



# REDD+ and Conservation of Prey Long Forest, Cambodia Summary of Scientific Findings 2007-2010

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Compiled and edited by  
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# PREFACE

Forest & Landscape, Denmark have had long term cooperation with Conservation International (CI) and the Forest Administration Cambodia (FA) on conservation and sustainable management of forest resources. Forest & Landscape has also facilitated the process of formulation of a National Forest Programme in Cambodia (GoC 2010). The NFP outlines the government's vision for the future management of the nation's forests. The NFP, among other things, acknowledges novel forms of financing through payments for environmental services for example in the form of conservation concessions and carbon sequestration (REDD+ projects). To assess the potential of Prey Long forest complex to provide income through conservation concessions and/or a REDD+ project, a number of studies have been undertaken.

A joint biodiversity assessment was conducted in 2007 by the Forest Administration Cambodia (FA), Forest & Landscape Denmark (FLD) and Conservation International, Cambodia (CI). The results were published in the document "A floral and faunal biodiversity assessment of Prey Long" (Olsson and Emmett 2007). Further botanical surveys were conducted in the northern part of Prey Long with focus on the rare and endemic evergreen swamp forests in 2008, 2009, and 2010. The objectives of these studies were to map and characterize the swamp forests and assess their conservation status. Secondly, the potential accumulation of dead plant material in the waterlogged soils of the evergreen swamp forests was investigated. In such areas deforestation and drainage may evoke massive emissions of carbon as the accumulated plant material decomposes. Therefore, soil samples were taken in order to analyze organic carbon contents in soils of lowland evergreen forest and swamp forest respectively. Thirdly, a study was conducted to estimate carbon stocks in forest fallows and their potential contribution to enhance carbon stocks, if included in a REDD+ project. Finally, a socio-economic study estimated total and relative income from resin collection in four villages adjacent to Prey Long.

This report contains a summary of findings from the studies. It also draws together background information on Prey Long forest complex, its people and their uses of the forest. Finally, it identifies areas of priority for conservation and outlines important elements for a potential REDD+ project in Prey Long.

We hope that this document will draw attention to the last large vestige of intact lowland rainforest in Indochina and the urgent need to develop a strategy for its continued protection and sustainable management. Protection of Prey Long would ensure a continued provision of environmental services such as watershed protection, biodiversity conservation and resources supporting local livelihoods.

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## 1. CLIMATE CHANGE AND THE PREY LONG FOREST PROJECT

Tropical forests are regarded as the biggest sink of terrestrial carbon. Tropical forests also become highly significant sources of greenhouse gases when cleared. Emissions from deforestation and forest degradation in developing countries constitute some 12-15 % of the total emissions of greenhouse gases annually. If we are to be serious in our efforts to combat climate change, reducing emissions from deforestation and forest degradation (REDD) in developing countries must be addressed.

REDD projects has the potential to generate substantial benefits in addition to the reduction of greenhouse gas emissions. These include positive impacts on biodiversity and sustainable development, including poverty reduction and strengthening indigenous people's rights. The proposed REDD+ project seeks to provide the financial means to manage and conserve the last intact vestige of lowland rainforest in Cambodia. In doing so, the project aims to produce a triple dividend – gains for the climate, for biodiversity and for sustainable development in Cambodia.

### BOX 1. REDD DEFINITIONS

**REDD** refers to mechanisms currently being negotiated under the UN Framework Convention on Climate Change process to **reduce** emissions from **deforestation** and forest **degradation** in developing countries.

## 2. PREY LONG - ECOLOGICAL IMPORTANCE AND CONSERVATION STATUS

Prey Long is the largest lowland evergreen forest in Cambodia, and probably in the Indo-Burma Hotspot<sup>(1)</sup>. Although Cambodia has a system of protected areas it reveals a clear lack of protection for wet lowland evergreen forest. Protected areas are presently located in mountainous regions where floral and faunal species often differ markedly from lowland habitats. This lack of representation of lowland evergreen forest in national protected area system is found across the Indo-Burmese hotspot. Consequently, the central lowland of Cambodia was identified as a critical ecosystem for the Indo-Burmese hotspot as it is the last intact vestige of Indochina's once widespread lowland evergreen forest (Birdlife International 2005, Appendix 1).

Lowland evergreen forests have historically been granted for logging concessions due to their ease of accessibility and their abundance of high value timber. As forest concession activities in Cambodia have declined in recent

1: The Indo-Burma hotspot is one of the worlds' 25 biodiversity hotspots, which represent areas with exceptionally high biodiversity. The Indo-Burma hotspot encompasses more than 2mill km2 covering Burma, Thailand, Laos, Cambodia, Vietnam, Southern China and part of the Indian West Bengal. [www.biodiversity-hotspots.org](http://www.biodiversity-hotspots.org)

years, land grabbing and the potentially excessive use of economic land concessions (ELCs)<sup>(2)</sup> have emerged as major threats to forests and rural livelihoods. Though lowland forest was once the most common vegetation type in Cambodia, today it is poorly protected, highly threatened, and receives virtually no attention from researchers and conservationists.

Lowland forests are gradually and continuously being reduced in size and quality due to illegal logging and agricultural encroachment into the area. The ongoing degradation causes an immediate threat to larger and endangered wildlife such as bears, banteng, gibbons, elephants, fishing cats, and several species of turtles. Continuous degradation will inevitably also reduce the diversity of smaller fauna (mammals, birds and reptiles) and flora.

The high ecological significance of Prey Long was highlighted as early as 1975 (McNeely 1975). More recently, it was included in a listing of tentative natural sites for World Heritage consideration for Cambodia (IUCN 2002). The importance of Prey Long for biodiversity conservation was reiterated by World Bank studies in 2004 and 2006. Prey Long forest is reportedly home to 80% of the most valuable and endangered indigenous tree species of Cambodia (CTSP/FA 2003). Furthermore, the area was identified as vital to the national reserve network by a group of national experts due to its importance for floral conservation (Strange *et al.* 2007). However, few surveys have been undertaken, and those that were conducted were mostly unsystematic and extremely limited in duration and taxonomic scope.

In order to assess the biological importance of the area and determine whether Prey Long should be a priority area for conservation, University of Copenhagen (KU), Conservation International (CI), and Forestry Administration (FA) began biological surveys of the area in 2007.

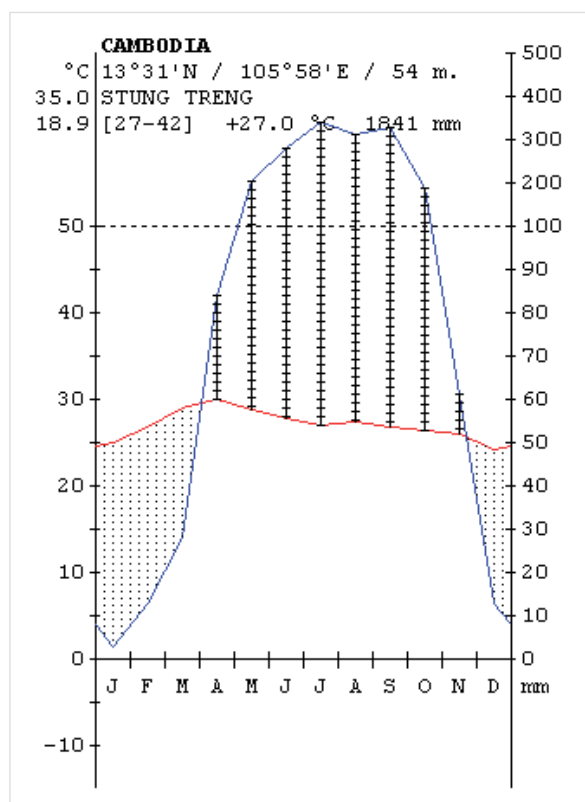


Figure 1. Climate diagram of Stung Treng on the northwest border of Prey Long forest complex. The climate is warm tropical climate with short dry season and excess precipitation during the rainy season.

2: According to the Cambodian Government's Sub-decree 146 on Economic Land Concessions (ELCs), "Economic Land Concessions refers to a mechanism to grant private state land ... through a contract to a concessionaire to use for agricultural and industrial-agricultural exploitation". ELCs are generally large land areas (limited by the 2001 Land Law to 10,000 hectares though larger concessions were granted prior to the Land Law) up to a maximum period of 99 years. ELCs are distinct from Forest Concessions (for private management of forest areas for timber) or Social Land Concessions (distribution of plots up to 5 hectares to the landless and land poor for family residential and agricultural use).



### 3. PREY LONG FOREST AREA, JURISDICTION AND LOCAL LIVELIHOODS

Prey Long is situated to the west of Mekong River in the northern part of Cambodia and stretches over four provinces: Kratie, Kampong Thom, Steung Treng and Preah Vihear. (Fig. 2 and Appendix 2). People in this region refer to this forest as Prey Long. These forests straddle various tributaries to the Mekong River, including the Siembok, O'Long, Chinit Rivers, and streams that feed the Steung Sen to the West, such as the Porong, O Ka-chong and O Ronul. The broadest definition of the Prey Long landscape covers about 520,000 ha. The most biologically important and most intact portion of Prey Long covers about 135,000 ha (Appendix 2).

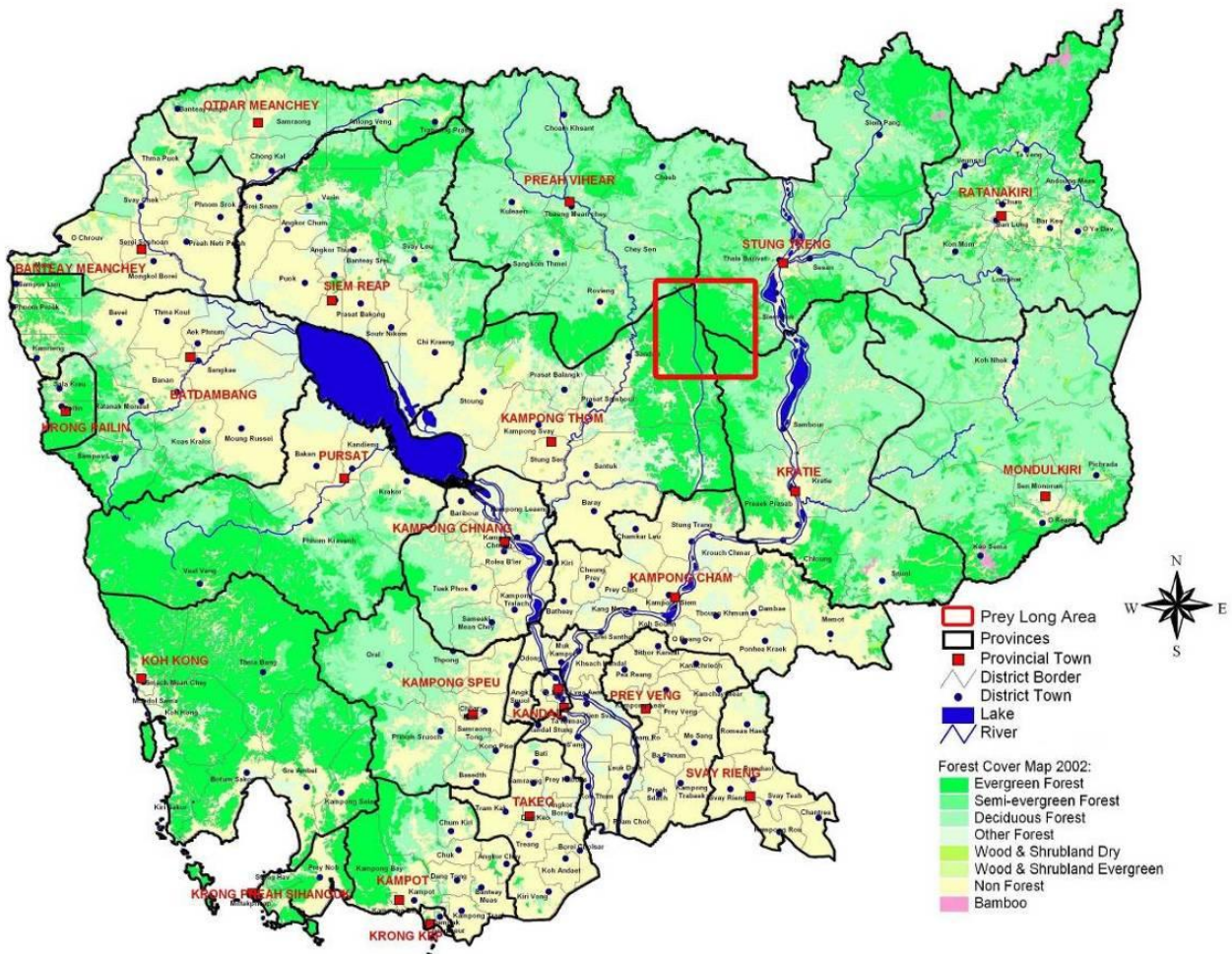


Figure 2. The Prey Long region demarcated on a map of Forest Cover of Cambodia (2002).

## Concessions

Prey Long is under the jurisdiction of the Forestry Administration (FA) and forms part of the forest estate governed by the Forest Law under which it is classified as state private land. Three logging concessions are located in Prey Long belonging to Pheapimex Fuchan, Everbright CIG Wood Co. Ltd., and Colexim Forest Concession. The Everbright concession is located in Kratie and Steung Treng Provinces and covers an area of 136,376 ha. The Colexim concession is located in the western part of Prey Long in Kampong Thom Province and covers 139,610 ha. Pheapimex Fuchan is located in Kampong Thom and Kratie provinces. Cambodia's significant reserves of high-value forests present an important economic resource, the sustainable use of which would be of considerable benefit to the country and contribute to national development. However, the recent history of Cambodian forestry has been turbulent. Following a period of anarchic logging, the concession system has been suspended since 2001.

## Local Communities

More than 250,000 people live in 340 villages in or within 10 kilometres around Prey Long, most of whom belong to the indigenous group called Kuy. The forest is an intricate part of their culture and spiritual life and they depend on it for their survival. Local villagers collect resin, building materials, medicine, and food from the forest and many depend on forest resources for their livelihoods. Much of Prey Long is found on infertile soil with little value for cultivation (coarse river sand). However, rivers and streams draining Prey Long are important spawning areas for fish of the greater Mekong River. Conservation of the Prey Long forest will benefit the indigenous communities living in the vicinity of the forest as well as farmers and fishermen relying on the downstream water resources of the Mekong River.



Figure 3. An estimated 250,000 persons live in villages bordering Prey Long. A few villages, such as Spong village, are situated within Prey Long. The communities are relatively self sufficient and may be isolated for periods of the year when heavy rain makes access by road very difficult. Photos: Lars Schmidt.

## Watersheds

Cambodian forests are intimately linked to rice-cultivation and in-land fisheries, and to maintaining the sustainability and productivity of these two sectors. Forest ecosystem services include regulation of local water-circulation, mitigation of droughts and floods, and reduction of waterway sedimentation. Prey Long is a primary watershed, regulating water and sediment flow to the Mekong River and the Tonle Sap Lake. An estimated 700.000 Cambodians depend directly on these watersheds for irrigation. In addition, southern Vietnam lies within the Mekong River watershed area, an area that makes up some of the richest agricultural, and most densely populated areas of the region. As such, Prey Long is vital to Cambodia's and the regions' long-term environmental sustainability and its people's food and water security, which in turn may be a precondition for political stability in the region. Deforestation and forest degradation may affect both frequency and severity of future events of flooding.



Figure 4. Prey Long is part of the greater Mekong watershed area. Forest destruction can disturb regional weather patterns and have serious implication for water flows of rivers and cause flooding during rainy seasons and drought during dry season. In addition, deforestation causes soil erosion and siltation of rivers which in turn affect production in aquatic ecosystems. Several million people live within the Mekong watershed area in Cambodia and Vietnam. Flooding is already experienced in Phnom Penh and other towns and cities along the Mekong during the rainy season.

## 4. PREY LONG – A MOSAIC OF DIFFERENT FOREST TYPES

Recent botanical surveys have revealed a diverse and unique floral composition within Prey Long forest complex. Prey Long is made up of at least seven distinct forest types (Box 2). The seven forest types can be classified into the broader categories of evergreen, semi-evergreen, or deciduous forests, but they differ significantly from each other on the basis of species composition, dominant trees, and plant community structure. Forest type classification combined with remote sensing is an important tool to estimate present carbon stocks in Prey Long and monitor future changes.

### BOX 2. FOREST TYPES OF PREY LONG

1. Deciduous Forest. This type of forest is similar to the dry seasonal forest found in dryer climates Indochina. Trees are relatively short (3-12 m). Mainly drought tolerant species with small leaves and thick barks. Dry deciduous forests form a transition to natural grassland, which are found on the very dry sandy sites.
2. Evergreen short forest. The forest is a transition type to tall evergreen forest, and often with similar species composition, yet trees are significantly smaller.
3. Tall evergreen dipterocarp forest. This forest type is found on the moist but not waterlogged areas. The forest consists of a large diversity of species with canopy closure at 30-50 m.
4. 'Sralao' (*Lagerstroemia*) forest. *Lagerstroemia* stands are distinct by their white bark and high, erect, fluted stems. They often dominate patches of forests.
5. Short riparian forest. This forest type occurs near rivers and streams, periodic inundated and remaining moist during the dry season.
6. Deciduous swamp forest. A quite unique forest type occurring around Pes Lake in the northern part of Prey Long. Several unique species and growth forms, normally associated with mangrove forest are found in this swamp forest.
7. Evergreen swamp forest. This forest type occurs on wet sites with permanent or long term inundation. The forest type is rare and endemic to central Cambodia.

From McDonald (2004), Theilade (2008), Theilade *et al.* 2011).



Figure 5. The dry deciduous forest is relatively open, trees are not more than 10-20 meter tall and diameter rarely more than 20 cm. However, the forest type contains extremely valuable tree species such as *Dalbergia*, *Xylia* and *Pterocarpus*. Right: On poor shallow, rocky soil the dry deciduous forest is dominated by *Dipterocarpus tuberculatus* and the ground vegetation of *Cycas*. Photos: Lars Schmidt.



Figure 6. Evergreen short forest is found as a transition between deciduous forest and the tall evergreen forest. It dominates on more moist sites and where soil consists of sand mixed with clay. Photos: Lars Schmidt and Ida Theilade.

In addition to the lowland evergreen forest, which is recognised as threatened globally, Prey Long is the last remaining area where forest types from deciduous to evergreen forests as well as the transition zones between them are found in a continuous and intact landscape. This has the extremely important conservation value of assuring a sustainable dynamic of the ecosystem complex. Conservation would provide future generations of Cambodians a chance to study the country's most productive forests and landscapes and the natural processes of succession and forest dynamics essential to develop sound forest management practices within the country (McDonald 2004). The forest types are illustrated in figures 5-11.



Figure 7. Tall evergreen dipterocarp forest covers the core area of Prey Long. This is the most productive forest type in Cambodia and also the forest type with the highest carbon stocks. Very large trees, some more than 2½ m in diameter and 50 meters tall, can be found in the evergreen tall forest. Here *Anisoptera costata* (left). *Lagerstroemia* (Sralao) is a forest type on mainly clay soil with high water holding capacity. It often forms more or less uniform stands. The wood is strong but the fluted trunks restrict the use as timber (right). Photos Lars Schmidt.



Figure 8. Short riparian forest. A distinct vegetation is found along streams and rivers. The streams and rivers of Prey Long are home to at least five species of endangered turtles and numerous freshwater fish (left). Deciduous swamp forest occurs at moist sites and is dominated by *Syzygium*, *Licuala*, *Calophyllum* and *Calamus* (right). Photos: CI.

## 5. THE EVERGREEN SWAMP FORESTS – A RARE AND ENDEMIC FOREST TYPE

The evergreen swamp forest of Prey Long is of particular importance for conservation as it is unique to Cambodia and to the region. It occurs in low-lying areas where slow-flowing streams drain shallow valleys. This type of forest has most likely covered larger areas of the lowland plains in the past. It is now extremely rare as virtually all such areas have been converted for rice cultivation. The swamp forests are disjunct patches covering from a few to several hectares of permanently inundated forest within the tall dipterocarp forest. The largest of the identified swamp forests, Choam Takong, covers about 35 ha. It is dominated by hydrophytic trees (*Syzygium*, *Litsea*, *Ficus*, *Macaranga*, *Myristica*, and *Pternandra*). Although these same genera also occur in upland forests, most are represented by different species in the swamp. Tall palms, *Livistona saribus*, emerges from the canopy as indicator species of this vegetation type while dense stands of palms (*Areca*, *Calamus*, *Licuala*) and sporadic clusters of tree ferns dominate the understory. Pneumatophores, stilt roots, and aerial roots characterize the hydrophytes. Many of the tree species recorded in the evergreen swamp forest are endemic to this forest type. It is not unlikely that some of these will be new to science (Theilade *et al.* 2011).



Figure 9. Evergreen swamp forest habitat with open understory. Evergreen swamp forests are less diverse than the surrounding upland forests but many of the species are endemic to this particular forest type. The evergreen swamp forests are extremely important to wildlife. Tracks of elephant, banteng, and fishing together with scratch marks of black bear and Malayan sun bear documents the importance of this ecotype. Photo: Simon Lægaard.



Figure 10. Wet evergreen swamp forest is dominated by palms, rattans, and smaller sized timber trees. Stilt roots and aerial roots (pneumatophores) are adaptations to long term inundation, and rarely found outside mangrove ecosystems. Evergreen swamp forest represents a relict forest type historically covering upper reaches of rivers of the former widespread lowland evergreen forest throughout the Mekong River catchment area and delta. Photos: Lars Schmidt.

So far, five evergreen swamp forests have been mapped. Botanical collections have been done in only two of these swamps. However, based on local knowledge a map showing the location of evergreen swamp forest in Prey Long was constructed (Fig 12). According to local guides, patches of evergreen swamp forest can be found along most upper reaches of rivers in the evergreen forest areas of Prey Long. It is also clear that this particular forest type is very prone to conversion for agriculture. Hence, almost all of the evergreen swamp forests of Kampong Thom Province have been cleared within the last 10 years according to local villagers. This finding is supported by forest cover maps of Prey Long (Fig 12) and underscores the urgent need to develop a strategy for conservation of this exceptional and important forest type.



Figure 11. Collection of plant specimens and local knowledge on species distribution and uses. Photo: Ida Theilade.



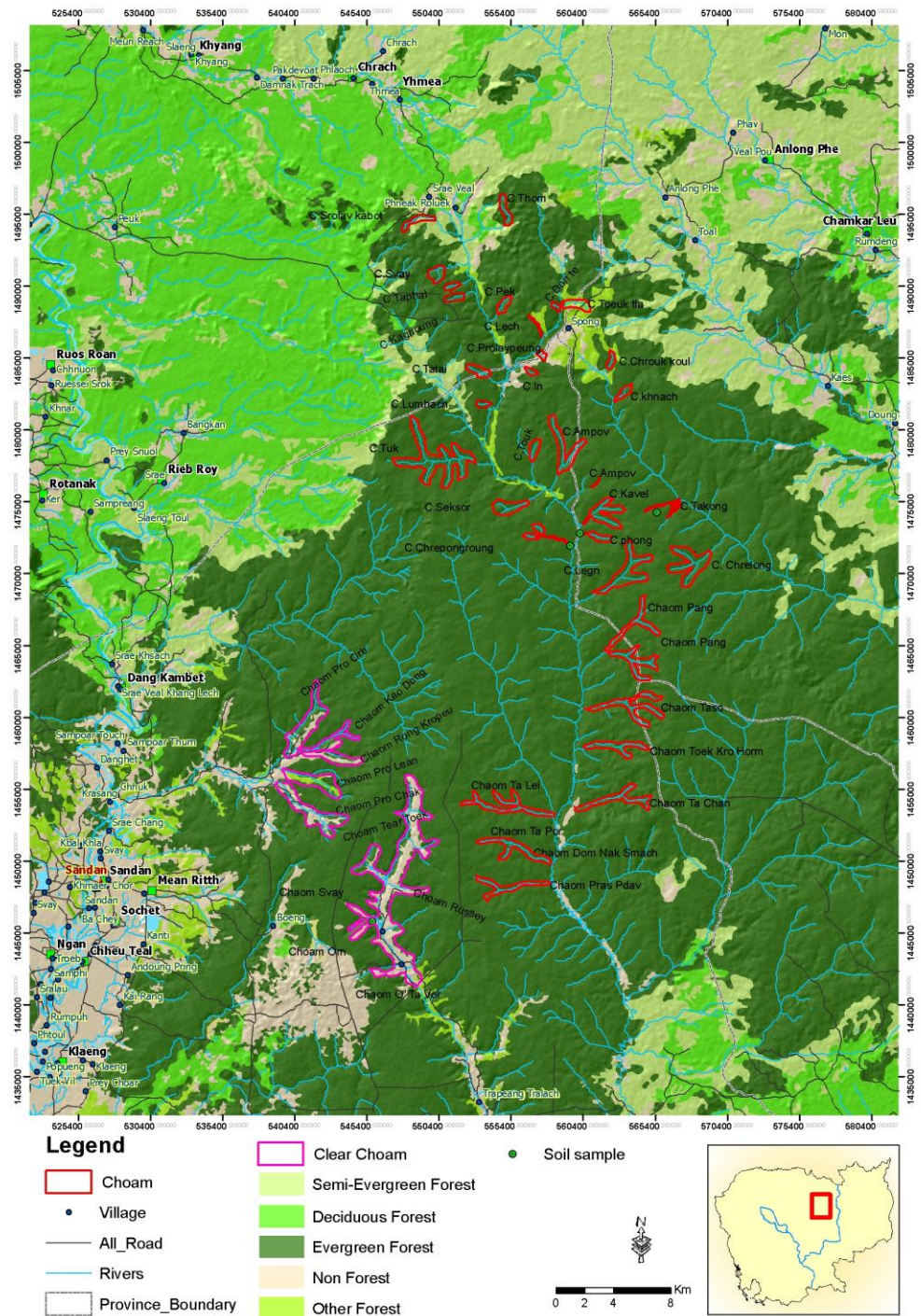


Figure 12. Forest cover map of prey Long showing the location of evergreen swamp forest ('Choam' in Khmer language) in Prey Long according to local guides. Patches of evergreen swamp forest can be found along most upper reaches of rivers in the evergreen forest areas of Prey Long. Choam Takong, Choam Leng, Choam Pong, Choam Ampov, and Choam Lech have been mapped using GPS (red fill in colour). Almost all of the evergreen swamp forests of Kampong Thom Province have been cleared within the last 10 years (shown in pink). Based on land use map by JICA (2004).

In addition to its floristic uniqueness, the evergreen swamp forest is of importance to endangered wildlife such as elephant, Malayan sun bear, black bear, gaur, banteng, and fishing cat. The critically endangered Siamese crocodile is reported from one of the evergreen swamps. Wildlife is attracted to the swamps, especially during the dry season when water is scarce.



Figure 13. Wild pigs gather around open pond in Prey Long caught by camera trap. Photo CI.

## 6. WILDLIFE OF PREY LONG

Greater Prey Long is considered to be particularly important as a wildlife habitat. It covers a large area of contiguous mixed forest habitats, which provides for a rich diversity of wildlife. Numerous streams and the seasonally inundated forest patches create open areas in-between the denser forest area which favours a variety of wildlife. Several species of globally threatened large mammals are found here, such as the Asian elephant (*Elephas maximus*), clouded leopard (*Neofelis nebulosa*), marbled cat (*Pardofelis marmorata*), Malayan sun bear (*Helarctos malayanus*), banteng (*Bos javanicus*), gaur (*Bos gaurus*), sambar deer (*Rusa unicolor*), wild dog (*Cuon alpinus*), sunda pangolin (*Manis javanica*), pileated gibbon (*Hylobates pileatus*), pig-tailed macaque (*Macaca memestrina*), and smooth-coated otter (*Lutrogale perspicillata*), (Olsson and Emmett 2007). Tiger (*Panthera tigris*) has been seen in the area as late as 2006 according to local guides.

Most large mammals are found at relative low densities, suggesting the high level of hunting pressure in the area. Unfortunately, for several of the large species the populations may have declined to a level below recovery, and some may already have gone extinct. However, with improved management and protection, mammal populations are likely to recover and become significant within Cambodia and the region.



Figure 14. Camera trap photo of banteng, Prey Long. Photo CI.



Figure 15. Camera trap photo of Malayan sun bear, Prey Long. Photo CI.



Figure 16. Camera trap photo of smooth-coated otters, Prey Long. Photo CI.



Figure 17. Camera trap photo of woolly-necked storks, Prey Long. Photo CI.

Prey Long is rich in turtles and tortoises such as the elongated tortoise (*Indotestudo elongata*), Asian box turtle (*Cuora amboinensis*), Asian leaf turtle (*Cyclemys oldhamii*), giant Asian pond turtle (*Heosemys grandis*), yellowed-headed temple turtle (*Heosemys annandali*), Malayan snail eating turtle (*Malayemys subtrijuga*), black marsh turtle (*Siebenrockiella crassicollis*) and Asiatic softshell turtle (*Amyda cartilaginea*). The very rare, critically endangered Siamese crocodile (*Crocodylus siamensis*) has also been recorded from this area.

In addition Prey long is home for a rich and diverse fauna of smaller animals like reptiles, amphibians, insects etc.



Figure 18. Prey Long contain a wide variety of reptiles such as lizards, monitors, leguans and snakes. Left is a water dragon, centre a red tailed pit viper and right a Malayan pit viper. Photos: Lars Schmidt and Ida Theilade.



Figure 19. Prey Long is rich amphibians, in particular frogs. Amphibians are, compared to many other smaller animals, a relatively sparsely studied group. The likelihood of finding new species is, accordingly, high. Photos: Lars Schmidt.

## 7. CARBON STOCKS

The IPCC (2003a) identifies five carbon pools that should be monitored to estimate emissions from deforestation and forest degradation: aboveground biomass, belowground biomass, litter, dead wood and soil organic carbon. The most practical method of estimating emissions is to monitor only aboveground biomass. However, degradation processes such as logging and burning can significantly influence emissions from other carbon pools such as dead wood, and litter. Peat swamp forests are a specialised ecosystem where trees grow on highly organic soil built of centuries' accumulation of waterlogged plant material. Peat represents a massive store of the world's carbon. In the case of deforestation and drainage, tropical peats release their carbon as CO<sub>2</sub> or the even more serious greenhouse gas methane (CH<sub>4</sub>) into the atmosphere as the peat decomposes. Furthermore, as peat dries, it becomes extremely susceptible to burning, intentional or accidental.

### Below ground carbon stocks

In order to assess the presence of peat in the waterlogged soils of the swamp forests in Prey Long, soil samples were taken from four different evergreen swamp forests: Choam Takong, Choam Svay, Choam Pong, and Choam Chre Pong Rong.

Organic carbon content is expected to be highest near the surface (upper 30 to 50 cm). Therefore, soil samples were divided into fractions; 0-10 cm, 10-15 cm, 15-25 cm, 25-50 cm.

Soils samples from upland forest, Choam Takong and Choam Svay were analysed; total C/N (Dumas), pH (methods H<sub>2</sub>O, CaCl<sub>2</sub> and KCl). The results are shown in Table 1. Results are based on averages from five soil samples taken from each test site in upland forest, evergreen swamp forest in Choam Takong and evergreen swamp forest Choam Svay respectively.

Table 1. Soil total carbon/Nitrogen (C/N) content an pH values from upland forest and evergreen swamp forests in Prey Long

	Total konc C/N	pH 1% H <sub>2</sub> O	pH 1% CaCl <sub>2</sub> 0.01M	pH 1% KCl 1M
Upland forest 0-10 cm	0.93/0.09	5.5	4.2	3.9
Upland forest 10-25 cm	0.52/0.081	5.7	4.2	4.3
Upland forest 25-50 cm	0.24/0.012	5.9	4.3	4.4
Choam Takong swamp 0-10 cm	5.31/0.464	5.0	4.1	4.0
Choam Takong swamp 10-25 cm	2.53/0.208	4.9	4.2	4.1
Choam Takong swamp 25-50 cm	2.33/0.144	4.9	4.1	3.9
Choam Svay swamp 0-10 cm	4.26/0.37	5.0	3.9	3.9
Choam Svay swamp 10-25 cm	3.98/0.259	5.1	4.0	4.0
Choam Svay swamp 25-50 cm	0.61/0.049	5.4	4.1	4.1

The total C/N concentration is low for upland forest soil. The soil is acidic and varied from pH 5.5 to 5.9 from the surface to 50 cm depth measured on standard H<sub>2</sub>O method and pH 3.9 - 4.4 using the KCl method. This is characteristic for soils of lowland evergreen forest.

The total C/N concentration is significantly higher in the evergreen swamp forest. Soils in Choam Takong, Stung Treng Province, is made up by a shallow, peat-like layer (5-10 cm), and followed by a black layer of humus rich clay (Fig. 20). The pH is lower than for the surrounding upland forests and varies from 5.0 to 4.9 (H<sub>2</sub>O method) from the surface to 50 cm depth. The soil of Choam Svay, Kampong Thom Province is made up by a deep, homogenous layer of humus rich clay (Fig. 21). The pH is lower than for the surrounding upland forests and varied from 5.0 to 5.4 (H<sub>2</sub>O method) from the surface to 50 cm depth. pH measured on CaCl<sub>2</sub> and KCl<sup>(3)</sup> basis appear from table 1.

In conclusion, the carbon and content in soils is 3-5 times as high in the evergreen swamp forests of Prey Long compared to the surrounding upland forest. Usually organic carbon to a depth of 30 cm is included in below ground carbon estimates. Further soil samples are necessary to assess the depth to which increased organic carbon contents occur in the swamps.

3: pH measured in a solution using CaCl<sub>2</sub> or KCl is normally considered a more exact method of pH measurement since the K or Ca ions replaces H<sup>+</sup> ions tightly attached to the soil colloids

However, the waterlogged soils make it very difficult to take soil samples in the swamps. More samples are needed to establish standard values for carbon content in soils of both swamp and upland forest of Prey Long.



Figure 20. Soil profile for Choam Takong (left) and Choam Svay (right). Choam Takong has a shallow, peat-like, humus layer above a dark humus rich clay soil. Choam Svay shows a deep, homogenous layer of humus rich clay. Photos: Simon Læggaard.



Figure 21. Soils in the evergreen swamp forest are waterlogged, and more acidic than in the surrounding upland forest. This impedes decomposition of organic material. Soils in the evergreen swamp forests has significantly higher carbon contents than the surrounding upland forests. Waterlogged soil in Choam Pong (left). Most of the evergreen swamp forests in the southwest of Prey Long, Kampong Thom Province, have already been cleared. Choam Svay (right). Photos: Simon Læggaard.

## **Carbon sequestration of forest fallows and the economic potential in REDD+**

Tropical forests have long been regarded as the biggest sink of terrestrial carbon, while they also become highly significant sources, when they are cleared. Shifting agriculture is a common land-use along the forest frontier in South East Asia. The role of forest fallows, and forest fallow re-growth in the global carbon cycle is therefore significant. Potential implications of REDD+ projects on shifting agriculture practices and the inherent carbon emissions or sequestration are important to assess. A study was conducted in Prey Long, Kratie Province to quantify the rate of carbon sequestration in re-growth of tropical fallows as a function of time. The data can be used to estimate the potential revenue from carbon credits in fallows, and compare these with income from alternative land uses.

A total of nine different fallow age-classes were sampled in plots of 10x10 meters at the Prey Long forest frontier, Kratie Province. A transition model of the biomass re-growth of fallows was computed across the chronosequence of age-classes. The above ground biomass in fallows were found to be positively correlated with time since abandonment. Below ground biomass was calculated using allometric equations for below ground biomass of trees (Kenzo *et al.* 2009, Niiyama 2010). Above and below ground biomass were found to increase by 5.9 tons of dry weight/hectare/year equivalent to a carbon sequestration of 2.9 tons carbon/hectare/year. This could provide an income from US\$100 - US\$300 depending on the interest rate and price of certified emission reduction (CER). This is similar to the income from teak and rubber plantations (Top 2004). The high rate of carbon sequestration in tropical fallows renders them economically attractive to include in future REDD+-projects. The analysis does not take start-up costs and transaction costs into consideration. However, the study indicates that re-growth of forest fallows may be economically feasible to include in REDD+-projects and that income from carbon credits may be able to compete with other land-uses.

The above results are based on the scientific report “Estimating carbon sequestration of forest fallows and the economic potential in REDD+” by Karsten (2010).

## 8. PAST AND PRESENT DEFORESTATION AND FOREST DEGRADATION IN PREY LONG

The lowland rain forest of Cambodia contains a vast amount of economically exploitable timber, which has been one of the major resources for generating foreign income for development as well as for direct use in the Cambodian industries and rural communities. Native forests have been converted to agricultural food production and highly productive plantations. However, the loss of natural forests and growing concerns of massive negative effects on biodiversity and watersheds led to suspension of all logging concessions in 2001 followed by a moratorium on logging in 2002. This stemmed the immediate threat by large-scale commercial logging in Prey Long. However, local and probably largely illegal activities still contribute to degrade the forest and its wildlife.



Figure 22. Industrial logging took place in Prey Long up to 2001, when a moratorium put an end to official logging. Prey Long still contain large diameter trunks with high commercial value (left). Illegal logging in Prey Long targets mainly luxury woods such as *Afzelia* and *Dalbergia* (right). These species are already locally extinct in many areas. Photos: Lars Schmidt.

### Illegal logging

Despite the official logging moratorium, there is widespread evidence of small-scale logging in Prey Long. Piles of sawn wood of luxury woods such as *Afzelia* are encountered in the forest and in villages. There is a steady stream of wood-loaded ox-carts leaving from the forest. Though a seemingly small activity, illegal logging is implicitly difficult to control, and often tends to escalate, as long as there is a demand and market for wood. Illegal logging in Prey Long target mainly luxury woods such as *Afzelia* and *Dalbergia*. These species are already locally extinct in many areas (Theilade et al. 2007). The continued fragmentation of the dwindling populations may affect regeneration and long-term survival of these highly valuable species in Prey Long. In addition, frequent opening of the canopy layer tends to create



very dense ground vegetation, which creates an inhospitable environment for larger ground living animals such as bears and elephants.



Figure 23. Agricultural encroachment usually starts with shifting cultivation, where trees are cut and burnt, and where the wood ash is the nutritious substrate for crop growing. Traditionally, the land was abandoned after some years of cultivation. However, nowadays most cleared forest become permanent fields and will not revert back to forest. Photos: CI.



Figure 24. Agricultural encroachment usually starts with shifting cultivation, where trees are cut and burnt, and where the wood ash is the nutritious substrate for crop growing. Traditionally, the land was abandoned after some years of cultivation. However, nowadays most cleared forest become permanent fields and will not revert back to forest. Photos: CI.

## **Agricultural encroachment and land speculation**

Cambodia has experienced a very rapid population increase and agricultural land is currently in need. Population increase has taken place both in the rural villages in or near Prey Long and villages and towns around. Opening of forests with logging roads and tracks, and improved roads to remote villages have made access to previous closed forest easier. Hence, there is both an internal expansion of agricultural area from the villages and an encroachment from the periphery and along the roads. Agricultural practice on newly opened sites is most often shifting cultivation. Insecure land tenure and shortage of agricultural inputs tend to create continuous degradation and encroachment of the forest. This development is currently fuelled by land speculation where small farmers are paid a nominal fee to clear land, which is later sold to agro-businesses. Large-scale conversion of forest to cassava growing is common along the road from Stung Treng to Spong village in northern Prey Long.



Figure 25. Local hunters use snares for hunting. Snares are placed at animal paths and are used for both smaller and larger animals. Photo: Lars Schmidt.

## **Hunting and wildlife collection**

Villagers have always hunted during time of less agricultural production and as a supplement to agricultural production. Traditional Indo-Chinese and Chinese medicine use many remedies from wild plants and animals. Strong commercial links to Vietnam and China has provided a huge market for such products, which in turn has put a strong pressure on native wildlife in Indo-China. Unfortunately many demanded products originate from endangered species. And as prices tend to increase with limited supply, the pressure on particular species can be self-perpetuating. In Prey Long, the populations of large wildlife is, after many years of uncontrolled hunting, probably reduced to a minimum and far below the potential density of wildlife the area could support.

## **Collection of non-timber forest products**

Non-timber forest products (NTFPs) include collection of resin from dipterocarps, collection of honey, medical plants, rattan and small construction material. Unfortunately very few studies have been done to document the socio-economical value of NTFPs from Prey Long. A preliminary inquiry suggested

that about 80% of the households within and in the vicinity of Prey Long practice resin collection for income generation (McDonald 2004). A follow-up study was undertaken to evaluate the economic importance of resin collection in villages bordering Prey Long. A total of 32 households in 4 villages were interviewed using semi-structured interviews. Households were selected using random sampling. Three of the villages; Spong, Doung, and Kaes, are situated in the northeast of Prey Long. This area is characterised by intact forest cover and little deforestation in recent years. The last village, Choam Svay, is located in the southwest of Prey Long in an area of rapid agricultural expansion, economic development and high deforestation rates (Fig. 12). The study shows that collection of liquid and solid resin provides a substantial, and often the only, cash income to many households in the vicinity of Prey Long. Resin collection was found to be an important activity to both poorer and better-off households. A total of 15288 resin trees were registered by the 32 households of which 9038 were tapped. These trees provided a total harvest of 38.000 liter resin/year. In addition 1800 kg of solid resin was collected/year. The total income from resin collection in the 32 households was estimated at 10.500 USD. This is equivalent to a daily income of 0.50 USD/adult in the household. In comparison the UNDP poverty line in Cambodia is 1.25 USD/day (Lægaard 2010).



Figure 26. Most dipterocarps contain valuable resin. The resin will collect in the small cut-out cave at the base of the stem. Burning promote resin exuding from the damaged part (left). Resin is one of the commercial forest products that can be collected from the forest and sold on the market. Resin buyers send trucks to the villages to collect bags of resin (above). Photos: CI and Lars Schmidt.

Collection of forest products such as resin does usually not pose immediate threats to forests albeit there is a limit of how much can be sustainably collected. It is strongly recommended that any future REDD+ scheme should take local peoples' reliance on forest products, such as resin collection, into account. These activities may be continued in a sustainable manner also after implementation of various REDD+ and forest conservation measures.



Figure 27. Forest honey collected from bee nests in forest trees. Honey collection provides significant income to local villagers (right). Collection of plants for medical purposes is widely practiced. Many people in rural area depend entirely on traditional medicine. The Zingiberaceae is rich in traditional medicinal plants. Here *Curcuma* sp. (right). Photos: Lars Schmidt

## 9. FEASIBILITY STUDY FOR THE PREY LONG AREA TO ESTIMATE CARBON STOCKS, DEFORESTATION RATES AND POTENTIAL VALUE OF CARBON CREDITS

A feasibility study conducted by Conservation International (2011) in which scenarios for expected slowed deforestation rates was to be modelled. The feasibility study stressed that any attempt to build a strategy for a REDD+ initiative in the Prey Long area has to be aligned to the Cambodia REDD+ UN-REDD Roadmap as well as the World Bank Forest Carbon Partnership Facility (FCPF). The Prey Long initiative therefore should aim to build upon Cambodia's national REDD+ strategy and the existing forest management strategies that REDD+ is envisioned to support as outlined in the National Forest Programme (GoC 2010).

The preliminary results of the feasibility study indicate that a developing a REDD+ initiative in Prey Long could generate great value in terms of climate change mitigation benefits, in the order of approximately 10 million ton CO<sub>2</sub> equivalents (tCO<sub>2</sub>e) within a 10-years timeframe, after having discounted for a 20% permanence risk buffer (see table below). This is due to the high rates of unplanned deforestation currently present in the area, mainly driven by encroachment for agricultural and commercial uses. A separate driver that has emerged recently includes the granting of Economic Land Concessions (ELCs) for agro-industrial uses. Two options are suggested as potential

REDD+ strategies for the Prey Long area: 1. Identifying areas under highest threat of unplanned deforestation for implementing local forest protection contracts with the local population through conservation agreements and enhanced law enforcement, building on CI's experience in the Cardamoms Mountains; and 2. Protecting a larger area of forest by designating Prey Long as a Protected Forest or a Conservation Concession for REDD+ management, in order to prevent the granting of further ELCs within the area, while implementing local forest protection contracts with the local population to reduce the rate of unplanned deforestation. These strategies produce similar benefits in terms of REDD+. However, further research and consultation with stakeholders and government institutions is needed in order to have a more complete picture of the dynamics of deforestation in the area, particularly with regards to the threat of future ELCs, that would allow to construct a planned baseline that would more accurately reflect the future of Prey Long and thus recognize the real efforts of protecting its forests. A REDD+ initiative in Prey Long could provide several co-benefits. It would be the first of its kind to address post-concession management. It would contribute to avoid further ecological and biological losses from the country's lowland evergreen forests and to conserve the unique wildlife of the region. If designed properly, it has the potential to provide socio-economic development to local communities and at the same time preserve a forest which is an integral part of their lives (Conservation International 2011).

Table 2. A REDD+ initiative in Prey Long could generate great value in terms of climate change mitigation benefits, in the order of approximately 10 million tCO<sub>2</sub>e within a 10-years timeframe, after having discounted for a 20% permanence risk buffer.

Ex ante REDD benefit estimate, Co2e (tCO2e) minus 20% permanence risk buffer			
Years	Scenario 1a: Unplanned deforestation	Scenario 1b: Unplanned plus allocation adjustment factor	Scenario 2: Unplanned plus planned
1-5	4,074,791	3,901,382	4,222,454
6-10	10,599,678	9,744,669	10,837,518

## 10. PREY LONG AND CLIMATE CHANGE, - LOCAL AND GLOBAL CONTEXTS

There are many inherent and ongoing challenges to sustainable forest management in Cambodia. The moratorium on logging, in effect since 2001, creates an opportune time for exploration of new approaches to sustainable and more equitable and socially responsible forest management. The Government of Cambodia has a desire to explore alternatives to the traditional forest concession management. Financing sustainable forestry through carbon credits is one of the potential future options. At recent high-level meetings, the Forestry Administration welcomed and encouraged the development of a pilot REDD+ demonstration project in the Prey Long region and the conversion of existing logging concessions for this purpose. A REDD+

proposal for Prey Long would be the first of its kind to address post-concession management. It would have to be closely aligned to existing and developing Cambodian policies on forest and climate change mitigation.

A REDD+ project for Prey Long would contribute to avoid further ecological and biological losses from the country's lowland evergreen forest and to conserve the unique evergreen swamp forests. It has the potential to provide socio-economic development to local communities and at the same time preserve a forest which is an integral part of their lives.

### **Next steps**

While the underlying idea of REDD+ is simple, there are complex issues to be solved in order to implement an effective, efficient and equitable REDD+ project. These include carbon stock measurements, permanence, additionality, leakage, and reference levels. Apart from the monitoring, reporting and verification (MRV) required in REDD+ projects, a number of issues, well-known from protected area management; will have to be dealt with. Some important next steps, in order for Prey Long to be managed under a REDD+ scheme, would include:

#### – Identify stakeholders

The Forest Administration under the Government of Cambodia has the mandate to manage Prey Long forest area. However, transition to and protection under a REDD+ project will involve a number of interest organisations outside FA. Stakeholders should cover key technical and policy areas involved in the implementation. It would include relevant institutions and NGOs with interest and experience within conservation and community development. The local Kuy communities, long term settlers as well as more recent immigrant communities in and around Prey Long must be involved in planning and decisions on future use of the forest area. A coordinating body with representation from different stakeholders could be a model for future management. Any future REDD+ project should strive to obtain the standards set by Climate, Community & Biodiversity Alliance (CCBA 2010).

#### – Boundaries and zoning

It is envisaged that the REDD+ project area will include at least two main categories i.e. a core zone and a buffer zone. The core area of Prey Long covers an area of approximately 130,000 hectares and is largely covered by primary forests (Annex 2). The area is proposed protected from fragmentation and degradation. A buffer zone is recommended in areas closer to permanent settlements and farming areas. Enhancement of carbon stocks may be feasible in parts of the buffer zone. It is acknowledged that the suggested REDD+ project must include a thorough community consultation. Local communities' use of forests should be mapped and taken into account in the delineation and regulations of the potential REDD+ core zone and buffer zone. The boundary around the core area alone is at least 150 km. Any future boundary delineation may be carried out partly under or in collaboration with the National Forest Programme of which forest boundary delineation is a sub-programme (GoC 2010).

- Negotiate with concessionaires

Prey Long is currently divided into three forest concessions, Pheapimex Fuchan, Everbright CIG Wood Co. Ltd., and Colexim Forest Concession. In order for concessionaires to forego future logging operations in the area some compensation scheme will have to be agreed upon. A road map for negotiation and compensation of concessionaires should be prepared.

- Identify sensitive and key conservation areas

Within the quite heterogeneous forest mosaic of Prey Long, some sites are envisaged to be particularly sensitive, either because they are very rare, or because they are subject to particular threats (the two factors usually coincide). Examples of such areas are the evergreen swamp forests, riverine forest, high dipterocarp forest and populations of endangered hardwoods/luxury woods. Swamps and riverine forests are known to be particularly endangered by agricultural encroachment because they are easily converted into rice paddies. However, in addition to being botanically unique, the permanent moist areas are important as permanent water sources for wildlife during the dry season. Riverine forests are particularly important for watershed protection. Tall Dipterocarp Forest may be subject to illegal logging, and as this late succession forest has a scattered distribution, protection of viable stands are crucial for protection of the species. Particular stands of endangered and valuable hardwoods such as *Azelia*, *Diospyros* or *Dalbergia* should be mapped and monitored.



Figure 28. Prey Long evergreen swamp forest and riverine forests are extremely important in a conservation context. Swamp forests are unique and probably the only reminiscent of this forest type in Indochina. Riverine forest form important corridors for migration of fish and amphibians as well as seed dispersal. Swamps and rivers provide permanent water sources for wildlife. Photos: Lars Schmidt.

- Revision and / or verification of forest types

The present classification of 7 forest types as referred to in section 2 is based on preliminary surveys by McDonald (2004) and Theilade et al. (2008, 2011), which in turn refer to categories described by Maurand 1943. However, the classifications need a thorough revision with inventories of species, abundance and soil description. This will involve botanical surveys employing qualitative and quantitative methods such as transects and collection of botanical specimens.

– Mapping and classification of forest and land use

Satellite images, aerial photographs and statistics give overall information about human population, villages, roads and rivers, main forest types, and topography. The latest land use map of the area is from 2002 (JICA 2002) and includes main land uses and vegetation types.

– Ensure local community benefit and minimise negative impact

Several villages are situated within the greater Prey Long. These villages are keys to the success of a future REDD+ scheme. Preferably villagers should be involved in monitoring and reporting of carbon and biodiversity stocks. Villagers should also be compensated for restrictions on activities and furthermore benefit from the conservation measures, which implies that substantial input be given to support and improve their livelihood and alternative income. Inputs to agriculture, schools, clinics etc could compensate for the inevitable restrictions on unsustainable use of forests. Improved infrastructure (roads) would ease both market and cultural exchange. Some communities may be able to benefit from incoming visitors in a type of ecotourism. Albeit probably limited in terms of monetary input, such activities can have a large symbolic value of environmental awareness rising.



Figure 29. People living within and around Prey Long use the forest and are dependent on it. Any conservation measure will inevitably affect them. It may be restrictive but could also create new opportunities. Whatever management regulation that may be implemented it is important that it is done in agreement with those living closest to the forest i.e. villagers within and around Prey Long. Photos: Lars Schmidt.

– Ensure biodiversity conservation

Biodiversity conservation is one of the important co-benefits of REDD+ projects. The biodiversity of Prey Long is of regional importance. Protection of Prey Long forest would be an important first step towards conservation of its biodiversity. However, special types of flora and fauna may need to be addressed by special conservation strategies. This could be rehabilitation of habitats for bears and elephants, which in turn may require enrichment planting by particular species or creating ‘artificial’ sites for foraging. Faunal and botanical expertise should be engaged to identify particular habitats of critical importance to conservation of biodiversity in Prey Long.





Figure 30. Prey Long is home to a variety of wildlife. Habitat destruction and hunting may threaten local species with extinction. Here villager with common monitor lizard. Photos: Lars Schmidt.

– Develop a REDD Project Design Document for Prey Long

The Project Design Document or master plan should contain the following key elements:

1. Mapping and classification of land use on landscape level
2. Legislative framework for REDD in Prey Long
3. Community involvement and development
4. Management plan, budget, and implementation
5. Funding

The Project Design Document is to include plans for the two main zones; the core zone and the buffer zone or forest user zone. In the protected forest, the aim is to maintain the forest cover while the buffer zone typically consists of forest user areas and agricultural land. The proposed zoning would ensure environmental services such as watershed protection, biodiversity conservation, and forest products, apart from generating carbon credits. The buffer zone should, as far as possible, maintain a high tree cover. This may be achieved by various types of agroforestry models, fruit trees or plantation crops. Involved communities and households should be closely involved in development of sustainable and productive methods for agriculture in the buffer zone and sustainable use of the forest.

– Create funds distribution structure within Cambodia.

On the long term, a REDD+ project is projected to generate funds in terms of carbon credits. However, substantial investments are needed for credits

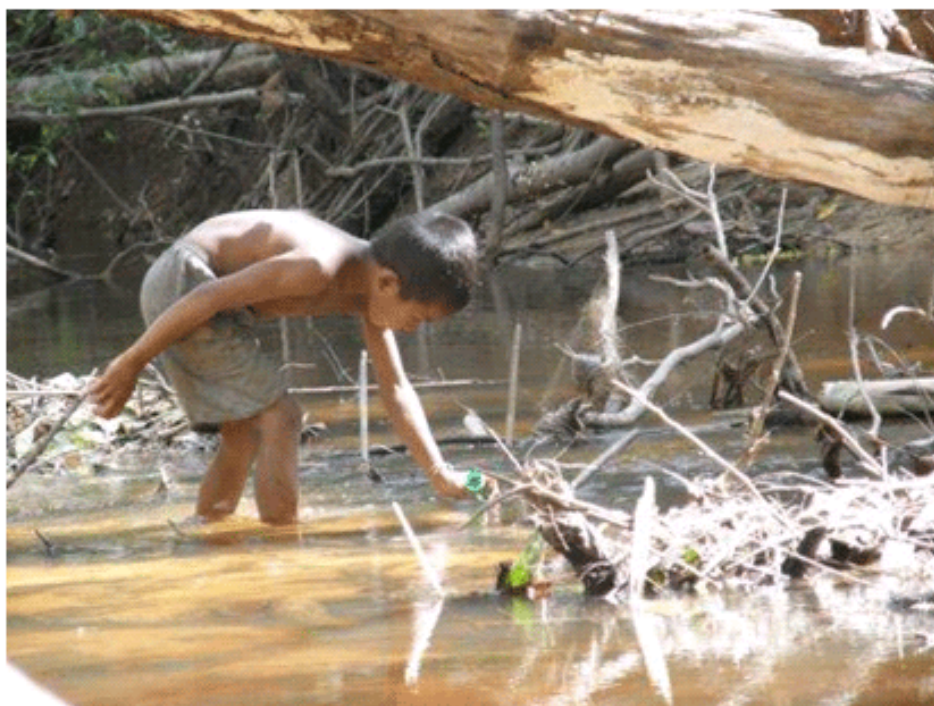
to be verified and marketed. Up-front funding is needed for calculation of baselines, certification and marketing of credits. Conservation trust funds as a model for REDD+ financing has been successfully used elsewhere (Spergel and Wells 2009). A conservation trust fund may also be responsible for a transparent and equitable distribution of funds.

– Research

Formulation and realisation of a REDD+ project is challenging. A REDD+ project for Prey Long will have to suit national legislation and interests as well as local conditions. To some extent it will involve learning while doing. A REDD+ project in Prey Long should advance human wellbeing, environmental conservation and equity by conducting research to inform policies and practices that affects forests at national level. Cooperative research programmes between Cambodian and overseas universities are assumed to be of interest for all partners. Research may encompass both student level (B.Sc., M.Sc. and Ph.D.) and post-graduates. Some urgent research areas are:

1. Carbon stock estimation and monitoring for Prey Long forest complex.
2. REDD+ architecture (financing, benefit distribution mechanism, stakeholder analysis).
3. Agricultural development including agroforestry.
4. Community development including community forestry.
5. Botanical and zoological research (systematics, ecology, basic bio-geography, conservation biology).

With strong political will and commitment from all partners, it is our hope and ambition that a REDD scheme for sustainable management of Prey Long can be put in place for the benefit of the climate, biodiversity and for the people of Cambodia.



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# Appendix 1.

Key Biodiversity areas in Indochina from Ecosystem Profile (Birdlife International 2005). Prey Long is situated in the Central Cambodian Lowlands (7) and harbours threatened lowland evergreen forest and swamps. So far this biome has not been granted any kind of protection.

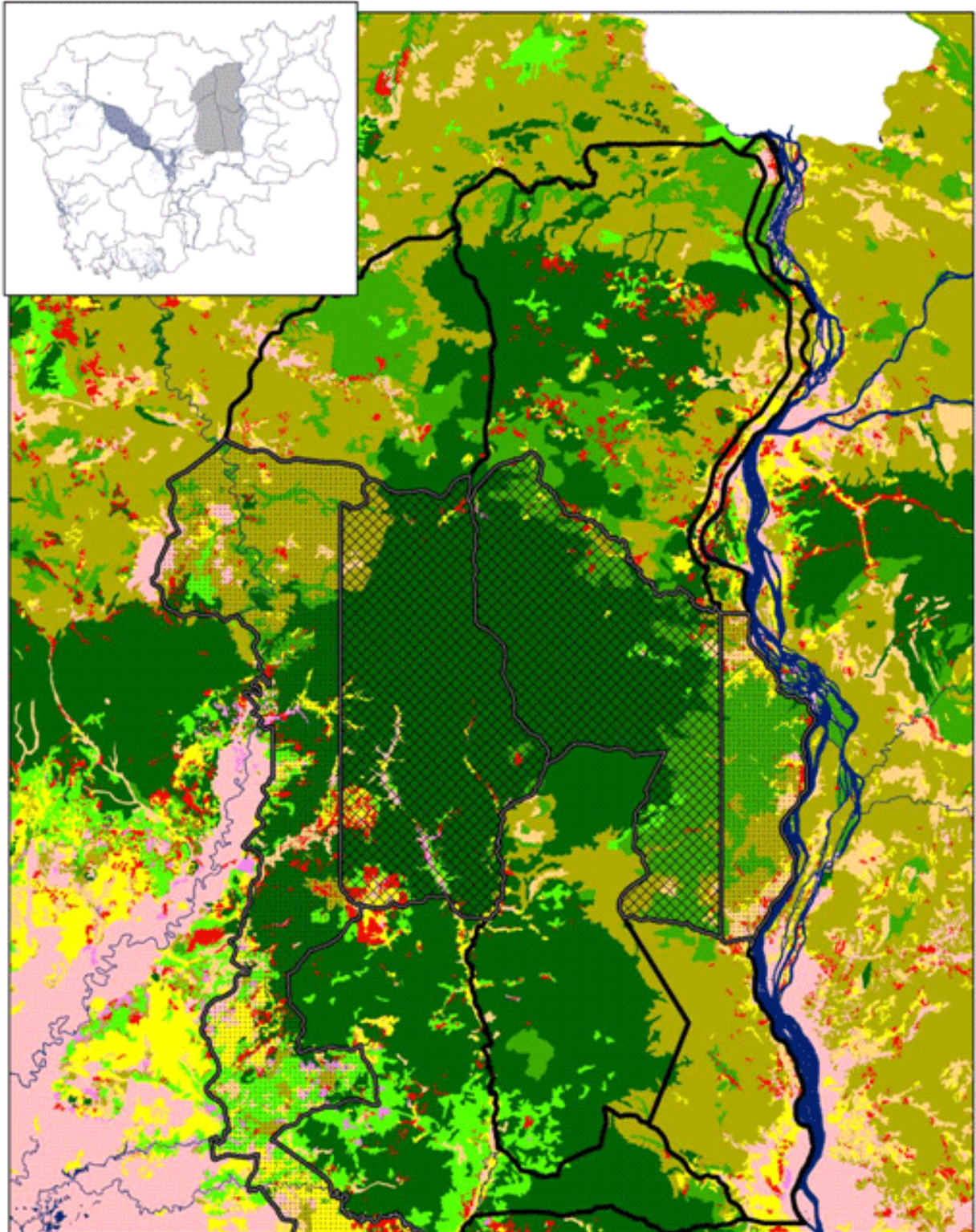


## Roster of Key Biodiversity Areas

- |                             |                                       |                                     |
|-----------------------------|---------------------------------------|-------------------------------------|
| 1 Ang Tropeang Thmor        | 15 Koh Rong Archipelago               | 30 Sesan River                      |
| 2 Bassac Marsh              | 16 Koh Tang Archipelago               | 31 Snoul / Keo Sema / O Reang       |
| 3 Bassac Marsh              | 17 Lomphat                            | 32 Sre Ambel                        |
| 4 Boeung Chhmar / Moat Khla | 18 Lower Stung Sen                    | 33 Stung / Chi Kreng / Kampong Svay |
| 5 Boeung Prek Lapouv        | 19 Mekong River from Kratie to Laos   | 34 Stung / Prasat Balang            |
| 6 Boeung Veal Samnap        | 20 Mondulkiri / Kratie Lowlands       | 35 Stung Kampong Smach              |
| 7 Central Cambodia Lowlands | 21 Northern Santuk                    | 36 Stung Sen / Santuk / Baray       |
| 8 Central Cardamoms         | 22 O Skach                            | 37 Upper Srepok Catchment           |
| 9 Chhiep                    | 23 Phnom Aural                        | 38 Upper Stung Sen Catchment        |
| 10 Chhnuk Tru               | 24 Phnom Bokor                        | 39 Veal Srongae                     |
| 11 Dei Roneat               | 25 Phnom Samkos                       | 40 Virachey                         |
| 12 Kampong Trach            | 26 Preah Net Preah / Kra Lanh / Pourk | 41 Western Siem Pang                |
| 13 Kirirom                  | 27 Prek Taek Sap                      |                                     |
| 14 Koh Kapik                | 28 Prek Toal                          |                                     |

## Appendix 2.

Proposed Conservation core zone of Prey Long covering two forest concessions is shown as hatched area. It covers 283,000 ha. The area is estimated to be able to generate 1-5 million USD/year in REDD payments. Dark green areas: evergreen lowland forest. Lighter green: mixed deciduous forest. Brownish: deciduous forests. Red areas: Cleared within past 10 years. Mekong River to the left.



# Appendix 3.

Map covering proposed core zone to the south of Spong village. Occurrence of the rare evergreen swamp forests according to local guides are shown in red outline. Swamps that have been surveyed are shown in red fill in colour. No villages are located within the core zone but an estimated 250.000 persons live in villages bordering Prey Long. The majority belongs to the indigenous group called the Kuys. Prey Long is a primary watershed upon which an estimated 700.000 thousand people depend for irrigation. The swamp forests of Prey Long plays a significant role in regulating water and sediments flowing into Tonle Sap and Mekong River.

