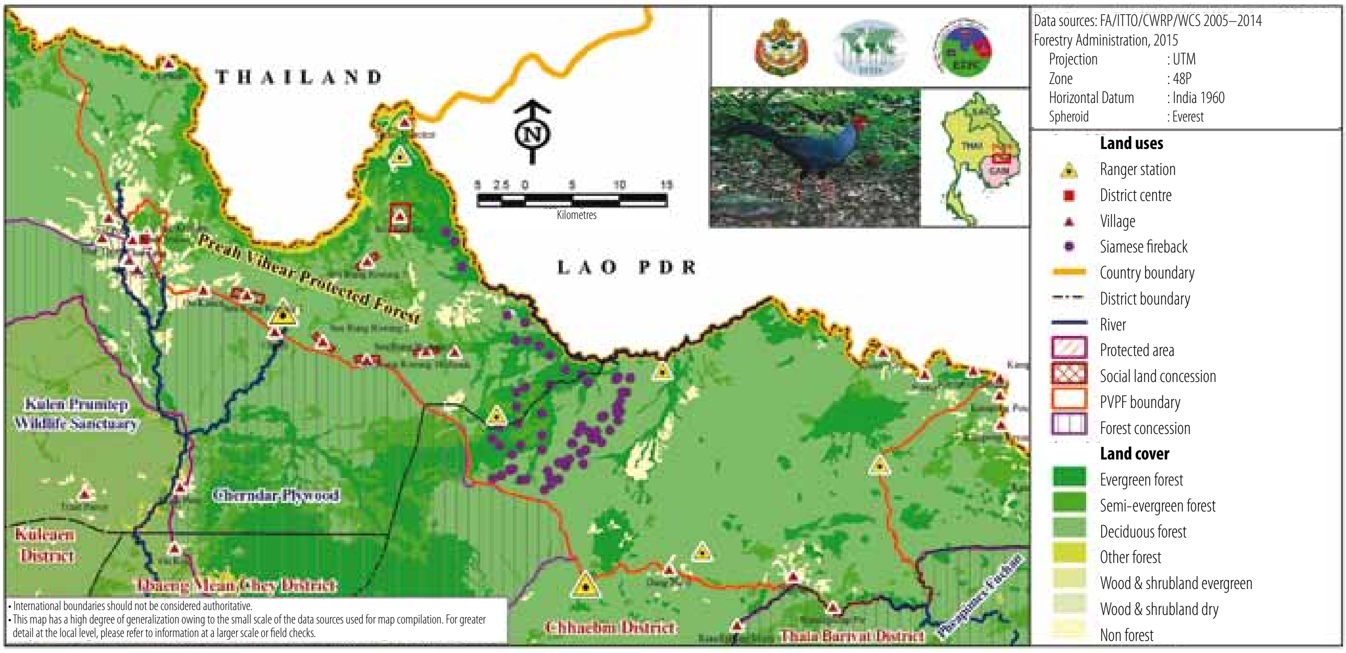


Photo: By Rushenb - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=37183738

Siamese fireback

The Siamese fireback has been observed in Cambodia, Lao PDR, Thailand and Viet Nam. It is thought to prefer undisturbed dry dipterocarp forests near streams and wetlands, where it is locally common (Figure 4.15). Its population in the region is thought to be between 20 000 and 50 000 individuals, and the population in Cambodia is conservatively estimated at 2000 individuals (Birdlife International 2015b). The species is thought to be undergoing a slow-to-moderate decline as the result of habitat loss and hunting pressure, but it is considered more resilient to those threats than previously recognized. The relatively intact dry dipterocarp forests of the PVPF provide an important protected habitat.

Figure 4.15: Distribution of Siamese fireback in and near the PVPF



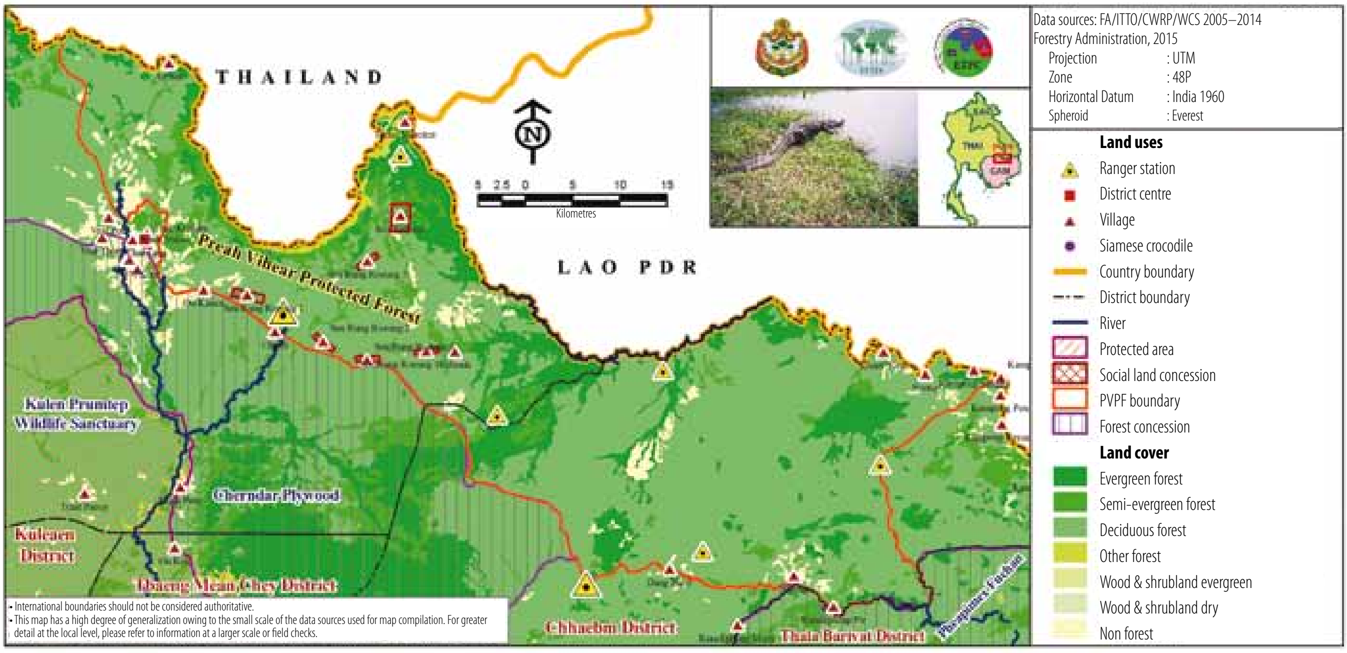
Reptile

Siamese crocodile

The relatively small Siamese crocodile occurs in freshwater rivers and marshes throughout Southeast Asia. Habitat destruction and hunting have reduced the population of this species by 80% in the past 75 years (Bezuijen et al. 2012). Only about 250 adult Siamese crocodiles remain in the wild, predominantly in the most remote highlands of the Southwest Cardamom Mountains of Cambodia. The principal threats to the continued survival of this species include hunting (for skins); large-scale hydroelectric dam development (the accompanying loss of habitat threatens remaining breeding populations in the Cardamom Mountains in southern Cambodia); and the by-catch of Siamese crocodiles in fishing nets in the PVPF. There is some indication that there may be Siamese crocodiles in the Lapov River in the PVPF, which forms the international border between Cambodia and Lao PDR, as well as in the southeast of the reserve, but Figure 4.16 shows no records in the area. A partnership between the Cambodian government and Fauna and Flora International has initiated an *ex situ* breeding programme and mitigation planning that might include the translocation of Siamese crocodiles to safer sites.

Photo: Cambodian Crocodile Conservation Program/Forestry Authority/Fauna & Flora International

Figure 4.16: Distribution of Siamese crocodile in and near the PVPF



Discussion and recommendations

The ITTO–CBD project has enabled the collection of a considerable amount of information on the habitats and distributions of landscape wildlife species in the PVPF. This information is important because it:

- Extends the state of knowledge on the distributions of these species, several of which are threatened or endangered.
- Provides valuable insights into the current use of habitats, thereby informing management planning processes, especially for species for which there are sufficient data for the development of habitat suitability models.
- Reaffirms the importance of the PVPF to biodiversity conservation in one of the world's most significant, globally recognized hotspots.

Recommendations

The most important recommendation arising from studies of the distributions of landscape wildlife species in the PVPF is that the Cambodia and Thailand components of the ITTO–CBD project, in cooperation with natural resource managers from Champasak University in Lao PDR, should use these results in their collective efforts to achieve transboundary biodiversity conservation in the ETPFC. This effort requires the development of a common management framework with shared and coordinated actions. The following components are necessary to achieve effective transboundary conservation:

- *Management plans that incorporate research results on wide-ranging wildlife species, ecological processes, planned adaptations to climate change, and projected patterns of land use throughout the ETPFC:* Necessary steps include broadening the areas of research, including the valuation of ecosystem services; expanding cooperative research agreements; increasing joint research activities among participating countries; and initiating management exchange programmes.
- *Strengthened management capacities of government officials and local authorities responsible for the management of protected areas in the ETPFC:* Necessary steps include increasing the convening of bilateral meetings and related mechanisms to reinforce efforts to reduce illegal forest activities; expanding the frequency of informal and formal meetings with government representatives in participating countries to establish stronger bonds of political support; and increasing training.
- *Support for local communities in efforts to increase incomes through activities linking livelihood improvements with reduced dependence on protected-area resources:* Necessary steps include expanding efforts to increase local incomes through the sustainable use of natural resources; extending outreach and information exchange initiatives directed at local communities; and increasing the participation of local communities in natural resource monitoring and law enforcement.

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5 WILDLIFE SPECIES IN THE DONG KHANTHUNG PROVINCIAL PROTECTED FOREST

Phonesavanh Thepphasoulithone, Inpeng Duangvongsa, Bounthavy Vongkhamchanh, Angkham Bouthdala, Sisamone Xaiyakanya and Xaiyasith Makvilaisane

The ETPFC consists of protected areas along the borders of Cambodia, Lao PDR and Thailand, which, combined, form a complex that supports what is regarded as a very rich fauna of unique species of endangered wildlife that roam through the area. Information on these unique wildlife species is very limited, however, and the capacity to manage them is hindered by the lack of even basic distributional data. This issue was raised in the initial development of the ITTO–CBD project for improving the management and conservation of transboundary biodiversity among Cambodia, Lao PDR and Thailand.

The DKPPA is a provincial-level protected area in southwestern Lao PDR (Figure 5.1) along the border with Cambodia to the south and Thailand to the west. It is in the Mounlapamok district of Champasak Province between latitudes 14° 07' and 14° 32' north and longitudes 105° 12' and 105° 45' east. Its southernmost part lies along the Xe Lamphao River, which forms the border between Lao PDR and the PVPF in Cambodia. The vegetative cover is dominated by dry evergreen forest, mixed deciduous forest, and small patches of dry deciduous dipterocarp forest.

Many important wildlife species, some of which are endangered, are reported to occur in the DKPPA reserve, such as the giant ibis, lesser adjutant stork, spot-billed pelican, green peafowl, white-winged duck, Asian elephant, gaur, banteng, Siamese Eld's deer, pileated gibbon, and Indochinese lutong (Round 1998; Duckworth et al. 1999).[1] The Indochinese lutong ("ta lung" in Laotian) was previously considered an Indochinese subspecies of *Trachypithecus cristatus* but has now been reclassified as a new species and is listed as endangered by IUCN (Groves 2001; Nadler et al. 2008).

Local people living in the ten villages inside the DKPPA harvest a diversity of wild flora and fauna. Among the main threats to wildlife in southern Lao PDR is the loss of habitat due to land-clearing and encroachment by local people (Round 1998); key species under threat include mammals (e.g. sambar and Indochinese lutong), large birds (e.g. giant ibis) and reptiles such as the reticulated python, king cobra, tree monitor and water monitor. Wildlife is also harvested illegally.

The Dong Khanthung Provincial Protected Area

A wildlife survey was carried out in the DKPPA, which has a total area of approximately 170 000 hectares. Most of the area is 90–120 m above sea level, with small areas of hilly slopes 200–500 m high along the border with Thailand to the west. The DKPPA contains a species-rich dry dipterocarp woodland, with many permanent and seasonal pools, streams and rivers. The semi-evergreen and evergreen forests are mainly low in stature and scrubby, with taller forest found chiefly along watercourses. Both deciduous and evergreen forests occur in a mosaic with savanna grassland patches.

As a segment of the Mekong River floodplain lying on the west bank of the Mekong, the DKPPA has unique biogeographical importance in Lao PDR. It also has international importance as a wetland site, according to criteria adopted by the Convention on Wetlands of International Importance, especially as waterfowl habitat.

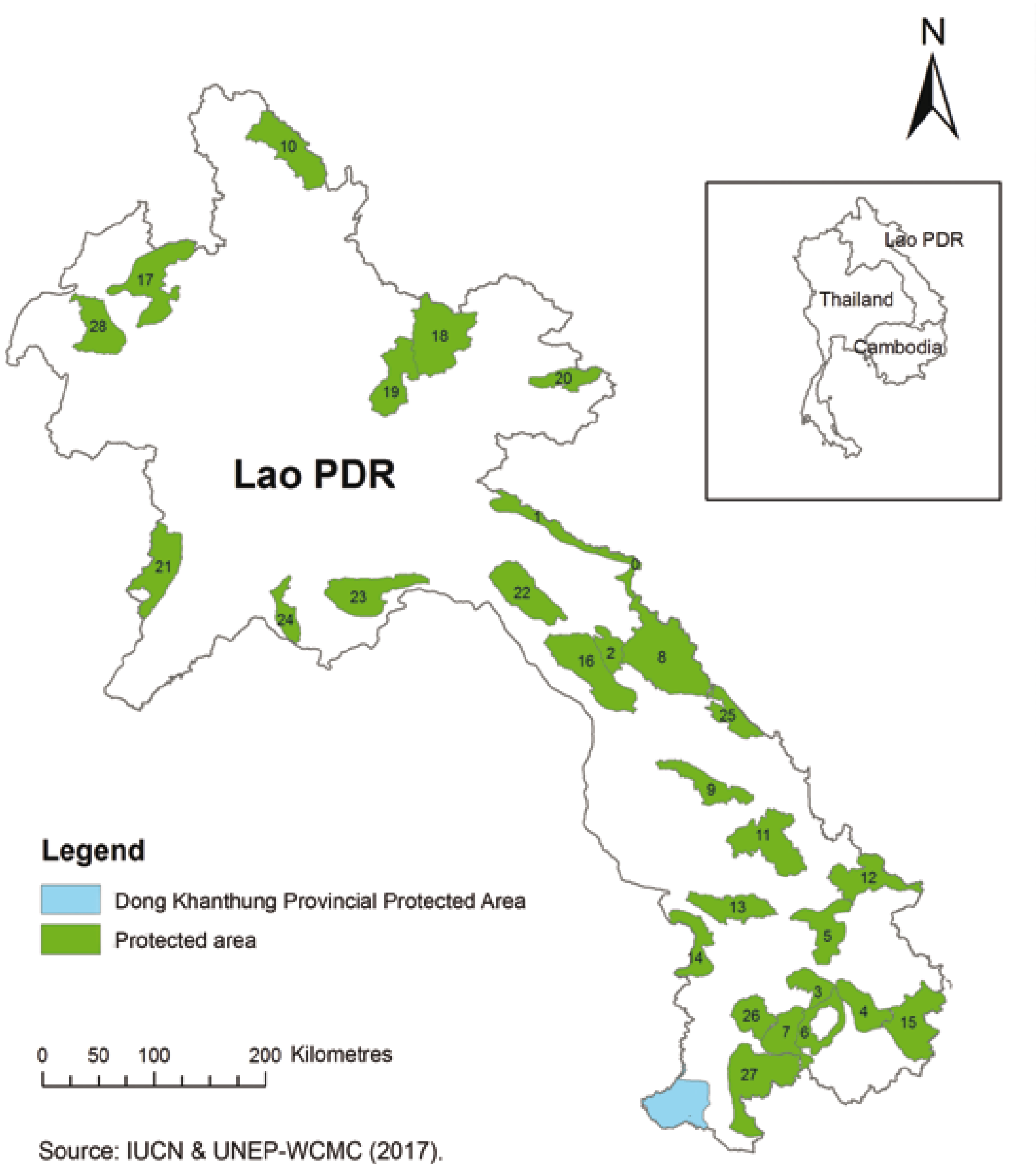
Methods

Data collection

The DKPPA wildlife survey was conducted in four villages in the Monlapamok district of Champasack Province by personnel from the Faculty of Agriculture and Forestry, Champasack University, and the Natural Resource and Environment Office. Surveys were conducted in four periods: 1) January to February 2014 in Nong Nga village; 2) March to April 2014 in Pel village; 3) April to May 2014 in Ban Khem village; and 4) May to June 2014 in Tahin village.

1 Table 1.2 provides the scientific names and conservation status of these and other fauna species.

Figure 5.1: The DKPPA in Lao PDR



0	Nam Theun Ext.
1	Nam Chuane
2	Corridor Nakai–Nam Theun and Phou Hin Poun
3	Phou Kateup (Bolovens Northeast)
4	Phou Kathong
5	Phou Theung
6	Phu Luang (Bolovens Southwest)
7	Xe Khampho
8	Nakai - Nam Theun
9	Phou Xang He
10	Phou Dene Din
11	Dong Phou Vieng
12	Xe Xap
13	Xe Bang Nouan
14	Phou Xiang Thong

15	Dong Ampham
16	Khammouane Limestone (Phou Hin Poun)
17	Nam Ha
18	Nam Et
19	Phou Loey
20	Nam Xam
21	Nam Pouy
22	Nam Kading
23	Phou Khao Khoay
24	Phou Phanang
25	Hin Nam No
26	Dong Houa Sao
27	Xe Pian
28	Nam Kan

Table 5.1: Sixteen wildlife landscape species assessed in the DKPPA with their habitat associations, and relative abundances in the three countries

Species	DE	DD	WL	AL	Slope %	Thailand	Cambodia	Lao PDR
Banteng	-	++++	-	-	0–10	+	+++	+
Siamese Eld's deer	-	++++	++	+	0–10	-	+++	+
Asian elephant	+++	+++	++	+++	0–20	++	+++	+
Gaur	+++	+	-	-	0–30	+	++	+
Sambar	++	++	++	-	0–30	++	++	+
Vulture (3 species)*	-	+++	+	+	0–10	-	+++	+
Lesser adjutant stork	-	++	++	-	0–10	+	+++	++
Giant ibis	-	++	++	-	0–10	-	+++	+
Siamese crocodile	-	-	++++	-	0–10	+	+	+
White-winged duck	+++	-	++++	-	all	+	+++	++
Greater adjutant stork	-	++	++	-	0–10	-	+++	+
Black-necked stork	-	+++	++	-	0–10	-	++	+
Green peafowl	-	+++	+	++	0–10	+	++	+
Irrawaddy dolphin (*Orcaella brevirostris*)	-	-	+	-	0	+	?	+

*Notes: DE = dry evergreen forest; DD = dry deciduous dipterocarp forest; AL = agricultural land; WL = wetland or water system; EN = endangered; CR = critically endangered; VU = vulnerable; NT = not threatened. ? = uncertain; = not occurring; + = relative abundance; * white-rumped, slender-billed (or long-billed) and red-headed. Table 1.2 provides the scientific names and conservation status for these and other fauna species.*

Source: Bhumpakphan (2013).

In light of information gathered from local people and advice from staff at Kasetsart University in Thailand, the Champasack University team focused on 16 species considered landscape species in the DKPPA (Table 5.1).

Survey techniques

The surveys used equipment such as GPS, maps, cameras, camera trapping, posters, wildlife books and questionnaires. Survey lines were determined by GPS and noted on maps. Records of wildlife species were collected from direct observations as well as the presence of scats and tracks (Figure 5.2) and the activation of camera traps. Local guides with knowledge of the forest landscape and wildlife species formed part of the survey teams. Questionnaires were developed and used in interviews with local people for additional information on wildlife occurrences. Camera traps were set in areas with good potential for observing various wildlife species based on game trails and habitat quality and were checked every two weeks.

Wildlife species richness

The wildlife surveys conducted in January to April 2014 in the Nong Nga and Pail villages reported the presence of very few wildlife species. In April to June 2014, camera surveys near Ban Khem and Tahin villages obtained images of several species, including: the Asian woolly-necked stork; lesser mouse deer; golden jackal; common barking deer; sambar; gaur; banteng; and Asian elephant. The questionnaires provided further information on wildlife species diversity in the DKPPA (Table 5.2).

Table 5.2: Number of wildlife species found in the DKPPA in the wildlife surveys, by group

Group	No. of species
Mammal	24
Bird	32
Reptile	22
Amphibian	8
Fish	37
Total	**123**

Figure 5.2: Examples of wildlife tracks in the DKPPA

Photos: Inpeng Duangvongsa

Members of the Champasak University Wildlife Study Team survey for wildlife and set camera traps in the DKPPA. Photo: Angkham Bouthdala

Mammals

At least 24 species of mammal were found in the DKPPA, including, in most parts of the reserve, the Asian elephant (but just three individuals), wild boar, common barking deer, lesser mouse deer, and golden jackal. Other rare mammals included the sambar, banteng and gaur. Most of the wildlife pictures below were obtained from camera traps at a forest pond near Ban Khem village.

A gaur and two sambar photographed by camera traps at a forest pond near Ban Khem village in the DKPPA. Photos: Inpeng Duangvongsa

Golden jackal and common barking deer photographed by camera traps in the DKPPA. Photos: Bounthavy Vongkhamchanh

Large birds

At least 32 species of large bird were recorded in the DKPPA, including the red jungle fowl, garganey, greater coucal and Brahminy kite. Rare species included the grey-headed fish-eagle, giant ibis and Asian woolly-necked stork.

Reptiles

Reptiles are known to be elusive, and surveying them is especially difficult. At least 22 species of reptile occur in the DKPPA, including the Indochinese rat snake, tree monitor, water monitor, Malayan snail-eating turtle, Indochinese box turtle and Siamese crocodile.

Asian woolly-necked storks in Ban Khem village, DKPPA. Photo: Sisamone Xaiyakanya

Amphibians

Eight species of amphibian were recorded in the DKPPA, such as the marsh frog, dark-sided froglet, blunt-headed burrowing frog and house tree frog.

House tree frog, DKPPA. Photo: Angkham Bouthdala

Fish

Thirty-seven species of fish were recorded in the Xe Lamphao River, such as the pa beuk or Mekong giant catfish, pa mark phang (Mekong herring), pa nam ngeuan, pa khan yaeng hin, pa do (giant snakehead fish), serpent-head fish, Jullien's golden carp, clown featherback, bronze featherback and goldfin tinfoil barb.

Jullien's golden carp (bottom), clown featherback (top), DKPPA. Photo: Inpeng Duangvongsa

Threats to wildlife and habitat in the DKPPA

Wildlife and biodiversity in the DKPPA face several threats, including wildlife poaching for subsistence and trade in several areas; deforestation by companies and local villagers; grazing by livestock, including domestic buffalo and cattle, where they increase ecological competition and could spread disease to wild ungulates; illegal cutting for valuable rosewood (*Dalbergia cochinchinensis*); and encroachment of forestland by local people. All these issues must be addressed though laws and regular patrolling; moreover, landmines need to be removed to help ensure the safety of staff and villagers when they conduct wildlife surveys and patrols.

Seasonal movements of wildlife

Local people confirmed that many kinds of mammal in the DKPPA, such as the Asian elephant, gaur, banteng and sambar deer, move frequently between the three adjacent reserve complexes in the three ETPFC countries for feeding and breeding. Wildlife movements also occur in response to threats such as wildlife poaching, deforestation, agricultural activities and the encroachment of settlements.

Discussion and recommendations

Many of the wildlife species recorded in the DKPPA are at high risk of extinction. Cambodia, Lao PDR and Thailand need to increase cooperation as well as improve data on wildlife species in the ETPFC, including by sharing information to provide greater understanding of the ecology and movements of large bird and mammal species. Critically endangered and endangered species—such as the Asian elephant, banteng, gaur, Siamese Eld's deer, sarus crane and giant ibis—should be the focus of individual management efforts. Habitats for these species need to be properly managed and conserved, and there is a need to raise awareness among local Lao people on wildlife conservation. More employment is needed in the area to enhance biodiversity conservation in the Lao PDR part of the ETPFC.

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6 SPECIES DISTRIBUTION MODELLING FOR TRANSBOUNDARY BIODIVERSITY CONSERVATION IN THE EMERALD TRIANGLE PROTECTED FORESTS COMPLEX

Yongyut Trisurat

The ETPFC is recognized as a globally outstanding area for biodiversity conservation, and it supports important habitats for large vertebrates in the Greater Mekong Subregion. As described in chapters 1–5, the ETPFC supports more than 50 species on the IUCN Red List, including several categorized as critically endangered or endangered (Bhumpakphan 2015; Forestry Administration 2009; Round 1998). Wikramanayake et al. (2000) reported that more than two-thirds of the original forests in the Indochina region have been converted to agriculture and human settlements. Forests in the ETPFC are mostly intact, however, and they provide habitats for many species that migrate seasonally across the borders between Cambodia, Lao PDR and Thailand, depending on the availability of food and water and the presence of threats.

Deforestation not only decreases wildlife habitat, it also results in habitat fragmentation and edge effects, the cumulative consequences of which increase extinction rates (Fahrig 2003; Ford et al. 2009); large-sized mammals such as the Indochinese tiger, Asian elephant, banteng and gaur are generally the first species affected (Kitamura et al. 2010; Lynam 2010; Trisurat et al. 2012). Changes in landscape patterns can also have impacts on birds and other small wildlife species. Trisurat and Duengkae (2011), for example, found that the predicted area of suitable habitat for the black-crested bulbul at a research station in northeastern Thailand would decline substantially from 3802 hectares in 2008 to 3342 hectares in 2020 in their “trend scenario”, although the decline would be only slight (to 3627 hectares) in an “integrated land-use management scenario”. Habitats in the trend scenario would be severely fragmented, which would diminish the recreational and educational values of the remaining forests to the birds and the public.

In addition to deforestation and habitat fragmentation, climate change is an emerging global threat to biodiversity. The Intergovernmental Panel on Climate Change (IPCC 2007) predicted a 2–4 °C shift in seasonal mean temperature in Southeast Asia by 2100 and that changes in precipitation are also likely, although their magnitude is more uncertain. Changes in seasonal temperature and precipitation may cause water scarcity and resultant shifts in species distributions (Corlett 2012; Trisurat et al. 2015). They would also limit or expand the ranges of species, or cause them to die out (Miles et al. 2004; Buytaert et al. 2011).

This chapter links directly with Chapter 2 (on land-use change) and the change scenarios presented there. It predicts the distributions of selected species in the ETPFC, as discussed in chapters 3–5, and quantifies the impacts of future land-use change and climate change on the habitats of those species.

Methods

Study area

The ETPFC comprises the PPFC in Thailand, the PVPF in Cambodia, and the Phou Xiang Thong National Biodiversity Conservation Area in Lao PDR. It covers a total of 483 695 hectares, although wildlife species are also found in the buffer zones beyond the protected areas and in the DKPPA, which is not officially part of the ETPFC. To be consistent with the land-use modelling study described in Chapter 2 and the spatial occurrences of wide-ranging species found in the ETPFC, the study area for the wildlife distribution modelling presented here is the same as for Chapter 2, covering 2 580 000 hectares.

Species distribution modelling

The process for mapping wildlife distributions involved the following five steps: 1) collection of wildlife presence point data; 2) target species selection; 3) generation of species distribution models; 4) validation and mapping distributions; and 5) assessment of land-use and climate-change impacts (Figure 6.1).

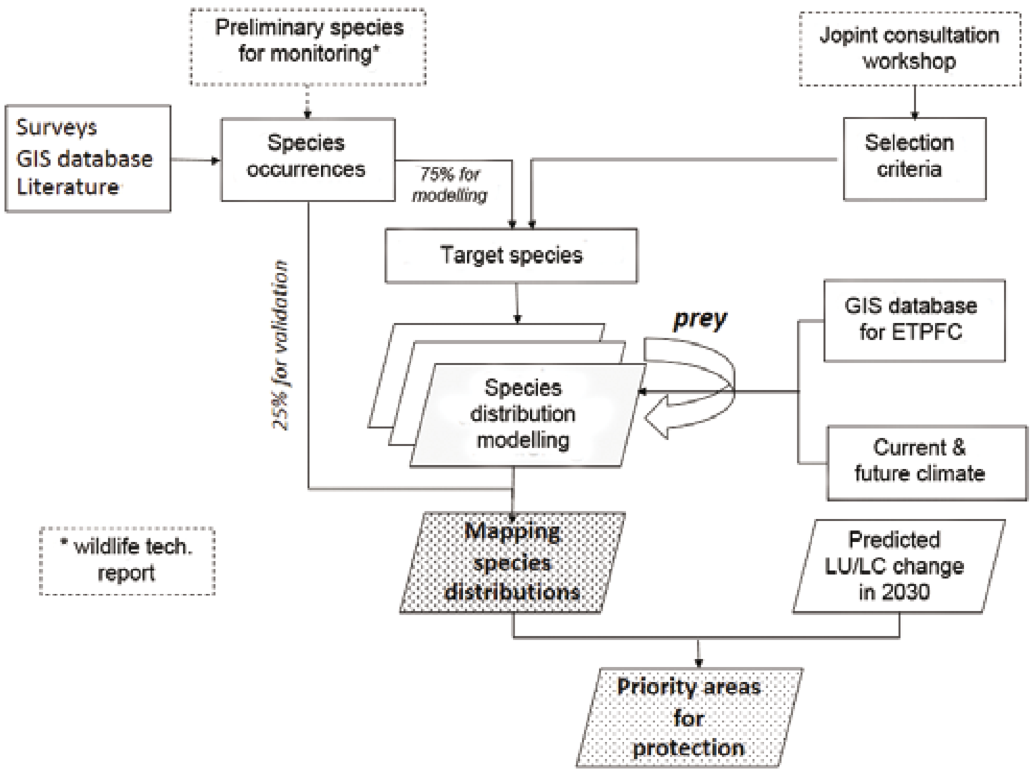
Wildlife occurrence data in the ETPFC were obtained from an existing GIS database (Trisurat 2006; Forestry Administration 2009) and wildlife reports from the DKPPA (Round 1998). Additional wildlife surveys were conducted in the PPFC in Thailand, the PVPF and the DKPPA and Phou Xiang Thong National Biodiversity Conservation Area in Lao PDR through a joint research programme on wide-ranging wildlife species distributions in the ETPFC (Bhumpakphan 2015; see also chapters 3 and 4).

Existing geo-referenced wildlife locations were gathered from the GIS database developed during phases 1 and 2 of the ITTO–CBD project (Trisurat 2004, 2010) and from the PVPF in Phase 2. The latter data were collected in 2000–2010 by Cambodia's Forestry Administration in cooperation with the Cat Action Treasury and the Wildlife Conservation Society as part of biodiversity conservation surveys on the northern plain of the PVPF.

Data on wildlife occurrence in the DKPPA were obtained from Round (1998). Locations of species occurrences were on paper maps, and these were entered into our GIS database using an onscreen digitizing technique. Data for the Phou Xiang Thong National Protected Area were obtained from Duckworth et al. (1999), published articles, and internet-based information.

Additional ground surveys were conducted in the PPFC in Thailand and the DKPPA in Lao PDR by a wildlife consultant (N. Bhumpakphan), scientists from Champasak University, and park rangers (Bhumpakphan 2015). The scientists and park rangers were trained in the use of wildlife guidebooks (e.g. Lekagul and McNeely 1977; Lekagul and Round 1991; Das 2010), GPS, cameras and an infrared camera-trapping system; the trainings were used to supplement field surveys and to identify tracks and other signs of wildlife before actual surveys. Local market surveys and interviews were conducted to help confirm the presence of wildlife species.

Figure 6.1: Main steps of species distribution modelling



Target species, models, and scenarios

Bhumpakphan (2015 and Chapter 3) proposed 15 wildlife species for monitoring. These species were further evaluated using four criteria: 1) their distribution in the ETPFC (i.e. whether they used transboundary areas); 2) whether they had regionally or nationally threatened status (Nabhitabhata and Charn-ard 2005); 3) the adequacy of observation records (≥10 points; Wisz et al. 2008); and 4) whether they had iconic or flagship conservation status.

Various species distribution models have been developed in the last decade to determine animal distributions using either presence and absence data (e.g. generalized linear models, Elith et al. 2011) or presence-only data (e.g. maximum entropy, MaxEnt, Phillips et al. 2006; environmental-niche factor analysis, Hirzel et al. 2002). For this project, MaxEnt was selected to generate distributions of species with limited numbers of records because this model generally produces the best performance compared with other presence-only data models, even with a small sample size (Wisz et al. 2008; Tognelli et al. 2009). MaxEnt takes a list of presence-only locations for a species as input with a set of environmental predictors across a landscape that is divided into grid cells. It extracts a sample of background locations and contrasts these with the presence locations. The model assumes that the data present a random landscape and predicts a probability of presence (see Phillips et al. 2006 and Merow et al. 2013 for details). Logistic regression models were used for species for which better occurrence data existed. A similar number of pseudo-absences beyond a 2-km radius were created for accuracy assessment.

Environmental variables used to determine wildlife habitats consisted of biophysical and socioeconomic factors. The biophysical factors were: patch area of deciduous and evergreen forest types; altitude; slope; aspect; distance to available water; annual rainfall; rainfall in the wettest quarter; rainfall in the driest quarter; and soil characteristics. The socioeconomic factors were distance to district; population density; and distance to main road. The distributions of prey species were included for carnivores. Existing maps for predicted LU/LC and climatic variables in 2030[1] were used to develop future wildlife distribution maps.

1 www.worldclim.org/download.

The four LU/LC scenarios applied were:

1) Low economic decline and localized resource degradation ("business as usual"), which assumes a continuation of the land conversion of recent years (2003–2013).
2) Unsustainable economic development and serious resource degradation.
3) Sustainable poverty and stable resources.
4) Sustainable development and limited resource degradation.

See Chapter 2 for more information on these scenarios.

Validation and mapping of species distributions

For each species, occurrence data were divided into two datasets. Seventy-five percent of the records were used to generate species distribution models, and the remaining 25% were kept as an independent dataset to test the accuracy of the modelled output. The probability value of 0.5 was selected as a cut-off value for binary prediction in the logistic regression models. If the probability value was equal to or greater than 0.5, it was classified as presence; otherwise, it was classified as absence. Commonly used threshold values recommended by Liu et al. (2005) were applied for classifying probability values derived from the MaxEnt model. The logistic threshold that yielded the highest overall accuracy and provided minimum omission and commission errors was selected for mapping species distributions. Commission errors are misclassifications that do not belong in a grid, and omission errors represent the opposite classification error (Lillesand and Kiefer 1987).

Assessment of land-use change and climate-change impacts

The prediction of presence or absence of a species resulted in predicted distributions in the landscape under current and future conditions (i.e. for each land-use change scenario, a climate-change scenario, and a combined land-use and climate-change scenario). The distributions were calculated for the current and predicted scenarios for each species and for total species richness. Species richness was obtained by overlaying the probability values of all selected species and classifying them into three classes (low, moderate or high). The potential impacts were assessed in terms of gained habitat (new suitable habitat) and lost habitat (an area currently predicted as suitable but predicted to no longer exist in the future).

Results

Species selected for modelling

Based on the selection criteria, 12 target species were identified for monitoring in the ETPFC landscape. These were: Asian elephant, gaur, banteng, sambar, Siamese Eld's deer, common barking deer, Indochinese tiger, leopard, sarus crane, lesser adjutant stork, giant ibis and wild boar (Table 6.1). Although common barking deer and wild boar did not meet three of the four selection criteria (both had adequate observation records), they are important to the ecosystem because they are the main prey species for Indochinese tigers and leopards (Simcharoen et al. 2007; Ngoprasert et al. 2012). Common barking deer had the most records (900) of any species, followed by Asian elephants (356 records) and wild boar (326 records). Gaur, banteng, Siamese Eld's deer, Sarus crane, lesser adjutant stork and giant ibis also had high numbers of observations. There were small numbers of sightings for Indochinese tigers, Siamese crocodiles, vultures and pileated gibbons; none of these species except the Indochinese tiger, therefore, were included in the modelling exercise. The Indochinese tiger is the top carnivore in this ecosystem and a management umbrella species in the ETPFC.

Used distribution models and logistic thresholds

MaxEnt was used to generate distribution maps for sambar, leopard and Indochinese tiger because only limited records were available (Table 6.2). The tenth percentile training presence was selected to reclassify the probability values for mapping distributions of these three species. This threshold extracts predicted values for all training locations and selects the value for the location in the tenth position if there were 100 locations (Liu et al. 2005). The tenth percentile provided the highest accuracy among the five potential logistic thresholds (Liu et al. 2005). The logistic model was used to determine suitable habitats for the remaining species, which were then mapped in a GIS.

Annual rainfall was excluded in all species distribution models due to the high correlation with precipitation in the wettest quarters. LU/LC did not contribute to species distribution models for the nine modelled species in the logistic models and contributed only slightly to the distribution of sambar, leopard and Indochinese tiger (Table 6.3). This may be because all 12 species are recognized

Table 6.1: Key wildlife species and those selected for modelling distributions in the ETPFC

Common name	Distribution			Iconic in the ETPFC?	No. of records[a]	Selected for modelling?
	T	L	C			
Gaur	x	x	x		203	Y
Banteng	x	x	x	✓	228	Y
Sambar	x	x	x		20	Y
Siamese Eld's deer		x	x	✓	142	Y
Siamese crocodile	x	x	x		9	N
Asian elephant	x	x	x	✓	356	Y
White-backed vulture		?	x		?	N
Long-billed vulture		?	x		?	N
Sarus crane		x	x	✓	272	Y
Pileated gibbon	x	x	x		30	N
Lesser adjutant stork	?	x	x	✓	310	Y
Common barking deer[b]	x	x	x		927	Y
Leopard	x	x	x		44	Y
Indochinese tiger	x	x	x	✓	10	Y
Giant ibis		x	x	✓	291	Y
Red-headed vulture (king vulture)		?	x		?	N
Wild boar[b]	x	x	x		326	Y

Notes: T = Thailand; C = Cambodia; L = Lao PDR. x = existing; ? = need to be confirmed/limited records (Bhumpakphan 2015); [a] number of records compiled from surveys, literature and GIS database; [b] important prey species for the selected carnivores. Table 1.2 provides the scientific names and conservation status of these and other fauna species.

as landscape species, meaning that they are able to inhabit most vegetation types in the landscape. Distance from city was positively correlated with most species distributions because most species are sensitive to human development; distance from city was not considerable, however, for the lesser adjutant stork and common barking deer. Altitude was negatively correlated with the distributions of many species, implying that those species, especially the large mammals, prefer low altitudes. In this research, wild boar, common barking deer, sambar and Siamese Eld's deer were chosen for modelling in part because they are prey species for leopard and Indochinese tiger; banteng and gaur were added because they are also prey for tigers. These prey layers were positively related to the distributions of leopards and tigers.

Extent of present distributions

The predicted distribution of common barking deer in 2013 covered an area of 761 200 hectares (30.4%) of the wider Emerald Triangle landscape (which, as indicated above, covers 2 580 000 hectares, comprising the ETPFC plus buffer zones). This is the largest distribution of any of the 12 species, in large part because it is a common species. The next most widely distributed species were wild boar (a predicted distribution in 2013 of 25.5% of the total area), Asian elephant (20.4%) and banteng (15.6%) (Table 6.4). Although the Asian elephant is classified as an endangered species, it inhabits various habitats in both intact and degraded forests and therefore has a large area of predicted suitable habitat. In contrast, the predicted habitats of the sambar, Siamese Eld's deer, leopard (Figure 6.2), Indochinese tiger and giant ibis each amount to less than 10% of the Emerald Triangle landscape, mainly concentrated in protected areas. If the predicted distributions of all 12 species are overlaid in the GIS, the predicted extent of habitat for all endangered species combined is approximately 1 146 000 hectares, or 46% of the Emerald Triangle landscape. Table 6.4 also shows the predicted distributions of the 12 species in 2030 under the four scenarios of land-use change and climate change.

Extent of future distributions

The study determined the consequences of land-use change and a combination of land-use change and climate change on the distributions of the selected species; Figure 6.3 shows the gains and losses of leopard habitat under each of the four scenarios. When the 2013 LU/LC map was replaced with the future LU/LC map (with less forest cover), the area of suitable habitat was predicted to be stable for most species under the four scenarios, even though the habitats of these species have declined historically. This is because LU/LC alone was not a significant factor in the distribution models of most species, and the predicted areas of deforestation were in the buffer zones of protected areas (only a small portion was assumed to be in protected areas). Sarus cranes prefer open areas, such as paddy fields and open woodlands close to water bodies (Purchkoon et al. 2014), and deforestation alone had a limited effect on such open-habitat species.

The predicted distributions of all species except banteng, common barking deer and wild boar decline significantly when predicted future climatic conditions (i.e. changes to precipitation in the wettest and driest quarters, as described above) were added to the models. The consequences of climate change are very clear for the distributions of three wetland birds: the habitats extant in 2013 were predicted to decline by approximately 40–60%, 95% and 100% for the sarus crane, lesser adjutant stork and giant ibis, respectively. In addition, the accumulated suitable habitats of the 12 selected species would decline from 2013 to 2030.

Contribution of protected areas to species protection

The protected areas in the Emerald Triangle landscape cover, in total, about 650 000 hectares, or 26% of the total study area. Not all land in the protected areas was defined by modelling as suitable habitat for the selected species. The average extent of suitable habitats for all species in the protected areas was 63% of the total area in 2013 and 50–64% in 2030 (Table 6.5).

More than 80% of the total current and future suitable habitats for sambar and Indochinese tiger are predicted to be in protected areas. The protected areas contributed 40–70% of habitats for banteng, Siamese Eld's deer, common barking deer, leopard and wild boar and less than 40% for the sarus crane, lesser adjutant stork and giant ibis. In general, most of the large avian species (except wetland birds) concentrate in the PVPF and the DKPPA, while protected areas in Thailand were predicted to provide only low to moderate suitability for all species. The modelling also

Table 6.2: Selected species and accuracy assessment of the predicted distributions derived from used logistic thresholds

Species	10th percentile[a] and accuracy			EQ[b] and accuracy			MTS[c] and accuracy			EQT[d] and accuracy			MTST[e] and accuracy			AUC[f]	Used threshold
	Threshold	Omission/ commission error	Accuracy	Threshold	Omission/ commission error	Accuracy	Threshold	Omission/ commission error	Accuracy	Threshold	Omission/ commission error	Accuracy	Threshold	Omission/ commission error	Accuracy		
Sambar	0.42	11/10	89	0.18	11/70	58	0.42	11/10	89	0.51	28/0	89	0.56	28/0	89	0.96	10PT/MTS
Leopard	0.36	17/9	87	0.33	17/27	78	0.29	17/45	79	0.24	8/45	74	0.24	8/45	74	0.95	10PT
Indochinese tiger	0.21	NA	NA	0.21	NA	NA	0.21	NA	NA	0.48	NA	NA	0.48	NA	NA	0.96	10PT

Notes: [a] 10 percentile training presence; [b] EQ = equal training sensitivity plus specificity; [c] MTS = maximum training sensitivity plus specificity; [d] EQT = equal test sensitivity plus specificity; [e] MTST = Maximum test sensitivity plus specificity; [f] AUC = area under curve.

Table 6.3: Relative contributions of environmental variables to the spatial distribution model for each wildlife species

Species	Constant	Distance from city	LU/LC	Population	Altitude	Slope	Stream distance	Road distance	Wet Q rain	Dry Q rain	Deciduous patch size	Evergreen patch size	Prey	AUC	Overall accuracy
Logistic regression															
Gaur	-3.5711	0.0001							-0.0088	0.5227		0.0006		0.83	74
Banteng	4.3376	0.0001			-0.015			0.0002	-0.0058			0.0007		0.84	76
Siamese Eld's deer	-12.215	0.0001				-0.701	0.0009	-0.0003		0.4853		-0.002		0.96	90
Elephant	-23.8579	0.0002			-0.008	-0.214	-0.0004	0.0003	0.0075	0.6834	0.0009	0.0006		0.91	83
Sarus crane	4.533	0.0002		0.0173			0.0006		-0.0282	1.0253	-0.0023	-0.0017		0.95	90
Lesser adjutant stork	-13.267				-0.042		0.0003			0.9544	-0.0011			0.89	79
Common barking deer	8.9072			-0.0386	-0.018				-0.0036	-0.1414	0.0007	0.0006		0.81	75
Giant ibis	2.0501	0.0002					0.0002		-0.0281	1.1752		-0.001		0.96	86
Wild boar	11.3316	8.20E-05		-0.0549	-0.023			-0.0001	-0.0044	-0.2783	0.0015	0.0007		0.86	81
MaxEnt model															
Sambar	NA	29.1	2.3	< 0.1	6.0	0.1	0..2	0.4	1.0	1.4	< 0.1	1.6	NA	0.96	90
Leopard	NA	15.1	0.3	3.5	8.1	0.5	2.0	3.6	1.2	24.8	3.0	10.5	24.6	0.95	87
Indochinese tiger	NA	48.1	5.0	< 0.1	< 0.1	< 0.1	0.3	0.2	< 0.1	< 0.1	0.2	< 0.1	46.2	0.96	NA

Notes: annual rain in 2000 = 1864 mm (1469–3247 mm); driest quarter 2000 = 16 mm (11–41 mm); wettest quarter 2000 = 1119 mm (847–2054 mm). Annual rain 2050 = 1779 mm (1381–3081 mm); driest quarter 2050 = 12.3 mm (8–33); wettest quarter 2050 = 1048 mm (787–1922 mm); AUC = area under curve; NA = not applicable.

Table 6.4: Predicted suitable distributions of each mammal species in 2013 and 2030 as a percentage of the total area of the Emerald Triangle landscape, for various scenarios of land-use change and climate change

Species	Predicted distribution in 2013	Predicted distribution in 2030, by scenario							
		Low economy	Low economy with climate change[a]	Sustainable poverty	Sustainable poverty with climate change	Sustainable development	Sustainable development with climate change	Unsustainable development	Unsustainable development with climate change
Gaur	14.62	14.66	8.51	14.79	8.52	15.37	8.55	15.19	8.99
Banteng	15.58	15.81	19.00	15.98	19.13	16.32	19.32	16.19	16.20
Sambar	4.02	3.78	3.84	4.02	3.11	3.90	3.86	3.90	3.99
Siamese Eld's deer	6.03	6.00	2.59	6.02	2.60	5.98	2.60	5.90	2.52
Elephant	20.46	20.05	7.74	19.48	7.72	14.01	7.82	20.07	8.13
Sarus crane	12.04	12.72	10.67	13.41	4.83	12.66	4.62	12.73	4.61
Lesser adjutant stork	18.12	18.36	0.85	19.03	0.86	18.34	0.85	18.54	0.85
Common barking deer	30.37	30.75	42.01	30.09	41.16	31.01	42.24	30.74	41.74
Leopard	6.08	5.92	6.09	6.08	6.59	5.96	6.16	5.87	6.07
Indochinese tiger	7.41	7.60	6.81	7.26	4.37	7.29	7.27	8.13	7.08
Giant ibis	8.15	8.15	0.45	8.14	0.45	8.14	0.45	8.13	0.45
Wild boar	25.55	24.79	41.39	23.45	39.87	25.35	41.66	24.67	40.81
Total habitat[b]	**45.73**	**45.29**	**55.82**	**43.96**	**49.25**	**46.14**	**50.76**	**45.03**	**49.86**

Notes: [a] *combination of LU/LC and climate change;* [b] *predicted suitable habitats for at least one species, excluding overlapped areas.*

Table 6.5: Predicted contribution of current protected areas (% of total habitat) to the conservation of selected mammal species in the Emerald Triangle landscape, various scenarios of land-use change and climate change

Species	Predicted contribution of protected areas, by scenario								
	Baseline	**Low economy**	**Low economy with climate change**	**Sustainable poverty**	**Sustainable poverty with climate change**	**Sustainable development**	**Sustainable development with climate change**	**Unsustainable development**	**Unsustainable development with climate change**
Gaur	73.00	73.18	92.52	53.07	92.20	69.94	92.25	72.90	92.72
Banteng	69.06	69.24	67.24	79.90	66.78	67.40	66.31	69.20	69.20
Sambar	99.52	99.18	99.02	97.99	99.20	99.38	99.40	99.54	99.11
Siamese Eld's deer	59.44	59.26	63.87	59.65	64.51	59.81	64.35	58.56	62.95
Asian elephant	71.26	71.94	84.47	71.08	84.31	70.38	83.85	71.91	84.92
Sarus crane	35.51	35.10	13.32	35.20	20.43	35.44	20.50	34.88	20.08
Lesser adjutant stork	38.91	38.42	2.42	0.11	2.41	38.40	2.42	38.60	2.42
Common barking deer	48.49	48.63	44.77	60.24	44.06	48.67	44.97	48.74	44.77
Leopard	72.27	73.14	71.25	72.36	70.59	73.29	71.52	72.36	70.78
Indochinese tiger	90.26	90.70	91.76	90.24	96.20	89.99	89.41	91.36	92.60
Giant ibis	48.63	48.58	0.00	0.00	0.00	48.70	0.00	48.44	0.00
Wild boar	54.53	55.73	45.06	75.09	44.20	55.19	45.36	55.72	45.10
Average	**63.41**	**63.59**	**56.31**	**52.69**	**50.16**	**60.17**	**56.69**	**63.52**	**57.50**
Richness class									
None	9.97	10.28	11.64	50.75	23.42	9.24	10.13	10.50	10.86
Low (1–4 species)	29.19	28.64	30.31	40.12	45.26	34.84	30.23	28.04	30.02
Moderate (5–8 species)	71.41	71.14	90.90	9.13	31.32	67.58	89.04	70.75	88.57
High (9–12 species)	85.83	91.31	NA	NA	NA	85.13	NA	90.04	NA

Note: NA = not applicable.

suggested that the average contribution of protected areas under a combination of land-use change and climate change would be less than under land-use change alone, suggesting that some habitats in the protected areas will be degraded under climate change.

Concentration of selected wildlife species

The probability values for presence derived from the distribution models of 12 species were overlaid using the GIS; each location was then sorted into four richness classes depending on the number of species for which it was suitable: 1) none; 2) low (1–4 species); 3) moderate (5–8 species); and 4) high (9–12 species). Approximately 45% of the Emerald Triangle landscape study area was classified as unsuitable habitat for any of the 12 species, both currently and in all future land-use scenarios. When future climate-change conditions were combined with land use, the predicted percentage of unsuitable habitat increased to 50–55%.

The "high" species richness class was predicted to occur on the border between the PVPF (except the western part) and the DKPPA. Most areas in the PVPF, the central and eastern parts of the DKPPA and the Phu Jong-Na Yoi National Park were classified as having moderate species richness. The remaining areas of the PVPF as well as Yot Dom, Bun Thrik-Yot Mon and part of Phou Xiang Thong were predicted to support low richness for the 12 species, now and in the future. The entire Pha Taem and Kaeng Tana national parks were categorized as non-habitat for all 12 species because of heavy human pressure (Bhumpakphan 2015).

Discussion

Uneven wildlife surveys and used distribution models

The combined wildlife survey data showed that the highest number of occurrences of all species were in the PVPF in Cambodia, followed by the DKPPA in Lao PDR. This resulted partially from the dissimilarity of survey efforts across the study area. Cambodia's Forestry Administration (2009) conducted biodiversity surveys in Preah Vihear Province in 1999–2008 in cooperation with the Cat Action Treasury and the Wildlife Conservation Society, and this comprehensive and long-term monitoring documented an impressive list of fauna and the locations where they occurred. More than 3000 of the 3500 data points (i.e. more than 85%) of the accumulated data from the three countries combined were from the Preah Vihear area. The DKPPA had about 200 data points, making it the second-largest source of data (Round 1998), while the fewest data points (60) were in the PPFC (Bhumpakphan 2015). This is because the wildlife surveys in Lao PDR and Thailand were conducted using rapid assessment techniques over a short period with few replications.

The unevenness of the survey effort and the clumped distributions of wildlife affected the selection of distribution models. In general, linear generalized models work well with adequate presence and absence data (Elith et al. 2011). For example, the overall accuracy of nine species using the logistic regression model ranged from 74% for gaur to 90% for Siamese Eld's deer and sarus crane, which are acceptable levels of accuracy. But this technique could not be applied to the sambar, leopard or Indochinese tiger because of the small number of records. Therefore, MaxEnt was used to generate predicted distributions for these three species because it generally produces satisfactory results, even with relatively few records (Wisz et al. 2008; Tognelli et al. 2009).

Relative effects of land-use change and climate change on species distributions

In general, deforestation decreases the availability of good habitats for wildlife and causes habitat fragmentation (Fahrig 2003; Ford et al. 2009). Moreover, endangered large-sized mammals are highly sensitive to habitat loss and fragmentation, which may result in extinction over time (Kitamura et al. 2010; Lynam 2010; Trisurat et al. 2012). Our results are not entirely consistent with these studies, however, mostly because the deforested areas were mainly predicted to be in the buffer zones of protected areas (Chapter 2). The results of species distribution models indicated that the contribution of all protected areas in the ETPFC to the provision of good habitats for the 12 selected wildlife species ranges from 63% of the ETPFC landscape at present to a forecast 50–64% in 2030, although the protected areas collectively cover only about 26% of the total landscape.

The predicted impacts are generally worse for most species when climate change is combined with land-use change, especially for the sarus crane, giant ibis and lesser adjutant stork, which prefer open areas such as paddy fields and open

Figure 6.2: Predicted distribution of leopard, 2013

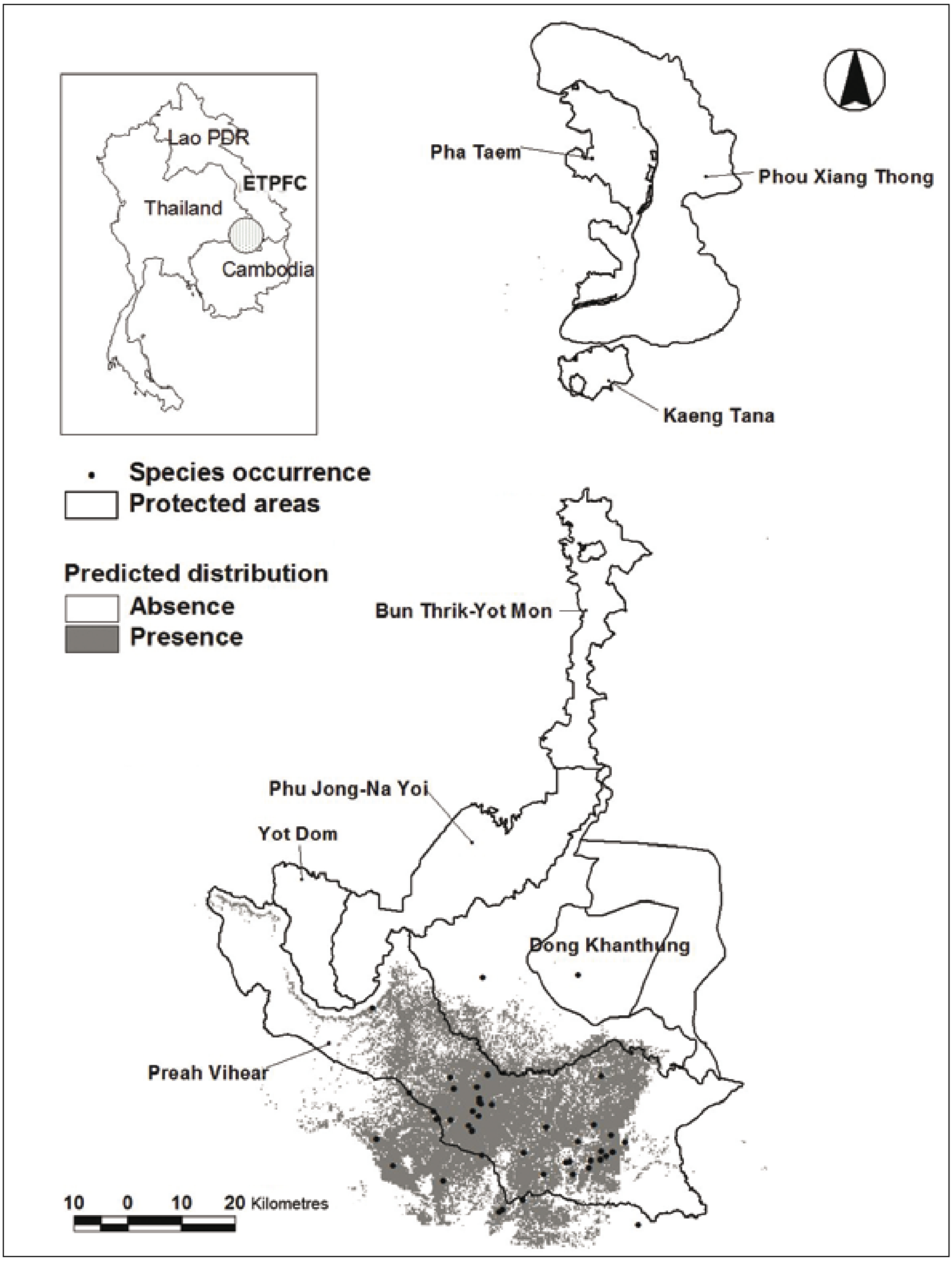
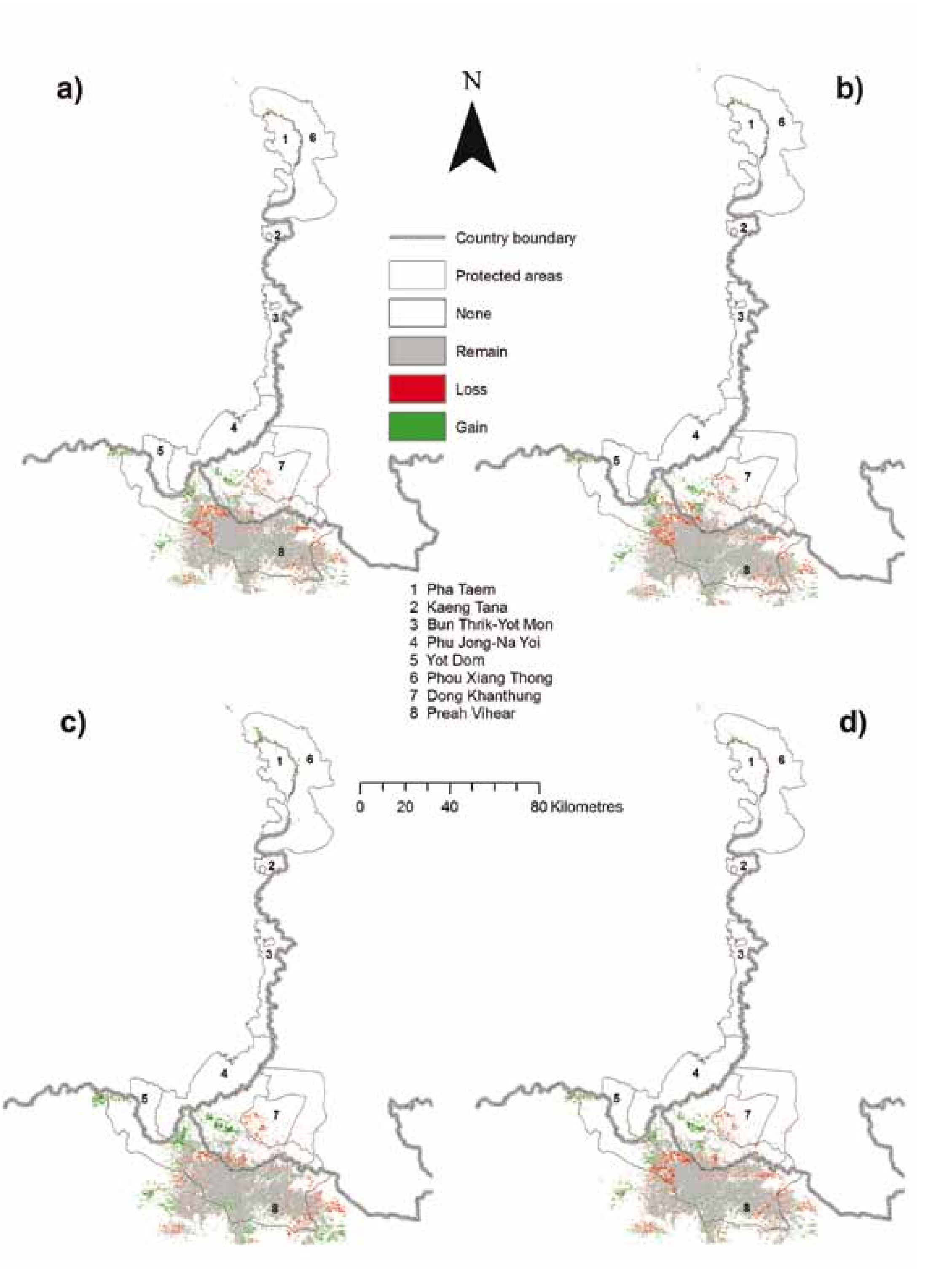
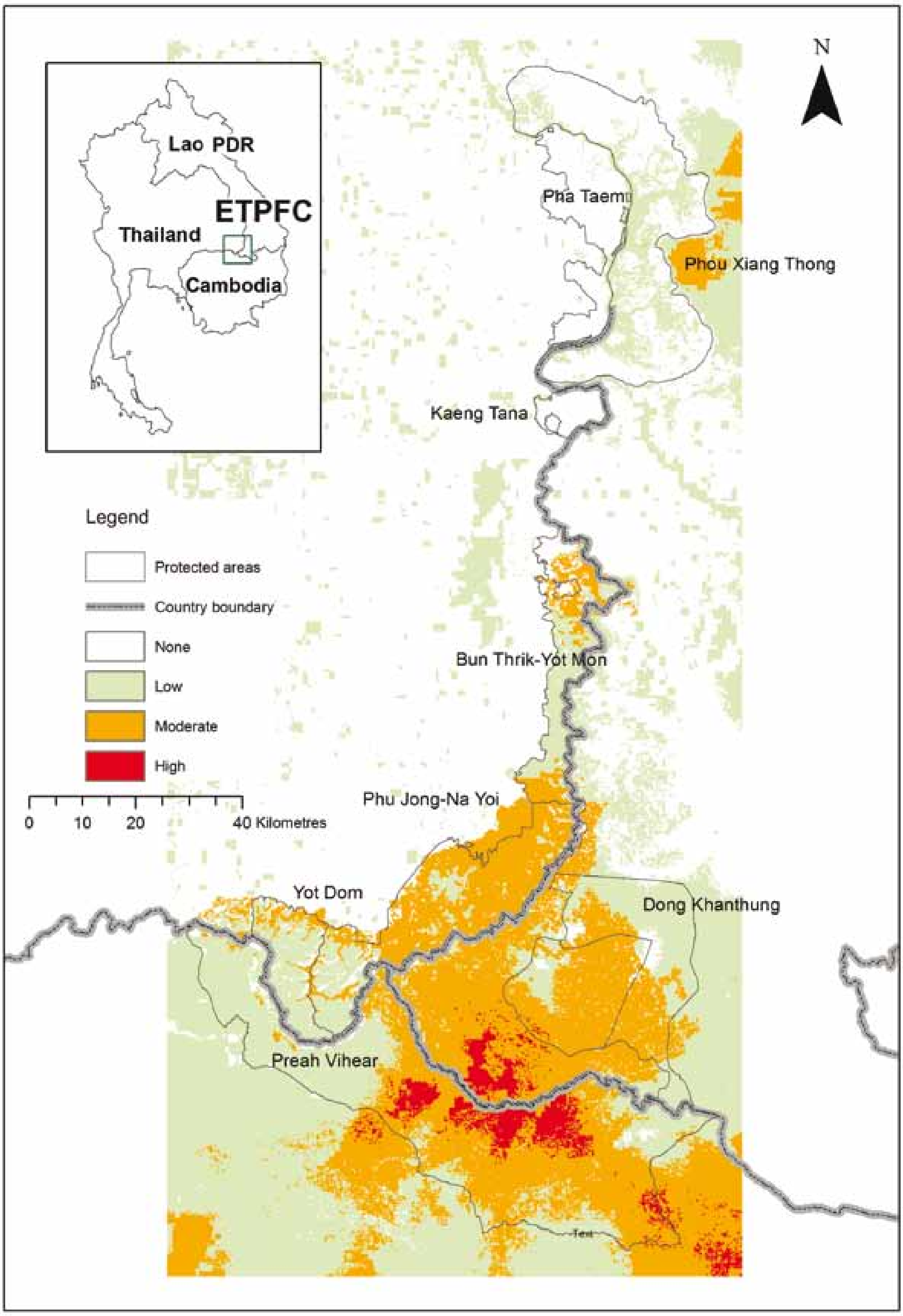


Figure 6.3: Predicted gain and loss of habitat for leopards in 2030 under the following scenarios: a) business as usual; b) unsustainable economic development; c) sustainable poverty; and d) sustainable development



Note: see Chapter 2 for scenario descriptions.

Figure 6.4: Species richness classes of selected species for modelling in the Emerald Triangle landscape



woodlands close to water bodies (Purchkoon et al. 2014). The predicted climatic conditions in 2030 include lower annual rainfall and longer dry months, which would affect food sources and reduce the availability of water for these species. On the other hand, climate change may have a positive effect on populations of gaur, Siamese Eld's deer and Asian elephant, all of which are classified as grazing species. Their suitable habitats were predicted to increase under the "sustainable poverty" and "sustainable development" scenarios in combination with climate change. More paddy fields or grasslands are expected under these two scenarios (Chapter 2), meaning more food resources for the three species.

Management implications

The results presented in Chapter 2 and here clearly indicate the benefits of joint research on land-use and wildlife modelling. Cooperation across the international borders is important for gathering ground-level data for modelling the large wildlife species that occupy the transboundary areas. The destruction of lowland dry deciduous forests in Cambodia and Lao PDR as a result of land allocation programmes for the military, and other unsustainable land uses, will have impacts on wildlife (e.g. sambar, Siamese Eld's deer, Asian elephant and leopard) in these areas because the lowland dry dipterocarp forests in the PVPF and the DKPPA are key habitats for these species (Round 1998). Sustainable land-use management is essential for maintaining wildlife habitats; moreover, the rehabilitation of degraded habitats and water resources will be necessary to minimize the impacts of climate change on these habitats.

The formulation of a transboundary biodiversity conservation framework and management plan among the three countries is essential for ensuring the maintenance of the large mammal species because they are concentrated on the trinational borders and move seasonally among the countries, depending on rainfall and the availability of food (Figure 6.4) (Bhumpakphan 2015). There is also a need to continue—and expand to other communities—the activities commenced in the ITTO–CBD project's Phase 2 to improve the livelihoods and raise the awareness of local people residing in the buffer zones. The outputs of planned integrated conservation and development activities can reduce pressures on these forests and the large-mammal communities they support.

Conclusion

The modelling presented in this chapter predicts the distributions of 12 large wildlife species, both at present and in the future under various scenarios. Future light-to-moderate LU/LC will have slight impacts on the distributions of selected species because most of the remaining suitable habitats are located in protected areas, while deforestation is most likely to occur in the buffer zones. Severe impacts are predicted, however, under the unsustainable land-use scenario in combination with future climate change for all species except grazing ungulates and elephants.

The distribution maps produced by this study should be used to guide smart forest law enforcement and to develop a collaborative framework for the protection of important habitats through a conservation partnership among Cambodia, Lao PDR and Thailand, as promoted through the ITTO–CBD project. In addition, the results should be used to encourage the staff of protected areas as well as decision-makers and local people to work together and to increase efforts to conserve biodiversity in the ETPFC.

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7 REDUCING FOREST USE THROUGH SMALL-ENTERPRISE DEVELOPMENT

Sapol Boonsermsuk, Onruedee Maneethong and Kamol Wisupakan

One of the objectives of the ITTO–CBD project (see Chapter 1) is to support local communities to engage in activities that improve their livelihoods while reducing their dependence on the resources of the ETPFC. Under the project, several subprojects, called "integrated conservation and development pilots" (ICDPs), were implemented in selected communities in Thailand to improve livelihoods while advancing conservation.

The Thailand government expected that each ICDP would lead to a reduction in poverty in the targeted communities, an increase in economic and social well-being, and the improved protection of ecosystems, with the active participation of people in the communities. The specific activities to be undertaken in each ICDP were to be determined through a participatory selection process.

More than 80 villages are situated within 3 km of the boundary of Thailand's PPFC, which is part of the ETPFC. The total population is estimated at about 89 000 individuals, the livelihoods of whom may affect biodiversity conservation and can often conflict with protected areas, such as through forest encroachment for unsustainable agriculture, raising cattle and buffaloes, and wildlife poaching. The main occupation of the majority of households in the area is agriculture, followed by fishing.

Certain initiatives in the project were aimed at strengthening local participation in the rehabilitation and conservation of natural resources by promoting environmentally friendly occupations. To support livelihood improvement, selected villages were allocated financial assistance to be used as a revolving fund for the start-up of pilot activities. Six promising ICDPs (Figure 7.1) were established during Phase 2 of the ITTO–CBD project from 2008 to 2010, as follows: one on the production of bamboo handicrafts; two projects to develop tourist homestays; one to create a food bank or fruit tree plantation; and two to propagate wild orchids using a micro-technique. In Phase 3 of the project (2012–2015), six new ICDPs and five other subprojects (Figure 7.2) were established: two for homestays and ecotourism; one to create an agroforestry food bank; one to produce bamboo handicrafts; two to propagate wild orchids using a micro-technique; three nurseries for seedling production; and two tissue-culture labs, including equipment (for micropropagation).

Livelihood improvement in the project area was an urgent need for several reasons, including increased population pressure; the expansion of cash-crop areas; the desire of people to improve their economic situations through tourism; infrastructure development; and, as a result of these, more encroachment into protected areas and a higher demand for forest products.

We expect that several community-based livelihood activities supported through the ICDPs, especially those associated with ecotourism and perhaps the domestication of wild flora and fauna, will be able to achieve self-sufficiency. Our intention is that success in the pilot areas will spread naturally to other communities, who will learn from local successes. The project team regularly monitors the status of livelihood activities and explores other potential sources of funding, including from the private sector through corporate social responsibility programmes, to help sustain activities until they become self-sufficient.

Objectives

The ICDPs aim to reduce dependency on natural resources; resolve conflicts; enhance local cooperation in transboundary conservation and management; and raise awareness of the negative effects that people can have on forests. Efforts to reduce dependency on natural resources and to resolve conflicts focus on: increasing the knowledge of local people so they can find sources of income that are less dependent on natural resources; promoting tree planting; allowing the seasonal collection of certain forest products for domestic consumption; and promoting sustainable agriculture and agroforestry in the buffer zones of the PPFC. The long-term management plan of the project defined the process of implementing ICDPs as follows:

- Organize meetings and workshops among park officials, the project team, local communities, local NGOs and ICDP members.
- Establish—and strengthen the capacity of—local community committees (called group management committees, described below) to oversee the implementation of ICDPs at the local level.
- Encourage and promote sustainable agriculture and agroforestry practices in the buffer zones.
- Develop regulations and criteria for ICDP selection and evaluation, as well as appropriate access to non-timber forest products.

Identifying promising ICDP projects

The project team encouraged group management committees to develop criteria and regulations for project selection and held discussions with stakeholders in local communities and officials of governmental community-development agencies to help identify promising ICDPs. Common subprojects chosen were as follows:

- *Bamboo handicrafts:* Villagers are encouraged to create bamboo furniture, rice containers and souvenir handicrafts. This ICDP increases the value of bamboo products and enables the development of various souvenirs for visitors.
- *Homestays for ecotourism:* Villagers are educated on tourism management. Many backpackers visit Thailand and seek inexpensive but clean local places to stay. Homestays in a unique environment are an ideal way to fill this need.
- *Homegardens and agroforestry:* The establishment of fruit-tree plantations provides income as well as food for local people. The project team worked closely with officials in the Department of Agricultural Extension to educate local people on growing fruit trees in suitable areas, and the project supported seedling production and fruit-tree plantation development.
- *Wild orchid micropropagation:* The project supported the propagation of wild orchids not listed as endangered species in community nurseries. It also trained local people to propagate ornamental tree species and seedlings for the market.

Production of brooms using tiger grass by the Ubon Ratchathani community in Thailand. Photo: Royal Forest Department/ITTO

Training on bamboo handicraft production provided under the ITTO–CBD project in Ubon Ratchathani, Thailand. Photo: Royal Forest Department/ITTO

Members of the Ubon Ratchathani community receive training on orchid production micro-techniques. Photo: Royal Forest Department/ITTO

A community nursery in Ubon Ratchathani, Thailand, for the production of forest and ornamental trees. Photo: Royal Forest Department/ITTO

Selection criteria for ICDPs

The selection criteria for the ICDPs were:

- Interest in working with the ITTO–CBD project.
- Indigenous knowledge on sustainable natural resource management (e.g. raising insects).
- The potential for community-based ecotourism.
- Experience in working with government agencies.
- The capacity of the activity to reduce forest pressure (e.g. the production of bamboo on farms would reduce the need to cut bamboo from protected forests).

The project team conducted several community needs assessments to obtain an up-to-date view of the situation and the development needs of the target communities. The team interviewed representatives of related agencies and local authorities to identify areas for possible collaboration in the development of livelihood improvement activities. The results of the community assessments and interviews were used in designing capacity-building training programmes and the selection of pilot villages. The beneficiaries were supported in various income-generating activities that contribute to conservation.

The development interventions of ICDPs

The selection process of pilot communities for ICDPs can be classified into three main sequential steps, as described below.

1) *Preliminary assessments of communities and review of relevant documents:* The preliminary assessments obtained up-to-date information on the local economic, social and environmental situation and in particular the development needs of target communities. This information was useful in designing and planning the ICDPs. Meetings with relevant partners helped stakeholders to better understand the project plan and objectives—a necessary first step in the participatory development approach.

   The team visited many villages during the assessments. The information obtained from interviews with responsible officers in administrative offices in target areas confirmed the level of interest of agencies and local authorities in cooperating in the development of alternative livelihood practices.

2) *The identification of potential villages and selection of pilot villages for ICDPs and pilot funds:* A taskforce comprising representatives of wildlife sanctuaries and national parks in the PPFC, and staff of the ITTO–CBD project, discussed the target village selection criteria and the selection process. The criteria used as guidelines for the selection of villages were:

   - The community should have indigenous and local knowledge, including knowledgeable persons, with respect to the management of natural resources and the environment.
   - The community should have been actively practising the rehabilitation and conservation of natural resources for some time.
   - Existing organizations should have strong roles in conducting natural resource and environmental management.
   - There should be potential for ecotourism and its management.
   - The community should be willing to exchange lessons learned with other communities (in the locality and in other regions, including internationally).
   - The community should be willing to collaborate with relevant agencies.

Discussions on village selection considered information on the potential and limitations of villages obtained in step 1. Factors of particular interest included the extent of destruction of the local bamboo resource base in communities with handicraft production; the potential for ecotourism (e.g. based on natural scenery or local ethnic cultures); and whether the quality of local products needed to be improved to meet tourist requirements while maintaining the uniqueness of local specialties.

The village selection process began by listing all potential villages proposed by the taskforce. Each proposed village had to be justified and the potential activities listed, for example whether it would be suitable for orchid propagation, homestay development, or integrated agriculture and handicraft development. It was important to conduct the selection process carefully because only limited grants could be made for the implementation of pilot activities. The superintendents of the wildlife sanctuaries and national parks were assigned as coordinators of the activities in the various target villages, arranged in zones.

Village community meetings were held in each target village to inform stakeholders of the results of the village selection process and to explain the purposes of the pilot funds. Villagers and village leaders were encouraged to prepare proposals for how the funds would be used. Also at these meetings, villagers elected the members of the group management committees.

3) *Capacity-building workshops for community members and relevant officers:* After the selection of the target villages, the ITTO–CBD project steering committee applied existing guidelines for community-based forest management funds prepared by the Office of Community Forest Management in the Royal Forest Department to each community request and in the establishment of the group management committees to be responsible for the management of granted funds at the village level.

Capacity-building workshops for community members and relevant officers were discussed and planned. The project supported and coordinated with local universities and resource persons to organize training courses on the following: ecotourism and homestays; handicraft improvement; bamboo plantation establishment, use and production; nursery techniques for fruit trees, ornamental trees and forest tree seedlings; micropropagation techniques for orchids and ornamental tree species; agroforestry techniques; edible insect domestication; and community forest establishment.

Results

Participatory monitoring and evaluation was conducted of the results of ICDP activities under Phase 2 of the ITTO–CBD project, coordinated by a consultant on participatory community development and tourism at Khon Kaen University. Workshops were convened in each village to educate stakeholders on using achievement indicators to evaluate the pilot activities. The monitoring system involved five levels of achievement:

0) Did not implement the activity/no activity in the plan

1) Did not achieve the planned output

2) Medium level of achievement

3) Good level of achievement

4) Very good or excellent level of achievement.

The following tables show the results of the evaluations performed by the various group management committees. Table 7.1 presents the evaluation of the general objective of the ITTO–CBD project, and Table 7.2 shows the evaluation results for specific activities and purposes of each target group.

Figure 7.1: Location of ICDPs in Thailand as part of Phase 2 of the ITTO–CBD project

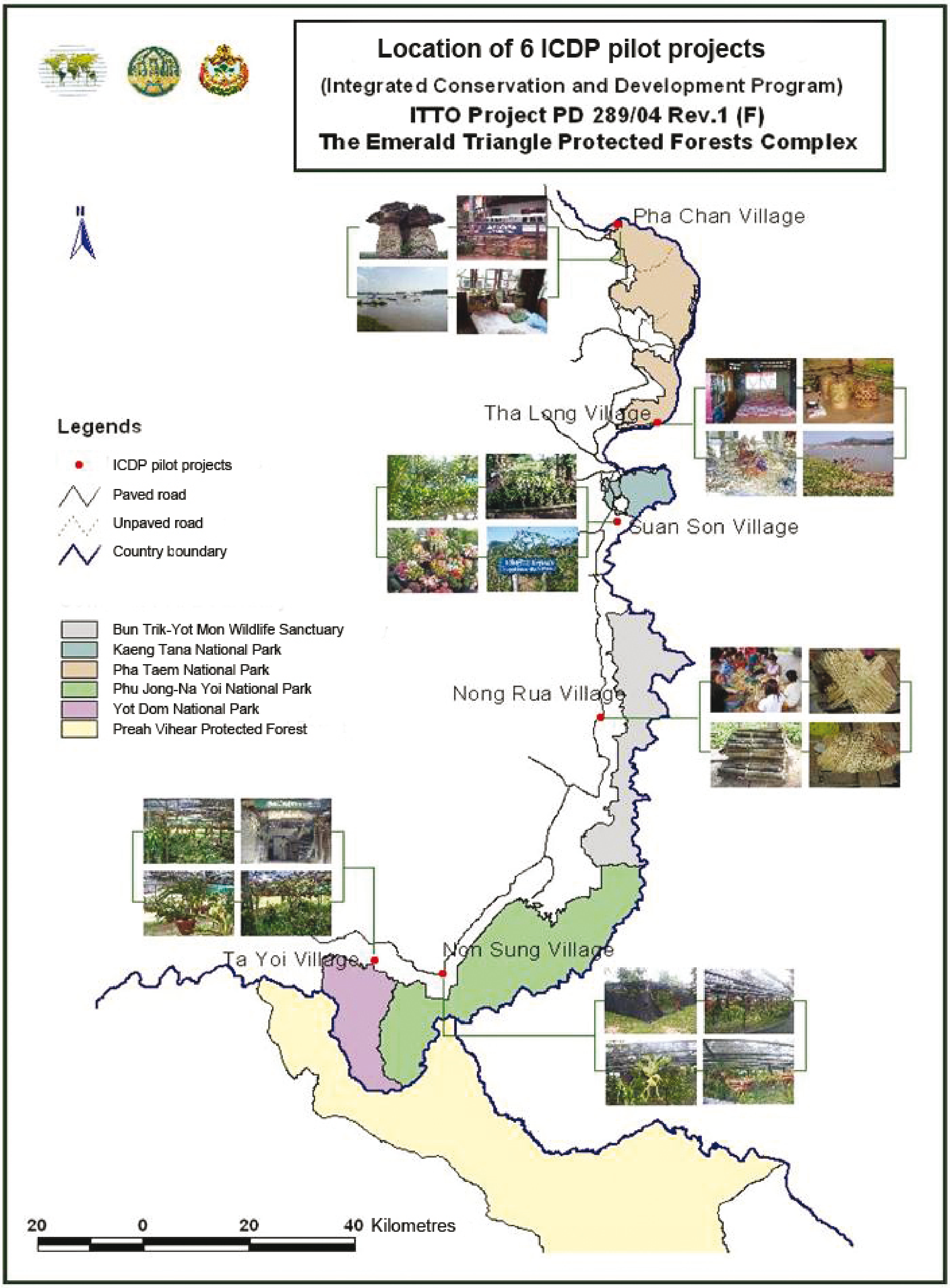

Figure 7.2: Location of ICDPs in Phase 3 of the ITTO–CBD project

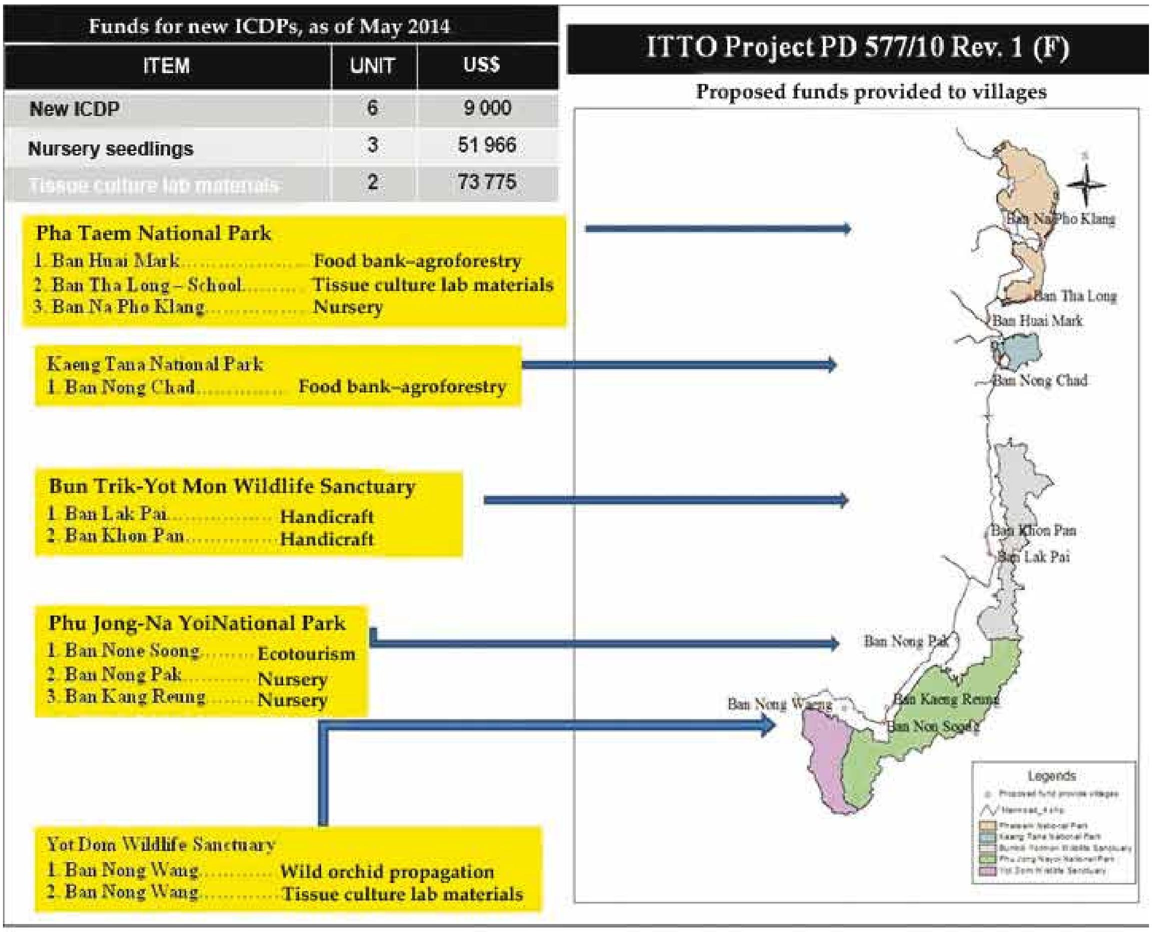

Table 7.1: Achievement indicators for general project purposes

Indicators	Average score*
Objective 1: To strengthen cooperation between communities and related officers in the development of community livelihoods	
Members and stakeholders of target group	
• Members composed of males and females from different age groups and with diverse socioeconomic status	3.2
• There are more new members	3.0
• Stakeholders participate actively in group activities	2.8
Level of community participation	
• Understanding the project's task and target activity	3.0
• Involvement in development planning of the target activity	2.7
• Participation in conducting the planned activities	3.3
• Involvement in monitoring and evaluation of target activity	2.5
• Sharing benefits or gains from implementation of the target activity	3.2
Wider coverage of cooperation	
• Cooperation with other groups within the community	2.7
• Cooperation with other groups outside the community	2.5
• Initiation of new development activities	2.7
Objective 2: Conservation of forest resources	
Decreased use of forest resources	2.7
More efficient use of resources	3.4
Implement natural resource conservation and rehabilitation activities	
• Planning	3.3
• Formation of regulations and agreement	2.8
• Implementation of planned conservation and rehabilitation activities	3.0
• Documentation of knowledge and lessons learned	2.3
• Monitoring and evaluation of success and constraints	2.7
Objective 3: Strengthening the community's capability in natural resource management	
Benefits gain by individual members	
• Income increase	2.5
• Reduction of expenses	1.7
• More knowledge gained	1.7
• Individual members take note of personal data	3.2
Capability of target group	
• Clear management and administration structure	3.2
• Regulations and agreements are formulated	2.5
• Group work plan is prepared	2.8
• Higher capital	2.7
• Monitoring and reporting system is in place	2.7
• There is a knowledge management system	3.0
• Members participate actively in group activities	3.2
Network	
• Existence of more experienced members capable of knowledge dissemination	2.8
• More participation of children and youths in target activity	3.0
• More youths learn about local wisdom	2.7
• There is more support from external sources	2.5

*Note: * lowest possible score = 0; maximum possible score = 4.*

Table 7.2: Achievement indicators for each target activity

Indicators	**Average score***
Homestay for ecotourism ***Specific objectives:*** 1) To enable the tourists to learn about the local way of life, local traditions and villagers' beliefs, as well as natural resource conservation practices 2) Villagers and local authorities perceive the importance of local wisdom, local culture and natural resources	
Human resources	
• Villagers are trained to work as local tour guides	2
• Local wisdom is conserved and transferred to youth	3
• There are more young handicraft producers	1
• Rural way of life can be observed: i.e. fishing methods, food preparation techniques, speaking language, and traditional shows	4
Natural resources	
• "Sang pa bamboo" (a bamboo species suitable for basket-making) conservation activity is initiated	3
Management of target activity	
• Tourist routes and necessary information is developed	2
• Tourist statistics are collected; number of tourists and their habits: i.e. accommodation, purchasing of souvenirs	3
• The handicraft production group is managed more systematically	2
• Home stay activity is properly managed	3
Homegardens–agroforestry ***Specific objective:*** To establish community learning plots of homegardens–agroforestry or to grow at home what the people used to collect from the forest	
Human resource development	
• There are more knowledgeable person/resource persons working as local tour guides	3
Natural resources	
• More homegardens and agroforestry plots in the community	3
• Decreased dependency on forest resources	3
Management of target activity	
• There are learning plots of homegardens–agroforestry in the communities	4
• Clear design of homegardens–agroforestry plots by group members	3
• Data on homegardens–agroforestry are documented	3
• Better public relations and appropriate media for dissemination of group knowledge are produced	3
• Availability of community market selling local products	3
Handicrafts from bamboo ***Specific objective:*** To conserve and rehabilitate "pung bamboo" (a local bamboo good for basket-making)	
Human resource development	
• There are more villagers who have better knowledge and capable in teaching on pung bamboo-growing	3
• More young people can produce bamboo baskets	3
• Consumers understand the status and importance of pung bamboo conservation	3
Natural resources	
• A monitoring system is in place to check the origin of pung bamboo (the cutting of pung bamboo from forest will eventually decrease)	4
• Bamboo seedling plots are arranged	3
• More pung bamboo is grown	2
Management of target activity	
• Knowledge on pung bamboo-growing is documented	1
• A properly managed plot of pung bamboo is in place	3
Wild orchid micro-technique propagation ***Specific objectives:*** 1) Conservation of wild orchids via tissue culture technique 2) Less wild orchid collecting from forests for trade 3) Establishment of wild orchid tissue culture centre for education	
Human resource development	
• There are group members who can provide knowledge on tissue culture	3
• The knowledge is transferred to the younger generation, especially school children	3
• More wild orchids are produced by various techniques (local knowledge is also applied)	3

Indicators	Average score*
Natural resources	
• Activity to return orchids to the forest is conducted	3
• Learning centre for wild orchids is built	3
• A tissue culture centre is built	3
Management of target activity	
• Monitoring system is in place	3
• Public relation on wild orchid protection	4
• List of wild orchids are documented	0
• Regulations within group are formulated	3
• Collection of wild orchid species	3

*Note: * lowest possible score = 0; maximum possible score = 4.*

Results and discussion

Community members actively participated and showed an interest in the ICDP evaluations. As a result of the workshops, group management committee members understood more about the achievement indicators and how these could be used as a tool for group development. Members were honest in evaluating their projects using the indicators. Some indicators received zero weight and very few indicators received full weight—because community members saw that the group management committees were at an early stage. Assessments made through the indicators suggested that, although most activities had been conducted according to the plan, the quality of the outcomes was not yet adequate. In particular, the documentation of lessons learned, the use of indigenous knowledge, and the publication of knowledge had been insufficient relative to targets. The latter outcome may not be within the capability of senior members of committees; nevertheless, those senior members saw that it was important and were willing to improve this aspect in future with assistance from younger members and knowledgeable persons in their villages.

Some activities, such as wild-orchid tissue culture, increased bamboo-growing, and the expansion of homegardens and agroforestry plots, required more time before the objective of reducing and eliminating dependence on forest resources could be achieved. It was clear that the selected villages became better known as a result of the activities. Closer coordination among nearby villages and with local authorities and related agencies is crucial for receiving and disseminating information and acquiring support for capacity building. The pilot villages have all made substantial progress in a short time, but continuous support is still needed before sustainability is achieved.

Assessing the impacts of ICDPs

A master's student in the Faculty of Forestry at Kasetsart University undertook research into the impacts of ICDPs during the project's Phase 3 (Maneethong 2015) with the aims of assessing the impacts of ICDPs on the economic, social and environment conditions of participating villages and comparing conditions of participating villages with those in non-participating villages.

The research classified the population into two groups. The first consisted of the six ICDP-participating villages, with 280 households, and the second comprised ten non-participating villages, with 330 households. The non-participating villages were located within a radius of 5 km of the participating villages. A simple raffle random sample was used to determine the sample size. It should be noted that not all communities or households participated in the same ICDP activities (i.e. orchid culture, homestay development, integrated agriculture and handicraft development). The research selected three key overarching attributes to represent the impacts of ICDP activities: 1) annual household income to represent economic condition; 2) participation in conservation activities (5 indicators) and natural resource management activities (2 indicators) to represent social condition; and 3) the use of natural resources (wood and non-wood) (1 + 8 indicators) to represent environmental condition. The means of these indicators between participating villages and non-participating villages were analyzed using *t*-tests (Table 7.3).

The results revealed that the net annual income of households in participating villages (total income = 72 490.15 baht per year) was significantly higher than annual net income in non-participating villages (Table 7.3). The increased income partly obtained from higher prices for value-added handicraft products and partly from the extra income generated from other ICDP activities. The levels of participation in reforestation, forest fire prevention in protected areas and awareness-raising meetings with protected-area staff were significantly different between participating and non-participating villages. The non-participating villages, however, were more involved in reforestation compared with participating villages because they are located outside protected areas and close to reforestation areas.

Participating villages harvested fewer bamboo poles, edible insects and bush meat (wild animals) than non-participating villages, possibly as a result of awareness-raising activities and participation in field work and other conservation activities provided by the ITTO–CBD project. The quantity of rattan, medicinal plants and herbs obtained from forest areas was statistically higher for participating villages than for non-participating villages, partly because participating villages are situated either inside or closer to protected areas where such non-wood forest products exist. Villagers were less concerned about this issue than they were about the negative effects of wildlife poaching.

Table 7.3: Results of t-test analysis comparing incomes and participation in conservation activities between ICDP-participating and non-participating households

Household	n*	Mean	Standard deviation	t-test		
				t	Degrees of freedom	Significance (2-tails)
Net income (baht)						
Participating villages	280	72 490.15	51 869.60	3.68	608	**0.010**
Non-participating villages	330	3 738.87	5 755.13			
Participation of households in conservation activities						
Natural resources training workshop						
• Participating villages	152	2.41	0.67	-0.193	306	0.847
• Non-participating villages	156	2.42				
Reforestation						
Participating villages	266	2.49	0.67	-2.591	421	**0.010****
Non-participating villages	157	3.12				
Fire prevention in protected areas						
Participating villages	266	2.42	0.55	3.893	421	**< 0.001****
Non-participating villages	157	2.17				
Establishment of fire line in protected areas						
Participating villages	265	2.52	0.59	0.823	429	0.411
Non-participating villages	166	2.46				
Raising awareness meeting with protected areas staff						
Participating villages	266	2.48	0.54	3.800	582	**< 0.001****
Non-participating villages	318	2.28				
Participation of households in natural resource management						
Planning						
Participating villages	266	2.49	0.55	2.160	587	0.310
Non-participating villages	323	2.38	0.65			
Field work						
Participating villages	266	2.54	0.58	2.393	585	**0.017****
Non-participating villages	321	2.43	0.55			
Use of natural resources						
Edible vegetation and wild fruit (kg)						
Participating villages	195	14.85	63.30	0.696	390	0.487
Non-participating villages	197	11.67	9.15			
Bamboo (poles)						
Participating villages	142	8.95	9.23	-3.669	223	**< 0.001****

Household	n*	Mean	Standard deviation	t-test		
				t	Degrees of freedom	Significance (2-tails)
Non-participating villages	83	15.99	19.42			
Bamboo shoot (kg)						
Participating villages	128	71.44	180.88	0.767	363	0.500
Non-participating villages	237	62.83	56.21			
Rattan						
Participating villages	112	51.21	44.54	1.923	132	**0.050****
Non-participating villages	22	32.41	23.83			
Mushroom (kg)						
Participating villages	116	36.42	47.58	0.200	364	0.842
Non-participating villages	150	35.56	32.95			
Medical wild plants and herbs (kg)						
Participating villages	47	17.81	22.67	2.838	93	**0.006****
Non-participating villages	48	6.88	13.94			
Edible insects (kg)						
Participating villages	57	4.67	5.45	-4.674	162	**< 0.001****
Non-participating villages	107	17.60	20.47			
Wild animals						
Participating villages	80	11.28	24.83	-4.348	36.75	**< 0.001****
Non-participating villages	21	34.28	20.63			
Firewood/charcoal						
Participating villages	93	149.02	301.74	1.024	187	0.307
Non-participating villages	96	111.82	185.77			

*Notes: * n = total number of observations;*
*** significant difference at 0.05.*

Conclusion

Integrated activities for conservation and development in the ETPFC increased incomes in participating communities, improved conservation outcomes and the use of forest resources such as bamboo, rattan, wood, medicinal plants, edible insects and wildlife, and increased knowledge of forest conservation compared with communities that did not participate in such activities. Integrated conservation and development activities helped strengthen the capacity of participating communities to develop a higher standard of living, with extra income, and simultaneously reduce their use of forest resources.

To strengthen ongoing ICDP activities and expand them to neighbouring communities, both in Thailand and the other ETPFC countries, the following recommendations—derived from meetings with participating communities and stakeholders—are made:

- Some pilot villages have more potential than others for development within the PPFC. Some villages, therefore, require additional support to increase their capacity for sustainable development, such as training in the skills needed for knowledge transfer.
- Project duration for different pilot activities should be considered in the funding formula. For example, wild orchid tissue culture and ecotourism management, which comprise very different activities, both require more than a one-year development period.
- Emphasis should be placed on community development through a clustered approach to the expansion of cooperation among existing groups, neighbouring communities, and other networking organizations. The project should encourage and support the exchange of lessons learned and development experiences between groups doing similar activities.
- The development approach of providing financial support for pilot activities is an effective tool for reducing local community impacts on protected areas. To make it more

useful and suitable for groups and communities with varying circumstances, the criteria for target group selection and grant amounts should be flexible and open not only to requests from single villages but also to requests from clusters of villages and networks of organizations.

- Pilot groups should be assisted to establish practical systems for accumulating knowledge, which is an important capability for self-adjustment in response to rapid socioeconomic transformation. The information gained can be disseminated to other communities in the PPFC and the wider public.

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8 PRELIMINARY MEASURES OF CARBON BIOMASS STOCKS IN THE PREAH VIHEAR PROTECTED FOREST, CAMBODIA

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The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2014) indicates a warming of 0.85 °C (0.65–1.06 °C) in the period 1880–2012 in the globally averaged combined land and ocean surface temperature calculated using a linear trend. Evidence is mounting that this increase in temperature is at least partially attributable to human-induced activities such as the burning of fossil fuels, the expanded and unsustainable use of natural resources, and the clearing of forests for agricultural crops and cattle ranching (IPCC 2014).

Tropical forests covered 1.77 billion hectares of the Earth's surface in 2014, or about 44% of the total area of forests worldwide (FAO 2015), and they constitute a significant carbon reservoir. An assessment by Saatchi et al. (2011) indicated that tropical forest biomass contained 247 gigatonnes (Gt) of carbon in live biomass, of which 193 Gt, or almost 80% of that total, is stored above ground (Chaturvedi et al. 2011). Pan et al. (2011) estimated the total carbon stored in the live biomass of tropical forests (above and below ground) at 264 ± 52 Gt.

The large volume of carbon estimated to be stored in tropical forests, coupled with increasing concern about human-induced climate change, underpin the significance of observations of tropical deforestation. The estimated annual rate of deforestation worldwide was 10–13 million hectares between 2000 and 2010, although that was less than the estimated annual rate of 16 million hectares in the previous decade (FAO 2010, 2015). Globally, an estimated 0.1 petagrams per year of carbon is emitted into the atmosphere due to land-use change in tropical forests (accounting for reforestation) (Pan et al. 2011). In Cambodia, the average annual rate of deforestation was 0.5% between 2002 and 2010 in a period of accelerated economic growth driven in part by the development of large-scale agroindustrial plantations (Forestry Administration 2011).

The maintenance and enhancement of Cambodia's tropical forest biomass carbon stocks are regarded as effective measures for the mitigation of climate change. This is especially the case in the evolving United Nations Framework Convention on Climate Change (UNFCCC) REDD+[1] mechanism, which includes "supporting forest conservation, strengthening the sustainable management of forests, and enhancing forest carbon stocks". The application of REDD+ in the PVPF could provide a source of financing for sustainable forest management strategies that recognize the importance of local livelihoods and deliver significant biodiversity conservation benefits. The realization of REDD+ in the PVPF could provide a model for all three countries participating in the ITTO–CBD project.

Our primary purpose for initiating this study was to establish preliminary estimates of carbon biomass stocks in the evergreen, semi-evergreen and deciduous forest types of the PVPF before a more extensive assessment of the practicability of applying REDD+ in the PVPF. The carbon pools incorporated into our measures were above-ground and below-ground live biomass, which accounts for 56% of the total stored carbon in tropical forests (Pan et al. 2011).

Methods

Study area

The PVPF was established under Royal Government of Cambodia Sub-decree No. 76 of 30 July 2002 as the Preah Vihear Protected Forest for Forest and Wildlife Genetic Resources Conservation. It is located in the northern part

1 REDD+ is the term used to refer to the efforts of countries to reduce greenhouse gas emissions from deforestation and forest degradation and to enhance forest carbon stocks through forest conservation and the sustainable management of forests.

Figure 8.1: Location of the PVPF

of the country and includes parts of two districts, Chhep and Choam Ksan. The PVPF borders Thailand and Lao PDR in the north and west; Kampong Sralou Mouy and Chhep Pi communes in Chhep district in the southeast; the suspended Chendar Plywood forest concession area in the south; and the Chom Ksan and Toeuk Kraham communes in Choam Ksan district in the southwest (Figure 8.1). The PVPF constitutes an important part of the Indo-Burma Biodiversity Hotspot, which is one of 25 such global hotspots worldwide (Myers et al. 2000). The area is crucial for the conservation of several species of endangered large mammals, including the Asian elephant, banteng and gaur. It also provides important habitat for other endangered, vulnerable and near-threatened mammals, including the dhole, fishing cat, Siamese Eld's deer, sambar and leopard. The PVPF supports the largest global breeding population of the critically endangered giant ibis and is an important nesting site, as well as habitat, for other large bird species, including the green peafowl, white-winged duck, white-shouldered ibis, greater adjutant stork, sarus crane and lesser adjutant stork (see Chapter 4 for more information on wildlife species in the PVPF).[2]

The PVPF contained 181 501 hectares of forest in 2010 (Forestry Administration 2011), which was nearly 96% of the total area of the reserve (Table 8.1). The PVPF has seasonal monsoons and a total annual rainfall of 1500 mm. The dominant forest type is deciduous forest, accounting for 66% of the total land area in 2010 (Table 8.1). Assessments conducted by Cambodia's Forestry Administration, which have classified the PVPF into several land-cover categories, indicate that the areas of deciduous forest and semi-evergreen forest (which, combined, account for 75% of total forest cover in the PVPF) decreased between 2002 and 2006 and again from 2006 to 2010; conversely, the area of non-forest land increased, particularly from 2002 to 2006.

Sampling procedure

The sampling area in the central portion of the PVPF was stratified by forest type, and plot locations in each of those forest types were assigned by the random selection of GPS coordinates (Figure 8.2). Thirty-three 30 x 30 m plots were established, comprising 12 in evergreen, eleven in semi-evergreen and ten in deciduous forests. The number of plots selected for sampling in each forest type was based on estimates of sample size using the Winrock Terrestrial Sampling Calculator (Walker et al. 2012). That calculator automated the estimation of the required number of sample plots based on previous estimates of the means and

2 Table 1.2 provides the scientific names and conservation status of these and other fauna species.

standard deviations of carbon stocks in evergreen, semi-evergreen and deciduous forest types and the confidence and error levels specified (90% and 10%, respectively, in this study), and it allocated those plots to each of the three forest types. Each sample plot was subdivided into quadrats at 10 m gridline intervals to facilitate tree measurement in each plot. It was not possible to establish plots in every part of the area because sampling was constrained by access.

Permanent plots were demarcated by concrete stakes in each corner to maintain stability with reference to soil movement, wind, animal activities and forest fire. The GPS position of each stake was recorded to facilitate the marking of the points on Lidar images. In each plot, all live trees with diameter at breast height (dbh) ≥ 5 cm were measured using diameter tapes; dead trees were not measured. The methodology used for carbon stock sampling was based on protocols established by Walker et al. (2012), which provide standard operating procedures for selecting sampling design, establishing sample plots, and measuring trees and other sources of carbon to estimate the carbon stored in the various organic pools in the forest landscape.

Data analysis

General allometric equations for moist tropical forests and tropical forests (Table 8.2) were used to convert dbh measurements to estimates of the above-ground (moist tropical forests) and below-ground (tropical forests) biomass of each live tree. It was assumed that the carbon content of a tree was 50% of its biomass (Brown 1997). We also determined average above-ground and below-ground biomass values for each forest type.

Results

Table 8.3 presents estimates of above-ground and below-ground biomass carbon stocks associated with the measurement of 3149 live trees in 33 sample plots in the PVPF for evergreen, semi-evergreen and deciduous forests. The column on the far right of Table 8.3 displays the estimates used to determine the numbers of plots to be sampled and other reported biomass carbon stocks in the same forest types in Cambodia.

Discussion

Our estimates of carbon in live biomass in evergreen and semi-evergreen forests in the PVPF were similar to those for forests elsewhere in Cambodia; they represent the carbon biomass in mature unlogged forests of those two forest types. That argument is especially meaningful if differences in carbon stocks in the evergreen forest reported by Sasaki et al. (2016) are attributable to dissimilarities associated with the unspecified division between logged and unlogged forest sample plots.

Estimates for deciduous forests, which account for two-thirds of the forests in the PVPF, were, however, considerably lower than equivalent estimates reported by both Kapos et al. (2010) and Sasaki et al. (2016). The extent to which these lower estimates were due to the random selection of logged sampling sites in deciduous forests in the PVPF, a lower tree density in the PVPF deciduous type than elsewhere in Cambodia, or the use of inappropriate allometric equations for moist tropical forests and tropical deciduous forests, is uncertain. The preliminary results of student researchers supported by the ITTO–CBD project

Table 8.1: Change in forest area, by type, PVPF, 2002–2010

Forest type	2002		2006		2010	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Deciduous forest	130 949	68.91	127 196	66.94	125 004	65.78
Evergreen forest	33 586	17.68	35 709	18.79	35 674	18.77
Semi-evergreen forest	18 512	9.74	18 231	9.59	18 189	9.57
Wood and shrubland–dry	1 714	0.90	438	0.23	350	0.18
Wood and shrubland–evergreen	65	0.03	0	0.00	0	0.00
Other forest	2 456	1.29	2 257	1.19	2 284	1.20
Total forest land	**187 282**	**98.55**	**183 831**	**96.74**	**181 501**	**95.5**
Non-forest	2 738	1.44	6 190	3.26	8 519	4.48
Total	**190 020**	**100**	**190 020**	**100**	**190 020**	**100**

Table 8.2: Allometric equations used to estimate above-ground and below-ground biomass of trees in evergreen, semi-evergreen and deciduous forests in the PVPF

Equation	Forest type	Source
AGB = 42.69-12.800(dbh)+1.242(dbh2)	Moist tropical forest	Brown et al. 1989
BGB = e (-1.0587+0.8836*ln(AGB))	Tropical forest	Cairns et al. 1997

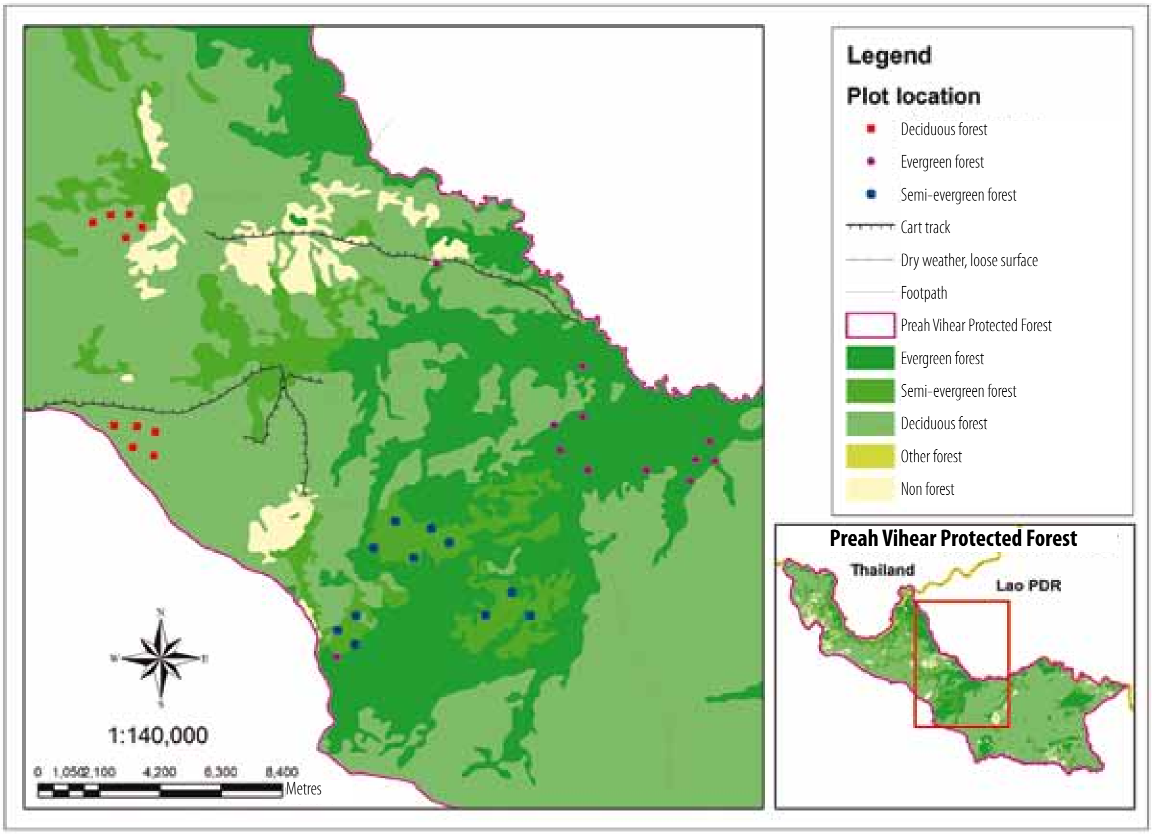
Notes: AGB = above-ground biomass in kg; dbh = diameter at breast height in cm; BGB = below-ground biomass in kg.

Table 8.3: Number of plots and estimated carbon stocks in above- and below-ground biomass in evergreen, semi-evergreen and deciduous forests in the PVPF, and comparison of reported biomass carbon stocks in evergreen, semi-evergreen and deciduous forests in Cambodia

Forest-cover type	No. of plots	No. of trees measured	Carbon stocks (t/ha)		Total live biomass carbon (t/ha)	Live carbon biomass estimates for Cambodia (t/ha)
			Below ground	Above ground		
Evergreen	12	1454	26.21	172.82	199.02 ± 37.83	191–211 ± 90[a] 124.0 ± 22.1[b]
Semi-evergreen	11	957	18.94	119.08	138.02 ±33.65	161–178 ± 93[a] 127.9 ± 3.6[b]
Deciduous	10	738	8.97	54.51	63.48 ± 11.23	114–126 ± 27[a] 123.0 ± 14.0[b]

Notes: t = metric tonnes; [a] estimates of biomass carbon stocks in Cambodia reported in Kapos et al. (2010); [b] estimates of above-ground and below-ground biomass carbon stocks reported by Sasaki et al. (2016).

Figure 8.2: The location of sample plots in the PVPF



estimate the above-ground biomass carbon stock at 80.24–99.30 tonnes per hectare in the deciduous forest type in the PVPF; this is higher than the 54.51 tonnes per hectare estimated in this study but still lower than the estimates of Kapos et al. (2010) and Sasaki et al. (2016).

The wide range of estimates of biomass carbon stocks in deciduous forests indicates the need for further sampling to increase accuracy and thereby provide a more inclusive and accurate evaluation of the potential carbon storage to be gained from REDD+ activities in the PVPF. Deciduous forest is the most abundant forest type in the PVPF and it is especially important, therefore, to obtain reliable estimates of biomass carbon stocks in that forest type. Such a study would entail a more extensive survey of biomass, stratified for tree density and height, as well as the development of allometric equations incorporating tree heights that are specific to deciduous tree species in the PVPF.

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9 SUMMARY OF ACCOMPLISHMENTS AND LESSONS LEARNED IN THE MANAGEMENT OF THE EMERALD TRIANGLE TRANSBOUNDARY PROTECTED FORESTS COMPLEX, 2000–2016

Ian D. Thompson, Kamol Wisupakan, Yongyut Trisurat, Chheang Dany, Dennis J. Cengel and Hwan-Ok Ma

This chapter summarizes the achievements and provides an understanding of the lessons learned over the course of the ITTO–CBD project. Although the chapter is not intended to be a project evaluation, some aspects of an assessment are inevitable. For the many reasons noted in Chapter 1, transboundary conservation is difficult to accomplish, even under the most favourable conditions. Each transboundary conservation initiative has a unique set of prevailing circumstances affecting the level of cooperation that can be achieved and, ultimately, the success of efforts to conserve ecosystems. Sixteen years after it began, the ITTO–CBD project has proved similar in various respects to other transboundary projects: it has had recognizable successes, but key aspects of the project objectives are still outstanding and more work remains to be done to achieve complete success. There have been advances in understanding of the ecosystems and some individual species in the area, and there is a commitment to continue working to achieve the original objectives, as well as to cooperate in developing a proposal for a (final) Phase 4. As with other internationally funded projects, a significant concern is the sustainability of conservation efforts after the ITTO–CBD project has finished.

The ETPFC, which traverses the borders of Cambodia, Lao PDR and Thailand, is one of the most important biodiversity conservation landscapes in Southeast Asia, particularly the Greater Mekong Subregion. The intact block of forests and other ecosystems in the trinational border area is recognized as globally outstanding for biodiversity conservation; it provides important habitats for the large vertebrates of the Greater Mekong Subregion. As in any transboundary protected area, an understanding of the recent history of the area is important for understanding the context of conservation objectives, difficulties and accomplishments. Until well into the 1990s and even as recently as 2011, there were civil and international conflicts in the area, especially during the Khmer Rouge regime and the Vietnamese occupation of Cambodia, as well as intermittent border disputes among all countries. Recent insecurity and strife, therefore, have characterized much of the area. Conservation was neither a priority nor a practical option in the area until the early 2000s, and mistrust and disagreements over borders continue at the highest governmental levels. The PVPF, for example, was established as recently as 2002 after a protracted period of civil unrest and forest mismanagement by remaining elements of the Khmer Rouge and as a result of the government's resettlement policy, and much of the border area still needs to be de-mined. Conservation in the area, therefore, has a relatively brief history. The value of the ITTO–CBD project and other conservation programmes in the Emerald Triangle landscape has been immense in terms of advancing forest management and biodiversity protection. Nevertheless, there are still competing visions for the area, including a development agenda that, although somewhat dormant, is nevertheless a consideration among senior government officials, especially in Cambodia.

Most activities of the ITTO–CBD project have been undertaken in the PPFC in Thailand and the PVPF in Cambodia. Despite efforts to have Lao PDR formally join the project, the government in that country has been reluctant to become an ITTO member and so has not yet contributed officially to the project. A memorandum of understanding between Champasak University (Lao PDR) and Kasetsart University (Thailand) has enabled some wildlife assessments to be undertaken in two separate areas as part of the project, and faculty and students from Champasak University attended some joint project meetings and participated in training activities during Phase 3. Moreover, a letter of cooperation between these two universities and the Royal University of Agriculture in Cambodia to increase joint research activities was signed on 24 July 2015. The DKPPA in Lao PDR is important for ensuring that the ETPFC maintains a sufficiently large area for biodiversity conservation. Including it in the ETPFC would connect the PPFC and PVPF and ensure a large intact forest area with sufficient habitat and area to support landscape connectivity for animal migrations.

The following sections summarize results for each of the project initiatives and lessons learned. These are followed by a discussion of transboundary conservation in the area and the important issues affecting the project's longer-term outcomes.

Research programme results

Land-use forecasting in the ETPFC

The LU/LC assessment for 2003–2030 (Chapter 2) indicated that dry dipterocarp forest is threatened in the ETPFC and surrounding areas. Approximately 30% of its extent has already been converted to agriculture and rubber plantations, primarily in the buffer zones around the PPFC in Thailand. Population growth and an economic transition in the region due to the ASEAN Economic Community scheme were identified as the key driving factors transforming land-use patterns by 2030.

Under the "sustainable poverty and stable resources" scenario, there would be a small expansion of rubber plantations and cultivated land by 2030, and protected forest areas would be secured from future land-use change (Figure 9.1). Limited deforestation in the buffer zones of the PPFC and in Lao PDR was forecast to occur under the "low economic decline and localized resource degradation" ("business as usual") scenario. The "unsustainable economic development and serious resource degradation" scenario indicated a larger extent of new cultivated land and rubber plantations. In the PVPF, substantial conversion of dry dipterocarp forest is projected to occur due to the establishment of social land concessions for military families and infrastructure development to increase regional connectivity. Based on projections of a continued decline in real rubber prices due to oversupply and a stable economy, the "low economic decline and localized resource degradation" scenario is considered most likely to occur.

Wildlife monitoring in the Emerald Triangle and Dong Khanthung Provincial Protected Forest

The Emerald Triangle, including the PVPF, the PPFC, the Phou Xiang Thong National Protected Area and the DKPPA, has high species richness for vertebrates, with at least 596 species, comprising 96 mammals, 288 birds, 81 reptiles, 30 amphibians and at least 101 freshwater fish species. Some key wildlife species have been extirpated from the ETPFC, however, and others are at high risk of extinction, including the Asian elephant, banteng, Siamese Eld's deer, sarus crane, giant ibis and Siamese crocodile (chapters 3–5).[1] Threats to wildlife in these areas include wildlife poaching and commercial wildlife trade; the collection of non-timber forest products; land encroachment inside and near the reserves; the illegal harvesting of logs (especially rosewood and other high-value wood species); livestock-raising in reserves; and landmines. Unregulated development is an additional threat, especially in corridor areas that would hinder animal movements and thereby fragment wildlife populations. Minimizing these threats will be important objectives if Cambodia, Lao PDR and Thailand are to protect their transboundary wildlife in the future.

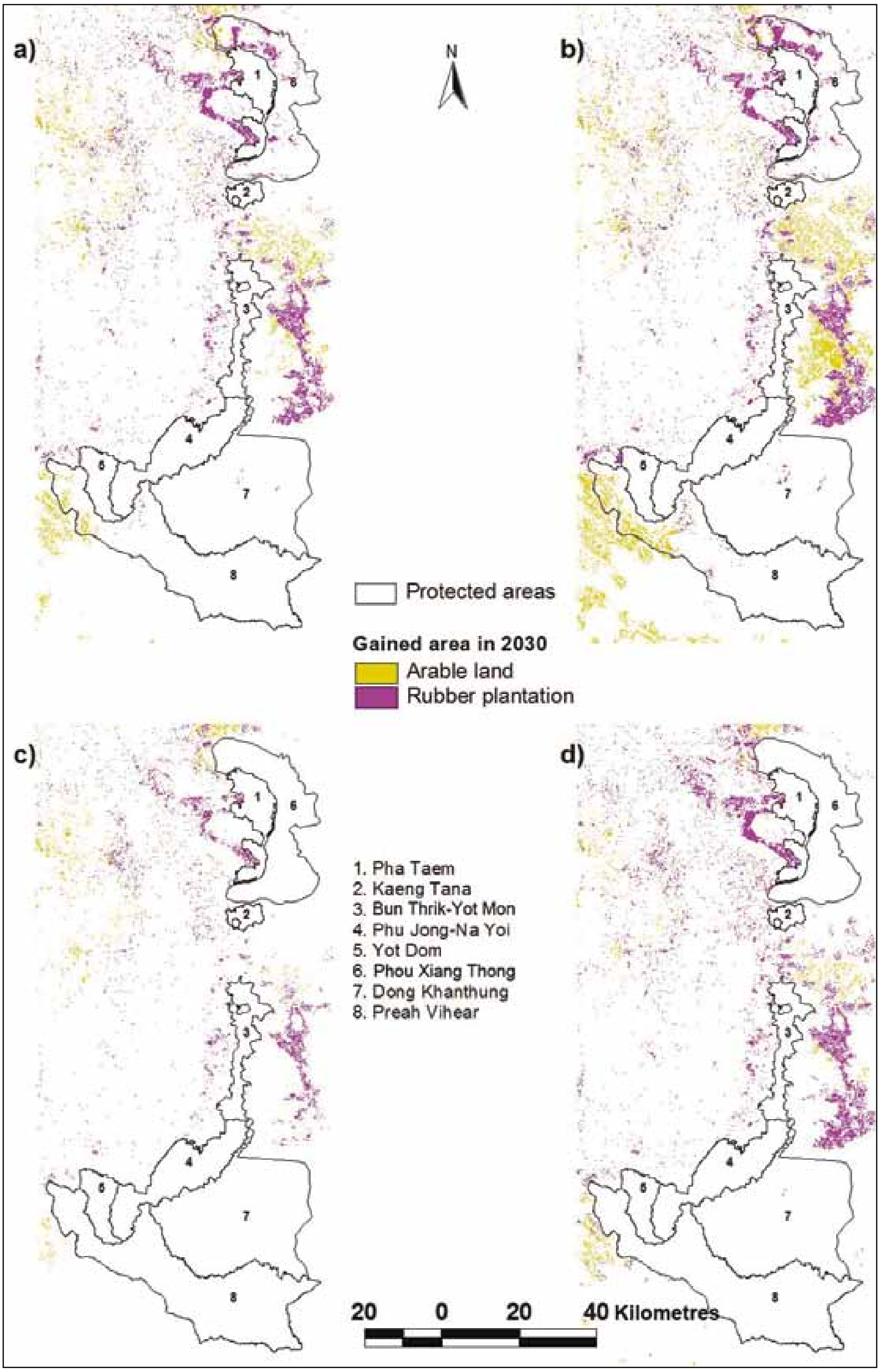
Elephant populations continue to be fragmented and are now separated into three subpopulations: a comparatively large population of 40–50 animals in the Bun Thrik-Yot Mon Wildlife Sanctuary in Thailand and in protection forest and rice paddies in Maung Soukhouma in Lao PDR, and two small populations of three individuals in the DKPPA and five individuals in the PVPF. A future consideration will be to enable connectivity to support wild elephant movements further south to the DKPPA and the PVPF. As it is now, the large population cannot move south from the Lao Border Protection Forest, where the elephants driven back to Thailand to protect against crop raids in Champasak Province in Lao PDR.

Species distribution modelling in the ETPFC

Twelve of 14 landscape wildlife species common to the three countries of the ETPFC were selected for habitat modelling in the ETPFC landscape

1 Table 1.2 provides the scientific names and conservation status of these and other fauna species.

Figure 9.1: Forecast forest change as a result of various land-use scenarios in 2030



Notes: [a] business as usual; [b] unsustainable economic development; [c] sustainable poverty; [d] sustainable development.

at present and into the future, on the basis of assumptions of projected land-use change and climate change (Chapter 6). Future light-to-moderate land-use change will generate only slight impacts on the distributions of the selected species because most of the remaining suitable habitats are in protected areas, while deforestation will most likely occur in the associated buffer zones, especially those in Thailand. In contrast, under the unsustainable land-use scenario in combination with future climate change, severe impacts are forecast for most selected species, except for some of the grazing ungulates that use open habitats. Severe impacts are predicted for large waterbird species due to the degradation of wetland habitats arising from future climate change.

Figure 9.2 shows that modelling classified approximately 45% of the ETPFC as unsuitable for any selected species under all future land-use scenarios because of deforestation. When projected climate-change conditions are added to the model, the predicted non-habitat class increases to 50–55% of the ETPFC. High species richness was maintained only in the protected interior border areas between the PVPF (except in the western part) and the DKPPA. Most areas in the PVPF, the central and eastern parts of the DKPPA, and the Phu Jong-Na Yoi National Park were classified as supporting moderate species richness. Remaining areas in the PVPF, Yot Dom, Bun Thrik-Yot Mon and part of Phou Xiang Thong were indicated to support low richness for the selected species, now and in the future. The Pha Taem and Kaeng Tana national parks were categorized entirely as non-habitats for all 12 species because of heavy human pressure (Bhumpakphan 2015).

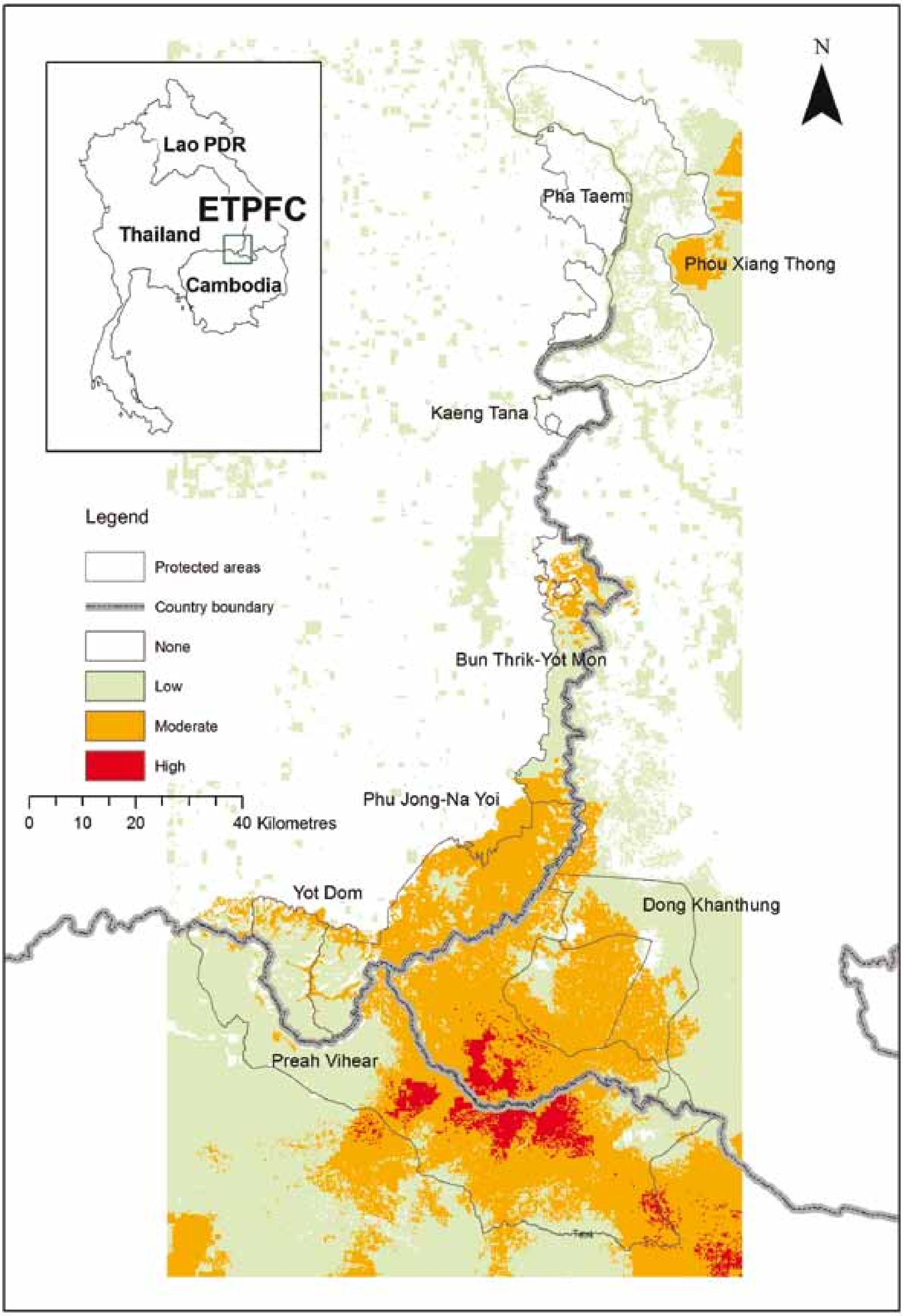
Effectiveness of integrated conservation and development activities in the PPFC

The study component on ICDPs (Chapter 7) was developed primarily in Thailand, where more than 80 villages are situated within 3 km of the boundary of the PPFC, with an estimated total population of about 89 000 people. These people's livelihoods affect biodiversity conservation and are often in conflict with the objectives of protected areas through, for example, forest encroachment for unsustainable agriculture, the raising of cattle and buffaloes, illegal logging, and wildlife poaching. An important objective of the ITTO–CBD project in phases 2 and 3 was to support selected local communities to implement activities linking livelihood improvement to a reduced dependence on resources in the protected areas by promoting ICDPs. In Thailand, these include handicraft production from bamboo, homestay nature-based tourism, homegardens and agroforestry, tree and plant nurseries, and wild orchid micropropagation. A revolving fund was allocated to six selected villages for the start-up of activities during Phase 2 of the project from 2008 to 2010. Six new ICDPs were established in Phase 3 (2012–2016).

ICDPs are at an earlier stage of development in Cambodia, and data have not been assessed for effectiveness. ICDPs there have included the establishment of rice banks and cow banks and the provision of infrastructure such as village water wells and ponds and the rehabilitation of local schools. Cambodian ICDPs have also been extended into Phase 3 with the establishment of a nursery to provide native tree species for reforestation and the introduction and expansion of agroforestry activities, including fruit trees for homegardens in local communities, especially for military families who have been relocated to social land concessions established inside the PVPF.

Research in Thailand on the impacts of ICDPs in the project's Phase 3 (Maneethong 2015) revealed that the net annual incomes of households in participating villages were higher than the incomes of households in non-participating villages, attributed to the selling of value-added handicraft products generated from ICDP activities. The level of participation in forest fire prevention in protected areas and attendance at awareness-raising meetings with protected-area staff were also significantly higher in participating villages than in non-participating villages. The ten non-participating villages were more involved in reforestation than were participating villages, however, probably because the monitored non-participating villages were located outside the protected areas and close to reforestation areas. In conclusion, the ICDPs increased incomes for participating communities, improved forest conservation and the use of forest resources such as bamboo, rattan, wood products, non-medicinal plants, edible insects and wildlife, and increased knowledge on forest conservation, relative to communities that did not participate. The ICDPs helped strengthen communities to develop higher living standards and incomes while, at the same time, reducing their use of forest resources.

Figure 9.2: Species richness classes of 12 species selected for modelling in the ETPFC



Source: Trisurat (2015).

Assessment of carbon in the PVPF

Preliminary sampling and modelling of carbon stored in above-ground and below-ground biomass were undertaken in evergreen, semi-evergreen and deciduous forest types in the PVPF (Chapter 8). Measurements indicated that the quantity of above- and below-ground carbon in both evergreen and semi-evergreen forest types was comparable with other similar forests in Cambodia and forests elsewhere in Southeast Asia. Estimates for deciduous forests, however, were about 50% lower than expected, and it appears that more sampling is warranted to determine the representativeness of estimates for the deciduous forest type. It may be necessary to obtain site-specific carbon pool data rather than using global data to ascertain actual carbon levels. Regardless, it is clear that the PVPF supports a large storehouse of carbon because of its relatively intact nature and that the ETPFC is important regionally because of its substantial store of forest carbon.

Conservation accomplishments

The primary technical accomplishments over the three phases of the ITTO–CBD project have been the development of individual protected-area management plans for the PPFC and the PVPF, a consolidation of species lists, the mapping of forest types, improved capacity for management and enforcement, increased knowledge of the key landscape animal species in the Emerald Triangle landscape, most of which are endangered, and a better understanding of the areas used by these species. There is now a formal mechanism to enable personnel from agencies, universities and others to meet to discuss project development and to share data and exchange information. Studies on wildlife, plants and insects have been completed. Considerable original work on animal distributions has been carried out, including in collaboration with other funding agencies and NGOs. For the first time, a large summary database has been constructed that amalgamates information on animal distributions in the ETPFC, and distribution maps and predictive models for key species distributions have been created. Sufficient information has been generated for use by governments in landscape planning and the long-term conservation of the ETPFC.

Nevertheless, much remains to be learned about the ecology of the ETPFC, including the timing and locations of the movement, basic ecology and demography of key indicator and endangered species and their habitat use patterns, the relative importance of various areas within the ETPFC for each species, and the functional roles that these species play in the ETPFC's ecosystems. Individual studies conducted by universities under the project are nearing completion, for example on gibbons in Cambodia and Lao PDR, and these will contribute further to knowledge on certain species. Governments now have sufficient information on which to act to protect major travel corridors for several large wildlife species, to reduce fragmentation through forest recovery, and to ensure that large wildlife species—such as the Asian elephant, gaur and Indochinese tiger—have sufficient habitat to enable their persistence in the ETPFC and the surrounding landscape.

Livelihood development initiatives

An important aspect of the ITTO–CBD project has been its focus on developing the means for local communities near the ETPFC to improve their livelihoods as a mechanism for reducing their dependency on forest resources. A suite of ICDPs has been initiated in Cambodia and Thailand, as described above. Most have been successful, and several have become self-sustaining. Measuring their impacts in terms of forest conservation is difficult; nevertheless, one assessment conducted in Thailand suggested a positive effect in reducing the use of resources in protected areas in the ETPFC.

Capacity building

An objective of the ITTO–CBD project's capacity-building component was to improve management and enforcement in the protected areas. The project contributed considerably to capacity building in governmental management agencies and in raising awareness in local communities of the importance of conservation. Activities included the provision of training to agency personnel in wildlife and plant identification; the formulation of development projects; nature-based tourism management; and the use of GIS tools for mapping and planning field studies and enforcement patrols.

The project strengthened the capacity of government staff at the national and local levels to manage project activities and provided them with a sense of ownership of the project and its outcomes. It also established interinstitutional coordination among relevant government agencies, which provided support for consultative and participatory processes introduced in Phase 2 of the project; increased understanding of conservation priorities; and promoted trust and respect for the voices of national stakeholders, each of which will contribute to the sustainability of activities after project completion.

The project made substantial capital investments in both Cambodia and Thailand, including in vehicles, laboratory equipment, field equipment, computers, mapping facilities, and tree and plant nursery infrastructure. It also provided funds to support the construction of a regional headquarters for management and enforcement staff in the PVPF. All these investments have strengthened the capacity of local staff to manage the ETPFC more effectively and efficiently.

Lessons learned

Lessons learned in the implementation of the ITTO–CBD project include the following:

- Each country involved in a transboundary conservation initiative should participate in, and agree to, the development of a shared vision and should indicate in the clearest manner that it is committed to the implementation and achievement of this vision to the greatest extent possible.
- Local research institutions are invaluable in providing technical assistance and knowledge to project staff. Involving these institutions early in projects will enhance success.
- It is essential to capitalize projects fully with equipment and to provide sufficient technical training to improve management practices and strengthen the capacity of local staff to conduct monitoring and enforcement activities.
- Technical cooperation preceded political cooperation in this transboundary conservation project. Much of the emphasis in the early stages should be directed to expanding opportunities for technical cooperation between participating countries.
- Substantial attention must be paid to fostering the social ownership of transboundary conservation initiatives among local communities and to developing a sense of the importance of conserving forests and biodiversity.
- It is crucial that a sufficient number of project team members is stationed in the project area to enable frequent contact with stakeholders and enhance communications with local communities and thereby maintain a consistent message of conservation and support for transboundary conservation activities.
- Political support is essential for the ultimate success of any transboundary conservation project. Sufficient consideration should be directed, therefore, to consolidating internal and external political support through the institutionalization of ongoing meetings with local and national government officials within each participating country, as well as between the government officials of all participating countries.
- The implementation of sustainable livelihood activities in the framework of a conservation project may be crucial for success, and it requires a broad range of skills often not present in project teams. It may be necessary, therefore, to develop strategic partnerships with international development agencies, NGOs and other institutions, including rural microcredit banks.
- Income generation in a transboundary conservation project is established most effectively as a community or family enterprise and not as a project activity, with a focus on the participatory village-level planning of natural resource use and conservation and the development of corresponding business plans that incorporate realistic assessments of markets.
- Efforts to raise the awareness of local communities, government officials and others of the importance of conservation in transboundary projects should be ongoing.
- The sustainability of transboundary conservation projects must be ensured at several interrelated levels: administrative and political; technical and managerial; rural community livelihoods; and financial resources. This must be accomplished in the much broader context of the socioeconomic and political conditions that define relationships between and within participating countries.

Conclusion

The primary impediment to the overall success of the ITTO–CBD project is the reluctance of Lao PDR to become an ITTO member and hence a formal and active project partner. This has not only had consequences for achieving comprehensive transboundary collaboration but could also have long-term implications for biodiversity conservation in the region. The level of protection afforded the DKPPA is only marginal, yet it is an essential component of the broader protected-area landscape shared by the three countries because of its inherent richness in biodiversity, the connectivity it provides between the PPFC and the PVPF, and the high-quality habitats it provides for landscape wildlife species. The collaborative interactions between universities in Thailand and Lao PDR, which will soon also be extended to Cambodia, is promising; universities do not make government policy, however, and nor do they make land-use decisions. Ultimately, the participation of the Lao PDR government is essential for achieving comprehensive transboundary forest and biodiversity conservation in the ETPFC.

A second major outstanding issue is the lack of a formal transboundary management plan between Cambodia and Thailand or between Cambodia, Lao PDR and Thailand. The development of such a plan has been an objective of the project since the beginning of Phase 2 in 2008, but it is still not in place at the close of Phase 3. Despite this, the project has been able to foster considerably improved cooperation between Cambodia and Thailand, which has increased the promise of a comprehensive cross-border management plan during the projected fourth phase of the project. Based on information in Chapter 3, it is clear that if crucial movement corridors for large mammals—some of which are already cut off—are to be maintained or restored, urgent transboundary conservation action is required very soon.

The project has promoted leadership among those national staff involved in the planning, decision-making and coordination of project activities, reducing reliance on external resources and technical expertise. The newly established participatory land-use planning processes with local communities and stakeholders, implemented through the project, have strengthened local capacity for land management and development planning. The project has strengthened the capacity of government staff at the national and local levels to manage project activities, and they have a sense of ownership of the process. The project established interinstitutional coordination among relevant government agencies that provided support for consultative and participatory processes. All these changes will ease the transition to the post-project implementation of activities.

The long-term sustainability of development assistance projects is always a concern. In the case of the ITTO–CBD project, however, certain design features mean there is a high probability that Cambodia and Thailand will be able to continue to maintain their management of the ETPFC. These features include the involvement of local communities; the provision of infrastructure; the development of alternative income-generating opportunities to reduce unsustainable forest use; staff training; and strengthened enforcement. The sustainability of project-funded activities in Thailand will require minimal post-project investment, in part because the required infrastructure and equipment were put in place during project implementation. Thai technical, administrative and managerial staff will be employed to continue activities under the supervision of the National Coordination Committee. The necessary human resource capacity was built during implementation, with project staff increasing their understanding and gaining experience in the processes, programmes, databases and collaborative activities created by the project.

The ITTO–CBD project has been very effective in establishing and promoting community development and involvement. The enhanced community livelihoods approach and participatory processes introduced to local communities and other stakeholders has strengthened their understanding of the importance of the protected areas; it has also improved buffer-zone management and increased the use of alternative income-generating opportunities to alleviate local poverty and reduce encroachment. In Thailand, the project has helped increase local incomes using a revolving fund formula; in Cambodia, local community livelihoods have been boosted by directly funded ICDPs. In many cases, beneficiary groups contributed above expectations to the protection of biodiversity in the Pha Taem National Park, for example by planting native orchids in forests.

The ITTO–CBD project has fostered important advances in transboundary conservation in the ETPFC. No formal transboundary management is in place, but independent management plans for the PPFC and the PVPF have been implemented. These plans represent an important regional advance; a binational or trinational plan is expected within a few years with the aim of achieving a truly transboundary approach to the conservation of this important shared landscape.

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This report presents the encouraging results of a long-running project to improve transboundary management in the Emerald Triangle Protected Forests Complex, a conservation jewel shared by Cambodia, the Lao People's Democratic Republic and Thailand. The report reviews the body of work conducted in the area by agencies in Cambodia, Lao PDR and Thailand under a project conducted as part of the ITTO–CBD Collaborative Initiative for Tropical Forest Biodiversity, a joint programme of the International Tropical Timber Organization and the Secretariat of the Convention on Biological Diversity.

The 483 400-hectare Emerald Triangle Protected Forests Complex is located in the Indo-Burma biodiversity hotspot, one of the world's most important centres of biodiversity. It is home to many threatened species, such as the Asian elephant, banteng, Eld's deer, fishing cat, tiger and giant ibis. The region also supports rural communities of farmers and fishers, and it is intermittently the focus of international political tension.

The ITTO–CBD project, underway since 2000, is increasing transboundary collaboration in the management of the Emerald Triangle. Work conducted under it includes land-use planning, wildlife surveys, community awareness-raising, livelihood diversification, and law enforcement to combat illegal logging and wildlife poaching. This nine-chapter report, written by local and international experts with strong credentials and vast field experience in the Emerald Triangle, sets out the findings and results arising from the many activities conducted under the project; it shows how the project has fostered important advances towards achieving a truly transboundary approach to the conservation of this important landscape.

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