Reduced Emissions from Deforestation and Degradation in Seima Protection Forest, Cambodia

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Convention

The project uses the India-Thailand 1960 (also called Indian 1960) datum throughout. This datum has been a long-established standard for the SPF project, chosen for conformity with topographic maps widely used by the field teams.

1 GENERAL

1.1 Summary Description of the Project (G3)

The Seima Protection Forest (SPF) covers 292,690 ha. It is located in eastern Cambodia, mainly in Mondulkiri Province with a small area extending into Kratie Province. The REDD project area covers 180,513 ha of forest in the SPF Core Protection Area. The SPF was created by a Prime Ministerial Sub decree in late 2009. This upgraded the conservation status of the former Seima Biodiversity Conservation Area, which operated during 2002-2009. The site is part of the ancestral homeland of large number of ethnic Bunong people, for whom the forest is a key source of income and central to their spiritual beliefs. The area is also a meeting place for two important ecoregions – the Annamite Mountains (notable for high levels of local endemism among evergreen forest species) and the lower Mekong dry forests (which are crucial for the survival of many species typical of lowland deciduous forests). There are 41 Globally Threatened vertebrate species recorded in the project area (including 4 Critically Endangered and 14 Endangered). Many of these occur in globally or regionally outstanding populations, including Asian Elephants, primates, wild cattle, several carnivores and birds such as the Giant Ibis and Green Peafowl.

The SPF is currently under threat from accelerating forest clearance for agriculture together with unsustainable resource extraction (including hunting, logging and fishing). These activities harm both biodiversity and local forest-dependent livelihoods. Current drivers of these direct threats include improved road access, population growth, weak law enforcement and governance frameworks, limited recognition of the value of biodiversity and environmental services and rising market demand for both wild products and agricultural produce. The development of mines and agro-industrial plantations could also become potential future deforestation drivers if the area lacked full protection by the government. The illegal selective harvesting of rare Luxury grade tree species is a serious law enforcement issue at the site, as elsewhere in Cambodia, but has negligible long-term effect on carbon stocks.

Since 2002, the Forest Administration (FA) has collaborated with the Wildlife Conservation Society (WCS) and other local NGO partners to develop management systems for the SPF, both to conserve and restore the biodiversity values and to protect the livelihoods of local people. The conservation project has a holistic approach with four direct interventions: strengthening legal mechanisms and political support, direct law enforcement, strengthening community natural resource management and developing alternative livelihoods. Effective law enforcement is essential as it underpins all other activities. The sustained investment in supporting land titling for all indigenous communities in the landscape is particularly notable as it protects livelihoods and land rights while also forming a strong basis for cooperation in project implementation.

Conservation interventions prior to the REDD project have been on a fairly limited scale. Law enforcement activities have been successful in moderating (but not preventing) major threats across some parts of the SPF, moderating deforestation rates and allowing several key wildlife species to persist in large populations. This limited level of intervention been assumed to continue as part of the future baseline scenario. However, it falls well below the level needed to match the scale of the threats. Most threats remain severe and are increasing in scale and diversity. Deforestation rates and logging have increased, at least one flagship species (Tiger) has been lost from the reserve and declines are suspected for other species. Boundary demarcation, effective patrolling, community outreach, alternative livelihoods activities etc have been implemented in only a minority of the reserve. The effectiveness of conservation management is severely constrained by insufficient, irregular and declining funding and competition with other land-uses. Hence sustainable financing from carbon revenue for the site is essential to enable conservation action to be expanded and sustained in the long-term. It will allow the Royal Government of Cambodia and its NGO partners to expand activities to match the level of threat; ensure long-term support by covering operating costs; and generate financial incentives for conservation at local and national level.

The project benefits from strong, sustained political and donor support, a very open and collaborative, stable, long-term government/NGO partnership, the presence of highly committed individuals in leadership positions, recognition that effective, equitable law enforcement is the foundation for all other interventions and a willingness to try innovative techniques. Piloting of techniques since 2002 has identified successful approaches to many of the key challenges that the reserve faces, and with the addition of adequate financing, comprehensive and effective management can be put in place.

A more detailed description of the project's objectives and activities can be found in Section 2.2. The project aims to achieve joint validation against the Verified Carbon Standard (VCS) and the Climate, Community and Biodiversity Alliance Standard (CCBA). The chosen VCS methodology (VM0015) is described in Section 4; for simplicity it is referred to throughout the text as 'the methodology'.

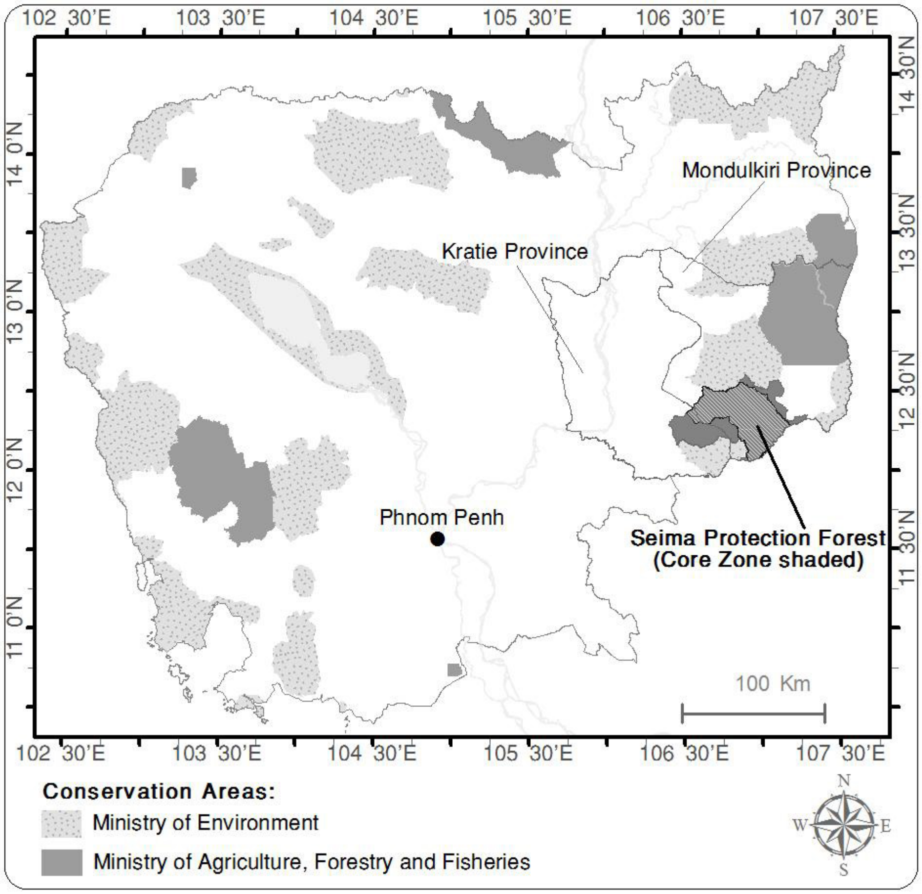
1.2 Project Location (G1 & G3)

The project takes place almost entirely within the Seima Protection Forest[1], which lies mainly in Mondulkiri Province with some sections extending into Kratie Province. The site abuts the Vietnamese border and is bisected by Cambodian National Route 76. The SPF headquarters lie at the south-western entrance to the reserve in Keo Seima District at 106°55'15.7"E 12°8'13.109"N.

The methodology requires the definition of several non-overlapping management zones, as described in detail in Section 4.4 and summarized here. The ***project area*** (which is the area from which credits will be generated), comprises those parts of the Core Protection Forest Area (as defined in Subdecree 143; 2009) that were forested as of the project start date, with the exception of small areas along the western margin excluded for technical reasons. The ***leakage belt*** encompasses adjacent areas of forest into which the project might risk displacing some deforestation activities. The ***leakage management area*** where selected livelihood improvement activities will take place comprises the non-forest, agricultural areas used by the participating villages. Together these three zones constitute the ***project zone*** which must be defined under the CCB Standard. Figure 1.1 shows an overview of the location of the project area; for a detailed map of all zones please refer to Section 4.4. The location of specific activities is described in Annex 2.1.

[1] Its full legal name is the *Seima Protection Forest and Biodiversity Conservation Area*

Figure 1.1 Project Location



Topography

The SPF and its surroundings form a topographically diverse landscape ranging from 60-750 m asl. The lower parts in the north and west of the project area lie in the Eastern Plains. Further east, the area climbs in elevation to the Sen Monorom plateau, forming the south-western extremity of the Annamite mountain range, one of Asia's great centres of endemism.

Soils

Soils are of moderate to high potential fertility on the younger rocks associated with the plateau, while the lowlands are mostly of low to moderate fertility except for pockets of alluvial soil (SCW 2006).

Hydrology

Two medium-sized tributaries of the Mekong drain most of the area whilst the southernmost valleys drain into the Dong Nai river system in Vietnam. Many of the rivers cease to flow during the prolonged dry season. The plains are characterised by hundreds of small seasonal grassy wetlands and pools ('trapeangs' in Khmer) dotted across the forest.

Climate

The climate is tropical monsoonal: the dry season from November to April with north easterly winds and the wet season from May to October with south-westerly winds (SCW 2006). Total annual rainfall is 2200-2800 mm at the SPF headquarters, higher on the plateau and probably lower in the plains [2].

[2] Combined results from WCS/FA and Nomad RSI (unpublished).

Over 85% of rain at the headquarters falls during May-October; December-April typically record less than 100 mm of rain per month and hence there are typically 5 'dry' months.

1.3 Conditions Prior to Project Initiation (G1)

This section covers four topics:

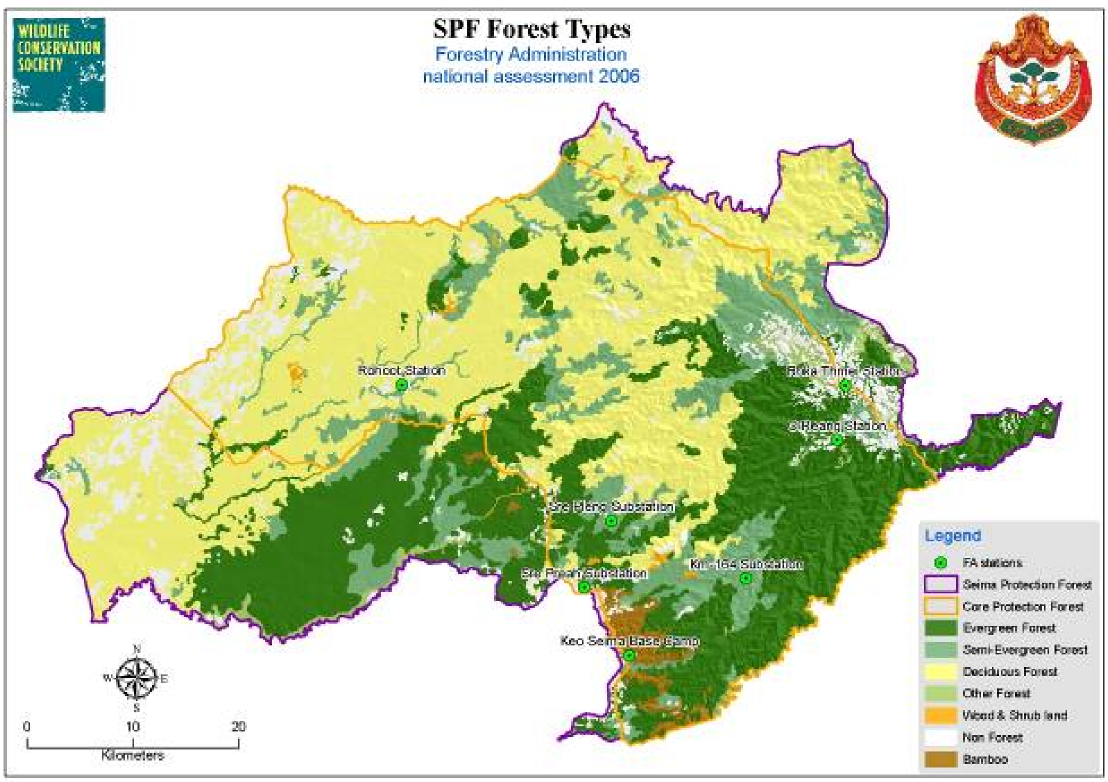
- the vegetation of the project area,
- the communities present and the land tenure situation
- the biodiversity of the project area
- the presence of High Conservation Values (both biodiversity and social values)

A more detailed stakeholder analysis can be found in Section 2.7.

Vegetation in and around the project area

In SPF studies have found a spectrum of forest types from fully deciduous to almost fully evergreen (e.g Walston *et al.* 2001, Zimmermann and Clements 2003), broadly becoming more open and deciduous from south-east to north-west but with the types forming a complex mosaic believed to reflect climate, altitude, edaphic factors and varying history of human disturbance. Different typologies can be imposed on this variation for different purposes (e.g. Rundel 1999, Tani *et al.* 2007). Under one commonly used national system based on floristics, phenology and structure the Seima forests mostly fall within four broad classes : Deciduous, Semi-evergreen, Evergreen and Bamboo Forests (FA 2007). These broad types, and the rarer types also present, are described below. When the carbon stocks of these forests are analysed it is found more efficient to group them into two broader forest classes with relatively uniform stocks as described in Section 5.3.

Figure 1.2 Vegetation types in the SPF according to the Forest Cover Assessment (2006)



Denser forest types

Overall, the Evergreen, Semi-evergreen and Bamboo forests in SPF each have high tree species diversity with a wide overlap in species lists and a generally similar range of tree forms, including many tall canopy and emergent species, often bearing buttresses. Trees heights of 35-55 m are common.

Evergreen forest: Evergreen forests are usually multi-storied forests where trees maintain their leaves during the whole year. They comprise the lowland tropical rain forests, the hill evergreen forests and the dry evergreen forest and along streams and rivers (gallery forests). Fires are very rare.

Semi-evergreen forest: Semi-evergreen forests contain variable percentages of evergreen and deciduous trees, the percentage of evergreen trees varying from 30% to 70%. Semi-evergreen forests continue to appear evergreen throughout the year, even when the percentage of deciduous trees is high. In SPF this type often has a high proportion of by the tall, pale-barked deciduous tree *Lagerstroemia calyculata* (Lythraceae; see cover picture). Another significant species is the massive evergreen emergent *Dipterocarpus alatus* (Dipterocarpaceae). Fires are very rare.

Bamboo: Areas dominated by tall tree bamboos, with or without trees. Bamboo areas taller than 5 m are included in the national definition of forest under the Marrakech Accords. In SPF the bamboo forests often contain a significant number of large trees and have quite high carbon stocks. Some bamboo stands in SPF are evidently signs of recent disturbance but others were already present on topographic maps from the 1960s and appear to represent long-term stable communities.

More open forest types

Deciduous forest: Deciduous forests comprise the Mixed Deciduous and Deciduous Dipterocarp forests. Deciduous forests drop their leaves more or less completely during the dry season and low-intensity understorey fires are frequent. Mixed Deciduous forest are floristically a depauperate version of semi-evergreen forest, often dominated by *Lagerstroemia calyculata*, with an understorey dominated by bamboo and some rattan but rarely much grass. Mixed Deciduous forests are sometimes of similar stature to semi-evergreen forest. Deciduous Dipterocarp forests naturally have an open character and are sometimes described as savanna forest. They have a small number of dominant species and tend to be of lower stature (typically 20-35 m). Individual stands usually have rather uniform structure dominated by just 2-3 species in any one location, but several different stand types can be found across the landscape. An undisturbed Deciduous Dipterocarp forests may have a crown cover of only 20-40%, an open understorey dominated by grass or herbaceous bamboos and no middle storey except along drainage lines.

'Other forests': In the project area and broader reference region this category mainly includes regrowth and stunted forests. Stunted forests grow very slowly because of poor site conditions on hydromorphic soils and rock outcrops. Heavily disturbed forest like mosaics of forest, regrowth, and cropping, corresponding to shifting agriculture in which the percentage of forest is more than 40%, and areas of old regrowth and young secondary forest in the process of regenerating after clear cutting, are also included in this category.

Wood and shrub land evergreen/dry: Wood and shrubland is a mixture of shrubs, grass and trees, the trees cover remaining below 20 percent. As the national forest definition includes land with a crown cover above 10%, much land in this category must be classed as forest for purposes of a REDD project. This class can be found mainly on shallow soils, on the top of mountains under climax conditions or as a result of non sustainable land use.

Most of the vegetation in the project area is in good or excellent condition, as shown by the assessment of carbon stocks (Section 5.3). However there have been some significant human impacts, as summarised here and discussed in more detail in Annex 4.3. The landscape has historically has rather low population densities (Evans *et al.* 2003), with near total depopulation during much of the 1970s and 1980s (Evans 2007) and poor road connections until the very recent past. There has thus been rather limited biomass harvesting by local communities, primarily for housing and firewood. This has only affected forest structure very close to villages, often in areas that have subsequently been deforested anyway.

Long rotation swidden cultivation has converted some mature forest to fallow, especially in and before the 1960s when tiny settlements were widely scattered across the denser forest parts of the landscape. Many of those pre Khmer Rouge fallows have now reverted to tall forest with >50 years of growth. Relatively few new fallows were created between the reoccupation of the upland villages through the 1990s, the opening up of new fields and the arrival of cashew (a cash crop that can be grown in place of fallowing) after about 2002. Given the trends towards agricultural intensification we treat these scattered new fallows as a transient element of the non-forest land cover class.

The most significant drivers of degradation have been episodes of larger scale mechanised logging (Walston *et al.* 2001). Local reports indicate that there was scattered, locally heavy logging during the 1960s (by Khmer forces) and 1980s (by Vietnamese-backed teams), targeting clumps of valuable species including koki *Hopea odorata* and beng *Afzelia xylocarpa* and leaving the landscape criss-crossed with old logging tracks that have facilitated subsequent illegal activity. In 1994 the area became part of the Samling International Chhlong logging concession. Organized commercial-scale operations took place in what is now the project area during only three dry seasons, 1997-1999, mainly in areas south of National Route 76, before the concession was mothballed as part of a national moratorium that has yet to be lifted. The scale of legal and illegal harvests during this period have not been well quantified, although Evans *et al.* (2003) made an estimate of losses for resin trees (mainly *Dipterocarpus alatus*) based on interviews with the traditional owners. Densities of desirable species were apparently relatively low as a proportion of the total stand in many areas and this has protected large areas of forest from excessive damage. Significant regeneration has also taken place in the subsequent decade. Nonetheless the evidence of these logging activities is still visible in patches of partly-degraded forest, for example around the former logging road network south of the km 164 guard station. Since the end of the Samling operations the main form of logging has been the illegal selective harvest of a few species Luxury grade trees (Annex 4.3), all of which occur scattered at low density, usually as solitary trees. This logging has caused widespread slight degradation which usually appears to be made good by ingrowth of other species.

Understorey fires affect a percentage of the deciduous forests each year. This is not believed to cause degradation of the vegetation, as it is a long-established feature practice and these forest types are considered highly fire-adapted (Rundel 1999, Stott 1984, 1988).

Participating communities

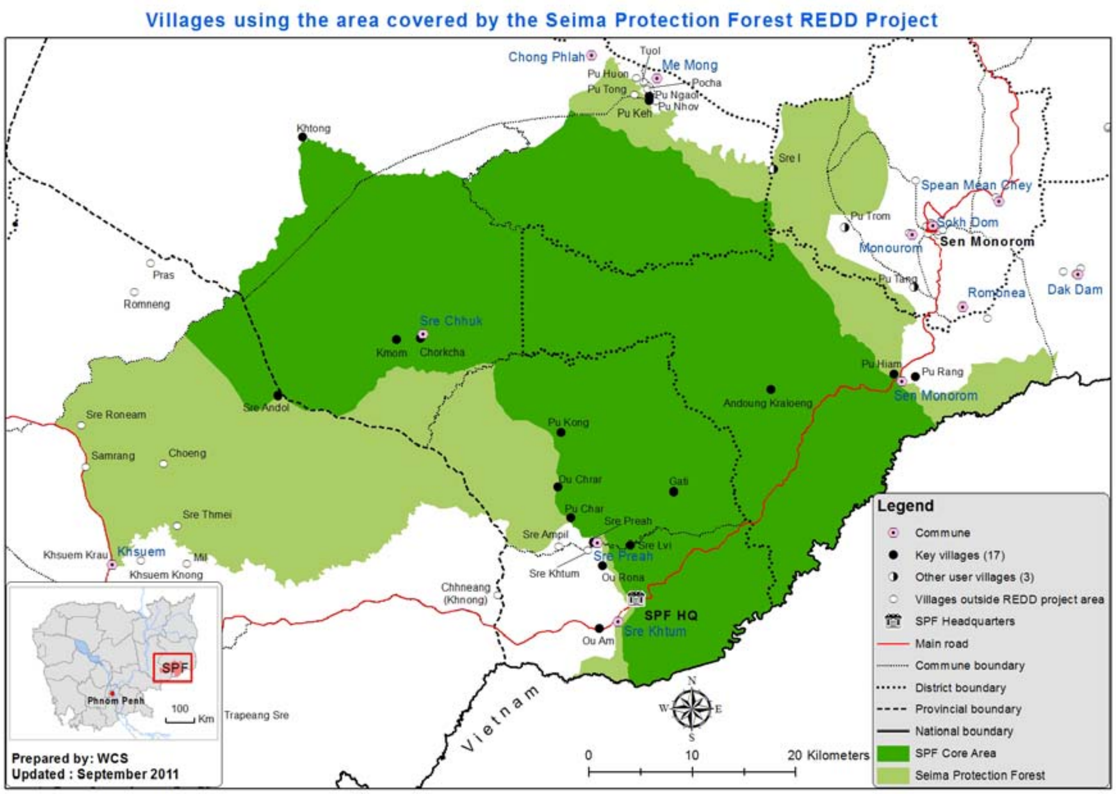
Administrative units

Table 1.1 and Figure 1.3 summarise the administrative units relevant to the project. Commune Councils are the lowest elected level of government in Cambodia; village chiefs are appointed by the Ministry of Interior. Surveys have determined that 20 villages are potentially affected by the project and are termed *participating villages*. They include 17 *key villages* (those with farmland or residential land inside the Core Protection Area) and 3 *other user villages* (those documented to have regular, significant forest use in the Core Protection Area but no agricultural or residential land inside). In the key villages, the whole village is involved in most aspects of the project, since most or all families are users; in the 3 other user villages project activities are focused more on those families identified as being regular users of the project area plus relevant village officials.

Table 1.1 Administrative units relevant to the project

Province	District	Commune	Key villages	Other user villages
Mondulkiri	Keo Seima	Sre Khtum	O Am, O Rona, Sre Lvi	
		Sre Preah	Sre Preah, Gati, Pu Char, O Chrar, Pu Kong	
		Sre Chhuk	Chakchar, Kmom, Sre Andaol, Sre Khtong	
		Memong	Pu Keh, Pu Ngaol	
	O Rang	Sen Monorom	Andoung Kraloeng, Pu Haim, Pu Rang	
	Sen Monorom	Romonea		Sre I, Pu Trom, Pu Tang
1 province	3 districts	6 communes	17 key villages	3 other user villages

Figure 1.3 Participating villages in the SPF REDD project



The words 'village' and 'settlement' are given precise, distinct meanings in this project document. A **village** is an administrative village – that is, a settlement or group of settlements overseen by a single official village chief (in Khmer, *phum*). A **settlement** is a discrete cluster of houses within an administrative village - something that looks like 'a village' to the casual observer. In Mondulkiri the various settlements in one administrative village are often several km from one another. Settlements often but not always correspond to administrative sub-villages (in Khmer, *krom*). Communes, villages and settlements are often given the same name. In this document, it can be assumed the whole administrative village is implied unless specified otherwise.

Official village centres have been mapped by the Department of Geography in a nationally available dataset dated 1999. In and near the SPF individual settlement locations have also been mapped and changes monitored (Evans and Delattre 2005, Evans 2007, Pollard and Evans 2009).

Ethnicity

The project zone is a traditional homeland for two indigenous ethnic groups and supports many people from Cambodia's dominant ethnic group, the Khmers. The main indigenous ethnic group is the **Bunong** (often spelt Phnong), who are members of the Mon-Khmer language group (Bourdier 2009). There are also a few **Stieng** households, who mix freely with Bunong families and have broadly similar appearance, customs, spiritual beliefs and traditional preferred livelihoods. Since the practical differences are so slight in most contexts the less numerous Stieng are grouped with the dominant Bunong in most project activities as 'indigenous people'; however when differences important to the communities are detected during field activities these are taken into account by the project team.

The languages of these groups are not traditionally written but a Bunong alphabet has recently been developed and is being taught in Mondulkiri. The Bunong are the largest ethnic group in Mondulkiri and also occur in small numbers in Ratanakiri and Kratie. The same group also occurs in neighbouring Vietnam, where they are called the Mnong. The Stieng are found mainly in Kratie and marginally in western Mondulkiri. They also occur in neighbouring southern Vietnam, where they are called the Xtieng. Many officials in local government are Bunong.

Ethnic lowland **Khmers** are primarily recent migrants to the area (since 1998), although a few have been resident for much longer. Those arriving in the project area have come especially from Kampong Cham, Takeo, Prey Veng and Svay Rieng Provinces (Pollard and Evans 2009).

Other groups present in much smaller numbers include Raong and Kraol (both indigenous peoples from the Mon-Khmer group), Lao, and Vietnamese (many of them of the Kampuchea Kraom group from the Mekong delta, who are ethnically Khmer).

The approximate number of people in each ethnic group is shown in Table 1.2. Most Khmer people are in the village of O Am. When O Am is excluded the percentage of Bunong and Stieng in other villages is 87%.

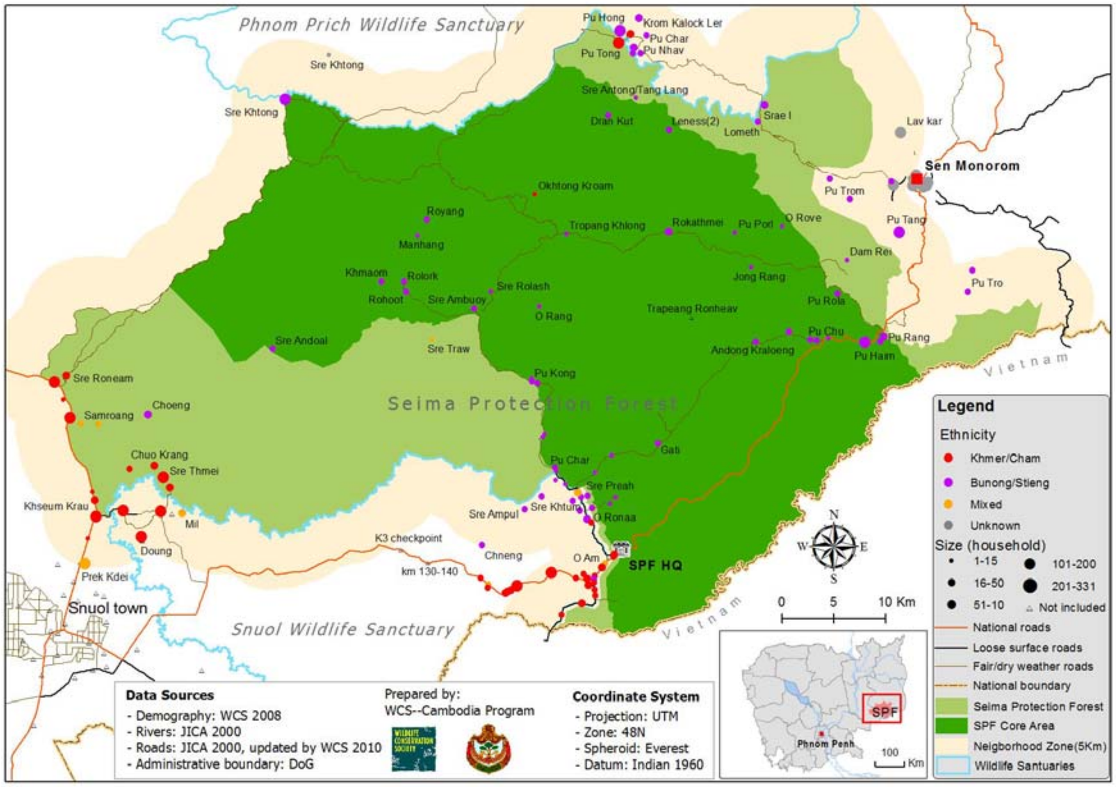
Table 1.2 Populations according to ethnic group, 2008

Participating villages	Bunong or Stieng	Khmer	Other*	Total
Households	1713	828	11	2552
Percentage	67%	32%	<1%	100%

Source: reanalysis of data in Pollard and Evans (2009)
*Lao, Vietnamese, Raong, Kraol etc

Figure 1.4 shows the pattern of village sizes and dominant ethnic groups. Note that most of the project area is occupied by Bunong-dominated settlements (purple spots), with Khmer-dominated settlements in or near the project (red spots) confined to the southwest margin. In typical, remote Bunong settlements almost everyone is ethnically Bunong except perhaps for one or two Khmer trading families running small shops. In contrast, Khmer-dominated villages tend to have grown up around existing Bunong settlements and so contain a minority of Bunong people intermixed.

Figure 1.4 Settlement size and ethnicity in the SPF



Demography

Official figures for each village, cross-checked by other surveys, provide the best population estimates for the area (Evans and Delattre 2005, Evans 2006, Pollard and Evans 2009). Table 1.3a summarises the estimated population as of 2010 and Table 1.3b summarises the age and gender profiles of these communities.Significant growth has occurred in these villages during the recent past, through a combination of migration and a surplus of births over death, as described by Pollard and Evans (2009).

Table 1.3a Population sizes of the twenty participating villages

KEY VILLAGES			
Commune	Village	Households (2010)	Population
Sre Khtum	O Am	733	3338
	O Rona	178	769
	Sre Lvi	33	160
Sre Preah	Sre Preah	128	589
	Gati	45	250
	Pu Char	72	350
	O Chrar	28	129
	Pu Kong	62	310
Sre Chhuk	Chakchar	112	571
	Kmom	72	376
	Sre Andaol	52	252
	Sre Khtong	174	841
Memong	Pu Keh	118	541
	Pou Ngaol	84	372
Sen Monorom	And. Kraloeng	114	466
	Pu Haim/Rokathmei	316	1327
	Pu Rang	94	414
Total	**17**	**2415**	**11055**
OTHER USER VILLAGES			
Romonea	Sre I	105	450
	Pu Trom	135	622
	Pu Tang	170	752
Total	**3**	**410**	**1824**
Grand total	**20**	**2825**	**12879**

able 1.3b Population profiles of the twenty participating villages

KEY VILLAGES								
Commune	Village	Male	Female	Age 0-6	Age 7-17	Age 18-35	Age 36-60	Age 60+
Sre Khtum	O Am	1707	1631	924	877	782	636	119
	O Rona	401	368	139	204	216	159	51
	Sre Lvi	102	58	41	43	44	27	5
Sre Preah	Sre Preah	290	299	122	165	159	122	21
	Gati	114	136	58	57	45	82	8
	Pu Char	177	173	101	88	91	61	9
	O Chrar	67	62	44	24	29	28	4
	Pu Kong	153	157	80	90	86	45	9
Sre Chhuk	Chakchar	293	278	118	186	151	100	16
	Kmom	178	198	72	108	125	60	11
	Sre Andaol	124	128	64	80	55	46	7
	Sre Khtong	432	409	224	221	231	147	18
Memang	Pu Keh	268	273	142	152	140	93	14
	Pu Ngaol	175	197	107	83	85	79	18
Sen Monorom	Andoung Kraloeng	259	207	136	97	83	113	37
Sen Monorom	Pu Haim	658	669	245	267	394	366	55
	Pu Rang	203	211	73	147	116	64	14
Total		**5601**	**5454**	**2690**	**2889**	**2832**	**2228**	**416**
OTHER USER VILLAGES								
Romonea	Sre I	224	226	133	125	95	80	17
Romonea	Pu Trom	316	306	129	217	157	102	17
Romonea	Pu Tang	389	363	203	211	170	143	25
Total		**929**	**895**	**465**	**553**	**422**	**325**	**59**
Grand total		**6530**	**6349**	**3155**	**3442**	**3254**	**2553**	**475**
%		**51%**	**49%**	**24%**	**27%**	**25%**	**20%**	**4%**

In the early 1970s most of the population of the 20 villages (then almost entirely made up of Bunong families) was relocated out of the area during the Khmer Rouge regime, with survivors and their children returning progressively as security improved during 1979-1998 (Evans 2007). People moved to their original home settlements or others nearby, depending on local circumstances. Rokathmei (an outlying settlemenr of Pu Haim village) and the settlements in Sre Chhuk commune were eventually re-occupied only around 1998, after which no other major settlements were re-established, although movements between established villages continued, as did inward migration to the landscape. Sre Ambouy (part of Chak Char village) was set up around 1998 by ethnically Bunong demobilised Khmer Rouge soldiers.

The large Khmer population of O Am village is a more recent phenomenon, having grown up through in-migration, with the migrants illegally grabbing land inside Snoul Wildlife Sanctuary and SPF[3]. A number of driving factors have been involved over time. Initially this included employment opportunities stemming from logging concession activities, and the demobilisation of around 200 ex-Khmer Rouge families here in 1998 (Degen *et al.* 2004). Subsequently road improvements, ineffective enforcement of forest protection laws by the local authorities and other factors have promoted continued growth.

Today settlements are mostly small, ranging in size from 12 to 1,598 people in 2006, median 161 or about 30 families (Evans 2007). Most of the larger settlements are at the margins of the SPF, in the Khsim, O Am-Chneng, and Memong-Chong Plas areas, and in these three areas neighbouring settlements are close together or almost continuous. By contrast, most of the settlements in the interior of the project area have only 50-250 people (10-50 families), sometimes fewer, and are scattered 5-15 km from each other.

Social features of Bunong villages[4]

Many Bunong in the area continue to live a mainly traditional lifestyle as outlined below. Others, especially those near main roads or in close contact with Khmer settlers (especially in O am village), have altered parts of their lifestyle to more closely match lowland Khmer people. Some have converted to Christianity which has also reduced their adherence to their traditional culture.

A traditional Bunong household is typically made up of a couple, their children (including those who have married but not yet moved out) and any surviving parents who are too frail to live alone. Household members jointly farm their land and mostly share food and income. Many of the other households in a typical settlement are closely related by blood or marriage. There are strong traditions of sharing and interest-free loans between family and close neighbours, providing a key livelihood coping strategy and serving to reduce some of the apparent disparities in income and wealth between households. Households tend to have two houses, a permanent one in the main settlement and a smaller one at the fields, which may be a few km from the village, where people often sleep and eat in the farming season. Nowadays people rarely dress in traditional costumes but in remote areas some still build their traditional style of low-walled house.

Bunong people are mostly animist, believing in powerful spirits that inhabit a wide range of natural objects or sites. This, and the economic dependence on natural resources, has built strong cultural ties to the land and forest. Many ceremonies are observed to ensure good relationships with these spirits, including sacrifices and libations, and it is believed that they communicate with humans through dreams. Each settlement has a small number of respected men who are considered elders, including one or more who have particular expertise in linking to the spirit world and performing ceremonies. These elders traditionally had a strong role in maintaining customs, adjudicating conflicts, deciding farming sites and leading the community in other ways. This role, though still important, has greatly declined in many villages, due to the dominance of the national government structures (village chief etc.) and the social turmoil of past decades.

[3] See Table 1.4 for a discussion of the current status of illegally grabbed land.

[4] This section is based mainly on studies by McAndrew et al. (2003), Evans et al. (2003), Richardson (2003), Ironside (2004a), ICC (2003), Degen et al. (2004) and Drury (2005) which together cover a broad cross-section of villages in the project zone.

Formal, externally recognised community-based organisations have recently been set up in some villages, both indigenous and Khmer, sometimes building on traditional structures, and usually with the assistance of NGOs and/or government agencies (Pollard and Evans 2009, WCS 2009). There is generally very little formal organisation or collective action at levels above the village, either traditional or modern, except for the government structures. However, some individuals are linked into national community forestry networks or human rights activist networks.

Even the most traditional village has many connections to the outside world. The history of displacement means that many adults have lived in other places, and some have travelled widely as members of the armed forces. There are generally friendly relationships between settlements, fostered by the extensive family connections and the low historical population densities leading to low resource competition. The market economy reached every settlement long ago, as evidenced by the high, prolonged involvement in resin-tapping for trade. Many villagers are in debt to traders.

Fluency in the spoken Khmer language is variable, being higher amongst adult men and lower among women, children and the elderly. Literacy and school attendance are very low, even if the settlement is lucky enough to have a school. Traditional doctors provide some herbal and spiritual healthcare but for serious problems a person might try to reach a government health centre or private clinic. Such treatment is poor and expensive and a serious illness can drive a family deeply into debt. Seasonal labour migration is rare among Bunong people in the project zone.

Social features of the Khmer communities

The Khmer communities in O Am, O Rona and Sre Preah villages are typical of recently established forest frontier settlements across Cambodia. Most people are Buddhist, attend local pagodas where available and view monks as community spiritual leaders. Most people live in nuclear families on or close to their farmland. The villages are larger and have lower levels of community cohesion or collective action than in traditional Bunong villages, due in part to the recent arrival of these families from many different provinces. Cultural ties to the land and to forest are naturally less than in long established Bunong villages. The Khmer population is better connected to distant parts of Cambodia, increasing linkages to markets and opening social channels for further migration.

Land-use

Overview of economic uses

Qualitative surveys reveal only a few common major livelihood activities across the SPF: rainfed lowland rice farming, upland rice farming, cash crop farming and resin-tapping in mature forest. These currently occur in predictable combinations depending on the topography, accessibility and ethnicity of each settlement (Evans 2007, Pollard and Evans 2009). In remote and hilly indigenous-dominated areas upland rice is combined with resin-tapping and a little cash cropping. In remote indigenous-dominated flat lowland areas lowland rice is combined with resin-tapping and a little cash cropping or upland rice. In more accessible lowland areas (especially those dominated by Khmers) cash crops tend to dominate, often in combination with lowland rice but little or no resin-tapping. Traditionally the lack of significant markets meant there was little interest in cash crop production before about 2002. As the road network has improved, some previously remote settlements have shifted recently to the cash-crop dominated model (Pollard and Evans 2009) and more, perhaps most, can be expected to do so in future.

A few settlements have reported other activities as being significant to many families in that location (Evans 2007, Pollard and Evans 2009) such as trading (in the central part of O Am), the production of bamboo incense sticks (near the main bamboo forest area; Mann Mouy 2010) and the collection of old military scrap metal (now ceased, but widespread briefly in 2005-2006). Many other smaller scale activities (handicrafts, labouring, extraction/processing of other NTFPs, service industries) are also important at particular times or for particular families, but are not dominant in any one locality. Indigenous people in particular have a highly diversified range of smaller livelihood activities linked to collection of forest products for subsistence or sale and based on their detailed ecological knowledge of the area.

Farming

The farming systems include many crops, with each farmer typically specialising in one or two but also growing a range of others. Of cash crops, cashew is planted most widely, with cassava, soy, rambutan and others only popular near to the main roads, due to transport constraints. At the time of writing cassava is clearly the dominant cash crop by area planted. Few productivity data are available but grower enthusiasm suggests that yields are attractive. Some plots of rubber have been planted in some areas on a small scale since 2008. Various other crops are also grown as minority components of the cash-crop system.

Upland and lowland rice productivity is low (typically around 1-1.5t/ha) with little or no irrigation and high losses in some years due to weather and insect pests. To cover annual rice shortfalls other starchy foods need to be bought, bartered or substituted by the collection of forest tubers. There are many other crops including cassava, yams, beans, corn, squashes and leaf vegetables, often inter-cropped with the upland rice or grown adjacent to lowland rice fields. Fruit trees are also increasingly grown.

Cash cropping can be very extensive or very small scale, depending on farmer preferences and population density. Upland and lowland rice fields tend to be scattered in small patches in the forest, sometimes several km from the nearest settlement, depending on availability of suitable soils. Historically upland rice fields were abandoned after 2-6 years and left fallow for 10-20 years before being cleared again, often but not always by the same family. Fewer and fewer fields are now fallowed, with most being converted to permanent crops, especially cashew, once rice production declines.

Most households keep 5-20 chickens, 1-2 pigs and possibly some ducks. If wealthy enough they may have a few cattle, buffalos or even an elephant. Larger stock are rarely eaten or sold but are kept as a store of wealth for special occasions or emergencies (e.g. a wedding or a serious illness). Cattle, buffalo and elephants are also used as draught animals.

Forest use - NTFPs and timber

A high proportion of total livelihood is drawn from the forest. Many products are used in the household (e.g. wood, vines, bamboo, vegetables, fish, wild meat and medicinal plants). Some forest products can also be sold. By far the most important in this landscape is liquid resin tapped from forest trees (mostly from mature *Dipterocarpus alatus*) the sale of which is a vital source of cash income, second only to rice farming in many settlements (Evans *et al.* 2003). The traditional system of ownership of individual trees makes this a reliable and sustainable source of income for participating families. Under this system almost all households own some trees (typically 10-100 or more) which they tap on a weekly cycle. The resin is sold to a middleman (often a Khmer shopkeeper from the settlement) who trades it to the Vietnamese border. In most of the landscape this trade appears to have begun after 1979. Prices have risen steadily in recent years. Resin trade networks cover the whole area with traders exporting large quantities of resin to Viet Nam or other parts of Cambodia. The resin transport network to remote villages is used for trading other products both legal (basic consumer goods) and illegal (e.g. wildlife).

Since 2006 the harvesting and home-processing of large stemmed bamboos has become important in some villages (e.g. O Am and O Rona), particularly amongst in-migrants from other parts of Cambodia who lack resin income as they do not own trees. The stems are split to form the core incense sticks, and are sold in large bundles to traders from Viet Nam (Mann Mouy 2010).

Trade in many other forest products tend to be driven by middlemen making specific orders on a sporadic basis – when there is a demand for rattan, live macaques, onkoit seeds (*Entada),* malva nuts (*Sterculia lychnophora*) and sleng fruit (*Strychnos* sp.) or some other product, villagers will typically go to collect as much as they can sell with little regard for sustainability.

Some timber harvesting by local communities in the landscape is illegal and trade-driven but some is permitted by law for house construction.

Fisheries

Fisheries in the SPF are small-scale by Cambodian standards but critically important for local livelihoods as they apparently supply a high proportion of protein needs, rather than wild or domestic animals as might be expected. A 2003 study in the Core Area of the SPF revealed that more than 50% of meals included fish, contrasting with less than 10% from other animal protein, most of that from domestic species (Richardson 2003). Most families in most settlements appear to fish regularly, usually catching fairly small amounts in ponds and streams. People sometimes go on long dry season fishing trips to productive locations. Fisheries are open access and declining partly due to destructive methods used by outsiders and a minority of local residents for trade.

Hunting

Wildlife hunting is common but much harder to quantify than fishing since hunting of rare species and hunting for trade are both illegal. Various studies in SPF have estimated that at least 20-70% of households engage in some hunting. Most of the hunting is for smaller species (eg monitor lizards, mouse-deer, porcupines) and are caught for consumption or trade, apparently in quite small quantities per family. Hunting of larger and high-value species (Red Muntjac, Sambar, wild cattle, pangolin, turtles) also takes place. This typically is not for consumption, but to sell meat or parts. Many people trade small amounts of small-bodied wildlife species and a few are involved in trade in large, high value species. Hunting of larger-bodied species is usually done by or in in cooperation with those with access to weapons, typically members of the armed forces.

Land tenure

Land in the project zone has varying legal status depending on its history and current use (Table 1.4; Figure 1.5; see also Oberndorf 2010). The project area is almost entirely Core Protection Forest which is a highly protected category within the Permanent Forest Estate, although the law still allows for a variety of customary economic uses. There are also now small areas of Indigenous Communal Title, which is explained in detail in a footnote to the table. In common with a high proportion of Cambodia's forest areas, parts of the project area are also overlain with mining exploration permits that do not in themselves confer ownership or use rights.

The leakage belt contains several other tenure categories, as set out in the table.

The project area and most of the leakage belt also lie within the area of the Samling International Ltd Logging Concession, which was issued in 1994 (see Section 3.2 for a fuller discussion).

Figure 1.5 Land tenure categories in the project area and leakage belt (as of 2010)

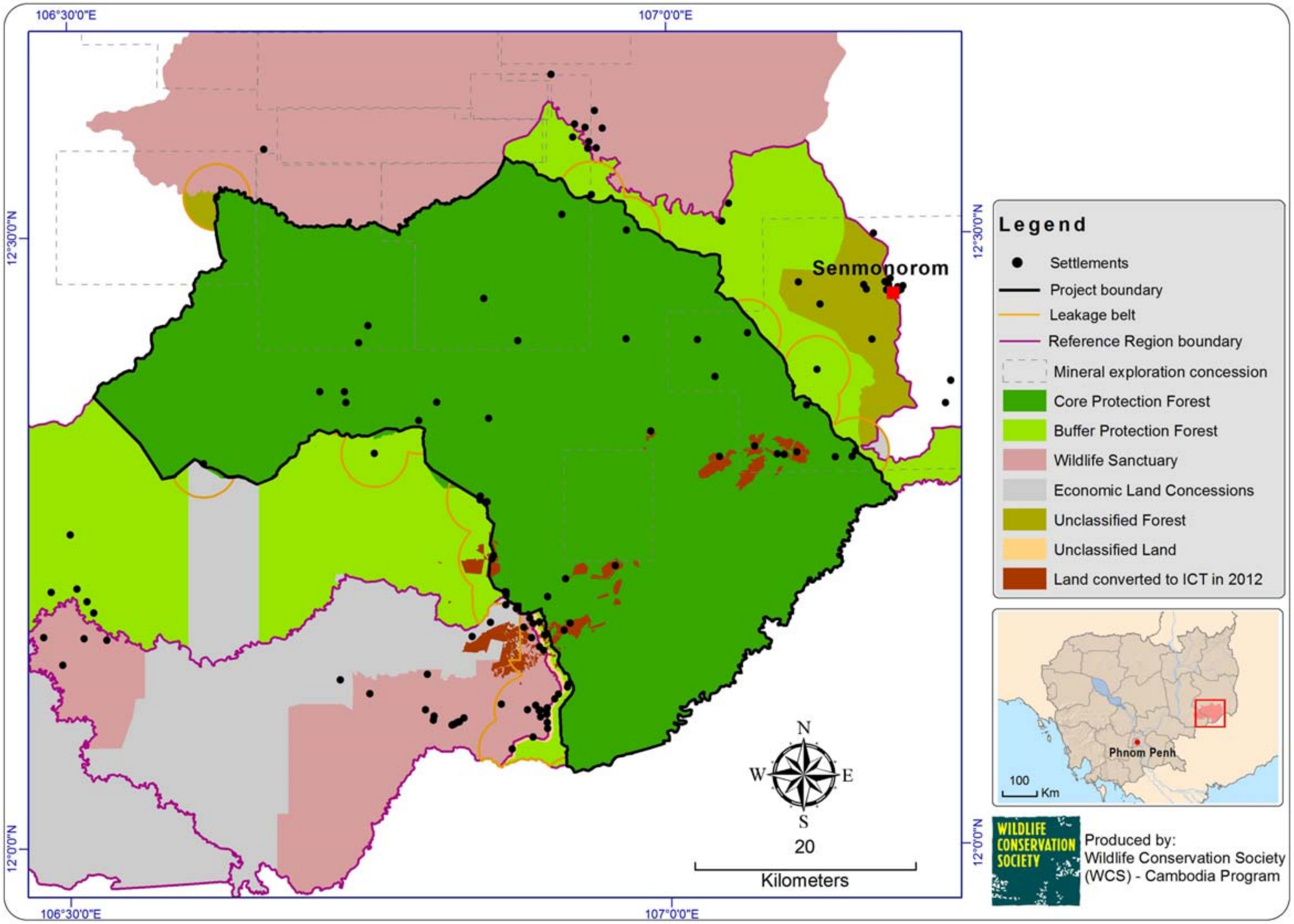


Table 1.4 Summary of legal categories of land tenure in the project zone

Category	Responsible^	Legal basis*	Project Area	Leakage Belt
Found in Project Area				
Core Protection Forest (State Public Land, Permanent Forest Estate)	FA	FL Art. 10 and Subdecree 143 (2009); see Note 1. Includes some areas potentially eligible for conversion to ICT (see below). Also includes some areas illegally cleared and hence subject to legal dispute (see Note 6 below).	The whole Project Area was classified as Core Protection Forest on the project start date. Small areas have now been reclassified as ICT.	None.
Indigenous Communal Title	Registered community	LL Arts 23-28. Owned by a community legal entity on behalf of the village; governed by traditional rules agreed during the titling process. Can include some forest (Note 2)	Since 2012 small areas exist around five villages with other villages in process and most of the remainder likely to do so. Potential extent covering forest land relatively small.	Several villages in process and most of the remainder likely to do so.
Mine exploration concessions	MIME + MAFF/MoE	ML Art. 11.5. Can co-exist with other legal designations; confers research rights and option to negotiate if a resource is found. No ownership/ management rights.	Five are known to overlap project area.	Four are known to overlap the project area.
Not in Project Area				
Buffer Protection Forest (State Public Land, Permanent Forest Estate)	FA	Defined by FL Art. 10 and Subdecree 143 (2009); see Note 1 for detail.	None	Present in some sections.
Unclassified forest areas (State Public Land, Permanent Forest Reserve, no specific management designation)	FA	Areas awaiting formal classification, but evidently part of the forest estate. See FL Art. 10. Customary use rights are protected; potentially available for ICT, Community Forests, logging concessions, Protected Forests or other uses.	None	Present in small areas to the north west and east of SPF.
Wildlife Sanctuaries (State Public Land)	MoE	Defined by PAL 2008 (notably Arts 7, 11-14 & 25-28) (Note 3).	None	Small sections of Snoul WS and Phnom Prich WS. Neither has been fully zoned but several SUZs created to allow large-scale economic concessions.
Economic Land Concessions (State Private Land)	MAFF + Company	See Subdecree 146 (2005) modified 2008. Essentially a long-term lease, does not confer ownership; requires conversion from State Public Land (Note 4).	None	Excluded from the Leakage Belt once they are issued, as they exclude unplanned deforestation.
Unclassified land	TBD (private?)	Outside all the above classes; status yet to be adjudicated (Note 5)	None	Some areas present e.g. a section of O Am village west of the SPF.

^ FA – Forestry Administration; MAFF – Ministry of Agriculture, Forestry and Fisheries; MoE – Ministry of Environment; MIME – Ministry of Industry, Mines and Energy
* FL - Forestry Law 2002; LL Land Law 2001; ML - Law on Mineral Resource Management and Exploitation 2001; PAL - Protected Areas Law 2008

Notes to Table 1.4

Note 1. The main difference set out in Subdecree 143 (2009) between the two zones is that Buffer Protection Forest allows for a somewhat higher level of economic development and extractive use - for example the Community-based Production Forestry pilot area lies in this zone although it has not yet been formally declared as such by MAFF. *Other legal sources*: rights to customary use set out in FL Art. 40; precise customary use rights and community zones will also be defined in the SPF Management Plan (FL Art. 23); ICT areas will be identified village by village following LL; Community-based Production Forestry is being piloted and so lacks a settled legal framework at present.

Note 2. ICT can include farmland, fallows, residential land, spirit and burial forests, according to the claims asserted by the community and the factual situation. This designation recognises the traditional management systems of these villages, whereby land is considered to be communally owned, although the products of the land are privately owned, and the concept of selling individual parcels, or of keeping ownership after leaving the village, is relatively new. It also recognises the vulnerability of this system to external pressures which can result in land alienation and serious livelihood impacts on weaker community members. These areas remain classified as PFR until community claims have been accepted by the MLMUPC, at which point they are reclassified to community ownership. Parts of the titled land are designated as State Private land whilst others are designated as State Public Land. The land cannot be sold in those parts registered as State Public Land and most communities set rules to forbid any sales. While the claims are being assessed, communities are permitted to continue with their traditional management systems in these areas.

Note 3. Wildlife Sanctuaries an be divided into four zones: Core, Conservation, Community, and Sustainable Use (SUZ); SUZ can include Community Protected Areas (CPA) and also large-scale economic concessions. It is not clear if ICT can be issued but it is presumed so. Core Zones have essentially zero human use, Conservation Zones permit limited extractive use, Sustainable Use zones permit more intensive use including certain kinds of commercial concessions and Community Zones permit agricultural and residential uses by community members, including the issuance of restricted forms of land title. Community Protected Areas are special management arrangements for sections of the Sustainable Use Zone that allow increased levels of extractive use based on approved management plans.

Note 4. Communities are generally prevented from using land within ELCs, although they may be allocated zones within the ELC boundary, for example to give access to established fields or spiritual sites.

Note 5. Land parcels that have been in uncontested use since before the passage of the 2001 Land Law are in most cases eligible to receive ordinary private land titles after adjudication, and this right may also seemingly be extended on a case-by-case basis to other parcels of land in use (e.g. those occupied after 2001, but uncontested).

Note 6. Illegal land clearance for agriculture has taken place in land of this category, although such land is not categorised at forest on the project start date and so is not a part of the project area. Dispute resolution procedures in accordance with Cambodia's legal framework are conducted by the Seima Protection Forest team and by other government stakeholders. In some cases, illegal settlers have been successfully removed from the cleared areas and the areas returned to the forest estate. In some others, high level government decisions have resulted in the cleared land being reclassified as private land and titles issued, whilst in the remaining areas the land remains temporarily occupied pending a resolution. Comparable outcomes are expected in areas that are cleared illegally after the project start date.

Biodiversity

The first known biological surveys of the project zone took place in 2000 (Walston *et al* 2001) and covered the southern portions. At that time much of the project zone was managed as a logging concession by Samling International. The survey focussed on large mammals and birds and revealed the importance of the area.

Following the commencement of conservation activities in 2002 a more systematic survey of selected key species was carried out in order to develop a biodiversity monitoring plan (Clements 2002). Since 2004 systematic collection of data has taken place annually which has yielded a great deal of information on the biodiversity of the project zone, and in particular the project area (e.g. O'Kelly *et al.* 2012). In addition to the annual monitoring, many other records of species have been collected by project staff, and by visiting researchers. These data are stored in a dedicated biodiversity database administered by WCS. Several taxon-specific surveys have also taken place in the project zone which have revealed more detailed information on the biodiversity of the area (see e.g. WCS/FA 2006a). As a result of these surveys the project zone is one of the best known areas in the country from a biological perspective.

SPF is unusual in south-east Asia in that it conserves large areas of both Annamitic evergreen forest and deciduous dipterocarp forests of the eastern plains, and the transition between the different forest types (Rundell 1999, Baltzer *et al.* 2001). This mosaic of forest types probably contributes to the high species richness in the area. To the end of 2010 334 bird species, 93 mammal species and over 60 reptile and amphibian species had been recorded in SPF (e.g. WCS/FA 2006a, Stuart *et al.* 2005, WCS/FA unpublished data; full species lists available on request). There are likely to be many more reptiles, amphibians and small mammals that have not yet been recorded. A preliminary survey of fish, based on interviews, was conducted by Degen *et al.* (2004) and preliminary botanical studies were made by MacDonald (2004a & b).

Species of global conservation concern

As of 2010 61 vertebrate species that are Globally Threatened, Near-threatened or Data Deficient (IUCN 2010) had been recorded in SPF (Table 1.5 below and Table 7.4).

Table 1.5 Number of species of global conservation concern present in SPF

Class	Number of species (number of species that are not yet confirmed, but suspected to occur, in brackets)					
	Critical	Endangered	Vulnerable	Near Threatened	Data Deficient	Total
Mammals		9 (2)	13	6	1	29 (2)
Birds	4 (1)	3	6	8 (1)		21 (2)
Reptiles	(1)	2	2 (2)	2		6 (3)
Amphibians			2	1	2	5
Fish		(1)			(2)	(3)
Total	4 (2)	14 (3)	23 (2)	17 (1)	3 (2)	61 (10)

The SPF (in particular the Core Protection Area) is especially notable for the conservation of several species groups:

- **Carnivores**: The SPF has an extraordinary richness of mammalian carnivores. To date 23 species have been recorded and several more are thought to be present. For example, the area is likely to have at least six species of wild cat. In 2000 the first ever photo of a wild Cambodian Tiger was obtained from a camera-trap in the SPF.
- **Primates**: The semi-evergreen and evergreen forests of southern Mondulkiri are internationally important for the conservation of primates. In 2010 the population of the Endangered Black-shanked Douc in the project area was estimated to be 15,100-35,300 individuals, probably the majority of the total world population (Rawson 2009). In addition an estimated 350-1700 Yellow-cheeked Crested Gibbons are present, a significant proportion of the world's population of this Endangered ape (Pollard *et al.* 2007, Rawson *et al.* 2009, O'Kelly and Nut Meng Hor 2010). There are also notable populations of five other threatened

primates including the Pygmy Loris (Starr *et al.* 2011) and Germain's Silvered Langur (Moody *et al.* 2011).

- **Deer, wild cattle and Asian Elephants**: The diversity of forest types, permanent rivers and water sources, and large numbers of mineral licks provides a highly productive landscape which can support high numbers of large herbivores. A recent survey found the population of Asian Elephants in the SPF to be 101-139 animals (Pollard *et al.* 2008). Together with groups in neighbouring protected areas it is one of the most important Elephant populations in the Lower Mekong Region. Gaur, Banteng, Eld's Deer and Sambar are important in themselves, and are also key prey species for large carnivores such as Dhole and Tiger. Good numbers of Banteng are found in SPF; photos of calves show that these are breeding successfully. Mondulkiri Province is thought to be home to one of the largest populations of Banteng in the world (IUCN 2010). Similarly it appears that Gaur numbers are stable and possibly recovering, and southern Mondulkiri may have one of the most important populations in Cambodia, and the region in general (IUCN 2010).
- **Galliforms**: SPF hosts globally significant numbers of three galliform birds. The Endangered Green Peafowl is seen regularly in most parts of the conservation area especially in open areas near to permanent water. The project area holds an estimated 150-700 individuals (O'Kelly and Nut Meng Hor 2010) and is part of what may be the last stronghold of this species in Cambodia (Goes 2010). The Orange-necked Partridge (Near threatened) was first recorded in the SPF in 2003. This Restricted-Range species was previously only known from a few locations in southern Viet Nam. Since then the bird has been seen and heard often. Although the size of the population is unknown it may be highly significant given the available area of its preferred habitat of bamboo-rich forest. The population of Germain's Peacock-pheasants in southern Mondulkiri is so large that it in 2005 it contributed to a change in the assessed status of the species from Endangered to Near-threatened (IUCN 2010).
- **Large waterbirds and Vultures:** Four Critically Endangered bird species have been recorded in the SPF: Giant Ibis, White-shouldered Ibis, Red-headed Vulture and White-backed Vulture (WCS/FA 2006a). These species have all been seen in recent years, mainly in the open forests in the west of the SPF (Bird *et al.* 2006). Although this sector has had relatively little survey effort, there have been multiple records of these species, and so it may prove to be of global importance for all them, in particular Giant Ibis. This area is also known to have breeding populations of Sarus Crane and Lesser Adjutant (both Vulnerable). White-winged Duck has been recorded on one river system and is reported to occur on several others.

There has been little botanical work carried out in SPF, but studies to date have shown that SPF has at least ten tree species that are listed on the IUCN Red List as Vulnerable, Endangered or Critically Endangered (Table 1.6).

Table 1.6 Globally Threatened and Near-threatened plant species confirmed in the project zone

Species	Local name	Conservation Status (IUCN 2010)*
Dipterocarpus turbinatus		CR
Dipterocarpus costatus		EN
Dipterocarpus alatus	Choeuteal tuk	EN
Dipterocarpus costatus	Choeuteal bangkouy	EN
Anisoptera costata	Phdiek	EN
Hopea odorata	Koki masao	VU
Dalbergia bariensis	Neang noun	EN
Dalbergia oliveri	Neang noun	EN
Dalbergia cochinchinensis	Kranhung	VU
Dialium cochinchinense	Kran lanh	nt
Afzelia xylocarpa	Beng	EN
Cycas siamensis		VU

*Cr = Critically Endangered En = Endangered Vu = Vulnerable nt = Low Risk/Near-threatened

Global Assessment Criteria

In recent years many conservation organisations have carried out global assessments of biodiversity. These exercises are designed to highlight areas of high biological diversity or regions that are highly threatened with destruction. SPF overlaps several of these, reinforcing the conservation importance of the area.

The SPF overlaps with **two** '**Last of the Wild**' areas identified in the Indo-Malayan Tropical & Subtropical Dry Broadleaf Forests biome. The Last of the Wild were identified by WCS in a global exercise that mapped the extent and intensity of human influence and then selected the ten least affected areas within each biome (Sanderson *et al* 2002a).

The southern, evergreen parts of SPF lie within the **South Viet Nam / Cambodia Lowlands Endemic Bird Area** (Stattersfield *et al* 1998). EBAs are defined as areas that contain a concentration of endemic bird species. This means areas that contain the entire breeding ranges of two or more restricted-range bird species (those with a breeding range less than 50,000 km^2). SPF has breeding populations of the 3 restricted-range bird species that characterise this EBA: Germain's Peacock-pheasant, Orange-necked Partridge and Grey-faced Tit-babbler.

The area also includes parts of **two Important Bird Areas** (IBAs) (Seng *et al* 2003). These are identified as being areas of high bird diversity, or with concentrations of endangered bird species, that are of high conservation importance. The southern parts of SPF are in IBA KH027 (Snoul / Keo Seima / O Reang) which is important for the conservation of Orange-necked Partridge, Siamese Fireback, Green Peafowl, White-winged Duck, and Great Hornbill, amongst other species. The northern deciduous dipterocarp sections of SPF are part of IBA KH026 (the Kratie / Mondulkiri lowlands) which is important for vultures, ibises, Sarus Crane and Green Peafowl.

The SPF includes parts of **two Global 200 Ecoregions**: **Annamite range moist forests,** and **Lower Mekong dry forests.** Ecoregions are large areas with relatively uniform climate that harbour a characteristic set of species and ecological communities. WWF identified about 200 of the most threatened of these globally which are defined as "outstanding representatives of the world's terrestrial and marine ecosystems" (Olson & Dinnerstein 2002, Baltzer et al 2001). Selection has been based on parameters such as species richness, species endemism, higher taxonomic uniqueness, unusual ecological or evolutionary phenomena and keystone habitats.

The conservation area lies within the **Indo-Burma Hotspot** (Myers *et al* 2000, Tordoff et al 2007). This is an area identified by Conservation International as a *biodiversity hotspot* with high levels of biodiversity and endemism and under high threat of destruction.

Southern Mondulkiri, including the SPF has been highlighted in two species level priority setting exercises. The area is part of the **Southern-central Annamites Tiger Conservation Landscape**. This area is classified as a Global Priority landscape offering the highest probability of persistence of Tigers over the long term (Dinerstein *et al* 2006). More recent assessments (Walston *et al.* 2010a, Lynam 2010, O'Kelly *et al.* 2012) have however determined that Tigers are now extirpated from the landscape. The area is still considered of high importance for long-term Tiger conservation as it represents part of the largest remaining block of deciduous dipterocarp forest in the region and one of the largest protected areas networks in mainland south-east Asia. The landscape therefore has high potential as a possible reintroduction site and is identified by Walston *et al.* (2010b) as a Potential Source Site.

The IUCN Asian Elephant specialist group is identifying range-wide priorities for elephants. The project area overlaps with a proposed **Asian Elephant 'core population'**, one of the highest priority landscapes for the conservation of Asian Elephants globally (S Hedges *in litt* October 2010). The Asian Elephant population in the project area is one of only two in the lower Mekong for which there is a robust population estimate. In addition this population is thought to be part of a metapopulation with neighboring areas, and as such is of regionally very high importance.

The importance of the SPF for the conservation of plants can be inferred from studies of neighbouring areas. Nearby Cat Tien National Park in Viet Nam has been identified as a centre of plant diversity, with an estimated 2,500 species of vascular plants, and has semi-evergreen and evergreen forest that is similar to those in the south of SPF. Yok Don National Park in Viet Nam is dominated by deciduous dipterocarp forest, with semi evergreen forest along river banks. This area is very similar to the northern and western parts of SPF and has also been identified as a centre of plant diversity. Yok Don has an estimated 1,500 species of vascular plants, many of which are unique to deciduous dipterocarp forest. Considering that SPF has large areas of forest that are very similar to both Yok Don and Cat Tien it is likely that SPF would also qualify as a **Centre of Plant Diversity** (WWF/IUCN 1995).

High Conservation Values

In the absence of a national interpretation the High Conservation Values of the project have been identified based on the Global HCV Toolkit (ProForest 2003). An assessment of which values are present in the project area was carried out by the project team (Pollard and Evans 2012). This assessment is based predominantly on existing studies and reports. In addition consultations with individual communities and multi-stakeholder discussions have been held to verify social values, and map their locations.

The assessment revealed that several values are present throughout the project zone (Table 1.7). Project activities have been developed to maintain or enhance these values (Section 2.4).

Table 1.7: Summary of High Conservation Values identified in the Project Zone

High Conservation Value	Details	References
HCV1: Forest areas containing globally, regionally or nationally significant concentrations of biodiversity values		
HCV 1.1: Protected Areas	The SPF Core Area is classified as a Protection Forest, a protected area managed by the Forestry Administration . Amongst the aims of the SPF are • *To protect, conserve and rehabilitate genetic resources of fauna and flora species which are globally threatened species;* • *To maintain and rehabilitate important ecosystems for habitats and breeding of all species and biodiversity resources.*	Subdecree 143 (2009)
HCV 1.2: Threatened and Endangered Species	41 Globally Threatened vertebrate and 10 Globally Threatened plant species have been confirmed from the SPF Core Area.	IUCN 2010. WCS/FA 2006a. WCS/FA data.
HCV 1.3: Endemic Species	3 restricted-range bird species are found in the SPF Core Area, consequently the area is part of the southern Vietnam/Cambodia Lowlands Endemic Bird Area. Yellow-cheeked Crested Gibbon and Black-shanked Douc are restricted to southern Vietnam and eastern Cambodia. Both are found in large numbers in the SPF Core Area One frog species currently known from only one river system in the SPF Core Area. The rattan *Calamus lateralis* is known only from the SPF Core Area and one other nearby site in Vietnam	Stattersfield *et al* 1998 Pollard *et al* 2007 Stuart *et al* 2006 Henderson 2009
HCV2: Forest areas containing globally, regionally or nationally significant large landscape level forests	The SPF Core Area can itself be considered a large, landscape-level forest. The SPF overlaps with two 'Last of the Wild' areas. In addition the SPF is part of the Eastern Plains Landscape (16,800 km^2 of contiguous forest)	Sanderson *et al* 2002a WWF/WCS 2008
HCV3: Forest areas that are in or contain rare, threatened or endangered ecosystems.	SPF Core Area conserves what is probably the largest remaining block of lowland southern Annamitic forest and large areas of deciduous dipterocarp forest. Both of these forest types have suffered globally from extremely high levels of deforestation and conversion. The SPF Core Area includes areas of the unique Sen Monorom grasslands. SPF is one of only two protected areas to do so.	Olson & Dinerstein 2002, Baltzer et al 2001 Tordoff et al 2007

High Conservation Value	Details	References
HCV5: Forest areas fundamental to meeting basic needs of local communities	Approximately 12,500 people live in 20 villages using the SPF Core Area, of whom a large proportion are dependent on forest resources. Collection of liquid resin from forest trees, mainly *Dipterocarpus alatus* is the most important source of cash income for remote communities, providing income that is essential for purchasing rice and other basic needs. The fisheries of the rivers and pools of the SPF Core Area are of fundamental importance as the main protein source for most households. Other important resources include rattan, bamboo, honey and medicinal plants.	Evans *et al* 2003 Degen *et al* 2004 Richardson 2003 Mann Mouy 2010 WCS/FA 2006b
HCV6: Forest areas critical to local communities' traditional cultural identity	19 of the 20 villages are predominately ethnic Bunong who are animist with very strong cultural links to the forest. Culturally important areas ('spirit forests', 'spirit pools' and grave forests) have been mapped for 9 villages and are known to exist for most other communities.	Evans 2007 Degen *et al* 2004 WCS/FA data

1.4 Project Proponent (G4)

The project proponent is the Royal Government of Cambodia (RGC), represented by Forestry Administration of the Ministry of Agriculture, Forestry and Fisheries (MAFF). For contact information see Annex 1.1. The FA is responsible for management of the site including, but not limited to, the following:

- assignment of staff, including a Protected Forest director, or equivalent
- developing workplans and budgets
- implementation of activities such as law enforcement, community work and demarcation
- oversight of participation by other government agencies such as the armed forces
- coordination with other branches of government
- oversight of involvement of non-governmental organisations

With regard to the REDD project, FA is responsible for

- overall oversight and management (including benefit-sharing frameworks and coordination of partners),
- assignment of key staff including team leaders and managers,
- approval of the PD, workplans and monitoring reports
- implementation of activities in the workplan for which FA is responsible
- coordination of the REDD work with other aspects of PF management

The roles of other project participants are described in Section 1.5. The involvement of village-level community-based organisations is described in Section 7.

1.5 Other Entities Involved in the Project (G4)

For contact information for organisations listed in this section see Annex 1.1.

Technical Partners

The Wildlife Conservation Society Cambodia Program is the lead technical partner. WCS has cooperated with FA at the site since the first wildlife surveys in 2000. WCS works on the REDD project under the terms of a renewable 3-year Project Agreement with MAFF. Successive three year agreements have been in place since 1999 and are likely to continue being renewed into the foreseeable future, by mutual consent. Should this agreement be terminated, at the discretion of either party, FA will be responsible for making other arrangements to fill the role played by WCS in the REDD activities.

To the extent possible by available funding and other resources, WCS is responsible for:

- provision of technical advice on all aspects of conservation at the site
- assisting in the drafting of certain project documents such as the PD, annual reports and verification reports
- management of their own non-governmental staff associated with the project
- coordination of the inputs of livelihood/development NGOs
- co-operatig in efforts to secure non-REDD funding required for business as usual activities

The other principal implementation partners are local and international development NGOs. The exact partners will depend on levels of funding and technical requirements of the project, and will vary over the course of the project on the basis of negotiated contracts for service provision. The key partner in the early years of the project is Cambodia Rural Development Team (CRDT). CRDT has cooperated with FA and WCS at the site since 2005 and during 2008-2010 worked there in part under direct contract to WCS. Other partners who cooperate on the project include, but are not limited to, the Sam Veasna Centre and World Education Inc.

CRDT, and other similar partners, will be responsible for implementing specific alternative livelihood activities, for example the development of sustainable agriculture projects, ecotourism and off-farm livelihood improvement projects. This mainly relates to actions under Sub-objective 4 of the workplan, although CRDT is also involved in some extension (Sub-objective 3, Action 5).

Three other organisations have participated in the development of the REDD project documentation. Winrock International assisted with initial conceptualization, staff training and technical review of sections of the PD. Forest Carbon assisted with PD drafting and technical review. The Community Legal Education Centre (CLEC) assisted extensively with the process of gaining Free, Prior and Informed Consent from local communities. Fixed term contracts will be issued to these or comparable organizations for similar services at intervals through the life of the project.

Skills necessary for project implementation

The project activities listed in Section 2.2 require a broad range of skills, all of which can be provided by the project participants as set out in Table 1.8.

Table 1.8 Key skills required to implement the project

Sub-objective	Key skills required	Main partners
#1: Key legal and planning documents for the Seima Protection Forest and surrounding landscape are approved and implemented	Protected area management planning, coordination with senior government officials, understanding of private sector	FA, WCS
#2: To reduce forest and wildlife crime by direct law enforcement	Implementation of enforcement patrols, monitoring outcomes	FA, WCS
#3: Land and resource use by all core zone communities is sustainable	Participatory land-use planning, implementation of Land Law and Forestry Law, design of natural resource management systems	FA, WCS
#4: Support for alternative livelihoods that reduce deforestation	Promotion of alternative livelihoods (forestry, tourism, agriculture, savings groups, adult education etc)	FA, WCS, CRDT other NGOs
#5: Collect information on long-term ecological and social trends	Scientific monitoring (remote sensing, wildlife and plant species, socio-economics)	FA, WCS,
#6: Effective administrative, accounting and logistical procedures are in place	Administration and accounting systems	FA, WCS
#7: Long-term financial security	Fund-raising from traditional donors, management of REDD activities	FA, WCS, CRDT other NGOs and tech. partners

The implementing organisation and several of the implementing partners had been active in conservation at the site for up to eight years prior to the project start date (Evans *et al.* 2013) and already had a well-established core team which will be expanded to achieve the additional activities required for the REDD project as resources become available. The team draws on the combined strengths of a government agency (FA), an international conservation NGO (WCS) and a number of local and international development NGOs.

The FA has the legal mandate to manage forest and forest resources in Cambodia, including Protected Forests. It has over 1500 staff, including senior managers and core technical offices in Phnom Penh and a network of local offices extending out to every district (RGC 2010).

Senior FA management staff assigned to the SPF REDD project vary over time. They are mainly drawn from the Department of Wildlife and Biodiversity and the Department of Forestry and Community Forestry, with involvement of other technical offices as required. These managers have extensive experience in protected area management, implementation of forestry law enforcement, design of community engagement programs, wildlife monitoring, coordination with other stakeholders and management of large budgets. They also provide training to and coordinate the involvement of officers from the provincial and district branches of the FA, who have skills in matters such as forest estate demarcation, law enforcement, oversight of community forestry and forest tree nurseries, and members of the Royal Cambodian Armed Forces who participate in law enforcement patrols.

WCS has strong institutional capacity to support the work of the project proponent. WCS, founded in 1895 as the New York Zoological Society, is an internationally recognized organization dedicated to preserving the Earth's wildlife and wild landscapes and seascapes. WCS currently oversees a portfolio of more than 500 conservation projects in 60 countries in Asia, Africa, Latin America, and North America. WCS works with national governments, universities, non-governmental organizations (NGOs) and dedicated individuals to increase understanding and awareness of the importance of wildlife through the establishment and strengthening of protected areas, conducting scientific research, strengthening national governmental organizations and NGO capacity, and training the next generation of conservation professionals.

More recently, WCS has engaged in the development of its Carbon for Conservation initiative. Currently, WCS is working with communities and governments in 18 landscapes and 14 countries to develop sub-national REDD+ demonstration projects and support the development of national REDD strategies. WCS believes that work at sub-national and national levels should be linked in such a way that national REDD strategies are informed by on-the-ground experience obtained through demonstration projects. WCS only works on sub-national REDD+ demonstration projects in landscapes where we have or plan to have a long-term presence. This long-term presence is a prerequisite to success in order to understand the drivers of deforestation and implement activities that reduce deforestation effectively and ensure permanence with community consent and participation.

WCS Cambodia employs various non-government national project staff on the SPF project including expatriate or national technical advisors, field team members, volunteers, and Phnom Penh based technical and administrative personnel. The technical advisors are often resident long term on-site and over the past few years as needed have included at various times Senior Natural Resources Management advisor, a Community and Civil Society Development advisor, a Wildlife and Threats Monitoring advisor and a Law Enforcement advisor. WCS Global Conservation Program also has a conservation support team based regionally and at the New York headquarters that provides technical assistance, analysis, training and capacity building to WCS field programs. The Conservation Support Unit, established >10 years ago, provides direct technical support in the areas of conservation strategic development, status and impact monitoring, landscape and ecological modelling, education outreach and capacity building.

The mission of CRDT is to improve food security, incomes, and living standards of poor rural communities in support of environmental conservation in Cambodia. CRDT has been active in SPF since 2005 through a small team of community extension workers supported by a core team of highly experienced development practitioners at their head office in adjacent Kratie Province. The team has experience implementing a range of projects in SPF including water/sanitation, agriculture/livestock, savings groups, environmental education and adult literacy.

1.6 Project Start Date (G3)

The project start date was 1 January 2010. Smaller-scale non-REDD-financed conservation activities had taken place prior to this date, which is chosen to mark the commencement of additional activities above and beyond these baseline levels. The creation of the Seima Protected Forest by subdecree took place in August-September 2009. This was a major necessary condition to allow REDD-specific activities to commence. The detailed information was communicated to the site management team in late October 2009 and to the other government stakeholders over the following few weeks. 1 January 2010, as the beginning of the next administrative quarter after these steps were completed, marks a convenient point to use for accounting purposes.

1.7 Project Crediting Period (G3)

The duration of the VCS project crediting period is 60 years, 1 January 2010-31 December 2069. In CCBA terminology, this is both the project lifetime and the GHG accounting period.

Thr methodology (page 8) requires that the baseline is fixed for periods of ten years and then adjusted as necessary. Each ten year period is called a fixed baseline period. The first fixed baseline period will run from 1 January 2010-31 December 2019.

2 DESIGN

2.1 Sectoral Scope and Project Type

This project is an Agriculture, Forestry and Other Land Use (AFOLU) project under the Reduced Emissions from Deforestation and Degradation (REDD) project category. Specifically, the project is of the "Avoiding unplanned deforestation and degradation" (AUD) type. This project is not a grouped project.

The project is only claiming credits generated from avoided *unplanned deforestation*. This is a conservative approach since the planned activities should also avoid the risk of future *planned deforestation* and avoid any future worsening of *degradation* (currently occurring at negligible levels from the perspective of GHG emissions).

Increased carbon sequestration from reforestation or assisted natural regeneration is not a major objective of the project. Some of the forest areas where deforestation is prevented may increase in carbon stock naturally due to recovery from past logging, and in theory this might be eligible for additional credits, but to reduce project complexity no credits will be claimed for this during the first fixed baseline period.

2.2 Description of the Project Activity (G3)

Objectives and conceptual model

The objectives of the REDD project in the Core Area link directly to the over-arching management objectives of the SPF. The original vision for the SPF was developed at a multi-stakeholder workshop in July 2006 (WCS/FA 2006b). This consultation included representatives from all the relevant government agencies, local government, village leaders and civil society. The agreed Vision for the site was: *A well-managed forest landscape that supports increasing wildlife populations and improving livelihoods for the people who currently live there*. At the same meeting a general conceptual model for the project was developed, linking the goal to four key measurable targets, a set of direct and indirect threats and a set of interventions. This was then used to develop the first three year strategic plan, 2008-2011, the annual workplans and the draft Subdecree.

Figure 2.1 shows the current conceptual model, based on the 2006 results, which was revised and updated slightly during the design of the REDD project based on the analysis of threats set out in Section 4.5.

Subdecree 143 (2009) lists nine management objectives for SPF, which map closely to the four high level Targets in the conceptual model. These are listed below in relation to the three CCBA themes - climate, community and biodiversity. The activities are then discussed in more detail.

Climate objectives

The SPF Subdecree contains the following two relevant objectives.
3- To contribute to protection and conservation, to meet the goals of the National Millennium Development Plan of the Royal Government of Cambodia, and to maintain forest cover;
7- To maintain carbon stored in vegetation in order to reduce carbon dioxide (CO_2) emissions into the atmosphere;

The target in the revised conceptual model is: '*Maintain the variety, integrity and extent of all forest types*'

Community objectives

The SPF Subdecree contains the following four relevant objectives.

4- To conserve the culture and tradition of indigenous communities and local communities where they are living within the Protection Forest area;
5- To maintain the natural resources that these communities depend on for their livelihoods and to implement the program of poverty reduction of the Royal Government of Cambodia;
6- To contribute to sustainable socio-economic development through participation in the management of harvesting forest resources by the local communities, development of ecotourism and other similar activities which have very small impact to biological resources, forest and wildlife;
8- To prevent soil erosion, to protect soil fertility and to maintain the stability and quality of water sources;

The targets in the revised conceptual model are : *Increase security and productivity of natural resources to support local livelihoods* and *Sufficient farmland to support the livelihoods of current residents.* Livelihoods are defined to include cultural aspects.

Biodiversity objectives

The SPF Subdecree contains the following two relevant objectives.
1- To protect, conserve and rehabilitate genetic resources of fauna and flora which are globally threatened;
2- To maintain and rehabilitate important ecosystems as habitat for all forms of biodiversity;

The target in the revised conceptual model is: *Increase populations of wildlife of conservation concern*.

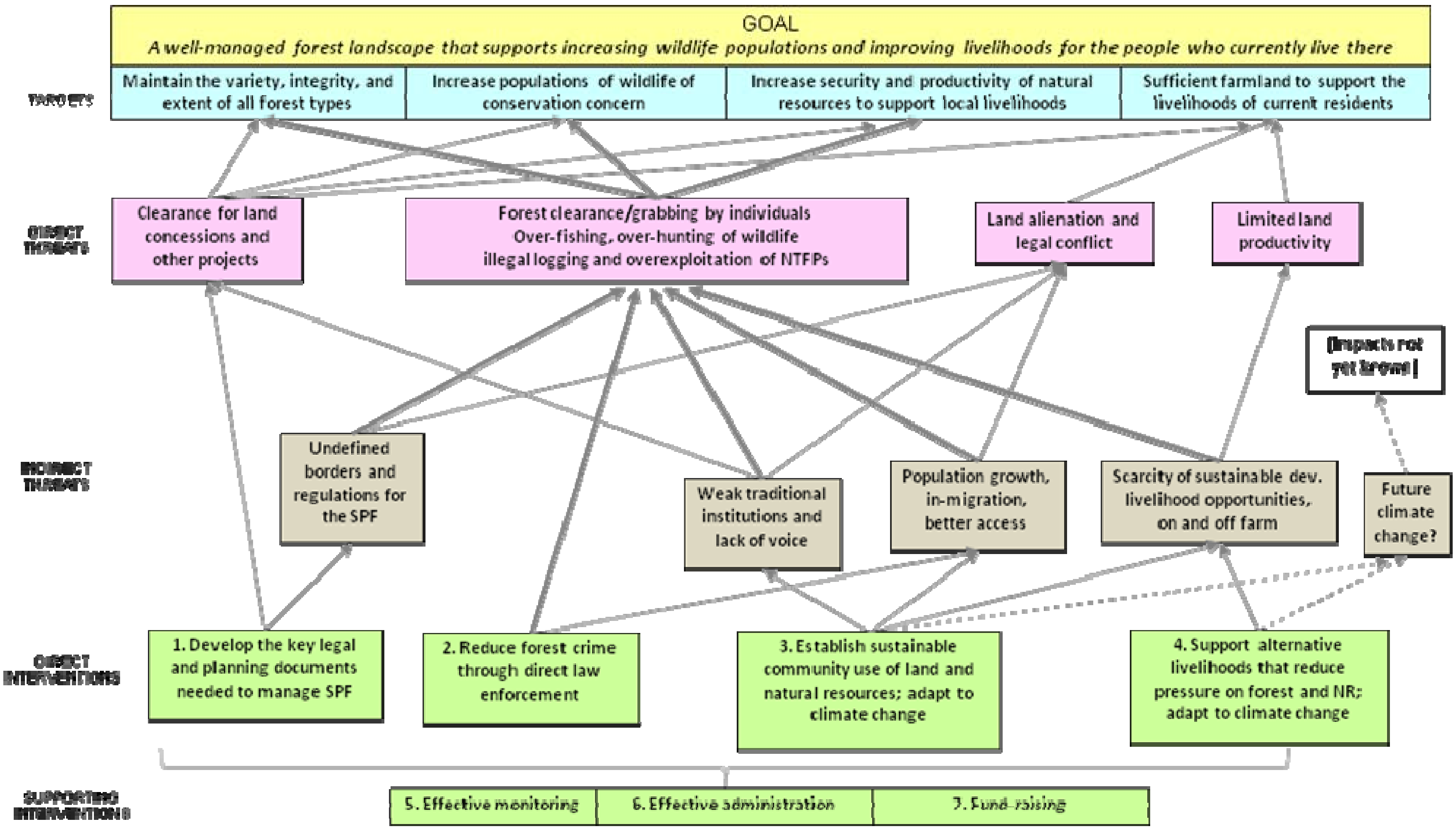
Cross-cutting objectives

The subdecree also contains the following general objective. In practice this will be largely covered by activities addressing the other objectives listed above. Many of the activities listed are included in Sub-objective 5 (see next section).

9- To support other activities including technical and scientific research, education, training, community development, and environmental studies which are related to sustainable development and conservation at local, national and international levels.

Figure 2.1 Conceptual model for the project

Note: links to one of the key direct threat boxes have been emphasized, for clarity



As shown in Figure 2.1 the conceptual model links the four targets to seven groups of interventions, four of them (1-4) direct and three (5-7) supporting. These groups are called Sub-objectives in SPF workplans. They are described below. More detail can be found in Annex 2.1.

Direct interventions

Sub-Objective #1: Key legal and planning documents for the Seima Protection Forest and surrounding landscape are approved and implemented

Action #1: Maintain support for sub-decree among senior government and general public
Action #2: Approve and implement Management Plan
Action #3: Implement Mondulkiri Provincial Corridors strategy
Action #4: Develop partnerships with the private sector
Action #5: Develop international cross-border dialogue
Action #6: Implement adaptive management systems

As shown in Figure 2.1 this group of actions addresses the indirect threat of *weak legal protection and undefined borders and regulations for the site*. Overall legal protection for the site was enhanced early in the project, a management plan with detailed zoning and clear regulations will be consulted upon and approved, provincial-level planning will help maintain connectivity to other forest blocks (see WWF/WCS 2010), and dialogue will be maintained with the private sector and cross-border authorities to minimise certain classes of threat. Annual public stakeholder meetings and the results of monitoring programs will provide inputs to the production of an annual report and workplan to ensure adaptive management and ensure on-going community consultation through the life of the project. This will help to reduce the direct threats that arise from *forest clearance/grabbing by individuals, over-fishing, over-hunting of wildlife, illegal logging and overexploitation of NTFPs*. It also addresses the direct threat from *issuance of large scale land concessions* within the project area. By addressing these threats, deforestation will be reduced as will pressure on wildlife populations and other natural resources, bringing benefits to climate, biodiversity and people with forest-dependent livelihoods. The actions also contribute to leakage management goals.

Sub-Objective #2: To reduce forest and wildlife crime by direct law enforcement

Action #1: Enforce wildlife, forest and protected forest laws and sub-decree through patrols
Action #2: Establish and implement law enforcement monitoring framework
Action #3: Ensure sufficient patrol buildings, equipment and staffing
Action #4: Ensure sufficient patrol personnel capacity
Action #5: Liaise with Provincial, National and other authorities
Action #6: Establish Community-based Patrolling and/or monitoring system

This group of actions centres on support to government-led law enforcement teams who conduct direct patrols, legal extension, stakeholder liaison and intelligence-gathering activities. Patrol activity and results are monitored with an advanced but user-friendly computerised system called MIST. Communities are also assisted to conduct some patrols themselves, although this can be challenging given the scale of the threats. As shown in Figure 2.1 this group of activities addresses the direct threats that arise from *forest clearance/grabbing by individuals, over-fishing, over-hunting of wildlife, illegal logging and overexploitation of NTFPs* as well as the indirect threat of *illegal in-migration*, which in turn will reduce the direct threat of *land alienation and legal conflicts over land*. Addressing these threats will bring benefits for all four of the project's targets, as well as contributing to leakage management goals.

Sub-Objective #3: Land and resource use by all core zone communities is sustainable

Action #1: Form and maintain land-use agreements with communities
Action #2: Legally register communities and users
Action #3: Support indigenous communal land titling in appropriate communities
Action #4: Demarcate the Forest Estate; reforest areas of recent clearance
Action #5: Conduct extension and communication activities
Action #6: Liaise with Commune Council and other agencies
Action #7: Engage with civil society organisations operating in the Project area
Action #8: Ensure the capacity of Project staff is sufficient

This group of actions harnesses the motivation and capacity of community members to address three important indirect threats - *weak traditional institutions and lack of voice*; *population growth, in-migration and better access*; and *scarcity of sustainable development livelihood opportunities, on and off farm*. The activities centre on the formation of community groups who are then assisted to develop systems for protection and sustainable use of the resources they depend upon, both forest and land. Some community groups, and some areas of land, can be legally registered to increase their level of protection. Communities are also encouraged to participate in government-led forest boundary demarcation activities. Outreach activities are necessary to ensure the understanding and support of all community, local government and NGO stakeholders. Addressing these indirect threats will significantly reduce the four direct threats - *forest clearance/grabbing by individuals, over-fishing, over-hunting of wildlife, illegal logging and overexploitation of NTFPs; land alienation and legal conflicts over land; issuance of large scale land concessions*; and *limited land productivity*, supporting efforts to achieve all four of the project targets, as well as contributing to leakage management goals. The activities will also include climate change adaptation measures, in anticipation of a worsening climate over the longer-term.

Sub-Objective #4: Support for alternative livelihoods that reduce deforestation
Action #1: Establish community-based ecotourism
Action #2: Support agricultural extension activities
Action #3: Provide infrastructure support linked to conservation activities
Action #4: Develop NTFP-based livelihood projects
Action #5: Develop and manage a system to share carbon benefits
Action #6: Improve literacy and numeracy

This group of actions addresses the indirect threat of *scarcity of sustainable development livelihood opportunities, on and off farm.* Doing so will develop alternative livelihoods that are less dependent on deforestation and NR harvests, reduce two of the key direct threats, *limited land productivity* and *forest clearance/grabbing by individuals, over-fishing, over-hunting of wildlife, illegal logging and overexploitation of NTFPs* and hence provide benefits for all four of the project targets. The exact alternative livelihoods will vary from village to village depending on opportunities and on the preferences of the local people determined through participatory methods. Agricultural support (including savings groups/micro-credit), small infrastructure projects, literacy/numeracy and the development of benefit-share systems for carbon benefits will be relevant in most villages whereas ecotourism and NTFP-based projects will be more localised. The activities will also include climate change adaptation measures, in anticipation of a worsening climate over the longer-term. As new options for livelihood development arise through changing economic conditions over the life of the project these will be added to the list of actions.

Supporting interventions

The remaining groups of actions do not relate directly to specific threats but rather create the enabling conditions for implementation of the four previous groups of actions. The *monitoring programs* are essential to enable project management to track success, identify weaknesses, take corrective action and communicate with stakeholders in-country; many are also necessary to ensure full reporting in accordance with VCS and CCB requirements. The importance of *effective administration* and staff capacity-building is self-evident. *Effective fund-raising* includes financial administration of the REDD project and is also important as the baseline scenario for the project assumes that donors will continue to support a certain level of activities through non-carbon funds.

Sub-Objective #5: Collect information on long-term ecological and social trends
Action #1: Monitoring of trends in forest cover
Action #2: Monitoring of key wildlife species and threats to them
Action #3: Socio-economic and demography monitoring
Action #4: Facilitate research that will benefit the management of the SPF
Action #5: Ensure sufficient staff capacity is available

Sub-Objective #6: Effective administrative, accounting and logistical procedures are in place
Action #1: Evaluation and feedback on staff capacity, effectiveness and training needs
Action #2: Develop and maintain effective management, administrative and accounting systems

Sub-Objective #7: Long-term financial security
Action #1: Develop and Implement REDD project
Action #2: Continued support of a wide range of donor partners
Action #3: Increase use of commune development funds for project activities

Overview of project benefits for communities and biodiversity

Table 2.1 summarizes the key expected benefits of the project in relation to the categories in the conceptual model above, and the core requirements of the CCB Standard. This table forms the basis for the description of benefits in sections 6 and 7 and the monitoring approach described in Section 8.

Table 2.1 Summary of key community and biodiversity benefits of the project

	Baseline scenario	Comm.^	Biod.^	With project trends
CCB Core Standards				
Net positive benefit for social and economic well-being of communities; equitable distribution of costs/benefits	Static or decline for vulnerable stakeholders; improve for less vulnerable stakeholders	y		Improving for all stakeholder groups, including vulnerable groups
Net positive impacts on biodiversity	Severe declines with extinction of many vulnerable species		y	Biodiversity values increasing, return to natural levels
Conceptual Model Target				
Maintain the variety, integrity, and extent of all forest types	Declining extent and quality of all vegetation types	y	y	Stabilized cover of natural vegetation, improving quality
Increase populations of wildlife of conservation concern	Declines/extinctions of most globally threatened species	y	y	Populations increased to carrying capacity
Increase security and productivity of natural resources to support local livelihoods	Declining security, abundance and productivity of harvested natural resources and availability of clean water	y		Security, abundance and productivity of key resources maximised; clean water freely available to all communities
Sufficient farmland to support the livelihoods of current residents	Increase in landlessness, static or decreasing agricultural productivity	y		Landlessness among the poor low and stable; agricultural productivity and sustainability increasing
Conceptual model threat				
Clearance for land concessions and other projects	Increasing loss to concessions	y	y	Losses to concessions minimised/halted
Undefined borders and regulations for the SPF	Continuing weaknesses in protection	y	y	Borders, zones and regulations clearly defined and enforced
Population growth, in-migration, better access	Continued high in-migration, increased competition; increased conflict	y	y	Population growth lower than in reference area; net in-migration negligible; access to forest areas fully controlled
Forest clearance/grabbing by individuals; over-fishing, over-hunting of wildlife; illegal logging and overexploitation of NTFPs	Widespread over-harvesting /clearance	y	y	Illegal activities (clearance, hunting, over-fishing, hunting, logging, NTFP harvest) at very low levels
Land alienation and legal conflict	Alienation, forced sales, Uncertain tenure due to expansion outside agreed land-use plans	y		Land alienation ceases, no land illegally occupied and subject to conflict
Weak traditional institutions and lack of voice	Seriously declined	y		Traditional and new community institutions effective, cultural cohesion improved
Limited agricultural productivity	Decline, stagnation or slow improvement	y		Agricultural productivity increasing
Scarcity of sustainable dev. livelihood opportunities, on and off farm	Continued dependence on limited number of often unsustainable livelihoods	y		Increasing diversity of viable, sustainable livelihood opportunities
Climate change	Difficulty adapting to changes in availability of wild-harvested resources and productivity of farming systems	y		Increased capacity to adapt to climate-driven changes

^ Comm. = Community impacts/benefits; Biod. = Biodiversity impacts/benefits
* Social impacts/benefits are likely to be felt most strongly by the most vulnerable categories of stakeholder.

2.3 Management of Risks to Project Benefits (G3)

Measures to ensure permanence

The project incorporates a number of measures to ensure long-term sustainability of the outcomes. The key measures are:

1. establishment of a strong legal basis, including the permanent declaration of the Protected Forest in the 2009 Subdecree and the program to support permanent titling of eligible land to all relevant villages
2. investments in physical demarcation of boundaries and construction of key infrastructure for park management
3. the inclusion of a permanence fund in the financial model, to ensure a proportion of early revenues is set aside to finance long-term recurrent management costs
4. the use of adaptive management approaches to ensure work planning responds to changing conditions
5. the establishment of mechanisms for long-term community involvement in management planning and implementation
6. the focus of alternative livelihood work on establishing long-term alternatives to deforestation, unsustainable hunting etc, including both income generation activities and the development of fundamental, transferable skills through adult education
7. the inclusion of environmental awareness activities in the community engagement program
8. measures to ensure an increasing proportion of staff are drawn from local communities and to develop staff capacity

Risks to climate benefits from emissions reductions

A risk analysis was conducted in accordance with the VCS AFOLU Non-permanence Risk Tool v3.2. The full risk report is presented in Annex 2.2 and a summary is given here. The project has a calculated risk rating of 13%. The minimum risk rating for a VCS AFOLU project is 10%, so the SPF project has a rating of 13%. This is equivalent to a 13% risk buffer set-aside at the time of each verification event. This risk analysis is holistic, covering climate, community and biodiversity benefits of the project.

Internal risks

Risks from weaknesses in project management are assessed as very low due to the high capacity of the implementing partners and the existence of a formal adaptive management system. The financial viability of the project is good, with a rapid breakeven point once credit sales begin, but limited callable resources or other funding streams prior to that. The high Net Present Value of alternative land uses relative to the income expected from the project also poses a risk, but this is largely offset by the strong legal basis for long-term protection at the site.

External risks

The land tenure complexity set out in Section 1.3 results in some assessed risk. The continued existence of the Samling concession contract poses a theoretical risk regarding benefit-share arrangements and so conservatively the maximum score has been given for this criterion. Furthermore, in a small percentage of the forest (estimated at less than 3%) the local communities may be able to claim formal legal ownership. The estimated risk scores are reduced somewhat by the clearly established legal basis for protection of the SPF and the evidence of strong community agreements clarifying the status of these overlapping claims with respect to the REDD project. Cambodia's relatively low scores on the database of Worldwide Governance Indicators increase the assessed risk, although this is partly offset by the existence of a national REDD+ Readiness process.

Natural Risks

The landscape is not prone to severe natural events. It is geologically stable and experiences only small flooding events that are part of the natural monsoonal cycle. Intact tropical forests of the types found in Seima or more broadly in Cambodia are not prone to catastrophic pest or disease outbreaks, due to the very high diversity of tree species present. The most likely natural risk is fire. However, the deciduous forests are well adapted to low intensity periodic understorey fires (which can be considered a non-destructive part of the ecology of the habitat), whilst the denser forests are not prone to fire due to their evergreen nature and humid understorey and there is no history of catastrophic fires in this habitat in the area. Only severe degradation of a kind that is not expected to occur (e.g. wide-scale industrial logging) is likely to make these denser forest prone to damaging fires.

2.4 Measures to Maintain High Conservation Values (G3)

The project activities outlined above will all contribute to maintaining or enhancing the HCVs of the project zone. As described above interventions are designed to mitigate both the direct and indirect threats to the project targets. These targets correspond closely to the identified HCVs and no additional activities are planned that manage HCVs alone. A summary of the HCVs and interventions is provided in Table 2.2 below. Greater detail on activities and interventions to manage HCVs are included in the HCV report (Pollard and Evans 2012).

Table 2.2 Management interventions to maintain or enhance HCVs in the project zone

High Conservation Value	Corresponding project targets	Interventions
HCV1: Forest areas containing globally, regionally or nationally significant concentrations of biodiversity values.	Increase populations of wildlife of conservation concern	o Law enforcement activities to reduce hunting & trapping of Globally Threatened and endemic Species o Law enforcement to reduce conversion of forest and wetland habitats o Livelihood support activities to improve management for forest resources and reduce hunting pressure
HCV2: Forest areas containing globally, regionally or nationally significant large landscape level forests.	Maintain the variety, integrity, and extent of all forest types	o Law enforcement to reduce conversion of forest and wetland habitats o Land-use planning at village, Provincial and National level to reduce conversion and fragmentation of SPF and wider landscape
HCV3: Forest areas that are in or contain rare, threatened or endangered ecosystems.	Maintain the variety, integrity, and extent of all forest types	o Law enforcement to reduce conversion of forest and wetland habitats o Land-use planning at village, Provincial and National level to reduce conversion and fragmentation of SPF and wider landscape
HCV5: Forest areas fundamental to meeting basic needs of local communities	Increase security and productivity of natural resources to support local livelihoods Maintain the variety, integrity, and extent of all forest types	o Land-use planning at a village level to protect forest resources o Development of community natural resources management rules to encourage more sustainable use of resources o Livelihood support activities to reduce the pressure to harvest resources unsustainably. o Law enforcement to protect forest and aquatic resources from external pressures o Appropriate zoning of the SPF that recognises NTFP collection and compensates any unreasonable reductions in access

High Conservation Value	Corresponding project targets	Interventions
HCV6: Forest areas critical to local communities' traditional cultural identity	Increase security and productivity of natural resources to support local livelihoods Maintain the variety, integrity, and extent of all forest types	o Village level land-use planning to map and protect spiritual sites o Law enforcement to protect spiritual sites from outside threats o Appropriate zoning of the SPF that recognises spiritual sites

2.5 Project Financing (G3 & G4)

Financial health of the implementing organizations

The FA is a legally constituted branch of the Royal Government of Cambodia and as such receives annual allocations from the national budget. Hence its basic financial health and long-term stability are good. The FA lacks adequate operating budget for the maintenance of SPF, and other protected forests under its mandate, and this is one of the key reasons that the SPF REDD project has been developed.

The Wildlife Conservation Society (WCS) was founded in 1895 as the New York Zoological Society. WCS is an internationally recognized not-for profit conservation organization dedicated to preserving the Earth's wildlife and wild landscapes and seascapes. WCS currently oversees a portfolio of more than 500 conservation projects in 60 countries in Asia, Africa, Latin America, and North America. The WCS financial report ending fiscal year 2009 (WCS Annual Report, 2009) demonstrates the financial stability of the organization with operating revenue of USD$205.4 million. These operating revenue and support exceeded expenditures by USD$1.5 million, the sixth consecutive year of operating surpluses. The WCS Cambodia program has been operational since 1999 and has a strong record of financial health and effective financial management. It has maintained a broad base of donors that enables it to avoid an excessive reliance on any one source of funds.

Funds for project implementation

Annex 2.3 summarizes the financial model for the project, based upon the VCUs available for sale according to ex-ante projections (Section 9) and conservative estimates of sale prices. The projections show that the expected revenues will be sufficient to:

- increase conservation effort to a much higher level than in the business as usual period
- set aside funds to support basic long-term operations and so ensure permanence of emission reductions beyond the project lifetime
- generate a significant operating surplus ('unassigned funds') that would provide funds for very significant benefit-sharing arrangements that will further motivate community participation in the project and increase development outcomes
- the unassigned funds could also be used partly by the project proponent for other national development purposes off-site, and hence offset some of the broader opportunity costs of forest conservation

The project is expected to break even and begin making payments in all three of these streams from the time of the first verification and sale. Since credits are expected to be generated from year 1 onwards, this first verification can take place immediately after validation in year 4 or year 5.

2.6 Employment Opportunities and Worker Safety (G4)

Staff training

The core FA/WCS staff team is organised in four main groups, each with distinct training needs and provision, as shown in Table 2.3. In addition to the provision shown, all partner organisations also encourage staff with special potential to pursue further education through day-release or sabbatical arrangements. As shown, most training activities occur on an annual basis, or more frequently, so that new staff can rapidly be inducted. The project has a generally low level of staff turnover, reducing the need for retraining.

Table 2.3 Training provision for the main staff groups

Staff group	Training needs	Planned provision
Senior management and technical advisors	Conservation project design, project management and administration	External mentoring through existing WCS and FA systems; short professional training courses, exchange visits, attendance at conferences
Law enforcement team	Patrol techniques, equipment and weapons handling Outcome monitoring methods (e.g. MIST) Human rights and related issues	Annual intensive training courses, including exchange with other sites and agencies; on-the-job mentoring from technical advisors, routine MIST refresher trainings, formal training courses provided through existing government systems
Community engagement team	Legal systems, effective communication techniques, technical forestry, forest zoning and indigenous land titling, agricultural development skills	Short-term issues-based professional training courses, provided by technical advisors, senior project staff or external trainers (e.g. other NGOs, government departments)
Monitoring team	Technical and reporting skills relating to measurement of biodiversity, remote sensing and social factors	Annual intensive FA/WCS joint wildlife monitoring training course; personally tailored training for GIS/RS officers; as-needed short term training courses on social measurement techniques

Community members and local authorities also have training needs. Training and awareness raising regarding project goals and procedures is conducted through periodic workshops, usually connected to a particular activity. This will also be an element of the annual project planning meeting. Technical trainings for community members are also conducted on specific village-level activities, most notably those under Sub-Objective 4 (development of alternative livelihoods). These are conducted on an as-needed basis by the community engagement team or the officers of local NGO partners, and may range on length from an hour to several days depending on the topic being covered. Selected key government officials and community leaders will also benefit from participation in conferences and other training courses.

Equal opportunities

Most jobs in the project are advertised, either in writing or verbally through our networks at national and local level. The project has an equal opportunities hiring policy, with no regard to race, gender, ethnic group, sexual orientation, or disability.

The project operates an equal opportunities policy and aims to increase the proportion of locally-recruited staff, female staff and staff from indigenous ethnic minorities wherever possible. An exception for the focus on local recruitment is currently made for law enforcement officers due to an observation that there can be increased risks of resentment or corruption among officers with strong local family connections; this policy is regularly reviewed. Retention of female staff can be especially difficult given the remote and difficult field conditions.

It is difficult to fill the more senior positions by local recruitment as there are very few local residents who have attained even a basic level of formal education, and almost none who have joined the relevant government technical agencies. However, there is a high proportion of local staff in the more junior levels of the community team, wildlife monitoring team and ancillary staff (administration, cooks, drivers etc). We are committed to identifying junior staff with potential and investing in their professional development, as outlined in Section G4.3. These staff will be promoted to more senior positions as their capacity grows.

In addition, we have regularly employed promising and motivated, but sometimes poorly qualified, local people as interns or volunteers for an initial period, and those who show strong commitment to the work have been hired and provided with further training.

Education and experience is steadily increasing in local communities as Cambodia develops, and the project regularly seeks staff from local communities who are fluent in Khmer and Bunong languages. During the past year we have employed three new indigenous Bunong field staff who have all recently completed Batchelor's degrees; these are some of the first generation of indigenous people in Cambodia who have attained such a level of education.

Health and safety

All project staff and counterparts enjoy the protection of WCS Health and Safety policies. Health and safety in the workplace is both an individual and shared responsibility of staff and the employer. WCS is committed to providing a safe working environment for all employees, contractors, volunteers and visitors. Whilst every effort is made to minimize work-related risks, there are inherent risks associated with any fieldwork.

Project staff and counterparts receive orientation to identify risks associated with fieldwork, and training is given to minimise the risk of injuries and illness, and to deal with an incident, should it occur. Project staff are expected to exercise due care at all times, to adhere to safe work practices and to follow site-specific safety guidelines (the Health and Safety Standard Operating Procedures, H&S SOPs), including the use of personal protection equipment provided by the project.

Project supervisors are required to continually conduct workplace risk assessments and to address issues regarding risk and risk avoidance at staff briefings. Similarly, as workplace health and safety is a shared responsibility, staff are required to inform project management of unsafe conditions or equipment, illness or injury, for prompt remedial action or treatment.

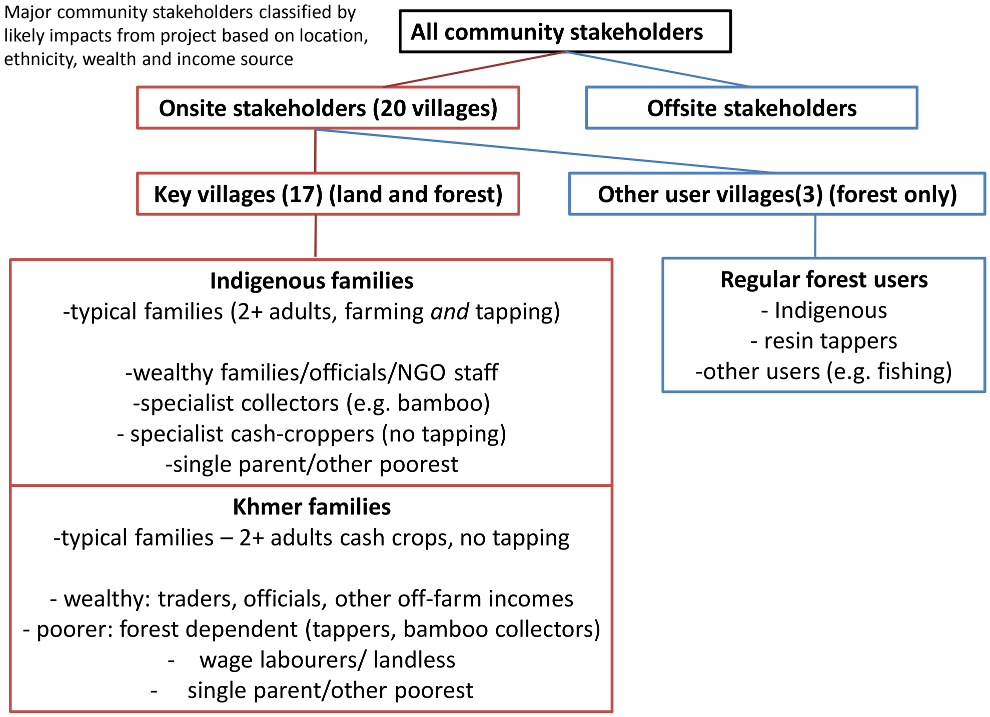
The project site is equipped with comprehensively stocked first aid kits and project staff have received first aid training, which will be refreshed as needed. In the unlikely event of a work-related incident or illness, the project provides health and accident insurance to staff and all expenses will be covered.

2.7 Stakeholders (G3)

Stakeholder analysis

Stakeholder can be separated into community members (on and off site) and non-community members (e.g. government agencies). A preliminary community stakeholder analysis (summarised in Figure 2.2) was developed by the project team based on their experience and the large number of past studies in the landscape. This was validated during workshop with community leaders from 15 of the 17 key villages (Sopha Sokhun Narong 2010c). The stakeholder analysis methodology is based on Richards and Panfil (2011). This framework forms a basis for project planning, discussion of impacts and also for monitoring.

Figure 2.2 Community stakeholder classification



The most important community stakeholders in terms of numbers and level of contact with the project are the people in the 17 key villages. They are classified here by ethnic group and then by major livelihood indicators, which are expected to correlate both with wealth and with the type of benefits/negative impacts they are likely to experience from the project. The next most important group is the regular forest users in 3 other user villages. These are also classified, but are likely to be a more homogenous subset of people since the great majority will be relatively poor resin-tappers who routinely make the long journey into the Core Area. Community members engaged in illegal forest-related activities are not identified as a separate category, since there are few if any people who specialise in such activities long-term - they are best considered supplementary activities that may be conducted by many people to varying degrees at different times.

Social surveys also indicate that there are a small number of legal, traditional users of the Core Area scattered across other villages more distant from the Core Area. Most of these individuals are resin tappers, since the valuable and predictable nature of resin income enables regular, consistent use. We estimate that they total 82 households spread across 17 additional villages (data available on request). These people evidently form a negligible part of the total population in those 17 villages (3443 households) and so those villages were not included in the REDD community consent process. They also represent a negligible proportion of the total population using the Core Area, and so they are not considered further in population-wide social monitoring. However, the individual rights of this small group of people must of course be recognised, and indeed current project design will reinforce their rights to harvest resin, and increase the likelihood of having those trees protected, with no predicted negative impacts. If resin harvesting is later proposed to be phased out in certain Strict Core Areas, which could lead to negative impacts on them, then these families will receive similar treatment and protection to those in the 20 participating villages.

The other community stakeholders are those living off-site, distant from the project zone and not using it directly, or not using it currently (Table 2.4).

Table 2.4 Classification of off-site community stakeholders

Stakeholder group/sub-group	Examples
People dependent on environmental services of SPF	Water users, people catching migratory fish
People interested in settling in the area or selling land	Settlers, land speculators
People interested in harvesting resources in the area	Loggers, hunters, fishermen, harvesters of NTFPs

The beneficiaries of environmental services are expected to receive net positive benefits from a successful REDD project. Since it is difficult to specify who they are and they have no theoretical possibility of negative impacts, it is acceptable and conservative to ignore them in this analysis. People in the other two categories who might theoretically hope to gain benefits from the Seima area in the absence of a REDD project would be breaking the law if they did so and have no legal claim on the reserve, so it is not necessary to analyse their costs and benefits under the CCB framework.

The preliminary *non-community* stakeholder classification is shown in Table 2.5. Since the project proponent is the FA on behalf of the Royal Government of Cambodia (RGC), in a sense other government agencies should not be considered distinct stakeholders, but rather as branches of the same organisation. Nonetheless, for effective project implementation it is important to understand and allow for the different mandates and agendas of these agencies, to ensure cooperation, so key government agencies are listed here.

Table 2.5 Preliminary non-community stakeholder classification

Stakeholder group/sub-group	Examples
Government	
Technical line agencies	Provincial departments such as Land Management, Urban Planning and Construction; Environment; Tourism; Agriculture; and Rural Development, plus the relevant national ministries for major issues.
Provincial authorities	
District authorities	
Commune Councils	
Armed Forces	Military, Military Police, Police
Non-government	
NGOs	Development and Partnership in Action (integrated rural development), Nomad (health), World Education (literacy)
Private Sector	
Logging concession	Samling International

The next stage of a stakeholder analysis is to assess the legal interests[5] of each group, and their relationships with other stakeholders. This analysis is presented in Annex 2.4, with a fuller assessment of expected positive and negative impacts in Sections 6.1 and 6.2.

Based on these analyses, Table 2.6 classifies stakeholders according to their *importance* (degree to which achievement of project goals depends upon the involvement of a given stakeholder; a function of population size and impacts from current activities) and *influence* (degree to which a stakeholder has power over the project and can therefore facilitate or hinder project interventions; a function of collective political power and special status accorded by CCBS) following Richards and Panfil (2011). Project design needs to focus on the stakeholders in the top left quadrant of the diagram, since they have the greatest power to move the project forward and also the greatest influence to prevent project success.

Table 2.6 Analysis of relative influence and importance of stakeholders (stakeholders outside participating villages in italic)

Influence of group	**Importance to project achievement**			
	Critical	**Significant**	**Moderate**	**Low**
Highly significant	Typical indig. families *Offsite - settlers* *Provincial authorities* *Armed Forces*	Elite indig. families	Khmer elite families	
Significant		Khmer typical families *Offsite - loggers* *District Authorities* *Commune Councils*		

[5] The incentives created by corruption do not have to be assessed in the calculation of net benefits under the CCBS (2009 standards, Section CM1 footnote 41). Nonetheless this is a significant practical issue which at times potentially affects the decisions made by officials, and project team members are fully aware of it.

		Line agencies		
Moderate			Indig cash-cropper Khmer forest specialist Other user - resin Other user - non-resin *NGO* *Private company**	
Low		IP poorest^ Khmer poorest^ Khmer landless^ Indig. bamboo collector		*Offsite - environment service beneficiary*

*Private companies will rise to critical importance and highly significant influence if any major projects are approved (e.g. mineral exploitation).
^These groups have elevated influence because of the importance accorded to them in the CCBS Gold Standard.

Samling International is not included in the table as the company is not judged to have any direct role in the implementation of the project.

Stakeholder consultation during project design

The existing conservation project has engaged in extensive consultation with community members and local officials since the project start in 2002. These consultations have informed the design of project interventions and ensured consent and participation in previously implemented activities. They have also built up a high level of community buy-in for many aspects of the project, raised awareness of the legal framework, delivered initial livelihood benefits and built a good level of trust between project staff and the communities.

An updated stakeholder consultation process was conducted to ensure full community understanding of and consent for the additional REDD-specific activities. This started with the project team going through the updated analysis described in the previous section, and the identification of the 20 participating villages. A formal consultation process was then developed on the basis of a review of Cambodian law, best practice guidelines from the literature and comments from a range of stakeholders. The design of the process is set out in detail in WCS/FA (2011). The process began with a series of preparatory meetings and workshops at provincial, district and commune level before the main village consultations, as outlined below. Workshop reports are available on request.

Provincial Level

Provincial level officials and NGO staff met on 28-29 September 2010 in Sen Monorom town at the Forestry Administration Cantonment office to discuss the project. The major comments that came from this meeting were related to integrating eco-tourism into the project and the need to collaborate with the Provincial Department of Tourism.

District Level

A separate meeting was held for district and commune-level officials on 1 October 2010 in Keo Seima district at the FA's SPF Headquarters. Those attending the meeting included a total of 37 participants from all relevant district offices; two commune councillors from each commune of the Keo Seima District; representatives from district Police department; representatives of district Military Units; the Provincial Conservation Planning Unit; and staff of WCS. Stakeholders at the district level were supportive of the project and were pleased with the in depth consultation process with all stakeholders.

Commune Council Level

As part of a program of events to raise awareness amongst local authorities of the REDD pilot project, the Forestry Administration, with support of WCS Cambodia, conducted two one day workshops on 15th November and 8 December 2010 for key community representatives from four of the six commune councils (Srae Khtum, Srae Preah, Srae Chhuk and Saen Monorom communes), six village

Indigenous Community Commissions (Andoung Kraleung, Ou Rona and Srae Lve, Gati, Sre Khtum and Chhnaeng), three village Forest Management Committees (Pu Kong, Pu Char and Ou Chrar) and five other villages (Pu Hiem, Pu Rang, Srae Preah and Ou Am). The meetings covered awareness of the REDD process and project design, a review of consultation awareness materials and a discussion of the likely environmental and social impacts of the project and ways to mitigate them. Similar meetings were held for the remaining two commune councils (Memong and Romonea) on 27 and 30 September 2011 respectively.

One of the major concerns from these meetings was related to the roles and responsibilities of the communities involved in the REDD project. In particular, some voiced concerns that they couldn't help stop illegal logging because it was being conducted by powerful entities within the region. Another concern from indigenous communities was that they had very little power to stop Khmer migrants from entering the forest and clearing land for farming and bamboo harvesting. These comments and concerns were addressed through a presentation on the project's monitoring and policing activities that are led by the Forestry Administration. The other major concern was related to farming activities. The communities raised their need to keep using their current farm lands. This concern was addressed by making it clear that they would be able to depend on their existing farm lands to plant a variety of crops.

Village level

The main consultation process at village level used two linked approaches: we engaged committees or village representative groups in intensive small group sessions as well as contacting all villagers in larger plenary sessions. Facilitation teams were mostly led by government officials working together with NGO staff and a cadre of community representatives who received additional training. At least one speaker of Bunong, the local indigenous language, was included in each team. The facilitation strongly encouraged participation from the village committee and women to make the process fair and transparent to all community members. The consultation was centred around a written Community Agreement to be signed by representatives of each community to demonstrate their Free, Prior and Informed Consent. The agreement includes an Annex that describes the project. The consultation was structured in three phases as follows:

Phase 1: Awareness raising and discussion of the draft social impacts assessment
- Part 1 - Awareness raising and impacts assessment with village leaders/committee
- Part 2 - Plenary discussions with all community members

Phase 2: Discussions on consent and presentation of the community agreement
- Part 1: Explanation and discussion of the draft community agreement
- Part 2: Independent legal advice for communities regarding the agreement

Phase 3: Finalization and signing of the community agreement

Phase 1: The initial consultations had several main objectives
1. Raise awareness on the concept of climate change and REDD carbon financing.
2. Explain rights of indigenous people based on Cambodian land and forestry law.
3. Encourage stakeholders to be actively involved in project implementation.
4. Review the proposed project design, identify potential risks as perceived by the communities and take comments on potential improvements to the design.

During Phase 1, community members were provided information through specially designed posters, booklets, and question and answer sessions in large meetings, small groups and through one-on-one conversations.

Phase 2: During Part 1 of Phase 2, the draft agreement was summarised by the project team in a series of meetings, copies were distributed to participants and question and answer sessions were held. During Part 2 the Community Legal Education Centre (CLEC), a specialist national NGO, held 2-day independent legal advice workshops for groups of 20-30 community leaders in each commune. WCS and FA were absent from these meetings to ensure community members felt free to raise sensitive questions.

Phase 3: Comments from the communities were fed back to senior decision-makers, any required changes to the agreement were made and both parties proceeded to sign it.

The schedule and dates of the community consultation process are listed in Table 2.7. All communities have signed the agreements. Detailed reports from the individual meetings during each Phase are available on request.

Table 2.7 Key dates in the village level consultations

Community Engagement – key meetings focused on REDD					
Key Villages with land in Core Area					
Village Name	Commune	Phase 1 – Raise awareness	Phase 2 Part 1 – Review agreement	Phase 2 Part 2 - Independent Legal Counsel	Phase 3 - Agreement Signed
Ou Am	Srae Khtum	10-12/12/11	12-18/12/11	14-15/11/11	15/1/13*
Ou Rona	Srae Khtum	01-02/12/10	25-28/10/11	14-15/11/11	15/1/13*
Srae Lve	Srae Khtum	26-28/01/11	28-29/10/11	14-15/11/11	15/1/13*
Srae Preah	Srae Preah	14/12/10	30-31/5/11	13-14/6/11	15/1/13*
Gati	Srae Preah	1-2/1/11	1-2/6/11	13-14/6/11	15/1/13*
Pu Char	Srae Preah	27-28/12/10	3-4/6/11	13-14/6/11	15/1/13*
Ou Chrar	Srae Preah	28-29/12/10	6-7/6/11	13-14/6/11	15/1/13*
Pu Kong	Srae Preah	30-31/12/10	9-10/6/11	13-14/6/11	15/1/13*
Chak Char	Srae Chhuk	12-13/1/11	11-13/7/11	5-6/8/11	15/1/13*
Khmom	Srae Chhuk	14-15/1/11	17-19/7/11	5-6/8/11	15/1/13*
Srae Andaol	Srae Chhuk	16-17/1/11	22-23/7/11	5-6/8/11	15/1/13*
Srae Khtung	Srae Chhuk	18-20/1/11	26-30/7/11	5-6/8/11	15/1/13*
Andoung Kraleung	Saen Monorom	17-18+27/11/10	13-16/6/11	21-22/6/11	15/1/13*
Pu Hiem	Saen Monorom	27-30/11/10	17-19/6/11	21-22/6/11	15/1/13*
Pu Rang	Saen Monorom	30/11/10	15-16/6/11	21-22/6/11	15/1/13*
Pu Ngourl	Memong	1-3/10/11	6-8/10/11	21-22/10/11	15/1/13*
Other User villages (Extensive NTFP use but no land inside the Project Area)					
Village Name	Commune	Initial Consultation	Second Meeting	Independent Legal Counsel	Agreement Signed
Sre I	Romonea	6-7/10/11	8-9/10/11	21-22/10/11	15/1/13*
Pu Trom	Romonea	10-12/10/11	15-17/10/11	21-22/10/11	15/1/13*
Pu Tang	Romonea	13-14/10/11	18-19/10/11	21-22/10/11	15/1/13*

*Approximate date, tbc.

Comments received during the consultations

The communities consulted were supportive of developing a REDD project as they saw it as a way to protect their long term access to the forest and their farmland. One of their major concerns was that if the forest did not generate revenue for the government, that the government would give land concessions within the forest to private companies essentially blocking community access to important resources. Specifically, communities raised concerns over whether the REDD project would block their rights to non-timber forest products. This concern was addressed by presenting the management strategy of the REDD project which allows local communities to continue NTFP harvesting. Another concern was that the REDD project would prohibit community stakeholders from entering into ancestral and burial forests. It was then clarified that access to ancestral and burial grounds within the SPF would be granted to all local and indigenous groups.

Community stakeholders were also concerned about losing their current agricultural lands. It was clearly presented that all current agricultural areas would be allowed to continue, where legally obtained. Furthermore, communities voiced the need to obtain secure agricultural land tenure. This concern was addressed by the project’s indigenous communal titling component that secures community land tenure on agricultural, fallow and residential lands. This process includes working with communities to map communal lands and developing the legal documents needed to request communal land titles from the government.

Many participants expressed concern that the government was not currently being effective in preventing land clearance, logging and many other crimes in the area, and that often powerful people in government were involved in the crimes. This is one of the key problems that the additional REDD funding is expected to reduce, by increasing the law enforcement effort and the level of political support that it receives.

Communities also expressed their desire that REDD provide them additional direct benefits. The project will achieve this through agricultural extension services that will help to increase farmer output and wages, and a range of other community development projects linked to community-identified priorities. These potentially include education, savings groups, community forestry, ecotourism and small-scale infrastructure projects. Also the project will formalize a system for sharing a proportion of the net revenues from the project with participating communities. The structure of this benefit-share system will be finalised, with community inputs, during the 12-18 months after project validation. Many participants in the consultations stated that it was important that this system is perceived to be fair, so that the project proponent can maintain the support of the participating communities.

Systems for ongoing consultation

This process described above was the start of a formal process of regular communication and review between the FA, WCS and the 20 participating communities regarding the REDD project. The exact nature of this process will be tested and developed step by step through the early years of implementation. Key elements will be:

- annual consultations with community representatives on benefits and impacts linked to the project annual planning process
- periodic formal consultations and assessments linked to the social benefits monitoring program
- routine consultations, evaluations etc during implementation of project activities in each village
- the grievance process described below

If these elements are found to be insufficient, further steps will be take to improve levels of consultation.

CCBA public comment period

The public comment period will be held after the PD has been submitted for validation. Public hearings will be hosted by the project proponent to collect feedback from the affected communities, following the model developed in the Oddar Meanchey REDD project[6].

Conflict resolution procedures

Complaints and grievances submitted to the project implementation team will be assessed and resolved directly. In addition, a grievance procedure managed by a third-party is required by the CCB Standard. One legally mandated role of the existing Commune Councils in the project zone is to receive complaints from their constituents on issues of any kind and either direct them to the appropriate place or seek to resolve them directly, often by mediating between the affected parties. Hence the Commune Councils in the project zone function as a third party grievance mechanism, and have done so implicitly since the beginning of conservation activities in 2002. The FA has committed to this as one element of the formal Community Agreements.

Whether they come directly, or via the commune councils, responsibility for resolving all reasonable grievances received will remain with the project implementation team. A written response to all reasonable grievances will be provided within 30 days, and the team will aim to resolve the grievance as quickly and effectively as possible. A senior member of the management team will be responsible for overseeing the process, and ensuring that cases are documented and processed efficiently.

[6] s3.amazonaws.com/CCBA/Projects%2FOddar_Meanchey_REDD_Project%2FComments_received_on_Oddar_Meanchey_REDD_Project.pdf

Decisions will be made in consultation with, or under the mediation of, the relevant commune council, and all written documentation will be copied to them.

The project is providing capacity-building to the Commune Councils and logistical support to increase their understanding of the REDD project and their role in performing this function.

This mechanism has the great advantage of using an existing, familiar and well-established system, increasing the likelihood that it will be accepted by all stakeholders and will be found to be sustainable and cost-effective. The perceived adequacy of the mechanism in receiving and resolving complaints will be assessed periodically during consultations with community representatives, and if judged necessary through periodic external evaluations. As the project grows in size and scope, it may be found necessary to develop a project-specific grievance procedure contracted out to another third party (e.g. a local NGO).

2.8 Commercially Sensitive Information

The following information is commercially sensitive and is not publicly available. This information will be made available to the validator.

- Detailed Financial Models
- VERPAs (Forward sales contracts)

3 LEGAL STATUS

3.1 Compliance with Laws, Statues, Property Rights etc. (G4 & G5)

Evidence of approval for the project

The SPF REDD project is one of the country's first REDD demonstration projects and is specifically listed as such in Cambodia's National REDD Readiness Roadmap (RGC 2010). This constitutes evidence of approval from the formal authorities. Evidence that the project has approval from the appropriate traditional authorities is set out in Section 3.7.

Forestry and Land Laws

The project activities comply with all Cambodian laws and specifically the Forestry Law (FL) of 2002. The land tenure and land use rights for the project area are specifically approved by the Council of Ministers in the form of a sub-decree (Decision no.143, 2009). Land tenure and land rights in areas that will subsequently be transferred to communal titles for indigenous communities are governed by Articles 23-28 of the Land Law (2001) and the relevant Sub decree 83 (2009).

Relevant forestry laws are available on: http://www.forestry.gov.kh/Law/Regulations_Eng.html.

Relevant land laws are available on: http://www.gocambodia.com/laws/index.asp#1 and http://www.mlmupc.gov.kh.

Local laws

There is no comprehensive system of sub-national law in Cambodia. Local laws, as defined by CCBA, are limited in this case to declarations, circulars and similar formal documents issued by the provincial, district and commune authorities in accordance with their authority. These typically refer to particular issues of local interest and may only be relevant for a defined period of time. They are formally announced to all relevant government departments, including the project proponent, who then inform the rest of the project team of their existence. The relevant senior project management staff maintain files of the declarations relevant to their area of responsibility.

Employment Laws

Applicable laws and official regulations in Cambodia which relate to employment include:

- Constitution of the Kingdom of Cambodia;
- Cambodian Labor Law, 1997;
- Regulations enacted by the Royal Government (Sub-Decrees) and the Ministry of Labor (Ministerial orders, Circulars, and Notices);

The following websites provide further detailed information regarding Cambodian laws and regulations covering worker rights:

- http://www.constitution.org/cons/cambodia.htm
- http://www.bnglegal.com/uploads/reports/Labor%20Law%20Guide%20for%20NGOs.pdf
- http://www.arbitrationcouncil.org/InformationforParties/LegalDocuments/tabid/72/language/en-US/Default.aspx

Employees of government agencies including the FA are covered by the employment conditions of their host Ministries. These can be assumed to adhere to all relevant government law and policies, and government employees are informed of their rights and responsibilities through routine government employment procedures.

For NGO partner staff, employer-employee rights and responsibilities are governed by the above laws, and additionally by their Employment Contracts, and by WCS's Internal Policies and Regulations. These policies meet or exceed the requirements of the laws and regulations covering workers' rights and conditions. All staff are given a copy of their employment contracts, which outline their rights, and refer to other relevant documents. A policy manual, working regulations and Site Operating Procedures are routinely distributed to new staff on commencement, and relevant documents are available in Khmer language at project offices.

3.2 Evidence of Right of Use (G5)

The main evidence for right of use arises under law (in accordance with VCS Standard Version 3.3. Section 3.11.1) for state-owned forest land. Evidence of right of use for the small areas of forest eligible for transfer to Communal Land Titles arises through signed agreements with the potential holders of these titles (another option permitted by Section 3.11.1 of the standard).

State-owned Forest Land

The project area that will generate credits was 100% State land at the project start date, under the territorial mandate of the Ministry of Agriculture, Forestry and Fisheries (MAFF) through the Forestry Administration (FA). It was first formally designated as Permanent Forest Estate in 1994, at which time it was implicitly classified as Production Forest. It was first made a conservation area in 2002 by a government regulation ('prakas') that was signed by the Minister of Agriculture, Forestry and Fisheries. This status co-existed with its status as Production Forest. The land status of the area was reclassified to Protection Forest on September 4th, 2009 by the endorsement of a sub-decree (No. 143, 2009) by the Council of Ministers and Prime Minister Samdech Hun Sen, thus enhancing its conservation status. This legal action created the Seima Protection Forest and reaffirmed MAFF, through the FA, as the government body responsible for managing it. The sub decree has nine objectives, which are listed below:

1. Protect, conserve and rehabilitate genetic resources of fauna and flora which are globally threatened.
2. Maintain and rehabilitate important ecosystems as habitat for all forms of biodiversity.
3. Contribute to protection and conservation, to meet the goals of the National Millennium Development Plan of the Royal Government of Cambodia, and to maintain forest cover.
4. Conserve the culture and tradition of indigenous communities and local communities where they are living within the Protection Forest area.
5. Maintain the natural resources that these communities depend on for their livelihoods and to implement the program of poverty reduction of the Royal Government of Cambodia.
6. Contribute to sustainable socio-economic development through participation in the management of harvesting forest resources by the local communities, development of ecotourism and other similar activities which have very small impact to biological resources, forest and wildlife.
7. Maintain carbon stored in vegetation in order to reduce carbon dioxide (CO_2) emissions into the atmosphere.
8. Prevent soil erosion, to protect soil fertility and to maintain the stability and quality of water sources.
9. Support other activities including technical and scientific research, education, training, community development, and environmental studies, which are related to sustainable development and conservation at local, national and international levels.

This sub decree is the necessary proof of title/right of use for the Forestry Administration to develop and manage a REDD project within the Seima Protection Forest on behalf of the RGC as the land is clearly government owned. Also objective seven gives the FA a clear mandate to implement policies to manage the area for avoidance of carbon emissions.

Forest that is later transferred to Communal Land Titles

Parts of SPF are potentially eligible to be claimed as Indigenous Communal Title lands (ICT) under Land Law Articles 23-28. In such areas ownership is eventually transferred by process of law to the communities and the land ceases to be part of the Permanent Forest Estate, although some parcels remain on the Land Register as State Land and the communities have no right of sale for these. Issuance of these titles is a core strategy of the project as it will help to stabilise permitted land-uses and protect community rights, and so most eligible areas will likely be titled during the first fixed baselinebaseline period. Around several villages such titles were issued during 2012-2013, during the project crediting period.

The RGC has yet to rule on the ownership of forest carbon rights within areas of ICT; they may remain with the state or be transferred to the communities. If they remain with the state, the evidence of right of use for state forest land mentioned above remains relevant. If the rights are transferred to the communities, signed agreements that anticipate this issue are in place with every community (see Section 3.7) and provide the necessary evidence of right of use. These agreements explicitly entrust any carbon credits generated on such land within the project area to the FA for aggregation and sale, notwithstanding any possible change in the underlying ownership.

Such land is likely to be a very small percentage of the project area. Land potentially eligible for titling is estimated (WCS unpublished data) as less than 3.8% of the total area of the legally defined Core Protection Area. Since much of this is already classified as non-forest (e.g. residential and agricultural parcels) it is not part of the REDD project area. Some forest is included in the total, although much of it is likely to be among those areas that are deforested before the project attains full effectiveness, and so will not contribute to the generation of credits in the long term. Hence the proportion of total credits generated that are attributable to permanently avoided deforestation on communally titled lands are expected to be very small (perhaps <1% of total emissions reductions).

Samling International Logging Concession

As noted in Section 1.3, the project area lies within the Samling International Ltd Chhlong logging concession, issued in 1994. The concession ceased timber operations in 1999 as part of the national moratorium on logging concession operations which remains in place and is not expected to be lifted for any concession in the country (RGC 2010). Hence there is no plausible risk of resumed commerical logging by Samling at this site. This has been reinforced by the 2009 Subdecree declaring the SPF which reassigns the whole area to Protection Forest, a land category that does not permit timber concession operations. The existence of the concession contract is not believed to entitle Samling International to any role in the management or benefit-sharing arrangements for the Seima REDD project.

3.3 Emissions Trading Programs and Other Binding Limits (CL1)

Cambodia is a non-Annex I signatory of the Kyoto Protocol and hence it does not have binding limits on its GHG emissions.

3.4 Participation under Other GHG Programs (CL1)

The project is only seeking registration under the VCS and CCB programs.

3.5 Other Forms of Environmental Credit (CL1)

Carbon credits are currently the only environmental credit being generated from this project. There is no intent to generate other GHG-related environmental credits for reductions claimed under the VCS program.

3.6 Projects Rejected by Other GHG Programs (CL1)

The project has not been rejected by any other GHG program.

3.7 Respect for Rights and No Involuntary Relocation (G5)

Free, Prior and Informed Consent

Consent for REDD activities is required from the communities that use the land, if the activities affect them. Futhermore, under VCS and CCBA rules the owner of carbon rights for a piece of land must formally agree to the sales of credits derived from these rights. At the project start date SPF was 100% State Public Land in the Permanent Forest Estate, leading to a simple situation where all carbon rights were the property of the state which was therefore the primary decision-maker. However, on parcels of land that are later transferred into Indigenous Communal Land Titles, the carbon rights may belong to either the state or the community, depending on future policy decisions. If the rights are later transferred to the communities, community consent would be required for continued sales of the credits derived from that land. If that consent is withheld, past emissions reductions on that land might no longer be considered permanent, with implications for past and future carbon accounting across the whole site.

To simplify this complex situation and remove this potential risk it was decided to pre-emptively seek community consent for the inclusion of credits from such land in the broader project, because although they are not (yet) formally owned, the communities clearly have a potential claim and asking their consent demonstrates government commitment to treating the communities as active project participants and rights holders.

Explicit written community consent was obtained from all 20 participating communities through a process starting in the early stages of the project, prior to any steps to validate the project or make sales of credits. The consent was freely given and based on extensive efforts to ensure signatories were well-informed, as described in Section 2.7. The design of the community consent agremeent (available on request) aimed to follow best practice in all important aspects. We believe it meets the requirements of Cambodian national law, and conforms with VCS and CCB requirements and the UN Declaration on the Rights of Indigenous Peoples (UNDRIP; 2007). It describes in detail what is being consented to, the term of the agreement, the rights and liabilities it confers and so on. The consent agreements were signed by the most appropriate community representatives, with thumbprinted support from the great majority of families in each village.

This consent is indefinite in duration but with clauses that allow either party to withdraw if necessary, without jeopardizing any credit sales that have already been made. The consent explicitly covers cases where the ownership of some land and credits is later transferred to the community. In these cases the community consents for the credits to continue to be pooled with, and sold with, the government-owned credits from the rest of the forest. Subsequent benefit-sharing, still under discussion, will take account in some way of this contribution from the communities concerned.

The process of obtaining this consent was part of the broader process of stakeholder consultations and so is described in Section 2.7.

Involuntary relocation

The project anticipates no involuntary relocations of legitimate occupants of the area from either residential land or farmland. However, illegal settlers or land grabbers attempting to occupy state or community land may be arrested by the relevant authorities and removed without compensation, and possibly prosecuted, in accordance with the law.

In general the project will impose no restrictions on customary use of forest resources beyond the basic legal requirements for sustainable practices, and in many cases will improve security of access and the status of these resources. The one exception is that the project is expected to propose some restrictions on customary use rights in areas to be designated as Strict Protection Zones, SPZs, (a provisional term) which will be areas of zero or near zero human use, designed to improve the survival prospects of the most vulnerable wildlife species (part of Action 1.2, Section 2.2). The size and location of the proposed SPZs has yet to be decided, but they will be placed to minimise the number of forest users affected. Restriction of use falls within the CCBS definition of 'relocation', but this will not be an involuntary process. Designation of such zones will be preceded by detailed consultations and consent process with potentially affected villages, identification of affected individuals/families and the negotiation of mutually acceptable compensation packages, which might include, but would not be limited to, employment opportunities, in-kind compensation (e.g. alternative livelihoods) or financial compensation (e.g. substituting the value of any resin tree income foregone). Confirmation that this process will entail consent is included in the text of the Community Consent Agreements.

3.8 Illegal Activities and Project Benefits (G5)

Project activities combine efforts to prevent illegal activities (e.g. through planning and direct enforcement) and efforts to enhance livelihoods through interventions that are clearly legal (e.g. agricultural assistance on lands that are legally farmed, ecotourism in sites that have government approval etc). Safeguards will be put in place to ensure that project funds are not used to promote illegal activities (e.g. by screening of grants for community projects).

Illegal activities drive many of the threats to climate, biodiversity and community well-being in the baseline scenario and so the project has been explicitly designed to address them (Section 2.2). Actions under Sub-objective 2 are all designed to enhance direct law enforcement, mainly by government-led patrol teams but also by community-led patrols and other measures, including monthly and annual monitoring of the levels of illegal activity. Sub-objective 1 aims to put in place the legal and planning frameworks that deter illegal activity and Sub-objective 3 aims to establish legal land tenure and land management systems for community areas.

4 APPLICATION OF METHODOLOGY

4.1 Title and Reference of Methodology

This project is using the methodology entitled "Methodology for avoided unplanned deforestation" which is the VCS's approved VM 0015, version 1.1 (December 2012).

4.2 Applicability of Methodology

The chosen methodology has no geographic restrictions and thus is applicable to a forest area located in Cambodia. The project also meets all of the following applicability conditions:

a) **Condition 1:** Baseline activities may include planned or unplanned logging for timber, fuel-wood collection, and charcoal production, agricultural and grazing activities as long as the category is unplanned deforestation according to the most recent VCS AFOLU requirements.
Project Condition: The baseline activities in the project area include unplanned expansion of agricultural activities.

b) **Condition 2:** Project activities may include one or a combination of the eligible categories defined in the description of the scope of the methodology.
Project Condition: The project activities consist of forest protection without logging or charcoal production.

c) **Condition 3:** The project area can include different types of forest, such as, but not limited to, old growth forest, degraded forest, secondary forests, planted forests and agro-forestry systems meeting the definition of "forest".
Project Condition: The project area consists of different types of forest including old growth, degraded, and secondary forest.

d) **Condition 4:** At project commencement, the project area shall include only land qualifying as "forest" for a minimum of 10 years prior to the project start date.
Project Condition: The project area has all been forest land since at least 1998, as confirmed by the historical satellite analysis presented in this document

e) **Condition 5:** The project area can include forested wetlands (such as bottomland forests, floodplain forests, mangrove forests) as long as they do not grow on peat. Peat shall be defined as organic soils with at least 65% organic matter and a minimum thickness of 50 cm. If the project area includes a forested wetlands growing on peat (e.g. peat swamp forests), this methodology is not applicable.
Project Condition: The project area has small areas of seasonal wetlands located within deciduous forest. There is no known peat soil located within the forest area.

4.3 Methodology Deviations

No methodology deviations are proposed.

4.4 Project Boundary (G1)

This project type has four categories of project boundaries listed below:

1. Spatial boundaries
2. Temporal Boundaries
3. Carbon Pools
4. Sources of emissions of greenhouse gases (other than carbon stock changes)

Step 1.1 Spatial Boundaries

With respect to the chosen methodology, the spatial boundaries consist of five categories namely:

1) Reference region
2) Project area
3) Leakage belt
4) Leakage management areas
5) Forest definition

Categories 2, 3 and 4 together constitute the Project Zone as defined under the CCB Standard.

The project area, leakage belt and leakage management areas are non-overlapping subsets of the reference region (Figures 4.1 and 4.2). The following sections describe how these spatial boundaries were selected.

Figure 4.1 Spatial boundaries of the project (reference region)

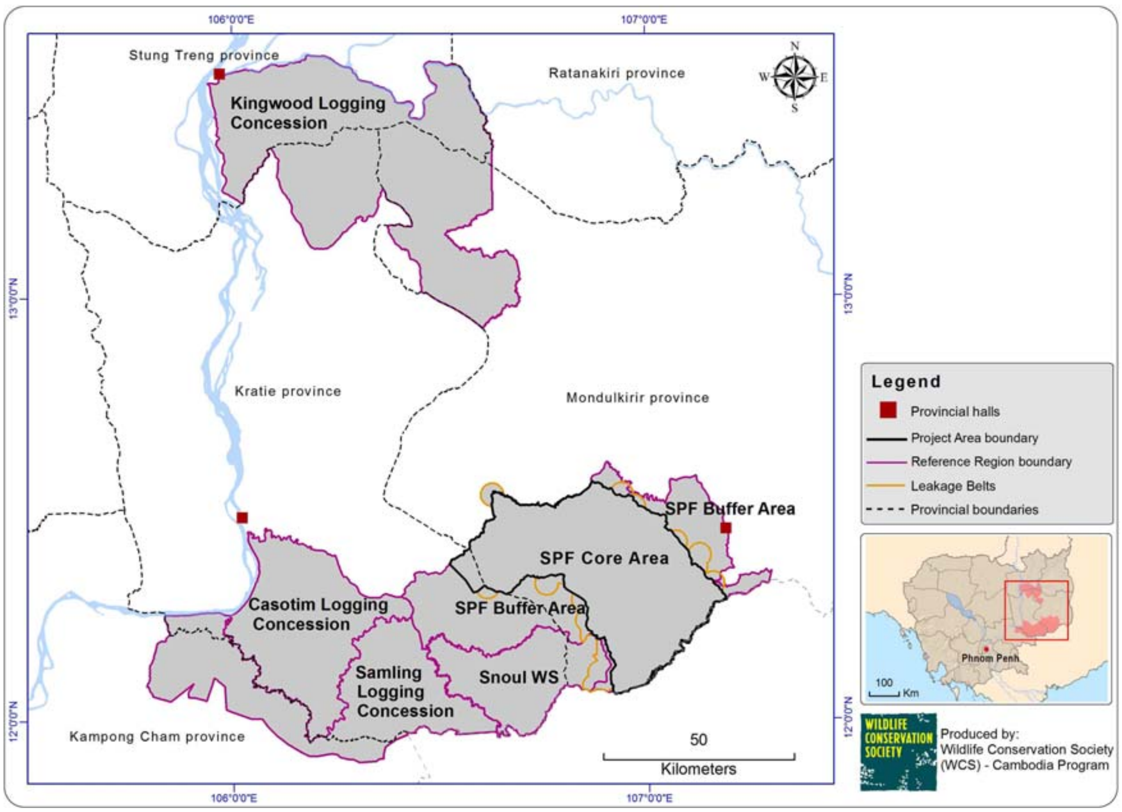
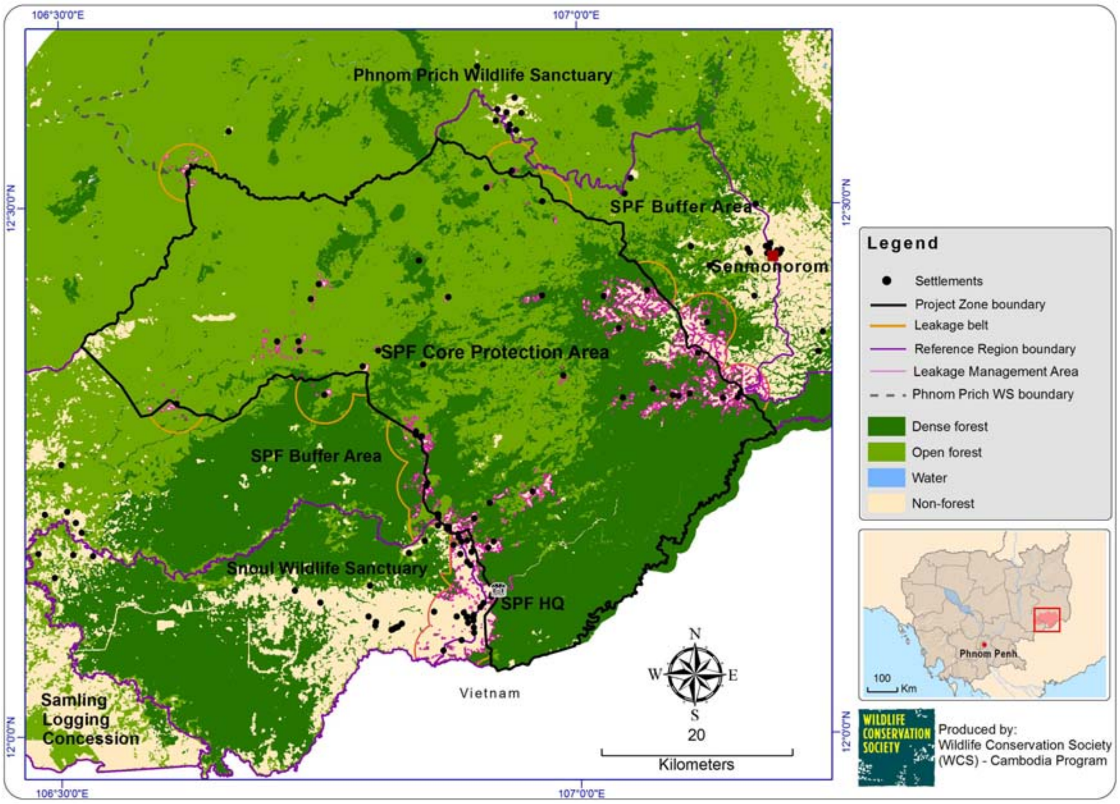


Figure 4.2 Spatial boundaries of the project (project zone)



Reference Region

No sub-national or national baseline exists and the national government has not divided the country into sub-national spatial units for which deforestation baselines will be developed.[7] Therefore, a reference region specific to the project has been delineated. A set of criteria is provided by the methodology, with the following guiding principle:

> "A geographic area is relevant for determining the baseline of the project area when agents, drivers and overall deforestation patterns observed in this area during the 10-15 year period preceding the start date of the proposed REDD project activity represent a credible proxy for possible future deforestation patterns in the project area." [methodology page 15]

The selected reference region covers a slightly discontinuous area including the project area, blocks adjacent to the project area and one other nearby block in north-east Cambodia. These blocks have similar levels of legal protection, contain similar vegetation and landforms and face comparable deforestation threats. Intervening areas do not meet the criteria for similarity as closely (in particular because they have differing legal status, and a lower proportion of dense evergreen forest), and hence have been omitted. The following legally defined management units are included in the reference region:

- The entire **SPF**, including the core area (project area) that will generate credits, and **two Buffer Protection Forest Areas**. The reference region also includes small areas that were excised from the Seima Biodiversity Conservation Area during the transition to Protection Forest status at the end of the historical reference period.
- Three dormant logging concessions (**Casotim**, **Kingwood** and that part of the **Samling** International Chhlong concession that is not now included in the SPF). These concessions are under FA jurisdiction. Small parts on the southern fringe of the Samling concession were excluded as inspection of satellite imagery showed them to have different patterns of

[7] Cambodian National REDD+ Readiness Roadmap (2011)

deforestation, with a highly complex mosaic of small patches that could not be adequately interpreted with medium resolution imagery.

- The **Snoul Wildlife Sanctuary** (SWS), an area managed by the Ministry of Environment (MoE). This area has been included since it has a legal conservation status similar to the project area.
- **Small areas outside the other management units but inside the Leakage Belt**. Some of these lie in Phnom Prich Wildlife Sanctuary and others in areas of unclassified forest estate. The Leakage Belt is defined below.

The reference region covers 966,603 ha of forest and non-forest land including the project area[8]. While the methodology does not set a strict numerical area requirement for the reference region it suggests a figure of 5-7 times the project size for project areas > 100,000 ha which would mean a range of approx. 902,000-1,263,000 ha. Hence the reference region for this project is of appropriate size.

The reference region represents a set of land areas with broadly similar legal status. All parts of the reference region are essentially following the same chrono-sequence of unplanned deforestation, but each sector has started at a different time in the past so some are more deforested than others. In the BAU case, each area progresses from remote seclusion with low deforestation rates through arrival of access routes and the deforestation frontier, followed by rapid deforestation and ending with a stabilised situation with very little forest remaining.

The south-west of the reference region has nearly reached the end of this sequence, whilst the north-east has barely begun, and areas in between are at varying points in the sequence, depending on where they lie on the gradients of threat. Hence taken together the reference region is characterised by the full range of states of each of the drivers relevant to the project area now and in the next 10 years. It thus provides a suitable area in which to calibrate predictive models. The project area lies in the lower part of this gradient of threat and is just entering the phase of rapid deforestation. This is expected to progress rapidly unless REDD funding becomes available to alter the sequence of events.

The reference region is stratified according to the dominant agents of deforestation, as explained in detail in Annex 4.1. The first and most important group of deforestation agents in the project area is small-holder farmers who cause unplanned deforestation (see Section 4.5). Areas affected by small-holder farmers causing unplanned deforestation are placed in Stratum 1 for the purposes of historical deforestation analysis. Stratum 1 includes the whole of the project area and so it is patterns in this stratum that determine the projected baseline within the project area. A second major agent group (companies with Economic Land Concessions) has increasingly caused deforestation in the reference region during the latter part of the historical reference period. This agent does not act in the project area and planned deforestation is not covered by the scope of the methodology, so this source of deforestation has to be separated from that of the first agent group during analysis. This is done by placing land affected by this agent group in Stratum 2, which is dynamically defined and increases in size as more land concessions are issued over time. It is not necessary to make quantitative projections of future deforestation within Stratum 2 as it does not overlap with the project zone.

The methodology requires that the project area and reference region have similar: 1) agents and drivers of deforestation, 2) Landscape configuration and ecological conditions, 3) Socio-economic and cultural conditions. These tests are applied below.

Test 1: Agents and drivers of deforestation existing or expected to exist within the project area must exist elsewhere in the reference region.

Smallholder farmers are the dominant agent group both within the project area and across the broader reference region, and their activities are associated with the same infrastructure drivers and other spatial drivers across both areas. The same ranges of levels/classes of the predictor variables found within the project area are also observed in various parts of the broader reference area,

[8] Historical deforestation analysis also covered a broader area around these units. This allowed for adjustments to the reference area during project development and enables a wider range of spatial statistics to be calculated for points within the reference region.

together with a broader range of values that allows predictive models to be developed since in part they represent likely BAU conditions in the project area 5-10 years in the future.

Test 2: Landscape configuration and ecological conditions

At least three of the four conditions listed in Table 4.1 must be satisfied. The project satisfies the first three conditions and so meets this test:

Table 4.1 Ecological conditions in the project area and preliminary reference area

	Methodology Requirement	**Project area**	**Reference Region**	**Test**
Forest classes (FCA 2007)	At least 90% of the project area must have forest classes or vegetation types that exist in at least 90% of the rest of the reference region.	94.6% falls in four vegetation classes of FCA 2007 (Deciduous, Evergreen, Semi-evergreen, Non-forest*)	93.9% is made up of the same four vegetation classes at similar proportions.	Pass
Elevation range	At least 90% of the project area must be within the elevation range of at least 90% of the rest of the reference region	92.6% lies in the range 0-499 m	96.8% lies in the same range.	Pass
Slope	Average slope of at least 90% of the project area shall be within ± 10% of the average slope of at least 90% of the rest of the reference region.	97.5% lies in the range 0-15 degrees	99.8% lies in the same range	Pass
Rainfall	Average annual rainfall in at least 90% of the project area shall be within ± 10% of the average annual rainfall of at least 90% of the rest of the reference region.	the driest 90% has a mean rainfall of 3060 mm/year	the wettest 90% has a mean rainfall of 2446 mm/year (21% lower)	Fail

* 'Non-forest' is listed here due to a slight difference in definitions - areas with 10-20% canopy cover are classed as forest by the definition used in this document but non-forest in the definition used by FCA (2007).

Test 3 Socio-economic and cultural conditions:

Test 3.1 Legal Status
Condition: The legal status of the land in the Project Area covered in the baseline case within the project area must exist elsewhere in the reference region.

Project Condition: Despite varying names, all the units in the reference region have similar levels of protection in law from unplanned deforestation by smallholder farmers, since in all cases the forest is state land and deforestation is essentially illegal except when it occurs on the basis of land-use allocation decisions by the Council of Ministers (e.g. excisions, ELCs, social land concessions). The *legal status* of the project area was Production Forest through the historical reference period (a status that existed in several other units of the reference region) and from 2002 onwards the area also had an overlying subsidiary designation as a 'Biodiversity Conservation Area' under a declaration issued by MAFF. This is also the status it would have in the business-as-usual scenario.

Test 3.2 Land Tenure
Condition: The land-tenure system prevalent in the project area in the baseline case is found elsewhere in the reference region.

Project Condition: Please see Section 1.3 for an analysis of land tenure in the project zone, which is mostly State Public Land owned and administered by the government. Almost all land under forest in the reference region at the project start date was also State Public Land, as implicit in the land designations shown on Figure 4.1. At the project start date some relatively small areas of forest in the SPF Core area (approx 3.8%, much of it already non-forest) were potentially eligible for registration as

Communal Land of Indigenous Communities. Forest land eligible for communal titling also occurs widely in small pockets across the reference region.

Test 3.3 Land use
Condition: Current and projected classes of land-use in the project area are found elsewhere in the reference region.

Project Condition: All the current and projected classes of *land-use* in the project area covering natural forest types and all the major agronomic systems are also found widely throughout the reference region

Test 3.4 Enforced Policies and Regulations
Condition: The project area shall be governed by the same policies, legislation and regulations that apply elsewhere in the reference region.

Project Condition: The *enforced policies and regulations* within the project area are the same as those applicable throughout the reference region and must adhere to all the same national laws. In Cambodia, there are no laws relating to land use that vary between provinces. The various forest management units are governed by different elements of the same body of national law.

One difference between the management units is in the exact extent to which these enforced policies and regulations are put into practice. Throughout Cambodia forest management units of all designations tend to be more actively protected when there is an NGO or private sector partner working with the government. This is largely a result of increased financial and technical resources. Hence in the BAU scenario, SPF (remaining under its previous designation as the SBCA) would receive somewhat higher levels of investment and active forest protection than the other four units due to the collaboration with WCS. This does not invalidate the use of the other units in the reference region, since it is evident that the same agents and drivers are prevalent in both cases and even the actively managed units face high and accelerating deforestation (Annex 4.5). However, it does require that the different levels of active management are taken into account during modelling and analysis of deforestation (Table 5.4). NGO support for the Seima area also occured through much of the historical reference period, so the reference region represents the full range of values for the key variables expected during the period of the first fixed baseline, which enables suitable analyses to be conducted.

Project Area

The project area comprises 180,513 hectares of forested land located within the Core Protection Area of the Seima Protection Forest (Figure 4.1). It excludes non-forest land within the boundary (Figure 4.2). It includes all forest in the Core Area as designated at the time of the 2009 Subdecree except for a small area along the western margin that has subsequently been reallocated to the Binh Phouc I rubber concession. This small area is now potentially subject to planned rather than unplanned deforestation and so is no longer covered by the scope of the methodology.

Immediately before the project start date the project area became classified as Protection Forest. The project area has the shape of a left leaning crescent that borders Vietnam to the south. The boundary of the project will be provided to the auditor in a GIS shape file.

The project consists of one activity, as defined by the Methodology (Table 1, p10), namely Type A, protection without significant logging, fuelwood collection or charcoal making in the baseline case of old growth forest without significant logging. This activity covers the whole of the project area and leakage belt. The boundary of the area of the activity will be provided to the auditor in a GIS shape file.

Leakage Belt

The leakage belt (Figures 4.1, 4.2) is the forest land surrounding or adjacent to the project area in which baseline activities could be displaced due to project activities implemented in the project area. The project has defined the leakage belt through a mobility analysis (Annex 4.2) by developing buffers around local community areas that are located within or adjacent to the park. Some parts of the

Leakage Belt applicable from 2010 became unavailable for unplanned deforestation from 2012 onwards due to the presence of active Economic Land Concessions. The leakage belt has been delineated in a GIS shape file and will be provided to the auditor.

Leakage Management Area

Since the project seeks to prevent leakage partly through agricultural intensification, the leakage management area includes all anthropogenic non-forest land that was located within the project zone at the project start date (Figure 4.2). This area is defined as all non-forest or recent deforestation (since 1998) as of 2010 within 3 km of a settlement (settlements are mapped by Pollard and Evans 2009). These areas were delineated using GIS software and will be provided to the auditor.

Several leakage management activities (e.g. ecotourism and NTFP management) will also be conducted within forested parts of the Project Area and Leakage Belt, but are not included in the Leakage Management Area map since this is required to contain only non-forest land.

Forest Definition

The 'forest' definition used here follows Cambodia's national definition under the Kyoto Protocol[9] - namely an area of at least 0.5 ha with at least 10% crown cover of trees taller than 5 m. Cambodia includes bamboo in this definition. Within this definition, the SPF has a spectrum of natural forest types from fully deciduous to almost fully evergreen[10], with the types forming a complex mosaic believed to reflect climate, altitude, edaphic factors and varying history of human disturbance. The forests mostly fall within four of the broad classes used by the 2006 National Forest Cover Assessment, namely Deciduous, Semi-evergreen, Evergreen and Bamboo Forests.

The analysis of satellite imagery has been conducted at the resolution of the raw LANDSAT imagery (0.09 ha), but in post-processing stages the resolution has been reduced to eliminate clumps of pixels <1 ha to eliminate noise. By doing so, the Minimum Mapping Unit has been set at 1 ha to accord with the requirements of the methodology. So, the operational forest definition used here is an area of at least 1 ha with at least 10% crown cover of trees taller than 5 m.

Step 1.2 Temporal Boundaries

Starting Date and End Date of the historical reference period

The historical reference period runs for twelve years from 1 January 1998 to 31 December 2009.

Starting date of the project crediting period of the AUD project activity

The crediting period of the AUD project activity will start on 1 January 2010 and will run for 60 years.

Starting date and end date of the first fixed baseline period

The first fixed baseline period is ten years and will start on 1 January 2010 and run until the end of December 2019.

Monitoring period

Monitoring and verification will take place at four points:

- Verification 1 - during 2014 (covering 2010-2013, years 1-4)
- Verification 2 - during 2016 (covering 2014-2015, years 5-6)
- Verification 3 - during 2018 (covering 2016-2017, years 7-8)
- Verification 4 - during 2020 (covering 2018-2019, years 9-10).

[9] cdm.unfccc.int/DNA/ARDNA.html?CID=37
[10] (e.g Walston *et al.* 2001, Zimmermann and Clements 2003)

The revision of the baseline for the second fixed baseline period will take place during 2018-2019, to come into force at the start of 2020.

Step 1.3 Carbon Pools

Table 4.2 shows which of the six carbon pools considered by the methodology have been selected for measurement under this project. The project will measure above and below ground tree biomass and dead wood. Other pools are deemed insignificant. The data that support these decisions are presented in Section 5.6.

Table 4.2 Carbon pools included or excluded within the boundary of the proposed project (=Methodology Table 3)

Carbon Pools	Included/Excluded	Justification/Explanation of Choice
Above Ground	Tree: Included	Carbon stock change in this pool is always significant.
	Non-tree: Excluded	This pool will be larger in the with-project case and so it is conservative to omit it. It is also not of significant size.
Below Ground	Included	This pool represents roughly 11.5% of the emission reductions of the project making it significant.
Deadwood	Included	This pool represents about 3% of the emission reductions of the project in each forest class, making optional whether to include it.
Harvested Wood Products	Excluded	Not Significant
Litter	Excluded	Not Significant
Soil Organic Carbon	Excluded	Not to be measured in conversions which include perennial crops, as is the case in the current project.

Step 1.4 Sources of GHG Emissions other than CO_2

The methodology only considers non-CO_2 emissions from biomass burning and livestock as sources of GHG emissions. Sources of emissions must be determined for the baseline and project scenarios as well as for leakage prevention activities. Emissions included in the baseline scenario consist of CO_2 emissions from deforestation and degradation. In terms of project activities, the methodology excludes GHG emissions from fossil fuel consumption. The methodology excludes emissions from fertilizer use. Table 4.3 shows that all non-CO_2 emission sources have been excluded from the project design.

Table 4.3 Sources of GHG included or excluded within the boundary of the project activity (=Methodology Table 4)

Source		Gas	Included?	Justification/Explanation
Baseline Scenario	Biomass Burning	CO_2	Excluded	Counted as carbon stock change
		CH_4	Included	It is optional to include this source of emissions.
		N_2O	Excluded	Considered Insignificant according to VCS program update of May 24^{th}, 2010.
	Livestock Emissions	CO_2	Excluded	Livestock are not found in significant numbers in the baseline or with project scenario, and emissions from them will be smaller in the with-project scenario so it is conservative to omit them
		CH_4	Excluded	
		N_2O	Excluded	
Project Scenario	Biomass Burning	CO_2	Excluded	Counted as carbon stock change
		CH_4	Included	It is optional to include this source of emissions.
		N_2O	Excluded	Considered Insignificant according to VCS program update of May 24^{th}, 2010.

4.5 Baseline Scenario (G2)

Baseline scenario with respect to climate

The most plausible baseline scenario for the project area is accelerating unplanned deforestation from small holder farmers partly mitigated by continued grant-funded conservation activities at declining levels.

In this scenario the project area would continue to be managed as it was during 2002-2010, as an area of Production Forest designated as a Biodiversity Conservation Area by Ministerial Decree. Management practices and outcomes during this historical period are described by Evans *et al.* (2013). This management approach would take place against a background of threats that are similar in nature but greater in intensity compared to the historical period, as demonstrated below.

In this baseline scenario operational funds would continue to derive from short-term grants that are raised by the Wildlife Conservation Society from a variety donors. Management effectiveness would decline under this baseline scenario due to declining availability of grant funds and probably also concomitant declines in political support. The funding history of the site and the reasons for projecting a decline in funding for core protection activities are set out in Annex 4.4. Past levels of funding have been enough to mitigate but not prevent the effects of these drivers on deforestation rates (see Step 2 below, Section 5.3, and Evans *et al.* 2013). Hence a decline in funding will exacerbate the impact of rising threats on rates of deforestation.

In the following sections this baseline scenario is described and justified in detail, including analysis of historical land-use and land-cover change and analysis of the agents, drivers and underlying causes of deforestation. In Section 4.6 the additionality of project activities is demonstrated relative to this baseline scenario, and to a set of other possible baseline scenarios.

Step 2 Analysis of historical land-use and land-cover change

The analysis is discussed in detail in Annex 4.5, which forms the Methodolical Annex required by section 2.6 of the methodology. An outline is provided here.

Step 2.1 Collection of appropriate data sources

We assembled medium resolution LANDSAT TM and ETM+ satellite images with a 30x30 m pixel resolution to map reductions in forest cover (deforestation). The LANDSAT imagery was acquired during the dry season (December-March) to minimize cloud cover. The image dates were chosen from available imagery to best represent the epochs of 1998, 2000, 2002, 2004, 2006, 2008 and 2010. To refine our classification and to improve interpretation of the land cover, we also analysed two types of radar imagery, ALOS PALSAR L-band and ERS C-band. This was used primarily to improve the discrimination between open forests and non-forest areas such as wetlands, grasslands, tarmacked areas, and paddy fields, because open forests can appear similar to non-forest areas on LANDSAT satellite acquired during the dry season. We selected high-resolution $1m^2$ pixel IKONOS imagery from 2002 for accuracy assessment. The images are listed in Annex 4.5 Table 5 (=Methodology Table 5).

Step 2.2 Definition of classes of land-use and land-cover

The definition of forest is given in Section 4.4 above. Four land use and land cover (LU/LC) classes were identified in the reference region (Table 4.4). Forest land was stratified in two broad classes having different average carbon densities (following Annex 5.3). These are 1) dense forest and 2) open forest. These two forest strata were mapped through the analysis of remote sensing data.

Table 4.4: List of all land use and land cover classes existing at the project start date within the reference region (=Methodology Table 6)

Class Identifier		Trend in Carbon stock	Presence in^	Baseline activity$			Description (including criteria for unambiguous boundary definition)
ID_{cl}	Name			LG	FW	CP	
Fd	Dense forest	Constant	RR, LK, PA	n*	n*	n	Areas of land meeting the definition of forest used in the project and meeting the definition of evergreen forest, semi-evergreen forest or bamboo forest used by FCA (2006).
Fo	Open forest	Constant	RR, LK, PA	n*	n*	n	Open forests are areas of land meeting the definition of forest used in the project and meeting the definition used by the FCA (2006) for deciduous forest, other forest (except plantations) and woodland (evergreen or deciduous).
Nf	Non-forest	Constant&	RR, LK, PA	n	n*	n	All areas not meeting the definition of forest (including cropland, grassland, settlements, roads, rubber plantations, etc)
We	Wetland	Constant	RR, LK, PA	n	n	n	Land not meeting the definition of forest and typically covered by standing or flowing open water during the Cambodian dry season (e.g. rivers, lakes, ponds)

^ RR = Reference Region; LK = Leakage Belt; PA = Project Area
$ LG = Logging FW = Firewood collection CP = Charcoal production
* Occurs widely (and often illegally) but at negligible levels with respect to carbon stocks (Annex 4.3)
& Value used is a 20-year time-weighted average and so by definition constant

Step 2.3 Definition of categories of land-use and land-cover change

All LU/LC change categories that could occur in the project area and leakage belt are shown in Table 4.5a &b. Permanent transitions from non-forest or wetland to either of the forest classes, or transitions between the two forest classes are so rare as to be negligible in the baseline case.

Table 4.5a: Potential land-use and land-cover change matrix [=Methodology Table 7a]

		Initial LU/LC class			
	ID_{cl}	*Dense Forest*	*Open Forest*	*Non-forest*	*Wetland*
Final LU/LC Class	*Dense Forest*	Fd/Fd	x	x	x
	Open Forest	x	Fo/Fo	x	x
	Non-Forest	Fd/Nf	Fo/Nf	Nf/Nf	x
	Wetland	x	x	x	We/We

Table 4.5b: List of land-use and land-cover change categories [=Methodology Table 7b]

ID_{ct}	Initial Name	Trend in Carbon stock	Presence in	Activity in the baseline case^			Final Name	Trend in Carbon stock	Presence in	Activity in the project case^		
				LG	FW	CP				LG	FW	CP
Fd/Nf	Dense Forest	Constant	RR, LK, PA	n*	n*	n	Non-forest	Constant[&]	RR, LK, PA	n	n*	n
Fo/Nf	Open forest	Constant	RR, LK, PA	n*	n*	n	Non-forest	Constant[&]	RR, LK, PA	n	n*	n

Step 2.4 Analysis of historical land-use and land-cover change

We processed and analysed fourteen medium resolution LANDSAT TM and ETM+ satellite images between 1998 and 2010, at roughly two year time intervals across the entire Reference Region and some adjacent areas. A multi-date composite stepwise pre-classification approach was adopted to map deforestation and remaining forest cover. Supplementary radar imagery was analysed for large portions of the reference area in 1998, 2000, 2002, 2006, 2008 and 2010. As required by VM0015, a highly trained specialist led each phase of the interpretation work. All processing steps employed the remote sensing platform ERDAS IMAGINE v8.6 combined with a supervised tree-based classification algorithm. The decision-tree program we used is called SEE5. It is a well-known program developed by Rulequest (http://www.rulequest.com/see5-info.html) for data mining and pattern recognition, and was coupled with ERDAS IMAGINE with a helpful interface called CART which was developed by EarthSat Corporation for the US Geologic Survey. These automated methods were supplemented by manual interpretation of some more difficult areas. A detailed description of the methods of interpretation can be found in Annex 4.5.

Figures 4.3a-d form the four key benchmark maps (methodology section 2.4.3 products a-d) required by the methodology.

Table 4.6 shows the quantity of land-use and land cover change in the most recent period (2008-2009; methodology section 2.4.3 product e).

Table 4.6 Land-use and Land Cover Change Matrix for Stratum 1 (non ELCs)

Initial LU/LC class	Final LU/LC Class	2008-2009 activity (ha)
Dense Forest	Dense Forest Non-Forest	302649 15851
Open Forest	Open Forest Non-Forest	358594 9739
Non-Forest	Non-Forest	195410
Water	Water	719
Cloud/shadow	Non-forest Cloud/shadow	113 873
No Data	No Data	46
	Total land area	883995

Figure 4.3a Forest cover benchmark map (forest cover at start of 2010)

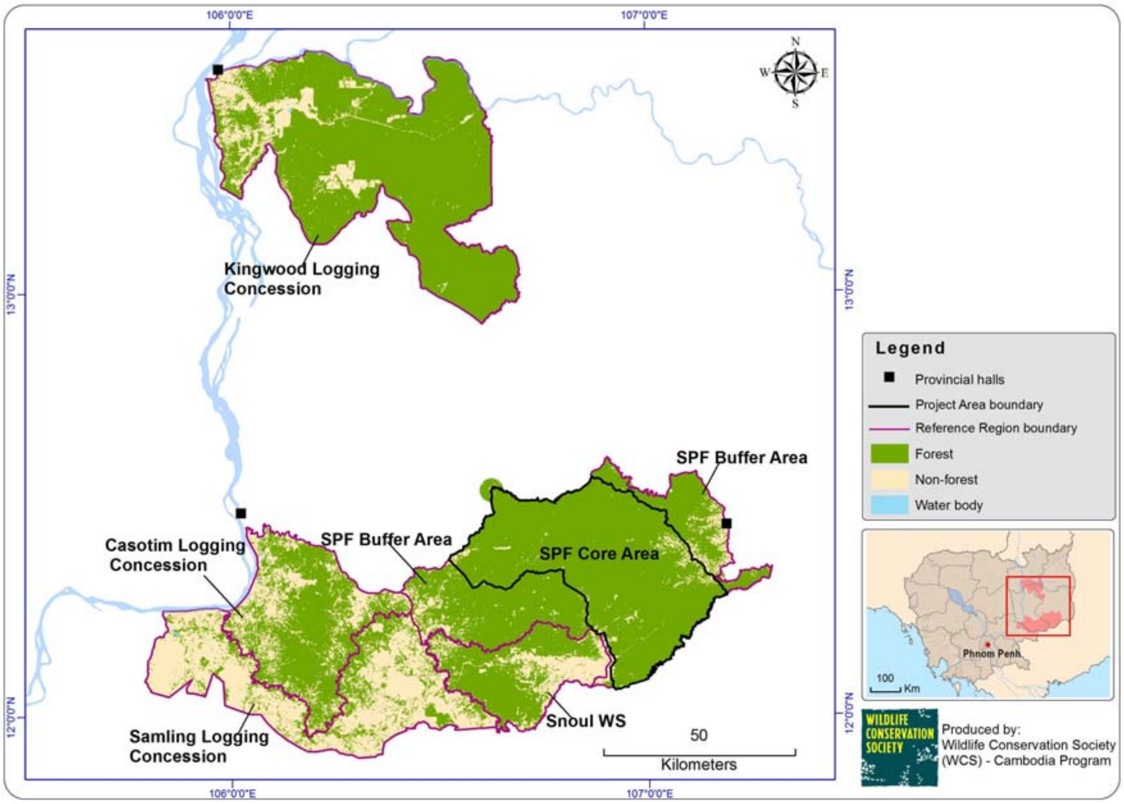


Figure 4.3b Land-Use and Land-Cover Map

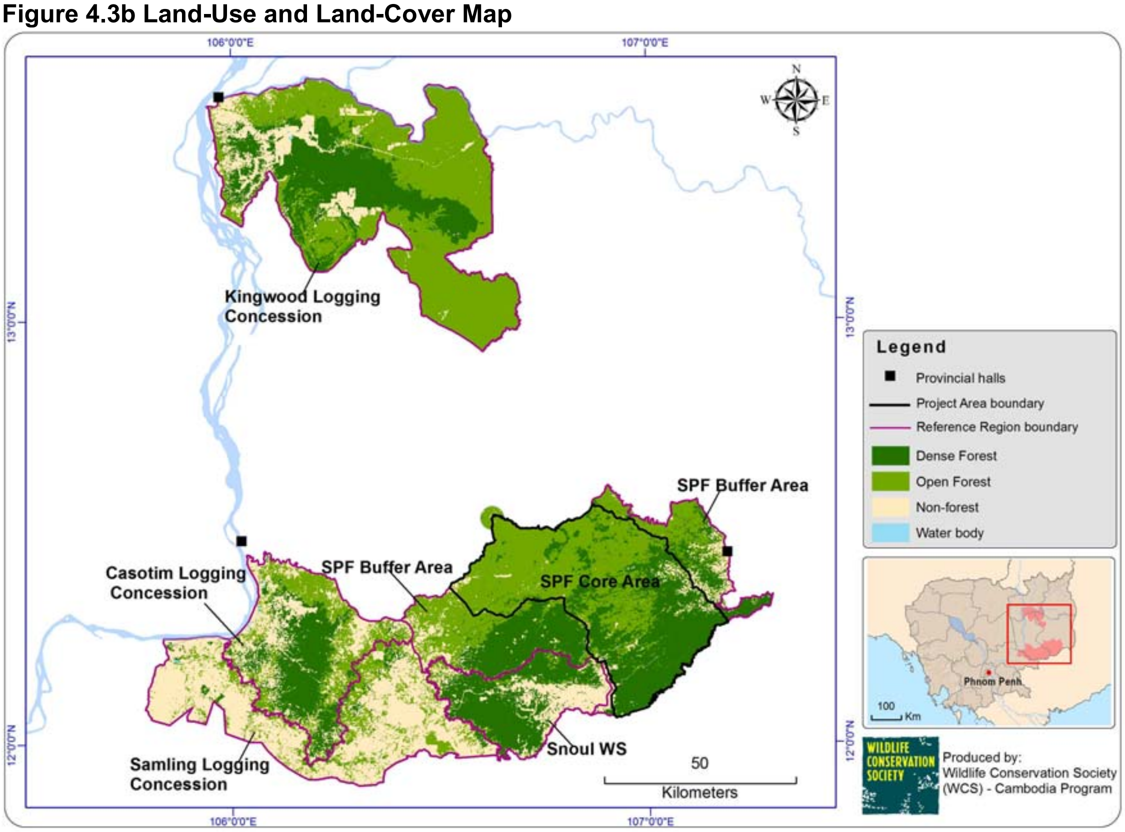


Figure 4.3c Deforestation Map

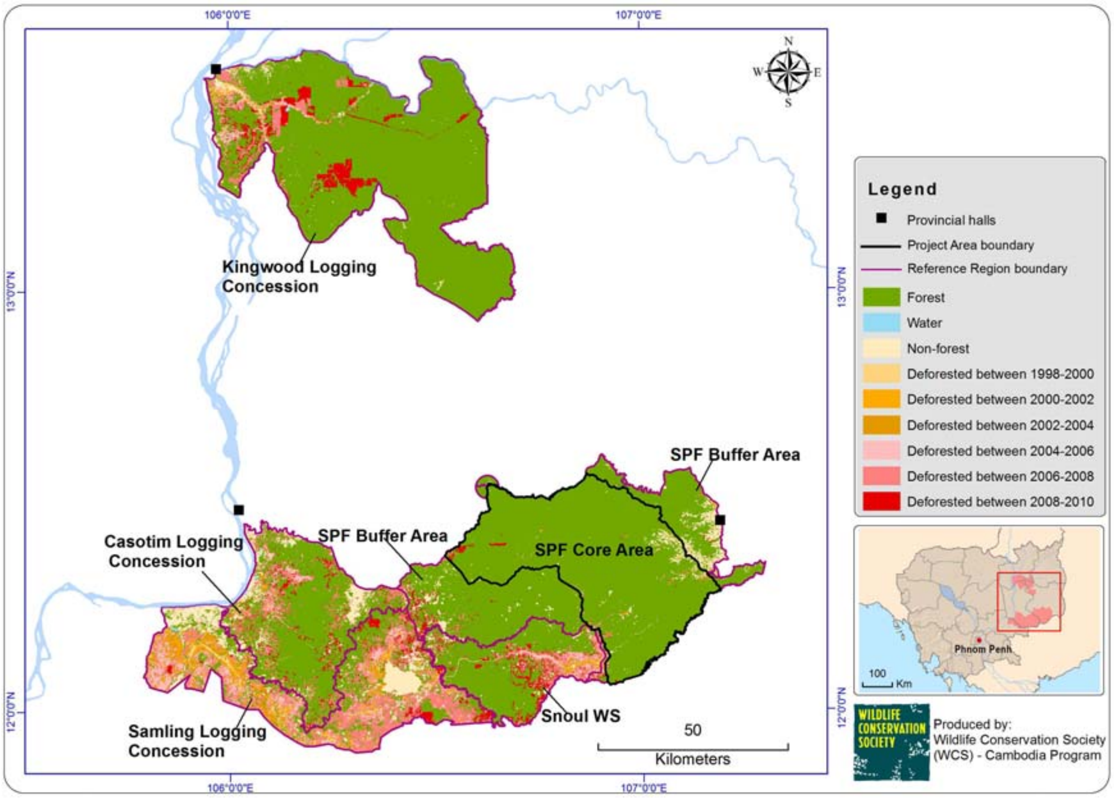
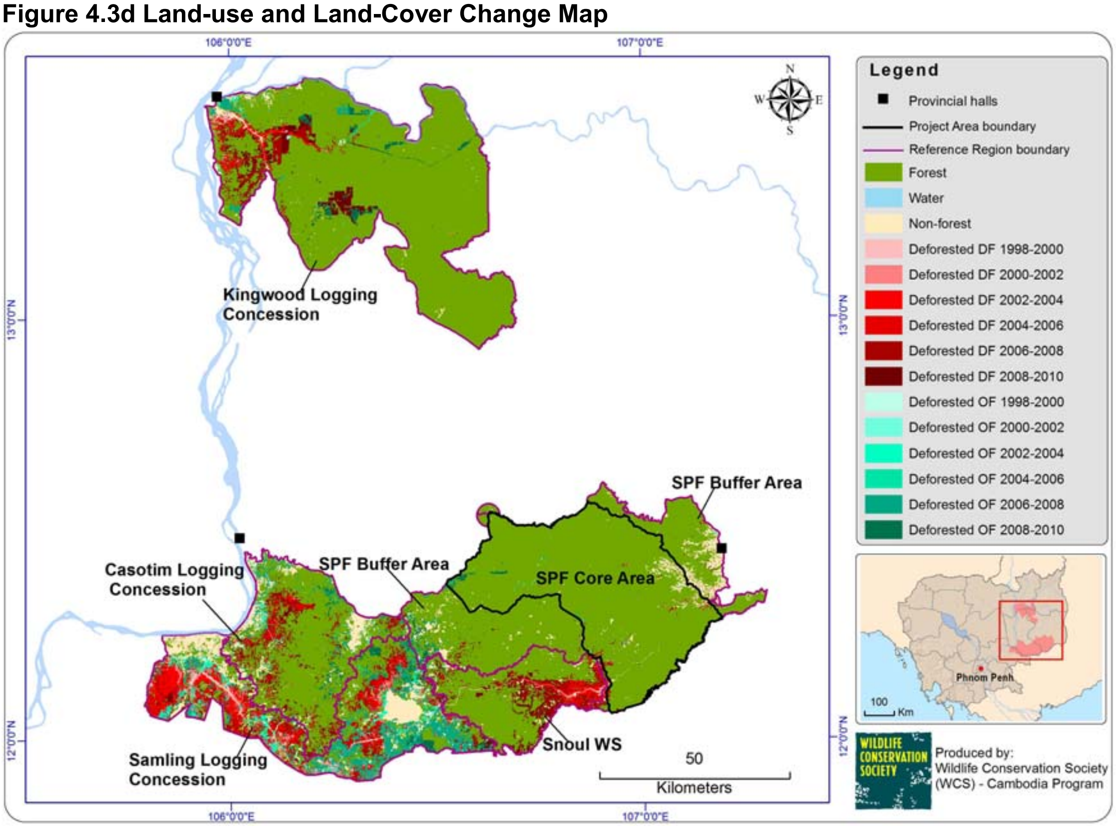


Figure 4.3d Land-use and Land-Cover Change Map



Step 2.5 Map accuracy assessment

We validated the accuracy of the 2002 forest cover map using IKONOS reference imagery that covered an area of 570 km^2 and was acquired on 28 February 2003, i.e. within 12 months of the 2002 LANDSAT imagery (13 February 2002) used for to classify 2002 forest cover. A total of 527 points was sampled within the reference imagery. An error matrix was generated by comparing the actual ground condition as determined by the high resolution imagery with the LANDSAT classification. This matrix was then used to calculate the producer's and user's class accuracies, omission and commission errors, the overall accuracy, *po* and the kappa coefficient, *k*.

The Producer's accuracy for the dense, and open forest classes was 91% and 94%, respectively. The producer's accuracy for the non-forest class was 94%. The user's accuracy for the evergreen, and deciduous forest classes was 93% and 94%, respectively. The producer's accuracy for the non-forest class was 90%. The overall accuracy for the 2002 forest/non-forest classification is *po*=93% with kappa statistics of *k*=0.88. The overall misclassification rate was 0.0683 (36/527). The overall omission error was 0.0683. The overall commission error was 0.0341. The classification accuracies for other years are expected to be as good as for 2002, given that the same sensors and processing methods were employed across each classification.

Step 3 Analysis of the causes of deforestation and their likely future development

Step 3.1 Identification of Agents of Deforestation

Two main groups of agents of deforestation have been identified in the reference region, as discussed below and summarised in Table 4.7. Insignificant agents/causes are listed in the following section.

Table 4.7 Summary of the main agents of deforestation in the reference region

Agent group	Type of deforestation	Stratum (see Annex 4.1)	Occurs in project area	Comments
Smallholder farmers	Unplanned	1 (Non-ELC)	Yes	Active throughout the historical reference period
Economic Land Concessions	Planned	2 (ELC)	No	Very limited prior to 2008; greatly increased through 2008-2012

Unplanned deforestation in the reference area during the historical reference period has been overwhelmingly dominated by one main agent group, **smallholder farmers.** As defined here smallholder farmers are a broad group comprising people of any ethnicity (including Khmer, Cham and various indigenous groups) who plant annual or perennial crops for consumption or sale on a family scale (that is, on holdings of typically <20 ha, often <5 ha but occasionally up to 50 ha and using either family labour or a small number of hired labourers).

The remainder of deforestation in the reference region is attributable to planned deforestation conducted by large agro-industrial concessions. Such concessions are generically called **Economic Land Concessions** (ELCs) and most are governed by the Subdecree on Economic Land Concessions (#146, 2005[11]). They can be issued to domestic or foreign companies and can legally be of any size up to 10,000 ha. In practice they are typically larger than 1000 ha. One of the key differences between smallholders and ELCS, which may grow the same crops, is that the smallholder farmers typically require no permits from central government, and so their expansion is consistent with the VCS concept of 'unplanned deforestation'.

ELCs do not occur in the project area but have progressively arisen elsewhere in the reference region during the historical period, mainly since 2008. They therefore need to be separated from the analysis of unplanned deforestation. Hence the reference region is divided into two strata (ELC and non ELC; see Annex 4.1) whose boundaries vary dynamically over time as more ELCs are issued.

Smallholder farmers

[11] http://www.maff.gov.kh/elc/laws/subdecree.html [downloaded 18/2/2011]

Most deforestation for smallholder farmers is conducted by the farmers themselves, or by somebody intending to sell the land to farmers as soon as possible. The sequence of deforestation sometimes begins with middlemen clearing land for speculation and later onward sale. However, the proportion of land in this idle state at any one time is quite small, and it is only a transitional stage as almost all such areas become actively farmed within a few years at most. Hence whatever the initial sequence of events, the primary driver for this clearance is the demand from smallholder farmers for agricultural land. Long-term farming is the end-point in most locations; for example there is no significant observed trend of land degradation leading to abandonment and conversion to pasture; and no significant urbanization.

In the reference region smallholder farmers typically cultivate a high diversity of crop species at the scale of individual holdings (e.g. ICC 2003, Ironside 2004a, Scally *et al.* 2007), although only a few crops are dominant across the landscape (e.g. Pollard and Evans 2009). Common staples for family consumption include paddy and hill-rice, corn, bananas and traditional cassava varieties. Dominant cash crops vary as farmers respond to varying market demand – for example in the project zone cashew became increasingly popular from about 2002 onwards, soy was briefly popular around 2004-2005 and high-yielding cassava varieties have been adopted widely since 2007. Rubber is planted by some smallholders, but due to its long non-productive period prior to maturity is mainly the domain of large companies or investors and so is associated with planned deforestation. The exact mix of crops grown in a given location is determined by economic factors (such as market access and demand), soil/climate suitability and personal factors such as access to credit, knowledge and planting materials.

The population of the smallholder farmer agent group has increased in the project area and the remainder of the reference region over the course of the historical reference period (Table 4.8) and is predicted to increase further over the first fixed baseline period (Annex 4.2).

Table 4.8: Observed population trends in each forest management unit of the reference region

	Population			Growth			
Forest Management Unit	**98**	**02**	**08**	**Net 98-02**	**Annual % 98-02**	**Net 02-08**	**Annual % 02-08**
Snuol Wildlife Sanctuary	2908	5063	9162	2155	**18.53%**	4099	**13.49%**
Seima Protection Forest*	14999	18341	25628	3342	**5.57%**	7287	**6.62%**
Samling Logging Concession	68576	79488	105819	10912	**3.98%**	26331	**5.52%**
Kingwood Logging Concession	29907	34027	36380	4120	**3.44%**	2353	**1.15%**
Casotim Logging Concession	36082	38991	38436	2909	**2.02%**	-555	**-0.24%**
Grand Total	152472	175910	215425	23438	**3.84%**	39515	**3.74%**

Source: 1998 – National Census; 2002 & 2008 – Commune Database
* Includes most but not all villages using the project area (some are centred in adjacent units) plus some that only use the Buffer Zones.

Overall growth has been high, with a sustained average of just under 4% per year during both the earlier and later parts of the historical reference period. The rank order of rates across the sites was consistent between the two time periods, with Snoul showing the highest rates in both periods and Casotim the lowest. This consistency over time and space shows that these are robust trends that are likely to be sustained into the future. Increases are caused by intrinsic growth (birth minus deaths) and net migration from other parts of Cambodia. The national average population growth rate during 1998-2004 was 1.81% (NIH 2004) and since it can be assumed to be largely unaffected by net migration, it can be assumed to represent the national average intrinsic rate of growth. Since social conditions are broadly similar to the rest of Cambodia a similar figure probably applies for the reference region and so one can assume that any growth greater than 1.81% was due to migration from elsewhere. This suggests that most parts of the reference region appear to have experienced moderately high and sustained rates of net in-migration throughout the historical period.

All unplanned deforestation in the historical reference period in Stratum 1 is attributable to this group of agents, with deforestation by other agents being negligible. This is evident from an inspection of the location and pattern of mapped deforestation during the period (see Step 2 above), combined with published accounts, extensive field inspections (including two overflights) and consultations with a range of key informants. Staff members from FA and WCS have been active widely across the reference area since 2000 and so have first-hand knowledge for almost the entire period in question.

ELCs

We compiled data on concession boundaries within the reference area from a variety of sources (data available to the auditor on request). The extent of issued ELCs in the reference region has increased significantly during the historical reference period, and is known to have increased further during the first three years of the fixed baseline period. The extent of land deforested within these issued concessions has also increased. Recent trends in the landscape and nationally suggest that further ELCs will probably be issued, and deforestation will continue in those that have been issued. However, considering the strict VCS rules on estimation of planned deforestation, the data available do not allow prediction of the future area to be deforested as a result of the issuance of ELCs. In any case, as long as ELCs are not issued in the project area there is no need to make quantitative predictions.

ELCS established to date have mostly been observed to begin operations within 0-2 years of receiving legal approval and then to begin clearance of existing natural vegetation in the allocated area, visible on satellite images as large homogeneous blocks with straight-line boundaries. The intended crops are not always stated in available documentation and cannot be determined from the available imagery, but from field observations and other data rubber is evidently one of the preferred ELC crops in the reference region. This may be inter-cropped with e.g. cassava in the early years. Other likely crops include sugar cane and jatropha at some locations.

Table 4.9 summarises the deforestation attributed to each of the two agent groups during the historical period, derived from the historical analysis of land-use change described above

Table 4.9 Deforestation attributable to each of the main groups of agents

	Deforestation (ha)					
Period	**1998-1999**	**2000-2001**	**2002-2003**	**2004-2005**	**2006-2007**	**2008-2009**
Smallholder farmers						
Extent of forest in stratum at start of period	901,670	890,927	871,524	842,444	734,052	661,244
Deforestation during period	5,194	10,743	19,403	27,413	80,574	25,590
Cuumulative deforestation		15,938	35,341	62,754	143,328	168,918
Economic Land Concessions						
Extent of forest in stratum at start of period	0	0	0	0	24,215	59,636
Deforestation during period	0	0	0	0	3,488	11,800
Cumulative deforestation		0	0	0	3,488	15,288
Total (all agents)						
Extent of forest in stratum at start of period	901,670	890,927	871,524	842,444	758,267	720,879
Deforestation during period	5,194	10,743	19,403	27,413	84,062	37,390
Cumulative deforestation		15,938	35,341	62,754	146,815	184,206

Agents of deforestation found to be insignificant

Compared to smallholder farmers and ELCs, other agent groups were absent or had a negligible effect on forest cover in this landscape during the historical period.

Large logging concessions were active up to 2000 and directly caused extensive forest degradation in some locations, but relatively little deforestation as defined by VCS. Most of the direct deforestation caused by logging concessions was through road construction and creation of logging camps, which represent a negligible part of the overall forest loss during the period. No such activity happened after about 2000, due to a national moratorium on the concessions. Indirect deforestation caused by logging concessions is mostly driven by their influence on factors such as accessibility (again, road construction) and population movements (settlements around active logging camps). The infrastructure and new settlements created prior to 1998 continued to have an effect through the historical reference period, as analysed below.

Other forms of **logging** vary in intensity across the reference region and cause widespread degradation in some poorly protected areas but are not severe enough to qualify as deforestation (as defined here) on a significant scale.

Deforestation for **mining** was negligible during the historical baseline period. Many licenses have been issued for mineral exploration, notably for gold and bauxite (e.g. maps in Pollard and Evans 2009, Pollard *et al.* 2010 and updated information available to the auditor on request). These do not provide a right to exploit the resources found, and there is no evidence so far that they are associated with significant deforestation in the reference region. Activities are mainly limited to exploratory drilling of trenches and small pits. There is a theoretical possibility that one or more of these licenses may eventually lead to an exploitation permit being issued for mine development. This would result in a centrally-issued license for planned deforestation, but the location and extent cannot be predicted at this stage. We conservatively assume that no such deforestation would occur in the project area in the baseline scenario during the first fixed baseline period and so no credits can be claimed for avoiding it. Nonetheless the slim risk that it may occur is accounted for in the Risk Buffer analysis.

Deforestation for **hydropower schemes** and **expansion of pastureland** was zero or negligible during the historical baseline period and is not expected to increase during the first fixed baseline period. There are no known hydropower schemes under active development in the reference region.

Step 3.2 Identification of deforestation drivers

Driver Variables Explaining Quantity of Deforestation

The quantity of deforestation in the landscape is partly determined by various proximate driver variables within the landscape, which are in turn influenced by the underlying causes discussed in the next section

Table 4.10 summarises key proximate driver variables which affect the rate of deforestation in the reference region. This list is based on unpublished statistical analyses supplemented by other sources. Some of the drivers can be partly mitigated by project activities, within the project area and leakage belt. The table below should be read in conjunction with the list of underlying drivers provided later in this section. No statistical model was developed for planned deforestation since no quantitative projection is required, so the conclusions in Table 4.10 in this case are based on qualitative sources and are provided mainly for illustration.

Table 4.10: Proximate drivers of the rate of deforestation in the reference region as a whole

Factor	Relevance for smallholder farmers	Relevance for economic land concessions	Likely trend in first fixed baseline period	Project measures to control drivers
Population size/density	More families interested in farm expansion; probably also a good proxy for higher local market demand and lower costs through access to local markets	Unknown. Implies better accessibility, available labour and lower input costs. However, it also implies higher risk of conflict over land ownership.	Likely to increase across the region, with rates varying from place to place.	Reduce population growth by deterring in-migration. Decouple poulation density from pressure of forest by facilitating move to off-farm/off-site livelihoods
Availability of fertile land to deforest	Areas with extensive fertile land are attractive	Companies are likely to prefer areas with a high % of forest, since they need large blocks of land for economies of scale	Likely to decline due to progressive forest loss and exclusion from land under ELCs but remain high relative to demand for land	No action possible.
Access to external markets/services (remoteness of the region as a whole)	Regions closer to Phnom Penh (or other major market centres/ports) have better market access and so higher returns of farming	Regions closer to Phnom Penh have better market access and so higher returns of farming	Increasing access as regional transport networks and infrastructure expand	No action possible.
Road density (ie proportion of region with easy market access)	Increases accessibility and lowers input costs; also a proxy for general levels of economic development	Increased accessibility and lowers input costs; also a proxy for general levels of economic development	Likely to increase significantly	Prevent the creation of unnecessary secondary roads in areas with high carbon density
Proportion of the region under effective protection	Deters deforestation	Reduces likelihood of permits being issued	Likely to decrease in the absence of REDD funding; government policies promote the region as a 'development pole'	Increase the extent of effectively protected areas; promote application of current environmental protection policies

Driver variables explaining the location of deforestation

The variation in the location of recent unplanned deforestation is evidently not random across the reference region. It is concentrated in certain areas from one time period to the next. Preliminary information (inspection of satellite images, field observations, law enforcement records, discussion with local farmers and development specialists and inspection of the broader literature on this topic) suggested that the following factors were likely to include most of the important drivers of the location of deforestation: accessibility by road, proximity to markets, proximity to settlements and/or the edges of recent clearance, soil fertility, slope and elevation, and protection status.

Table 4.11 summarises the most important factors influencing the two main agents of deforestation and the likely trends in the drivers over time. For unplanned deforestation these conclusions are based on a formal statistical analysis (Annex 5.2). In general the importance of these variables can be explained using the framework of the Theory of Land Rents because they generally correlate with both the market value of the land and its productive potential. Other factors analysed, such as soil fertility and slope, were not selected as significant additional predictors in this analysis, which may be because they correlate with other factors (e.g. vegetation, elevation or location of roads) or because they do not vary enough in this landscape to have a measurable additional influence on land quality. No statistical model was developed for planned deforestation since no quantitative projection is required, so the conclusions in Table 4.11 in this case are based on qualitative sources and are provided mainly for illustration.

Table 4.11: Factors correlated with location of deforestation during the historical reference period

Factor	Relevance for smallholder farmers	Relevance for economic land concessions	Likely trend in next 10 years in project area	Project measures to control drivers
Distance to recently deforested land	Economies of scale, minimised travel cost, preference to live near others, proven fertility of area	Probably not relevant (may even be a negative factor)	Increased relative risk - Declining distance to nearest recent deforestation as deforestation expands according to modeled trends	Reduce the total extent of deforestation and limit it to near existing locations where possible; decouple risk from this variable by improved demarcation, patrolling and community acceptance of forest boundaries
Travel time to nearest district town and distance to Mekong River	Proximity to markets/suppliers	Proximity to markets/ suppliers	Increased relative risk - reducing travel times to remote areas as road network improves	Prevent the creation/upgrading of unnecessary secondary roads; decouple risk from this variable by increased controls on freedom of movement along forest roads through better law enforcement and community-based management
Protection status (combination of legal status and level of investment/ technical support)	Ease of deforesting without intervention of the authorities	Diffculty of obtaining permits; risk of public criticism	Increased relative risk - flat or declining effectiveness, due to increasingly constrained funding opportunities	Enhance protection status and effectiveness
Vegetation type (dense vs open forest)	Presumably an indicator of better soils for farming	Presumably an indicator of better soils for farming	No change	Not applicable
Elevation	Steep slopes are impractical to farm and often of lower fertility	Steep slopes are impractical to farm and often of lower fertility	No change	Not applicable

Step 3.3 Identification of underlying causes of deforestation

As elsewhere in the world the fundamental driving force for deforestation in the reference area by both smallholder farmers and large economic concessions is the general aspiration of people to improve their material standard of living. For the poorest this means attaining food security, for the less poor, middle-income and rich smallholders it means seeking increasing levels of wealth and for companies it means achieving a strong return on investments. Deforestation results when it is perceived as the easiest way of fulfilling these aspirations in a given location. Project interventions are aimed both at reducing the factors that encourage deforestation whilst strengthening some of the opportunities for people to follow other paths for improving their well-being.

In the reference region, as in most of Cambodia, agriculture is currently a dominant source of income, and one of a number of sectors where smallholders and large companies seek income growth. Several factors encourage a focus on agriculture rather than other sectors, in particular the rising prices of agricultural products, limited rural education levels that make it difficult to enter other sectors and the relatively limited availability of employment in other sectors in Cambodia. Within the agricultural sector, growth can come about through expansion or intensification. While intensification does not directly cause deforestation, expansion usually does (since most unfarmed land with agronomic potential in Cambodia is still forested).

Several factors encourage people to expand the area of land they farm rather than intensifying or concentrating on other economic activities. Five of the dominant underlying factors are listed in Table 4.12. For some of these underlying drivers the trends are predicted to be either flat or rising. It should be noted that flat levels of underlying drivers (e.g. governance effectiveness) combined with rising levels of proximate drivers (e.g. human population size) still combine to give a rising level of threat of deforestation.

Table 4.12: Underlying causes encouraging expansion of agriculture into forest

Factor	Relevance for small holders	Relevance for ELCs	Likely trend in first fixed baseline period	Project measures to control drivers
Barriers to farm intensification or moving into other sectors	y	y	Flat or rising (and hence an increasing driver)	Reduce barriers to intensification; promote access to other sectors (alternative livelihoods)
Weak governance and poor funding to enforce laws protecting forest	y		Rising (and hence an increasing driver)	Increase funding, strengthen governance
Limited ability of local stakeholders who value forest to prevent clearance	y	y	Flat, currently very low (and hence a steady driver)	Empower community approaches and increase formal land tenure
Low perceived value of standing forest by many stakeholders (costs of clearance externalised)	y	y	Flat currnetly very low (and hence a steady driver)	Increase value through environmental payments (REDD etc)
High and rising prices for agricultural products, linked to national, regional and global demand trends	y	y	Rising (and hence an increasing driver)	Outside scope of project

Step 3.4 Analysis of chain of events leading to deforestation

Based on an analysis of the historical relationship between the main agent groups, key drivers and underlying causes, it has been found that the following two sequences of causative steps have typically led to and will lead to deforestation.

1. Sequence for smallholder farmers

- Small-holder farmers wish to achieve food security and improve their levels of income
- Income growth is mainly dependent on agriculture as opportunities to move into other sectors are often limited.
- Opportunities to intensify agriculture are often limited. By contrast, expansion of farmland into forest areas is relatively easy under current conditions, despite the law.
- Weak forest governance, low investment in forest protection, poor recognition of non-monetary forest values, and limited opportunities for current forest-users to protect their resources all facilitate expansion of farmland into forest areas
- This process is accelerated by rising commodity prices, improving road networks, rising populations and other economic development factors

2. Sequence for ELCs

- Companies and investors increasingly wish to invest in profitable ventures in Cambodia
- Rising regional and global demand creates strong markets for crops
- Good soils, climate and access make the reference region potentially attractive and so companies propose projects

- Rising availability of foreign direct investment and pro-business government policies interact with weak forest governance, low investment in forest protection, poor recognition of non-monetary forest values, and limited opportunities for current forest-users to protect their resources to facilitate issuance of concessions in forest areas

Step 3.5 Deforestation analysis conclusion

Conclusive evidence has been presented above that many of the direct and underlying drivers of deforestation in the reference region (and specifically in the project area) are expected to increase during the project crediting period compared to the historical reference period with respect to both smallholder farmers and ELCs, and, while some may remain stable none are likely to decline. This can be considered conclusive evidence that deforestation rates rise will across the reference region, and within the project area, through the first project crediting period. This provides a basis for the quantitative projection of the most credible baseline scenario in Section 5.

Baseline scenario with respect to biodiversity

This section describes the main known threats to biodiversity in the project zone. Combined with the business-as-usual levels of conservation action and the expected trends in drivers (Section G2.1). a without project scenario can be developed for biodiversity. Since quantitative wildlife population trends are not yet known and cannot be modelled with current data, the scenario is qualitative. The drivers of threats to biodiversity overlap widely with those for deforestation so those are not repeated here; some additional drivers are highlighted where relevant.

Threats to biodiversity

The main threats to biodiversity in the Project Zone are similar to those familiar to conservationists throughout tropical Asia (e.g. Corlett 2009), most notably deforestation, illegal logging, unsustainable fishing and hunting. These threats were first documented for the site in 2000 (Walston *et al.* 2001) and have been systematically documented since 2005, providing an indication of historical baseline trends and informing predictions. The threats are grouped below into three major, widespread threats (hunting, habitat loss and selective logging/overharvest of NTFPs) which affect many species and are given full treatment in the project conceptual model (Section 2.2) plus several other threats which are less severe or affect only a subset of species. These smaller threats are addressed through specific actions in the workplan but not shown explicitly in the conceptual model, to improve clarity.

Major, widespread threats affecting many species

i) Hunting

The most significant threat to key wildlife populations is over-hunting. This has already probably long ago eliminated several species from the project zone (e.g. Kouprey *Bos sauvelii* and Wild Water Buffalo *Bubalus arnee* [12]), and over recent decades has dramatically reduced populations of ungulates, Tigers, pangolins, turtles and other taxa. Tigers have also been reduced to critically low levels across Mondulkiri Province as a whole, due to hunting and loss of prey species. Hunting in SPF involves guns, snares, traps, dogs, poison baits and many other methods, targeting a wide range of species (Walston *et al.* 2001, Lynam and Men Soriyun 2004, Drury 2005, FA/WCS unpublished law enforcement patrol monitoring data). Most hunting with serious conservation impacts is driven by trade and supplies markets locally and internationally with bushmeat, traditional medicinal products and trophies (Lynam and Men Soriyun 2004). Regional demand for wildlife products is rapidly increasing.

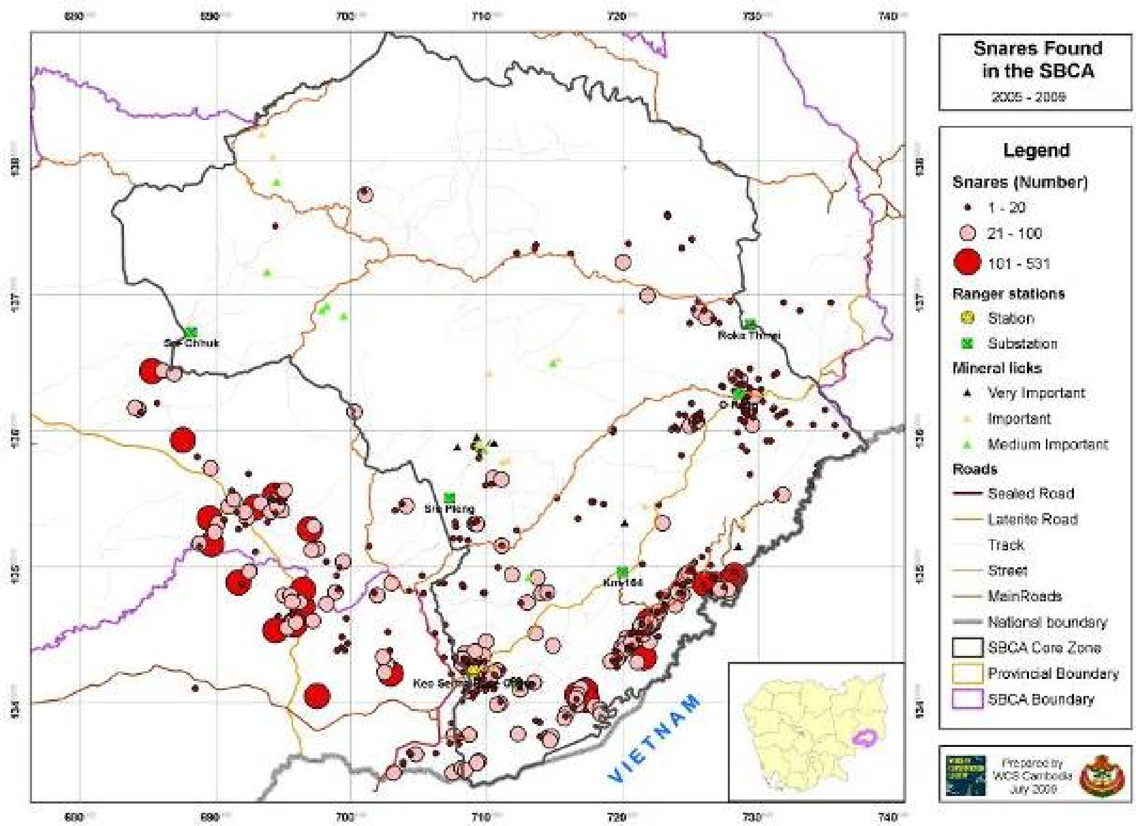
Most forms of hunting are difficult to detect, map or quantify. However, snares are more easily found and probably provide a useful proxy for hunting pressure in general. Figure 4.4 shows that the snaring pressure is very high. There are many records of snare lines of more than 100 snares, and during the period mapped almost 13,000 snares were removed, suspected to be a small proportion of the total in

[12] There are no confirmed records of these species from the site but its habitat and location make it very likely they were once present.

use. These snares capture large numbers of terrestrial mammals and birds from the size of mouse deer, civets and junglefowl up to Sambar, wild cattle, bears and big cats. When compared to maps of patrol effort (WCS/FA unpublished data) it is evident that:

a) snaring (and hence other forms of hunting) are likely to be under-recorded in the north east and west of the SPF due to lower patrol effort
b) the highest current levels of snaring (and hence presumably other forms of hunting too) appear to occur in those less heavily patrolled areas which are also more accessible from areas of dense human settlement.

Figure 4.4 Distribution of snare lines found in and around SPF during the historical references period



Comparison with similar areas elsewhere in Cambodia and adjacent countries shows that the level of enforcement effort achieved to date has partially reduced hunting compared to a 'no protection' scenario but has not brought it fully under control. Despite active enforcement, large numbers of snares continue to be found whenever systematic searches are made of vulnerable areas. Prices for the target species have increased dramatically in recent years, with increases ranging from 200-1000% over a recent six year period (Table 4.13), as demand for wildlife and wildlife parts has grown in Cambodia and more widely across Asia, especially in China.

Table 4.13 Trends in prices of selected wildlife species in the project zone

Species	$/kg 2003	$/kg 2009
Banteng	$0.75	$3.75
Sambar	$1.00	$3.75
Gaur	$1.00	$3.75
Pangolin	$16.25	$50.00
Wild Pig	$0.60	$3.75
Muntjac	$0.75	$3.75

Small Turtle	$0.50	$1.25
Monitor Lizard	$1.25	$2.50
Soft-shelled Turtle	$1.50	$10.00
Frog	$0.50	$2.50
Porcupine	$0.50	$5.00

Source: FA/WCS unpublished surveys

Apart from high snaring levels, recent examples of the continuing high level of threat include reports of over-hunting of Pygmy Loris (Starr *et al.* 2011), the documented killing of at least one Elephant and several wild cattle during 2008-2011 and frequent reports of gunshots heard at night during wildlife monitoring surveys.

Given these data, the without-project scenario is that snaring and other forms of hunting would greatly increase over large parts of the reserve, gradually overwhelming current enforcement efforts, due to increase in human pressure, accessibility and other factors. The outcome will eventually be the elimination of most large-bodied vertebrate species except for a few highly resilient species of low conservation concern, as has happened in many other forests in Indochina.

ii) Habitat loss

Deforestation and other forms of habitat conversion have severe impacts on biodiversity. This usually leads to the total destruction of natural habitats and their replacement with farmland or residential areas. These habitats typically support very few of the species present in the original forest, and almost none of those are currently of conservation significance in Indochina. Some of the SPF's threatened species (e.g. Eld's Deer, Asian Elephant, Green Peafowl) occasionally visit remote patches of agriculture in predominantly forest areas (Scally *et al.* 2007), but they do not occur regularly in areas dominated by such habitats (WCS/FA 2006a).

Detailed data on deforestation trends are presented earlier in this section. Deforestation is expected to affect all main forest types, in particular the lower altitude evergreen, semi-evergreen and bamboo forests near to National Route 76 In addition to gross loss of habitat, fragmentation will result in smaller forest patches with a higher edge:core ratio. Such patches are typically less suitable for wide-ranging or forest interior species, many of which are among the most threatened in the landscape, and smaller patches are also more vulnerable to pressures such as logging, hunting and invasive alien species, leading to synergistic impacts.

Non-forested habitats are also at risk. In particular, lowland grasslands/wetlands are being converted to agriculture, mainly rice paddy. Since 2000 the loss of several important small wetlands in the reserve due to this cause has been documented (e.g. Trapeang Ronheav, Trapeang Khlong and Sre Traw). This is difficult to detect using remote sensing and is of course not represented in the deforestation models, but the rate of loss is believed to be higher than for deforestation since these rare alluvial soils are preferred for rice production and people will travel across several kilometres of forest to access wetland sites. The relative biodiversity impact may also be higher than for deforestation, since many of the more threatened species are highly dependent on these rare habitats including Giant and White-shouldered Ibis, Eld's Deer, White-winged Duck, Sarus Crane and Lesser Adjutant. In the without-project scenario a high proportion of the lowland grasslands and wetlands in the SPF is likely to be converted in this way.

The distinctive upland grasslands of the Sen Monorom plateau are rapidly being converted to tree crops and cassava. In the without-project scenario it is predicted that a high proportion of this habitat will be converted, since it typically lacks even the weak protection afforded to forest and is seen as 'unused land' ripe for development. The direct biodiversity impacts of this are unknown. They may not be especially severe for threatened and endemic birds and mammals, since these habitats are relatively little used by such species (Walston *et al.* 2001, Sok Ko *et al.* 2004), but the value of these grasslands for other taxa such as amphibians, plants and invertebrates remains unstudied. Furthermore, the increased human activity in the grasslands will result in pressure from hunting, logging and fire in adjacent forest habitats.

An indirect impact of deforestation will be an increase in human-wildlife conflict, especially with elephants. Scally *et al.* (2007) found that although many human communities live in the forest, levels of human-wildlife conflict remained low compared to many other sites in tropical Asia. Since that time however there has been some increase in problems with human-elephant conflict near O Am village, linked to significant forest loss and planting of crops in former elephant range areas. This may lead to retaliatory killing of elephants, or increased exposure to poachers. The without project scenario predicts further encroachment leading to increased raiding of crops by elephants, and increased conflict with farmers, potentially leading to more elephant killings and declines in elephant numbers.

iii) Selective logging and over-harvest of plant NTFPs
Unsustainable illegal logging of rare Luxury class timber species takes place in almost any dense forest area across the project zone (see Annex 4.3), and indeed throughout Cambodia where such species persist. Several other plant resources are over-harvested as well, including the large bamboo species *russei thngor* (Mann Mouy 2010), several species of rattan and trees with valuable fruit such as *Strychnos nux-vomica* (sleng) and *Sterculia lychnophora* (samraong). This is both a direct threat to the species concerned (some are Red Listed e.g. *Afzelia xylocarpa*, *Dalbergia bariensis* and *D. cochinchinensis*[13] are all IUCN Endangered) and an indirect threat through degradation of habitat (e.g. loss of nest sites, fruit sources and the undisturbed shady understorey required by certain forest species).

Project observations suggest that in the past logging has been reduced somewhat in areas that are patrolled regularly. However, without a sharp increase in patrol effort, coverage and effectiveness, illegal logging will likely continue to be a serious threat in all parts of the reserve, even given current levels of the underlying drivers.

Figure 4.5 Trend in detection of logging cases by law enforcement teams (cases / km patrolled)

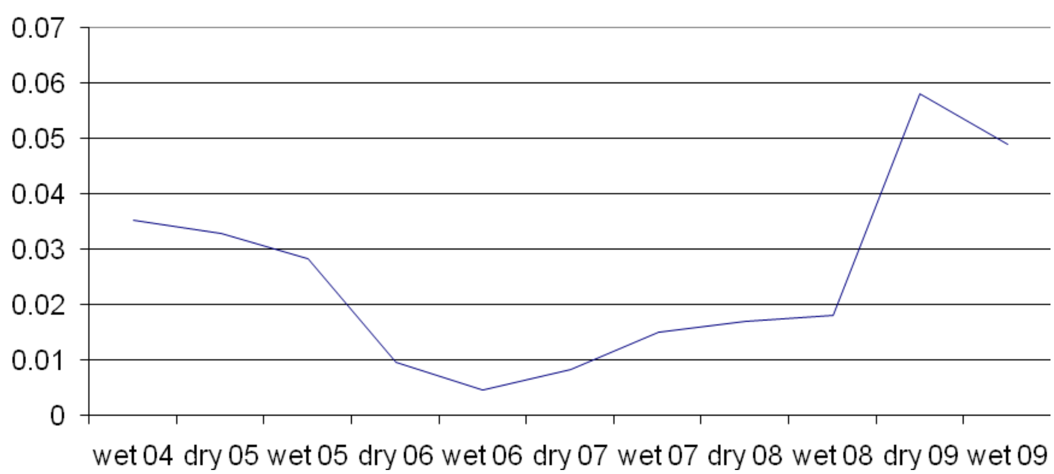


Figure 4.5 shows the increase in incidences of illegal logging as recorded by patrol teams. These suggest a decline during 2006-2007 followed by a more recent increase. Ranger-based evidence is prone to many confounding factors but other evidence at the site points in the same direction, including the perceptions of law enforcement officers, observations by biological monitoring staff and market information. Staff believe that logging intensity declined in the early years of the project due to better law enforcement, but rising pressures have caused the intensity to rise again. Prices for the target species have increased dramatically in recent years, with increases ranging from 200-600% over a recent four year period (Table 4.14), as demand has grown in Cambodia and Vietnam. The Cambodian economy continues to grow, and demand for furniture made from Luxury wood is increasing, driving further increases in the levels of illegal logging. Hence the without-project scenario predicts that this increasing trend will continue.

[13] The Khmer names are beng, neang nuon and kranhoung respectively.

Table 4.14 Trends in timber prices in the project zone

Local Name	Scientific Name	2005 Price $/m^3	2009 Price $/m^3
Beng	*Afzelia cochinchinensis*	$120.00	$800.00
Neangnoun	*Dalbergia bariensis*	$180.00	$1,000.00
Koki	*Hopea odorata*	$90.00	$250.00
Choeutealtoeuk	*Dipterocarpus alatus*	$80.00	$250.00
Thnung	*Pterocarpus pedatus*	$150.00	$500.00
KraKah	*Sindora cochinchinensis*	$90.00	$250.00
SoKroam	*Xylia dolabriformis*	$80.00	$250.00
SroLao	*Lagerstroemia sp*	$80.00	$250.00
Doungcheam	*Tarrietia javanica*	$100.00	$250.00

Source: FA/WCS unpublished data

Threats which are currently thought to be less severe or affect only a subset of species

i) Incidental disturbance
Incidental disturbance is quite high in many sectors of the reserve, due to the large number of people in the forest (conducting both legal and illegal activities) and their tendency to concentrate at scarce water sources which are also critical limiting resources for many wildlife species. This is thought to reduce the suitability of the habitat for shy species such as large carnivores and wild cattle (e.g. U. Karanth pers. comm.). This threat is believed to be increasing due to rising human populations using the project zone.

ii) Specific threats to vultures
The two Critically Endangered vultures face several very specific threats across their Cambodian range (Clements *et al.* in prep.). As an indirect impact of over-hunting of wild ungulates they are threatened by scarcity of naturally occurring carrion. As a result of that, most surviving populations in Indochina are now dependent on dying or specially provided domestic animals, and so changes in animal husbandry practices are also significant potential indirect threats. Another indirect threat to vultures is that they often eat poisoned animal carcases (e.g. poisoned stray dogs, or incidental casualties from fishing with poison; Clements *et al.* in prep.). In the non-project scenario all three of these threats will worsen and vultures will almost certainly be lost from the area.

iii) Pollution
Water pollution is not currently known to be a problem in most of the project zone, but data are lacking. It may emerge as a problem, now or in the future, in the intensively farmed areas within and adjacent to Snoul Wildlife Sanctuary. Existing economic land concessions upstream of the SPF may also be causing pollution unnoticed. In the without-project scenario it is predicted that levels of waterborne pollution will increase greatly, due to activities by small holders and concessionaires and upstream actors, and that this will have significant impacts on many aquatic species, most notably top predators such as otters, fish-eagles and predatory fish, as well as terrestrial species that drink from affected sources.

iv) Invasive species
Invasive species have not been identified as a threat to date, presumably because the area is remote and habitats are largely intact. However, in the without project scenario increased infrastructure development, human access, habitat degradation, fragmentation and other factors will expose the site to potentially damaging invasives. For example, Giant Mimosa *Mimosa pigra* is a serious problem in the floodplains of the Tonle Sap Basin (van Zalinge 2006), has invaded remote areas of the Mondulkiri Protected Forest along river corridors (T. Evans pers. obs.), and requires expensive control operations in nearby Cat Tien National Park, Vietnam (G. Pollett, pers. comm.). The extent of this threat is hard to predict but it is likely to be significant, and to reduce habitat availability for riverine and static wetland species.

Conclusion - long term prospects for biodiversity in the without-project scenario

The above analysis indicates a worrying long-term future for biodiversity at the site. Threats are already severe and a worsening situation is predicted where threats continue to increase and current levels of conservation action cannot ultimately keep pace. This will lead to increased over-exploitation of forest products, wildlife and fish, increasing levels of deforestation, conversion of non-forest habitats, habitat degradation, and, over time also increasing pollution, human disturbance and competition with invasive species. Current levels of investment in law enforcement, infrastructure, demarcation and other key activities, can apparently prevent the declines of some species (e.g. some primates, Pollard *et al.* 2007, Rawson *et al.* 2009), at least over the area where activities can be funded, and can likely slow the declines of others, but in the without-project scenario eventually many of these species will be lost from the SPF or very severely depleted. An important negative feedback to consider is that, as a reserve loses charismatic flagship species it becomes harder to attract traditional sources of funding and this may lead to accelerated losses. The very low number of recent Tiger records from the reserve has already been linked to the withdrawal of two key donors, whose funding for this flagship species supported conservation efforts benefiting many others, and the carbon stocks in Tiger habitat (Annex 4.4).

Over the next 30 years, the without-project scenario predicts a mostly deforested landscape with the remaining forest fragmented, degraded, significantly disturbed by humans due to easier access and heavily over-hunted, leading to a depauperate fauna and flora lacking most of the species of conservation significance present today, with many of the other species surviving in severely reduced numbers. This results in the 'Empty Forest syndrome', with cascading effects on food webs, pollination, seed dispersal and many of the other ecological functions that maintain a healthy forest (Redford 1992, Corlett 2009). It cannot be predicted exactly which species will be lost or reduced, but it seems likely that all Critically Endangered and Endangered species will almost certainly be lost, along with many of the Vulnerable species. Some other Vulnerable and most Near-threatened species will probably survive in greatly reduced numbers. Some species will increase, but this will mainly be tolerant, open-country ('weedy') species of little conservation significance. These predictions are highly plausible since similar trends have been observed in many other forested landscapes with a longer history of high pressure across Indochina, including protected areas, especially in Thailand and Vietnam where threats became severe at an earlier date than in Cambodia.

Baseline scenario with respect to communities

Analytical approach

This section reviews key factors that will affect communities in the project zone in the baseline land-use scenario, without REDD project funding. Combined with the projected levels of conservation action and the expected trends in deforestation drivers a without project scenario can be developed for the communities.

Predictions of trends in community well-being are arguably harder than for biodiversity, as many more factors operate, not all in consistent directions. The CCB Standards require a prediction of changes *attributable to project activities*, whilst livelihood changes attributable to other factors are considered part of the baseline, without-project scenario. The social assessment manual developed by CCBA and partners (Richards and Panfil 2011) recommends that the no-project scenario '*should therefore focus on the outcomes of processes or conditions that are most likely to be affected by the project - these are often linked to project-related land uses*.' This is a valuable distinction, as overall livelihood trends in the project zone will partly mirror a wide variety of changes in the broader Cambodian and regional economy that are difficult to predict, such as population growth, employment, commodity markets and the effects of globalization, levels of Foreign Direct Investment, the political and security situation, natural disasters, levels of corruption and so on. Expected future changes in the climate are also very hard to predict with enough accuracy to inform management decisions. Following the rationale above it can be assumed that for most or all of these factors the trajectory of change will be the same in the with-project and without-project scenarios, and so they are not directly relevant to identifying net project impacts. The conceptual model helps us to concentrate on those factors that we may be able to change, relative to their baseline trajectories.

The widely used Sustainable Livelihoods Approach[14] (SLA) formed the basis for analysis. This conceptualizes wellbeing as the combination of family or personal assets in five broad classes (natural, physical, social, human, and financial) and predicts trends in assets on the basis of the immediate pressures families face (‘ the vulnerability context’ such as health risks and crop failures)

[14] e.g. poverty-wellbeing.net/en/Home/Livelihood_Approaches

and a set of external 'transforming structures and processes' such as changing government policies and social norms. Since many factors cannot be modelled quantitatively with current data, especially over such a long period, the scenario is qualitative and focuses on those aspects which can confidently be predicted to improve or worsen significantly, and for which the project will attempt interventions. Most drivers overlap with those for deforestation (see above) so those are not repeated here, but some additional drivers are highlighted where relevant. Where relevant, trends are differentiated between the main stakeholder groups set out in Section 2.7

Changes in the vulnerability context

Under the SLA vulnerability is one of the over-arching factors that determines how families respond to other changes. Vulnerability is a key issue for the poorer communities in the project zone - here as in many parts of rural Cambodia families live close to the edge of economic viability and one severe financial shock (health crisis, crop failure, loss of land or resin trees) can push them into a downward spiral of indebtedness than can take years or even generations to escape from. The future potentially contains economic opportunities for many families in the landscape, due to increasing market access, better public services and a likely continuation of recent gradually improving trends in the overall Cambodian economy (e.g. World Bank 2006). However, in the baseline scenario many vulnerable stakeholders in this particular area may not see lasting improvements, and may face negative impacts or lower than possible net benefits from those trends.

To the extent that livelihoods improve and levels of capital increase in the communities, people will be more buffered against shocks and so less vulnerable, which is a positive trend. However, several competing factors may increase the vulnerability of many families and communities in the landscape:

1) The rapid arrival of modern Cambodian culture and economic forces in indigenous villages with inadequate safeguards is likely to lead to increased vulnerability due to pressures on social relationships, natural resources and existing economic systems.
2) The potential impacts of large economic concessions in the project zone, reducing the areas of forest available, potentially impacting on farmland and also bringing other threats such as pollution, social disruption and competition for remaining resources by migrant labourers.
3) Diversification of livelihoods tends to buffer against shocks; rural livelihoods in the landscape are currently highly diversified but may become less so if there is an increased dependence on a few cash crops or agricultural wage labour, or if some current resources (such as NTFPs and fish) decline without parallel increase in access to new opportunities.
4) Mondulkiri is predicted to be one of the most vulnerable provinces in South-east Asia to climate changes, due to a combination of biophysical and social factors (Yusuf and Francisco 2009).

Predicted trends in livelihood assets

Table 4.15 lists selected key livelihood assets that are likely to change in the baseline scenario, arranged in the five categories of the SLA. It also notes changes in the factors that tend to increase or decrease these assets ('transforming structures and processes' in SLA terminology). The list is based on the results of a workshop held in SPF in 2006 (WCS/FA 2006b). At the workshop, the rural development NGO CEDAC, together with WCS and FA, asked community representatives to help select indicators to monitor livelihood trends in the SPF in relation to the conceptual model then in place.

Table 4.15 Projected trends in key livelihood assets

Asset class Asset	Trend without project	Mainly affects	Changes in transforming structures and processes
Natural Capital			
Farmland/housing land	Alienation, forced sales	Indigenous	High levels of forest crime, weak enforcement, weak community control
	Uncertain tenure due to expansion outside agreed land-use plans	Khmer, offsite settlers, some indigenous	High levels of forest crime, weak enforcement, weak community control
	Loss to concessions	All communities	Concessions granted, mainly over land lacking clear title
Predictable climate for	Decline	All communities	Climate change, lack of adaptation support

agriculture etc			
Soil fertility	Decline	All onsite communities	Insufficient tech. support, lack of tenure to encourage investment, frontier (short-term) attitude, 'hungry' crops esp. cassava, possibly also climate change
Water	Declining quality and quantity	All communities, offsite env. service users	Poor management of catchments, pollution from intensive agriculture and possibly also mines, poison fishing
Forest resources (NTFP, timber, fish, wildlife)	Brief increases in harvest followed by steep declines in all resources	All forest dependent on-site communities, off-site env. service users (fisheries)	Market-driven harvests without effective management, high levels of forest crime, declining forest cover, possibly also climate change
Social capital			
Cultural identity	Seriously declined	Indigenous	Weakening of traditional structures; Khmer/Cham migration; loss of forest and land base
	Stable/improving?	Khmer	Stabilisation of transient/settler communities?
Social relationships	Seriously declined	Indigenous	Breakdown of communal systems, conflict over resources
	Unknown	Khmer	Too many factors to predict; one issue is conflict over resources with neighbours and concessions
Labour rights	Remain poor or improve	All on and off site communities	Unpredictable political/cultural factors
Gender equity	Remain poor or improve	All onsite communities	Unpredictable political/cultural factors
Human capital			
Education levels	Slowly improve for children, not improved for adults	All onsite communities (but vulnerable groups may decline)	Gradual increase in primary/secondary education, better road network, ?increasing purchasing power
Health levels	Slowly improve	All onsite communities (but vulnerable groups may decline)	Gradual increase in public services, better road network, ?increasing purchasing power
Physical capital			
Household level	Improve	Families that benefit from new development activities, illegal land-grabbing etc (mainly Khmer non forest-users)	
	Decline	Families that lose out from new development activities (mainly indigenous /Khmer forest users)	Loss of access to existing income sources, lack of replacements
Community level	Slowly improve	Mainly accessible communities	Gradual increase in public services, investments in better road network and water-sanitation projects
Financial capital			
Savings	Improve	Families that benefit from new development activities, land-grabbing etc (mainly Khmer?)	
	Decline	Families that lose out from new development activities (mainly indigenous?)	Loss of access to existing income sources, lack of replacements, competition
Low-cost community credit	Decline	Indigenous	Breakdown of social ties
Commercial credit	Improve	All communities (except vulnerable groups lacking collateral)	Arrival of banks, better roads

As a result of this analysis the following overall changes are expected in the major livelihood outcomes as defined by the SLA. Average **income** may increase or decrease overall, depending on the macro-economic situation. We suspect that long-term it will tend to increase in most plausible scenarios, due to underlying national trends. However, we note that these average increases concela differences between groups and some may become worse off. In particular, **increasingly unsustainable use of the NR base** (rattan, timber, bamboo, sleng fruits, fish, wildlife, etc.) is likely to produce brief income peaks as each resource is over-harvested, followed by a decline until the next resource is targeted, with an overall **long-term decline in NR-based income**. Dipterocarp resin is the most important harvested natural resource. Although resin harvests are thought to be sustainable (Evans *et al.* 2003), the trees themselves are at risk from deforestation and logging and so will decline. This will be true for both Khmer and indigenous families, but more significant for the latter due to their higher dependence on NR. **Declines in water supply and quality** are also predicted.

Some farmers will benefit from the expansion of their land holdings, but many others, especially weaker indigenous families, may experience land alienation and lose income or subsistence products from this source, **increasing vulnerability** and **reducing food security**. Many Khmer families may experience high insecurity due to **insecure tenure on illegally grabbed land**, and all families face the potential risk of dispossession and conflict due to **problems with land concessions**, which have been widely documented in Cambodia. **Land fertility** is likely to decline in many areas due to unsustainable practices made worse by insecure tenure, lowering farm-based incomes after brief peaks due to the exploitation of freshly exposed forest soils.

Indigenous communities are also likely to suffer declines in **non-material aspects of well-being**, due to weakening of cultural institutions, loss of access to spiritually important forest and land, the shift from farming to labouring and so on. Trends in **labour rights and gender equality** are hard to predict, and could improve or decline depending on many factors. **Health and child education levels** seem likely to improve with increasing public investment, but again there will be losers who cannot afford to buy into these services, and there is little prospect of non-formal education to address the persistent very low **levels of adult literacy**.

These various threats to livelihoods in the baseline scenario are represented in the project conceptual model (Section 2.2). The focus is on threats to land and natural resource capital, since this is the natural entry point for a project of this kind to have greatest impact. Threats to other kinds of capital, and the various transforming structures/processes are addressed through the design of the interventions (e.g. formation of community groups addresses social capital, while livelihood development activities address physical and financial capital).

4.6 Additionality (G2)

Project additionality is demonstrated below following the methodology, which requires use of the most recent approved VCS "*Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other land use (AFOLU) Project Activities*", namely VCS Tool VT0001. The analysis is relevant to climate, community and biodiversity outcomes.

Step A0: Preliminary screening based on the starting date of the AUD project activity

The project passes this screening as the project start date is after 1 January 2002.

Step A1: Identification of alternative land use scenarios to the proposed AUD project activity

Sub-step 1.a: Identify credible alternative land use scenarios to the proposed AUD project activity

Given the conclusive evidence in Section 4.5 all four scenarios set out below assume an intensifying threat from unplanned deforestation from small holder farmers. This is combined with a continuation of the pre-REDD project model of management of the site, whereby FA and WCS collaborate with other stakeholders to manage an area designated by Ministerial Declaration as the Seima Biodiversity Conservation Area. The scenarios vary in the level of conservation action which is feasible (determined primarily by financial resources), and in the degree of threat within the project area from a second agent group, ELCs.

We consider the first two land-use scenarios to be genuinely credible alternatives to the with-project case. Scenario 2 results in higher project additionality than the chosen baseline scenario, and is arguably credible, but the available evidence is insufficient to document conclusively that it is more likely than Scenario 1 and so we conservatively reject it. Scenarios 3 and 4 are mandatory for inclusion here and would result in lower additionality but we consider they are demonstrably not credible, for the reasons stated.

Scenario 1 - the chosen baseline scenario – Continued grant-funded conservation activities at declining levels: Escalating threats from residents and migrants due to improving road access and other drivers etc combine with a decline of non-REDD funding for conservation action. This decline in funding is demonstrably plausible, based on funding trends over the past seven years and a donor-by-donor analysis of funding prospects in the future (Annex 4.4). In this case the nature of the threats remains on a similar trajectory to those in Scenario 4, but the levels of ongoing donor-funded conservation investment achieved during the historical reference period become impossible to maintain and there is a proportionate decline in conservation effectiveness, leading to an increased relative risk of deforestation in the project area. Funding projections suggest a decline to just over 40% of past funding levels for core conservation activities such as law enforcement support.

Scenario 2 Economic land concessions in parts of the project area, plus continued grant-funded conservation activities at declining levels: Threats and protection are generally as in Scenario 1 but in addition parts of the project area are excised from the SPF and re-issued as agro-industrial concessions; conservation activities are excluded from these areas and deforestation rates rise greatly. This scenario is plausible as it has already affected the Mondulkiri Protected Forest during 2007, when about 650 km^2 was excised to facilitate the issuance of land concessions, and is currently affecting large sections of nearby Wildlife Sanctuaries and the SPF Buffer Area. Specific current theats of this kind to the Project Area cannot be conclusively documented, and so it is not appropriate to apply methodologies for avoidance of planned deforestation, but there is good reason to believe that this is a plausible future threat.

Scenario 3 - Greatly increased grant-funding for conservation and increased conservation effort without being registered as a VCS AFOLU Project: This scenario assumes a greatly increased level of long-term financial support compared to baseline levels, combined with increased political support for conservation rather than other land uses. This scenario is consistent with the mandatory scenario (ii) according to VCS Tool VT0001 and is plausible in theory since some protected areas elsewhere in the tropics do receive adequate funding and very secure political support, but this cannot be said for any forest conservation area in Cambodia. It would be dependent on identifying a very large, novel source of revenues (e.g. watershed protection payments, large trust fund endowments or major budget allocations from central government) but there is no evidence that such payments are likely to be available for this site in the foreseeable future.

Scenario 4 - Continued conservation effort at historical levels of grant-funding: This scenario assumes escalating threats from smallholder farmer residents and migrants driven by improving roads and other factors, plus continued partial conservation action without REDD funding, at levels equal to those achieved during the historical reference period. This is equivalent to the ‘continuation of existing land-use’ scenario (scenario i) required by Tool VT0001. This scenario has been observed to be not credible during the early years of the project crediting period, since despite sustained fund-raising efforts across all classes of potential donor, non-REDD funding for core conservation activities fell to 83% of historical levels during the first three years of the first fixed baseline period and is projected to fall to just over 40% thereafter, primarily due to changes in the external funding environment but also due to the loss of at least one charismatic wildlife species (Tiger) from Seima.

All the relevant land-uses and agents alluded to in these four scenarios exist commonly within the reference area and project area except for ELCs, which occur widely in the reference region but have not so far occured within the project area. However, they have occurred right up to its margins and there is no agronomic reason why they should not be proposed inside the project area, especially if pressures continue to rise and the degree of protection for the reserve declines. All the trends postulated for the future have been observed to some degree in the recent past for Scenarios 1 and 2, and hence can be deemed realistic and credible. As noted, we do not consider this to be true for the mandatory Scenarios 3 and 4 as they pre-suppose unrealistic levels of conservation funding.

Further improvements to roads in and around the project area are likely in the coming years and if included in projections would increase the baseline rates of deforestation in all scenarios, but have conservatively been omitted in the absence of conclusive documentation (following Methodology Section 4.2.1).

Sub-step 1.b: Consistency of credible land use scenarios with enforced mandatory applicable laws and regulations.

All of the listed scenarios are credible under enforced laws and regulations. In circumstances where the scenarios are not consistent with national laws, the scenarios are consistent with local norms of non-compliance.

The construction of roads and the excision of areas from Protected Forests to permit their issuance as Economic Land Concessions or Mineral Exploitation Concessions are legal within certain constraints. The use of forest areas for farming by members of indigenous ethnic minority villages is also legal within certain constraints.

The majority of unplanned forest loss in all scenarios is technically illegal, but those legal requirements are weakly enforced for a variety of reasons and non-compliance is the norm across the majority of the reference area and the broader region of north-east Cambodia. This is evident from an inspection of deforestation data for the historical baseline period and from participatory rapid assessments conducted in many villages in the area. Strengthening law enforcement, boosting incentives for legal compliance and access to legal alternatives to deforestation as a livelihood strategy are among the key elements of the proposed project.

Step A2: Investment analysis

Sub-step 2.a: Determine appropriate analysis method

Since the REDD project generates no financial or economic benefits to the project proponents other than carbon market-related income, Option I (Simple Cost Analysis) is appropriate.

Sub-step 2.b: Apply the selected analysis method

The incremental costs associated with the project activity are set out in Annex 4.7. These costs are substantial, and there is no evidence that these costs will be possible to meet from other sources in the foreseeable future. Some of the alternative livelihood activities funded by the project (e.g. tourism and agricultural development support) do or will produce revenue for local communities from sales, but this revenue is treated as a livelihood benefit and is not available to be reinvested on a significant scale in forest protection or project implementation. Given this conclusion the analysis proceeds to Step 4.

Step A3: Barrier Analysis

Since the project is additional from a financial perspective, a barrier analysis is not necessary. Instead a common practice analysis has been performed.

Step A4: Common practice analysis

Many forest areas in Cambodia, including large parts of the reference area, receive little or no active protection. However, forest conservation activities do take place at some locations in the reference area and more widely in Cambodia. These are often associated with the presence of a large NGO working in partnership with government and are typically funded primarily by donor support. The pre-existing conservation project in Seima (FA/WCS) is a good example of this kind of project, as are the nearby projects conducted in Mondulkiri Protected Forest (FA/WWF) and Phnom Prich Wildlife Sanctuary (GDANCP/WWF).

However, there are essential differences between such activities and the SPF REDD project in scope on spatial, temporal and financial scales. No existing projects achieve full spatial coverage and address all key threats with sustainable funding over a period of decades. The norm for conservation projects in the country is to achieve partial coverage with limited capacity to address only some key threats. Funding for these projects is dependent on short-term (1-3 year) donor funding cycles. Furthermore, none of the mentioned projects offers the possibility of covering any of the national-level opportunity costs of forest conservation[15], which leaves them vulnerable to declining political support and formal transfer of the forest to other designated land uses. The REDD project is clearly distinct from these similar, 'common practice' conservation activities based on the following components:

1. Greatly increased, sustained financing, commensurate with the scale and duration of the threats facing the site, in particular for law enforcement activities.
2. Direct linkage of project success to further revenue, ensuring a sustained long term focus on achieving measurable emissions reductions.
3. Creation of a new conservation-based revenue stream for the RGC, increasing the level of long-term political support for protection of the reserve.
4. Resources available for large scale benefit-share arrangements structured to incentivize forest protection by local communities.

Conclusion

The conclusion of this analysis is that the climate, community and biodiversity benefits of the project can be considered additional in comparison to the most plausible yet conservative baseline Scenario (Scenario 1), since it would not happen in the absence of REDD finance.

[15] With the possible exception of those with potential for catchment protection payments from hydropower project developers. This option does not exist in Seima since no large dams are planned.

5 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS (CLIMATE)

5.1 Project Scale and Estimated GHG Emission Reductions or Removals

This is a project of normal scale. The projected emission reductions over the first fixed baseline period are summarized in Table 5.1, based on Table 5.18. The figures in Table 5.1 do not include the deduction of a risk buffer. No projections have been attempted beyond this period, since the baseline must in any case be revised at the end of the first ten year crediting period.

Project	
Large project	Y

Table 5.1 Estimated emissions reductions for the first fixed baseline period

Years	Estimated GHG emission reductions (tCO_2e)
2010	41,389
2011	234,630
2012	1,301,368
2013	2,858,170
2014	4,580,656
2015	8,701,017
2016	11,261,341
2017	10,900,199
2018	10,039,747
2019	8,244,557
Total estimated ERs	58,163,073
Total number of crediting years	10
Average annual ERs	5,816,307

5.2 Leakage Management (CL2)

The project will implement a series of activities that are designed to reduce the risk of deforestation in both the project area and leakage belt. These project activities are described in detail in Section 2.2 and Annex 2.1. Table 5.2 summarises the planned activities relevant to leakage management.

Table 5.2 Summary of leakage management activities

Sub-objective	Leakage management activities
1. Legal and planning	Maintain legal support for the whole SPF (including Buffer Areas); SPF Management plan covers Buffer Areas; Corridor activities address leakage risks (e.g. through liaison with Ministry of Environment)
2. Direct law enforcement	Law enforcement also covers areas of the leakage belt within FA mandate
3. Community land-use	Extend land-use agreements, titling and demarcation to sections of village land adjacent to Project Area (especially leakage belt and leakage management areas); encourage parallel work by civil society organisations
4. Alternative livelihoods	Support a full range of alternative livelihood support activities in leakage belt and leakage management area, including agricultural extension and NTFP-based livelihoods; include leakage management in REDD benefit-share criteria

5.3 Baseline Emissions (G2)

Step 4 Projection of future deforestation

The objective of this step is to locate in space and time the baseline deforestation expected to occur within the reference region during the first fixed baseline period. It comprises two main parts – projection of the overall quantity of deforestation and projection of the locations where it occurs. The reference region has been divided into two strata to account for the spread of economic land concessions, as explained in Section 4.4 and Annex 4.1. Projection of the quantity and location of deforestation are only required for Stratum 1, since this is the only stratum that is present in the project area and the only stratum where unplanned deforestation occurs.

Step 4.1 Projection of the quantity of future deforestation

This sub-step is to determine the quantity of baseline unplanned deforestation for each future year within the reference region as a whole. The analysis is presented in Annex 5.1 and summarised here. Step 4.2 then goes on to predict the distribution of this unplanned deforestation within the reference region.

Step 4.1.1 Selection of the baseline approach

The methodology provides a decision tree to assist in the selection of the most appropriate of the three possible baseline approaches (historical average, time function or modelling approaches). The tree refers to the conclusions of Step 3 (Section 4.5) above. Use of the tree identifies the time function approach as the preferred approach for the Seima project since:

- The deforestation rate measured in Stratum 1 in different historical time periods reveals a clear trend;
- This trend is increasing and;
- Conclusive evidence emerges from the analysis of agents and drivers explaining the increased trend and making it likely that this trend will continue in the future and;
- The future deforestation trend is not likely to be higher using a modelling approach

The evidence for this sustained trend in deforestation rates is supported by the statistical analysis in Annex 5.1.

Step 4.1.2 Quantitative projection of future deforestation

Projection of the annual areas of baseline deforestation in the reference region

A logistic curve was identified as the best time series function for projecting deforestation. A curve with good fit to the historical data was found (Figures 5.1 and 5.2). As the projected annual rate of deforestation declines after year 3, no additional constraints need to be included to allow for land scarity.

Figure 5.1 Modeled cumulative deforestation 1998-2029 in comparison to observations from the historical reference period

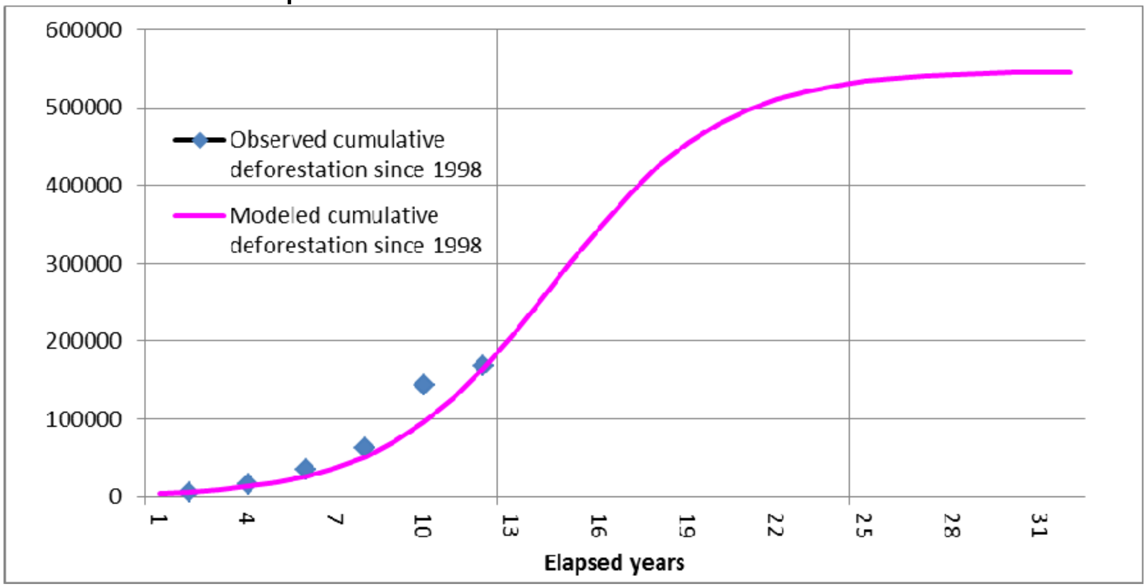
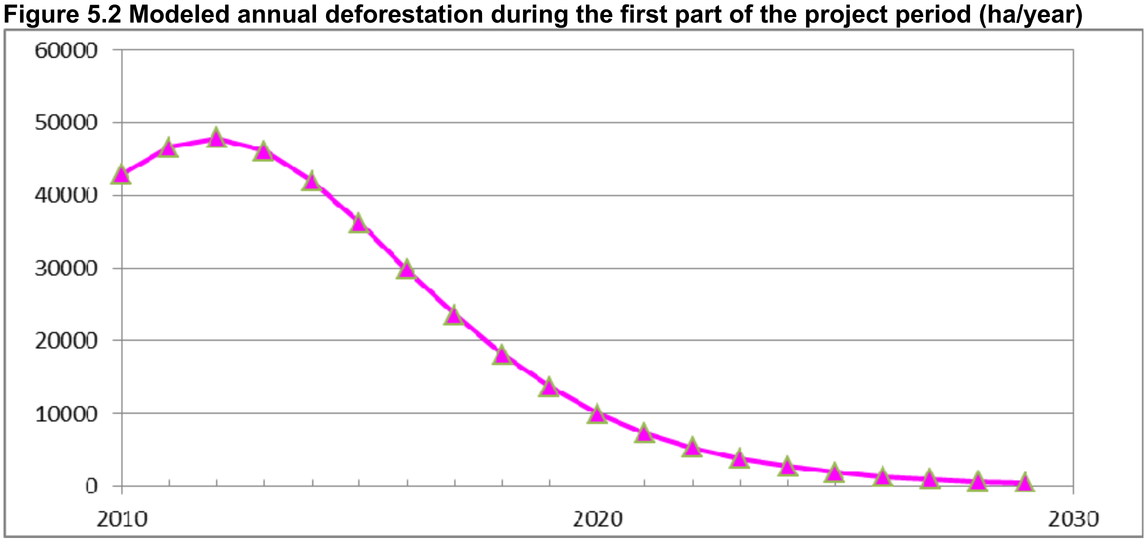


Figure 5.2 Modeled annual deforestation during the first part of the project period (ha/year)



Projection of the annual areas of baseline deforestation in the project area and leakage belt

This step draws on the location analysis in the next section. The rate model selected above provides inputs at each time step for the location model, and the output maps of predicted deforestation are then analysed to determine the amount predicted to occur in each landscape unit. The results are summarised in Tables 5.3a-c, which correspond to Tables 9a-c as required by the methodology.

Table 5.3a Annual area of baseline deforestation in the reference region in Stratum 1

Project year [t]	Projected deforestation in stratum 1 of the reference region [$ABSLRR_{1,t}$] ha [= total $ABSLRR_t$]	Cumulative total [ABSLRR] ha
1	42441	42441
2	46202	88643
3	47414	136057
4	45846	181904
5	41817	223721
6	36187	259907
7	29895	289803
8	23792	313594
9	18354	331948
10	13833	345781

Table 5.3b Annual area of baseline deforestation in the project area

Project year [t]	Projected deforestation in the project area [ABSLPA1,t] ha [= total $ABSLPA_t$]	Cumulative total [ABSLPA] ha
1	1191	1191
2	6544	7734
3	23487	31221
4	17445	48667
5	12695	61362
6	15303	76665
7	21458	98123
8	21340	119463
9	19772	139235
10	15021	154256

Table 5.3c Annual area of baseline deforestation in the leakage belt

Project year [t]	Projected deforestation in the leakage belt [ABSLLK1,t] ha	Cumulative total [ABSLLK] ha
1	303	303
2	1805	2108
3	1804	3912
4	473	4385
5	63	4448
6	190	4637
7	336	4973
8	181	5154
9	332	5486
10	494	5980

Step 4.2 Projection of the location of future deforestation

The aim of this step is to match the location of projected deforestation with carbon stocks. The analysis is presented in detail in Annex 5.2 and summarised here.

Step 4.2.1 Preparation of factor maps

Spatial data on variables that may explain the distribution of deforestation caused by each group of agents are referred to in the methodology as 'factor maps'. The historical reference period runs from 1998 to the end of 2009. The boundaries of the two strata changed during this period, as did the spatial distribution of some of the key drivers (e.g. trunk roads, protected areas). This variation in spatial boundaries over time complicates analysis and risks obscuring the effects of the drivers of deforestation at any point in time. Therefore we selected a subset of the reference period from 2002-end of 2007 for the modeling of risk and developed factor maps for this period.

In general, smallholder farmers act to maximize profits by allocating any parcel of land to the use that earns the highest rent (Angelsen 1999; Mertens and Lambin 2000), which includes a calculation of relevant costs *vs.* benefits of forest conversion as perceived by the smallholder. Management category of the land (e.g. Protected Area, Logging Concession), agronomic potential (which varies with soil fertility etc) and geographic accessibility determine to a large extent the spatial distribution of relative land value and therefore relative probability of deforestation. Based on the literature on deforestation in the tropics, the main variables that capture geographic accessibility include topography (slope and elevation), distance to previously deforested areas, distance to roads, distance to main markets and distance to navigable rivers (Kaimowitz and Angelsen 1998, Vuohelainen *et al.* 2012). Slope and elevation have an effect on both agronomic potential and accessibility. As shown in Annex 5.2, Table 1, we compiled existing data on these potential explanatory factors (e.g. forest type or elevation) or derived the relevant variables ourselves from existing data products (e.g. by calculating slope, distance to roads, travel time etc).

Step 4.2.2 Preparation of deforestation risk maps

The methodology allows these explanatory variables to be related to deforestation risk using either an empirical (preferred) or a heuristic approach. We used the empirical approach. We used a logistic regression approach (i.e. Generalised Linear Model (GLM) analysis with binomial or quasibinomial errors). This is a widely-used method for depicting probability of change in a landscape based on a set of explanatory spatial variables (e.g. Mertens & Lambin 2000, Soares-Filho *et al.* 2001, Wilson *et al.* 2005, Gaveau *et al.* 2009; for theory see Grafen & Hails 2002, Gelman & Hill 2007, Crawley 2007, Burnham & Anderson 2010). We parameterized a spatially-explicit model of unplanned deforestation that occurred in Stratum 1 during 2002- end of 2007. The dependent variable was the occurrence or not of deforestation in each pixel, which was determined from the Landsat-derived historical land-use/land-use change analysis described in Section 4.5.

To allow calibration and confirmation from the same time period we divided the reference region into 38,540 500 m x 500 m tiles and randomly selected half of these (19,102 tiles) to parameterize the model (calibration) and the other half (19,438 tiles) for model confirmation. The value of the central point of each tile on each GIS data layer (if forested) was extracted and used in the GLM analysis so each data point was separated by >500 m distance on the ground (a sufficient distance to ensure that spatial autocorrelation effects will be minimal). We measured or calculated the value of each variable at each sample point and then analyzed this dataset using R statistical software (R Development Core Team 2012). We considered in total 16 candidate GLMs (specified in detail in Annex 5.2).

Step 4.2.3 Selection of the most accurate deforestation risk map

We compared all candidate models to identify the ones that best explained the spatial distribution of deforestation and to rank them in order of importance. We used an information theoretic selection process based on the Akaike Information Criterion (AIC, see e.g. Gelman & Hill 2007, Burnham & Anderson 2010) to determine the most parsimonious model of a suite of candidate models (i.e. the most plausible model that has the smallest number of explanatory locational driver variables).

The best fit to the deforestation map was found by first selecting the candidate models for which the AIC was in the lowest 50% (from the range of AIC across all candidate models) and then testing their performance against the confirmation dataset as described below. The model with the highest Figure of Merit (FOM) score was chosen. This is a statistical measure of model performance which ranges from 0% for no agreement between simulated parameters and reference data to 100% for perfect agreement (Pontius *et al.* 2008).

Model #16 (Table 5.4) had the best AIC and FOM score and so was unequivocally the best performing model by a small margin (Annex 5.2, Table 2). The FOM score was 50.03% compared to a required minimum figure of 13.6%. The accuracy of our model is good compared to most other studies that have employed deforestation models in a similar fashion.

Table 5.4: Parameter estimates of the best-fit model (Model #16).
Predictors are presented in order of their z values (ignoring sign), which are Wald test scores showing the degree of association between the predictor and deforestation probability (= square roots of χ^2 statistics).

Model variables	***Variable coefficients (β)***	Standard error	*z* value	Significance (*p*-value)
Distance to all patches of previous deforestation >10 ha (km) (*d2degt10*)	-0.2290799	0.0101975	-22.46	<0.0001
Travel time to the nearest local town (h) (*t2t*)	-0.3191870	0.0159888	-19.96	<0.0001
Natural vegetation is Dense Evergreen Forest *vs.* Deciduous Forest, Open forest (*natveg*)	1.1352346	0.0713631	15.91	<0.0001
Distance to Mekong River (km) (*d2mekong*)	0.0263701	0.0020293	12.99	<0.0001
Elevation above sea level (m asl) (*elev*)	-0.0112606	0.0009134	-12.33	<0.0001
Intercept (= constant value β_0)	1.1170759	0.0909723	12.28	<0.0001
Snuol Wildlife Sanctuary *vs* Logging Concession (*lmc05*)	-1.3952941	0.1321333	-10.56	<0.0001
Seima Biodiversity Conservation Area *vs* Logging Concession (*lmc05*)	-2.6993849	0.1640929	-10.56	<0.0001

Step 4.2.4 Mapping the location of deforestation

Having selected the best model fitted to historical data it is necessary to determine the predicted locations of future deforestation in the baseline scenario for each year of the first project crediting period (2010-2019 inclusive). In any given year it is necessary to calculate the overall risk map using the model identified above, then rank the pixels by their relative risk of deforestation and assign them to a deforested category in strict order of rank, highest first, until the quantity of deforestationshown i Table 5.3c for that year has been reached. The stratum boundaries and some of the risk factors in the chosen model are dynamic, that is they vary through the first fixed baseline period. Therefore the following sequence of steps was followed for the projections:

2010

i) Determine distribution of driver variables at start of 2010 and any new stratum boundaries
ii) Calculate the first annual deforestation risk map for Stratum 1
iii) Assign the appropriate quantity of deforestation to the highest ranked pixels as described above.
iv) Output the first annual map of predicted unplanned deforestation (for end of 2010).

2011

v) Determine spatial distribution of driver variables at start of 2011 using the new predicted map of deforestation from end of 2010 combined with updated maps of any other dynamic variables such as road layers and any known changes in the stratum boundaries.
vi) Calculate the second annual unplanned deforestation risk map
vi) Assign the appropriate quantity of deforestation to the highest ranked pixels as described above.
vii) Output the second annual map of predicted deforestation (for end of 2011).

Subsequent years

This annual cycle is repeated until the end of 2019.

The spatial input data used for the projections and the way they vary over time are described in Annex 5.2 and will be provided to the auditor upon request. The resulting shapefiles were used to generate the estimates of deforestation for the project area and leakage belt in Annex 5.1. Figure 5.3 shows the predicted deforestation for the first year (2010) and Figure 5.4 shows the expected total baseline deforestation for the fixed baseline period, as required by the methodology. Figure 5.5 shows the project area in close-up, with the ten successive years of projected deforestation shown separately. Maps of the projected deforestation for each year across the whole reference region are available on request.

Figure 5.3 Projected deforestation for 2010

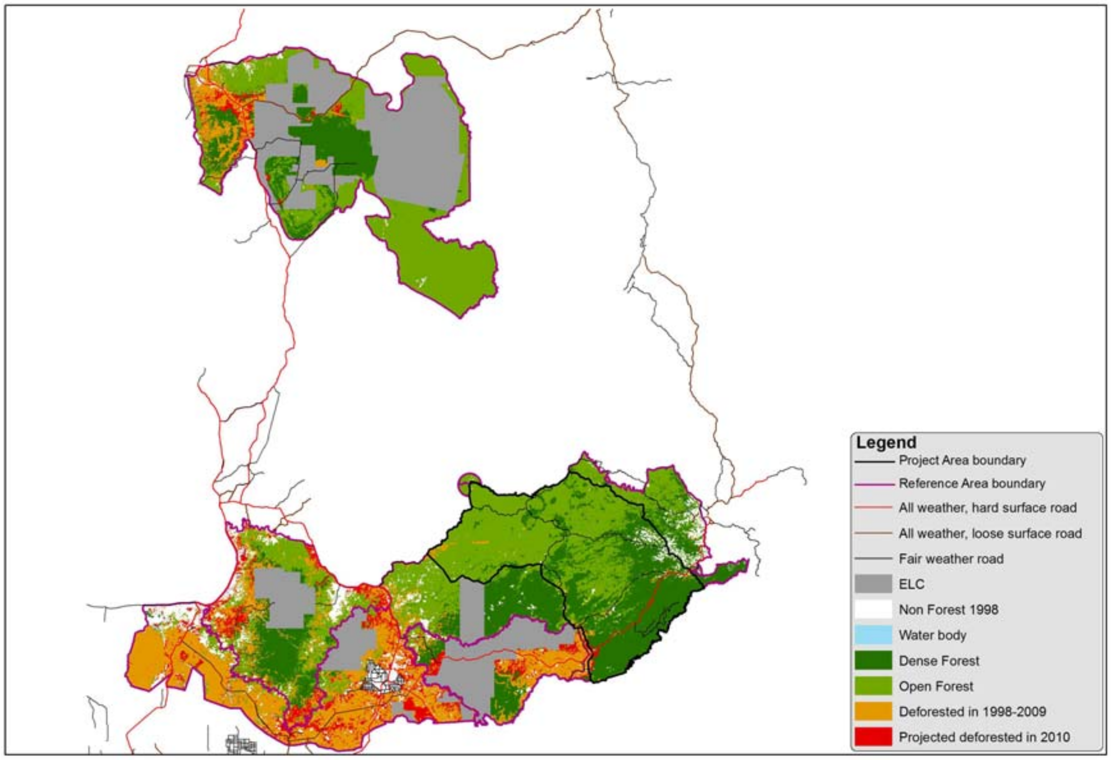


Figure 5.4 Total projected deforestation 2010-2019

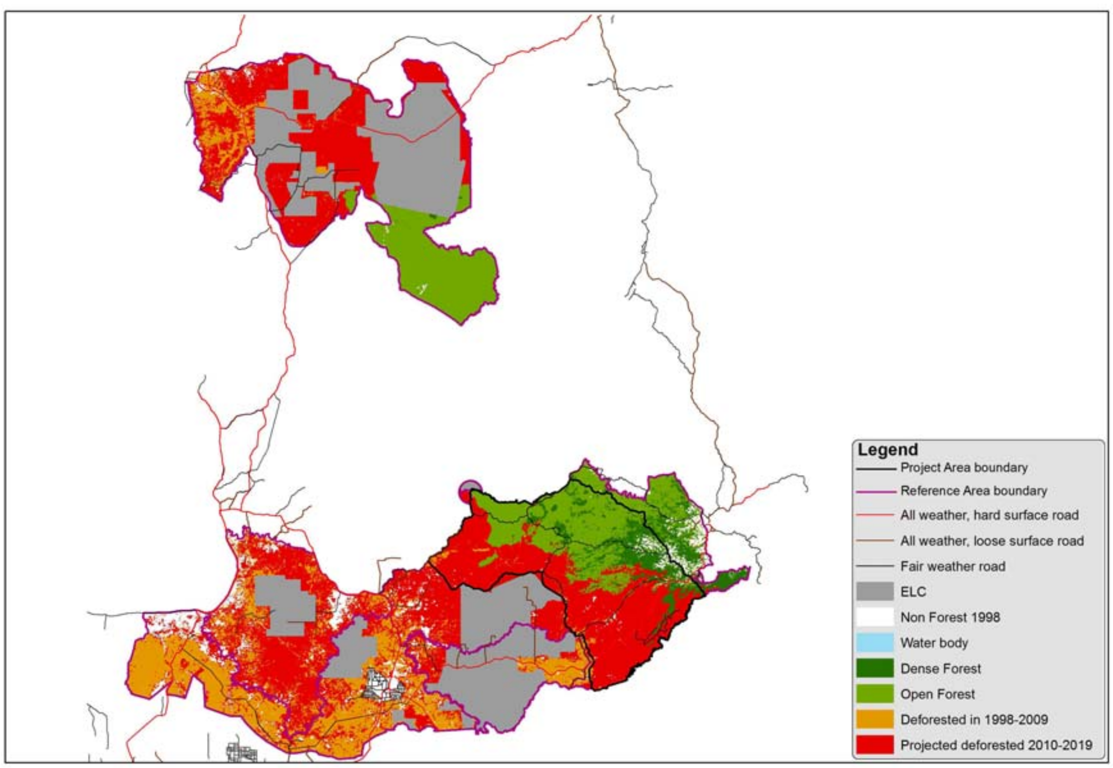
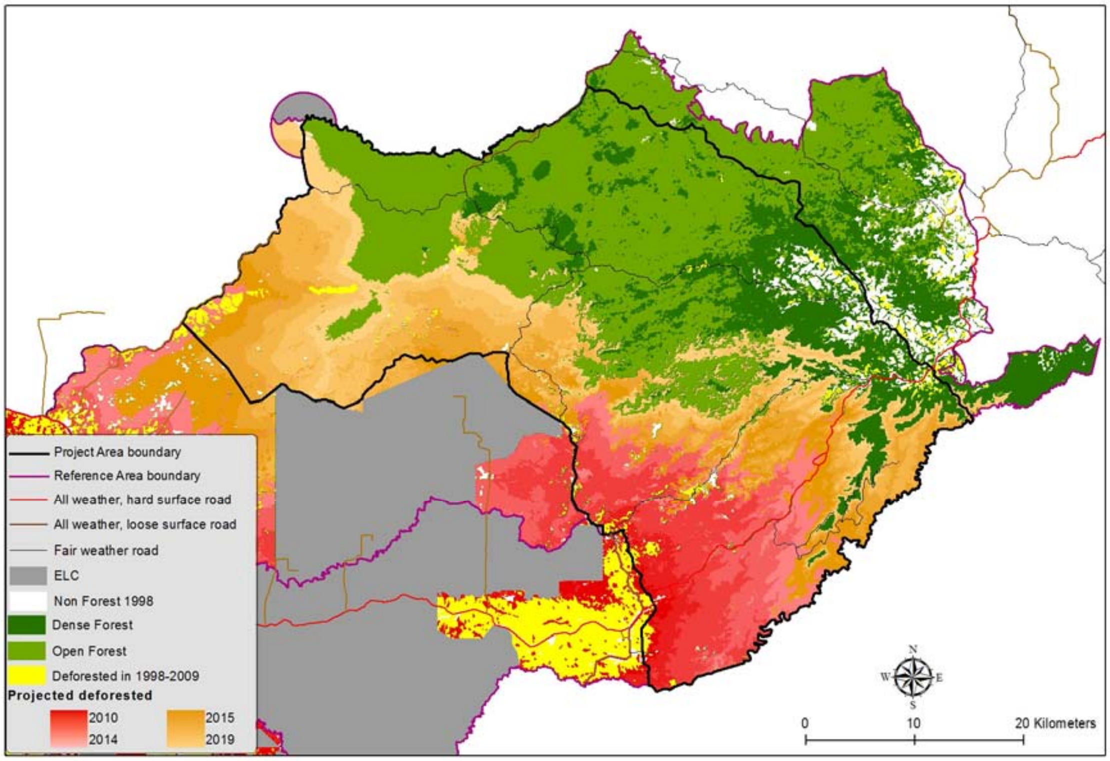


Figure 5.5 Projected annual deforestation in the project area, 2010-2019



Step 5 Definition of the land-use and land-cover change component of the baseline

The goal of this step is to calculate the activity data of the initial forest classes that will be deforested and activity data of the post-deforestation classes that will replace them in the baseline case.

Step 5.1 Calculation of baseline activity data per forest class

A set of maps was produced showing for each forest class which polygons would be deforested each year in the absence of the Seima REDD project. An example for one year is shown below as Figure 5.6 and the other maps are available to the auditor on request. We extracted from these maps the number of hectares of each forest class that will be deforested in the reference region, the project area and the leakage belt (Tables 5.5a-c).

Figure 5.6 An example of an annual deforestation map: projected baseline deforestation within each forest class of the reference region for 2011

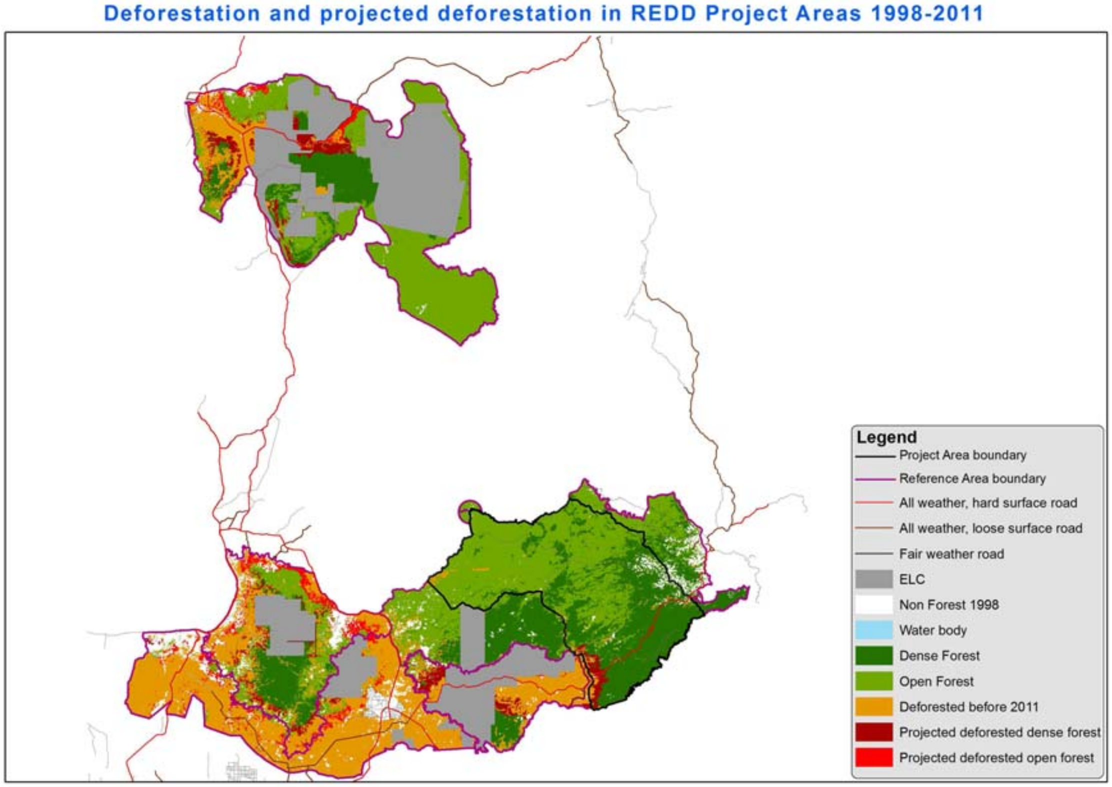


Table 5.5a Annual areas deforested per forest class *icl* within the reference region in the baseline case (baseline activity data per forest class). [=Table 11a of the methodology].

	Area deforested per class within the reference region		Total baseline deforestation in the reference region	
Project year [t]	Fd Dense forest	Fo Open forest	$ABSLRR_{1,t}$ annual	ABSLRR cumulative
	ha	ha	ha	ha
1	23954	18487	42441	42441
2	26062	20141	46202	88643
3	29204	18211	47414	136057
4	25889	19958	45846	181904
5	15787	26030	41817	223721
6	16622	19565	36187	259907
7	13835	16060	29895	289803
8	6555	17236	23792	313594
9	4674	13680	18354	331948
10	3822	10011	13833	345781

Table 5.5b Annual areas deforested per forest class *icl* within the project area in the baseline case (baseline activity data per forest class) [= Table 11b of the methodology]

	Area deforested per class within the project area		Total baseline deforestation in the project area	
ID	Fd	Fo	$ABSLPA_{1,t}$	ABSLPA
Name	Dense forest	Open forest	annual	cumulative
Project year [t]	ha	ha	ha	ha
1	681	510	1191	1191
2	3458	3086	6544	7734
3	11595	11893	23487	31221
4	8464	8981	17445	48667
5	5709	6986	12695	61362
6	6198	9105	15303	76665
7	6960	14497	21458	98123
8	5677	15663	21340	119463
9	4444	15328	19772	139235
10	3640	11382	15021	154256

Table 5.5c Annual areas deforested per forest class *icl* within the leakage belt in the baseline case (baseline activity data per forest class) [= Table 11c of the methodology]

	Area deforested per class within the leakage belt		Total baseline deforestation in the leakage belt	
ID	Fd	Fo	$ABSLLK_{1,t}$	ABSLLK
Name	Dense forest	Open forest	annual	cumulative
Project year [t]	ha	ha	ha	ha
1	171	132	303	303
2	1609	196	1805	2108
3	1608	196	1804	3912
4	211	262	473	4385
5	0	63	63	4448
6	160	30	190	4637
7	54	282	336	4973
8	2	179	181	5154
9	43	289	332	5486
10	33	462	494	5980

Step 5.2 Calculation of baseline activity data per post-deforestation forest class

For this step we only estimate post-deforestation land uses and carbon stocks for the project area and leakage belt alone, rather than for the whole reference region, as permitted by the methodology (p57). As described in Section 4, all deforestation in Stratum 1 leads to a single broad non-forest land-use class, which contains a mosaic of smallholder agricultural crops. Hence all the deforestation listed in Tables 5b and 5c above is considered to enter the same land-use class. The carbon stock of this class is estimated in a later section as the historical area-weighted average, and so there is no requirement to map or analyse separate post-deforestation land-use classes. As no modeling is attempted, Step 5.3 of the methodology is not required and Tables 12, 13 and 14 therein do not need to be completed.

Step 6 Estimation of baseline carbon stock changes and non-CO2 emissions

The aim of this step is to finalize the baseline assessment by calculating the baseline carbon stock changes. We also choose to estimate baseline non-CO_2 emissions from forest fires used to clear forests. Before estimating the baseline carbon stock changes it is necessary to estimate the average carbon stock of each land use/land cover class.

Step 6.1 Estimation of baseline carbon stock changes

Carbon stocks are estimated below for forest classes existing in the project area and leakage belt and for post-deforestation classes existing in the project area, leakage belt and leakage management area in both the baseline and project cases

Step 6.1.1 Estimation of the average carbon stocks of each LU/LC class

Forest classes within the project area

Suitable literature values were not available so an extensive field survey of forest carbon stocks in the project area was conducted during 2009-2011 (Annex 5.3). A systematic random sample of 104 plot clusters was enumerated across the whole Project Area, with a higher intensity of sampling in the dense forest, which has higher carbon stocks. As explained in Section 4.4, carbon pools measured were living trees (>5 cm diameter at breast height) and dead wood (including both standing and lying wood), whilst root biomass was estimated using standard conversion factors. Plot survey protocols follow the Standard Operating Procedures (SOPs) of Walker *et al.* (2009). The biomass equation for living trees (Chave *et al*. 2005; Moist forest equation) was used after being validated by the destructive sampling of trees from both forest types at the site (Annex 5.4) and found to be conservative. Other relevant equations and conversion factors are listed in Annex 5.3. Formal quality control measurements on 10% of plots found only a 1% difference in above ground biomass stocks compared to the initial survey, indicating excellent data quality.

The two forest strata, dense and open, were mapped from satellite analysis (Section 4.5). The dense forest stratum comprises evergreen, semi-evergreen and bamboo stands and has a total average above and below ground carbon stock of 298.62 tC/ha (+/- 7.4% at the 90% confidence level). The open forest stratum comprises mixed deciduous forest, deciduous dipterocarp forest and open woodland and has a total stock of 150.72 tC/ha (+/- 15.6%). These values are set out in more detail in Table 5.6a. These values are presumed to remain constant from the date of measurement until the year at which deforestation takes place, as degradation has been shown to be negligible (Annex 4.3). The harvested wood products, litter and soil organic carbon pools are not measured, for the reasons set out in Section 4.4, and so are not included in the tables.

An uncertainty analysis was conducted using standard error propagation techniques. For the dense forest stratum the uncertainty of the total carbon stock is less than 10% of the average value so following methodology section 6.1.1.f the average carbon stock value is used throughout (Table 5.6bi). This is presumed to apply also to the individual pools. For the open forest stratum the uncertainty exceeds 10% of the average stock and so the lower bound of the 90% confidence interval is used for the pre-deforestation stock in the project area (Table 5.6bii) and the upper bound is used in the leakage belt (Table 5.6biii).

This is one of the first systematic landscape-scale surveys of carbon stock to have been completed in Cambodia. The results show high carbon stocks, well above IPCC Tier 1 median figures, but review of the literature shows that these results are fully consistent with other studies and with expected values in this particular location (Annex 5.3) and so confirm the great regional importance of the SPF for carbon storage.

Forest classes existing within the leakage belt

Satellite analysis, national land cover assessments and field observations show that the same two forest strata exist in the leakage belt as are found in the project area. Conservatively it is assumed that the carbon stocks in these two classes are the same as are found in the project area. In practice they are likely to be somewhat lower, due to a different history of protective measures during the past 10 years, and so higher rates of degradation. Limited inventory data collected by another project from one section of the leakage belt in Sre Preah commune in 2011 support this by showing substantially lower mean carbon stocks in the dense forest stratum there than the average for the project area (data available to the auditor on request).

Table 5.6ai Carbon stocks per hectare of the initial forest class 'dense forest' existing in the project area and leakage belt

This is equivalent to a part of Table 15a of the methodology.

	Initial forest class [icl]							
Name	Dense forest							
ID[icl]	Fd							
	Cab[Fd]		**Cbb[Fd]**		**Cdw[Fd]**		**Ctot[Fd]**	
	ave. stock	**+/- 90% CI**	**ave. stock**	**+/- 90% CI**	**ave. stock**	**+/- 90% CI**	**ave. stock**	**+/- 90% CI**
Project year	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**
0	760.69	76.07	258.68	23.02	75.57	13.62	1094.94	80.63*
1	760.69	76.07	258.68	23.02	75.57	13.62	1094.94	80.63*
2	760.69	76.07	258.68	23.02	75.57	13.62	1094.94	80.63*
3	760.69	76.07	258.68	23.02	75.57	13.62	1094.94	80.63*
4	760.69	76.07	258.68	23.02	75.57	13.62	1094.94	80.63*
5	760.69	76.07	258.68	23.02	75.57	13.62	1094.94	80.63*
6	760.69	76.07	258.68	23.02	75.57	13.62	1094.94	80.63*
7	760.69	76.07	258.68	23.02	75.57	13.62	1094.94	80.63*
8	760.69	76.07	258.68	23.02	75.57	13.62	1094.94	80.63*
9	760.69	76.07	258.68	23.02	75.57	13.62	1094.94	80.63*
10	760.69	76.07	258.68	23.02	75.57	13.62	1094.94	80.63*

Cab[cl]: *Average carbon stock per hectare in the above-ground biomass carbon pool of class cl*
Cbb[cl]: *Average carbon stock per hectare in the below-ground biomass carbon pool of class cl*
Cdw[cl]: *Average carbon stock per hectare in the dead wood biomass carbon pool of class cl*
Ctot[cl]: *Average carbon stock per hectare n all accounted carbon pools cl*
* As this is <10% of the mean the average stock can be used in subsequent calculations

Table 5.6aii Carbon stocks per hectare of the initial forest class 'open forest' existing in the project area and leakage belt

This is equivalent to a part of Table 15a of the methodology.

	Initial forest class [icl]							
Name	Open forest							
ID[icl]	Fo							
	Cab[Fo]		**Cbb[Fo]**		**Cdw[Fo]**		**Ctot[Fo]**	
	ave. stock	**+/- 90% CI**	**ave. stock**	**+/- 90% CI**	**ave. stock**	**+/- 90% CI**	**ave. stock**	**+/- 90% CI**
Project year	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**
0	438.64	73.65	79.05	11.54	36.19	8.58	553.89	75.04
1	438.64	73.65	79.05	11.54	36.19	8.58	553.89	75.04
2	438.64	73.65	79.05	11.54	36.19	8.58	553.89	75.04
3	438.64	73.65	79.05	11.54	36.19	8.58	553.89	75.04
4	438.64	73.65	79.05	11.54	36.19	8.58	553.89	75.04
5	438.64	73.65	79.05	11.54	36.19	8.58	553.89	75.04
6	438.64	73.65	79.05	11.54	36.19	8.58	553.89	75.04
7	438.64	73.65	79.05	11.54	36.19	8.58	553.89	75.04
8	438.64	73.65	79.05	11.54	36.19	8.58	553.89	75.04
9	438.64	73.65	79.05	11.54	36.19	8.58	553.89	75.04
10	438.64	73.65	79.05	11.54	36.19	8.58	553.89	75.04

Cab[cl]: *Average carbon stock per hectare in the above-ground biomass carbon pool of class cl*
Cbb[cl]: *Average carbon stock per hectare in the below-ground biomass carbon pool of class cl*
Cdw[cl]: *Average carbon stock per hectare in the dead wood biomass carbon pool of class cl*
Ctot[cl]: *Average carbon stock per hectare n all accounted carbon pools cl*

Table 5.6bi Values to be used after discounts for uncertainties (dense forest)
This is equivalent to a part of Table 15b of the methodology.

	Initial forest class [icl]							
Name	Dense forest							
ID[icl]	Fd							
	Cab[Fd]		**Cbb[Fd]**		**Cdw[Fd]**		**Ctot[Fd]**	
	ave. stock	**stock change**	**ave. stock**	**stock change**	**ave. stock**	**stock change**	**ave. stock**	**stock change**
Project year	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}
0	760.69	-	258.68	-	75.57	-	1094.94	-
1	760.69	-	258.68	-	75.57	-	1094.94	-
2	760.69	-	258.68	-	75.57	-	1094.94	-
3	760.69	-	258.68	-	75.57	-	1094.94	-
4	760.69	-	258.68	-	75.57	-	1094.94	-
5	760.69	-	258.68	-	75.57	-	1094.94	-
6	760.69	-	258.68	-	75.57	-	1094.94	-
7	760.69	-	258.68	-	75.57	-	1094.94	-
8	760.69	-	258.68	-	75.57	-	1094.94	-
9	760.69	-	258.68	-	75.57	-	1094.94	-
10	760.69	-	258.68	-	75.57	-	1094.94	-

Notes: For abbreviations see Table 5.6ai.

Table 5.6bii Values to be used after discounts for uncertainties (open forest, project area)
This is equivalent to a part of Table 15b of the methodology.

	Initial forest class [icl]							
Name	Open forest							
ID[icl]	Fo							
	Cab[Fo]		**Cbb[Fo]**		**Cdw[Fo]**		**Ctot[Fo]**	
	ave. stock	**+/- 90% CI**	**ave. stock**	**+/- 90% CI**	**ave. stock**	**+/- 90% CI**	**ave. stock**	**+/- 90% CI**
Project year	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**
0	365.00	-	67.51	-	27.61	-	478.85	-
1	365.00	-	67.51	-	27.61	-	478.85	-
2	365.00	-	67.51	-	27.61	-	478.85	-
3	365.00	-	67.51	-	27.61	-	478.85	-
4	365.00	-	67.51	-	27.61	-	478.85	-
5	365.00	-	67.51	-	27.61	-	478.85	-
6	365.00	-	67.51	-	27.61	-	478.85	-
7	365.00	-	67.51	-	27.61	-	478.85	-
8	365.00	-	67.51	-	27.61	-	478.85	-
9	365.00	-	67.51	-	27.61	-	478.85	-
10	365.00	-	67.51	-	27.61	-	478.85	-

For abbreviations see Table 5.6aii.

Table 5.6biii Values to be used after discounts for uncertainties (open forest, leakage belt)
This is equivalent to a part of Table 15b of the methodology.

	Initial forest class [icl]							
Name	Open forest							
ID[icl]	Fo							
	Cab[Fo]		**Cbb[Fo]**		**Cdw[Fo]**		**Ctot[Fo]**	
	ave. stock	**+/- 90% CI**	**ave. stock**	**+/- 90% CI**	**ave. stock**	**+/- 90% CI**	**ave. stock**	**+/- 90% CI**
Project year	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**
0	512.29	-	90.60	-	44.77	-	628.93	-
1	512.29	-	90.60	-	44.77	-	628.93	-
2	512.29	-	90.60	-	44.77	-	628.93	-
3	512.29	-	90.60	-	44.77	-	628.93	-
4	512.29	-	90.60	-	44.77	-	628.93	-
5	512.29	-	90.60	-	44.77	-	628.93	-
6	512.29	-	90.60	-	44.77	-	628.93	-
7	512.29	-	90.60	-	44.77	-	628.93	-
8	512.29	-	90.60	-	44.77	-	628.93	-
9	512.29	-	90.60	-	44.77	-	628.93	-
10	512.29	-	90.60	-	44.77	-	628.93	-

For abbreviations see Table 5.6aii.

Non-forest classes projected to exist in the project area in the baseline case

All non-forest land that is created in the project area after the project start date in the baseline case arises from deforestation. All of it is assigned to a single land use/land cover class, which is occupied by a mosaic smallholder agriculture. The methodology requires that, rather than estimating current stocks, as for the forest classes, a long-term average carbon stock of this class is estimated, to allow for variations over time in the abundance and maturity of different crops. This was done using a historical area-weighted average approach. This approach is based on the assumption that land in and around the project area which has been deforested for a significant length of time already is representative of likely future land-use in areas yet to be deforested. A local study was conducted to provide data for analysis. The methods, assumptions and results are discussed in detail in Annex 5.5.

Sample sites were selected on the basis of land management practices identified as the most likely post-deforestation baseline scenario. Three agro-ecological sectors with slightly different expected stocks were sampled. The relative abundance of each vegetation/crop type by area was assessed using a point-sampling approach (n=258). The average stock of each vegetation/crop type was then estimated from field measurements on representative plots (n=20) combined with additional data obtained from credible literature sources. Weighted averages of these values provide conservative estimates of carbon stocks in the post-deforestation landscape (Table 5.7). The same carbon pools were measured as in the forest classes.

Table 5.7 Long-term (20 years) average carbon stocks per hectare of the post-deforestation LU/LC class present in the project area and leakage belt
This table fulfills the data requirements of Tables 16 and 17 in the methodology.

	Initial forest class [icl]							
Name	Non-forest							
ID[icl]	Nf							
	Cab[Fo]		**Cbb[Fo]**		**Cdw[Fo]**		**Ctot[Fo]**	
	ave. stock	**+/- 90% CI**	**ave. stock**	**+/- 90% CI**	**ave. stock**	**+/- 90% CI**	**ave. stock**	**+/- 90% CI**
	tCO_2eha^{-1}	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**	**tCO_2eha^{-1}**
Average to be used in calculation	28.87	-	6.34	-	11.34	-	46.55	-

Step 6.1.2 Calculation of carbon stock change factors

Carbon stock changes do not all happen instantaneously during deforestation. In the methodology linear functions are applied to account for the decay of some carbon stocks from initial forest classes and increases in some carbon stocks from post-deforestation classes, as follows:

Above ground biomass
- Initial forest classes – 100% release of carbon stock is assumed to occur in the end of the year when deforestation occurred, t*.
- Post-deforestation classes – a linear increase is assumed taking ten years (t* through to t*+9) to reach the eventual long-term average

Below ground biomass
- Initial forest classes – an annual release of 1/10 of the initial carbon stock (see Table 15b) during each year t* to t*+9
- Post-deforestation classes – a linear increase is assumed taking ten years (t* through to t*+9) to reach the eventual long-term average

Dead wood
- Initial forest classes – 100% release of carbon stock is assumed to occur in the end of the year when deforestation occurred, t*.
- Post-deforestation classes – a linear increase is assumed taking ten years (t* through to t*+9) to reach the eventual long-term average

In the following tables we uses these rules and the stock estimate presented earlier in the section to calculate the carbon stock change factors for each category of change in LU/LC for the ten year period during and after deforestation occurs at a given location. Table 5.8i covers the change from dense forest to non-forest, Table 5.8ii covers the change from open forest to non-forest in the project area and Table 5.8iii covers the change from open forest to non-forest in the leakage belt.

Table 5.8i Carbon stock change factors for the dense forest to non-forest LU/LC change category

This table partly fulfills the requirement of Table 20c of the methodology.

ID_{ct} = Fd/Nf		ΔCab[ct,t]	ΔCbb[ct,t]	ΔCdw[t,t]	ΔCtot[ct,t]
Year after deforestation		tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}
1	t*	-757.80	-25.23	-6.42	-789.46
2	t*+1	2.89	-25.23	-6.42	-28.77
3	t*+2	2.89	-25.23	-6.42	-28.77
4	t*+3	2.89	-25.23	-6.42	-28.77
5	t*+4	2.89	-25.23	-6.42	-28.77
6	t*+5	2.89	-25.23	-6.42	-28.77
7	t*+6	2.89	-25.23	-6.42	-28.77
8	t*+7	2.89	-25.23	-6.42	-28.77
9	t*+8	2.89	-25.23	-6.42	-28.77
10	t*+9	2.89	-25.23	-6.42	-28.77
11 et seq	t*+10 et seq	0.00	0.00	0.00	0.00
Total		*-731.82*	*-252.34*	*-64.23*	-1048.39

Note: Year 1 is taken to be the year in which deforestation is observed.

Table 5.8ii Carbon stock change factors for the open forest to non-forest LU/LC change category in the project area

This table partly fulfills the requirement of Table 20c of the methodology.

ID_{ct} = Fo/Nf		ΔCab[ct,t]	ΔCbb[ct,t]	ΔCdw[ct,t]	ΔCtot[ct,t]
Year after deforestation		tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}
1	t*	-362.11	-6.12	-1.63	-369.86
2	t*+1	2.89	-6.12	-1.63	-4.86
3	t*+2	2.89	-6.12	-1.63	-4.86
4	t*+3	2.89	-6.12	-1.63	-4.86
5	t*+4	2.89	-6.12	-1.63	-4.86
6	t*+5	2.89	-6.12	-1.63	-4.86
7	t*+6	2.89	-6.12	-1.63	-4.86
8	t*+7	2.89	-6.12	-1.63	-4.86
9	t*+8	2.89	-6.12	-1.63	-4.86
10	t*+9	2.89	-6.12	-1.63	-4.86
11 et seq	t*+10 et seq	0.00	0.00	0.00	0.00
Total		*-336.13*	*-61.17*	*-16.27*	*-413.57*

Note: Year 1 is taken to be the year in which deforestation is observed.

Table 5.8iii Carbon stock change factors for the open forest to non-forest LU/LC change category in the leakage belt

This table partly fulfills the requirement of Table 20c of the methodology.

ID_{ct} = Fo/Nf		ΔCab[ct,t]	ΔCbb[ct,t]	ΔCdw[ct,t]	ΔCtot[ct,t]
Year after deforestation		tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}
1	t*	-509.40	-8.43	-3.34	-521.17
2	t*+1	2.89	-8.43	-3.34	-8.88
3	t*+2	2.89	-8.43	-3.34	-8.88
4	t*+3	2.89	-8.43	-3.34	-8.88
5	t*+4	2.89	-8.43	-3.34	-8.88
6	t*+5	2.89	-8.43	-3.34	-8.88
7	t*+6	2.89	-8.43	-3.34	-8.88
8	t*+7	2.89	-8.43	-3.34	-8.88
9	t*+8	2.89	-8.43	-3.34	-8.88
10	t*+9	2.89	-8.43	-3.34	-8.88
11 et seq	t*+10 et seq	0.00	0.00	0.00	0.00
Total		-483.42	-84.26	-33.43	-601.11

Note: Year 1 is taken to be the year in which deforestation is observed.

Step 6.1.3 Calculation of baseline carbon stock changes

We have calculated the baseline carbon stock change for each category of LU/LC change in the project area and leakage belt by multiplying the activity data in Tables 5.5b&c by the corresponding emissions factors in Tables 5.8i-iii for the first fixed baseline period. The results are shown in Tables 5.9ai-iii and 5.9bi-iii. We note that in each year there are two relevant pairs of activity values and emission factors – the activity and emission factor associated with the fresh clearance in the chosen year and those relating to the residual, delayed emissions from all deforestation that took place during the preceding years of the project crediting period. In year 2 of the period these deferred emissions only relate to land cleared in the previous year, but by year 10 they relate to land cleared in all preceding years. to make these calculations clear, each table has been divided into three parts.

Table 5.9ai Baseline carbon stock changes in the above-ground biomass in the project area
This table fulfills the requirement of Table 22b.1 of the methodology.

Part 1 - Fresh clearance

	Activity data x Carbon stock change factor Fd/Nf		Fo/NF[PA]		Total baseline carbon stock change Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLPAct,t	∆Cab[ct,t]	ABSLPAct,t	∆Cab[ct,t]	∆CabBSLPA[ct,t]	∆CabBSLPA[ct,t]	∆CabBSLPA[t]	∆CabBSLPA
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	681	(757.8)	510	(362.1)	(516,063.8)	(184,677.6)	(700,741.5)	(700,741.5)
2	3458	(757.8)	3086	(362.1)	(2,620,482.8)	(1,117,480.7)	(3,737,963.5)	(4,438,705.0)
3	11595	(757.8)	11893	(362.1)	(8,786,725.8)	(4,306,609.9)	(13,093,335.7)	(17,532,040.7)
4	8464	(757.8)	8981	(362.1)	(6,414,044.6)	(3,252,136.9)	(9,666,181.4)	(27,198,222.1)
5	5709	(757.8)	6986	(362.1)	(4,326,297.3)	(2,529,721.4)	(6,856,018.7)	(34,054,240.8)
6	6198	(757.8)	9105	(362.1)	(4,696,863.0)	(3,297,038.9)	(7,993,901.9)	(42,048,142.7)
7	6960	(757.8)	14497	(362.1)	(5,274,308.9)	(5,249,552.2)	(10,523,861.0)	(52,572,003.7)
8	5677	(757.8)	15663	(362.1)	(4,302,047.6)	(5,671,775.9)	(9,973,823.6)	(62,545,827.3)
9	4444	(757.8)	15328	(362.1)	(3,367,676.5)	(5,550,468.1)	(8,918,144.6)	(71,463,971.9)
10	3640	(757.8)	11382	(362.1)	(2,758,402.9)	(4,121,570.2)	(6,879,973.1)	(78,343,945.0)

Part 2 - delayed emissions

	Activity data x Carbon stock change factor Fd/Nf		Fo/NF[PA]		Total baseline carbon stock change Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLPAct,t	∆Cab[ct,t]	ABSLPAct,t	∆Cab[ct,t]	∆CabBSLPA[ct,t]	∆CabBSLPA[ct,t]	∆CabBSLPA[t]	∆CabBSLPA
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	0	2.9	0	2.9	-	-	-	-
2	681	2.9	510	2.9	1,966.0	1,472.4	3,438.4	3,438.4
3	4139	2.9	3596	2.9	11,949.3	10,381.7	22,330.9	25,769.4
4	15734	2.9	15489	2.9	45,424.1	44,716.7	90,140.8	115,910.2
5	24198	2.9	24470	2.9	69,859.6	70,644.9	140,504.5	256,414.7
6	29907	2.9	31456	2.9	86,341.5	90,813.5	177,155.0	433,569.7
7	36105	2.9	40561	2.9	104,235.1	117,099.6	221,334.7	654,904.4
8	43065	2.9	55058	2.9	124,328.7	158,952.4	283,281.1	938,185.5
9	48742	2.9	70721	2.9	140,718.2	204,171.5	344,889.7	1,283,075.2
10	53186	2.9	86049	2.9	153,548.0	248,423.5	401,971.4	1,685,046.6

Part 3 - Totals

	Activity data x Carbon stock change factor Fd/Nf		Fo/NF[PA]		Total baseline carbon stock change Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLPAct,t	∆Cab[ct,t]	ABSLPAct,t	∆Cab[ct,t]	∆CabBSLPA[ct,t]	∆CabBSLPA[ct,t]	∆CabBSLPA[t]	∆CabBSLPA
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	*	*	*	*	(516,063.8)	(184,677.6)	(700,741.5)	(700,741.5)
2	*	*	*	*	(2,618,516.7)	(1,116,008.3)	(3,734,525.1)	(4,435,266.5)
3	*	*	*	*	(8,774,776.5)	(4,296,228.3)	(13,071,004.7)	(17,506,271.3)
4	*	*	*	*	(6,368,620.5)	(3,207,420.1)	(9,576,040.6)	(27,082,311.9)
5	*	*	*	*	(4,256,437.7)	(2,459,076.5)	(6,715,514.2)	(33,797,826.2)
6	*	*	*	*	(4,610,521.5)	(3,206,225.4)	(7,816,746.9)	(41,614,573.0)
7	*	*	*	*	(5,170,073.7)	(5,132,452.6)	(10,302,526.3)	(51,917,099.3)
8	*	*	*	*	(4,177,719.0)	(5,512,823.5)	(9,690,542.4)	(61,607,641.8)
9	*	*	*	*	(3,226,958.4)	(5,346,296.5)	(8,573,254.9)	(70,180,896.7)
10	*	*	*	*	(2,604,854.9)	(3,873,146.7)	(6,478,001.6)	(76,658,898.4)

* Two differing pairs of activity data and emission factor apply, see preceding tables

Table 5.9aii Baseline carbon stock changes in the below-ground biomass in the project area
This table fulfills the requirement of Table 22b.2 of the methodology.

Part 1 - Fresh clearance

	Activity data x Carbon stock change factor				Total baseline carbon stock change			
	Fd/Nf		Fo/NF[PA]		Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLPAct,t	ΔCbb[ct,t]	ABSLPAct,t	ΔCbb[ct,t]	ΔCbbBSLPA[ct,t]	ΔCbbBSLPA[ct,t]	ΔCbbBSLPA[t]	ΔCbbBSLPA
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	681	(25.2)	510	(6.1)	(17,184.4)	(3,119.7)	(20,304.0)	(20,304.0)
2	3458	(25.2)	3086	(6.1)	(87,259.2)	(18,877.1)	(106,136.2)	(126,440.3)
3	11595	(25.2)	11893	(6.1)	(292,588.2)	(72,749.5)	(365,337.7)	(491,778.0)
4	8464	(25.2)	8981	(6.1)	(213,580.6)	(54,936.8)	(268,517.4)	(760,295.3)
5	5709	(25.2)	6986	(6.1)	(144,060.9)	(42,733.4)	(186,794.3)	(947,089.6)
6	6198	(25.2)	9105	(6.1)	(156,400.3)	(55,695.3)	(212,095.6)	(1,159,185.2)
7	6960	(25.2)	14497	(6.1)	(175,628.6)	(88,678.1)	(264,306.8)	(1,423,492.0)
8	5677	(25.2)	15663	(6.1)	(143,253.4)	(95,810.6)	(239,064.0)	(1,662,556.0)
9	4444	(25.2)	15328	(6.1)	(112,139.9)	(93,761.4)	(205,901.3)	(1,868,457.3)
10	3640	(25.2)	11382	(6.1)	(91,851.8)	(69,623.7)	(161,475.5)	(2,029,932.7)

Part 2 - delayed emissions

	Activity data x Carbon stock change factor				Total baseline carbon stock change			
	Fd/Nf		Fo/NF[PA]		Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLPAct,t	ΔCbb[ct,t]	ABSLPAct,t	ΔCbb[ct,t]	ΔCbbBSLPA[ct,t]	ΔCbbBSLPA[ct,t]	ΔCbbBSLPA[t]	ΔCbbBSLPA
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	0	(25.2)	0	(6.1)	-	-	-	-
2	681	(25.2)	510	(6.1)	(17,184.4)	(3,119.7)	(20,304.0)	(20,304.0)
3	4139	(25.2)	3596	(6.1)	(104,443.5)	(21,996.7)	(126,440.3)	(146,744.3)
4	15734	(25.2)	15489	(6.1)	(397,031.8)	(94,746.2)	(491,778.0)	(638,522.3)
5	24198	(25.2)	24470	(6.1)	(610,612.3)	(149,683.0)	(760,295.3)	(1,398,817.6)
6	29907	(25.2)	31456	(6.1)	(754,673.2)	(192,416.4)	(947,089.6)	(2,345,907.2)
7	36105	(25.2)	40561	(6.1)	(911,073.6)	(248,111.6)	(1,159,185.2)	(3,505,092.4)
8	43065	(25.2)	55058	(6.1)	(1,086,702.2)	(336,789.8)	(1,423,492.0)	(4,928,584.4)
9	48742	(25.2)	70721	(6.1)	(1,229,955.6)	(432,600.4)	(1,662,556.0)	(6,591,140.4)
10	53186	(25.2)	86049	(6.1)	(1,342,095.5)	(526,361.7)	(1,868,457.3)	(8,459,597.6)

Part 3 - Totals

	Activity data x Carbon stock change factor				Total baseline carbon stock change			
	Fd/Nf		Fo/NF[PA]		Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLPAct,t	ΔCbb[ct,t]	ABSLPAct,t	ΔCbb[ct,t]	ΔCbbBSLPA[ct,t]	ΔCbbBSLPA[ct,t]	ΔCbbBSLPA[t]	ΔCbbBSLPA
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	*	*	*	*	(17,184.4)	(3,119.7)	(20,304.0)	(20,304.0)
2	*	*	*	*	(104,443.5)	(21,996.7)	(126,440.3)	(146,744.3)
3	*	*	*	*	(397,031.8)	(94,746.2)	(491,778.0)	(638,522.3)
4	*	*	*	*	(610,612.3)	(149,683.0)	(760,295.3)	(1,398,817.6)
5	*	*	*	*	(754,673.2)	(192,416.4)	(947,089.6)	(2,345,907.2)
6	*	*	*	*	(911,073.6)	(248,111.6)	(1,159,185.2)	(3,505,092.4)
7	*	*	*	*	(1,086,702.2)	(336,789.8)	(1,423,492.0)	(4,928,584.4)
8	*	*	*	*	(1,229,955.6)	(432,600.4)	(1,662,556.0)	(6,591,140.4)
9	*	*	*	*	(1,342,095.5)	(526,361.7)	(1,868,457.3)	(8,459,597.6)
10	*	*	*	*	(1,433,947.3)	(595,985.4)	(2,029,932.7)	(10,489,530.3)

* Two differing pairs of activity data and emission factor apply, see preceding tables

Table 5.9aiii Baseline carbon stock changes in the dead wood in the project area
This table fulfills the requirement of Table 22b.3 of the methodology.

Part 1 - Fresh clearance

	Activity data x Carbon stock change factor				Total baseline carbon stock change			
	Fd/Nf		Fo/NF[PA]		Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLPAct,t	ΔCdw[ct,t]	ABSLPAct,t	ΔCdw[ct,t]	ΔCdwBSLPA[ct,t]	ΔCdwBSLPA[ct,t]	ΔCdwBSLPA[t]	ΔCdwBSLPA
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	681	(6.4)	510	(1.6)	(4,374.1)	(829.8)	(5,203.8)	(5,203.8)
2	3458	(6.4)	3086	(1.6)	(22,210.7)	(5,020.9)	(27,231.7)	(32,435.5)
3	11595	(6.4)	11893	(1.6)	(74,474.7)	(19,349.9)	(93,824.6)	(126,260.1)
4	8464	(6.4)	8981	(1.6)	(54,364.3)	(14,612.1)	(68,976.4)	(195,236.4)
5	5709	(6.4)	6986	(1.6)	(36,668.9)	(11,366.2)	(48,035.1)	(243,271.6)
6	6198	(6.4)	9105	(1.6)	(39,809.8)	(14,813.8)	(54,623.6)	(297,895.2)
7	6960	(6.4)	14497	(1.6)	(44,704.1)	(23,586.6)	(68,290.7)	(366,185.9)
8	5677	(6.4)	15663	(1.6)	(36,463.4)	(25,483.7)	(61,947.1)	(428,132.9)
9	4444	(6.4)	15328	(1.6)	(28,543.8)	(24,938.7)	(53,482.5)	(481,615.4)
10	3640	(6.4)	11382	(1.6)	(23,379.7)	(18,518.5)	(41,898.2)	(523,513.6)

Part 2 - delayed emissions

	Activity data x Carbon stock change factor				Total baseline carbon stock change			
	Fd/Nf		Fo/NF[PA]		Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLPAct,t	ΔCdw[ct,t]	ABSLPAct,t	ΔCdw[ct,t]	ΔCdwBSLPA[ct,t]	ΔCdwBSLPA[ct,t]	ΔCdwBSLPA[t]	ΔCdwBSLPA
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	0	(6.4)	0	(1.6)	-	-	-	-
2	681	(6.4)	510	(1.6)	(4,374.1)	(829.8)	(5,203.8)	(5,203.8)
3	4139	(6.4)	3596	(1.6)	(26,584.8)	(5,850.7)	(32,435.5)	(37,639.3)
4	15734	(6.4)	15489	(1.6)	(101,059.5)	(25,200.6)	(126,260.1)	(163,899.4)
5	24198	(6.4)	24470	(1.6)	(155,423.8)	(39,812.7)	(195,236.4)	(359,135.9)
6	29907	(6.4)	31456	(1.6)	(192,092.7)	(51,178.9)	(243,271.6)	(602,407.4)
7	36105	(6.4)	40561	(1.6)	(231,902.4)	(65,992.7)	(297,895.2)	(900,302.6)
8	43065	(6.4)	55058	(1.6)	(276,606.5)	(89,579.4)	(366,185.9)	(1,266,488.4)
9	48742	(6.4)	70721	(1.6)	(313,069.9)	(115,063.1)	(428,132.9)	(1,694,621.4)
10	53186	(6.4)	86049	(1.6)	(341,613.7)	(140,001.7)	(481,615.4)	(2,176,236.8)

Part 3 - Totals

	Activity data x Carbon stock change factor				Total baseline carbon stock change			
	Fd/Nf		Fo/NF[PA]		Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLPAct,t	ΔCdw[ct,t]	ABSLPAct,t	ΔCdw[ct,t]	ΔCdwBSLPA[ct,t]	ΔCdwBSLPA[ct,t]	ΔCdwBSLPA[t]	ΔCdwBSLPA
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	*	*	*	*	(4,374.1)	(829.8)	(5,203.8)	(5,203.8)
2	*	*	*	*	(26,584.8)	(5,850.7)	(32,435.5)	(37,639.3)
3	*	*	*	*	(101,059.5)	(25,200.6)	(126,260.1)	(163,899.4)
4	*	*	*	*	(155,423.8)	(39,812.7)	(195,236.4)	(359,135.9)
5	*	*	*	*	(192,092.7)	(51,178.9)	(243,271.6)	(602,407.4)
6	*	*	*	*	(231,902.4)	(65,992.7)	(297,895.2)	(900,302.6)
7	*	*	*	*	(276,606.5)	(89,579.4)	(366,185.9)	(1,266,488.4)
8	*	*	*	*	(313,069.9)	(115,063.1)	(428,132.9)	(1,694,621.4)
9	*	*	*	*	(341,613.7)	(140,001.7)	(481,615.4)	(2,176,236.8)
10	*	*	*	*	(364,993.4)	(158,520.2)	(523,513.6)	(2,699,750.4)

* Two differing pairs of activity data and emission factor apply, see preceding tables

Table 5.9aiv Baseline carbon stock changes in all selected carbon pools in the project area
This table sums the results of Table 22b.1-3 of the methodology.

	Activity data x Carbon stock change factor				Total baseline carbon stock change			
	Fd/Nf		Fo/NF[PA]		Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLPAct,t	ΔC[ct,t]	ABSLPAct,t	ΔC[ct,t]	ΔCBSLPA[ct,t]	ΔCBSLPA[ct,t]	ΔCBSLPA[t]	ΔCBSLPA
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	*	*	*	*	(537,622.3)	(188,627.1)	(726,249.3)	(726,249.3)
2	*	*	*	*	(2,749,545.1)	(1,143,855.8)	(3,893,400.8)	(4,619,650.2)
3	*	*	*	*	(9,272,867.7)	(4,416,175.1)	(13,689,042.8)	(18,308,693.0)
4	*	*	*	*	(7,134,656.6)	(3,396,915.8)	(10,531,572.4)	(28,840,265.4)
5	*	*	*	*	(5,203,203.6)	(2,702,671.8)	(7,905,875.4)	(36,746,140.8)
6	*	*	*	*	(5,753,497.5)	(3,520,329.8)	(9,273,827.2)	(46,019,968.0)
7	*	*	*	*	(6,533,382.5)	(5,558,821.7)	(12,092,204.2)	(58,112,172.2)
8	*	*	*	*	(5,720,744.5)	(6,060,486.9)	(11,781,231.4)	(69,893,403.5)
9	*	*	*	*	(4,910,667.6)	(6,012,660.0)	(10,923,327.6)	(80,816,731.1)
10	*	*	*	*	(4,403,795.6)	(4,627,652.4)	(9,031,448.0)	(89,848,179.1)

* Two differing pairs of activity data and emission factor apply, see preceding tables

Table 5.9bi Baseline carbon stock changes in the above-ground biomass in the leakage belt
This table fulfills the requirement of Table 22c.1 of the methodology.

Part 1 - Fresh clearance

	Activity data x Carbon stock change factor				Total baseline carbon stock change			
	Fd/Nf		Fo/NF[LB]		Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLLBct,t	∆Cab[ct,t]	ABSLLBct,t	∆Cab[ct,t]	∆CabBSLLB[ct,t]	∆CabBSLLB[ct,t]	∆CabBSLLB[t]	∆CabBSLLB
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	171	(757.8)	132	(509.4)	(129,383.1)	(67,196.7)	(196,579.8)	(196,579.8)
2	1609	(757.8)	196	(509.4)	(1,219,321.2)	(99,914.8)	(1,319,236.0)	(1,515,815.8)
3	1608	(757.8)	196	(509.4)	(1,218,613.2)	(99,914.8)	(1,318,528.0)	(2,834,343.8)
4	211	(757.8)	262	(509.4)	(159,808.5)	(133,268.4)	(293,076.9)	(3,127,420.8)
5	0	(757.8)	63	(509.4)	(51.6)	(32,062.1)	(32,113.8)	(3,159,534.5)
6	160	(757.8)	30	(509.4)	(121,029.9)	(15,300.8)	(136,330.7)	(3,295,865.2)
7	54	(757.8)	282	(509.4)	(40,602.6)	(143,787.2)	(184,389.8)	(3,480,255.1)
8	2	(757.8)	179	(509.4)	(1,660.2)	(91,166.6)	(92,826.9)	(3,573,082.0)
9	43	(757.8)	289	(509.4)	(32,338.4)	(147,370.3)	(179,708.6)	(3,752,790.6)
10	33	(757.8)	462	(509.4)	(24,638.8)	(235,104.4)	(259,743.3)	(4,012,533.9)

Part 2 - delayed emissions

	Activity data x Carbon stock change factor				Total baseline carbon stock change			
	Fd/Nf		Fo/NF[LB]		Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLLBct,t	∆Cab[ct,t]	ABSLLBct,t	∆Cab[ct,t]	∆CabBSLLB[ct,t]	∆CabBSLLB[ct,t]	∆CabBSLLB[t]	∆CabBSLLB
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	0	2.9	0	2.9	-	-	-	-
2	171	2.9	132	2.9	492.9	380.8	873.7	873.7
3	1780	2.9	328	2.9	5,138.2	947.1	6,085.2	6,959.0
4	3388	2.9	524	2.9	9,780.7	1,513.4	11,294.1	18,253.0
5	3599	2.9	786	2.9	10,389.5	2,268.6	12,658.2	30,911.2
6	3599	2.9	849	2.9	10,389.7	2,450.3	12,840.1	43,751.3
7	3759	2.9	879	2.9	10,850.8	2,537.1	13,387.9	57,139.1
8	3812	2.9	1161	2.9	11,005.5	3,352.0	14,357.5	71,496.6
9	3814	2.9	1340	2.9	11,011.8	3,868.6	14,880.5	86,377.1
10	3857	2.9	1629	2.9	11,135.0	4,703.9	15,838.9	102,215.9

Part 3 - Totals

	Activity data x Carbon stock change factor				Total baseline carbon stock change			
	Fd/Nf		Fo/NF[LB]		Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLLBct,t	∆Cab[ct,t]	ABSLLBct,t	∆Cab[ct,t]	∆CabBSLLB[ct,t]	∆CabBSLLB[ct,t]	∆CabBSLLB[t]	∆CabBSLLB
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	*	*	*	*	(129,383.1)	(67,196.7)	(196,579.8)	(196,579.8)
2	*	*	*	*	(1,218,828.3)	(99,534.0)	(1,318,362.3)	(1,514,942.1)
3	*	*	*	*	(1,213,475.0)	(98,967.7)	(1,312,442.7)	(2,827,384.8)
4	*	*	*	*	(150,027.8)	(131,755.0)	(281,782.9)	(3,109,167.7)
5	*	*	*	*	10,337.9	(29,793.5)	(19,455.6)	(3,128,623.3)
6	*	*	*	*	(110,640.2)	(12,850.4)	(123,490.6)	(3,252,114.0)
7	*	*	*	*	(29,751.8)	(141,250.2)	(171,002.0)	(3,423,115.9)
8	*	*	*	*	9,345.2	(87,814.7)	(78,469.4)	(3,501,585.4)
9	*	*	*	*	(21,326.6)	(143,501.6)	(164,828.2)	(3,666,413.5)
10	*	*	*	*	(13,503.8)	(230,400.6)	(243,904.4)	(3,910,317.9)

* Two differing pairs of activity data and emission factor apply, see preceding tables

Table 5.9bii Baseline carbon stock changes in the below-ground biomass in the leakage belt area

This table fulfills the requirement of Table 22c.2 of the methodology.

Part 1 - Fresh clearance

	Activity data x Carbon stock change factor Fd/Nf		Fo/NF[LB]		Total baseline carbon stock change Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLLBct,t	ΔCbb[ct,t]	ABSLLBct,t	ΔCbb[ct,t]	ΔCbbBSLLB[ct,t]	ΔCbbBSLLB[ct,t]	ΔCbbBSLLB[t]	ΔCbbBSLLB
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	171	(25.2)	132	(8.4)	(4,308.3)	(1,111.5)	(5,419.8)	(5,419.8)
2	1609	(25.2)	196	(8.4)	(40,602.0)	(1,652.7)	(42,254.7)	(47,674.5)
3	1608	(25.2)	196	(8.4)	(40,578.5)	(1,652.7)	(42,231.2)	(89,905.7)
4	211	(25.2)	262	(8.4)	(5,321.4)	(2,204.4)	(7,525.8)	(97,431.5)
5	0	(25.2)	63	(8.4)	(1.7)	(530.3)	(532.1)	(97,963.6)
6	160	(25.2)	30	(8.4)	(4,030.2)	(253.1)	(4,283.3)	(102,246.8)
7	54	(25.2)	282	(8.4)	(1,352.0)	(2,378.4)	(3,730.4)	(105,977.2)
8	2	(25.2)	179	(8.4)	(55.3)	(1,508.0)	(1,563.3)	(107,540.5)
9	43	(25.2)	289	(8.4)	(1,076.8)	(2,437.6)	(3,514.5)	(111,055.0)
10	33	(25.2)	462	(8.4)	(820.4)	(3,888.8)	(4,709.3)	(115,764.3)

Part 2 - delayed emissions

	Activity data x Carbon stock change factor Fd/Nf		Fo/NF[LB]		Total baseline carbon stock change Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLLBct,t	ΔCbb[ct,t]	ABSLLBct,t	ΔCbb[ct,t]	ΔCbbBSLLB[ct,t]	ΔCbbBSLLB[ct,t]	ΔCbbBSLLB[t]	ΔCbbBSLLB
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	0	(25.2)	0	(8.4)	-	-	-	-
2	171	(25.2)	132	(8.4)	(4,308.3)	(1,111.5)	(5,419.8)	(5,419.8)
3	1780	(25.2)	328	(8.4)	(44,910.4)	(2,764.2)	(47,674.5)	(53,094.3)
4	3388	(25.2)	524	(8.4)	(85,488.8)	(4,416.9)	(89,905.7)	(143,000.0)
5	3599	(25.2)	786	(8.4)	(90,810.3)	(6,621.2)	(97,431.5)	(240,431.6)
6	3599	(25.2)	849	(8.4)	(90,812.0)	(7,151.6)	(97,963.6)	(338,395.1)
7	3759	(25.2)	879	(8.4)	(94,842.2)	(7,404.7)	(102,246.8)	(440,642.0)
8	3812	(25.2)	1161	(8.4)	(96,194.2)	(9,783.0)	(105,977.2)	(546,619.2)
9	3814	(25.2)	1340	(8.4)	(96,249.5)	(11,291.0)	(107,540.5)	(654,159.7)
10	3857	(25.2)	1629	(8.4)	(97,326.3)	(13,728.7)	(111,055.0)	(765,214.7)

Part 3 - Totals

	Activity data x Carbon stock change factor Fd/Nf		Fo/NF[LB]		Total baseline carbon stock change Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLLBct,t	ΔCbb[ct,t]	ABSLLBct,t	ΔCbb[ct,t]	ΔCbbBSLLB[ct,t]	ΔCbbBSLLB[ct,t]	ΔCbbBSLLB[t]	ΔCbbBSLLB
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	*	*	*	*	(4,308.3)	(1,111.5)	(5,419.8)	(5,419.8)
2	*	*	*	*	(44,910.4)	(2,764.2)	(47,674.5)	(53,094.3)
3	*	*	*	*	(85,488.8)	(4,416.9)	(89,905.7)	(143,000.0)
4	*	*	*	*	(90,810.3)	(6,621.2)	(97,431.5)	(240,431.6)
5	*	*	*	*	(90,812.0)	(7,151.6)	(97,963.6)	(338,395.1)
6	*	*	*	*	(94,842.2)	(7,404.7)	(102,246.8)	(440,642.0)
7	*	*	*	*	(96,194.2)	(9,783.0)	(105,977.2)	(546,619.2)
8	*	*	*	*	(96,249.5)	(11,291.0)	(107,540.5)	(654,159.7)
9	*	*	*	*	(97,326.3)	(13,728.7)	(111,055.0)	(765,214.7)
10	*	*	*	*	(98,146.7)	(17,617.5)	(115,764.3)	(880,978.9)

* Two differing pairs of activity data and emission factor apply, see preceding tables

Table 5.9biii Baseline carbon stock changes in the below-ground biomass in the leakage belt area

This table fulfills the requirement of Table 22c.3 of the methodology.

Part 1 - Fresh clearance

	Activity data x Carbon stock change factor				Total baseline carbon stock change			
	Fd/Nf		Fo/NF[LB]		Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLLBct,t	∆Cdw[ct,t]	ABSLLBct,t	∆Cdw[ct,t]	∆CdwBSLLB[ct,t]	∆CdwBSLLB[ct,t]	∆CdwBSLLB[t]	∆CdwBSLLB
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	171	(6.4)	132	(3.3)	(1,096.6)	(441.0)	(1,537.6)	(1,537.6)
2	1609	(6.4)	196	(3.3)	(10,334.7)	(655.7)	(10,990.4)	(12,528.1)
3	1608	(6.4)	196	(3.3)	(10,328.7)	(655.7)	(10,984.4)	(23,512.5)
4	211	(6.4)	262	(3.3)	(1,354.5)	(874.6)	(2,229.1)	(25,741.6)
5	0	(6.4)	63	(3.3)	(0.4)	(210.4)	(210.8)	(25,952.4)
6	160	(6.4)	30	(3.3)	(1,025.8)	(100.4)	(1,126.2)	(27,078.7)
7	54	(6.4)	282	(3.3)	(344.1)	(943.6)	(1,287.8)	(28,366.4)
8	2	(6.4)	179	(3.3)	(14.1)	(598.3)	(612.4)	(28,978.8)
9	43	(6.4)	289	(3.3)	(274.1)	(967.1)	(1,241.2)	(30,220.0)
10	33	(6.4)	462	(3.3)	(208.8)	(1,542.9)	(1,751.7)	(31,971.7)

Part 2 - delayed emissions

	Activity data x Carbon stock change factor				Total baseline carbon stock change			
	Fd/Nf		Fo/NF[LB]		Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLLBct,t	∆Cdw[ct,t]	ABSLLBct,t	∆Cdw[ct,t]	∆CdwBSLLB[ct,t]	∆CdwBSLLB[ct,t]	∆CdwBSLLB[t]	∆CdwBSLLB
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	0	(6.4)	0	(3.3)	-	-	-	-
2	171	(6.4)	132	(3.3)	(1,096.6)	(441.0)	(1,537.6)	(1,537.6)
3	1780	(6.4)	328	(3.3)	(11,431.4)	(1,096.7)	(12,528.1)	(14,065.7)
4	3388	(6.4)	524	(3.3)	(21,760.1)	(1,752.4)	(23,512.5)	(37,578.2)
5	3599	(6.4)	786	(3.3)	(23,114.6)	(2,627.0)	(25,741.6)	(63,319.8)
6	3599	(6.4)	849	(3.3)	(23,115.1)	(2,837.4)	(25,952.4)	(89,272.2)
7	3759	(6.4)	879	(3.3)	(24,140.9)	(2,937.8)	(27,078.7)	(116,350.9)
8	3812	(6.4)	1161	(3.3)	(24,485.0)	(3,881.4)	(28,366.4)	(144,717.3)
9	3814	(6.4)	1340	(3.3)	(24,499.1)	(4,479.7)	(28,978.8)	(173,696.1)
10	3857	(6.4)	1629	(3.3)	(24,773.2)	(5,446.8)	(30,220.0)	(203,916.1)

Part 3 - Totals

	Activity data x Carbon stock change factor				Total baseline carbon stock change			
	Fd/Nf		Fo/NF[LB]		Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLLBct,t	∆Cdw[ct,t]	ABSLLBct,t	∆Cdw[ct,t]	∆CdwBSLLB[ct,t]	∆CdwBSLLB[ct,t]	∆CdwBSLLB[t]	∆CdwBSLLB
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	*	*	*	*	(1,096.6)	(441.0)	(1,537.6)	(1,537.6)
2	*	*	*	*	(11,431.4)	(1,096.7)	(12,528.1)	(14,065.7)
3	*	*	*	*	(21,760.1)	(1,752.4)	(23,512.5)	(37,578.2)
4	*	*	*	*	(23,114.6)	(2,627.0)	(25,741.6)	(63,319.8)
5	*	*	*	*	(23,115.1)	(2,837.4)	(25,952.4)	(89,272.2)
6	*	*	*	*	(24,140.9)	(2,937.8)	(27,078.7)	(116,350.9)
7	*	*	*	*	(24,485.0)	(3,881.4)	(28,366.4)	(144,717.3)
8	*	*	*	*	(24,499.1)	(4,479.7)	(28,978.8)	(173,696.1)
9	*	*	*	*	(24,773.2)	(5,446.8)	(30,220.0)	(203,916.1)
10	*	*	*	*	(24,982.0)	(6,989.7)	(31,971.7)	(235,887.9)

* Two differing pairs of activity data and emission factor apply, see preceding tables

Table 5.9biv Baseline carbon stock changes in all selected pools in the leakage belt area
This table sums the results of Tables 22c.1-3 of the methodology

	Activity data x Carbon stock change factor				Total baseline carbon stock change			
	Fd/Nf		Fo/NF[LB]		Fd/Nf Annual	Fd/Nf Annual	Total Annual	Cumulative
Project yr	ABSLLBct,t	∆C[ct,t]	ABSLLBct,t	∆C[ct,t]	∆CBSLLB[ct,t]	∆CBSLB[ct,t]	∆CBSLLB[t]	∆CBSLLB
t	ha	tCO_2eha^{-1}	ha	tCO_2eha^{-1}	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	*	*	*	*	(134,788.0)	(68,749.2)	(203,537.2)	(203,537.2)
2	*	*	*	*	(1,275,170.1)	(103,394.8)	(1,378,564.9)	(1,582,102.1)
3	*	*	*	*	(1,320,724.0)	(105,137.0)	(1,425,860.9)	(3,007,963.1)
4	*	*	*	*	(263,952.7)	(141,003.3)	(404,956.0)	(3,412,919.0)
5	*	*	*	*	(103,589.1)	(39,782.5)	(143,371.6)	(3,556,290.7)
6	*	*	*	*	(229,623.3)	(23,192.9)	(252,816.2)	(3,809,106.8)
7	*	*	*	*	(150,431.0)	(154,914.6)	(305,345.6)	(4,114,452.4)
8	*	*	*	*	(111,403.3)	(103,585.4)	(214,988.7)	(4,329,441.1)
9	*	*	*	*	(143,426.1)	(162,677.1)	(306,103.2)	(4,635,544.3)
10	*	*	*	*	(136,632.6)	(255,007.8)	(391,640.4)	(5,027,184.7)

* Two differing pairs of activity data and emission factor apply, see preceding tables

Step 6.2 Baseline non-CO_2 emissions from forest fires

Estimates are made here of emissions from forests used in the process of clearing forests (to remove downed vegetation after it has been cut and left to dry). N_2O emissions are considered insignificant according to the VCS Standard (see Table 4.3) but we have chosen to consider CH_4 emissions. We estimate the average percentage of the deforested area in which fire is used, the average proportion of mass burnt in each carbon pool and the average combustion efficiency of each pool, separately for each forest class. The equations used are set out in the Methodology section 6.2, and embedded in the spreadsheets supplied to the validator. The sources of the default values are also set out in the spreadsheets.

The estimated parameters are set out in Table 5.19. The estimated emissions are small – 2.82 tCO_2e/ha for dense forest and 1.60 tCO_2e/ha for open forest.

Table 5.19 Parameters used to calculate non-CO2 emissions from forest fires
This table fulfills the requirements of Table 23 of the methodology. It is deliberately numbered out of sequence.

Category	% F burnticl	Cab	Cdw	Cl	% Pburntab,icl	% Pburntdw,icl	% Pburntl,icl	% CEab,icl	% CEdw,icl	% CEl,icl	ECO2-ab	ECO2-dw	ECO2-l	EBBCO2-tot	EBBCH4icl	EBBtoticl
		t/ha	t/a								t CO2e/ha	t CO2e/ha	t CO2e/ha	t CO2e/ha	t CO2e/ha	t CO2e/ha
Clearance - dense forest	1	207.46	20.61	na	0.45	0.45	na	0.3	0.3	na	28.01	2.78	0	30.79	2.82	2.82
Clearance - open forest	1	119.63	9.87	na	0.45	0.45	na	0.3	0.3	na	16.15	1.33	0	17.48	1.60	1.60

Table 5.20 Baseline non-CO_2 emissions from forest fires in project area
This table fulfills the requirements of Table 24 of the methodology. It is deliberately numbered out of sequence.

Project year t	Dense forest		Open forest		Total	
	Area defor and burned ABSLPAtot ha	emissions EBBtoticl t CO2e	Area defor and burned ABSLPAtot ha	emissions EBBtoticl t CO2e	Annual EBBBSLPAt t CO2e	Cumulative EBBBSLPA t CO2e
1	681	1921.4	510	817.0	2738.4	2738.4
2	3458	9756.5	3086	4943.9	14700.4	17438.8
3	11595	32714.5	11893	19053.0	51767.5	69206.3
4	8464	23880.6	8981	14387.9	38268.5	107474.8
5	5709	16107.6	6986	11191.8	27299.4	134774.1
6	6198	17487.2	9105	14586.5	32073.8	166847.9
7	6960	19637.2	14497	23224.7	42861.8	209709.7
8	5677	16017.3	15663	25092.6	41109.9	250819.7
9	4444	12538.4	15328	24556.0	37094.4	287914.1
10	3640	10270.0	11382	18234.3	28504.4	316418.4

5.4 Project Emissions (CL1)

Step 7 Ex-ante estimation of actual carbon stock changes and nonCO_2 emissions in the project area

The goal of this step is to provide an ex-ante estimate of the future carbon stock changes under the project scenario (ie what is expected to happen *instead of* the baseline scenario). Since actual carbon stock changes will be subject to Measurement, Reporting, Verification and Accounting, the rationale of these ex-ante estimates is to guide optimal implementation of emission reduction measures, and to allow reasonable projections of revenues to be made.

Step 7.1 Ex-ante estimation of actual carbon stock changes

Step 7.1.1 Ex-ante estimation of actual carbon stock changes due to planned activities

The project activities do not include any planned deforestation or harvesting above that existing in the baseline case. Furthermore, no carbon stock increases will be claimed for in areas that would be deforested in the baseline scenario. Therefore it is not necessary to complete Tables 25a-d or 26a-d of the methodology.

Step 7.1.2/7.1.3 Ex ante estimation of carbon stock changes due to unavoidable unplanned deforestation, and hence total emissions, within the project area

Some unplanned deforestation is likely to happen in the project areas despite the planned activities. The level at which deforestation will actually be reduced in the project case depends on the effectiveness of the proposed activities, which must be estimated *ex-ante* for the purposes of this section. This is done by developing an Effectiveness Index (EI) ranging from 0 (no effectiveness) to 1 (full effectiveness). The projected baseline emissions are multiplied by (1-EI) to give the estimated emissions from unavoidable unplanned deforestation.

For the Seima project Sub-objectives 1-4 involve direct contact with the agents of deforestation (see Section 2.2) so their coverage and effectiveness will ultimately determine the impact the project has on deforestation. The impacts of Sub-objectives 5-7 (finance, administration, monitoring etc) are felt indirectly, by strengthening the implementation of Sub-objectives 1-4. Table 5.10 presents estimates of the level of effectiveness expected to be reached by each sub-objective during each year, with all four of them predicted to reach full effectiveness by 2015. Full effectiveness cannot be reached immediately, in part because no major additional REDD-related finance will likely become available until the time of the first credit sales (after the first verification report). The benefit-sharing system will also take some time to design and test before becoming fully operational, even given sufficient finance. Other important aspects that will take time to scale up or modify include:

- staffing levels
- staff capacity
- infrastructure and other facilities
- community attitudes towards conservation
- responses by local authorities
- attitudes by legal violators

Table 5.10 uses expert opinion to combine these factors into sub-objective effectiveness scores. It also provides an assessment of the relative weight of the four sub-objectives. Law enforcement will undoubtedly be the key factor in the first ten years of the project, since historical levels of law enforcement have been generally weak. Alternative livelihoods, in particular perhaps the benefit-share system, also have a key part to pay in motivating changed behaviour and reducing some of the underlying drivers of deforestation. Development of the legal framework and improvement of mechanisms for land tenure sustainable land use by communities have some direct impact and are crucial enabling conditions for other aspects of the project, but have less overall weight. Combining the individual effectiveness scores and weights gives the overall ex ante Effectivenesss Index (EI) in the final column.

Table 5.10 Calculation of the Effectiveness Index for the first fixed baseline period

	Impact of sub-objectives				Weighted coverage [=EI]
	1. Legal framework	2. Law enforcement	3. Sustainable land-use	4. Alternative livelihoods	
Relative importance	*10%*	*60%*	*10%*	*20%*	
Project year t					
1	20%	20%	5%	0%	15%
2	20%	20%	10%	5%	16%
3	20%	30%	20%	20%	26%
4	30%	50%	50%	30%	44%
5	50%	75%	75%	50%	68%
6	100%	100%	100%	100%	100%
7	100%	100%	100%	100%	100%
8	100%	100%	100%	100%	100%
9	100%	100%	100%	100%	100%
10	100%	100%	100%	100%	100%

Table 5.11a uses the estimated EI from Table 5.10 to predict the actual emissions reductions that will be achieved. This is calculated as follows:

$$\Delta CUDdPA[t] = \Delta CtotBSLPA[t] * (1-EI)$$

Where:

ΔCUDdPA[t] = Total ex ante actual carbon stock changes due to unavoided unplanned deforestation at year t in the project area; tCO_2e

EI = Ex ante estimated Effectiveness Index, %

and ΔCtotBSLPA[t] was defined earlier.

Table 5.11a Ex-ante estimated net carbon stock change in the project area under the project scenario

This table fulfills the requirements of Table 27 of the methodology.

	Total baseline CO2 emissions		Proportion of baseline emissions NOT affected by project activities	Total carbon stock decrease due to unavoided unplanned deforestation		Total carbon stock change in the project case		Gross ex ante reductions in emissions from carbon stocks due to project activities	
	annual	cumulative	annual	annual	cumulative	annual	cumulative	annual	cumulative
Project yr	ΔCtotBSLPA[t]	ΔCtotBSLPA	1-EI	ΔCUDdPA[t]	ΔCUDdPA	ΔCPSPA[t]	ΔCPSPA		
t	tCO_2e	tCO_2e		tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	(726,249.3)		86%	(620,943.2)	(620,943.2)	(620,943.2)	(620,943.2)	105,306.2	105,306.2
2	(3,893,400.8)	(4,619,650.2)	84%	(3,270,456.7)	(3,891,399.9)	(3,270,456.7)	(3,891,399.9)	622,944.1	728,250.3
3	(13,689,042.8)	(18,308,693.0)	74%	(10,129,891.7)	(14,021,291.5)	(10,129,891.7)	(14,021,291.5)	3,559,151.1	4,287,401.4
4	(10,531,572.4)	(28,840,265.4)	56%	(5,897,680.5)	(19,918,972.1)	(5,897,680.5)	(19,918,972.1)	4,633,891.9	8,921,293.3
5	(7,905,875.4)	(36,746,140.8)	33%	(2,569,409.5)	(22,488,381.6)	(2,569,409.5)	(22,488,381.6)	5,336,465.9	14,257,759.2
6	(9,273,827.2)	(46,019,968.0)	0%	-	(22,488,381.6)	-	(22,488,381.6)	9,273,827.2	23,531,586.4
7	(12,092,204.2)	(58,112,172.2)	0%	-	(22,488,381.6)	-	(22,488,381.6)	12,092,204.2	35,623,790.6
8	(11,781,231.4)	(69,893,403.5)	0%	-	(22,488,381.6)	-	(22,488,381.6)	11,781,231.4	47,405,021.9
9	(10,923,327.6)	(80,816,731.1)	0%	-	(22,488,381.6)	-	(22,488,381.6)	10,923,327.6	58,328,349.5
10	(9,031,448.0)	(89,848,179.1)	0%	-	(22,488,381.6)	-	(22,488,381.6)	9,031,448.0	67,359,797.5

Step 7.2 Ex ante estimation of actual non-CO_2 emissions from forest fires

Emissions in the project case have been calculated by multiplying the projected baseline emissions in each year by the with-project Effectiveness Index (Table 5.10). With-project emissions and consequent emission reductions are shown in Table 5.11b.

Table 5.11b Total ex ante estimated actual emissions of non-CO_2 gases due to forest fires used for clearance in the project area.
This table fulfills the requirements of Table 28 of the methodology.

	Total baseline non-CO2 emissions		Proportion of baseline emissions NOT affected by project activities	Total ex ante estimated actual non-CO2 emissions from forest fires used for clearance in the project case		Total ex ante estimated reduction in non-CO2 emissions from forest fires used for clearance in the project case	
	annual	cumulative	annual	annual	cumulative	annual	cumulative
Project yr	EBBBSLPAt	EBBBSLPA	1-EI	EBBPSPAt	EBBPSPA		
t	tCO_2e	tCO_2e		tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	(2,738.4)	(2,738.4)	80%	(2,190.7)	(2,190.7)	(547.7)	(547.7)
2	(14,700.4)	(17,438.8)	70%	(10,290.3)	(12,481.0)	(4,410.1)	(4,957.8)
3	(51,767.5)	(69,206.3)	50%	(25,883.7)	(38,364.8)	(25,883.7)	(30,841.6)
4	(38,268.5)	(107,474.8)	25%	(9,567.1)	(47,931.9)	(28,701.4)	(59,542.9)
5	(27,299.4)	(134,774.1)	0%	-	(47,931.9)	(27,299.4)	(86,842.3)
6	(32,073.8)	(166,847.9)	0%	-	(47,931.9)	(32,073.8)	(118,916.0)
7	(42,861.8)	(209,709.7)	0%	-	(47,931.9)	(42,861.8)	(161,777.9)
8	(41,109.9)	(250,819.7)	0%	-	(47,931.9)	(41,109.9)	(202,887.8)
9	(37,094.4)	(287,914.1)	0%	-	(47,931.9)	(37,094.4)	(239,982.2)
10	(28,504.4)	(316,418.4)	0%	-	(47,931.9)	(28,504.4)	(268,486.5)

***Step 7.3 Total* ex ante estimations for the project area**

Table 5.11c presents the total ex-ante emissions estimates, combining those due to carbon stock changes and those due to CH_4 emissions. Table 5.11d presents the gross estimated emission reductions, before the calculation of leakage.

Table 5.11c Total ex-ante estimated actual net carbon stock changes and emissions of non-CO2 gasses in the project area
This table fulfills the requirements of Table 29 of the methodology.

	Total carbon stock decrease due to unavoided unplanned deforestation		Total carbon stock change in the project case		Total ex ante estimated actual non-CO2 emissions from forest fires used for clearance in the project case	
	annual	cumulative	annual	cumulative	annual	cumulative
Project yr	ΔCUDdPA[t]	ΔCUDdPA	ΔCPSPA[t]	ΔCPSPA	EBBPSPAt	EBBPSPA
t	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e
1	(620,943.2)	(620,943.2)	(620,943.2)	(620,943.2)	(2,190.7)	(2,190.7)
2	(3,270,456.7)	(3,891,399.9)	(3,270,456.7)	(3,891,399.9)	(10,290.3)	(12,481.0)
3	(10,129,891.7)	(14,021,291.5)	(10,129,891.7)	(14,021,291.5)	(25,883.7)	(38,364.8)
4	(5,897,680.5)	(19,918,972.1)	(5,897,680.5)	(19,918,972.1)	(9,567.1)	(47,931.9)
5	(2,569,409.5)	(22,488,381.6)	(2,569,409.5)	(22,488,381.6)	-	(47,931.9)
6	-	(22,488,381.6)	-	(22,488,381.6)	-	(47,931.9)
7	-	(22,488,381.6)	-	(22,488,381.6)	-	(47,931.9)
8	-	(22,488,381.6)	-	(22,488,381.6)	-	(47,931.9)
9	-	(22,488,381.6)	-	(22,488,381.6)	-	(47,931.9)
10	-	(22,488,381.6)	-	(22,488,381.6)	-	(47,931.9)

Table 5.11d Gross emissions reductions in the project area under the project scenario, prior to leakage estimation

This table does not relate directly to any of those set out in the methodology.

Project yr t	Gross ex ante reductions in emissions from carbon stocks due to project activities annual tCO_2e	cumulative tCO_2e	Gross ex ante emission reductions due to nonCO2 GHGs annual tCO_2e	cumulative tCO_2e	Gross ex ante emission reductions from all sources annual tCO_2e	cumulative tCO_2e
1	105,306.2	105,306.2	547.7	547.7	105,853.8	105,853.8
2	622,944.1	728,250.3	4,410.1	4,957.8	627,354.2	733,208.1
3	3,559,151.1	4,287,401.4	25,883.7	30,841.6	3,585,034.9	4,318,243.0
4	4,633,891.9	8,921,293.3	28,701.4	59,542.9	4,662,593.2	8,980,836.2
5	5,336,465.9	14,257,759.2	27,299.4	86,842.3	5,363,765.3	14,344,601.4
6	9,273,827.2	23,531,586.4	32,073.8	118,916.0	9,305,901.0	23,650,502.4
7	12,092,204.2	35,623,790.6	42,861.8	161,777.9	12,135,066.0	35,785,568.4
8	11,781,231.4	47,405,021.9	41,109.9	202,887.8	11,822,341.3	47,607,909.7
9	10,923,327.6	58,328,349.5	37,094.4	239,982.2	10,960,422.0	58,568,331.7
10	9,031,448.0	67,359,797.5	28,504.4	268,486.5	9,059,952.3	67,628,284.0

5.5 Leakage (CL2)

Step 8 Ex-ante estimation of leakage

The goal of this step is to provide an ex-ante estimate of the possible decrease in carbon stock and increase in GHG emissions due to leakage. This will assist in designing the optimal leakage prevention measures, identify sources of leakage that are potentially significant and therefore subject to MRV, and to allow making reasonable projections of revenues. Two sources of leakage are considered – that associated with leakage prevention measures, and that associated with activity displacement leakage.

Step 8.1 Ex ante estimation of the decrease in carbon stocks and increase in GHG emissions due to leakage prevention measures

To reduce the risk of activity displacement leakage, baseline deforestation agents should be given the opportunity to participate in activities within the project area and in specially designated leakage management areas (outside the project area) that together will replace baseline income, product generation and livelihood of the agents as much as possible, so that deforestation will be reduced and the risk of displacement minimized.

If leakage prevention measures include tree planting, agricultural intensification, fertilization, fodder production and/or other measures to enhance cropland and grazing land areas, a reduction in carbon stocks and/or an increase in GHG emissions may occur compared to the baseline case. If such decrease in carbon stock or increase in GHG emission is significant, it must be accounted and monitoring will be required. If it is not significant, it must not be accounted and ex post monitoring will not be necessary.

Step 8.1.1 Carbon stock changes due to activities implemented in leakage management areas

The planned leakage management activities are summarized in Section 5.2. Table 5.12 analyzes the likely impact of each activity on carbon stocks in the leakage management areas. It is concluded that none of the planned activities is expected to have any net impact on carbon stocks.

Table 5.12 Potential impacts of leakage management activities on carbon stocks in leakage management belt

Sub-objective	Leakage management activities	Effect on carbon stocks in leakage management areas
1. Legal and planning	Maintain legal support for SPF (including Buffer Areas); SPF Management plan covers Buffer Areas; Corridor activities address leakage risks (e.g. through liaison with Ministry of Environment)	None or positive
2. Direct law enforcement	Direct law enforcement, monitoring activities etc	None or positive
3. Community land-use	Extend land-use agreements, titling and demarcation to sections of village land adjacent to Project Area (especially Leakage Belt and Leakage Management Areas)	None or positive
4. Alternative livelihoods	Action #1: Establish community-based ecotourism	None. Safeguards will ensure that no deforestation, significant felling of trees, increased collection of firewood etc take place as part of any tourism activities.
	Action #2: Support agricultural extension activities	None. Safeguards will ensure no additional deforestation is encouraged by linking all activities to areas idenbtified in official land-use plans. Carbon stocks on farmland itself are generally very low and the extension activities are likely to improve this situation through promotion of mixed systems, agroforestry and on-farm production of firewood etc. Support for diversification through processing and marketing will include sustainable sourcing of all inputs.
	Action #3: Provide infrastructure support linked to conservation activities	None. Safeguards will ensure that no forest clearance or forest degradation takes place as part of any infrastructure project. These will typically be community-activities such as water/sanitation facilties and improvements to bridges, existing roads or public buildings.
	Action #4: Develop NTFP-based livelihood projects	None. All such projects will enhance sustainable management, so avoiding degradation of the forest either through direct harvesting or secondary activities.
	Action #5: Develop and manage a system to share carbon benefits	None. Benefits system will include safeguards to avoid increasing emissions (e.g. by excluding grants for certain types of community investment).
	Action #6: Improve literacy and numeracy	None.

Given that these activities are judged to pose no risk of carbon stock reductions, it is not deemed necessary to map them or make calculations of significance and Tables 30a-c of the methodology need not be completed.

Step 8.1.2 Methane and nitrous oxide emissions from livestock intensification

Whilst pigs and poultry are commonplace, grazing livestock are only kept in small numbers in the participating villages. This is partly for cultural reasons and partly due to the low demand for draft animals in some of the farming systems in place. For this reason leakage management activities will not focus on the promotion of grazing animals and the numbers of grazing animals in the project case will be fewer than in the baseline case, where the extent of cultivated land requiring draft animals is projected to be much larger.

Thus Tables 32 and 33 of the methodology are not required, since expected ex-ante emissions above baseline from these sources will be zero.

Step 8.2 Ex ante estimation of the decrease in carbon stocks and increase in GHG emissions due to activity displacement leakage

The framework for analysis of activity displacement leakage by smallholders in the project is set out in Annex 4.2, following the methodology. To estimate this leakage ex-ante a Displacement Leakage Factor (DLF) must be calculated. Ex-post, this leakage is then monitored directly.

We consider the approach described for assessing leakage in the methodology for Step 8.2 omits one potential source of leakage - those potential future in-migrant smallholders who are deterred from moving to the site by project activities and who are therefore not spatially constrained in the same way as those who have already settled at the site. Therefore we make a conservative addition to the approach described, to take account of this.

We analyse leakage due to activity displacement by smallholders who are either
(i) resident/newly settled at the site or
(ii) those who are deterred from moving to the site by project activities.

Displacement of group (I) is analysed within a spatially delimited leakage belt, defined in section 4.4 following the procedure described in the Methodology Step 8.2.

Displacement of group (ii) is estimated in comparison to projected levels of business-as-usual in-migration extrapolated from the historical reference period. We calculate the DLF as the sum of two components, as follows:

$$DLF = DLFr+DLFa$$

where:

DLF = Displacement Leakage Factor, ie the percent of deforestation expected to be displaced outside the project boundary, %
DLFr = Displacement Leakage Factor for Residents, ie the the percent of deforestation attributable to resident smallholders (including those who have settled in the participating villages since the start of the project crediting period) expected to be displaced outside the project boundary, %
DLFa = Displacement Leakage Factor for Avoided Migrants, ie the the percent of baseline deforestation attributable to potential in-migrants who were deterred from settling due to the existence of the project and have hence been displaced outside the project boundary, %

Activity shifting by residents

Ex-ante, DLFr must be estimated from an analysis of the proportion of local residents engaged in leakage management activities, following page 101 of the methodology. Annex 4.2 shows the % of families in each village who have an opportunity to participate in leakage management activities, and hence the proportion of the total population who have such opportunities, projected over the first ten year fixed baseline period. The results are summarised in Table 5.13. The ex-ante estimate of the proportion of the population not participating is equal to the factor DLFr, defined above.

Table 5.13 Ex-ante estimated proportion of households able to participate in leakage management activities

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
% participating	40%	40%	40%	66%	91%	100%	100%	100%	100%	100%

% not participating (=DLFr)	60%	60%	60%	34%	9%	0%	0%	0%	0%	0%

Activity shifting due to avoided in-migration

The baseline scenario assumes continuing in-migration to the site. However, a proportion of these expected migrants may not come to inhabit the area in the with-project scenario, because project activities are expected to reduce the attractiveness of the area for new migrants. By definition these people cannot participate in leakage management activities, and they may decide to settle (and perhaps deforest) at some distant location outside the monitored leakage belt. Conservatively we consider that any deforestation that is prevented by preventing this in-migration will leak to distant forested locations with comparable carbon stocks and so must be discounted at 100%.

Monitoring the movement of people who never even arrive in the landscape presents a conceptual challenge. We find that this displacement factor can be estimated conservatively by projecting the expected overall population growth of the participating villages through the first fixed baseline period and comparing it to the observed growth over the same period. During any given year it is conservative to ascribe the entire difference between the expected population size at the time and the true population size to avoided in-migration. This approach also has the advantage of accounting for any movements out of the area by existing residents that might be attributable to the project, removing the need to monitor these separately. It is assumed that on average any one migrant family is equally likely to cause deforestation as any resident family, and so the percentage of expected deforestation attributable to newly arrived smallholder migrants is equal to the percentage of the population in this sub-category.

Hence DLFa for a given one year period (as defined above) is calculated as the ratio of the *cumulative avoided in-migration from the start of the project to the end of that year* ('all missing families') to *the expected population at the end of that year* (see Annex 4.2 for details). To give a simple numerical example, if the expected population at the end of a given year was 10,000 families, including 2000 in-migrant families (from baseline calculations) but only 9,000 families were actually observed to be present, then 1,000 families are assumed to have been deterred from migrating to the area by project activities up to that date. Therefore, 10% (1,000/10,000) of the expected business-as-usual agents of deforestation are not in practice able to participate in leakage management activities during that year and so 10% of any emissions avoided during that period should be assumed to have leaked for this reason.

Expected populations can easily be calculated since good historical information exists from government sources 2002-2009 and provides a very close statistical fit to an increasing linear trend (Annex 4.2). Table 5.14 summarises the ex-ante estimated DLFa for the first fixed baseline period, assuming 50% effectiveness in deterring migration each year.

Table 5.14 Ex-ante estimated activity displacement due to avoided in-migration

Year	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
Proportion of avoided in-migration (DLFa)	0.9%	2.6%	3.7%	4.7%	5.6%	6.5%	7.2%	7.8%	8.4%	9.0%

Total expected displacement due to activity shifting

DLFa and DLFr can be added to give DLF (Table 5.15).

Table 5.15 Ex-ante estimated activity displacement due to activity shifting by residents and avoided in-migration

Project year	**1**	**2**	**3**	**4**	**5**	**6**	**9**	**9**	**9**	**10**
DLF	60.9%	62.6%	63.7%	38.7%	14.6%	6.5%	7.2%	7.8%	8.4%	9.0%

These DLF values can be combined with the estimated gross emissions reductions in Table 5.11 to make an ex-ante estimate of leakage (Table 5.16).

Table 5.16 Ex ante estimate leakage due to activity displacement

This table fulfills the requirements of Table 34 and 35 of the methodology.

	Total gross ex ante emissions reductions from carbon stocks in the project area		Gross ex ante emission reductions due to nonCO2 GHGs		Displacement leakage factor	Total ex ante estimated decrease in carbon stocks outside the project area due to displaced deforestation		Total ex ante estimated increase in GHG emissions due to displaced forest fires used during clearance		Total net increase in emissions due to leakage	
	annual	cumulative	annual	cumulative		annual	cumulative	annual	cumulative	annual	cumulative
Project year					DLF	ΔCADLK[t] = ΔCLK[t]	ΔCADLK = ΔCLK	EADLKt	EADLK	ELKt	ELK
t	tCO2e	tCO2e	tCO2e	tCO2e	%	tCO2e	tCO2e	tCO2e	tCO2e	tCO2e	tCO2e
1	105,306.2	105,306.2	547.7	547.7	61%	(64,131.4)	(64,131.4)	(333.5)	(333.5)	(64,465.0)	(64,465.0)
2	622,944.1	728,250.3	4,410.1	4,957.8	63%	(389,963.0)	(454,094.5)	(2,760.7)	(3,094.3)	(392,723.8)	(457,188.7)
3	3,559,151.1	4,287,401.4	25,883.7	30,841.6	64%	(2,267,179.3)	(2,721,273.7)	(16,487.9)	(19,582.2)	(2,283,667.2)	(2,740,856.0)
4	4,633,891.9	8,921,293.3	28,701.4	59,542.9	39%	(1,793,316.1)	(4,514,589.9)	(11,107.4)	(30,689.6)	(1,804,423.6)	(4,545,279.5)
5	5,336,465.9	14,257,759.2	27,299.4	86,842.3	15%	(779,124.0)	(5,293,713.9)	(3,985.7)	(34,675.4)	(783,109.7)	(5,328,389.3)
6	9,273,827.2	23,531,586.4	32,073.8	118,916.0	7%	(602,798.8)	(5,896,512.7)	(2,084.8)	(36,760.1)	(604,883.6)	(5,933,272.8)
7	12,092,204.2	35,623,790.6	42,861.8	161,777.9	7%	(870,638.7)	(6,767,151.4)	(3,086.1)	(39,846.2)	(873,724.8)	(6,806,997.6)
8	11,781,231.4	47,405,021.9	41,109.9	202,887.8	8%	(918,936.0)	(7,686,087.4)	(3,206.6)	(43,052.8)	(922,142.6)	(7,729,140.2)
9	10,923,327.6	58,328,349.5	37,094.4	239,982.2	8%	(917,559.5)	(8,603,646.9)	(3,115.9)	(46,168.7)	(920,675.4)	(8,649,815.6)
10	9,031,448.0	67,359,797.5	28,504.4	268,486.5	9%	(812,830.3)	(9,416,477.3)	(2,565.4)	(48,734.1)	(815,395.7)	(9,465,211.4)

5.6 Summary of GHG Emission Reductions and Removals (CL1 & CL2)

Step 9 Ex-ante total net anthropogenic GHG emission reductions

Step 9.1 Significance assessment

The six carbon pools were calculated to assess their significance using the latest EB-CDM approved 'Tool for testing significance of GHG emissions in A/R CDM project activities' (Version 01). Source of non-GHG emissions were not estimated as it has been shown that it conservative to exclude them in all cases. The results of the analysis are shown in Table 5.17. Significance is assessed by ranking the pools in order of their percentage contribution to the total climate benefits of the project and summing the contributions, in order, until the threshold of 95% is reached, beyond which any remaining pools can be considered insignificant. The data underlying this table are available to the auditor on request.

Table 5.17 Analysis of significance of the six carbon pools

Rank		Benefits net of leakage (tCO_2e)	% of grand total	Cumulative sum of %	Comments
	Significant				
1	Above ground tree	65,926,653	84.3%	84.3%	
2	Below ground tree	9,020,996	11.5%	95.8%	First item to exceed 95%
3	Dead wood	2,321,785	3.0%	98.8%	Could optionally be deemed insignificant but it was chosen to include it
	Insignificant				
4	Above ground non-tree	1,175,390	1.5%*		Insignificant despite highly conservative assumptions
5	Litter	387,511	0.5%*		Insignificant despite highly conservative assumptions
6	Harvested Wood Products	(632,544)	-0.8%		Insignificant despite highly conservative assumptions
	Grand total	**78,199,790**	**100%**		

*Since these two pools probably result in net benefits, it would in any case be conservative to omit them. Conservative assumptions, in the context of this table, maximise the size of the estimated benefits of the smaller pools so as to ensure they are not wrongly concluded to be insignificant.

Step 9.2 Calculation of ex-ante estimation of total net GHG emissions

Since emissions from biomass burning have conservatively been excluded, the net anthropogenic GHG emission reduction of the proposed project in a given year is calculated as follows

$$\Delta REDD_t = \Delta CBSLPA_t - \Delta CPSPA_t - \Delta CLK_t$$

Where:

$\Delta REDD_t$ = ex-ante estimated net anthropogenic greenhouse gas emission reduction attributable to the project activity at year t; tCO_2e

$\Delta CBSLPA_t$ = Sum of baseline carbon stock changes in the project area at year t; tCO_2e [see Table 5.11]

$\Delta CPSPA_t$ = Sum of ex ante estimated actual carbon stock changes in the project area at year t; tCO_2e [see Table 5.11]

ΔCLK_t = Sum of ex ante estimated leakage net carbon stock changes at year; tCO_2e [see Table 5.16]

These values are collated in Table 5.18, below.

Step 9.3 Calculation of ex-ante Verified Carbon Units

The number of Verified Carbon Units (VCUs) to be generated through the project in year t is calculated as:

$$VCU_t = \Delta REDD_t - VBC_t$$
$$VBCt = (\Delta CBSLPA_t - \Delta CPSPA_t)*RF_t$$

Where:

VCU_t = Number of Verified Carbon Units that can be traded at time t; tCO_2e
VBC_t = Number of Buffer Credits deposited in the VCS Buffer at time t; tCO_2e
RFt = Risk factor used to calculate VCS buffer credits, % [see Section 2.3]
and the other variable are defined in step 9.2.

The results of these final calculations are presented in Table 5.18.

Table 5.18 Ex ante estimated net anthropogenic GHG emission reductions (ΔREDD$_t$) and Verified Carbon Units (VCU$_t$)
This table fulfills the requirements of Table 36 in the methodology.

	Baseline carbon stock changes		Baseline GHG emissions		Ex ante project carbon stock changes		Ex ante project GHG emissions		Ex ante leakage carbon stock changes		Ex ante leakage GHG emissions	
	Annual	Cumulative	Annual	Cumulative	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative
Project yr	ΔCBSLPA[t]	ΔCBSLPA	EBBBSLPAt	EBBBSLPA	ΔCPSPA[t]	ΔCPSPA	EBBPSPAt	EBBPSPA	ΔCLK[t]	ΔCLK	EADLKt	EADLK
t	tCO2e	tCO2e	tCO2e	tCO2e	tCO2e	tCO2e	tCO2e	tCO2e	tCO2e	tCO2e	tCO2e	tCO2e
1	(726,249)	(726,249)	(2,738)	(2,738)	(620,943)	(620,943)	(2,191)	(2,191)	(64,131)	(64,131)	(334)	(334)
2	(3,893,401)	(4,619,650)	(14,700)	(17,439)	(3,270,457)	(3,891,400)	(10,290)	(12,481)	(389,963)	(454,094)	(2,761)	(3,094)
3	(13,689,043)	(18,308,693)	(51,767)	(69,206)	(10,129,892)	(14,021,292)	(25,884)	(38,365)	(2,267,179)	(2,721,274)	(16,488)	(19,582)
4	(10,531,572)	(28,840,265)	(38,268)	(107,475)	(5,897,681)	(19,918,972)	(9,567)	(47,932)	(1,793,316)	(4,514,590)	(11,107)	(30,690)
5	(7,905,875)	(36,746,141)	(27,299)	(134,774)	(2,569,410)	(22,488,382)	-	(47,932)	(779,124)	(5,293,714)	(3,986)	(34,675)
6	(9,273,827)	(46,019,968)	(32,074)	(166,848)	-	(22,488,382)	-	(47,932)	(602,799)	(5,896,513)	(2,085)	(36,760)
7	(12,092,204)	(58,112,172)	(42,862)	(209,710)	-	(22,488,382)	-	(47,932)	(870,639)	(6,767,151)	(3,086)	(39,846)
8	(11,781,231)	(69,893,404)	(41,110)	(250,820)	-	(22,488,382)	-	(47,932)	(918,936)	(7,686,087)	(3,207)	(43,053)
9	(10,923,328)	(80,816,731)	(37,094)	(287,914)	-	(22,488,382)	-	(47,932)	(917,560)	(8,603,647)	(3,116)	(46,169)
10	(9,031,448)	(89,848,179)	(28,504)	(316,418)	-	(22,488,382)	-	(47,932)	(812,830)	(9,416,477)	(2,565)	(48,734)

Table 5.18 continued

	Ex ante net anthropogenic GHG emission reductions		Ex-ante VCUs tradable		Ex ante buffer credits		Risk Buffer
	annual	cumulative	annual	cumulative	annual	cumulative	
Project yr	ΔREDD$_t$	ΔREDD	VCU[t]	VCU	VBC[t]	VBC	Rf[t]
t	tCO2e	tCO2e	tCO2e	tCO2e	tCO2e	tCO2e	%
1	41,389	41,389	27,628	27,628	13,761	13,761	13%
2	234,630	276,019	153,074	180,702	81,556	95,317	13%
3	1,301,368	1,577,387	835,313	1,016,015	466,055	561,372	13%
4	2,858,170	4,435,557	2,252,033	3,268,048	606,137	1,167,509	13%
5	4,580,656	9,016,212	3,883,366	7,151,414	697,289	1,864,798	13%
6	8,701,017	17,717,230	7,491,250	14,642,664	1,209,767	3,074,565	13%
7	11,261,341	28,978,571	9,683,783	24,326,447	1,577,559	4,652,124	13%
8	10,900,199	39,878,770	9,363,294	33,689,741	1,536,904	6,189,028	13%
9	10,039,747	49,918,516	8,614,892	42,304,633	1,424,855	7,613,883	13%
10	8,244,557	58,163,073	7,066,763	49,371,396	1,177,794	8,791,677	13%

5.7 Climate change adaptation benefits

The long-term effects of climate change in the landscape remain poorly understood. The key threat posed by climate change in the near future is believed to be impacts on agricultural productivity among smallholder farmers, with longer term threats to the productivity of forest resources and changes in water supply. Responses will be integrated with Sub-objective 4 Action 2 (Support agricultural extension activities) and Sub-objective 2 Action 1 (Form and maintain land-use agreements with communities). Communities will be assisted to understand and analyse the risks from climate change, develop simple monitoring approaches as early warning systems and promote climate-smart responses.

6 COMMUNITY

6.1 Net Positive Community Impacts (CM1)

Impact of project activities on communities

The project has been designed so as to maximise the positive impacts on communities and minimise the negative ones, seeking to ensure a net positive impact for all stakeholder groups. Two main sources of guidance have been adopted for this process - the Convention on Biodiversity's Akwé:Kon guidelines and the Manual for Social Impact Assessment of Land-based Carbon Projects Version 2.0 (Richards and Panfil 2011). The latter source in particular provides a structured way to assess both positive and negative impacts in a format consistent with the CCB approach.

Table 6.1 lists the expected benefits in relation to the planned activities.

Table 6.1 Positive community impacts of project activities

Project action	Positive impacts
Sub-Objective #1: Key legal and planning documents for the Seima Protection Forest and surrounding landscape are approved and implemented	
Action #1: Support for sub-decree maintained among senior government and general public	o Recognition of the importance of the SPF for local communtiies o Maintenance of natural resources o Deterrence of large-scale external threats
Action #2: Management plan approved and implemented (including zonation and regulations)	o Land-use zoning ensures long-term access for legitimate users o Clarified regulations for forest use will ensure long-term access and deter damaging activities
Action #4: Develop partnerships with the private sector (to reduce impacts by companies) Action #5: Develop international cross-border dialogue Action #6: Apply adaptive management	o Reduced impact from industrial activities in the landscape will minimise disturbance to the SPF. Key aspects that will be controlled are land-grabbing by company staff, illegal logging, land pollution o Cross-border threats to natural resources reduced o Increased opportunities for participation and influence on reserve management
Sub-Objective #2: To reduce forest and wildlife crime by direct law enforcement	
Action #1: Enforce wildlife, forest and protected area laws and sub-decree through patrols	o Reduced threats to natural resources, risk of land alientation etc
Action #2: Establish and implement law enforcement monitoring framework	o Monitoring of law enforcement impacts will enable the project to track effectiveness and improve practices as necessary.
Action #3: Ensure sufficient patrol buildings, equipment and staffing and Action #4: Ensure sufficient patrol personnel capacity	o Sufficient staff and resources are available leading to improved effectiveness of enforcement efforts and increased protection of natural resources and land against all threats
Action #5: Liaise with Provincial, National and other authorities	o Coordination will improve effectiveness, for example in processing criminal cases.
Action #6: Establish Community-based Patrolling and/or monitoring system	o Community-based patrolling will increase social capital and increase protection efforts further, ensuring continued protection of species and habitat
Sub-Objective #3: Land and resource use by all core zone communities is sustainable	
Action #1: Form and maintain land-use agreements with communities	o Agreements will strengthen tenure security and use rights o Agreements allow for the improved management of forest resources thus controlling over-harvesting
Action #2: Legally register communities and users	o Further strengthening of tenure security and use rights
Action #3: Support indigenous communal land titling in appropriate communities	o Further strengthening of tenure security and use rights
Action #4: Demarcation of the Forest Estate	o Clarification of the forest boundary will reduce forest conversion thus protecting natural habitats and reducing future conflict
Action #5: Conduct extension and communication activities Action #7: Engage with civil society organisations operating in the Project area	o Increased awareness of rights and of the opportunities for better forest managemernt o Organizations with specialist rural development skills can improve project services

Sub-Objective #4: Support for alternative livelihoods that reduce deforestation	
Action #1: Establish community-based ecotourism	o Income generation and livelihood diversification; opportunities for skill development
Action #2: Support agricultural extension activities	o Improved agricultural productivity increases food security, incomes, resilience to shocks and climate change and livelihood diversity.
Action #3: Provide infrastructure support linked to conservation activities	o Improved quality of life and/or income generating opportunities
Action #4: Develop NTFP-based livelihood projects	o Improved NTFP marketing increases food security, incomes, resilience to shocks and climate change and livelihood diversity.
Action #5: Develop and manage a system to share carbon benefits	o Benefit depends on type of benefits selected – in each community may increase incomes, development activities or both
Action #6: Improve literacy and numeracy	o Increase adult literacy and numeracy, increasing off farm livelihood options

The expected overall positive impacts of the project on livelihoods are set out in Section 2.2 (especially Table 2.1) using a conceptual model ('theory of change') to make the links and assumptions clear, as recommended by Richards and Panfil (2011). These positive outcomes include improvements in overall livelihood measures, improved status of natural resources and agricultural productivity for participating communities and a reduction in the levels of several key threats to livelihoods. These net benefits will be positive for all community groups. Specific livelihood indicators and targets have not yet been set but will be developed within 12 months of validation (Section 8).

Potential negative impacts should also be considered but for these, instead of a theory of change approach, it is recommended to conduct multi-stakeholder assessments, reviewing each element of the project in turn and assessing its likely impacts on each stakeholder group (Richards and Panfil 2011). In the Seima REDD Project we developed a preliminary impact assessment within the project team, and then consulted widely on this with local stakeholders, incorporating most of these discussions into the awareness raising stage for the consultation described in this document and also holding a dedicated workshop for community leaders (Sopha Sokhun Narong 2010). The results are shown in Annex 6.1. The proposed mitigation measures were in most cases already a part of project design, and the remainder have now been incorporated. The Annex will will be used as a tool to review the occurence of negative impacts during project monitoring and adaptive management.

Impact on social High Conservation Values (HCVs 5 & 6)

As described in Section 1.3 the identified HCVs correspond closely to the overall project targets. Thus the interventions outlined in Sections 2.2 and 2.4, designed to have a net positive impact on local communities, will also benefit the social HCVs. The positive impacts of project activities on HCVs are detailed in the HCV assessment report (Pollard and Evans 2012) and are summarised in Table 6.2 below.

Table 6.2 Positive impacts of project activities on social HCVs

High Conservation Value	Corresponding project targets	Positive impacts
HCV5: Forest areas fundamental to meeting basic needs of local communities	Increase security and productivity of natural resources to support local livelihoods Maintain the variety, integrity, and extent of all forest types	o Productivity of critically important NTFPs (including fisheries) is maintained o Security of resources and access to resources increased. o Extent of productive forest maintained.
HCV6: Forest areas critical to local communities' traditional cultural identity	Increase security and productivity of natural resources to support local livelihoods Maintain the variety, integrity, and extent of all forest types	o All spiritual sites protected.

6.2 Negative Offsite Stakeholder impacts (CM2)

The stakeholder analysis (Section 2.7) shows that there are no negative offsite stakeholder impacts expected, as all significant legitimate user groups of the area have been included in the project design.

6.3 Exceptional Community Benefits (GL2)

The project demonstrably qualifies for Gold Level for its exceptional community benefits, because the comprehensive set of community approaches will effectively bring benefits to the poorer sections of the local community, in a country which is itself one of the poorest in the world. The five criteria are addressed in turn below.

Project zone is in a low human development area

Cambodia is medium human development country ranking 139/187 with a score of 0.533 according to the UNDP Human Development Report and so not all parts of Cambodia automatically qualify under this criterion. However, the SPF area does qualify as the group of rural provinces that includes Mondulkiri (the 'Plateau/Mountain' group) had an estimated 58% of people below the poverty line in 2004, the last date for which relevant data are available (World Bank 2006).

Benefits for people in the lowest category of well-being

Project benefits are provided in two main ways. One is community-wide benefits stemming from protection of the natural resource base (through legal protection, improved law enforcement etc) and communal approaches to natural resource management. These community-wide benefits evidently accrue to people currently in the lowest category, since they accrue to all forest-users and since most people in this category typically have a high dependency on natural resources of this kind. Such people are also those most vulnerable to loss of livelihood through land alienation, land conflict etc, which are threats that the project aims to reduce.

The second class of benefit is from development assistance and other forms of benefit-sharing from project REDD revenues. The project will put in place structures to ensure that a significant share of these benefits is targeted at the poorest segments of the community. This will be achieved by (i) including locally defined perceptions of need among the criteria that are used to desicde allocation of these benefits and (ii) by ensuring that representatives from the poorer segments of the community are able to express their opinions regarding governance of these benefits, e.g. by having designated places on community committees for people from vulnerable categories.

Removal of barriers to prevent such benefits going to poorer households

Barriers to participation will be identified and mitigated as a matter of course when site-wide or village specific benefit-share systems (or natural resource management systems) are designed and during periodic evaluations. The barriers will vary depending on the form of the benefit so it is difficult to specify how they will be removed in advance. One example of a common barrier is that people in the lowest category may lack the resources necessary to invest time, land, expertise or capital into a new livelihood activity, and so struggle to gain much from it. This can sometimes be addressed by making available small grants, loans or other forms of assistance to people in this category, or by offering them other kinds of assistance that require less investment. Another is that people in this category tend to have less voice in decision-making due to lower social status, education and/or a lack of free time to participate. This will be addressed by socially acceptable forms of 'affirmative action' as mentioned above.

Avoidance or mitigation of negative impacts

The analysis of negative impacts out in Annex 6.1 explicitly consider who might be the most vulnerable segments of the community. This has formed the basis for the proposed mitigation and also forms a tool to allow any such impacts to be detected and dealt with during project implementation.

Impact monitoring can detect benefits for all social categories

The social impact monitoring system has yet to be finalized (Section 8). One criterion for its design is that it is able to distinguish people in different social categories, and that it is sufficient to identify trends separately for the main categories.

7 BIODIVERSITY

7.1 Net Positive Biodiversity Impacts (B1)

Impact of project activities on biodiversity

South-east Asia has seen major losses of biodiversity in the last 40 years (Sodhi *et al* 2010) and this project aims to reverse that trend for a site of acknowledged international importance. The project aims to maintain the variety, integrity, and extent of all forest types and increase populations of wildlife of conservation concern (Table 2.1). This will be achieved by reducing the threats outlined in Section 4.5. The key threats that need to be addressed to bring net benefits for biodiversity are habitat loss (forest and lowland wetlands/grasslands), hunting in all its forms, and selective logging and over-harvest of plant NTFPs. These, and other threats listed in Section 4.5, will be addressed by the suite of activities set out in Section 2.2. Table 7.1 below outlines which activities mitigate these threats, and the positive impacts that will result from the successful implementation of each intervention, whilst the following text summarises efforts in relation to each threat. No negative effect on biodiversity in the project area is anticipated from any project activities.

Table 7.1 Positive biodiversity impacts of project activities

Project action ***Threats addressed (major threats underlined)***	Positive impacts
Sub-Objective #1: Key legal and planning documents for the Seima Protection Forest and surrounding landscape are approved and implemented	
Action #1: Support for sub-decree maintained among senior government and general public *All threats, especially important in controlling habitat loss.*	o Recognition of the importance of the SPF. o Maintenance of natural habitats o Deterrence of large-scale external threats
Action #2: Management plan approved and implemented (including zonation and regulations) *All threats.*	o Stabilised land-use by residents will protect natural habitats o Clarified regulations for forest use will reduce damaging activities o Areas of strict protection identified and managed appropriately, leading to reduced disturbance to wildlife populations and optimal hunting controls, creating source areas for the entire landscape.
Action #3: Mondulkiri Provincial Corridors strategy implemented (maintain links to other forests) *Habitat loss and fragmentation in the wider landscape*	o Protection of the wider landscape will help conserve species that range widely through the area, for example Asian Elephants, Tigers and vultures
Action #4: Develop partnerships with the private sector (to reduce impacts by companies) *Hunting, habitat loss, illegal logging, incidental disturbance, pollution*	o Reduced impact from industrial activities in the landscape will minimise disturbance to the SPF. Key aspects that will be controlled are hunting and trapping by company staff, illegal logging, and pollution
Sub-Objective #2: To reduce forest and wildlife crime by direct law enforcement	
Action #1: Enforce wildlife, forest and protected area laws and sub-decree through patrols *Hunting, habitat loss, illegal logging and over-harvest of NTFPs*	o The key strategy to protect biodiversity. o Will protect biodiversity from direct exploitation and disturbance leading to increasing or stable populations of species and protection of threatened ecosystems
Action #2: Establish and implement law enforcement monitoring framework *Hunting, habitat loss, illegal logging and over-harvest of NTFPs*	o Monitoring of law enforcement impacts will enable the project to track effectiveness and improve practices if necessary. This will ensure that efforts adapt to changing threats, and protection of species and habitat is maintained
Action #3: Ensure sufficient patrol buildings, equipment and staffing and Action #4: Ensure sufficient patrol personnel capacity *All threats*	o Sufficient staff and resources are available leading to improved effectiveness of enforcement efforts and increased protection of species and habitat against all threats
Action #5: Liaise with Provincial, National and other authorities *All threats*	o Coordination will improve effectiveness, for example in processing criminal cases and for addressing threats such as wildlife trade that extent beyond the borders of the project zone
Action #6: Establish Community-based Patrolling and/or monitoring system *Hunting, habitat loss, illegal logging and over-harvest of NTFPs, incidental disturbance*	o Community-based patrolling will increase community support for activities and increase protection efforts further, ensuring continued protection of species and habitat
Sub-Objective #3: Land and resource use by all core zone communities is sustainable	

Action #1: Form and maintain land-use agreements with communities *Habitat loss, illegal logging, over harvesting of NTFPs, incidental disturbance*	o Agreements will stabilise land-use and reduce conversion of natural habitats, especially critical areas such as grasslands and wetlands important to large waterbirds, and Eld's Deer, bamboo groves used by elephants and salt-licks used by ungulates. o Agreements allow for the improved management of forest resources thus controlling over-harvesting and minimising habitat disturbance.
Action #4: Demarcation of the Forest Estate; reforestation of recent clearance *Habitat loss*	o Clarification of the forest boundary will reduce forest conversion thus protecting natural habitats
Action #5: Conduct extension and communication activities *All threats.*	o Increased awareness of forest laws, and the impact of activities on the forest and wildlife will lead to changes in attitude and behaviour. Increased compliance with the laws will reduce pressures on species and ecosystems
Sub-Objective #4: Support for alternative livelihoods that reduce deforestation	
Action #1: Establish community-based ecotourism *Habitat loss, illegal logging, over harvesting of NTFPs*	o Income generation from the legal activities will reduce the need for local communities to engage in destructive activities such as hunting, illegal logging and the conversion of forest to cash crops o Tourism links income to forest and species conservation, providing a direct incentive for local residents to protect species and habitats
Action #2: Support agricultural extension activities *Habitat loss*	o Improved agricultural productivity and diversity will stabilise land-use, thus reducing habitat conversion. o Cash income from farming will reduce the need for local communities to engage in destructive activities such as hunting, illegal logging
Action #3: Develop NTFP-based livelihood projects *Over harvesting of NTFPs*	o Improved NTFP management will lead to more sustainable harvesting and reduced habitat disturbance.

The key activities that will address deforestation are: the development of key legal and policy documents for the project zone, including a comprehensive management plan and zonation and; and active enforcement of Cambodia's forestry, fisheries and land laws. Forest habitats will be protected from illegal logging by law enforcement. Wetland habitats are especially threatened throughout Asia (Bezuijen *et al* 2008) and particular effort will be made to protect rivers and forest pools throughout the Project Area. Protecting such wetlands for conversion is vitally important for several highly threatened species including Giant and White-shouldered Ibis, White-winged Duck, and freshwater turtle species. Permanent pools also serve as vital dry season water sources for large mammals and their protection is essential for the recovery of a number of ungulates such as Banteng, Elephant and Eld's Deer. The enabling environment to support the application of these activities will be improved through community engagement to enhance land-use patterns and reduce pressures on forest resources.

Control of hunting will primarily be by patrolling of key habitats and areas known to be under threat from hunting and trapping. This will act as a deterrent to hunters who fear arrest or loss of equipment, and the confiscation and removal of snares, weapons and other hunting equipment will directly reduce pressures on all species. Law enforcement activities will also target trade routes, markets and known middle-men.

Illegal and unsustainable fishing will be controlled through enforcement of laws and SPF regulations. Plant resources (timber and NTFPs) will be harvested sustainably and in accordance to Cambodian law and agreements between the SPF management and local communities. Enforcement of these agreements will be by law enforcement teams and self-regulation by community institutions.

Several more minor threats have been identified (Section 4.5). These threats are currently having a relatively low impact on the biodiversity of the area, or only affect a few species.

Incidental disturbance will be reduced as a secondary effect of other management activities. Livelihood support and law enforcement efforts will reduce the total number of people accessing the forest by excluding illegal users and increasing the amount of time people spend on non-forest livelihoods. In addition zonation will create strict protection areas where human disturbance will be minimised. This will reduce disturbance a key sites such as dry season water sources and mineral licks enabling key species such as ungulates to survive through seasonal stresses.

Specific threats to vultures from reduced food sources will be addressed through the use of 'vulture restaurants'. These provide supplementary food in the form of slaughtered domestic cattle and have proved to be a successful strategy in other parts of Cambodia. Accidental poisonings will be mitigated as part of a nationwide program to raise awareness on the appropriate use of agro-chemicals. These methods will increase the suitability of the project zone for vultures and should see their return to the area, and aid the recovery of the species globally.

The main project strategy to address the threat of *increasing pollution*, especially of freshwater ecosystems, is engaging with private sector developments as they arise in the landscape. Project staff and partners will engage with the private sector and relevant government line agencies to encourage leading-edge and best practices in plantation development and mining. Key strategies that will be encouraged are the maintenance of riparian corridors of natural habitats and reduced use of agro-chemicals in plantations, and the application of the recommendations of the International Council on Mining and Metals and the Australian Enduring Values framework (ICMM 2006, MCA 2005). Agricultural assistance with local communities will also promote the minimisation of pesticide use and adherence to good practices where use is unavoidable.

Invasive species are dealt with in the section below.

The main net benefits for biodiversity from these activities will be the protection of globally threatened ecosystems and the recovery of populations of species of conservation concern. The status of the key forest ecosystems will be measured against the baseline set out in Section 4.5. It has been provisionally decided that the status of other aspects of biodiversity will be indicated by the status of six target Landscape Species which together represent larger suites of biodiversity present in each of the main vegetation types, and also represent species vulnerable to each of the major classes of threat present in the project zone. It is therefore assumed that by ensuring the survival and recovery of these species most or all the other key biodiversity values will also be protected (WCS/FA 2010)[16].

The provisional targets for net positive outcomes for these target species for the first ten years of the project period are set out in Table 7.2 below. These targets will be finalised at the time the monitoring plan is finalised, within 12 months of validation. These targets form the basis of the provisional biodiversity monitoring program (see Section 8). As the ecological carrying capacity is not known for any of these species, the provisional targets are phrased in terms of long-term trends. Achieving stable populations over this period will represent a major net positive outcome since most of these species are predicted to be lost or severely reduced in the project zone without project activities (Section 4.5). in the longer term the aim is to recover these populations, and those of other key species, to their former natural levels of abundance over large parts of the SPF.

Table 7.2: Provisional targets for indicator species

Species	Measure	Species target (to 2019)
Asian Elephant	Population size	Long-term trend stable or growing
Banteng	Population size	Long-term trend stable or growing
Sambar	Population size	Long-term trend stable or growing
Eld's Deer^	Extent of occurrence	Long-term trend stable or growing
S. Yellow-cheeked Cr. Gibbon	Population size	Long-term trend stable or growing
Smooth-coated Otter^	Extent of occurrence	Long-term trend stable or growing

^ Quantified baselines yet to be established

Impact of project activities on ecological High Conservation Values (HCV1-4)

The identified HCVs correspond closely to the overall project targets (Section 1.3). The interventions outlined in Section 2.2 are designed to have a net positive impact on biodiversity (as decribed above and see also Section 2.4). The positive impacts of project activities are described in full in the HCV assessment report (Pollard and Evans 2012) and are summarised in Table 7.3 below.

Table 7.3 Positive impacts of project activities on ecological HCVs

[16] A seventh species, Tiger, was initially included in that list but no longer occurs at the site. Hence it is not treated as a management target for now, although eventual reintroduction is a possibility (Lynam 2010, O Kelley *et al* 2012).

High Conservation Value	Corresponding project targets	Positive impacts
HCV 1: Significant concentrations of biodiversity values	Increase populations of wildlife of conservation concern	o Increasing or stable populations of all Globally Threatened, and endemic species
HCV 2: Landscape level forests	Maintain the variety, integrity, and extent of all forest types	o Maintenance of large intact forest areas. o Maintained connectivity with wider forest landscape
HCV 3: Threatened ecosystems	Maintain the variety, integrity, and extent of all forest types	o Deforestation rates reduced to 0%. o Conversion of wetlands and natural grasslands halted

Project activities involving potentially harmful species

Potentially invasive species

No project activities are planned that might increase the potential for problem invasive species. The project does not envisage any problems with invasive species if habitat protection measures are successful.

Some potentially invasive species are present in the project area but none appear to impacting severely on natural ecosystems, and probably will not unless habitats become highly fragmented and degraded as in the without-project scenario. For example, various *Mimosa* species occur in anthropogenically disturbed sites such as farm and road edges, but have not spread into natural forest. *Chromalaena odorata* is found on road edges and in regenerating vegetation along old logging roads, however it also does not appear to be spreading into natural forest.

Non-native species

The project will not involve the use of non-native species except possibly on a very small scale, for ornamental purposes. Some non-native tree species (notably *Accacia mangium*) were planted as ornamentals prior to the start of project activities, but none have been planted in the project area since 2010. Any assisted regeneration or re-forestation activities in the project area will use native species which are readily available from local FA nurseries (for example *Dipterocarpus alatus* and *Hopea odorata*) or from seeds collected in the project area.

Genetically Modified Organisms

No Genetically Modified Organisms (GMOs) are currently used in the Project Zone, as far as is known. GMOs will not be used in any project activities. The use of GMOs on farms in the Project Zone will not be supported by REDD-funded agricultural assistance projects.

7.2 Negative Offsite Biodiversity Impacts (B2)

Potential negative offsite biodiversity impacts

The project has identified potential negative offsite biodiversity impacts by reviewing the threats to biodiversity in Cambodia, and predicting how project activities may affect these outside the project zone. These issues have been discussed with stakeholders working in other parts of eastern Cambodia, including those working in areas that may potentially be affected.

Various offsite impacts could potentially occur. The most severe threat to the site is deforestation for small-holder farms or plantation development. Control of deforestation in the project zone could lead to deforestation elsewhere leading to negative impacts on forest biodiversity elsewhere. The issues of deforestation leakage are covered in Section 5.5, and will not be dealt with further in this section.

The control of the other threats to biodiversity listed in section 4.5 could potentially lead to them being displaced to other parts of the project zone, or elsewhere in the country. Hunting and trapping of high value species, for example trophy species such as Banteng, Sambar and Eld's Deer, species for traditional medicine (eg Pygmy Loris) or bushmeat could all theoretically be displaced. Similarly illegal collection of forest resources (NTFPs, and fish) may be displaced. Finally, it is possible that illegal logging of high-value species, and for domestic use, could be displaced to other forest areas in Cambodia.

Mitigation of negative offsite biodiversity impacts

Most of the potential negative offsite impacts will be avoided or mitigated through several approaches at different scales. These are part of overall project activities as listed in Section 2.2. Some offsite impacts of hunting and logging will be managed by working with government and non-government partners across the landscape to support conservation activities beyond the project zone (Sub-objective #1: Actions #3, #4, #5; and Sub-objective #2: Action #5). Phnom Prich Wildlife Sanctuary (PPWS) and Mondulkiri Protection Forest (MPF) are the sites of long-running conservation programs by the World Wildlife Fund Cambodia program (WWF), in collaboration with Ministry of Environment and FA. WCS has collaborated with WWF in forming a Mondulkiri Provincial Conservation Planning Unit. This unit works with Provincial departments and Governors offices to improve land planning decisions and to support the management of protected areas. A coordinated approach at the provincial level will minimise the possibility that improved protection of the project area will simply displace pressures to neighbouring protected areas. The SPF project team also works closely with MoE, FA and WWF staff to share information on threats, and methods to mitigate them.

The project will work with local residents to improve natural-resource management patterns and alternative income sources (Sub-objectives #3 and #4). Therefore many practices that have negative impacts on biodiversity will not be displaced, but rather they will be replaced with alternative options. For example, in the bamboo-rich areas of Sre Khtum commune the project will work with village groups to develop bamboo management strategies to enhance the sustainability of harvesting and minimise the pressure to over-harvest, or harvest bamboo in neighbouring areas (Sub-objective #4: Action #5). Similar resource-use plans will be developed for all villages in the project area where key resources are being over-harvested. These will enhance the sustainability of vital subsistence activities such as collection of forest foods, and fishing and reduce the need to collect these commodities beyond the project zone. Similarly livelihood support work (Sub-objective #4: Action #1, 2, 3) will provide alternative sources of income and reduce levels of hunting for food or income, or the over-exploitation of other forest resources. Livelihood development is supported by a program in literacy and numeracy (Sub-objective #4: Action #7). Acquisition of functional literacy is a crucial step in the process of improved livelihoods and alleviation of poverty for the residents of the project zone. Without these basic, foundational skills, making any sustainable improvements in livelihood skills or attendant knowledge is far more difficult.

The project is not committing to achieve net conservation benefits for Luxury grade timber species at risk from illegal logging, other than protecting habitat in which future regeneration may be possible from the stock of immature trees. The with-project emissions scenario conservatively assumes that most stocks of these highly sought-after species in SPF may eventually be cut, despite the best efforts of the project, because the level of pressure is so intense in relation to the law enforcement effort that is feasible. If some success is achieved in preventing cutting of these species, net benefits will probably occur since these species are now economically extirpated from many, perhaps most other areas in North-east Cambodia and so there is little scope for leakage.

Demonstration of net positive biodiversity impacts

The predicted positive biodiversity impacts of the project will far outweigh any potential unmitigated negative offsite impacts.

It may not be possible to control all offsite negative impacts. Within Cambodia and neighboring countries there continues to be high demand for wildlife products including meat, trophies and parts thought to have medicinal properties (Ashwell & Walston 2008). Control of hunting in the project zone cannot be accompanied by a nationwide reduction in demand given the resources of the proposed REDD project. It is also beyond the scope of the project to improve management and protection of conservation areas throughout Cambodia. Hence it is possible that cessation of hunting of high-value species in the project zone will lead to some increased pressure on other, less well protected populations.

Any unmitigated negative offsite impacts are however likely to be more than compensated for by the positive biodiversity benefits within the project zone. Most forest areas beyond the SPF and neighboring protected areas have been heavily hunted and logged during the last few decades (Loucks *et al.* 2009). The biodiversity values of these areas are now severely degraded. Most of the threatened wildlife species (such as elephants, Sambar, large carnivores, large waterbirds) have been extirpated from these forests. Many of the high-value species (eg Sambar, Banteng, Gaur, Serow) are now restricted to a few highly reduced populations in the most remote or well protected areas.

Any displacement of subsistence hunting and trapping activities from the SPF will therefore largely be to areas of less value for biodiversity. The populations of key species, such as Banteng, Gaur, Elephant and Southern Yellow-cheeked Crested Gibbon, in the project zone are amongst the largest in the country, and are of regional or global importance. The successful protection of globally important populations of endangered species within the project zone will eventually lead to the recovery of these populations to much higher population levels, approaching carrying capacity for the habitat. These population recoveries, and their ability to seed the repopulation of neighboring areas (should management improve there) form a very significant positive biodiversity impact of the project. Populations of these species beyond the project zone not in protected areas are generally already very small and likely to decline to extinction even in the baseline scenario. Therefore any marginal increase in threats to them caused by displacement due to project activities will have limited impact on long-term outcomes and will be more than outweighed by the postive impacts within the project area. The same general argument can be made for the protection of the rare non-forest habitats in the project area, and over-harvested rare NTFP species.

7.3 Exceptional Biodiversity Benefits (GL3)

The project qualifies for Gold Level as it will have globally exceptional biodiversity benefits. The project zone jm meets both of the main criteria for Gold Level:

1. Vulnerability – many Globally Threatened species occur in the project zone
2. Irreplaceability – the project zone holds significant populations of at least three restricted-range species and large proportions of the world's population of at least five other species

The site has also been recognised as outstanding in many previous priority-setting exercises, as described in section 1.3.

The project goes beyond simply noting the presence of these key species. Project design aims to improve the population status of these key species through targeted measures, and a significant number of them are included among the species that are formally monitored to confirm that their status improves (e.g. Table 7.2).

Vulnerability

The project area is home to at least 41 Globally Threatened vertebrate species, as listed in Table 7.4. Population data are given for 2010 or the nearest available year following Pollard *et al.* (2008) and O Kelly *et al.* (2010, 2011, 2012). The site is also of exceptional importance for the conservation of threatened trees (Section 1.3).

Table 7.4: Globally threatened species recorded in the project zone

English Name	Scientific Name	Status*	SPF importance^	Population estimate [year of estimate]
MAMMALS				
Malayan Pangolin	*Manis javanica*	EN	Regional	
Pygmy Loris	*Nycticebus pygmaeus*	VU	Global	

Northern Pig-Tailed Macaque	*Macaca leonina*	VU	National	2294 [2010]
Stump-Tailed Macaque	*Macaca arctoides*	VU	Possibly regional	
Germain's Silvered Langur	*Trachypithecus germaini*	EN	Possibly global	2999 [2010]
Black-Shanked Douc	*Pygathrix nigripes*	EN	Global	22,003 [2010]
S. Yellow-Cheeked Cr. Gibbon	*Nomascus gabriellae*	EN	Global	891 [2010]
Dhole	*Cuon alpinus*	EN	Possibly regional	
Asiatic Black Bear	*Ursus thibetanus*	VU	Possibly regional	
Sun Bear	*Helarctos malayanus*	VU	National	
Smooth-Coated Otter	*Lutrogale perspicillata*	VU	Unknown	
Asian Small-Clawed Otter	*Aonyx cinereus*	VU	Unknown	
Binturong	*Arctictis binturong*	VU	Unknown	
Large-spotted Civet	*Viverra megaspila*	VU	Unknown	
Marbled Cat	*Pardofelis marmorata*	VU	Unknown	
Clouded Leopard	*Neofelis nebulosa*	VU	Possibly regional	
[Tiger]	*[Panthera tigris]*	EN	Regional	[probably 0] [2010]
Asian Elephant	*Elephas maximus*	EN	Regional	116 (101 - 139) [2006]
Sambar Deer	*Rusa unicolor*	VU	Possibly regional	167 (67-420) [2010]
Eld's Deer	*Rucervus eldii*	EN	Regional	
Banteng	*Bos javanicus*	EN	Global	$
Gaur	*Bos gaurus*	VU	Regional	$
BIRDS				
Green Peafowl	*Pavo muticus*	EN	Global	569 [2010]
White-Winged Duck	*Cairina scutulata*	EN	Regional	
Pale-Capped Pigeon	*Columba punicea*	VU	Unknown	
Sarus Crane	*Grus antigone*	VU	Unknown	
Masked Finfoot	*Heliopais personata*	EN	Unknown	
White-Rumped Vulture	*Gyps bengalensis*	CR	Possibly Global	
Red-Headed Vulture	*Sarcogyps calvus*	CR	Possibly Global	
White-Shouldered Ibis	*Pseudibis davisoni*	CR	Possibly Global	
Giant Ibis	*Pseudibis gigantea*	CR	Possibly Global	
Lesser Adjutant	*Leptoptilos javanicus*	VU	National	
Manchurian Reed Warbler	*Acrocephalus tangorum*	VU	Unknown	
Yellow-breasted Bunting	*Emberiza aureola*	VU	Unknown	
Great Slaty Woodpecker	*Mulleripicus pulverulentus*	VU	Unknown	
REPTILES				
Giant Asian Pond Turtle	*Heosemys grandis*	VU	Regional	
Yellow-Headed Temple Turtle	*Hieremys annandali*	EN	Global	
Elongated Tortoise	*Indotestudo elongata*	EN	Global	
Asiatic Softshell Turtle	*Amyda cartilaginea*	VU	Unknown	
AMPHIBIANS				
Marten's Floating Frog	*Occidozyga martensii*	VU	Unknown	
Annam Tree Frog	*Rhacophorus annamensis*	VU	Unknown	

* = Status from the 2010 IUCN Red List of Globally Threatened Species: Cr = Critically Endangered; En = Endangered; Vu = Vulnerable
^ Subjective assessment based on expert assessment of likely contribution of SPF to maintaining global population size and ancestral range
$ The 2010 population estimate for wild cattle (Gaur and Banteng combined) is 1072.

The table includes 18 vertebrate species that are listed as either Critically Endangered or Endangered, each of which alone would qualify the site for Gold Level status. The Gold Level threshold for Vulnerable species is 30 individuals or ten pairs, a level that is likely to be met by almost all of the remaining species listed in the table.

Irreplaceability

Endemic species

The southern part of the project zone which is dominated by evergreen and semi-evergreen forest formations is part of the Southern-Vietnam / Cambodia Endemic Bird Area (Stattersfield *et al* 1998). This is in recognition of the presence of three restricted-range bird species: Germain's Peacock-pheasant, Orange-necked Partridge and Grey-faced Tit-babbler. It is not yet known whether the project zone support more than 5% of the global population of these species. The Orange-necked

Partridge is known from only 17 disjunct forest patches in southern Vietnam, and the SPF in Cambodia (IUCN 2010). Given that the potential area in SPF of the species' preferred habitat of bamboo forest is large relative to many of the <20 Vietnamese sites, it seems likely that more than 5% of the global population of the species is found in the project zone. Further research is required to confirm this.

Two frog species new to science have been described from the project area (Stuart 2005), the O'Reang Horned Frog (*Ophryophryne synoria*) and Mouhot's Litter Frog (*Leptobrachium mouhoti*). The horned frog is still known globally from only one river system in the south of the SPF, and Mouhot's Litter Frog is known from only a few locations (J Rowley *pers comm*). The project area therefore contains the entire world's known population of O'Reang Horned Frog, and most likely has more than 5% of the world's population of Mouhot's Litter Frog.

Globally significant populations

Globally significant populations of several other species occur in the project zone. Lack of robust data on global population sizes or species ranges for these species makes assessment of whether they qualify under the *irreplaceability* criterion hard to judge but on current evidence it is reasonable to presume that, among others, some or all of the species listed below have globally significant populations (>1% of global population) in the project zone.

<u>Black-shanked Douc</u> This monkey is restricted to southern Vietnam and eastern Cambodia. It is currently known from a few fragmented forest patches but the total area species' range is yet to be estimated. The population of the species in the project area has been estimated (O'Kelly and Nut Meng Hor 2011) at 22,003 (range 14,518-33,347) individuals. This is the largest known population in the world, and significantly larger than the next largest reported population of an estimated 500-700 in Nui Chau National Park, Vietnam (Nader *et al* 2003, Rawson 2009).

<u>Southern Yellow-cheeked Crested Gibbon</u> This species is restricted to southern Vietnam and eastern Cambodia but the total range of the species is yet to be estimated. The population of the species in the project area has been estimated (O'Kelly Nut Meng Hor 2011) at around 891 (range 411-1933) individuals . This is the largest known population in the world. The next largest recorded populations are around 150 groups in Phnom Prich Wildlife Sanctuary (Phan Channa and Gray 2009), and around 150 groups in Cat Tien National Park, Vietnam (Hao et al 2005 in IUCN 2010)

<u>Banteng</u> This was historically a wide ranging species found in Java and Borneo, through peninsular Malaysia, Thailand, Myanmar, Cambodia, Vietnam and Laos. It is now restricted to a few scattered populations, none thought to be larger than 400-500 animals. The global wild populations is not known, but could be between 5,000 and 8,000 (IUCN 2010). The population of both wild cattle species in the project zone has been estimated as 1094 (range 352-3264), of which about half are Banteng (O'Kelly and Nut Meng Hor 2011). This may represent over 5% of the maximum estimated global population of 8,000 (IUCN 2010). The population in the SPF is part of a larger meta-population in neighboring protected areas (Gray *et al.* 2012). Such significant populations make SPF and Mondulkiri as a whole of global importance for the species.

<u>Green Peafowl</u> The range of this formerly widespread and abundant species covered parts of Java and peninsular Malaysia, Thailand, Myanmar, north-east India, Indochina and southern China. It is now restricted to a few small fragmented populations, with a global population estimated at 10,000-20,000 (IUCN 2010). The population in the project zone is estimated as 569 (range 271-1194), which is 2.5-5% of the global estimates. Birdlife International (2001), Brickle *et al.* (2008) suggested that Mondulkiri was a global stronghold of this Endangered species, with the SPF forming a core part of the population.

<u>Giant Ibis.</u> The largest ibis species in the world is restricted to the deciduous dipterocarp forests of the lower Mekong. It lives at low densities (IUCN 2010) and is dependent on areas of forest with very low levels of human disturbance. As a consequence of habitat loss and disturbance the global population of the species was estimated as a minimum of only 100 pairs (IUCN 2010), and is now found almost exclusively in northern and eastern Cambodia. Giant Ibis have been recorded in the project zone on several occasions (Bird *et al* 2006, Claasen and Ou 2007, WCS data), and although no nests have yet been found it is highly likely that the species breeds there. Given the area of

potential habitat, and the number and dispersal of records obtained, it seems likely that several pairs occur in which case the population would easily represent more than 1% of the estimated global population.

8 MONITORING

8.1 Description of the Monitoring Plan (CL3, CM3 & B3)

Adaptive management system and the annual monitoring cycle

SPF operates an adaptive management system which is informed by the quantitative monitoring programs for climate, community and biodiversity benefits, set out below, as well as a broad range of other qualitative information. Key outputs from this system form the basis of the periodic verification reports that are required to demonstrate project benefits.

Verification reports will be produced periodically (Section 4.4) but the adaptive management system itself is based on the annual work-planning cycle. A new annual plan is developed each year at a convenient time during the period June-August. The new plan is based on two main inputs – the strategic management plan and the results of implementing the previous year's plan.

a) The first strategic management plan was developed in 2009 and is closely based on the structure of the conceptual model for the project (Section 2.2). It has now been updated to form the project workplan presented in Annex 2.1. This will be updated from time to time as required to take account of changing circumstances. Any significant changes will be mentioned in verification reports.
b) Results from the previous year are collated during a 2-3 day annual planning workshop during which each of the seven sub-objectives is reviewed in turn. Most technical and managerial staff of the project participate, together with selected external stakeholders (e.g. FA Cantonment staff, local NGO team leaders). Team members and technical advisors make presentations on activities, monitoring results and other observations from the preceding year, outcomes are compared to targets from the previous workplan, and then a participatory process is followed to develop a new workplan and propose adjustments to the overall strategic plan.

The new workplan and a summary report against the previous workplan in tabular format are submitted to the Director of DWB and shared with component leaders on the SPF team and partner organizations.

In order to increase the formal involvement of local communities in the adaptive management process as it relates to the REDD project, structured community consultations are being introduced in a step-wise fashion, beginning in June 2012 with a community leaders' feedback workshop held immediately before the annual planning workshop. The section on monitoring community benefits below explains how this system will be expanded step-by-step during the life of the project.

Responsibility for the adaptive management process rests with the National Project Manager, in collaboration with the SPF Senior Technical Advisor.

The sections below describe in detail those elements of the monitoring program that are required for the verification reports. Verification reports timetable is set out in Section 4.4 Step 1.2.

The monitoring includes four main tasks:
1) Monitoring of carbon stock changes and GHG emissions for periodical verifications within the fixed baseline period; and
2) Monitoring of key baseline parameters for revisiting the baseline at the end of the fixed baseline period.
3) Monitoring community benefits
4) Monitoring biodiversity benefits

Task 1: Monitoring of carbon stock changes and GHG emissions for periodical verifications

There are three main monitoring tasks:
1.1 Monitoring of actual carbon stock changes and GHG emissions within the project area;
1.2 Monitoring of leakage; and

1.3 *Ex post* calculation of net anthropogenic GHG emission reduction.

For each of these a monitoring plan is set out below.

Task 1.1 Monitoring of actual carbon stock changes and GHG emissions within the project area

Task 1.1 is divided into four components: (i) Monitoring of project implementation; (ii) Monitoring of land-use and land-cover change (iii) Monitoring of carbon stock changes and non CO_2 emissions from forest fires and (iv) Monitoring of impacts of natural disturbances and other catastrophic events. Each of these is described in detail below, followed by step (v): Calculation of total ex-post estimated actual net changes in carbon stocks and emissions of GHG gases in the project area.

1.1.1 Monitoring of project implementation

a) Technical description of the monitoring tasks.

Project implementation is based on the long-term workplan presented in Annex 2.1, with task lists for each year in annual workplans developed according to the adaptive management system described above. The monitoring task will collect data on whether these activities were conducted, to what level they were completed and if not completed, how the subsequent year's workplan will compensate for this.

b) Data to be collected.

At the end of each year at minimum an annual report is completed in tabular format identifying the degree to which each action has been completed. The exact data to be collected depends on the specific action being reported on, but might for example include the number of law enforcement patrol days conducted, number of villages in which land titles were issued and number of km of forest boundary demarcated.

c) Overview of data collection procedures.

The data for each activity are provided the responsible staff for that activity, supported by documentary information where appropriate (e.g. patrol records in the computerised MIST system, copies of new land titles). The data are collected at or around the time of the annual work-planning and reporting meeting.

d) Quality control and quality assurance procedures.

The officers collating the report will cross-check a subset of the data and evidence reported under each Sub-objective to ensure that reporting is of acceptable quality.

e) Data archiving.

Data will be archived at the Department of Wildlife and Biodiversity and at the WCS Country Program office, with a copy of key records also held at the SPF HQ.

f) Organization and responsibilities of the parties involved in all the above.

Responsibility for the monitoring of project implementation rests with the National Project Manager, in collaboration with the SPF Senior Technical Advisor.

1.1.2 Monitoring of land-use and land-cover change

a) Technical description of the monitoring tasks.

The only mandatory category of change subject to MRV in the SPF project is Category I, the area of forest land converted to non-forest land (methodology Table 37). No existing national monitoring program exists that is comparable to those used to determine the project baseline, so data must be collected specifically for the project.

The monitoring task will be conducted in as similar a fashion as possible to the analysis of the historical baseline period (Annex 4.5). The task should be completed prior to each verification report. Interim analyses can be completed over shorter periods (e.g. annually), to inform adaptive management, but to maximise accuracy each analysis for verification purposes should span the full period since the project start date (in the first report) or the previous verification report (for subsequent reports) and not be the sum of several annual analyses.

b) Data to be collected

Methods used to monitor LU/LC change categories and to assess accuracy will be similar to those explained in part 2, step 2.4 and part 2, step 2.5, respectively of the Methodology. They will be consistent with the methods used to develop the historical baseline deforestation maps.

The area to be analyzed will include the whole project zone at each verification event and, to accord with the methodology, the entire reference region at the second and fourth verification events (years 5 and 10).

The result of this process will be estimates of the deforestation (ha) within each forest class for the project area and leakage belt as required to produce ex-post versions of tables 5.3b & c (=Tables 9b & c of the methodology) and 5.5b & c of the PD (=Tables 11b & c of the methodology). As there is only one post-deforestation land-use class, there is no need to produce tables 13b & c and 14b & c of the methodology.

c) Overview of data collection procedures.

Medium-resolution imagery will be obtained from two sources:

i) covering the whole area to be analyzed for the relevant dry season (ideally during December-March) from whichever Landsat sensor is most appropriate at the relevant time, if available, or the most similar alternative sensor if not
ii) covering as much as possible of the project zone, especially the open forest areas, for the preceding rainy season (approx June-October) from a relevant medium-resolution radar sensor.

The images should be co-registered to the 1998 Landsat images used in the historical period and, if required, subject to radiometric correction. Multi-date supervised classification should be conducted using the same land-use classes and definitions as in Annex 4.5, with training data derived from field observations. The same software, tools and analytical steps as in Phase 1 (Steps 1-5) of the analysis should be used, unless changes in software availability necessitate the use of a closely equivalent package or tool.

The analyst(s) will also write a report in the format of Annex 4.5 detailing the steps followed, including any necessary tables (such as Table 5 of the methodology).

d) Quality control and quality assurance procedures.

The analyst will conduct an accuracy assesment comparable to that set out in Annex 4.5, using high resolution imagery or field ground truth collected according to a statistically robust sampling framework. Imagery or field data should relate to a date within 12 months +/- from the date of the main analysis. The required accuracy threshold will be as for the historical deforestation baseline.

e) Data archiving.

All imagery, working data and final classifications will be archived with the Department of Wildlife and Biodiversity and at the WCS Country Program office.

f) Organization and responsibilities of the parties involved in all the above.

Responsibility for organizing the analysis rests with the National Project Manager, in collaboration with the SPF Senior Technical Advisor. *The actual analysis should be conducted by one or more highly skilled analysts, either in-house or external as convenient, who have a proven track record of* producing high quality land-cover change analyses in comparable vegetation types.

1.1.3 Monitoring of carbon stock changes and non CO_2 emissions from forest fires

Monitoring of carbon stock changes

Under current ex ante assessment, no areas will be subject to controlled deforestation and planned harvest. However, all activities taking place inside the project area will be monitored as described above. If these activities are initiated, the management plan will include the monitoring of carbon stock changes following each harvest event. Tables 25.a, 25.b, 25.c, and 27 of VM0015 will be used to estimate CO_2 emissions resulting from such harvesting.

Monitoring due to unplanned and significant carbon stock decrease resulting from fires is described below under section 1.1.4.

Monitoring of non-CO_2 emissions from forest fires

Estimation of the non-CO_2 emissions from fires used during forest clearance in the with-project case will follow the same calculations used in Tables 5.19 and 5.20 of the PD. The only variable that needs to be monitored is the area of forest cleared. Monitoring of this variable is set out in Section 1.1.2 above. Tables 23 and 24 of the methodology will be used to calculate emissions from this source.

Monitoring of unplanned and significant non-CO2 emissions from forest fires not associated with forest clearance is described below under section 1.1.4.

1.1.4 Monitoring of impacts of natural disturbances and other catastrophic events

a) Technical description of the monitoring tasks.

According to VM0015, decreases in carbon stocks and increases in GHG emissions (e.g. in case of forest fires) due to natural disturbances (such as hurricanes, earthquakes, flooding, fires etc) or man-made events, including those over which the project proponent has no control (such as acts of terrorism or war), are subject to monitoring and must be accounted under the project scenario, when significant. According to VM0015, the significance of the potential emission will be determined using the most recent CDM-approved and VCS-endorsed version of the “Tool for testing significance of GHG emissions in A/R CDM project activities”.

Catastrophic natural disturbances are not expected to occur in the area as there is no history of them occuring, but there is a theoretical possibility that they will. Annual monitoring will be conducted to detect whether such an event has occurred, and if it has then to trigger more detailed assessments.

b) Data to be collected.

Tables 23k, 24, 25.e, 25.f, 25.g, and 27 of VM0015 will be used to estimate the CO_2 and non-CO_2 emissions resulting from such events and potentially Tables 26.e, 26.f, and 26.g to report carbon stock increases during subsequent regrowth.

The carbon stock change ($\Delta Ctoti_{cl,t}$) will be calculated using one of the two below approaches. The locations of natural disturbances and other catastrophic events will be delineated in a GIS. For those judged significant the emissions associated with each event and location will be determined in one of two ways at the discretion of the project management team:

(i) The carbon stock change ($\Delta Ctoti_{cl,t}$) will be assumed to equal the total carbon stock of each relevant forest class ($Ctoti_{cl,t}$) within the area delineated.

(ii) In cases where only a portion of the carbon stocks are believed to have been impacted by the event, field data collection will take place to estimate the carbon stocks remaining following the methods delineated in Section 5.3 of VM0015. The carbon stock change ($\Delta Ctoti_{cl,t}$) will be assumed to be the difference between the total carbon stock of the forest class prior to the event ($Ctoti_{cl,t}$) and the carbon stocks following the event.

If the event results in sufficiently large emissions, then it will be described as a loss event in accordance with the VCS Standard Definitions (p7) and the appropriate reports and other procedures will be completed.

If substantial regrowth is judged to have occurred at subsequent verification events, the project management team may opt to measure and account for this regrowth using the same approach described in point b(ii) above.

c) Overview of data collection procedures.

The methods set out in Section 1.1.2 do not provide annual data and so are not suitable for monitoring catastrophic natural events. Medium resolution imagery (Landsat or similar) will be visually inspected on an annual basis by a trained analyst in combination with fire hotspot data from publicly available MODIS products. Verbal reports of catastrophic events will also be collated on a routine basis from project field staff. If either of these sources suggests a significant natural loss of carbon has occurred, a field inspection will be made to assess the site. Routine annual grass fires in the fire-adapted open forest are not considered to have any effect on the average carbon stocks of any pool and so will not be delineated in this way.

d) Quality control and quality assurance procedures.

The satellite inspection and interviews with field staff will provide a cross-check on one another. Quality assurance for the field measurements will be conducted in accordance with the standard operating procedures listed in Annex 4.3.

e) Data archiving.

All imagery, working data and final classifications will be archived with the Department of Wildlife and Biodiversity and at the WCS Country Program office.

f) Organization and responsibilities of the parties involved in all the above.

Responsibility for the monitoring of such events rests with the National Project Manager, in collaboration with the SPF Senior Technical Advisor. Inspection of imagery will be conducted by a trained analyst.

Total ex-post estimated actual net changes in carbon stocks and emissions of GHG gases in the project area

The data gathered above are combined with the carbon stock change data for land-use/land cover change categories set out in Tables 5.8i-iii to calculate the actual ex-post net changes in each carbon pool, which can then be compared with the baseline changes (Table 5.9, relevant sections = Table 22 of the methodology) to calculate the ex-post emission reductions in the project area (Table 5.11, = Tables 27 and 29 of the methodology).

Task 1.2 Monitoring of leakage

a) Technical description of the monitoring tasks.

No significant decrease in carbon stocks or GHG emisssions is expected due to leakage management activities so the only activity displacement leakage needs to be measured.

In accordance with the methodology, where strong evidence can be collected that deforestation in the leakage belt is attributable to deforestation agents that are not linked to the project area, the detected deforestation may not be attributed to the project activity and considered leakage. This evidence will be collected by the project management team as appropriate to the agent encountered.

With regard to deforestation that is believed to be attributable to the project, as described in Section 5 Step 8.2 above, activity displacement leakage is made up of two components – that due to smallholders who are

(i) resident/newly settled at the site and
(ii) those who are deterred from moving to the site by project activities.

b) Data to be collected.

Activity displacement leakage by smallholders in category (i) is detected by comparing deforestation in the leakage belt to baseline projections.

Activity displacement leakage by smallholders in category (ii) is detected by comparing observed population trends with baseline projections.

c) Overview of data collection procedures.

The extent of deforestation in rhe leakage belt is detected and reported during the analysis described above under Task 1.1, which will cover the project area and leakage belt simultaneously. The deforestation data per land-use/land cover category are then combined with the carbon stock change data for land-use/land cover change categories set out in Tables 5.8i-iii to calculate the actual ex-post net changes in each carbon pool, which can then be compared with the baseline changes (Table 5.9, relevant sections) to calculate the ex-post emission increases, if any.

Activity displacement leakage by smallholders in category (ii) is estimated by the calculation of the Displacement Leakage Factor for Avoided Migrants (DLFa), which is the percent of avoided deforestation attributable to potential in-migrants who were deterred from settling due to the existence of the project and have hence been displaced outside the project boundary relative to the baseline scenario, %. The smallholders in this category cannot, by definition, participate in leakage management activities and so it is conservative to assume that the proportion of emission reductions attributable to their absence leaks with 100% effect.

DLFa was calculated ex-ante from a projection of population sizes in the 20 participating villages, but ex-post is determined from actual population data. Village population sizes are determined for each village for the relevant year by collation of official government data (from the Commune Database or an equivalent source) after conducting basic quality control to identify and resolve any significant non-conformities in the way data are presented by the government in comparison to earlier periods. The total population of the 20 villages is then compared to the projected figures in Annex 4.2. If the observed population is greater than or equal to the projected population then no leakage is attributed to this source. If the observed population is smaller than projected then DLFa[observed] is calculated as

DLFa[observed] = 1-(observed population at time t/projected population at time t)

Where

DLFa[observed] = Observed Displacement Leakage Factor for Avoided Migrants i.e. is the percent of deforestation attributable to potential in-migrants who were deterred from settling due to the existence of the project and have hence been displaced outside the project boundary relative to the baseline scenario, %.

DLFAa[observed] can be calculated annually, but where deforestation data are collected over periods of more than one year, DLFa[observed] should be calculated for the final year and then applied to all preceding years since the last verification event. This is conservative.

The leakage attributable to this category of smallholders is then calculated by multiplying the gross emission reductions attributed to the project (before any deducations have been made for leakage) by DLFa[observed]. This leakage is added to the leakage calculated within the leakage belt to give the total leakage for the time period in question. This information is reported in the ex-post version of Table 5.16 (= methodology Tables 34 and 35).

d) Quality control and quality assurance procedures.

Quality control procedures for the analysis of land cover change are set out under Task 1.1. Quality control procedures for demographic data will use independently collected demograpghic data from social surveys to periodically review the reliability of the official village population dfigures used above. When they match to within +/-5% across the project area, the official figures will be used. If the difference is greater, then the more conservative dataset will be used.

e) Data archiving.

All relevant data will be archived with the Department of Wildlife and Biodiversity and at the WCS Country Program office.

f) Organization and responsibilities of the parties involved in all the above.

Responsiblity for organizing the analysis rests with the National Project Manager, in collboration with the SPF Senior Technical Advisor. Actual analysis can be conducted by a suitably qualified technical officer either in-house or externally.

Task 1.3 Ex post calculation of net anthropogenic GHG emission reduction

The final step is to calculate the ex post net anthropogenic GHG emission reduction. This is calculated in a way analogous to the ex-ante emission reduction with the exception that the ex-post values for emissions in the project area and leakage belt are used instead of the ex-ante projections. The emissions reductions, VCUs and buffer are calculated using an ex-post version of Table 5.18.

Finally, a map showing the cumulative areas credited should be updated and presented to the verifiers at each verification event.

Task 2: Revisiting the baseline projections for future fixed baseline period

To enable projections for the second fixed baseline period, years 11-20, the baseline must be reviewed at the end of year 10. It is anticipated that by this stage a national jurisdictional baseline will be in place, in line with the timetable of the ongoing national REDD+ Readiness process, but this is not yet certain.

Update information on agents, drivers and underlying causes of deforestation

Prior to updating the baseline Step 3 of the ex-ante methodology should be completed, building on the previous analysis but taking full account of newly collated data. Furthermore, the analysis of the location of deforestation presented in Annex 4.5 should be revised using new datasets and an updated analysis of deforestation across the reference region. At this stage it is also permissible to review and adjust the boundaries of the reference region, so as to ensure that it still meets all the criteria set out in the methodology Step 4.4.

Adjustment of the land-use and land-cover change component of the baseline

Assuming that a jurisdictional baseline has become available that meets the applicability requirements of the methodology, this will (and must) be used in subsequent periods. If not, the baseline models should be reassessed following the guidance in the methodology, page 117. The carbon component of the baseline should only be updated if one of the triggers listed in the methodology Part 3 Section 1.1.3 is activated.

Task 3 Monitoring community benefits

Preliminary community impact monitoring plan

A preliminary commmunity impact monitoring plan (including social HCVs) has been developed (WCS 2012) and testing of the detailed methodologies is underway at the time of submission of the PD. A full monitoring program will be put in place within 12 months of validation. It is expected that the program will involve a combination of quantitative and qualitative measures for each of the indicators listed in Table 2.1, including an extensive, periodic questionnaire-based household survey and a range of qualitative, participatory approaches.

Monitoring biodiversity benefits

Initial biodiversity monitoring plan

The biodiversity monitoring plan is presented here in provisional form. It is largely completed, but some details remain to be finalized and methods and baselines for two target species are still under development. The full monitoring plan will be completed within twelve months of validation.

Biodiversity benefits are predicted for i) key habitats and ii) for species assemblages, as set out in Section 7. Monitoring of the status of key habitats is covered by the system for monitoring forest cover change as a factor in measuring climate change benefits from the project (see above). A detailed species-focused biodiversity monitoring plan is already in place in the project area. Development of this program began in 2002 (Clements 2003) and is now one of the largest and most robust in south-east Asia (O'Kelly and Nut Menghor 2010). It is based around the concept of landscape species (Sanderson *et al.* 2002b), which then become the conservation target species whose status indicates overall ecosystem health. Six target species have been selected for SPF that collectively cover the full range of habitats and threats (WCS/FA 2010 and Section 7.1 of this document) and provisionally these six have been selected as indicator species for the biodiversity benefits of the REDD project.. Regular monitoring is already conducted on several ofthe target species as set out below, while supplementary data on key threats other than deforestation (e.g. hunting) are generated through Sub-objective 2 (see Section 2.2).

The monitoring of target species where possible employs absolute measures rather than relative indices, to ensure accurate, precise and repeatable results. A summary of the methods and parameters for each provisional REDD+ target species is provided in Table 8.1.

Table 8.1: Summary of target species monitoring methods used in the Seima Protection Forest

Species	Parameter	Units	Method	Frequency
Asian Elephant	Population size	Individuals in project area	Fecal DNA capture-recapture	Every 5 years.
Banteng	Population size	Individuals in project area	Distance sampling on line transects	Every 1-2 years
Sambar	Population size	Individuals in project area	Distance sampling on line transects	Every 1-2 years
S. Yellow-cheeked Cr. Gibbon	Population size	Individuals in project area	Distance sampling on line transects	Every 1-2 years
Eld's Deer	Extent of occurrence	% of grid cells occupied	Occupancy surveys*	tbd
Smooth-coated Otter	Extent of occurrence	% of grid cells occupied	Occupancy surveys	tbd

* May also be detected on line transects but to date encounters are too few to estimate densities.

Three main methods are used to monitor the conservation targets and other species of conservation concern: line transects, fecal DNA capture-recapture and occupancy surveys. Supplementary, qualitative data are also collected through camera-trapping, and opportunistic observations/studies. Standard operating procedures for the two quantitative methods currently in use are available for validation.

Line transects

Distance sampling on line transects is recognised internationally as one of the most robust and appropriate methods for measuring the absolute density of wildlife populations (Thomas *et al* 2010). The method is based on standardised repeat walks along a network of transects. All observations with target species are recorded, noting the distance to the individual, and the bearing from the observer. These data are used by the program DISTANCE to calculate absolute densities.

Line transects are used to monitor the population densities of Banteng, Sambar and Yellow-cheeked Crested Gibbon. Eld's Deer may also be adequately covered by this method if encounter rates increase in future due to successful conservation. Data are also collected on several other species at negligible additional cost. This has two main purposes:

1. it enables the project to monitor the populations of other species of conservation concern as they are either Globally Threatened, or they are key large carnivore prey; and

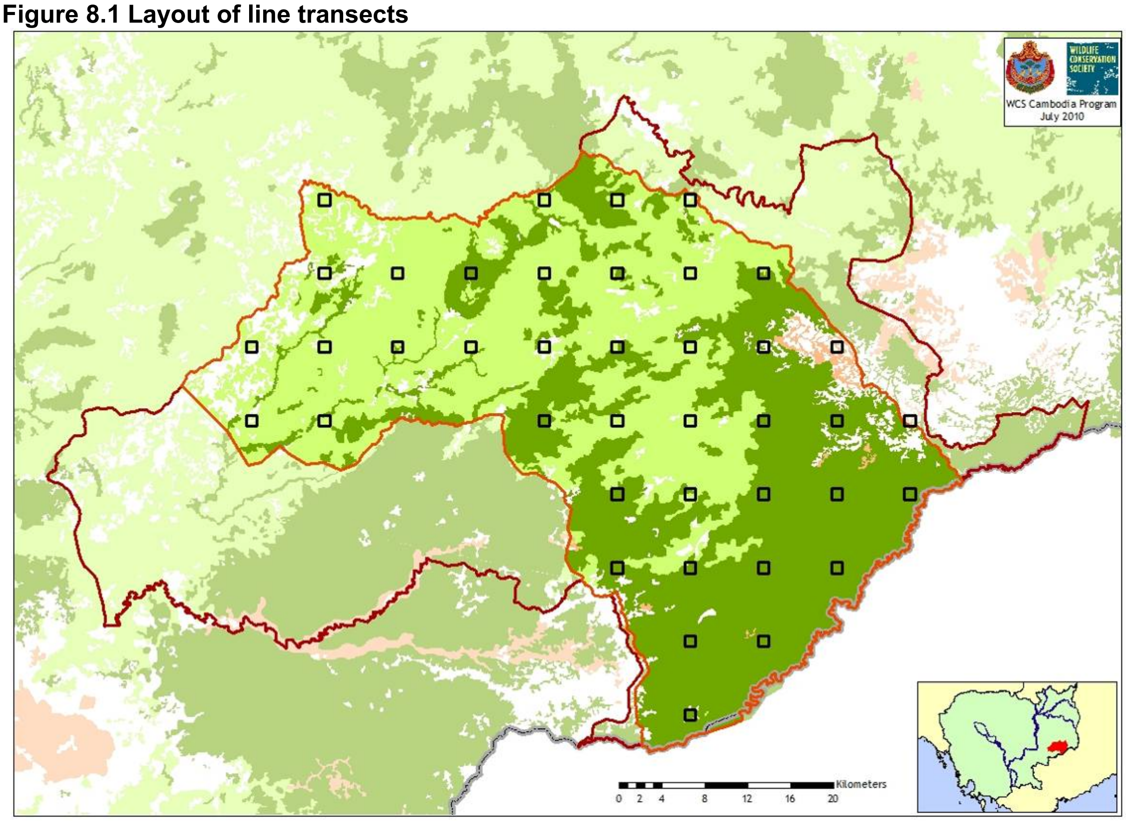
2. in the long term it will allow the project to assess the assumptions of the choice of *landscape species*, ie whether the target species are representative of trends in these other species.

The additional species currently monitored using line transects are:

- Gaur
- Red Muntjac
- Wild Pig
- Black-shanked Douc
- Germain's Silvered-langur
- Long-tailed Macaque
- Stump-tailed Macaque
- Pig-tailed Macaque
- Green Peafowl

A network of 40, 4km square transects has been placed systematically (with a random start) across the whole of the project area (Figure 8.1) in accordance with statistical good practice. For each survey every transect is walked multiple times, partly in the morning, starting at first light, and partly in the hours before dusk. Annual surveys are preferred, during Jan-April of each year, but when funds are limited surveys every two years are considered adequate. A total annual survey effort of about 1,600 km has been found a suitable compromise between obtaining enough encounters with low density species, and the logistical constraints imposed by access to remote transects, the relatively small number of skilled staff and varying levels of funding. The exact number of transects in total, and in each sector of the site, can be varied from year to year to maximise the statistical efficiency of the design without compromising the validity of the data.

Figure 8.1 Layout of line transects



Fecal DNA capture-recapture

Fecal DNA is currently used to monitor the population of Asian Elephants in the project area. This method uses DNA extracted from small samples of fecal matter to identify individual animals. A survey design involving repeat collection of samples throughout a season enables a population estimate to be calculated based on standard capture-recapture methods. This is an approved method under the CITES MIKE monitoring protocols and was used to estimate the elephant population of the SPF in 2006 (Pollard *et al* 2008) and 2010 (data analysis currently underway). Due to the slow rate of population change of Asian Elephants it has not been deemed necessary to carry out this survey annually. After consultation with the WCS Global Species Coordinator for Asian Elephant (S Hedges *in litt*) it was decided to apply this technique approximately every five years.

Supplementary, routine monitoring of illegal killings (currently very rare events) provides an early warning system for one driver of population trends. SPF is a designated site under the CITES Monitoring of Illlegal Killing of Elephants (MIKE) program and follows the global MIKE protocols.

Occupancy surveys

For Eld's Deer and Smooth-coated Otter occupancy surveys are likely to be the most suitable and affordable method to detect trends. This element of the monitoring program has not yet been designed. Trials and the development of protocols, including a monitoring schedule, will be conducted within 12 months of validation, with baseline surveys conducted as soon as funds allow after that.

Camera-trapping

Camera-traps triggered by heat-in-motion sensors are a qualitative method used to confirm the continued presence of target species (particularly Asian Elephant, Banteng, Sambar and Smooth-coated Otter), to show usage of key sites to and to obtain pictures that are useful for communicating with other stakeholders. This method also provides evidence of the continued occurrence a broad range of other species, most notably carnivores and ungulates. The presence of young in photos is evidence that breeding is successful. It is not planned to use camera-trapping to obtain quantitative estimates and no formal monitoring schedule will be set for camera-trapping; rather it is seen as a supplementary tool for use at the discretion of the site managers. Generally camera-traps are set:

- at mineral licks or water sources to monitor their use by ungulates (Bussey *et al* 2005);
- if signs of large cats are located camera-traps are set to confirm what species is present;
- at otter spraint sites to confirm the species, and understand more about their distribution.

All photos are examined to identify the species present, number of individuals, and if possible sex and age of the animal.

Opportunistic records and studies

Notable records of all species encountered in the project zone are documented, whether or not they were collected during formal structured surveys such as transects. Records of observations, signs (tracks and dung), and calls are collated from monitoring team members, project staff and visiting researchers and bird tour groups. For highly vocal species, such as gibbons, peafowl and Germain's Peacock Pheasant call records are a particularly important source of information (e.g. Bird *et al.* 2006).

These records supplement the routine quantitative methods and in partivcular enhance understanding of the presence and distribution of lesser-known species. They can help to alert project managers to possible changes in population size, ranging behaviour, altered group sizes and other factors that may indicate changed threat levels and call for more detailed study. Although they do not provide absolute measures of varying population size over time, they do confirm the continued presence of target species in each sector and also help to identify areas of critical importance. For example records of tracks, and occasional observations of Eld's Deer reveal that they are currently to be found only in the far west of the project zone, in areas of very open deciduous dipterocarp forest with large natural grasslands.

From time to time selected species will also be the subject of focused studies by visiting researchers facilitated by the project (e.g. recent PhD studies on Green Peafowl and Germain's Silvered Langur). These are valuable in clarifying threats, identifying management priorites and informing design of future monitoring efforts.

Monitoring impacts outside the project area

Impacts of project activities outside the project area are monitored qualitatively through regular communication with villages using the outer parts of the project zone and collaboration with government agencies and NGOs working in neighboring areas (MoE, FA and WWF in Cambodia, Bu Gia Map NP in Vietnam; see workplan Sub-Objective 1, Annex 2.2). These agencies carry out their own biodiversity and threats monitoring activities and data and results of biodiversity monitoring are shared by all of these partners. This information will indicate whether there is reason to suspect significant displaced negative impacts on the most significant concentrations of biodiversity adjacent to the project zone (primarily the buffer zones of SPF itself, and Phnom Prich WS).

Responsibilities and logistics

The biodiversity monitoring team is led by staff from the Department of Wildlife and Biodiversity of the FA. The current team leader has many years experience and training in the field methods employed. The field team consists of team leaders employed by WCS how have been recruited from Cambodia's leading universities, and local high schools. The teams are assisted by local residents employed by WCS who are intimately familiar with the forest and its wildlife. The whole biodiversity monitoring program is assisted by a technical advisor from WCS and also draws on assistance from other highly experienced WCS scientists.

Refresher training courses on all monitoring methods are held annually before any field data collecting is carried out. All staff participate in the training, regardless of previous experience. Quantitative monitoring methods are carried out in the dry season (December to May) when access to all areas of the forest is possible. Qualitative data are collected on an as-needed basis. Camera-trapping efforts are highest in the dry season but also take place in the wet season. Incidental records of species are collated year-round and reviewed periodically, e.g. during production of the SPF annual report.

Data management, reporting and dissemination of results

All biodiversity data are stored in a dedicated MS Access database maintained by WCS. Data extracted from the database are used for Distance sampling, capture-recapture modeling, and mapping species presence.

Results of the biodiversity monitoring activities are documented in technical reports (eg O'Kelly and Nut Menghor 2010, 2011, Pollard *et al.* 2007). These present the quantitative results for target species where possible, including population trends, as well as selected qualitative results obtained that year. These results are also included in the SPF annual reports where they are reviewed against annual and longer-term project targets. The annual biodiversity monitoring and project reports are shared with all project partners, and posted on the WCS Cambodia website (www.wcscambodia.org). In addition the annual results are presented to project staff and partners (local government, line agencies, and civil society) at annual planning meetings.

The most significant results are also prepared for presentation at conferences and in peer-reviewed journals (eg Rawson *et al.* 2009, O'Kelly et al. 2012)

Monitoring of ecological High Conservation Values

The monitoring of HCVs is outlined in more detail in the HCV assessment report (Pollard and Evans 2012). Monitoring of ecological HCVs (HCV 1-3) is effectively covered by the overall project monitoring framework outlined above since the same methods are suitable for assessing whether the project activities maintain or enhance the HCVs. A summary of the methods used to monitor the values is provided in Table 8.2.

Table 8.2: Methods used for monitoring High Conservation Values 1-3 in SPF

High Conservation Value	Indicators	Monitoring Method
HCV 1: Significant concentrations of biodiversity	See Table 8.1.Population size or occupancy statistics for six	Line transects, fecal DNA capture-recapture, occupancy

values	landscape species as indicators of the status of other threatened and/or endemic species	surveys (see above)
HCV 2: Landscape level forests	Forest cover	Remote sensing forest cover assessments (see earlier in Section 8)
HCV 3: Threatened ecosystems	Forest cover & condition	Remote sensing forest cover assessments (see earlier in Section 8); measurements of forest condition during reassessment of the project baseline

8.2 Data and Parameters Available at Validation (CL3)

Data Unit / Parameter:	**Regional forest cover at time t in historical reference period**
Data unit:	ha
Description:	Extent of vegetation meeting forest definition in reference region
Source of data:	Analysis of Landsat and radar satellite imagery for the years 1998, 2000, 2002, 2004, 2006, 2008 and 2010, as detailed in Annex 4.5
Value applied:	Please see Annex 5.1 supporting materials.
Justification of choice of data or description of measurement methods and procedures applied:	Suitable national datasets do not exist. Interpretation followed standard practice in this field and achieved a 93% overall accuracy for the 2002 dataset.
Any comment:	Dataset allows amount of deforestation to be estimated between any pair of dates by subtraction, and also for any subset of the reference region (e.g. the project area and leakage belt)

Data Unit / Parameter:	**Extent of land-cover classes, 2010**
Data unit:	ha
Description:	Extent of vegetation classified as dense forest, open forest, non-forest and water at the project start date.
Source of data:	Derived from the regional forest cover map mentioned above; see Annex 4.5
Value applied:	Please see Table 4.6 and figure 4.3b
Justification of choice of data or description of measurement methods and procedures applied:	Suitable national datasets do not exist. Interpretation followed standard practice in this field and achieved a 93% overall accuracy for the 2002 dataset.
Any comment:	

Data Unit / Parameter:	**Driver stratum boundaries**
Data unit:	ha
Description:	Extent of land within the reference region accessible to two groups of agents of deforestation – smallholder farmers (Stratum 1) and Economic Land Concessions (ELCs; Stratum 2)
Source of data:	Derived from an assessment of available data on agents of deforestation, in particular a database of ELC boundaries; see Annex 4.1
Value applied:	Varies over time. Please see Annex 4.1

Justification of choice of data or description of measurement methods and procedures applied:	Unplanned deforestation occurs overwhelmingly in Stratum 1 and planned deforestation in Stratum 2; these must be separated before rate and location of deforestation can be attempted.
Any comment:	

Data Unit / Parameter:	**Carbon stock in the above ground tree biomass pool**
Data unit:	tCO_2e/ha
Description:	Estimated carbon stock in live trees >5 cm DBH in each land cover class at project start date
Source of data:	For forest classes, statistically robust carbon inventory conducted in 2 phases, 2009 and 2011; for non-forest, survey of prevalence of crop types in 2009 combined with literature values and plots. Please see Annexes 5.3-5.5 for details
Value applied:	Please see Tables 5.6ai, 5.6aii and 5.7.
Justification of choice of data or description of measurement methods and procedures applied:	Mandatory carbon pool according to methodology. Standard plot-based and other other sampling procedures were used.
Any comment:	

Data Unit / Parameter:	**Carbon stock in the below ground tree biomass pool**
Data unit:	tCO_2e/ha
Description:	Estimated carbon stock in roots of live trees >5 cm DBH in each land cover class at project start date
Source of data:	Derived from carbon stock in above ground living trees (see above) according to a widely recognized conversion equation. Please see Annex 5.3 for details
Value applied:	Please see Tables 5.6ai, 5.6aii and 5.7.
Justification of choice of data or description of measurement methods and procedures applied:	Strongly recommended carbon pool according to methodology, 11.5% of total estimated GHG benefits. Standard plot-based and other other sampling procedures were used.
Any comment:	

Data Unit / Parameter:	**Carbon stock in the dead wood pool**
Data unit:	tCO_2e/ha
Description:	Estimated carbon stock in standing and lying dead wood in each land cover class at project start date
Source of data:	Please see Annexes 5.3 and 5.5 for details
Value applied:	Please see Tables 5.6ai, 5.6aii and 5.7.
Justification of choice of data or description of measurement methods and procedures applied:	Optional carbon pool according to methodology, 3% of total estimated GHG benefits. Standard plot-based and line-intersect sampling procedures were used.
Any comment:	

Data Unit / Parameter:	**Human population of the project area**
Data unit:	individuals
Description:	Official population of the 20 villages participating in the REDD project
Source of data:	Reported annually in the government's Commune Database for each year since 2002

Value applied:	Please see Annex 4.2
Justification of choice of data or description of measurement methods and procedures applied:	Official figures have been found to be a reliable measure of the resident population in the lanscape, subject to data screening to detect occasional obvious typographic errors.
Any comment:	

8.3 Data and Parameters Monitored (CL3, CM3 & B3)

Data Unit / Parameter:	**Extent of deforestation since project start date until time t**
Data unit:	ha
Description:	Decline in extent of vegetation meeting forest definition in extent of analysis (project zone or reference region as applicable)
Source of data:	Analysis of Landsat and radar imagery
Description of measurement methods and procedures to be applied:	Methods are described in Annex 4.5
Frequency of monitoring/recording:	Project zone prior to verification 1 and 3; entire reference region prior to verification 2 and 4
Value applied:	Please see Tables 5.3a-c
Monitoring equipment:	Standard computer hardware and software plus commerically available satellite imagery
QA/QC procedures to be applied:	
Calculation method:	Simple GIS analysis to report forest cover change between any two dates and for any relevant management unit
Any comment:	

Data Unit / Parameter:	**Extent of deforestation since project start date until time t in each forest type**
Data unit:	ha
Description:	Decline in extent of vegetation meeting definition of open forest or dense forest in extent of analysis (project zone or reference region as applicable)
Source of data:	Analysis of Landsat and radar imagery
Description of measurement methods and procedures to be applied:	Methods are described in Annex 4.5
Frequency of monitoring/recording:	Project zone prior to verification 1 and 3; entire reference region prior to verification 2 and 4
Value applied:	Please see Tables 5.5a-c
Monitoring equipment:	Standard computer hardware and software plus commerically available satellite imagery
QA/QC procedures to be applied:	
Calculation method:	Simple GIS analysis to report forest cover change between any two dates and for any relevant management unit
Any comment:	

Data Unit / Parameter:	**Driver stratum boundaries**
Data unit:	ha
Description:	Extent of land within the reference region accessible to two groups of agents of deforestation – smallholder farmers (Stratum 1) and Economic Land Concessions (ELCs; Stratum 2)

Source of data:	Derived from an assessment of available data on agents of deforestation, in particular a database of ELC boundaries; see Annex 4.1 for methods
Value applied:	Varies over time. Please see Annex 4.1.
Justification of choice of data or description of measurement methods and procedures applied:	Unplanned deforestation occurs overwhelmingly in Stratum 1 and planned deforestation in Stratum 2; these must be separated before rate and location of deforestation can be attempted.
Any comment:	Stratum 2 does not occur in the project area but does occur in the leakage belt and broader reference region.

Data Unit / Parameter:	**Human population of the project area**
Data unit:	individuals
Description:	Official population of the 20 villages participating in the REDD project
Source of data:	Reported annually in the government's Commune Database for each year since 2002
Value applied:	Please see Annex 4.2
Justification of choice of data or description of measurement methods and procedures applied:	Official figures have been found to be a reliable measure of the resident population in the lanscape, subject to data screening to detect occasional obvious typographic errors.
Any comment:	

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Annex 2.1 Workplan

Sub-Objectives and Actions	Activities	Indicators	Timing	Location	Explanatory notes
Sub-Objective #1: Key legal and planning documents for the SPF and surrounding landscape are approved and implemented					
Action #1: Support for sub-decree maintained among senior levels of government and general public	Maintain national level support and awareness	High level visits, annual reporting, national media visibility	as needed throughout project period	off-site	
	Maintain physical markers	Signboards etc	as needed throughout project period	main access points and junctions	
	Maintain provincial level support/awareness	Meetings held at Prov & Dist and comm & village level. Documents shared. MDK and KRT	as needed throughout project period	provincial/district capitals	
Action #2: Management plan approved and implemented (including zonation and regulations)	Provincial Deika on regulations	Community consent, provincial signature	2014-2015	all villages, provincial capital	Regulations will specify permitted activities for each zone in more detail than national law
	Agreement of Strictly Protected Zones	Community consent; physical demarcation	2014-2016	all villages, provincial capital	Acceptable zones will be identified through consultation; any displaced regular users will give consent and be compensated
	Management plan approved and implemented	Community consent, signed by minister, renewed as needed	2014-2015; renewed periodically	all villages, provincial capital	Specifies management objectives, zonation, regulations, staffing levels, workplan and monitoring
Action #3: Mondulkiri Provincial Corridors strategy implemented	Agreed strategy	Signed by MDK Gov'nor	2013-2015	provincial capital	Defines high priority areas for ecosystem protection and connectivity across whooe province
	Implement and monitor strategy	Implementor id'd. Evidence of problems mitigated/avoided	as needed throughout period of strategy	whole site	
	Coodinate with WWF on Kratie PCPU	PCPU formed, and providing assistance for SPF	as needed throughout period of strategy	Kratie town	
Action #4: Develop partnerships with the private sector in Mondulkiri (to reduce impacts by companies)	Coordinate with other NGOs working on mining and plantations	Effective joint NGO strategies	as needed throughout project period	as needed	
	Code of conduct for companies operating in SPF	Code agreed by FA and adherence monitored	to be determined	as needed	
Action #5: Develop international cross-border dialogue	Effective system in place to manage cross border issues	Reduced levels of cross-border threat	to be determined	as needed	System likely to include regular coordination meetings with 'opposite numbers' on Vietnamese side of border

Action #6: Adaptive Management (regular public reviews and workplans)	Miradi model in use and regularly updated	Conceptual model understood and used by all senior staff.	2011-2013	HQ	Miradi is a software package for managing the conceptual model and monitoring information
	Regular review of strategic plan	Plan remains relevant to current threats and opportunities	review every 3-5 years	HQ	
	Annual planning/reporting cycle with community involvement	Annual reporting by components and planning on time, widely shared; preparatory annual community workshop	annual	HQ	The process may eventually also lead to a formally recognisedy consultation committee made up of community reps
	Grievance procedures	Understood and used	as needed throughout period of strategy	all villages/communes	3rd- party system required - may be run by independent NGO or by Commune Councils
Sub-Objective #2: To reduce forest and wildlife crime by direct law enforcement					
Action #1: Enforce wildlife, forest and protected area laws and sub-decree through patrols	Regular Foot and vehicle patrols	Full spatial coverage. Highly targeted information-driven patrolling. Key threats reduced to near zero.	routine	whole project zone, mainly in project area	
	Ranger Stations Manned	All stations fully manned	routine	all stations in project area	
	Verify and respond to informant information	Most villages regularly sharing information	routine	all villages	
	Snare collection team	Snaring reduced to zero in all zones where forbdden	routine	whole project zone, mainly in project area	
Action #2: Establish and implement law enforcement monitoring framework	Monthly Patrol review and planning meetings	MIST report + summary report + snare team report + MIKE carcase reports	monthly	HQ	
	Quarterly evaluations against targets; annual reporting	Summary reports with recommendations + MIKE annual report	quarterly	HQ	
	Independent assessment of human activities from land-use mapping, monitoring team etc	Deforestation reports. MIST data from monitoring teams. Targeted monitoring of hotspot villages.	annual	as needed	
Action #3: Ensure sufficient patrol buildings, equipment and staffing	New stations built, HQ rebuilt, all stations maintained and full fleet of vehicles	All necessary stations built, vehicles not limiting activities	building program complete by 2017; routine mainenance	whole site	
	Field teams fully equipped	Field teams able to patrol safely in all seasons	routine	whole site	

	Field teams fully staffed		routine	whole site	
Action #4: Ensure sufficient patrol personnel capacity	Patrol strategy, techniques and legal training	Training sessions, skill levels	every 1-2 years or more as needed	whole site	
	MIST training	Training sessions, skill levels	1-2 per year or as needed	whole site	MIST is the software used to handle patrol data, providing summary tables and maps of effort/results
	First Aid and health and safety	Training sessions, skill levels	annual	HQ	
Action #5: Liaise with Provincial, National and other authorities	Work more closely with judiciary and use outside legal assistance	# of successful prosecutions; training on wildlife laws	recurrent, as needed	off-site	
	Continue good collaboration with MDK FA Cantonment; expand to Kratie	Quarterly reports from SPF to Cantonment; case reports; share work plans; [cooperation on technical issues see below]	routine	off-site	
Action #6: Establish Community-based Patrolling and/or monitoring system	Put mechanism in place	All key communities engaged; regular reviews of effectiveness	Pilot 2012-2014, roll out behind land use agreements; all key villages by 2020	all relevant villages	
	Bird's nest protection scheme	All known nests protected each year, breeding success high	initiate in 2014-2015	all relevant villages	Based on model developed in Northern Plains landscape.
Sub-Objective #3: Land and resource use by all core zone communities is sustainable					
Action #1: Form and maintain land-use agreements with communities	Monthly liaison with all villages	Regular meetings and follow-up	routine	all villages	
	Agreed land zonation for all villages	Approved by commune, included in management plan, physically demarcated, included in CLUPs (Commune Land-use Plans)	All relevant villages by 2019	all villages	Participatory mapping process; focus on near-village uses (residential, agriculture, fallow, spirit and burial sites)
	Zone management plans or resource management plans	Agreed in all villages where required to maximise carbon benefits or ensure sustainable harvests	All relevant villages by 2018	all villages	
	Participatory monitoring of agreements	All villages actively monitoring	routine monitoring, annual review	all villages	
Action #2: Legally registering communities and users	All eligible Indigenous Community Commissions (ICCs)registered		All relevant villages by 2019	all eligible and interested villages	Registration of the ICC is the first step to communal land registration
	All non ICC Community Based Organisations established		All elevant villages by 2019	all other villages wishing to form groups	
	Implement card system for		All relevant villages by 2018	all villages	Formalises Article 40 of the Forestry

	forest users				Law and helps to control non-legal users
Action #3: Indigenous land titling in appropriate communities	All ICT demarcated	Registered with MLMUPC	All relevant villages by 2019	all indigenous villages that choose communal land	
Action #4: Demarcation of the Forest Estate; recovery of unstocked areas	Demarcation of forest estate completed	Stakeholder agreement. Concrete posts in ground	All high priority boundaries by 2019	all forest boundaries, including indigenous land	
	Recovery of forest in key areas	Assisted natural regeneration in all appropriate areas	routine, as needed	selected areas of recent deforestation vulnerable to land-grabbing	
Action #5: Conduct extension and communication activities	Awareness raised and maintained among local authorities and NGOs	Sub-decree and REDD project understood by key stakeholders	routine, with major campaigns as needed	all villages	
	Manage Human-WilldifeConflict	Conflicts minimised, local attitudes acceptable	routine, as needed	all villages with significant HWC	
Action #6: Liaise with Commune Council and other agencies	Make inputs to Commune Development Plan/ Commune Investment Plan to include SPF priorities and prevent damaging activities	CDP/CIPs reflect SPF priorities	annual	All relevant villages and communes	
	Regular meetings with Commune Councils to discuss issues arising	Meetings held and reported. Issues solved	routine	all communes	
	Regular meetings with PSDD advisors & Prov Govnr office	Meetings held and reported	routine	provincial capital	
Action #7: Engage with civil society organisations operating in the Project area	Attend regular network meetings	NGOs have coordinated response to key issues	routine	as needed	
	Direct contracts or MoUs with key partners		as needed	as needed	
	Engage other local NGOs in annual planning cycle	NGOs give input to SPF annual and strategic plans	annual	HQ or other locations	
Action #8: Ensure the capacity of Project staff is sufficient	Training for staff and local NGO partners on land management issues	Increased understanding of training in law, conservation,NRM, facilitation skills, health and safety	annual or as needed	as needed	
	Increase proportion of locally hired staff	Majority of staff are residents of the provinces; more than 25% are native Bunong speakers	routine	as needed	
Sub-Objective #4: Support for alternative livelihoods that reduce					

deforestation					
Action #1: Establish tourism activities that benefit conservation	Wildlife-based tourism underway in all suitable villages	Financially and environmentally sustainable; target species stable/increasing	By 2019	to be determined (after feasibility studies)	
	Other forms of ecotourism active and well managed (e.g. wateralls, resorts, trekking)	number of visitors, level of income to village and SPF	By 2019	to be determined (after feasibility studies)	
Action #2: Support agricultural extension activities	Relevant NGO partners active in all villages	Reduced demand for fresh land, increased compliance with REDD targets due to incentives, enhanced climate change adaptation	All relevant villages by 2019	all villages	
Action #3: Provide infrastructure support linked to conservation activites	Infrastructure support as requested by target communities.	Increased compliance with REDD targets due to incentives	All relevant villages by 2019	all villages	
Action #5: Develop NTFP-based livelihood projects	NTFP-linked livelihoods sustainable and profitable in all relevant villages	No NTFPs being over-harvested; improved incomes reduce pressure for deforestation	All relevant villages by 2019	to be determined (after feasibility studies)	
Action #5: Develop and manage a system to share carbon benefits	Create model for benefit sharing (direct and indirect)	model created and implemented	All relevant villages within 2 years of first carbon sale	all villages	
	Identify suitable forms of assistance		All relevant villages within 2 years of first carbon sale	all villages	
Action #6: Improve literacy and numeracy	Literacy campaign covers whole landscape.	high levels of functional literacy and numeracy in all villages; increased opportunities for off-farm employment	All relevant villages by 2019	all key villages	
Sub-Objective #5:Collect information on long-term ecological and social trends					
Action #1: Monitoring of trends in forest cover	Regular deforestation monitoring reports, SPF and surroundings	reports distributed	internal assessments every 1-3 years; full assessments according to verification schedule	whole site	
Action #2: Monitoring of key willdife species	Regular line transect surveys of ungulates, primates etc	reliable densities and trend data for all target key species	1-2 year cycle, as feasible	core area	
	Periodic systematic surveys of elephant, otter, Eld's Deer and other target species	reliable trend data for all key species in conceptual model	2-5 year cycles as appropriate	as needed	

	Informant system for key species and for human-animal conflict	Regular community reporting of selected key species. Regular community based-monitoring of human-animal conflcit	systems in place by 2014	as needed	
	Camera-trapping for other target species; exploratory surveys to find new key species populations; vulture restaurants		as needed	as needed	
Action #3: Socio-economic and demography monitoring	Regular demographic surveys	demographic trends clearly understood; new threats detected	1-3 year cycle as feasible	all villages	
	Social benefit/impact monitoring consistent with CCBA	System desigend and outlined in PDD; overall wellbeing indicators and results of specific interventions	to be determined in design process	all villages	
Action #4: Facilitate research that will benefit the management of the SPF	Maintain list of priority research topics	Researchers attracted to do research on SPF priority list	routine	HQ	
	Regular production of papers and reports in khmer and English	Published research relevant to SPF profile or management planning	as needed	as needed	
	Oversee visiting researchers	Published research relevant to SPF profile or management planning	as needed	as needed	
	Construction of a research and training centre	Centre built, often used	date to be determined	to be determined, probably near HQ	
Action #5: Ensure sufficient staff capacity is available	Training courses in social and biological monitoring techniques	number of people capable of carrying out social and biological monitoring	as needed	as needed	
	Recruit staff, where possible locally resident	# staff recruited	routine	as needed	
Sub-Objective #6: Effective administrative, accounting and logistical procedures are in place					
Action #1: Organise evaluation and feedback on staff capacity, effectiveness and training requirements	Staff reviews	Managers review team member performance	annual or as needed	as needed	
Action #2: Develop and maintain effective management, administrative and accounting systems	Hire and retain on-site admin staff		routine	as needed	
	Management team meet regularly	Weekly progress meetings; quarterly budget meetings	weekly and quarterly	as needed	

Sub-Objective #7: Long-term financial security					
Action #1: Develop and Implement REDD project	Gain and maintain community consent; impact assessments and HCV assessment	Agreements made and regularly renewed	before validation, plus reviews before 10-yearly revalidation	all villages	
	Initial validations and revalidation	Vallidations achieved and renewed	once per fixed baseline period	as needed	
	Reporting, verification, registration	Reports submitted, verified	2-3 yearly (see Section 8)	as needed	
	Marketing and sales		as needed	as needed	
Action #2: Establish financial mechanism for REDD revenues and other income	Finalise Business plan	finished and written up	2013	as needed	
	Prepare scoping paper on fund structure	Completed and distributed	2013	as needed	
	Consultations with legal & financial experts, and stakeholders	Agreed design for fund & launch	before first sales	as needed	
	Consultatins with potential donors	Donor interest	routine	as needed	
Action #3: Obtain continued support of a wide range of donor partners	Continued fund raising from usual and new sources	$ raised	routine	as needed	
	Facilitation of site visits	# visits	routine	as needed	
Action #4: Increase use of commune development funds for project activities	Proportion of locally administered investment funds spent on SPF priorities		annual	all communes	

Annex 2.2 Non-permanence risk assessment

Introduction

One of the main elements of the REDD+ concept is that emission reductions have to be permanent. In the case of AFOLU projects, permanence of emission reductions can be at risk due to various factors and has therefore to be assessed in order to determine the necessity and level of buffer credits to be set aside for mitigating the potential effects of non-permanence of generated emission reductions. In accordance with the applied methodology, non-permanence risks have been determined using the most recent version (version 3.2) of the VCS AFOLU Non Permanence Risk Tool. Non-permanence risk assessment has been conducted in the following two steps:

- Step 1: Risk analysis (internal, external and natural risks);
- Step 2: Overall non-permanence risk rating and buffer determination.

Risk factors are classified into three categories: internal risks, external risks and natural risks, and further into sub-categories such as project management, financial viability and community engagement. The project has been evaluated against each of the risk factors in each category and sub-category as set out in the sections below. A risk score has been assigned to each risk factor, which was then used to determine the risk rating for each risk sub-category and category, based on the provided equations.

Internal Risk

Internal risks are non-permanence risks related to the management of the emission reduction activities, the financial viability of the planned project, the opportunity costs of the implementation of the planned activities, as well as the expected duration of the project.

Risks from weaknesses in project management are assessed as very low due to the high capacity of the implementing partners and the existence of a formal adaptive management system. The financial viability of the project is good, with a rapid breakeven point once credit sales begin, but limited callable resources or other funding streams prior to that. The high Net Present Value of alternative land uses relative to the income expected from the project also poses a risk, but this is largely offset by the strong legal basis for long-term protection at the site. The detailed calculations are presented below.

Project Management		
Risk Factor	Risk Factor and/or Mitigation Description	Risk Rating
a)	Species planted (where applicable) associated with more than 25% of stocks on which GHG credits have previously been issued are not native or proven to be adapted to the same or similar agro-ecological zones (s) in which the project is located. **Not applicable.**	NA
b)	Ongoing enforcement to prevent encroachment by outside actors is required to protect more than 50% of stocks on which GHG credits have previously been issued. Not **Applicable**. No GHG credits have previously been issued.	0
c)	Management team does not include individuals with significant experience in all skills necessary to successfully undertake all project activities (ie, any area of required experience is not covered by at least one individual with at least 5 years experience in the area). **Applicable**. *Mitigation*: Section 1.5 shows the participating organisations have strong track records and a pool of suitably qualified staff. Qualifications of key staff currently involved in the project can be provided on request. **Residual risk** – nil.	0
d)	Management team does not maintain a presence in the country or is located more than a day of travel from the project site, considering all parcels or polygons in the project area. **Applicable.** Management team is based partly on site and partly in Phnom Penh, less than 5 hours travel from the site. **Residual risk** – nil.	0

e)	***Mitigation:*** *Management team includes individuals with significant experience in AFOLU project design and implementation, carbon accounting and reporting (eg, individuals who have successfully managed projects through validation, verification and issuance of GHG credits) under the VCS Program or other approved GHG programs.* ***Applicable****. But the in-country management team does not currently include such individuals.*	*0*
f)	***Mitigation****: Adaptive management plan in place.* ***Applicable****. Fully implemented. Since 2009 SPF has operated under an adaptive management cycle involving systematic monitoring, annual participatory review of progress, drafting of workplans and updating strategic plans.*	*-2*
Total Project Management (PM) [as applicable, (a + b + c + d + e + f)] Total may be less than zero.		**-2**

Financial Viability		
Risk Factor	Risk Factor and/or Mitigation Description	Risk Rating
a)	Project cashflow breakeven point is greater than 10 years from current risk assessment **Not applicable**	NA
b)	Project cashflow breakeven point is between 7 up to 10 years from current risk assessment **Not applicable**	NA
c)	Project cashflow breakeven point is between 4 up to 7 years from current risk assessment **Not applicable**	NA
d)	Project cashflow breakeven point is less than 4 years from current risk assessment **Applicable** Breakeven point is predicted to be early in project life as shown by the financial projections in Annex 2.3	0
e)	Project has secured less than 15% of funding needed to cover the total cash out before the project reaches breakeven **Applicable** Project is largely dependent on revenues from REDD sales to reach breakeven.	3
f)	Project has secured 15% to less than 40% of funding needed to cover the total cash out before the project reaches breakeven **Not applicable**	NA
g)	Project has secured 40% to less than 80% of funding needed to cover the total cash out before the project reaches breakeven **Not applicable**	NA
h)	Project has secured 80% or more of funding needed to cover the total cash out before the project reaches breakeven **Not applicable**	NA
i)	***Mitigation****: Project has available as callable financial resources at least 50% of total cash out before project reaches breakeven.* ***Applicable*** *But project lacks these callable resources.*	0
Total Financial Viability (FV) [as applicable, ((a, b, c or d) + (e, f, g or h) + i)] Total may not be less than zero.		**3**

Opportunity Cost		
Risk Factor	Risk Factor and/or Mitigation Description	Risk Rating
a)	NPV from the most profitable alternative land use activity is expected to be at least 100% more than that associated with project activities; or where baseline activities are subsistence driven, net positive community impacts are not demonstrated. **Applicable**.	8
b)	NPV from the most profitable alternative land use activity is expected to be between 50% and up to 100% more than from project activities	NA
c)	NPV from the most profitable alternative land use activity is expected to be between 20% and up to 50% more than from project activities	NA

d)	NPV from the most profitable alternative land use activity is expected to be between 20% more than and up to 20% less than from project activities; or where baseline activities are subsistence-driven, net positive community impacts are demonstrated.	NA
e)	NPV from project activities is expected to be between 20% and up to 50% more profitable than the most profitable alternative land use activity	NA
f)	NPV from project activities is expected to be at least 50% more profitable than the most profitable alternative land use activity.	NA
g)	***Mitigation:*** *Project proponent is a non-profit organization* **Not applicable** *Proponent is government agency.*	*NA*
h)	***Mitigation:*** *Project is protected by legally binding commitment (see Section 2.2.4) to conitue management practices that protect the credited carbon stocks over the length of the project crediting period.* **Applicable** *The Subdecree creating the SPF is indefinite in duration.*	*-2*
i)	***Mitigation****: Project is protected by legally binding commitment (see Section 2.2.4) to conitue management practices that protect the credited carbon stocks over at least 100 years.* **Applicable** *The Subdecree creating the SPF is indefinite in duration.*	*-8*
Total Opportunity Cost (OC) [as applicable, (a, b, c, d, e or f) + (g or h)] Total may not be less than 0.		**0**

Project Longevity		
a)	Without legal agreeement or requirement to continue the management practice.**Not applicable.**	NA
b)	With legal agreeement or requirement to continue the management practice. **Applicable.** Legal status can be assumed to apply through to the 100 year time horizon cutoff. Therefore score is calculated as 30-(100/2) = -20. Negative scores are not permitted so score = 0	0
Total Project Longevity (PL) May not be less than zero		**0**

Internal Risk	
Total Internal Risk (PM + FV + OC + PL) Total may not be less than zero.	**(-2)+3+0+0 = 1**

External Risks

The land tenure complexity set out in Section 1.3 of the PD leads to some assessed risk. The continued existence of the Samling concession contract poses a theoretical risk regarding benefit-share arrangements and so conservatively the maximum score has been given for this criterion. Furthermore, in a small percentage of the forest (<3%) the local communities may be able to claim formal legal ownership of forest lands. The estimated risk scores are reduced somewhat by the clearly established legal basis for protection of the SPF and the evidence of strong community agreements clarifying the status of these overlapping claims with respect to the REDD project. Cambodia's relatively low scores on the database of Worldwide Governance Indicators increase the assessed risk, although this is partly offset by the existence of a national REDD+ Readiness process.

Land Ownership and Resource Access/Use Rights		
Risk Factor	Risk Factor and/or Mitigation Description	Risk Rating
a)	Ownership and resource access/use rights are held by same entity(s)	0

	Applicable. The Forestry Administration holds these rights on behalf of the Cambodian government.	
b)	Ownership and resource access/use rights are held by different entity(s) (eg, land is government owned and the project proponent holds a lease or concession) **Not Applicable**.	NA
c)	In more than 5% of the project area, there exist disputes over land tenure or ownership **Applicable** The continued existence of the Samling logging concession (see Section 1.3 and 3.2) raises the theoretical possibility that Samling may wish to be involved in benefit-sharing from the project. The assessment of the proponent is that this will not occur, but to be conservative this score is included in the calculations. from land remaining under government ownership (Sections 3.2 and 3.7).	10
d)	There exist disputes over access/use rights (or overlapping rights) **Applicable** No dispute exists. It is acknowledged that overlapping rights exist over an estimated <3% of the project area as a result of land being potentially eligible for conversion to Indigenous Communal Title. *Mitigation* – all communities with potential claims have signed agreements that credits from those areas potentially eligible for titling will continue to be amalgamated into a single REDD project. A process of assisting these villages to map and claim their titles is well underway.	5
e)	WRC projects unable to demonstrate that potential upstream and sea impacts that could undermine issued credits in the next 10 years are irrelevant or expected to be insignificant, or that there is a plan in place for effectively mitigating such impacts. **Not applicable**	NA
f)	*Mitigation: Project area is protected by legally binding commitment (eg, a conservation easement or protected area) to continue management practices that protect carbon stocks over the length of the project crediting period* **Applicable** *The Subdecree creating the SPF is indefinite in duration.*	-2
g)	*Mitigation: Where disputes over land tenure, ownership or access/use rights exist, documented evidence is provided that projects have implemented activities to resolve the disputes or clarify overlapping claims* ***Applicable*** *The consent processes described in Sections 2.7 and 3.7 effectively resolve all overlapping community claims.No formal mechanism is believed to be needed to resolve the Samling issue.*	-2
Total Land Tenure (LT) [as applicable, ((a or b) + c + d + e+ f)] Total may not be less than zero.		**11**

Community Engagement		
Risk Factor	Risk Factor and/or Mitigation Description	Risk Rating
a)	Less than 50 percent of households living within the project area who are reliant on the project area, have been consulted **Applicable**. But far more than 50% of households have been consulted, see Sections 2.7 and 3.7.	0
b)	Less than 20% percent of households living whithin 20km of the project boundry outside the project area, and who are reliant on the project area, have been consulted. **Applicable** The great majority of dependent households living outside the project area have also been consulted, see Sections 2.7 and 3.7.	0
c)	**Mitigation:** The project generates net positive impacts on the social economic well-being of the local communities who derive livelihoods from the project area	-5
Total Community Engagement (CE) [where applicable, (a+b+c)] Total may be less than zero.		**-5**

Political Risk		
Risk Factor	Risk Factor and/or Mitigation Description	Risk Rating
a)	Governance Score of less than -0.79 **Applicable**. Cambodia has a score of -0.84 (calculations available on request).	6

b)	Governance Score of -0.79 to less than -0.32 **Not applicable**	NA
c)	Governance Score of -0.32 to less than -0.19 **Not applicable**	NA
d)	Governance Score of 0.19 to less than 0.82 **Not applicable**	NA
e)	Governance Score of 0.82 or higher **Not applicable**	NA
f)	**Mitigation:** Country is implementing REDD+ Readiness or other activities, as set out in this section 2.3.3 **Applicable.** Cambodia is conducting a REDD+ Readiness process with supoort from both FCPF and UN-REDD.	-2
Total Political (PC) [as applicable ((a, b, c, d or e) + f)] Total may not be less than zero.		**4**

External Risk	
Total External Risk (LT + CE + PC) Total may not be less than zero.	**11+(-5)+4 = 10**

Natural Risks

Fire (F)	
Significance	**Insignificant losses**
Likelihood	Every less than 10 years.
Score (LS)	1
Mitigation	0
Pest and Disease Outbreaks (PD)	
Significance	**No loss**
Likelihood	NA
Score (LS)	0
Mitigation	NA
Extreme Weather (W)	
Significance	**No loss**
Likelihood	NA
Score (LS)	0
Mitigation	NA
Geological Risk (G)	
Significance	**No loss**
Likelihood	NA
Score (LS)	0
Mitigation	NA

Score for each natural risk applicable to the project (Determined by (LS × M)	
Fire (F)	2
Pest and Disease Outbreaks (PD)	0
Extreme Weather (W)	0
Geological Risk (G)	0
Other natural risk (ON)	NA
Total Natural Risk (as applicable, F + PD + W + G + ON)	**2**

Overall Non-Permanence Risk Rating and Buffer Determination

Overall Risk Rating

Risk Category	Rating
a) Internal Risk	1
b) External Risk	10
c) Natural Risk	2

Overall Risk Rating (a + b + c)	**13**

The project has a calculated risk rating of 13%. The minimum risk rating for a VCS AFOLU project is 10%, so the SPF project has a rating of 13%. This is equivalent to a 13% risk buffer set-aside at the time of each verification event.

Calculation of Total VCUs

The number of buffer credits is calculated in Step 9 of the Project Document.

Annex 2.3 Financial model

The project financial model is contained in a set of spreadsheets, which are available to the validator on request. It contains the following elements:

1. a cost model based on past operations at the site:
   - the cost model includes a worksheet for each of the main compenents of the project (site management, law enforcement, biological monitoring, community engagement and land tenure etc), a set of sheets collating subtotals and a master sheet summarizing the annual costs
   - the cost model also has a dashboard sheet containing a number of variables that the project planner can adjust to cost differing scenarios. These include three broad, user-defined scenarios regarding the overall level of ambition (default values being 1x, 2x and 3x the basic funding level) and a number of variables that can be adjusted independently (e.g. number of vehicles, number of sub-stations, tax and inflation rates).

2. a set of sample outputs from the cost model, embodying scenarios that are likely to be relevant to the project crediting period. Three sample scenarios are provided (H – High, M – medium and M2 lower medium) and others can be generated.

3. revenue projections, based on the predicted VCU volumes in Section 9 of the PD and the monitoring and verification schedule proposed in Section 1.7. The PD only predicts revenues for the first fixed baseline period. Revenues are expected to be markedly lower in subsequent periods due to the shape of the deforestation curve in Annex 5.1 Therefore an indicative, conservative estimate of 500,000 credits per year during 2020-2029 and zero further revenues thereafter has been used for budgeting purposes.

4. a 30 year project budget, which is presented below as Tables 1 and 2. The main elements of this are
   - annual operating costs based on the various scenarios mentioned above
   - annual grant (non-REDD) revenues following Annex 4.4
   - REDD credit sale revenues, based on point 3 above
   - expenditure from the sale revenues under three headings
     - annual operating costs net of grant revenues
     - deposits into a long term permanence fund
     - unassigned net revenues available for community benefit-sharing and for other expenditures

The permanence fund is designed to allow for the need for long-term operating funds beyond the period during which revenues are expected. It can be capitalised to a sufficient level to ensure core operating costs are available over a 100 year horizon, although clearly precise financial projections over such a long period are challenging.

Since the benefit-sharing mechanism and division of funds have not yet been decided pending community consultations and governmental decisions, no effort is made here to estimate the amounts involved.

Table 1 – Financial model, 2010-2024

	Year														
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Annual budget for management of SPF															
Budget level	a	a	a	a	M	M	H	H	H	H	M	M	M	M	M
Annual budget for core management activities of SPF	399,241	329,703	320,355	195,042	1,321,937	1,321,937	1,816,196	1,816,196	1,816,196	1,816,196	1,321,937	1,321,937	1,321,937	1,321,937	1,321,937
REDD valid./verif costs (annualized)					46,168	46,168	46,168	46,168	46,168	46,168	46,168	46,168	46,168	46,168	46,168
Total required budget	399,241	329,703	320,355	195,042	1,368,104	1,368,104	1,862,364	1,862,364	1,862,364	1,862,364	1,368,104	1,368,104	1,368,104	1,368,104	1,368,104
ANNUAL OPERATING DEFICIT/SURPLUS															
Grant funding	399,241	329,703	320,355	195,042	195,042	195,042	195,042	195,042	195,042	195,042	195,042	195,042	195,042	195,042	195,042
Annual financing surplus/deficit before REDD revenue	0	0	0	0	1,173,062	1,173,062	1,667,322	1,667,322	1,667,322	1,667,322	1,173,062	1,173,062	1,173,062	1,173,062	1,173,062
REDD REVENUES															
Sales revenues				3,412,163		19,202,645		53,267,972	-	-	77,739,241	0	3,000,000	-	3,000,000
Cumulative annual revenues from REDD				**3,412,163**	**3,412,163**	**22,614,808**	**22,614,808**	**75,882,780**	**75,882,780**	**75,882,780**	**153,622,021**	**153,622,021**	**156,622,021**	**156,622,021**	**159,622,021**
ANNUAL OPERATIONS PAYMENTS FROM REDD REVENUES															
REDD fund payments for annual operations					1,173,062	1,173,062	1,667,322	1,667,322	1,667,322	1,667,322	1,173,062	1,173,062	1,173,062	1,173,062	1,173,062
Cumulative spend on annual operations					**1,173,062**	**2,346,124**	**4,013,446**	**5,680,768**	**7,348,090**	**9,015,412**	**10,188,474**	**11,361,536**	**12,534,599**	**13,707,661**	**14,880,723**
PERMANENCE FUND															
Payments into permanence fund						10,000,000		30,000,000			40,000,000				
Payments out of permanence fund															
Size of permanence fund						**10,000,000**	**10,000,000**	**40,000,000**	**40,000,000**	**40,000,000**	**80,000,000**	**80,000,000**	**80,000,000**	**80,000,000**	**80,000,000**
UNASSIGNED FUNDS															
Funds net of operating costs and permanence fund				**3,412,163**	**2,239,100**	**10,268,684**	**8,601,362**	**30,202,012**	**28,534,690**	**26,867,368**	**63,433,547**	**62,260,485**	**64,087,423**	**62,914,361**	**64,741,299**

Table 2 Financial model 2025-2039

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Annual budget for management of SPF															
Budget level	M	M	M	M	M	M2	M2	M2	M2	M2	M2	M2	M2	M2	M2
Annual budget for core management activities of SPF	1,321,937	1,321,937	1,321,937	1,321,937	1,321,937	1,124,695	1,124,695	1,124,695	1,124,695	1,124,695	1,124,695	1,124,695	1,124,695	1,124,695	1,124,695
REDD valid./verif costs (annualized)	46,168	46,168	46,168	46,168	46,168	46,168	46,168	46,168	46,168	46,168	46,168	46,168	46,168	46,168	46,168
Total required budget	1,368,104	1,368,104	1,368,104	1,368,104	1,368,104	1,170,863	1,170,863	1,170,863	1,170,863	1,170,863	1,170,863	1,170,863	1,170,863	1,170,863	1,170,863
ANNUAL OPERATING DEFICIT/SURPLUS															
Grant funding	195,042	195,042	195,042	195,042	195,042	195,042	195,042	195,042	195,042	195,042	195,042	195,042	195,042	195,042	195,042
Annual financing surplus/deficit before REDD revenue	1,173,062	1,173,062	1,173,062	1,173,062	1,173,062	975,821	975,821	975,821	975,821	975,821	975,821	975,821	975,821	975,821	975,821
REDD REVENUES															
Sales revenues	-	3,000,000	-	3,000,000	-	3,000,000									
Cumulative annual revenues from REDD	**159,622,021**	**162,622,021**	**162,622,021**	**165,622,021**	**165,622,021**	**168,622,021**	**168,622,021**	**168,622,021**	**168,622,021**	**168,622,021**	**168,622,021**	**168,622,021**	**168,622,021**	**168,622,021**	**168,622,021**
ANNUAL OPERATIONS PAYMENTS FROM REDD REVENUES															
REDD fund payments for annual operations	1,173,062	1,173,062	1,173,062	1,173,062	1,173,062	975,821	975,821	975,821	975,821	975,821	975,821	975,821	975,821	975,821	975,821
Cumulative spend on annual operations	**16,053,785**	**17,226,847**	**18,399,909**	**19,572,972**	**20,746,034**	**21,721,855**	**22,697,675**	**23,673,496**	**24,649,317**	**25,625,138**	**26,600,959**	**27,576,780**	**28,552,601**	**29,528,422**	**30,504,243**
PERMANENCE FUND															
Payments into permanence fund															
Payments out of permanence fund							975,821	975,821	975,821	975,821	975,821	975,821	975,821	975,821	975,821
Size of permanence fund	**80,000,000**	**80,000,000**	**80,000,000**	**80,000,000**	**80,000,000**	**80,000,000**	**79,024,179**	**78,048,358**	**77,072,537**	**76,096,716**	**75,120,895**	**74,145,075**	**73,169,254**	**72,193,433**	**71,217,612**
UNASSIGNED FUNDS															
Funds net of operating costs and permanence fund	**63,568,236**	**65,395,174**	**64,222,112**	**66,049,050**	**64,875,988**	**66,900,167**	**66,900,167**	**66,900,167**	**66,900,167**	**66,900,167**	**66,900,167**	**66,900,167**	**66,900,167**	**66,900,167**	**66,900,167**

Annex 2.4 Analysis of stakeholder interests

A Interests of on-site community stakeholders

Stakeholder group/sub-group	Interests in the project	Effect of the project on their interests*	Capacity and motivation to participate	Relationship w other stakeholders
Key village Indigenous families				
typical families (2+ adults, usually both farming and tapping)	land and forest protection, continued access, freedom to develop, better governance, development assistance, jobs	generally positive.	usually moderate capacity; motivation depends on perceived project benefits	some conflict/distrust with Khmer settlers, some mutual support to poorest indigenous families
wealthy families / officials/NGO staff	land and forest protection, continued access, freedom to develop, better governance, development assistance, jobs	generally positive.	usually high capacity; motivation depends on perceived project benefits	
single parent/other poorest	land and forest protection, continued access, freedom to develop, better governance, development assistance, jobs	generally positive, elevated risk of negative impacts due to high intrinsic vulnerability	low capacity; motivation depends on perceived project benefits	some dependence on other families
bamboo collectors	forest protection, freedom to develop, continued access, better governance, development assistance, jobs	positive in long term, could be negative in short term	variable capacity; motivation depends on perceived project benefits	
specialist cash-croppers (no tapping)	land protection, freedom to develop, better governance, development assistance, jobs	neutral or positive.	higher capacity?; motivation depends on perceived project benefits	
Key villages Khmer families				
typical families – 2+ adults cash crops, no tapping	land protection, freedom to develop, better governance, development assistance, jobs	reduced scope for illegal land clearance	variable capacity; motivation depends on perceived project benefits	
forest dependent (tappers, bamboo collectors)	land and forest protection, continued access, freedom to develop, better governance, development assistance, jobs	generally positive.	usually moderate capacity; motivation depends on perceived project benefits	
single parent/other poorest (forest or farm dependent)	land and forest protection, continued access, freedom to develop, better governance, development assistance, jobs	generally positive, elevated risk of negative impacts	low capacity; motivation depends on perceived project benefits	
traders, officials, other off-farm incomes	better governance, development assistance, jobs	generally positive?; reduced scope for illegal land sales	high capacity, motivation to work on nat. resources often limited	

specialist wage labourers/ landless	better governance, development assistance, jobs, possibly allocation of land	?	variable capacity; motivation depends on perceived project benefits	
Other user villages				
Resin tappers	land and forest protection, continued access, freedom to develop, better governance, development assistance, jobs	generally positive.	usually moderate capacity; motivation depends on perceived project benefits	links with local traders (resin, other products, credit/debt)
Non-resin tappers (fishing, other NTFPs)	land and forest protection, continued access, freedom to develop, better governance, development assistance, jobs	generally positive.	usually moderate capacity; motivation depends on perceived project benefits	

B Interests of off-site community stakeholders

Stakeholder group	Interests in the project	Effect of the project on their interests	Capacity and motivation to participate	Relationship w other stakeholders
People dependent on the environmental services of the area	Continued maintenance of services (climate, watershed, fisheries)	positive.	Capacity limited as mostly distant and poor -e.g. few business/urban users	Little relationship - population diffuse, distant, no mechanisms for expressing concerns
People interested in settling in the area or selling land	Limited. Migration to existing villages where space exists for outsiders in the land-use plans	largely negative, through preventing illegal activities (land grabbing, deforestation etc)	Not applicable, as cannot be identified in advance; limited motivation.	Conflict with existing forest/land users; cooperation with relatives in some cases
People interested in harvesting resources in the area	Limited. Benefit from improved status of resources but likely to have reduced access.	largely negative, through preventing illegal activities (most occasional visitors harvest using unsustainable methods)	Not applicable, as cannot be identified in advance; limited motivation.	Conflict with existing forest/land users; cooperation with relatives in some cases

C Interests of government and NGO stakeholders

Stakeholder group	Interests in the project	Effect of the project on their interests	Capacity and motivation to participate	Relationship w other stakeholders
Government				
Provincial authorities	Improved governance, livelihoods, environmental services	potential conflicts with desire for rapid economic development projects	High capacity and high motivation	Position of high authority
District authorities	Improved governance, livelihoods, environmental services	potential conflicts with desire for rapid economic development projects	High capacity and high motivation	Position of high authority
Commune Councils	Improved governance, livelihoods, environmental services	potential conflicts with desire for rapid economic development projects	Low to moderate capacity, motivation depends on perceived benefits to themselves and constituents	Position of authority; also responsible for resolving disputes
Technical line agencies	Depends on specific technical mandate	Depends on specific technical mandate	Typically moderate to high capacity, esp at provincial level	Position of authority
Armed Forces	Cooperation to reach shared goals	Overlapping jurisdictions, challenges to informal business activities	Highly variable capacity and motivation	Position of authority; some conflict with FA over enforcement of forestry laws
Non-government				
Private companies	Improved Corporate Social Responsibility, information sharing	May hinder their access to land and resources	High capacity, motivation depends on policies of each company	Variable - cooperation in some cases, conflict in others
NGOs	Cooperation, funding ensuring human rights	Largely or wholly positive.	High and high	Broadly cooperative; varying positions on illegal acts by community members

Annex 4.1 Stratification of the reference region

Introduction

A conservation finance project is being developed in the Core Area of the Seima Protection Forest (SPF), Cambodia under the REDD framework (Reduced Emissions from avoided Deforestation and Degradation). The project will follow a carbon accounting methodology validated against the Verified Carbon Standard. The chosen methodology is the Unplanned Deforestation Methodology, VM0015. (hereafter 'the methodology').

Where different agents of deforestation act within differing sections of the reference region the methodology (p 38) suggests that the region be stratified. This annex describes the process used to do this in the current project.

Stratification approach

The region is stratified in accordance with the analysis of the agents of deforestation presented in the Project Document. There are two groups of agents, namely smallholder farmers and economic land concessions (ELCs: large agro-industrial plantations). All unplanned deforestation is attributed to smallholder farmers, and this is the focus of the analysis below. Areas affected by small-holder farmers causing unplanned deforestation are placed in Stratum 1. The whole reference region is potentially attractive to smallholder farmers from an agronomic viewpoint, and a similar broad mixture of perennial and annual crops is grown across the whole area. Therefore the whole region fell in this stratum at the start of the historical reference period. Over time, as ELCs were issued and became active, sections of the reference region moved into the second stratum.

This agent does not act in the project area and planned deforestation of this kind is also not covered by the scope of the methodology, so this source of deforestation has to be separated from that of the first agent group during analysis. . It is not necessary to make projections of deforestation within Stratum 2 as it does not overlap with the project zone. It is conservatively assumed here that once an ELC becomes active, no further unplanned deforestation is possible within it but that smallholders already farming land within the boundary are not displaced. In practice, smallholders reportedly are displaced in some cases, if the concessionaire can demonstrate that they are illegally occupying state land, and this could cause a increased level of unplanned deforestation in what remains of stratum 1.

Evidence used to assign areas to Stratum 2

Information on whether a concession is active for the purposes of this analysis is drawn from legal documentation, information in the public domain and inspection of satellite images. A concession is assumed to be active during a given year if:

1. Key legal approvals have been granted and not subsequently cancelled AND
2. Evidence of company activities (e.g. large rectilinear areas of clearance and/or grids of roads) can be observed from satellite imagery during the relevant period.

Several stages of legal approvals are required in the process of issuing an ELC including reclassification of land on the state land register, investment contracts and approval of implementation plans. Given that it can be difficult to obtain evidence of these, confirmation of any one of these approvals being granted is considered sufficient for our purposes, if it occurs in combination with the evidence of on-the-ground activities in point 2 above.

Analysis of deforestation is done for successive 2-year time periods (e.g. 1998-1999, 2000-2001 etc). During a 2 year period when a given concession is deemed active, all deforestation is attributed to the concession. This is conservative as it probably disregards some areas of unplanned deforestation from the early part of the period in question, and if it was possible to identify and quantify these it would increase the overall level of unplanned deforestation used to callibrate the rate model for the project.

Figure 1 shows the expansion of Stratum 2 over time.

Figure 1 Varying locations of the two strata of the reference region over time

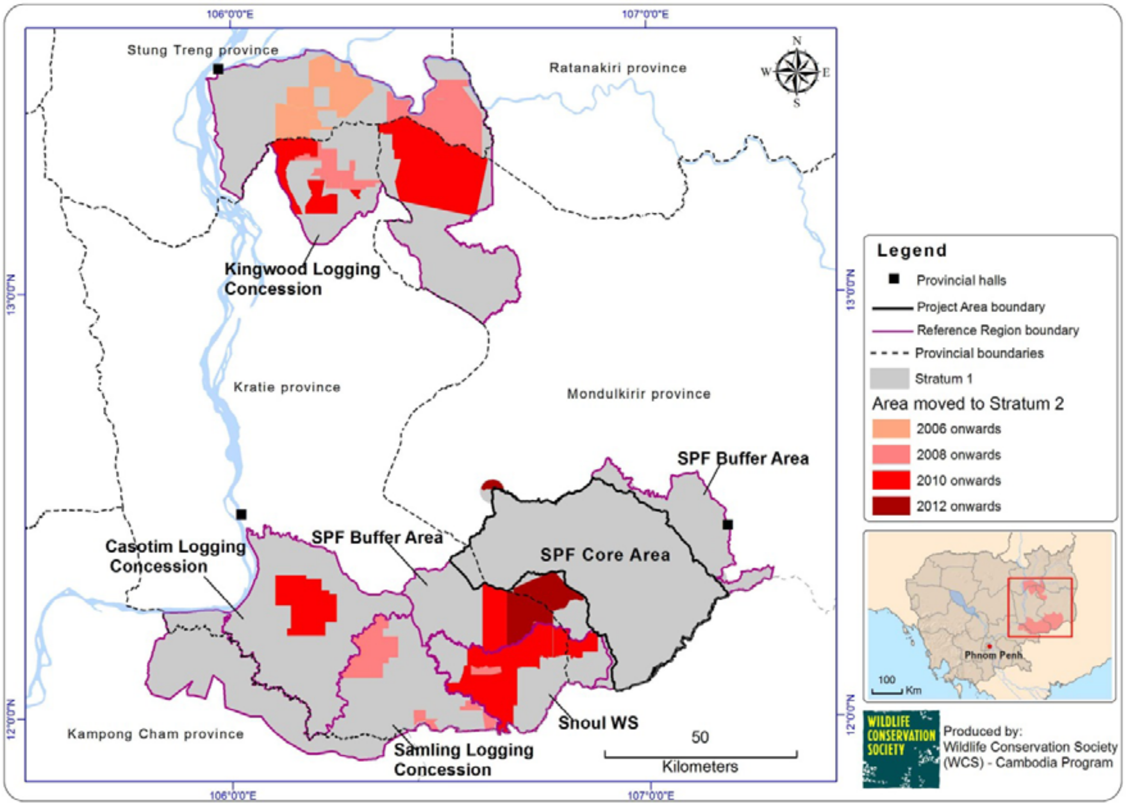


Table 1 shows the area of each stratum during each period of analysis. The final periods, 2010-2011 and 2012 onwards, form part of the first fixed baseline period, and the data are presented here to support the development of a projected baseline. The locations of ELCs cannot be projected beyond 2012 as the relevant planning processes are confidential. This is conservative since if further concessions are issued they will cause the size of the No ELC stratum to decrease, concentrating the same amount of unplanned deforestation into smaller area of concession-free land and raising the % deforestation rate within it.

Table 1 Stratification of the reference region

This Table fulfills the requirements of Table 8 in the methodology.

Stratum	Description	Area (ha) 98-99	00-01	02-03	04-05	06-07	08-09	10-11	2012 on
1. No ELC	No known active Economic Land Concession	966604	966604	966604	966604	937931	883995	758261	720752
2. ELC	Active Economic Land Concessions known	0	0	0	0	28673	82609	208342	245852
All strata		966604	966604	966604	966604	966604	966604	966604	966604
% in Stratum 2		0%	0%	0%	0%	3%	9%	27%	34%

Annex 4.2 Framework for analysis of leakage in the Seima Protection Forest

Summary

This Annex summarises the framework for estimating activity displacement leakage from the REDD project in the Core Area of the Seima Protection Forest. The analysis considers leakage due to activity displacement by smallholders, including those who are resident or move into the site and those who are deterred from moving to the site. Activity displacement leakage factors due to these two types of displacement are combined into a single ex-ante Leakage Displacement factor. A method is also described for calculating the actual Avoided Migration Displacement Factor during the project crediting period.

Introduction

A conservation finance project is being developed in the Core Area of the Seima Protection Forest (SPF), Cambodia under the REDD framework (Reduced Emissions from avoided Deforestation and Degradation). The project will follow a carbon accounting methodology validated against the Verified Carbon Standard. The chosen methodology is the Unplanned Deforestation methodology (hereafter 'the methodology'), which has been approved by VCS (VM0015).

Among other steps, this methodology requires an estimation of the degree to which emissions reductions in the project are displaced ('leak') to other locations and so continue to cause damage to the atmosphere. To estimate this leakage ex-ante a Displacement Leakage Factor (DLF) must be calculated. Ex-post, this leakage is monitored directly.

This report explains the framework used to analyse leakage from the project area both for ex-ante calculations and for project monitoring. The analysis considers leakage due to activity displacement by smallholders, including those who are resident/newly settled at the site and those who are deterred from moving to the site by project activities. Displacement of the former group is analysed within a spatially delimited leakage belt, defined below. Displacement of the latter group is estimated in comparison to projected levels of business-as-usual in-migration extrapolated from the historical reference period.

We calculate the DLF as the sum of two components, as follows:

$$DLF = DLFr+DLFa$$

where:

DLF = Displacement Leakage Factor, ie the percent of deforestation expected to be displaced outside the project boundary, %

DLFr = Displacement Leakage Factor for Residents, ie the the percent of deforestation attributable to resident smallholders (including those who have settled in the participating villages ince the start of the project crediting period) expected to be displaced outside the project boundary, %

DLFa = Displacement Leakage Factor for Avoided Migrants, ie the the percent of deforestation attributable to potential in-migrants who were deterred from settling due to the existence of the project and have hence been displaced outside the project boundary relative to the baseline scenario, %

Definition of the leakage belt for resident smallholders

Smallholder farmers generally conduct their operations at the family scale, in or near to the village where they reside or migrate to. Most families affected by the REDD project are expected to remain resident and in this case are spatially constrained in the locations that they can deforest. For these families a leakage belt has been defined according to a mobility analysis (Option II in the methodology section 1.1.3).

As described in the PD section discussing constraints to deforestation at a landscape scale, deforestation leakage by smallholders is facilitated by the widespread availability of suitable land and the limited enforcement of laws forbidding deforestation. Hence all forest areas can be considered agronomically suitable.

Resident smallholders are constrained primarily by practicalities such as travel time, so most farming takes place within a certain distance of existing settlements[17]. A mobility analysis was conducted, following Option II on the methodology (p22). We used empirical data to estimate a conservative threshold distance within which all forest clearance attributable to these settlements takes place. Using a GIS, a distance buffer was placed around the settlement centres within each of the 20 participating villages and the quantity of deforestation within each buffer was calculated. As shown in Table 1, deforestation drops off sharply with distance and the quantity of deforestation more than 3 km from the nearest settlement is negligible. This is evidence of a significant mobility constraint. It appears very unlikely that activity displacement leakage would take place more than 3 km from an identified settlement. Therefore we take 3 km around each participating settlement as the width of the leakage belt.

Table 1 Relationship between historical deforestation and distance to settlement centres

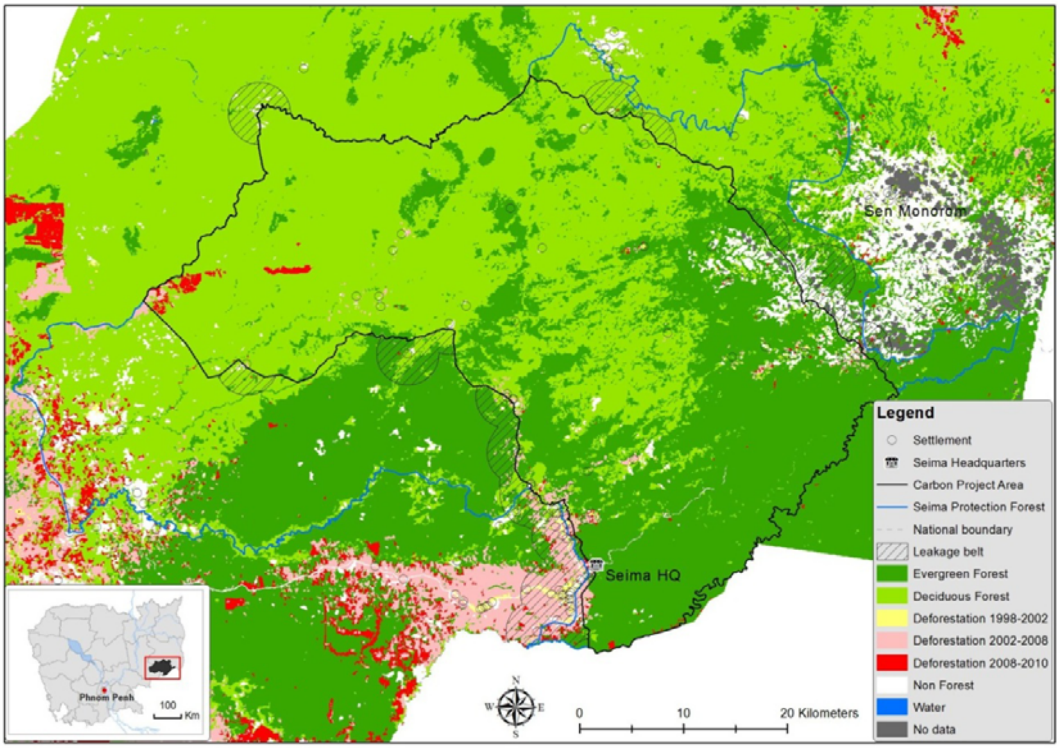
Distance Buffer in GIS	Area of forest in 2002/ha	Area of forest in 2010/ha	Area deforested 2002-2010/ha	% deforested over 8 years
0-1 km from settlements	4,003.3	1,953.5	2,049.8	51%
1-2 km from settlements	7,358.7	5,490.5	1,868.3	25%
2-3 km from settlements	8,129.0	7,656.1	472.9	6%
3-4 km from settlements	7,202.3	7,165.4	36.9	1%
4-5 km from settlements	6,837.7	6,812.3	25.4	0%
5-6 km from settlements	6,295.0	6,283.9	11.0	0%

The leakage belt excludes the three relatively distant ‘other user villages’ that use the project area only for collection of forest products and not for farming. No restriction on these livelihood activities is envisaged under the project and it is not considered plausible that changes in deforestation close to these villages would be the result of any farming displaced from the project area.

The resulting leakage belt is shown in Figure 1. It encloses an area of 23,373 ha of which 15,209 ha was forest in 2010.

[17] This analysis considers the location of all settlement centres (as mapped by project monitoring activities) and not merely village centres as shown in national administrative datasets, so as to take account of the dispersed nature of settlements and deforestation in this landscape (Pollard and Evans 2009).

Figure 1 Location of the leakage belt



Activity displacement into the leakage belt is monitored ex-post by comparing projected and actual deforestation in the belt. However, ex-ante, this leakage must be estimated from an analysis of the proportion of local residents engaged in leakage management activities, following page 101 of the methodology. Appendices 1 and 2 show the % of families in each village who have an opportunity to participate in leakage management activities, and hence the proportion of the total population who have such opportunities, projected over the first ten year fixed baseline period. The results are summarised in Table 2. The ex-ante estimate of the proportion of the population not participating is equal to the factor DLFr, defined above.

Table 2 Ex-ante estimated proportion of households able to participate in leakage management activities

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
% participating	40%	40%	40%	66%	91%	100%	100%	100%	100%	100%
% not participating (=DLFr)	60%	60%	60%	34%	9%	0%	0%	0%	0%	0%

The proportion of leakage due to avoided deforestation

A minority of the smallholder families expected to be resident at some stage in the baseline scenario may not come to inhabit the area in the with-project scenario, because project activities are expected to reduce the attractiveness of the area for these new migrants. By definition these people cannot participate in leakage management activities, and they may decide to settle (and perhaps deforest) at some distant location outside the monitored leakage belt. Conservatively we consider that any deforestation that is prevented by preventing this in-migration will leak to distant forested locations with comparable carbon stocks and so must be discounted at 100%. This is consistent with the analytical principles set out by the methodology

> 'If deforestation agents do not participate in leakage prevention activities and project activities, the Displacement Factor shall be 100%. Where leakage prevention activities are implemented the factor shall be equal to the proportion of the baseline

agents estimated to be given the opportunity to participate in leakage prevention activities and project activities.' (footnote, page 101)

This displacement factor can be estimated conservatively for migrants by projecting the expected overall population growth of the participating villages through the first fixed baseline period and comparing it to the observed growth over the same period. During any given year it is conservative to ascribe the entire difference between the expected population size at the time and the true population size to avoided in-migration. This approach also has the advantage of accounting for any movements out of the area by existing residents that might be caused by the project, removing the need to monitor thse separately.

It is assumed that on average any one migrant family is equally likely to cause deforestation as any resident family, and so the percentage of expected deforestation attributable to newly arrived smallholder migrants is equal to the percentage of the population in this sub-category. This is supported by the fact that many of the families already resident at the project start date are themselves recently arrived migrants (and so intrinsically likely to behave in a similar way), that migrants are drawn from all ethnic groups, arrive in all villages to some extent and typically plant the same crops as existing residents in the same villages. It is consistent with the methodology requirement to calculate the DLF on the basis of the proportion of baseline agents participating in the leakage control measures.

Hence DLFa for a given one year period (as defined above) is calculated as the ratio of the *cumulative avoided in-migration from the start of the project to the end of that year* ('all missing families') to *the expected population at the end of that year*. To give a simple numerical example, if the expected population at the end of a given year was 10,000 families (from baseline calculations) but only 9,000 families were actually observed to be present, then 1,000 families are assumed to have been deterred from migrating to the area by project activities up to that date. Therefore, 10% (1,000/10,000) of the expected business-as-usual agents of deforestation are not in practice able to participate in leakage management activities during that year and so 10% of any emissions avoided during that period should be assumed to have leaked for this reason.

Predicted human populations in the project area in the baseline and project scenarios

The expected growth of the human population in the business-as-usual case is predicted on the basis of observed historical trends. Good annual population data at village level exist for the historical reference period, contained within the Commune Database (CDB) which is available from the Ministry of Planning and begins in 2002. The pooled data for the 20 project villages conform closely to a straight line ($y = 575.0x + 7805.1$, $R^2 = 0.9763$, y = population in a given year, x = (year-2000)).

Figure 2 and Appendix 3 show the observed data for 2002-2010 plus three projected scenarios 2010-2019.

- The highest scenario shown is a projection of the historical growth rate, and shows business as usual with a combination of intrinsic local growth (births exceeding deaths) and net in-migration.
- The lowest scenario represents the estimated intrinsic growth in the absence of any further net in-migration[18], which is a preferable outcome from a REDD perspective, but is likely not feasible. This is a useful step in the ex-ante calculation of with-project population growth.
- The intermediate scenario shows ex-ante estimates of population growth in the project case, assuming the project avoids 50% of the expected migration during each annual period.

Table 3 summarises the ex-ante estimated DLFa for the first fixed baseline period. This is conservative; data for 2010 show that the observed factor was 0.2%, suggesting a lower than 50% reduction in net in-migration and so less leakage than might be expected from the ex-ante figures.

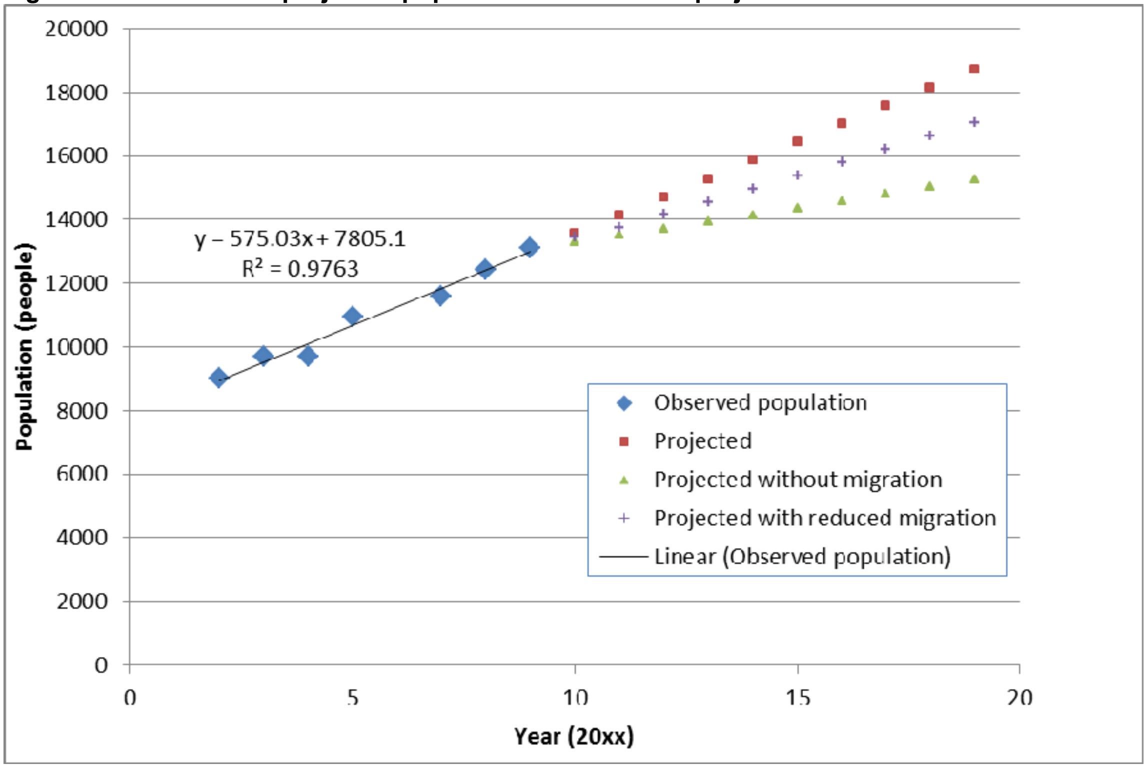
Table 3 Ex-ante estimated Migration Displacement Factor*

[18] This is derived from the average recent growth rate for Cambodia as a whole (1.54%), which is free from migration effects and hence is expected to represent quite accurately the intrinsic rate of increase (ie births minus deaths) of any broad subset of the Cambodian population.

Year	10	11	12	13	14	15	16	17	18	19
DLFa	0.9%	2.6%	3.7%	4.7%	5.6%	6.5%	7.2%	7.8%	8.4%	9.0%

* assuming 50% effectiveness in deterring migration

Figure 2 Observed and projected population trends in the project area under various scenarios



Total expected displacement due to activity shifting

DLFa and DLFr can be added to give DLF (Table 4).

Table 4 Ex-ante estimated activity displacement due to activity shifting by residents and avoided in-migration

Year	10	11	12	13	14	15	16	17	18	19
DLF	60.9%	62.6%	63.7%	38.7%	14.6%	6.5%	7.2%	7.8%	8.4%	9.0%

Monitoring considerations

In years when emissions reductions are achieved in the project area, a deduction may need to be made for leakage due to activity displacement, using data from monitoring activities. Two deductions are required.

1) Deduction due to activity displacement by smallholders already resident in the project villages, ioncluding those who have arrived since the start of the project.

Monitoring requirements are explained in Chapter 8 of the PD. This replaces the estimated figures for DLFr presented above.

2) Deduction due to avoided migration

To calculate the deduction due to actual avoided migration (DLFa) the following steps should be followed:

1. The total projected population (PP) at the end of each project year is estimated from Appendix 3 - figures for 'Historical Rate (Linear)'
2. The total observed (monitored) population of the 20 participating villages (OP) must be determined for each year of the project crediting period based on figures in the Commune Database or a directly comparable source.
3. If OP>PP, no deducation for leakage due to avoided migration is required
4. If PP>OP, the difference (PP-OP) is calculated and referred to as the 'avoided migration' (AM) relevant to that year.
5. DLFa is calculated as DLFa = AM/PP
6. The Gross Emissions Reductions (GER) for the year in question are known from the results of deforestation monitoring protocols in the project document.
7. The Leakage due to Avoided Migration (LAM) is calculated (LAM = GER*DLFa)
8. The LAM is then added to leakage due to activity displacement of resident small-holders calculated under point 1 above to give the total emissions due to activity displacement.

Reference

Pollard, E. H. B and Evans T D (2009). *A survey of communities in and around the Seima Biodiversity Conservation area in 2008*. Wildlife Conservation Society – Cambodia Program. Phnom Penh.

Appendix 1 Proportion of families in each village able to participate in leakage management activities

Commune	Village	Households	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Sre Khtum	O Am	623	0%	0%	0%	50%	100%	100%	100%	100%	100%	100%
	O Rona	160	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Sre Lvi	28	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Sre Preah	Sre Preah	112	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%
	Gati	54	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Pu Char	66	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	O Chrar	27	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Pu Kong	62	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Sre Chhuk	Chakchar	124	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Kmom	62	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Sre Andaol	50	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Sre Khtong	165	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Memong	Pu Keh	114	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%
	Pou Ngaol	95	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%
Sen Monorom	And. Kraloeng	107	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Pu Haim	303	0%	0%	0%	50%	100%	100%	100%	100%	100%	100%
	Pu Rang	91	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%
Total	**17**	**2243**										

Appendix 2 Number of families in each village able to participate in leakage management activities

Commune	Village	Households (2010)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Sre Khtum	O Am	623	0	0	0	311.5	623	623	623	623	623	623
	O Rona	160	160	160	160	160	160	160	160	160	160	160
	Sre Lvi	28	28	28	28	28	28	28	28	28	28	28
Sre Preah	Sre Preah	112	0	0	0	112	112	112	112	112	112	112
	Gati	54	54	54	54	54	54	54	54	54	54	54
	Pu Char	66	66	66	66	66	66	66	66	66	66	66
	O Chrar	27	27	27	27	27	27	27	27	27	27	27
	Pu Kong	62	62	62	62	62	62	62	62	62	62	62
Sre Chhuk	Chakchar	124	124	124	124	124	124	124	124	124	124	124
	Kmom	62	62	62	62	62	62	62	62	62	62	62
	Sre Andaol	50	50	50	50	50	50	50	50	50	50	50
	Sre Khtong	165	165	165	165	165	165	165	165	165	165	165
Memong	Pu Keh	114	0	0	0	0	0	114	114	114	114	114
	Pou Ngaol	95	0	0	0	0	0	95	95	95	95	95
Sen Monorom	And. Kraloeng	107	107	107	107	107	107	107	107	107	107	107
	Pu Haim	303	0	0	0	151.5	303	303	303	303	303	303
	Pu Rang	91	0	0	0	0	91	91	91	91	91	91
Total	**17**	**2243**	905	905	905	1480	2034	2243	2243	2243	2243	2243
% of HH participating			40%	40%	40%	66%	91%	100%	100%	100%	100%	100%
% of HH not participating			**60%**	**60%**	**60%**	**34%**	**9%**	**0%**	**0%**	**0%**	**0%**	**0%**

Appendix 3 Calculations associated with estimation of the Migration Displacement Factor, ex-ante and ex-post

MODELS

	coefficient	**constant**
Historical rate (linear)	575	7805.1
	rate of growth	
Projected without migration	1.54%	
	not prevented	
Projected with reduced migration	50%	

Year*	2	3	4	5	7	8	9
Observed population	9003	9710	9711	10936	11582	12437	13108

*complete data not available for 2006

	Initial	Projected									
YEAR	9	10	11	12	13	14	15	16	17	18	19
Historical rate (linear)		13555	14130	14705	15280	15855	16430	17005	17580	18155	18730
Projected without migration	13108	13310	13515	13723	13934	14149	14367	14588	14813	15041	15272
1 year growth with migration		447	447	575	575	575	575	575	575	575	575
1 year growth baseline, no migration		202	205	208	211	215	218	221	225	228	232
1 year growth imputed to migration		245	242	367	364	360	357	354	350	347	343
Cumulative growth from migration		245	487	854	1218	1578	1935	2289	2640	2986	3330
% of current population that are migrants since 2010			3.4%	5.8%	8.0%	10.0%	11.8%	13.5%	15.0%	16.4%	17.8%
Ex-ante estimates											
Projected with reduced migration	13108	13432	13760	14156	14556	14960	15369	15782	16201	16624	17051
1 year growth baseline, reduced migration		202	207	212	218	224	230	237	243	249	256
Estimated migration		123	121	183	182	180	179	177	175	173	172
Total growth		324	328	395	400	404	409	414	418	423	428
Avoided Migration		123	370	549	725	895	1061	1223	1379	1532	1679
Annual Migration Displacement Factor		**0.9%**	**2.6%**	**3.7%**	**4.7%**	**5.6%**	**6.5%**	**7.2%**	**7.8%**	**8.4%**	**9.0%**

Annex 4.3 Analysis of degradation pressures for forest in the SPF Core Area

Summary

This report assesses degradation rates in the carbon stocks of the forests of the Seima Protection Forest Core Area, the site of a REDD project[19]. It forms a methodological annex to the Seima Protection Forest REDD Project Document. The degradation is too limited to be detected by remote sensing so indirect methods are used. A review of published and unpublished data and expert knowledge amongst long-serving staff identified five drivers of degradation that required more detailed assessment. Of these four can easily be shown to be far below levels that would be considered significant. Using conservative estimates of offtake rates, **subsistence logging** for housing timber and **collection of firewood** were calculated to be far below the level that is likely to cause degradation. **Understorey grass/litter fires**, while common in the open forest stratum, are also dismissed as a source of progressive degradation as the affected habitats are already highly fire-adapted, the fires are of low intensity and there is no trend of increasing frequency over a 9-year period. **Wooded fallows** are a small and declining part of the landscape and so for carbon accounting purposes are best treated within the context of the post-deforestation stratum rather than as a degraded forest stratum.

One category of driver, **illegal logging of Luxury grade timber**, required more detailed analysis, since it appears large in scale and extent. Only three species make up the vast majority of timber ilegally cut at this site. Inventory data indicated average stocks of carbon within three species together of 10.9 tC/ha and 3.2 tC/ha respectively in the dense and open forest strata (conservatively taking the upper bound of the 90% CI in each case). The worst case scenario if law enforcement efforts fail is that this stock will be mostly logged out across the whole landscape during the first 10 year fixed baseline period, due to rising demand. Even if 100% of the biomass of these three species is lost (a conservative assumption), this will result in estimated biomass loss well below predicted natural increments for these forest types, and so is considered unlikely to result in any long-term degradation of the carbon stocks. However, illegal logging is a concern for other reasons than its effect on carbon stocks and remains a focus of enforcement activities.

Introduction

A conservation finance project is being developed in the Core Area of the Seima Protection Forest (SPF), Cambodia under the REDD framework (Reduced Emissions from avoided Deforestation and Degradation). The project will follow a carbon accounting methodology validated against the Verified Carbon Standard. The chosen methodology is the Unplanned Deforestation methodology (hereafter 'the methodology'), which has been approved by VCS (VM0015).

Among other steps, this methodology requires an estimation of the baseline rate of degradation of carbon stocks in standing forests in the project area. This report explains the calculations that contribute to the proposed baseline.

Overview - history of forest degradation

The landscape has historically has rather low population densities (Evans *et al.* 2003), with near total depopulation due to civil unrest during much of the 1970s and 1980s (Evans 2007) and poor road connections until the very recent past. There has thus been rather limited logging by local communities, primarily for housing and firewood. This is expected to have had negligible impacts on average carbon stocks. Traditional thatch-and-bamboo houses in this area used little sawn timber, although this has changed quite recently with the adoption of larger, more permanent wooden houses.

Long rotation swidden cultivation converted some mature forest to fallow, with brief periods of cultivation, especially in and before the 1960s, but relatively few new fallows were created between the reoccupation of the upland villages through the 1990s, the opening up of new fields and the

[19] We acknowledge the assistance of Scott Stanley and Jeff Chatellier in compiling this Annex.

widespread adoption of cashew (a cash crop that can be grown in place of fallowing) after about 2002.

The most significant drivers of degradation have been episodes of intensive mechanised logging, which are unlikely to be repeated in the foreseeable future. Local reports indicate that there was scattered, locally heavy logging during the 1960s (by Khmer forces) and 1980s (by Vietnamese-backed teams), targeting clumps of valuable species including koki *Hopea odorata* and beng *Afzelia xylocarpa* and leaving the landscape criss-crossed with old logging tracks that have facilitated subsequent illegal activity. In 1994 the area became part of the Samling International Chhlong logging concession. Operations took part in what is now the Core Area during only three seasons, 1997-1999, mainly in areas south of National Route 76 (Walston *et al.* 2001) before the concession was mothballed as part of a national moratorium that will not now be lifted (National Forestry Program 2010). The scale of legal and illegal harvests during this period have not been well quantified, although Evans *et al.* (2003) made an estimate of losses for resin trees (mainly *Dipterocarpus alatus*) based on interviews with the traditional owners. Densities of desirable species were apparently relatively low overall, and this has protected large areas of forest from excessive damage.

There has been a conservation project at the site since 2002 so there is an excellent body of knowledge on current activities that degrade forest, including publications, unpublished data and staff experience. From this basis we identified the following candidate sources of degradation:

- trade-driven logging of high value timber species
- subsistence logging for housing timber
- collection of firewood
- forest fires
- swidden farming

Each is analysed in turn below. There is no commercial charcoal production in the landscape and negligible trade-driven harvest of other timber species. Bamboo harvest is very localised and conducted at a cottage industry scale (Pollard and Evans 2009, Mann Mouy 2010) and is also considered negligible in carbon terms.

There are three main options for measuring degradation in the landscape - remote sensing, monitoring of permanent plots and indirect approaches such as measuring off-take. Current degradation rates are generally low and damage is highly dispersed in small ephemeral patches, so it is most unlikely to be detectable using medium-resolution imagery. Estimation using permanent plots would also be unduly expensive. Therefore, the main sources of degradation are estimated below using indirect methods.

Trade-driven illegal logging of high value timber species

A large amount of data exist on this, which is considered the largest potential baseline cause of forest degradation during the first 10 year fixed baseline period of the REDD project. Figure 1 and Table 1 show the total number of timber pieces, logs and stumps detected by law enforcement teams in SPF in recent years, and the proportions of Luxury and non-Luxury grade timber. These do not allow an estimate of total offtake since they represent an unknown proportion of the total harvest, and the exact area of the harvest is also unknown, but they do indicate the general scale, the preferred species and the locations where logging occurs. As in the historical period, only a handful of species are preferred, and this appears to have been accentuated by recent price rises for three Luxury grade species, beng, neang nuon *Dalbergia bariensis* and thnung *Pterocarpus macrocarpus*. Forest-gate prices have soared from around \$120-180/m^3 in 2005 to \$1700/m^3 in mid 2011 (WCS/FA unpublished data), and there has been a corresponding increase in logging pressure, plus an increasing focus on these three species, as is evident from Figure 1. This is part of a nationwide trend, as evident from frequent articles in the national press.

Figure 1 Proportion of seized timber in SPF identified as Luxury grade

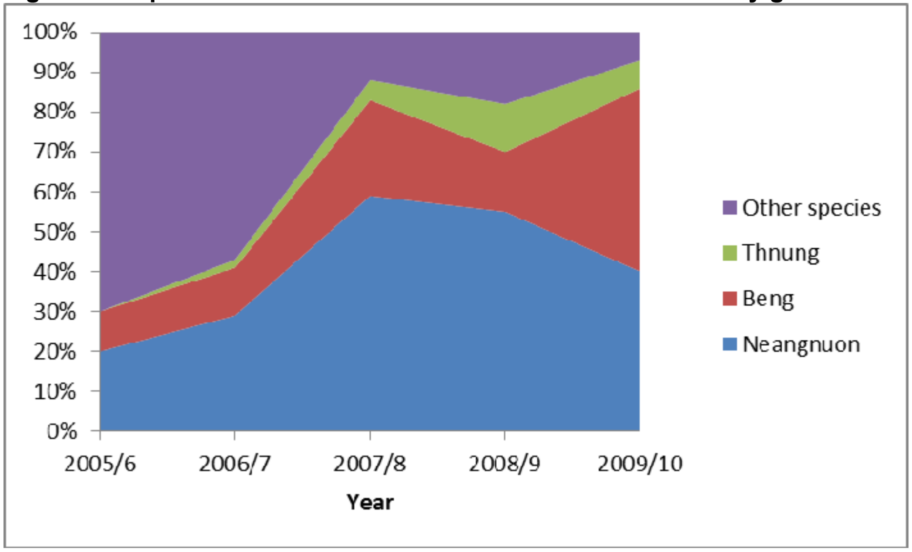


Table 1 Pieces of timber confiscated or observed during law enforcement activities

Period	05/06	06/07	07/08	08/09	09/10
Neangnuon	20%	29%	59%	55%	40%
Beng	10%	12%	24%	15%	46%
Thnung	0%	2%	5%	12%	7%
% Luxury	**30%**	**43%**	**88%**	**82%**	**93%**
Other	51%	51%	10%	8%	4%
Sokram	0%	4%	0%	5%	0%
Koki	18%	2%	1%	4%	2%
Krakah	1%	0%	0%	1%	1%
Chheuteal	0%	0%	0%	0%	0%
Total pieces	1011	685	553	1961	1990

Source: SPF unpublished data held by WCS and FA

Hence neangnuon, beng and thnung made up 82-93% of the trade-driven illegal harvest of timber in and around SPF in the three years prior to the project start date, and the proportion is expected to remain at or above this level in the future, as prices continue to rise. Trade-driven harvest of other species is evidently negligible. It is believed that a substantial proportion of the remaining larger individuals of the three Luxury species are being taken. Despite increasing law enforcement efforts, and soaring confiscations, it is clear that logging of these species is not currently under full control and will likely contribute to forest degradation to at least some extent. It is possible to make a conservative estimate of the level of degradation based on data from the forest carbon plots surveyed for this project.

Plot-derived carbon stock estimates for 2009 and 2011 for beng, neang nuon and thnung for the Project Area are shown in Table 2. No other Luxury grade species was found on the plots, indicating that these must occur at negligibly low densities across the project areas as a whole. The table estimates the gross degradation rate (ie excluding regrowth) that would result if the entire Luxury stock was removed during the first ten year fixed baseline period. This is a conservative, worst case scenario if current efforts to control the logging are not effective. It is also conservative because in practice not all trees would be removed, since some will be overlooked, have stem defects or be too small, and no account is taken of partly compensatory increases in the dead wood pool. Secondary damage to other trees is limited in most cases, since new roading is rare and in general single, often quite moderately-sized Luxury trees are felled leaving small, rapidly-filled canopy gaps.

Table 2 Carbon stocks in Luxury timber species in the Project Area compared to total carbon stocks

Stratum	Mean above ground[#] (tC/ha)	Mean above and below ground (tC/ha) [90% CI]	Upper bound of 90% CI (tC/ha)^	Stratum total stock (tC/ha)	% of total stock	% gross degr. per year*
Dense	6.5	7.7 [2.5]	10.2	262.8	3.9%	0.39%
Open	1.7	2.0 [1.5]	3.6	135.1	2.6%	0.26%

Source: Evans *et al.* (2011) and unpublished WCS/FA data
[#]Beng, neangnuon and thnung combined
^The upper bound is taken to ensure that the estimate is conservative.
* Assuming total loss over ten year period

The estimated gross offtake equates to 1.02 tC/ha/year (2.04 t/ha/year biomass) and 0.36 tC/ha/year (0.72 t/ha/year biomass) respectively for the dense and open strata. This is markedly less than the approximately 5t/ha/year biomass increment reported for slightly less well stocked forests in Kompong Thom Province (Top *et al.* 2006), and so is presumed to be well within the biomass regeneration capacity of the forest. Hence it is likely to have almost no long-term effect on the carbon stock of a given forest stand, since it will be made up by growth from other species, and it is therefore considered negligible for carbon calculations.

Conservatively, all parts of the Project Area can be considered more or less equally at risk over the period of the estimate. This is because at current prices it has been observed to be cost-effective to cut single trees anywhere in the reserve and transport the timber out by truck, car, ox-cart, motorbike or even reinforced push bikes. Although accessible areas might be assumed to be most at risk these are also often the areas with high patrol effort and observation by concerned villagers, making chainsaws and log transport harder to conceal, so in practice less-well protected areas in the north and west of the site have also been widely targeted by loggers. Figure 2 shows an example of relative patrol effort for 2009/10 whilst Figure 3 shows cases of logging detected during that year. A concentration of cases can be seen where access and patrol effort are highest, but there are also evidently cases detected wherever in the reserve patrols have taken place.

Figure 2 Patrol effort in SPF in a typical year (2009/10)

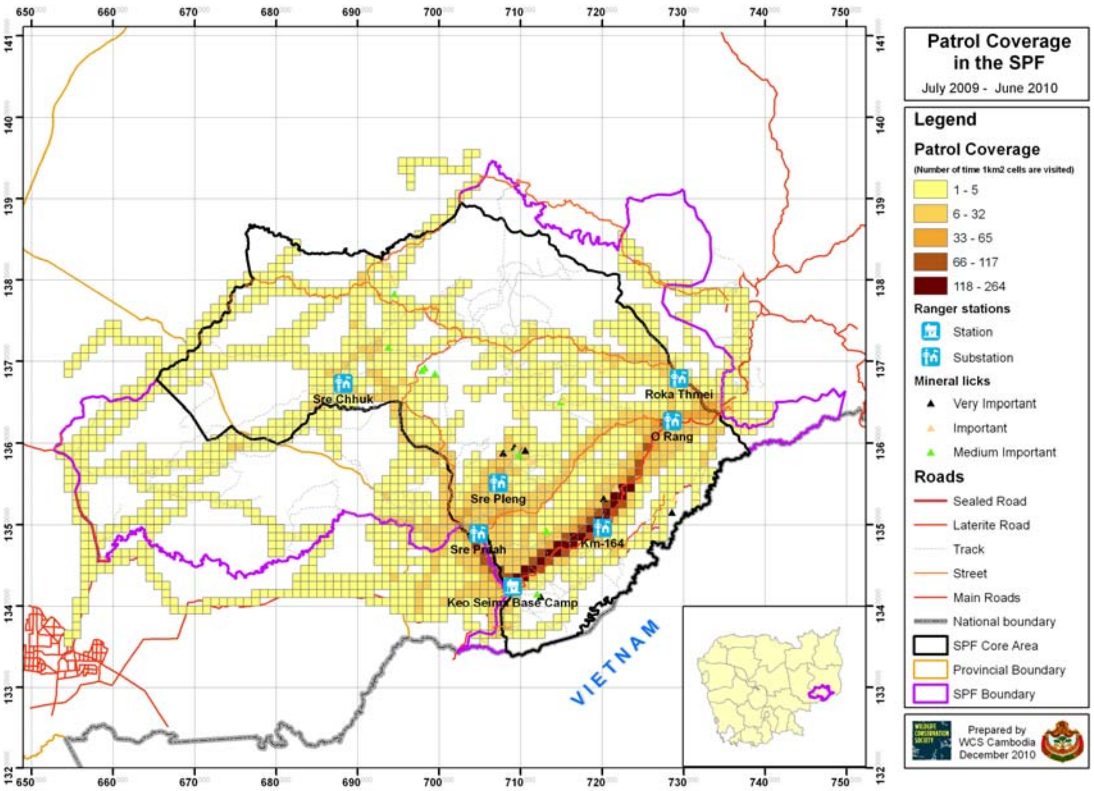
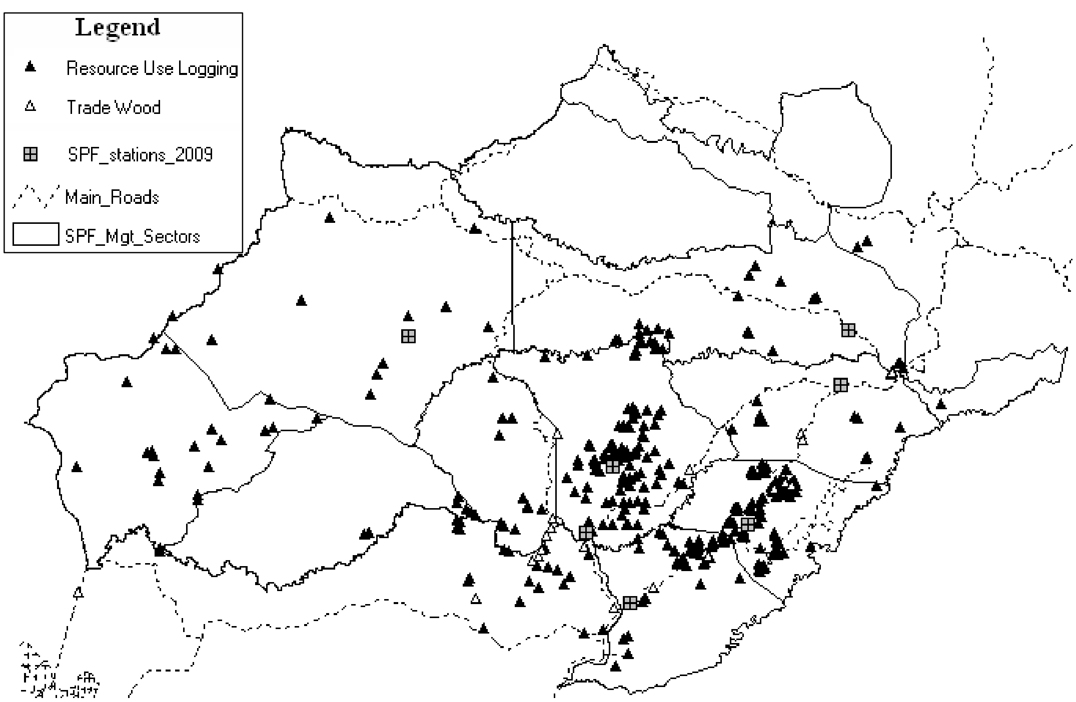


Figure 3 Distribution of detected logging cases in SPF during 2009/10



Although it is demonstrated to be negligible with regard to carbon stocks, this logging is an important management issue for other reasons - the loss of a valuable state timber asset, increased likelihood of associated illegal activities such as hunting and the loss of genetic diversity in three tree populations of high conservation significance. For these reasons prevention of illegal logging remains a key goal of the project.

Monitoring considerations: Detailed considerations for the monitoring of logging as a law enforcement issue are presented elsewhere. In terms of carbon accounting, it is necessary to monitor the preferred species, by annual analysis of confiscation records. If a broader range of species comes into trade at significant levels then the conclusion that illegal logging has negligible implications for carbon stocks will need to be reassessed. Future plot-based surveys of carbon stocks should incorporate a measure of logging prevalence, to assist with long-term quantification of this threat.

Subsistence logging for housing timber

There is a local demand for timber for housing. Under the Forestry Law traditional forest users have the right to cut some wood for house construction, once they have been issued a permit by the local authorities. This offtake is estimated by local forestry officials (Pet Phaktra pers. comm. 2011) to amount to about $10m^3$ of usable timber for each house, with houses replaced/upgraded about once every ten years, or about $1m^3$/family/year. To estimate an upper bound on the scale of this offtake, it can be assumed all 2243 families in the 20 villages using the Core Area draw all their housing wood requirements from the Core Area. This is a highly conservative assumption, since a significant part will be taken from other areas, or from land being deforested. Hence the offtake of usable timber is estimated to be about 0.012 m^3/ha/year, which, at an approximate 25% conversion rate from total volume and 0.57 g/cm^3 default timber density (Reyes *et al.* 1992) would equate to 0.03 t biomass/ha/year total timber removals (ignoring compensatory increases in the dead wood pool). This is negligible compared to the regeneration capacity of these forests (see previous section) and hence is assumed to have no significant impact on long term carbon stocks. The contribution to the long-lived wood products pool can also be considered negligible given current building practices and the species of tree used.

Monitoring considerations: The level of timber harvest for housing construction should be monitored by qualitative means as the population and their housing expectations rise over time.

Collection of firewood

Almost 100% of families in and around the Project Area cook over firewood, which is collected from nearby forest, and in many cases from the villagers' own agro-forestry lots. Top *et al.* (2006) estimated annual household consumption in another Cambodian lowland forest province as 137-178 kg/person per year, dry weight, or roughly 1t/household/year. Assuming similar rates apply in SPF, and that all user families draw their firewood from the Project Area (the latter an unlikely assumption), the average demand is approximately 2243t biomass/year. This equates to 1.2 t biomass/km^2/year across the Project Area, which is clearly a negligible amount in comparison to the biomass increments reported by Top *et al.* (2006). Furthermore, local information shows that the great majority of firewood is collected from within existing or recently cleared farmland, not standing forest, since this requires the least labour. This is expected to remain true for the duration of the first ten-year fixed baseline period. Firewood from SPF is not traded on a significant scale in the local market (Keo Seima) or more widely.

Monitoring considerations: Firewood stocks in freshly opened fields are naturally higher than in old fields, due to the availability of freshly felled forest trees. Deforestation in the with-project scenario will slow to zero during later fixed baseline periods, so eventually the amount of firewood of this kind available within farmland will decline. The decline in supply from felled forest trees on farmland may or may not be compensated for by an increased supply from trees planted on farmland. This should be monitored during subsequent fixed baseline periods. If changes in supply are judged to place significant pressure on adjacent forests then alternative sources of firewood should be developed.

Forest fires

Open forest

Low-intensity understorey fires are a very common part of the ecology of the open, deciduous forest stratum, especially in the deciduous dipterocarp forests, where a high proportion of the grassy understorey burns every year, usually in the early-mid dry season (especially January-March). Most of these fires are set by humans (McInnes 2007), but they are nonetheless an established part of the ecology of the forest since humans have been a part of the system for hundreds, if not thousands of years. Such forests experience little or no negative impact from the annual fires, since they are usually low intensity grass/litter fires and the species that have come to predominate are highly fire tolerant due to a range of adaptations such as thick fire-resistant bark or underground storage organs (Stott 1984, 1988). Hence the fire regime is believed to have negligible effect on long term biomass stocks. Long-term average dead wood stocks can also be assumed to have achieved equilibrium between rates of production and rates of destruction.

There is no evidence of any trend in fire frequency over the past decade - fire location data from the MODIS satellite[20] show an average of 168 fires per year in the open forest stratum during 2001-2009, with no significant trend (r-sq = 0.037, p=0.619). The same is true for the SPF Buffer Area (68 fires per year, r-sq = 0.09, p=0.431).

Dense forest

Catastrophic crown fires have not been reported from this vegetation type anywhere in Cambodia. Observations by the project team since 2002 show that forest fires of any kind are a very rare event in the dense forest stratum and can be considered a negligible potential cause of degradation. The forest is moist all year and usually only burns after it has been cleared for farmland and left to dry for several weeks. Analysis of MODIS data (Table 3) confirms that that the frequency of fires in the dense forest stratum is very low, the fires are scattered and isolated and there is no increasing trend during 2001-2009. Points mapped within 100 m of the forest edge are likely to have only marginally entered dense forest or, given the data resolution, may well have occurred in adjacent open habitats. Therefore these two classes of point are analysed separately. There are only 11 fires per year at or near the margins of the dense forest stratum and only 4 per year at any distance inside this stratum, none of them extending into a second pixel and all thus assumed to be very limited in extent. The same pattern is evident in other nearby dense forest areas. This is consistent with the reports of long-serving forestry officials working at the site.

Table 3 Fire frequency in dense forest stratum in and around SPF

	Fires/year	
Area	Interior: More than 100 m from forest edge	Edge: Within 100 m of dense forest edge
Project Area	4.4	11.3
SPF Buffer	4.0	7.0
Snoul WS	5.9	6.7

Monitoring considerations: In the dense forest stratum, surveillance for catastrophic fires should be conducted through routine patrol team activities and emergency reporting by community committees. In both dense and open forest strata, the annual frequency of fires should be monitored using MODIS data, triangulated through consultations with local communities. If an increasing trend occurs in either stratum, this should be investigated to identify the causes and any possible implications for carbon stocks.

Swidden farming

Long rotation shifting cultivation in the past led to the formation of areas of tall fallow in SPF. These are secondary forest from an ecological/silvicultural perspective, but from a carbon accounting viewpoint can potentially be treated as a degraded forest class, assuming that forest cover is the dominant long-term land use. In such a case during the short cultivation period between periods of forest cover the land parcel would be classed as 'temporarily unstocked forest' for carbon accounting purposes. However, if cropping is the dominant use of the plot over time, with fallow periods being

[20] Excluding locations reported with <30% confidence

short or ceasing altogether, then it is more appropriate to classify this as a deforested area and include the fallow periods in an assessment of its long-term average carbon stock.

This form of farming is permitted by Cambodian law and can be sustainable under some circumstances, so there is no policy of stopping it within the Protection Forest, as long as it takes place within the areas registered for such activity. However, field observations and community discussions show that long-fallow rotational shifting cultivation has greatly declined in significance in the landscape through farmer preferences as people increasingly switch to growing cash crops on more permanent fields. Hence the current extent of such fallow in the landscape is rather limited and is likely to decline in the future, with most currently existing long fallows predicted to become non-forest in the medium to long term. It is therefore most appropriate to classify such areas as non-forest, rather than degraded forest, and to account for the carbon stocks of fallow patches within the average carbon stock of the post-deforestation land use class. Given this choice of classification, shifting cultivation in SPF does not result in the creation of degraded forest as defined for carbon accounting purposes.

Monitoring considerations: Since conservative assumptions have been made in estimating the contribution of fallows to the carbon stock of deforested areas, no further monitoring is required from that perspective. However, the effects of the decline of fallowing on soil quality should be monitored. It may be that fallows may need to be reintroduced on some soils in the SPF to ensure long-term sustainability of land use. In principle dramatic changes in the demand for cash crops could result in the reversion to a subsistence-based shifting cultivation farming system, in which case tall, long-term fallows may once again become a significant part of the landscape. This remote possibility should be monitored through periodic assessments.

Annex 4.4 Funding history and projections for the Seima Protection Forest

Summary

The historical levels of non-REDD funding in SPF have been enough to achieve partially effective conservation, but fell well short of the level required for full protection. The aim of the REDD project is to increase funding to the level required for full protection, whilst at the same time putting in place various crucial enabling conditions. To quantify this additionality it is important to estimate future baseline funding levels accurately and conservatively.

This estimation has been done on the basis of two sources of evidence – (i) observed funding levels (over seven full years, including the first three years of the first fixed baseline period) and (ii) predictions regarding donor intentions in the future.

Funding was highest in 2008 and has declined since then. In particular funds for core activities that are most relevant to the prevention of deforestation have declined substantially since the start of the project crediting period. Projections show that this decline will worsen.

Introduction

A conservation finance project is being developed in the Core Area of the Seima Protection Forest (SPF), Cambodia under the REDD framework (Reduced Emissions from avoided Deforestation and Degradation). The project will follow a carbon accounting methodology validated against the Verified Carbon Standard. The chosen methodology is the Unplanned Deforestation methodology (hereafter 'the methodology'), which has been approved by VCS (VM0015).

To enable projection of the baseline scenario without a REDD project, business-as-usual funding trends need to be estimated for the existing conservation project at the site. This report explains the funding calculations that contribute to the proposed baseline.

Overview

The Seima Protection Forest and its precursor, the Seima Biodiversity Conservation Area have been the site of conservation action throughout the historical reference period (Evans *et al.* 2013). This work has been supported almost entirely by international donors, including private foundations, bilateral aid agencies and multi-lateral institutions. Given this history it is necessary to assume that conservation action is also part of the future business-as-usual scenario at the site, with some level of continued funding by these traditional, non-REDD donors.

The level of funding of a protected area is a crucial determinant of its effectiveness. Full funding is a necessary but not sufficient condition for success. Other conditions include effective legal frameworks, public support, high quality technical inputs and good management of staff and personnel, but none of these have much effect in the absence of adequate funding for core activities.

The historical levels of non-REDD funding in SPF have been enough to achieve partially effective conservation, but fell well short of the level required for full protection (e.g. see Annex 4.5 of the PD, and Evans *et al.* 2013). Deforestation has continued, albeit at reduced levels, at least one key species (Tiger) has been lost from the site and many other impacts have been documented. In the future this funding will decline, as shown below, worsening the shortfall. The aim of the REDD project is to increase funding to the level required for full protection, whilst at the same time putting in place various crucial enabling conditions. To quantify this additionality it is important to estimate future baseline funding levels accurately and conservatively.

This estimation has been done on the basis of two sources of evidence – (i) observed funding levels (over seven full years, including the first three years of the first fixed baseline period) and (ii) predictions regarding donor intentions in the future. Each of these is supported by documented evidence, which is available to the auditor for inspection on request.

Observed funding levels 2005-2012

In common with all Protected Forests, SPF receives only very limited operational funding from the Cambodian government. Almost all relevant funding in SPF has been raised by WCS from a wide variety of donors and is documented in the financial accounts of the WCS country program. Carbon accounting for the REDD project operates on a calendar year basis, but the WCS financial year runs from July to June, and is numbered according to the second calendar year of the period – e.g. Financial Year 2006 (FY6) runs from July 2005 to June 2006. However, this apparent mismatch is of little concern due to the annual cycle of deforestation pressures. Funds spent from e.g. July 2005 to June 2006 would have their most direct impacts on forest clearance during the January-May 2006 dry season (because less clearance happens during the rainy season), so it is appropriate to correlate expenditure in FY6 mainly with outcomes during calendar year 2006.

The accounts of the country program were fully computerised from the start of FY6 (ie July 2005) so this was taken as the starting point for this analysis. The analysis was conducted on the basis of the agreed budgets for each separate donor-funded project for each year. An MS Access database was created to manage the information. All the funding from 22 major donors during this period was incorporated, totaling $5,099,049. Funds from 11 other minor donors (never more than $10,000 from any of them in any one year) were excluded, as together they represented less than 2% of the total.

Each budget element was assigned by theme to one of ten activity types linked in some way to the overall SPF workplan (Table 1). An additional category ('0') was added for money that WCS was required to spend on activities unrelated to SPF (e.g. sub-grants to NGOs elsewhere in the province)[21].

Table 1 Activity categories for analysis of the SPF funding history

Activity	Grouping
1. Law enforcement and PA management	Core activity
2. Monitoring (bio/social/defor)	Core activity
3. Community work	Core activity
6. Construction	Non-core activity
7. LNGO Grants in Seima	Non-core activity
8. Community small grants in Seima	Non-core activity
11. REDD project development	Non-core activity
4. ICR (WCS overheads)	Non-core/offsite activity
5. Phnom Penh Admin costs	Non-core/offsite activity
9. Provincial planning Unit	Non-core/offsite activity
0. To be spent elsewhere in Mondulkiri	Non-core/offsite activity

The funding categories were also grouped into 3 core activities and 8 non-core activities, with four of the latter classified as offsite. Project effectiveness in controlling deforestation is expected to be highly correlated with the levels of onsite, core funding – the fundamental work of law enforcement and demarcation, community engagement and monitoring of key indicators. Non-core activities, on or offsite contribute indirectly or not at all to effective reduction in carbon emissions. Some of them are relevant to the enhancement of co-benefits, and so will be taken into account in the documentation of these co-benefits during parallel validation against the Climate, Community and Biodiversity Standard.

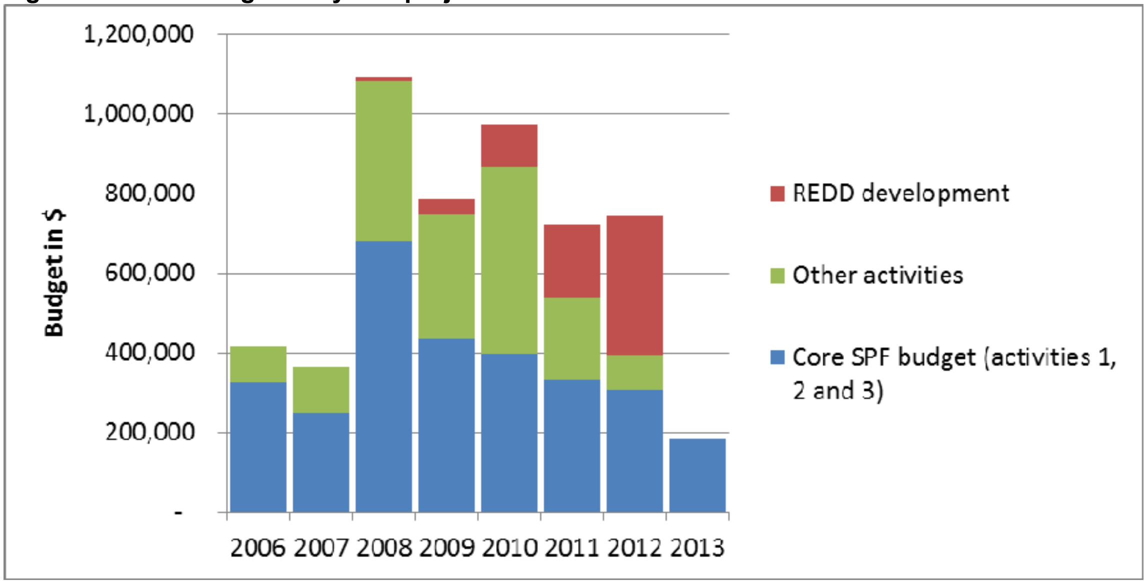
The results are summarised in Table 2 and Figure 1 and detailed in Appendix 1. The full database is also available for audit on request. Funding was highest in 2008 and has declined since then. Not all budgets were spent fully in the year they were allocated to, especially during the best-funded years, so the peaks were in practice slightly less abrupt than shown. The multi-year average total budget was higher in 2010-2012 than in 2006-2009, but this includes REDD start-up funds (clearly not part of the business-as-usual scenario) and also disguises a dramatic and sustained decline in funding for core activities since 2008 (more than halving during 2008-2012, with further falls expected in 2013).

Donor support for necessary, but relatively 'unfashionable' core activities of this kind has declined, outside a small group of consistent and reliable donors focused on biodiversity conservation discussed in the next section. The budget in most recent years has instead been dominated by non-

[21] Two further categories were added for completeness, but not used: 'Earmarked funds for REDD-additional protection activities' and 'Miscellaneous'.

core funding. A part of this has been for the development of the REDD project, which, while a valuable investment in long term sustainable finance, does not contribute to implementation costs such as patrolling, and is not likely to be continued past the point that the REDD project documents are validated. The other major part has been a series of investments by donors interested in improving livelihoods through setting up community-operated natural resource management activities. Again, these do not in themselves contribute significantly to the core costs of preventing deforestation and preventing emissions in SPF.

Figure 1 SPF funding history and projection for 2013



Projected funding in and beyond 2013

Appendix 1 also includes the predicted grant budget for 2013 in the business-as-usual case. Just five donors are listed, all of them supporting core activities, and as a result the total budget is about $195,000, representing only 46% of the 4-year average observed during the historical reference period for core activities.

We consider this a realistic level of funding to project through the remainder of the baseline period. It is lower than historical levels because many of those early grants were for start-up activities. As a newly established reserve within a newly established protected area system, SPF enjoyed relatively good start-up funding opportunities during 2002-2010, much of it framed in terms of training, capacity building, piloting new approaches and so on. Such opportunities have a finite lifespan, beyond which there is an expectation from donors that activities will be self-sustaining or supported by sustainable finance. It is highly unlikely that SPF will enjoy similar opportunities during the coming ten years.

Furthermore, many of the donors who provided this support have now ceased to invest in the forestry sector in Cambodia, or in SPF specifically, and seem highly unlikely to return. Table 2 reviews the funding prospects for each of the 22 donors who contributed significantly to the SPF budget during 2006-2012. For 18 of the 22 historical donors, there is no realistic prospect of further funding for activities that might reduce emissions at SPF. At least one of the four surviving donors had indicated that they are unlikely to renew in FY14, further reducing funds for core activities. In partial compensation, one small new donor was found for FY13.

Table 2 Summary of funding history and 2013 projections

Financial year of budget	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13 (est.)**	**4 year mean**	**3 year mean**	**FY 10-12 as % of 4 year mean**	**FY 13 est. as % of 4 year mean**
Mainly affects deforestation in:	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2006-2009*	*2010-2012*	*2010-2012*	*2013 on*
Total in SPF (i.e. excl external grants, admin/ICR, prov planning)	**366,150**	**283,482**	**837,168**	**561,671**	**674,721**	**581,663**	693,885	195,042	**512,118**	**650,090**	**127%**	**38%**
Core SPF budget (activities 1, 2 &3)	**325,650**	**250,432**	**680,518**	**433,271**	**399,241**	**329,703**	320,355	195,042	**422,468**	**349,766**	**83%**	**46%**
BREAKDOWN BY ACTIVITY												
1. Law enforcement and PA management	**97,000**	**152,217**	**218,678**	**230,888**	**197,487**	**150,396**	154,181	89,974	**174,696**	**167,355**	**96%**	**52%**
2. Monitoring (bio/social/defor)	**106,150**	**50,475**	**157,920**	**61,230**	**45,644**	**60,800**	**51,825**	**47,405**	**93,944**	**52,756**	**56%**	**50%**
3. Community work	**122,500**	**47,740**	**303,920**	**141,153**	**156,110**	**118,507**	**114,349**	**57,663**	**153,828**	**129,655**	**84%**	**37%**

Please see the excel detailed worksheets and MS Access database for a fuller breakdown.

Table 2 Prospects of further funding by each of the significant past donors in SPF

Donor	Notes
Good prospects of support for core activities	
Eleanor Briggs	Consistent donor [renewal not confirmed beyond 2013]; increased demands elsewhere in program reduce proportion available for Seima
USFWS-AsECF	Consistent donor [but future renewals not confirmed]
USFWS-GACF	Consistent donor [but renewals not confirmed]
Elephant Livelihood Initiative Environment (ELIE)	Small new donor in FY13. Commitment in principle to provide further support in FY14.
Unlikely to support SPF again	
McKnight	Have indicated that renewal in FY14 unlikely.
LCAOF	Tiger-focused - tigers extinct at site
Tigers Forever	Tiger-focused - tigers extinct at site
MacArthur	9 year start up funding ended; other published geographical priorities in next phase
World Bank	No further support to Cambodian forestry sector envisaged
Anonymous donor	One-time top-up funding in 2012, not renewable
ADB-BCI	Future support in province directed towards poverty alleviation
No longer operate in Cambodia	
Elyssa Kellerman	Association with WCS ended
BHP Billiton	Exploration activities in Mondulkiri ended
CSPPM	Both Dfid and Danida are closing their country offices
TWG F&E	Danida are closing their country office
Royal Danish Embassy	Embassy is closing
Support is REDD-focused, so not part of business-as-usual	
JICA	Further support possible, but only for REDD
UN-REDD	Further support possible, but only for REDD
WCS Strategic Investment Fund	Further support possible, but only for REDD
SIF2	Further support possible, but only for REDD
IGES	Further support possible, but only for REDD
Winrock MacArthur	GASF regional project closing
Translinks	Program is completed

Appendix 1 Historical breakdown of funding in SPF by activity and estimated funding for 2013

Financial year of budget Mainly affects deforestation in:	6 *2006*	7 *2007*	8 *2008*	9 *2009*	4-year mean *2006-2009*	10 *2010*	11 *2011*	12 *2012*	3 year mean *2010-2012*	13 (proj) *2013*	FY 10-12 as % of 4 year mean *2010-2012*	FY 13 proj as % of 4 year mean *2013 on*
Total in SPF (i.e. excl external grants, admin/ICR, prov planning)	**366,150**	**283,482**	**837,168**	**561,671**	**512,118**	**674,721**	**581,663**	693,885	**650,090**	195,042	**127%**	**38%**
Core SPF budget (activities 1, 2 &3)	**325,650**	**250,432**	**680,518**	**433,271**	**422,468**	**399,241**	**329,703**	320,355	**349,766**	195,042	**83%**	**46%**
BREAKDOWN BY ACTIVITY												
1. Law enforcement and PA mgmt	**97,000**	**152,217**	**218,678**	**230,888**	**174,696**	**197,487**	**150,396**	**154,181**	**167,355**	**89,974**	**96%**	**52%**
ADB-BCI		14,975	38,720	20,130						-		
Eleanor Briggs	50,000	25,000	25,000	25,000		25,000	20,000	20,000		20,000		
Elyssa Kellerman				3,287		21,711				-		
LCAOF		22,550	33,975	49,030		50,880				-		
MacArthur	47,000	54,000	44,000	43,000		74,750	36,500	35,500		-		
New York Grant								17,200		-		
Tigers Forever		15,000	14,500	15,600			21,000			-		
TWG F&E			51,183							-		
USFWS-AsECF			11,300			25,146	35,880	25,363		24,422		
USFWS-GACF		20,692		30,879			37,016	43,618		33,051		
World Bank				43,962						-		
ELIE								12,500		12,500		
2. Monitoring (bio/social/defor)	**106,150**	**50,475**	**157,920**	**61,230**	**93,944**	**45,644**	**60,800**	**51,825**	**52,756**	**47,405**	**56%**	**50%**
ADB-BCI		14,975	38,720	20,130						-		
BHP Billiton			13,500							-		
Eleanor Briggs	20,000	8,000	8,000	8,000		5,500	10,800	10,000		10,000		
MacArthur		7,500	7,500	7,500		16,750	19,750	18,750		-		
Royal Danish Embassy	32,500									-		
Tigers Forever		-	55,000	15,600		11,344	9,000			-		
USFWS-AsECF	53,650		35,200			12,050	13,250	13,875		25,605		
USFWS-GACF		20,000		10,000			8,000	9,200		11,800		
3. Community work	**122,500**	**47,740**	**303,920**	**141,153**	**153,828**	**156,110**	**118,507**	**114,349**	**129,655**	**57,663**	**84%**	**37%**
ADB-BCI		18,240	103,220	35,755						-		
CSPPM			73,700	78,898		119,110	43,844	37,686		-		

Eleanor Briggs	5,500	1,000		2,000		15,000	10,000	10,000		10,000	
MacArthur	35,500	28,500	29,500	24,500		22,000	22,000	24,000		-	
McKnight							42,663	42,663		47,663	
Royal Danish Embassy	81,500									-	
TWG F&E			97,500								
11. REDD project development			**9000**	**35000**	**n/a**	**106480**	**186960**	**348640**	**14,027**	**-**	n/a
ADB-BCI			9000							-	
IGES							24900	45365		-	
JICA							30000	79330		-	
SIF1				35000						-	
SIF2						66656				-	
Translinks						39824	49996			-	
UN-REDD								150000		-	
Winrock MacArthur							82064	73945		-	
6. Construction	**10,000**	**32,450**	**47,300**						**-**	**-**	
BHP Billiton			24,000								
LCAOF		32,450	23,300								
MacArthur	10,000										
7. LNGO Grants in Seima	**30,500**	**600**	**90,350**	**70,900**	**48,088**	**114,000**	**35,000**			**-**	
ADB-BCI		600	40,350	25,400						-	
CSPPM			50,000	45,500		114,000	35,000			-	
Royal Danish Embassy	30,500									-	
8. Community small grants in Seima			**10,000**	**22,500**	**16,250**	**55,000**	**30,000**	**24,890**	**36,630**	**-**	
CSPPM			10,000	22,500		55,000	25,000	19,890		-	
McKnight							5,000	5,000		-	
Costs outside SPF											
9. Provincial planning		**54,400**	**94,550**	**86,270**	**78,407**	**44,247**	**18,019**	**13,260**	**25,175**	**-**	
ADB-BCI		54,400	67,250	54,500						-	
CSPPM			27,300	31,770		44,247	18,019	13,260		-	
5. PP Admin costs	**16,000**	**5,000**	**5,000**	**5,000**		**5,000**	**5,000**	**11,564**			
CSPPM								6,564		-	
MacArthur	16,000	5,000	5,000	5,000		5,000	5,000	5,000			
4. ICR	**35,153**	**20,378**	**48,216**	**40,998**		**61,816**	**44,731**	**37,765**		**19,951**	
CSPPM			17,325	18,911		36,412	13,685	5,417		-	
MacArthur	16,275	14,250	12,900	11,980		17,775	12,487	12,487		-	
McKnight							3,336	3,336		3,336	

Royal Danish Embassy		11,560										
TWG F&E				11,289								
USFWS-AsECF	7,318			6,702			7,629	7,944	7,957		7,957	
USFWS-GACF			6,128		6,814			7,279	8,568		8,658	
World Bank					3,293							
0. Outside Seima				**107,500**	**91,500**		**187,811**	**73,631**			**n/a**	
BHP Billiton				37,500								
CSPPM				70,000	91,500		187,811	73,631				

Annex 4.5 Historical deforestation baseline for the SPF REDD Project

Section numbering follows the steps of the methodology for convenience.[22]

Step 2: Analysis of historical land-use and land-cover change

2.1 Collection of appropriate data sources

We processed and analysed fourteen medium resolution LANDSAT TM and ETM+ satellite images with a 30x30 m pixel resolution to map reductions in forest cover (deforestation) between 1998 and 2010, at roughly two year time intervals across the entire Reference Region (RR) and some adjacent areas. The LANDSAT imagery was acquired during the dry season (December-March) to minimize cloud cover (Table 5).

To refine our classification and to improve interpretation of the land cover, we also analysed two types of radar imagery, ALOS PALSAR L-band and ERS C-band. This was used primarily to improve the discrimination between open forests and non-forest areas such as wetlands, grasslands, tarmacked areas, and paddy fields, because open forests can appear similar to non-forest areas on LANDSAT satellite acquired during the dry season. When available, L-band radar is superior to C-band radar for separating non-forest from open forests. Nevertheless, ERS C-band radar was still useful for this purpose. We analysed nine ERS C-band radar images with a 30x30 m resolution acquired in 1998, 2000 and 2002 and eleven ALOS PALSAR L-band radar images with either 12.5 m x 12.5 m or 50x50 m resolution acquired in 2006, 2008 and in 2010 (Table 5). All images were projected to UTM zone 48N using the Indian 1960 datum and co-registered to within 1m positional error.

We validated the accuracy of the 2002 forest cover map, which included three main classes: i) dense forest, ii) open forest, and iii) non-forest using high-resolution $1m^2$ pixel IKONOS imagery. The IKONOS reference imagery covered an area of 570 km^2 and was acquired on 28 February 2003, i.e. within 12 months of the 2002 LANDSAT imagery (13 February 2002) used for to classify 2002 forest cover.

[22] This Annex was largely prepared by two remote sensing specialists, Dr David Gaveau and Dr Justin Epting.

Table 5 Data used for historical LU/LC change analysis
Projection, spheroid and datum = UTM48N, Everest, Indian 1960 for all data

Satellite	Sensor	Resolution		Average location error^	Acquisition date	Source	Scene or point identifier	
		Spatial	Bands				Path / Latitude	Row / Longitude
Classification								
LANDSAT5	TM	30m	6 opticalbands	N/A	09/01/1998	GISDAT (Bangkok)	125	051
LANDSAT5	TM	30m	6 opticalbands	N/A	09/01/1998	GISDAT (Bangkok)	125	052
LANDSAT5	TM	30m	6 opticalbands	<1pixel	30/12/1999	GISDAT (Bangkok)	125	051
LANDSAT5	TM	30m	6 opticalbands	<1pixel	30/12/1999	GISDAT (Bangkok)	125	052
LANDSAT 7	TM	30m	6 opticalbands	0.94 pixel	13/02/2002	USGS	125	051
LANDSAT 7	ETM+	30m	6 opticalbands	0.99 pixel	13/02/2002	USGS	125	052
LANDSAT5	TM	30m	6 opticalbands	<1pixel	11/02/2004	GISDAT (Bangkok)	125	051
LANDSAT5	TM	30m	6 opticalbands	<1pixel	11/02/2004	GISDAT (Bangkok)	125	052
LANDSAT5	TM	30m	6 opticalbands	<1pixel	31/01/2006	GISDAT (Bangkok)	125	051
LANDSAT5	TM	30m	6 opticalbands	<1pixel	31/01/2006	GISDAT (Bangkok)	125	052
LANDSAT5	TM	30m	6 opticalbands	0.88 pixel	25/03/2008	GISDAT (Bangkok)	125	051
LANDSAT5	TM	30m	6 opticalbands	0.70 pixel	25/03/2008	GISDAT (Bangkok)	125	052
LANDSAT5	TM	30m	6 optical bands	<1pixel	27/02/2010	GISDAT (Bangkok)	125	051
LANDSAT5	TM	30m	6 optical bands	<1pixel	27/02/2010	GISDAT (Bangkok)	125	052
ERS-2	Radar	30m	C-band, VV polarization	0.00pixel	28/09/1998	ESA	125	052
ERS-2	Radar	30m	C-band, VV polarization	0.001pixel	09/09/1998	ESA	125	051
ERS-2	Radar	30m	C-band, VV polarization	0.001pixel	25/09/1998	ESA	125	051
ERS-2	Radar	30m	C-band, VV polarization	0.001pixel	28/09/1998	ESA	125	052
ERS-2	Radar	30m	C-band, VV polarization	0.001pixel	09/09/1998	ESA	125	052
ERS-2	Radar	30m	C-band, VV polarization	<1pixel	01/10/2000	ESA	125	051
ERS-2	Radar	30m	C-band, VV polarization	<1pixel	17/01/2000	ESA	125	052
ERS-2	Radar	30m	1 C-band	0.001pixel	01/09/2002	ESA	125	052
ERS-2	Radar	30m	1 C-band	0.001pixel	01/09/2002	ESA	125	051
ALOS	PALSAR	12.5m	L-band, multiple polarizations	<1pixel	10/06/2006	JAXA	125	051
ALOS	PALSAR	12.5m	L-band, multiple polarizations	<1pixel	10/06/2006	JAXA	125	052
ALOS	PALSAR	30m	Polarized L-band	0.90 pixel	Apr-Oct/2008	JAXA	125	051
ALOS	PALSAR	30m	Polarized L-band	0.39 pixel	Apr-Oct2008	JAXA	125	052
ALOS	PALSAR	30m	Polarized L-band	<1pixel	June-Oct 2010	JAXA	125	051
ALOS	PALSAR	30m	Polarized L-band	<1pixel	June-Oct 2010	JAXA	125	052
Validation								
Quickbird	Quickbird	1m	Red Green Blue	< 1 pixel	28/02/2003	Google Earth	11.982-12.407	106.20-106.314

^ Average Root mean square error

2.2 Definition of classes of land-use and land-cover

The definition of forest used here closely follows Cambodia's national definition under the Kyoto Protocol[23] - namely an area of at least 0.5 ha with at least 10% crown cover of trees taller than 5 m, as discussed in Section 4.4 of the Project Document. Cambodia includes bamboo in this definition. The status of rubber plantations is not specified in the definition. We here treat them as part of the non-forest class.

The analysis of satellite imagery has been conducted at the resolution of the raw LANDSAT imagery (0.09 ha), but in post-processing stages the resolution has been reduced to eliminate clumps of pixels <1ha to eliminate noise. By doing so, the *Minimum Mapping Unit*has been set at 1 ha to accord with the requirements of the methodology. So, the operational forest definition used here is an area of at least 1 ha with at least 10% crown cover of trees taller than 5 m.

Four land use and land cover classes were identified in the reference area (Table 6). Forest land has been stratified in two forest classes having different average carbon densities. These are i) dense forest and 2) open forest. These two forest strata have been mapped through remote sensing (i.e., by analyzing optical LANDSAT TM , ETM+, and radar PALSAR imagery described in Table 5).

Non-forest was divided into open water and a terrestrial non-forest class. The non-forest class has not been further sub-divided as, although there is variation in carbon stocks in this class across the reference region as a whole (e.g. incuding rubber plantations, montane grasslands and smallholder cropping kosaics), this is not the case for newly deforested land within the project zone, which is the land area subject to detailed carbon accounting under this project. Within the project zone essentially all newly deforested land is expected to be incorporated into a smallholder cropping mosaic for which a single area-weighted average carbon stock can be used.

Table 6. List of all land use and land cover classes existing at the project start date within the reference region

Class Identifier		Trend in Carbon stock[1]	Presence in[2]	Baseline activity[3]			Description (including criteria for unambiguous boundary definition)
ID$_{cl}$	Name			LG	FW	CP	
1	Dense forest	Constant	RR, LK, PA	n	n	n	Areas of land meeting the definition of forest used in the project and meeting the definition of evergreen or semi-evergreen forest used by FCA (2006).
2	Open forest	Constant	RR, LK, PA	n	n	n	Open forests are areas of land meeting the definition of forest used in the project and classified by the FCA (2006) as deciduous forest, bamboo forest, other forest (except plantations) and woodland (evergreen or deciduous).
3	Wetland	Constant	RR,LK,PA	n	n	n	Land not meeting the definition of forest and typically covered by standing or flowing water during the Cambodian dry season (e.g. rivers, lakes, ponds and marshes)
4	Non-forest	Constant	RR, LK, PA	n	n	n	All areas not meeting the definition of forest or wetland (cropland, grassland, settlements, roads,etc)

1. Note if “decreasing”, “constant”, “increasing”
2. RR = Reference region, LK = Leakage belt, LM = Leakage management Areas, PA = Project area
3. LG = Logging, FW = Fuel-wood collection; CP = Charcoal Production (yes/no)

[23] cdm.unfccc.int/DNA/ARDNA.html?CID=37

2.3 Definition of categories of land-use and land-cover change

Identify all LU/LC-change categories that could occur within the project area and leakage belt during the project crediting period in both, the baseline and project case. This can be done by analyzing a land-use change matrix that combines all LU/LC-classes previously defined.

List the resulting LU/LC-change categories in table 7.a and 7.b:

Table 7.a. Potential land-use and land-cover change matrix

		Initial LU/LC class			
	ID_{cl}	*1 Dense Forest*	*2 Open Forest*	*3 Wetland*	*4 Non-forest*
Final LU/LC class	*1 Dense Forest*	Dense Forest/ No change	x	x	x
	2 Open Forest	x	Open Forest/ No change	x	x
	3Wetland	x	x	Wetland/ No change	x
	4 Non-Forest	Dense Forest/Non-forest	Open Forest/Non-forest	x	Non-forest/ No change

Table 7.b. List of land-use and land-cover change categories

ID_{ct}	Name	Trend in Carbon stock	Presence in	Activity in the baseline case			Name	Trend in Carbon stock	Presence in	Activity in the project case		
				LG	FW	CP				LG	FW	CP
1/4	1 Dense forest	Stable	All	n	n	n	4 Non-forest	Stable	All	n	n	n
2/4	2 Open forest	Stable	All	n	n	n	4 Non-forest	Stable	All	n	n	n

Step 2.4 Analysis of historical land-use and land-cover change

We processed and analysed fourteen optical LANDSAT TM and ETM+ satellite images with a 30m spatial resolution acquired between 1998 and 2010. The image dates were chosen from available imagery to best represent the epochs of 1998, 2000, 2002, 2004, 2006, 2008 and 2010. These images were acquired during the dry season in order to reduce cloud cover. For those clouds that were present, supplementary radar imagery was analysed for large portions of the reference area in 1998, 2000, 2002, 2006, 2008 and 2010. This included both ERS C band and ALOS PALSAR L-band radar. The ERS and PALSAR radar imagery also served to improve detection of non-forest areas (e.g. wetlands, grasslands, tarmacked areas, and paddyfields) and areas of deforestation in deciduous forests that can be misclassified as non-forest (bare ground) with LANDSAT satellite during the dry season (i.e., from November until May).

Step 2.4.1 Pre-processing

All images were georectified to the 1998 LANDSAT imagery using a second or third order polynomial co-registration technique. We used the Geo correction tools in ERDAS IMAGINE v8.6 to carry out these corrections. The 1998 LANDSAT imagery was retained as the reference imagery with UTM projection, zone 48 North, Everest spheroid, and Indian 1960 datum. The average positional error (the average root mean square error) between two images was < 1 pixel.

Cloud and shadow detection and removal was not performed at the pre-processing stage, but rather classified as such and subsequently dealt with during the post-processing stage (as below).

Radiometric correction and haze reduction were not deemed necessary.

Step 2.4.2 Interpretation and classification

Forest cover and forest loss was mapped within the reference area in two distinct phases. The first phase (Phase I) dealt only with image epochs 1998, 2002, 2008 and 2010. For this phase, a multi-date, stepwise supervised classification approach was adopted to map deforestation and remaining forest cover within the PRA. In the second phase of the analysis (Phase II) additional images from the epochs 2000, 2004 and 2006 were added in order to provide a biannual quantification of deforestation during the entire period. Phase II utilized the results from Phase I to "lock in" areas of forest loss, nonforest and remaining forest and relied primarily on manual interpretation to more finely determine the date of deforestation. The details of each phase are described below.

<u>Phase I. (1998, 2002, 2008, 2010 epochs):</u>

Classification software/algorithm

All processing steps employed the remote sensing platform ERDAS IMAGINE v8.6 combined with a supervised tree-based classification algorithm. The decision-tree program we used is called SEE5. It is a well-known program developed by Rulequest (http://www.rulequest.com/see5-info.html) for data mining and pattern recognition, and was coupled with ERDAS IMAGINE with a helpful interface called CART which was developed by EarthSat Corporation for the US Geologic Survey.

Decision trees are mathematical tools designed for use in a wide variety of data processing applications. They don't rely on normal distributions of data and therefore have been found to offer superior results to traditional maximum likelihood classifiers (MLC). In fact, several remote sensing studies have shown decision trees to be approximately 10% higher accuracy rates than MLC. The way that decision trees work is to create a series of rules. These rules are hierarchical and therefore resemble a tree (Fig 1).

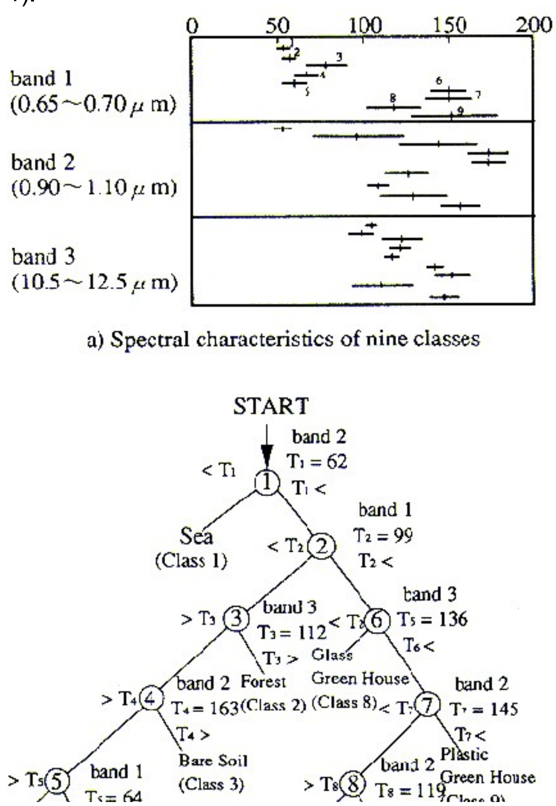


Fig. 1.Decision tree schematic showing rules for classification.

(Class 4) (Class 5)

b) Decision Trees

Figure 11.5.1 Hierarchical Classification by Decision Tree Classifier

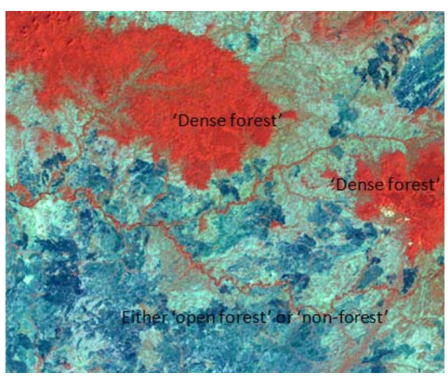
Step 1: The first step in the analysis was the creation of two-date image composites. For example, the LANDSAT images acquired in 1998 and 2002 were combined into a single two-date image file with 12 bands and covering both years using the "layer stack" function in ERDAS IMAGINE v8.6. This was repeated to create composite images for 2002-2008 and 2008-2010. The ERS and PALSAR images as separate single-date image files.

Step 2: A trained remote sensing analyst visually interpreted the spectral signatures of the 1998-2002 two-date LANDSAT image file, in conjunction with various ancillary data, to identify training sites over forested and non-forested areas of land (as well as cloud, cloud shadow, and large water bodies such as wetlands and the Mekong river), which were then used as input statistics into a supervised tree-based classification algorithm (RULEQUEST RESEARCH, 2007) to generate a semi-automated forest cover change classification across the reference region for the period 1998-2002. This approach has the advantage of classifying deforestation (and changes in cloud cover) in one step, reducing the classification error compared to a post-classification approach where two single-date images are classified independently and then changes are categorized between the two classifications.

During this classification step, the analyst did not try to separate 'open forest' from 'non-forest' because the spectral colors of those land cover types ('open forest' and 'non-forest') on the LANDSAT imagery acquired during the dry season were too similar (both 'open forest' and 'non-forest' appear blue in RGB 453 combination, see Snapshot below). In Step 2, the analyst combined 'open forest' and 'non-forest' into one class, which we refer to as the 'non-dense forest' class. In Step 2, the analyst mapped: i) areas of dense forest in 2002, ii) deforestation of dense forest between 1998-2002, and iii) areas of non-dense forest,cloud and cloud shadow cover, and v) large water bodies (wetlands and Mekong river).

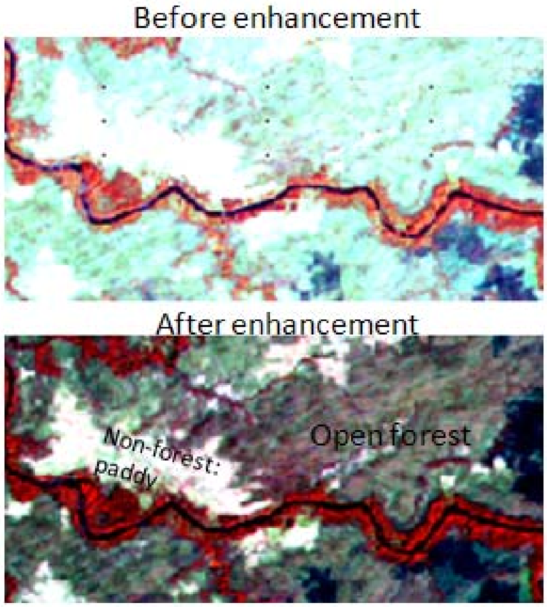
The analyst repeated Step 2 over the 2002-2008 two-date LANDSAT image file to map areas of dense forest in 2008, ii) deforestation of dense forest between 2002-2008. The 2008 PALSAR L-band Radar imagery was used to remove residual cloud & cloud shadow cover in 2008.

The analyst repeated Step 2 over the 2008-2010 two-date LANDSAT image file to map areas of dense forest in 2010 and ii) deforestation of dense forest between 2008-2010. The 2010 PALSAR L-Band Radar imagery was used to remove residual cloud & cloud shadow cover in 2010.

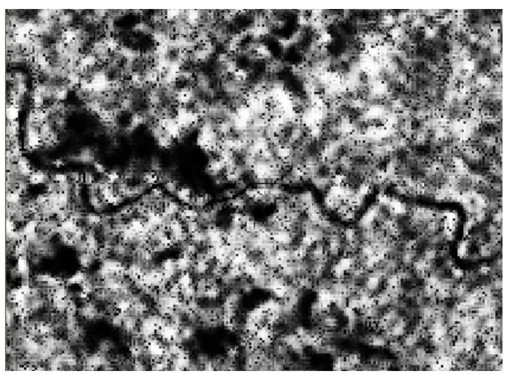


1998 LANDSAT imagery in RGB (band4, Band5, Band3). Dense forest appears as red-brown.
The blue areas are either 'open forest' or 'non-forest' areas

Step 3: To separate 'open forest' in 2002 from deforestation of 'open forests' during 1998-2002, and from 'non-forest' in 1998 (all three classes being previously combined into one 'non-dense forest' category) the analyst re-interpreted the 1998-2002 two-date LANDSAT image file only within areas previously classified as 'non-dense forest'.The analyst used contrast enhancement techniques to reveal small differences in spectral colors to enhance the spectral colors of open forests from those of non-forest. Next, he identified training sites over 'open forests' and 'non-forests', which he then used as input statistics into a supervised tree-based classification algorithm (RULEQUEST RESEARCH, 2007) to generate a semi-automated open forest cover change classification across the PRA for the period 1998-2002. While the contrast enhancement techniques picked up well bare land areas and dry paddy fields, it did not pick up grasslands, paddy fields before harvest, and plantations well. Additional ERS C-Band radar data acquired in 1998 and in 2002 was used to separate paddy fields before harvest, but ERS C-Band radar imagery still did not pick up well, grasslands and plantations. Additional contextual knowledge of the study area was used to separate grassland areas and plantations from open forest areas.

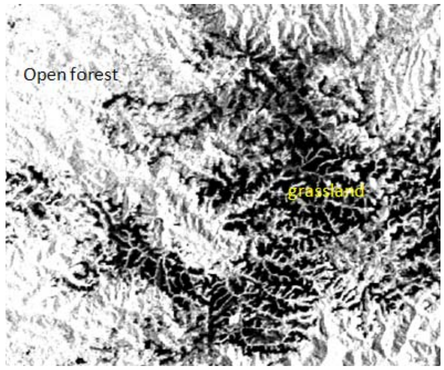


1998 LANDSAT imagery in RGB (band4, Band5, Band3). Dense forest appears as red-brown. The blue/white areas are either 'open forest' or 'non-forest' areas. After enhancement, 'open forest' appear grey, while non-forest (paddy fields) appear white.



1998 ERS C-Band radar imagery. Paddy fields appear dark (whether before or after harvest).

Step 4: To map areas of 'open forest' in 2008 and 2010, and ii) deforestation of 'open forest' between 2002-2008 and 2008-2010 we used 2008 and 2010 PALSAR L-Band radar imagery since L-band imagery is superior to C-Band radar imagery to detect 'non-forest' areas, such as grasslands, from open 'forests'. Here, the analyst visually interpreted the panchromatic polarized PALSAR L-Band radar imagery, to identify areas of non-forest in 2008 and 2010 that had been previously (in step 3) defined as 'open forest' in 2002.



2008 PALSAR L-Band radar imagery. Grasslands appear dark. Forests appear bright

Step 5: all the classes derived above were combined into one single classification file. Measures were then taken to ensure high accuracy of the finished product, including: (1) filtering the final classification results to remove areas < 1 ha using the "clump&eliminate" function in Erdas Imagine 8.6; and (2) manually editing complex areas such as those obscured by haze or in steep topography, where the classification algorithm produced noticeable classification errors, but where a trained remote sensing analyst could still visually interpret the imagery.

Phase II. (2000, 2004 and 2006 epochs):

Phase II involved "back-filling" the missing epochs of 2000, 2002 and 2004 into the framework of results from Phase I. The approach taken for this phase relied primarily upon manual interpretation of the imagery and utilizing the classes generated from Phase I.

The first step in the Phase II analysis was to separate all deforestation classes from forest, non-forest and water classes. Areas classified as nonforest in 1998 were automatically assigned the nonforest class for the three epochs in Phase II. In a similar way, those areas that were classified as 'open forest' or 'dense forest' in both 1998 and 2012 were assigned the same class for the 2000, 2004 and 2006 epochs.

Manual editing was done in a vector environment so the results of Phase I were first converted to polygons with a 'cover type' field representing the output from Phase I. The nonforest, water, open forest and dense forest classes were first assigned as described above. Those classes were then eliminated from the remainder of the analysis. Only those polygons that were recognized as deforestation in Phase I were isolated for further processing. The technique employed was a systematic comparison of deforestation polygons between epochs and then manually assigning the appropriate deforestation class to it. For example, the first round of editing isolated all polygons identified as "dense forest deforestation between 1998-2002" in Phase I. For each of those polygons, the 2000 and 2002 epoch images were visually inspected to determine if deforestation had occurred between 1998-2000 or 2000-2002. In many cases, additional editing of the polygons was necessary because a portion of the area was deforested between 1998 and 2000 and a portion was deforested between 2000 and 2002.

The same process was carried out for the 2004 and 2006 epochs by isolating those polygons from Phase I that were classified as deforestation between 2002-2008. In order to facilitate efficient processing, open forest and dense forests were interpreted separately with the radar imagery helping to inform classification of open forest deforestation. All open forest deforestation was interpreted through visual inspection, whereas the supervised classification approach described in Phase I was utilized to assist in the analysis of the southern portion of the reference area (path/row 125/052) for dense forest deforestation between 2002-2008. A decision tree classification was run with the epochs 2002, 2004, 2006 and 2008 in order to more quickly identify areas of deforestation in each epoch. This area was slightly complicated by the presence of clouds and cloud shadow in 2006 and 2008 which required the additional interpretation of radar imagery to correct for false identification of deforestation in areas where the bright cloud signatures often appeared similar to deforested land. Additional visual interpretation was performed to correct these errors.

A fundamental rule followed during the Phase II analysis required that the epochs be analyzed in chronological order. For example, for the 2002-2008 analysis, the loss of forest cover was first analyzed between 2002-2004 and then for 2004-2006. If no deforestation was recognized by 2006, the assumption was made that deforestation had occurred between 2006-2008 and the polygon was assigned that class. The same is true for the 1998-2002 analysis where if deforestation was not detected between 1998-2000, it was assumed to have occurred between 2000-2002. Strict adherence to the results of Phase I were maintained so as not to disrupt the derivative products that had been produced from it.

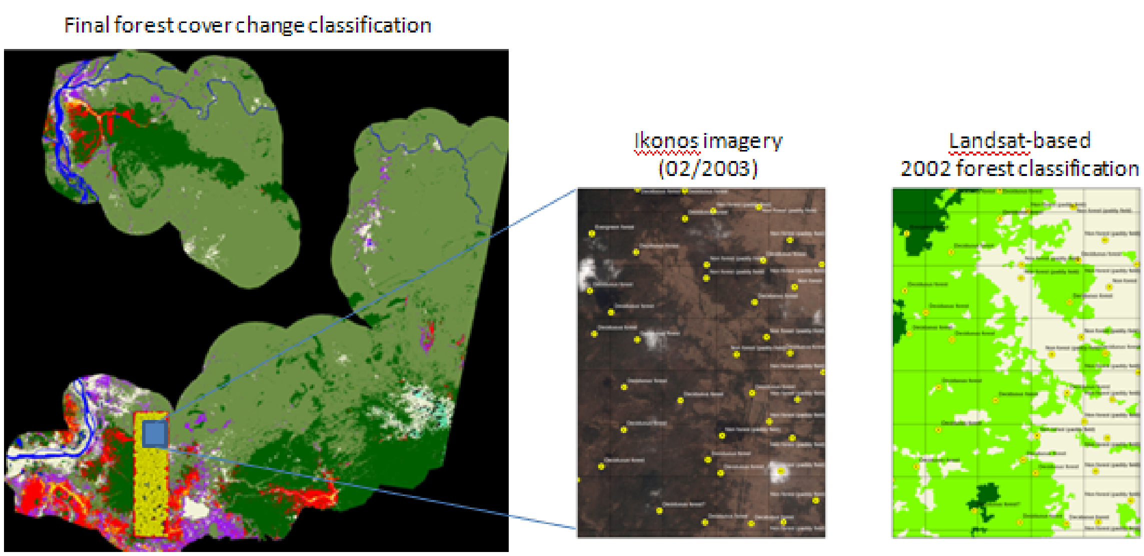
2.4.3 Post-processing

No other post-processing steps were required. The Forest Cover Benchmark Map and other required maps were produced and are presented in the main text of the project document.The matrix of activity data is also presented in the main project document.

2.5 Map accuracy assessment

We validated the accuracy of the LANDSAT-based 2002 forest cover map, which included three mainclasses: i) denseforest, ii) open forest, iii) non-forest. We employed 1m^2 resolution IKONOS imagery as the reference imagery. The reference imagery covered an area of 570 km^2 and was acquired on 28 February 2003, i.e. within 12 months of the 2002 LANDSAT imagery (13 February 2002) used for to classify 2002 forest cover. The reference imagery was downloaded from Google Earth using the Google Earth download Manager in UTM 48N spheroid: WGS84, datum: WGS84

Following the methodology a number of sample points were distributed within the reference higher resolution imagery. The sampling design used a stratified systematic nonaligned sampling approach. This sampling method works by first creating a grid across the reference imagery and then randomly assigning one point per grid cell. In this way, the entire reference image is sampled, thereby ensuring representation of all cover types while at the same time eliminating artificial clumping that may occur from complete randomization, while also minimizing spatial autocorrelation effects. The grid size chosen for this validation was 1 km^2. A total of 527 points were sampled within the reference imagery. There were 187 reference dense forest points, 290 reference open forest points, and 50 reference non-forest points. In the classification, areas of forest cleared during the study period (1998-2002) were counted as non-forest, and areas of forest cleared during the period 2002-2008 were counted as forest.



An error matrix (Table 8) was generated by comparing the actual ground condition as determined by the high resolution imagery with the LANDSAT classification. This matrix was then used to calculate the producer' s and user's class accuracies, omission and commission errors, the overall accuracy, *po* and the kappa coefficient, *k*.

Following the methodology the land cover map was assessed for accuracy on a class-by- class basis. The Producer's accuracy for the dense, and open forest classes was 91% and 94%, respectively. The producer's accuracy for the non-forest class was 94%. The user's accuracy for the dense, and openforest classes was 93% and 94%, respectively. The producer's accuracy for the non-forest class was 90%. The overall accuracy for the 2002 forest/non-forest classification is *po*=93% with kappa statistics of *k*=0.88. The overall misclassification rate was 0.0683 (36/527). The overall omission error was 0.0683. The overall commission error was 0.0341.

Table 8. Error matrix

	Dense forest	Open forest	Non forest	$N_{classification}$	Producer accuracy
Denseforest	171	13	0	184	92.9%
Open forest	15	273	3	291	93.8%
Non forest	1	4	47	52	90.4%
Nr_{ef}	187	290	50		
User accuracy	91.4%	94.1%	94.0%	**Total Accuracy**	**93.2%**

Nr_{ef}: The total number of points falling under a given class on the IKONOS reference imagery classification results.
$N_{classification}$: The total number of points falling under a given class according to classification results.

The methodology states that if ground-truthing data are not available for time periods in the past, the accuracy can be assessed only at the most recent date, for which ground-truthing data can be collected. This is interpreted to indicate that a single accuracy assessment can be used if ground truth data is not available for other time periods. Because the 1998, 2002, 2008 and 2010 land cover maps were all created using the same methods the accuracy should remain relativity consistent. The 2000, 2004 and 2006 land cover maps were created using a different method however this method simply up-dated the deforestation extent manually by looking at the 1998, 2002, 2008 and 2010 deforestation results, and therefore these land cover maps are all based on a similar accuracy.

Annex 5.1 Projection of the quantity of future deforestation in the reference region

Summary

This Annex provides an estimation of the deforestation rates in forests across the reference region, an area of analysis that covers the project area itself plus a much larger of land across north-eastern Cambodia that is judged to face a comparable mixture of threats. Projection of the quantity of deforestation is only required for Stratum 1, since this is the only stratum that is present in the project area and the only stratum where unplanned deforestation occurs. Following criteria in the methodology the time series modeling approach was selected. A logistic curve was found to have very good fit to the data, and predicted initial increases in the rate of deforestation followed by a gradual decline. Using this curve, the annual and cumulative amounts of defoestation are estimated for the reference region, project area and leakage belt.

Introduction

A conservation finance project is being developed in the Core Area of the Seima Protection Forest (SPF), Cambodia under the REDD framework (Reduced Emissions from avoided Deforestation and Degradation). The project will follow a carbon accounting methodology validated against the Verified Carbon Standard. The chosen methodology is the Unplanned Deforestation Methodology, VM0015. (hereafter ‘the methodology’).

Among other steps, this methodology requires an estimation of the deforestation rates in forests across the reference region, an area of analysis that covers the project area itself plus a much larger of land across north-eastern Cambodia that is judged to face a comparable mixture of threats. The reference region has been divided into two strata, as explained in the Project Document Section 4.4 and Annex 4.1. Projection of the quantity of deforestation is only required for Stratum 1, since this is the only stratum that is present in the project area and the only stratum where unplanned deforestation occurs. This report summarises the numerical results of that process[24].

Selection of the baseline approach

The methodology provides a decision tree to assist in the selection of the most appropriate of the three possible baseline approaches (historical average, time function or socio-economic modelling). The tree draws on the conclusions of the agents and drivers analysis in Step 3 (Section 4.5 of the Project Document). It is found that the tree identifies the time function approach as the preferred method for the Seima project since:

- The deforestation rate measured in Stratum 1 in different historical time periods reveals a clear trend;
- This trend is increasing and;
- Conclusive evidence emerges from the analysis of agents and drivers explaining the increased trend and making it likely that this trend will continue in the future and;
- The future deforestation trend is not likely to be higher using a socio-economic modelling approach

These conclusions are supported by the formal analysis below.

In principle the time function approach allows for any function to be fitted, including but not restricted to linear and logistic curves. The key requirement is that the model must demonstrably comply with statistical good practice.

Fitting of the preferred model

Three alternative models were fitted to the data – linear, logistic and exponential. The analysis was conducted in SPSS Version 16.0. Due to limitations on the number of decimal places this package can display in certain outputs it was found convenient to conduct a simple linear transformation of the

[24] We acknowledge the assistance of David Gaveau, Edward Mitchard and Toby Marthews in this analysis.

raw data. All deforestation values were divided by the number 546,536. Any large arbitrary number would have been suitable, but as this value is the extent of forest available in Stratum 1 at the start of the first fixed baseline period it conveniently converts each raw deforestation value to a proportion of the total available forest, resulting in a new value that is intuitively easy to understand. The numerical results of the analysis are presented in Appendix 1.

The logistic function and exponential function had identical high levels of fit, both of them performing slightly better than the linear function. The logistic function was chosen above the exponential fucntion because it is known to have the most desirable theoretical properties, which ensure that it provides more realistic and conservative projections. In particular, its structure does not allow projected deforestation to increase without limit, nor to remain at high levels indefinitely, which is consistent with observed deforestation trajectories in many other studies elsewhere in the world.

Hence the system of equations that predicts cumulative deforestation at the end of a given year is as follows:

$$ABSLRR_{1,t} = CAD_{1,t} - CAD1_{,t-1}$$

$$CAD_{1,t} = CADT_{1,t} * 546536$$

$$CADT_{1,t} = 1 / (1 + 157.374 * 0.704^{t})$$

Where:

$ABSLRR_{1,t}$ = Annual area of baseline deforestation in stratum 1 within the reference region as defined by the methodology (p44); ha yr^{-1}

$CAD_{1,t}$ = Cumulative area of baseline deforestation in stratum 1 within the reference region from the start of the project crediting period to the end of year t; ha

$CADT_{1,t}$ = Mathematically transformed cumulative area of baseline deforestation in stratum 1 within the reference region from the start of the project crediting period to the end of year t; dimensionless

t = a year of the proposed project crediting period; dimensionless

With simple rearrangement this system of equations can be expressed as

$$ABSLRR_{1,t} = (546536/(1 + 157.374 * 0.704^{t})) - (546536/(1 + 157.374 * 0.704^{t-1}))$$

This is a single equation of the form $ABSLRR_{1,t} = f(t)$, and so is consistent with the format required by the methodology (p44, option 4c).

Figures 1 and 2 show the projections derived from this curve as cumulative and incremental deforestation quantities.

Figure 1 Modeled cumulative deforestation 1998-2029 in comparison to observations from the historical reference period

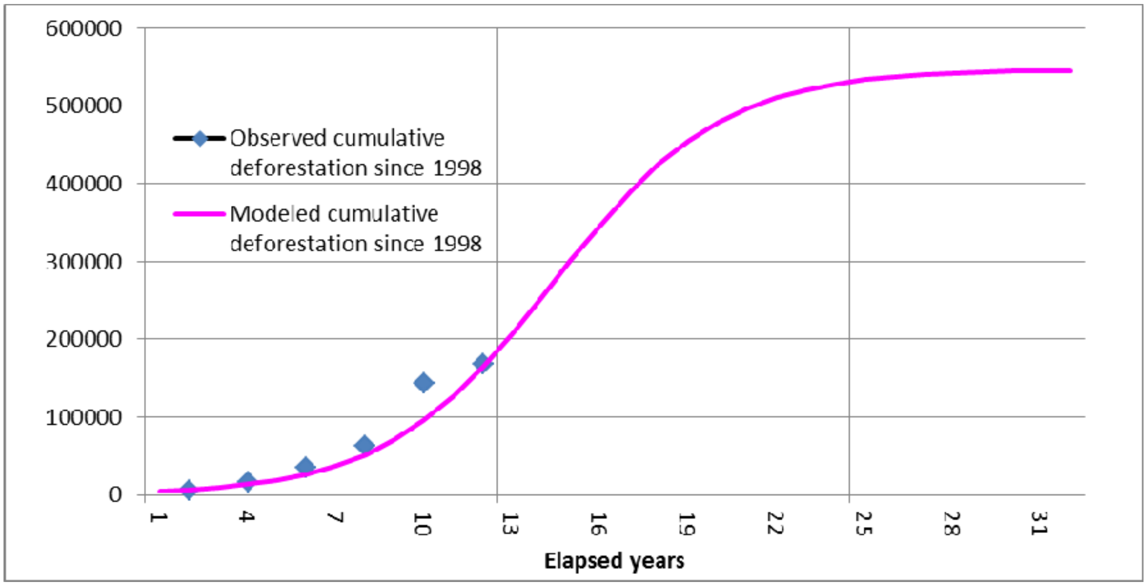
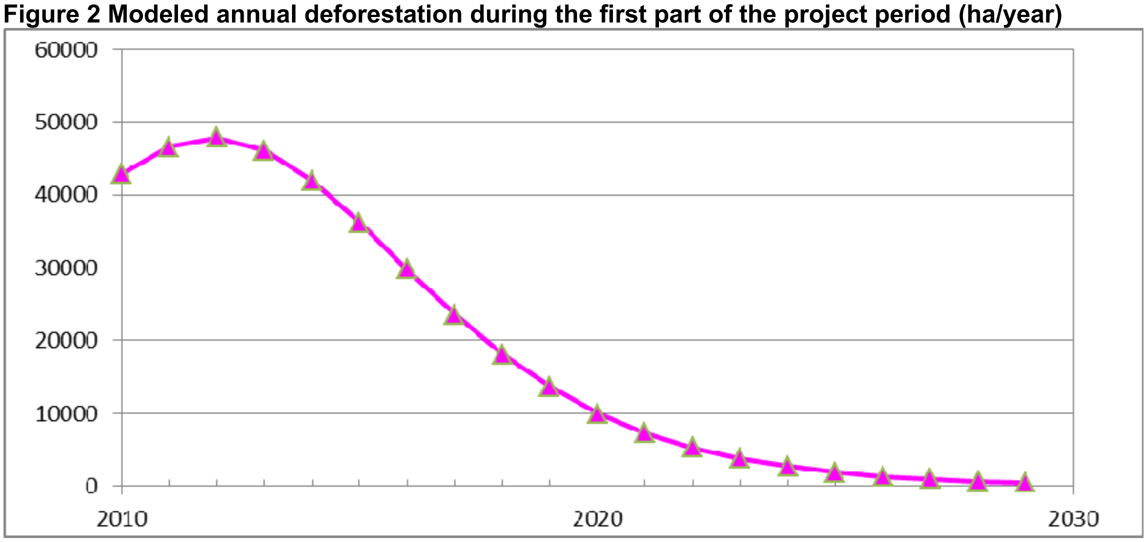


Figure 2 Modeled annual deforestation during the first part of the project period (ha/year)



Allowing for constraints to deforestation

The methodology does not permit models that predict deforestation at a high rate for an indefinite period of time. Beginning with an unconstrained model, it is necessary to estimate a parameter $Toptimal_1$, which is the initial time period after which constraints are imposed.

For time functions,the methodology sets the following tests:

1) If $ABSLRR_{1,t}$ decreases as a function of time ('case 1)' then $Toptimal_1$ is the period of time during which $ABSLRR_{1,t}$ yields a positive value (i.e. no additional constraint needs to be imposed as rates are declining anyway).

2) If $ABSLRR_{1,t}$ increases as a function of time ('case 2') then $Toptimal_1$ is the period of time between t=1 and $t=toptimal_1$, the latter being the year at which the following condition is satisfied

$$Apotimal_1 = \Sigma \text{ [between t=1 and } toptimal_1\text{] } ABSLRR_{1,t}$$

Where:

$Apotimal_1$ = the area of 'optimal foresat land suitable for conversion to non-forest land within stratum 1; ha

Put simply, deforestation proceeds at the rate predicted by the model until an area equal to the area of optimal land in the reference region has been deforested. Thereafter, a constraint is imposed.

The model predicted for the Seima reference region does not quite fit these simple categories, as the predicted rates first increase (case 2) and then after year 3 decrease (case 1). We consider that the appropriate course of action here is to conclude that overall case 1 predominates (see Figure 2) and so no further constraints need to be applied and $Toptimal_1$ is the entire period of time during which $ABSLRR_{1,t}$ yields a positive value

We note that if a constraint was to be imposed after year 4, this constraint would be to fix $ABSLRR_{1,t}$ for a subsequent period at the level it reached in the year when t = $Toptimal_1$ (i.e. 46,147 ha yr^{-1}, Table 2a; see methodology p46). To follow this approach in the current case would result in fixing the annual deforestation rate for an extended period at a higher level than is predicted by our model (in which the rate rapidly falls to below 30,000 ha yr^{-1}). This is evidently a less conservative approach than we have taken, and confirms the appropriateness of the decision not to impose a constraint.

Projection of the annual areas of baseline deforestation in the project area and leakage belt

This step draws on the location analysis completed for the PD. The rates calculated above are used as inputs at each time step for that model, and the output maps are then analysed to determine the amount of deforestation predicted to occur in each landscape unit. The results are summarised in Tables 2a-c, which correspond to Tables 9a-c as required by the methodology.

Table 2a Annual area of baseline deforestation in the reference region in Stratum 1

Project year [t]	Projected deforestation in the whole reference region [$ABSLRR_{1,t}$] ha	Cumulative total [ABSLRR] ha
1	42856	42856
2	46634	89490
3	47822	137312
4	46147	183458
5	41990	225448
6	36214	261663
7	29818	291481
8	23627	315108
9	18160	333268
10	13633	346901

Table 2b Annual area of baseline deforestation in the project area in Stratum 1

Project year [t]	Projected deforestation in the project area [ABSLPA1,t] ha	Cumulative total [ABSLPA] ha
1	1191	1191
2	6544	7734
3	23487	31221
4	17445	48667
5	12695	61362
6	15303	76665
7	21458	98123
8	21340	119463
9	19772	139235
10	15021	154256

Table 2c Annual area of baseline deforestation in the leakage belt in Stratum 1

Project year [t]	Projected deforestation in the leakage belt [ABSLLK1,t] ha	Cumulative total [ABSLLK] ha
1	302.6	302.6

2	1805.2	2107.8
3	1804.2	3912.0
4	472.5	4384.5
5	63.0	4447.5
6	189.7	4637.3
7	335.8	4973.1
8	181.2	5154.3
9	332.0	5486.3
10	494.0	5980.3

Appendix 1 Output of the modelling process in SPSS

Model Description

Model Name		MOD_1
Dependent Variable	1	Cumulative deforestation (transformed)
Equation	1	Linear
	2	Exponential[a]
	3	Logistic[a]
Independent Variable		End of Period
Constant		Included
Variable Whose Values Label Observations in Plots		Unspecified

a. The model requires all non-missing values to be positive.

The dependent variable is cumulative deforestation since the start of 1998, with a simple linear transformation as explained in the text.

The logistic regression was fitted without specifying an upper bound. This provided a more conservative estimate of deforestation over the life of the project.

Case Processing Summary

	N
Total Cases	7
Excluded Cases[a]	1
Forecasted Cases	0
Newly Created Cases	0

a. Cases with a missing value in any variable are excluded from the analysis.

Variable Processing Summary

		Variables	
		Dependent	Independent
		Cumulative deforestation (transformed)	End of Period
Number of Positive Values		6	6
Number of Zeros		0	0
Number of Negative Values		0	0
Number of Missing Values	User-Missing	0	0
	System-Missing	1	1

Model Summary and Parameter Estimates

Dependent Variable:Cumulative deforestation (transformed)

	Model Summary					Parameter Estimates	
Equation	R Square	F	df1	df2	Sig.	Constant	b1
Linear	.916	43.837	1	4	.003	-.093	.032
Exponential	.965	111.711	1	4	.000	.006	.351
Logistic	.965	111.711	1	4	.000	157.384	.704

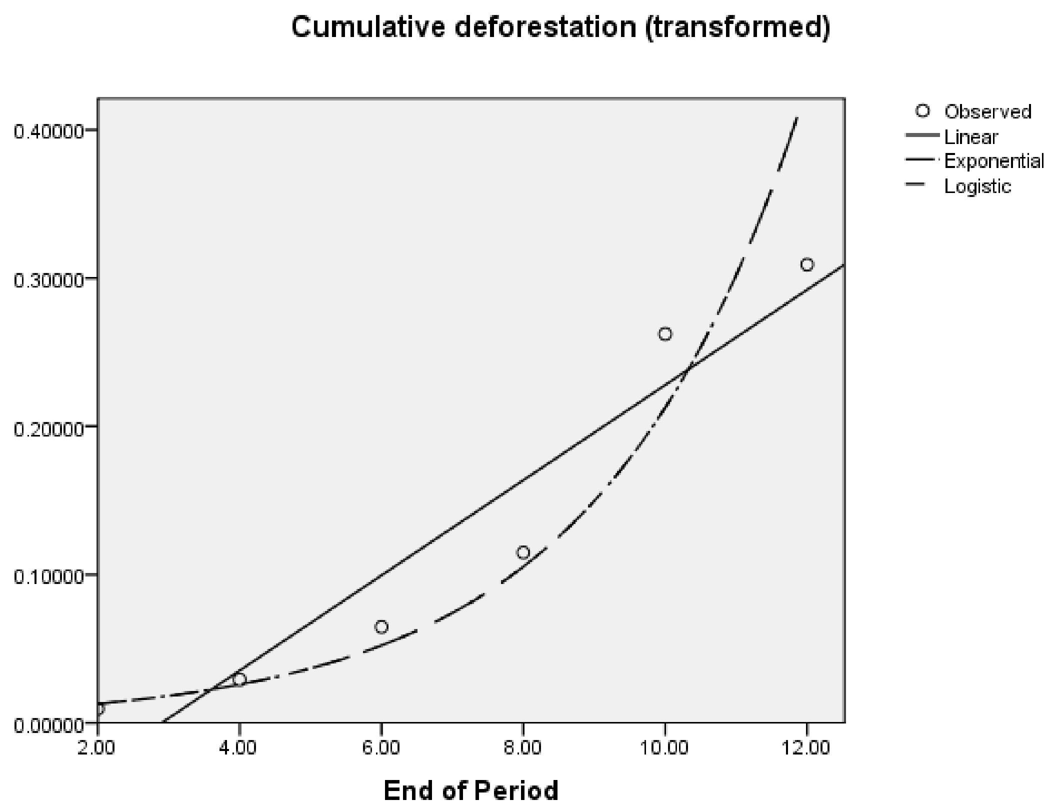
The independent variable is End of Period.

SPSS syntax for the three models is listed in the ‘ Topics’ help function as follows:

Linear. Model whose equation is Y = b0 + (b1 * t).

Exponential. Model whose equation is Y = b0 * (e**(b1 * t)) or ln(Y) = ln(b0) + (b1 * t).

Logistic. Model whose equation is Y = 1 / (1/u + (b0 * (b1**t))) or ln(1/y-1/u) = ln (b0) + (ln(b1) * t) where u is the upper boundary value.



Annex 5.2 Modelling the spatial distribution of deforestation in the reference region

Summary

This annex describes the development of a model for the location of deforestation in the reference region. We parameterized a spatially-explicit logistic regression model of deforestation risk using the observed spatial distribution of deforestation during 2002-2008. We tested for the influence of 14 explanatory driver variables. We used an information theoretic selection process to select the best four models from 16 candidates and then chose the one which performed best against an independent subset of the 2002-2008 dataset. The chosen model, which included six predictive variables, had a Figure of Merit score of 50.03%. This is well above the required threshold value.

The Wald test statistics, which indicate the relative weights of the explanatory variables in the model, showed that distance to previously deforested areas >10 ha in extent was the most important explanatory variable, followed by travel time to the nearest market town and forest type (dense vs open). Protection status, distance to the Mekong river and elevation were also important.

Updated spatial datasets for these explanatory variables and for the stratum boundaries were combined with estimates of the total quantities of deforestation from Annex 5.1 to enable projected deforestation maps to be produced for each year of the first fixed baseline period.

Introduction

A conservation finance project is being developed in the Core Area of the Seima Protection Forest (SPF), Cambodia under the REDD framework (Reduced Emissions from avoided Deforestation and Degradation). The project will follow a carbon accounting methodology validated against the Verified Carbon Standard. The chosen methodology is the Unplanned Deforestation Methodology, VM0015. (hereafter 'the methodology').

Among other steps, this methodology requires a model to be developed of the expected location of deforestation across the reference region, an area of analysis that covers the project area itself plus a larger area of land across NE Cambodia that faces a comparable mixture of threats. The aim of this step is to match the location of projected deforestation with carbon stocks. This report summarises the numerical results of that process, including a confirmation of the performance of the model against observed data[25].

Projection of the location of future deforestation (Methodology Step 4.2)

Preparation of factor maps (Step 4.2.1)

Spatial data on variables that may explain the distribution of deforestation caused by each group of agents are referred to in the methodology as 'factor maps'. A qualitative analysis of drivers of deforestation in the reference region (presented in the PD, Section 4.5) identified agricultural smallholders as the main agents of unplanned deforestation across the majority of the region (Stratum 1), with planned deforestation being confined to clearly defined concession areas (which are placed in Stratum 2). We modelled the spatial distribution of unplanned deforestation in Stratum 1 following standard Generalised Linear Modelling techniques (GLM, Grafen & Hails 2002), using data from the reference region during the historical reference period.

The historical reference period runs from 1998 to the end of 2009. The boundaries of the two strata changed during this period, as did the spatial distribution of some of the key drivers (e.g. trunk roads, protected areas). This variation over time complicates analysis and risks obscuring the effects of the drivers of deforestation at any point in time. Therefore we selected a subset of the reference period from 2002-end of 2008 for the modeling of risk. These dates are appropriate because it was a period during which a large proportion (75.4%) of the total deforestation occurred but the boundaries of the

[25] We acknowledge the assistance of Toby R. Marthews and David L. A. Gaveau in the preparation of this annex.

two strata and the spatial pattern of many of the key drivers (in particular, the boundaries of the SBCA, which is the key management unit in the projected baseline scenario) remained broadly constant.

In general, smallholder farmers act to maximize profits by allocating any parcel of land to the use that earns the highest rent (Angelsen 1999; Mertens and Lambin 2000), which includes a calculation of relevant costs *vs.* benefits of forest conversion as perceived by the smallholder. Management category of the land (e.g. Protected Area, Logging Concession), agronomic potential (which varies with soil fertility etc) and geographic accessibility determine to a large extent the spatial distribution of relative land value and therefore relative probability of deforestation. Based on the literature on deforestation in the tropics, the main variables that capture geographic accessibility include topography (slope and elevation), distance to previously deforested areas, distance to roads, distance to main markets and distance to navigable rivers (Kaimowitz and Angelsen 1998, Vuohelainen *et al.* 2012). Slope and elevation have an effect on both agronomic potential and accessibility.

As shown in Table 1, we compiled existing data on these potential explanatory factors or derived the relevant variables ourselves from existing data products. For example, distances to various types of road, to the Mekong river, and to previously deforested areas were derived as straight-line distance using the Euclidean Distance generator in ArcGIS 10.0. Distance to markets was derived using a more complex method based on travel times to account for the difficulty, or friction, of travelling along roads of different quality using the Path Distance generator in ArcGIS 10.0. Friction surface maps were created by assigning all-weather hard surface roads, all-weather loose surface roads, and other non-all weather roads (inc. cart tracks) a traveling speed of 30 km/h, 10 km/h and 3 km/h, respectively. Slope dependent off-road walking speeds calculated for a complex agricultural landscape at the forest margin in the Philippines (Verburg *et al.* 2004) were also used to generate a friction map. Off-road speeds were assumed to be the same in forest as in agricultural landscapes.

In some cases data from national sources were modified on the basis of more precise or up to date information collected within the reference region. To increase the probability of finding the most powerful explanatory variables, some of the variables were presented in more than one way (e.g. distance to recent deforestation was expressed both as distance patches of any size and as distance only to the larger patches). Where the spatial distribution of a variable changed during the course of the period 2002-2008 we used the distribution as of 2005, as this is mid-way through the period and is likely to be the distribution that was most closely related to deforestation during the majority of the period.

Table 1: Variables used in the full (unreduced) models (i.e. all proposed predictor variables), as required by VCS (2011:§4.2.2). Values of each of these at the central points of the 38,540 tiles covering Stratum 1 of the reference region were the values used in the GLM analysis.

Model (predictor) variable		Units	Source*	Notes
t2p	Travel time to Phnom Penh (used as a surrogate for distance to international markets)	h	Road maps, terrain maps	Path distance generator in spatial analyst ArcGIS 10.0 using a Friction map derived from SRTM DEM and travel speeds from Verburg *et al.* (2004).
t2t	Travel time to the nearest market town (distance to local markets)	h	Road maps, terrain maps	Path distance generator in spatial analyst ArcGIS 10.0 using a Friction map derived from SRTM DEM and travel speeds from Verburg *et al.* (2004).
d2mekong	Distance from the Mekong River	km		Straight-line distance using the Euclidean Distance generator in spatial analyst of ArcGIS 10.0
d2deall	Distance from post-1998 deforestation	km	Analysis of historical land use and land-use change reported in PD Section 4.5	Straight-line distance using the Euclidean Distance generator in spatial analyst of ArcGIS 10.0
d2degt10	Distance from post-1998 deforestation patches >10 ha in extent	km	Analysis of historical land use and land-use change reported in PD Section 4.5	Straight-line distance using the Euclidean Distance generator in spatial analyst of ArcGIS 10.0
soilf	Soil fertility (low, medium or high)	-	SCW (2006) based on Crocker (1963)	Soil fertility (in three broad classes) from a standard national dataset georectified to the project area.
lmc05	Land management category in 2005: Biodiversity Conservation Area (Seima), Wildlife Sanctuary (Snuol) or Logging Concession (Casotim, Kingwood or Samling West)	-	GIS layer of protected areas and logging concessions	Boundaries of conservation areas of different status and of logging concessions as of year 2005.
d2awhro05	Distance from all-weather, hard-surfaced roads in 2005	km	Road maps	
d2awlro05	Distance from all-weather, loose-surfaced roads in 2005	km	Road maps	
d2fwro05	Distance from fair-weather roads in 2005	km	Road maps	
d2tracks	Distance from cart-tracks in 2002	km	Road maps	No later data are available
natveg	Natural vegetation cover (dense or open forest)	-	Analysis of historical land use and land-use change reported in PD Section 4.5	
elev	Elevation above sea level	m asl	NASA SRTM Digital Elevation Model (DEM)	
slope	Slope of terrain	%	NASA SRTM Digital Elevation Model (DEM)	

*All road maps are a combination of the standard national data layers from the Japan International Cooperation Agency (JICA) and Ministry of Public Works updated with WCS field survey data.

A more detailed description of these variables is presented in Appendix 1 (to comply with the data requirements of Table 10 of the methodology).

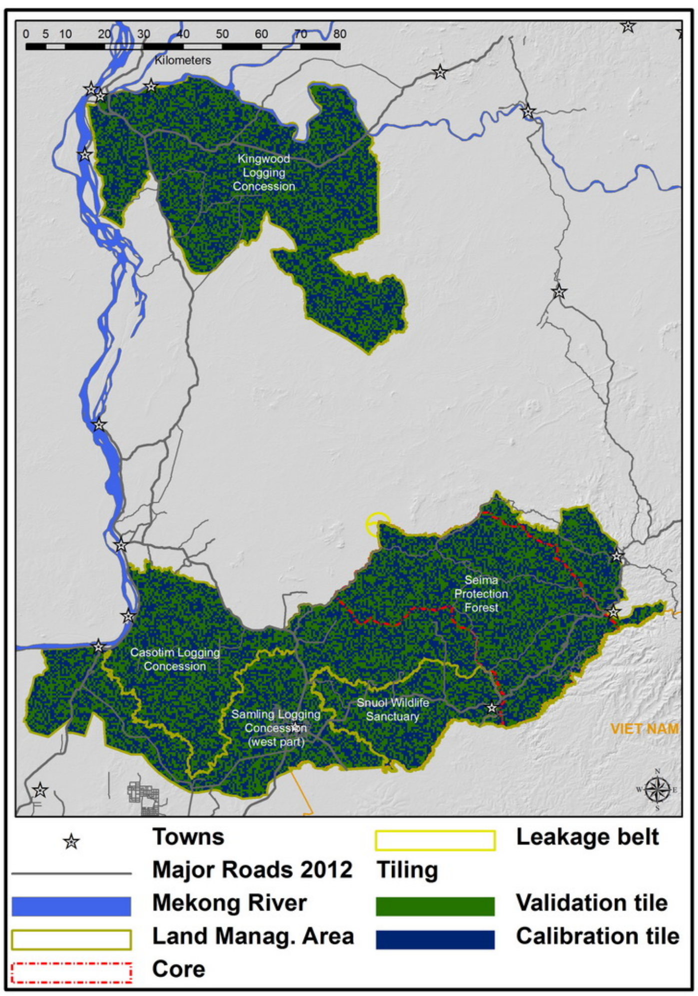
Preparation of deforestation risk maps (Step 4.2.2)

The methodology allows the explanatory variables to be related to deforestation risk using either an empirical (preferred) or a heuristic approach. We used the empirical approach. We used a logistic regression approach (i.e. Generalised Linear Model (GLM) analysis using binomial or quasibinomial errors). This is a widely-used method for depicting probability of change in a landscape based on a set of explanatory spatial variables (e.g. Mertens & Lambin 2000, Soares-Filho *et al.* 2001, Wilson *et al.* 2005, Gaveau *et al.* 2009; for theory see Grafen & Hails 2002, Gelman & Hill 2007, Crawley 2007, Burnham & Anderson 2010). We parameterized a spatially-explicit model of unplanned deforestation that occurred in Stratum 1 during 2002-2008 in terms of the explanatory variables listed Table 1. The dependent variable was the occurrence or not of deforestation in each pixel, which was determined from the Landsat-derived historical land-use/land-use change analysis described in Section 4.5.

Tiling for calibration and confirmation

In order to confine analysis to the period when the stratum boundaries and key drivers were broadly constant (see above) we both calibrated and confirmed the deforestation model for the 2002-2008 period by tiling the analysis area following the approach of Castillo-Santiago *et al.* (2007), as permitted by the methodology. We divided the reference region into 38,540 500 m x 500 m tiles (Figure 1) and randomly selected half of these (19,102 tiles) to parameterize the model (calibration) and the other half (19,438 tiles) for model confirmation. These are not split exactly 50-50 because they are randomly chosen without replacement.

Figure 1 Tiling of the dataset before analysis



Logistic regression modeling to parameterize the model

The value of the central point of each tile on each GIS data layer was extracted and used in the GLM analysis so each data point was separated by >500 m distance on the ground (a sufficient distance to ensure that spatial autocorrelation effects will be minimal). Before the GLM analysis, we excluded the 6.3% of calibration points that were clear of forest cover in 2002 (*natveg*=NF, Table 1), i.e. we removed pixels that were not 'candidates for change', as advised by Pontius *et al.* (2008).

We measured or calculated the value of each variable at each sample point and then analyzed this dataset using R statistical software (R Development Core Team 2012). The presence of cross-correlations (multi-collinearity) among the variables was tested before including them as inputs in the logistic regression model (multi-collinearity may bias GLM parameter estimates, Aguilera *et al* 2006), following advice in Burnham & Anderson (2010) about choosing reasonable candidate models. Only two pairs of variables showed a degree of correlation close to the maximum acceptable level of r^2=0.56 (r=0.75, Green 1979) - *d2deall* & *d2degt10* with r^2=0.51 and *t2t* & *t2p* with r^2=0.56 - so we did not include both variables in any one candidate model fit (Burnham & Anderson 2010). Along with considering the road categories separately, we considered in total 16 candidate GLMs (specified in detail in Appendix 2).

We compared all candidate models to identify the ones that best explained the spatial distribution of deforestation and to rank them in order of importance. We used an information theoretic selection process based on the Akaike Information Criterion (AIC, see e.g. Gelman & Hill 2007, Burnham & Anderson 2010) to determine the most parsimonious model of a suite of candidate models (i.e. the most plausible model that has the smallest number of explanatory locational driver variables).

Selection of the most accurate deforestation risk map (Step 4.2.3)

Approach

We follow the most standard method of model selection for each candidate GLM, beginning with the 'full model' containing all possible predictor variables and removing predictors one-by-one (a "backward-deletion" method). Because we are predicting deforestation probabilities (binary data), the errors are binomial and we must use a logit link function, as is standard in logistic regression (Gelman & Hill 2007). As was clear from a preliminary analysis, these data are overdispersed (this is usual with binomial data over a spatial domain, e.g. Vuohelainen *et al.* 2012) and therefore we follow standard practice for overdispersed binomial regressions and apply the in-built quasibinomial function in R (Gelman & Hill 2007). Information theoretic AICs are not returned from quasibinomial model fits, therefore we followed the backwards-deletion method with quasibinomial errors and then recalculate the final GLM fit for the minimal version of each candidate GLM with binomial errors to generate the AIC of the fit (see e.g. Vuohelainen *et al.* 2012).

The best fit to the deforestation map was found by first selecting the candidate models for which the AIC was in the lowest 50% (from the range of AIC across all candidate models) and then testing their performance against the confirmation dataset as described below to ensure independence between the calibration and confirmation datasets.. The model with the highest Figure of Merit (FOM) score was chosen.

To generate model predictions, the cartographic layers of each statistically significant explanatory driver variable $X_i\ (x,y)$ were weighted by their respective model's coefficient, β_i (Table 2) then summed along with the model's constant coefficient term β_0, finally producing a relative probability map of deforestation $P(x,y)$ over the surface of stratum 1 using:

$$P(x,y) = \frac{e^{\beta_0 + \sum_{i=1}^{n} \beta_i X_i(x,y)}}{1 + e^{\beta_0 + \sum_{i=1}^{n} \beta_i X_i(x,y)}}$$

This calculation allows pixels to be ranked in terms of their relative probability of unplanned deforestation. A threshold probability is then calculated such that the deforestation of all pixels above this threshold will result in the same total amount of deforestation as was observed during the period in question.

To give a numerical example based on the model coefficients in Table 3, if a pixel is situated 10 hours' travel from the nearest local town in an area of dense forest in Snuol Wildlife Sanctuary, 5 km from the nearest patch of previous deforestation larger than 10 ha, 68 km from the Mekong River at 30 m asl, then calculate η = (-0.3191870*10 + 1.1352346 - 0.2290799*5 + 0.0263701*68 - 0.0112606*30 + 1.1170759 - 1.3952941) =-2.024904 and then, because this is a logistic regression, invert the link function to get (probability of deforestation) = 100 × exp(η)/(1 + exp(η)) = 11.7%. This is lower than the threshold 44.35% for this model (Table 1) so we conclude that this pixel would not be deforested during the year in question.

Most explanatory driver variables used in the simulation (e.g. elevation, forest type) were static during the period of analysis and therefore calculated only once before the simulation started, using the values as they were in 2005. Travel time to previous deforestation was dynamic and therefore recalculated at the beginning of each time period, based on updated deforestation statistics, taking into account new deforestation predicted in previous years.

The Figure of Merit, *FOM* is a statistical measure of model performance which is expressed as the ratio of the intersection of the observed 2002-2008 deforestation and simulated 2002-2008 deforestation to the union of the observed and predicted deforestation (Pontius *et al.* 2008). It ranges from 0% for no agreement between simulated parameters and reference data to 100% for perfect agreement. It is calculated as:

$$FOM = \frac{B}{A + B + C}$$

Where:

A is the area of error due to observed deforestation predicted as remaining forest
B is the area correct due to observed deforestation predicted as deforestation
C is the area of error due to observed remaining forest predicted as deforestation (Pontius *et al.* 2008).

Values for relevant candidate models have been calculated in Table 2. The minimum threshold for the FOM is defined as the net observed change in the reference region for the calibration period of the model (ie total area of change being modeled in the reference region as a percentage of the total area of the reference region). In the case of the current project this threshold is 127,390 ha/937,931 ha = 13.6%.

Results

Model #16 had the best AIC and FOM score and so was unequivocally the best performing model, although by a relatively narrow margin in both cases (Table 2). The FOM score easily exceeds the threshold calculated in the previous section. The accuracy of our model is good compared to most other studies that have employed deforestation models in a similar fashion. For example, Pontius *et al.* (2008) performed a survey of 13 different land change models and showed that the Figure of Merit was <45% for 10 out of 13 models. This is true despite the high spatial resolution of our model (30 m x 30 m) relative to the level of resolution actually required for accurate calculation of greenhouse gas emissions (ie assigning deforestation to the correct carbon density stratum).

The coefficients of model #16 are shown in Table 3.

Table 2: The top four candidate logistic regression models
All models are for predicting the probability of deforestation during 2002-08. For the *FOM* (Figure of Merit) higher means a better fit (Pontius *et al.* 2008), but for AIC lower means a better fit (Grafen & Hails 2002). For reasons of space, of the 16 candidate models tested, only the four best in terms of Figure of Merit are shown.

Model			***No. of terms***	XD * (%)	AIC	Figure of Merit calculation			
#	Full model terms:	Minimal model terms:				A (km2)	B (km2)	C (km2)	F (%)
9	*d2mekong, elev, slope, d2awhro05, d2tracks, t2p, d2degt10, soilf, lmc05, natveg*	*elev, slope, d2awhro05, t2p, d2degt10, lmc05, natveg*	7	43.94	7837.2	213.75	420.25	215.25	49.48
10	*d2mekong, elev, slope, d2awlro05, d2tracks, t2p, d2degt10, soilf, lmc05, natveg*	*d2mekong, elev, slope, t2p, d2degt10, lmc05, natveg*	7	43.85	7844.2	216.75	417.25	218.25	48.96
11	*d2mekong, elev, slope, d2fwro05, d2tracks, t2p, d2degt10, soilf, lmc05, natveg*	*elev, slope, t2p, d2degt10, lmc05, natveg*	6	44.06	7870.8	219.75	414.25	221.00	48.45
16	***d2mekong, elev, slope, d2awhro05, d2tracks, t2t, d2degt10, soilf, lmc05, natveg***	***d2mekong, elev, t2t, d2degt10, lmc05, natveg***	6	44.35	7981.0	210.75	423.25	212.50	50.03

* XD is the threshold probability of deforestation required for each model to predict the correct deforestation area for 2002-08 (see text).

The Wald test statistics (Table 3), which indicate the relative weights of the explanatory variables in the model, show all the parameters have quite high and relatively similar weights. Distance to previously deforested areas >10 ha in extent was the most important explanatory variable, followed by travel time to local market towns and the additional desirability of dense forest over open forest (Table 3). Dense forest areas located near large previously deforested areas and with easy access to local market towns are therefore the most highly vulnerable to deforestation. Patches of dense forest presumably have a higher probability of deforestation in comparison to other natural land cover types perhaps because this cover type is perceived to lie on better soils for agriculture.

Probability of deforestation increased with distance from the Mekong River. Elevation has a minor effect on deforestation risk, with highland areas being slightly less vulnerable to deforestation. The management activities in Snuol Wildlife Sanctuary and Seima Biodiversity Conservation Area reduce deforestation probabilities in these reserves, notably rather more strongly in Seima, but do not prevent deforestation entirely. This clearly demonstrates the measurable positive impact that conservation measures can have on deforestation threat in a Cambodian context, as well as the scope for additionality by further enhancing the effectiveness of conservation in the Seima project area.

Surprisingly, proximity to roads of any category did not reduce deforestation risk according to this model, but this should be interpreted carefully: travel time to the nearest local town was a very significant predictor and this variable is calculated taking account of the road network (i.e. the model indicates that roads have no significant effect on deforestation probability beyond causing a reduction in travel times).

Table 3: Parameter estimates of the best-fit model (Model #16, Table 2).

The null deviance was 14251.0 on 17058 degrees of freedom and the residual deviance was 7965.0 on 17051 degrees of freedom. Note that all these predictors were highly significant (p-values very close to zero) and may be used to calculate deforestation risk *. Predictors are presented in order of their z values (ignoring sign), which are Wald test scores showing the degree of association between the predictor and deforestation probability (= square roots of $\chi 2$ statistics).

Model variables	***Variable coefficients (β)***	Standard error	***z*** value	Significance (***p***-value)
Distance to all patches of previous deforestation >10 ha (km) (*d2degt10*)	-0.2290799	0.0101975	-22.46	<0.0001
Travel time to the nearest local town (h) (*t2t*)	-0.3191870	0.0159888	-19.96	<0.0001
Natural vegetation is Dense Evergreen Forest *vs.* Deciduous Forest, Open forest (*natveg*)	1.1352346	0.0713631	15.91	<0.0001
Distance to Mekong River (km) (*d2mekong*)	0.0263701	0.0020293	12.99	<0.0001
Elevation above sea level (m asl) (*elev*)	-0.0112606	0.0009134	-12.33	<0.0001
Intercept (= constant value β_0)	1.1170759	0.0909723	12.28	<0.0001
Snuol Wildlife Sanctuary *vs* Logging Concession (*lmc05*)	-1.3952941	0.1321333	-10.56	<0.0001
Seima Biodiversity Conservation Area *vs* Logging Concession (*lmc05*)	-2.6993849	0.1640929	-10.56	<0.0001

Mapping the location of deforestation (Step 4.2.4)

Having selected the best model it is necessary to determine the predicted locations of future deforestation in the baseline scenario for each year of the first fixed baseline period (2010-2019 inclusive). The mathematical process is as described for the confirmation phase above. As in the confirmation phase, in any given year it is necessary to rank the pixels by their calculated relative risk of deforestation and then assign them to a deforested category in strict order of rank, highest first, until the quantity of deforestation determined in Annex 5.1 for that year has been reached.

The stratum boundaries and some of the risk factors in the chosen model are dynamic, that is they vary through the first fixed baseline period. Therefore the following sequence of steps must be followed for the projections:

2010

i) Determine spatial distribution of driver variables at start of 2010 and any changes in the stratum boundaries
ii) Calculate the first annual deforestation risk map for Stratum 1
iii) Assign the appropriate quantity of deforestation to the highest ranked pixels as described above.
iv) Output the first annual map of predicted unplanned deforestation (for end of 2010).

2011

v) Determine spatial distribution of driver variables at start of 2011 using the new map of deforestation from end of 2010 combined with updated maps of any other dynamic variables such as road layers and any known changes in the stratum boundaries.
vi) Calculate the second annual unplanned deforestation risk map
vi) Assign the appropriate quantity of deforestation to the highest ranked pixels as described above.
vii) Output the second annual map of predicted deforestation (for end of 2011).

Subsequent years

This annual cycle is repeated until the end of 2019.

The spatial input data used for the projections and the way they vary over time are described in Appendix 3 below, and will be provided to the auditor upon request.

The resulting shapefiles were used to generate the estimates of deforestation for the project area and leakage belt in Annex 5.1. Figure 2 shows the predicted deforestation for the first year (2010). Figure 3 shows the expected baseline deforestation for the fixed baseline period, as required by the methodology. Figure 4 shows the project area in close-up, with the ten successive years of projected deforestation shown separately. Maps of the projected deforestation for each year across the whole reference region are available on request.

igure 2 Predicted deforestation for 2010

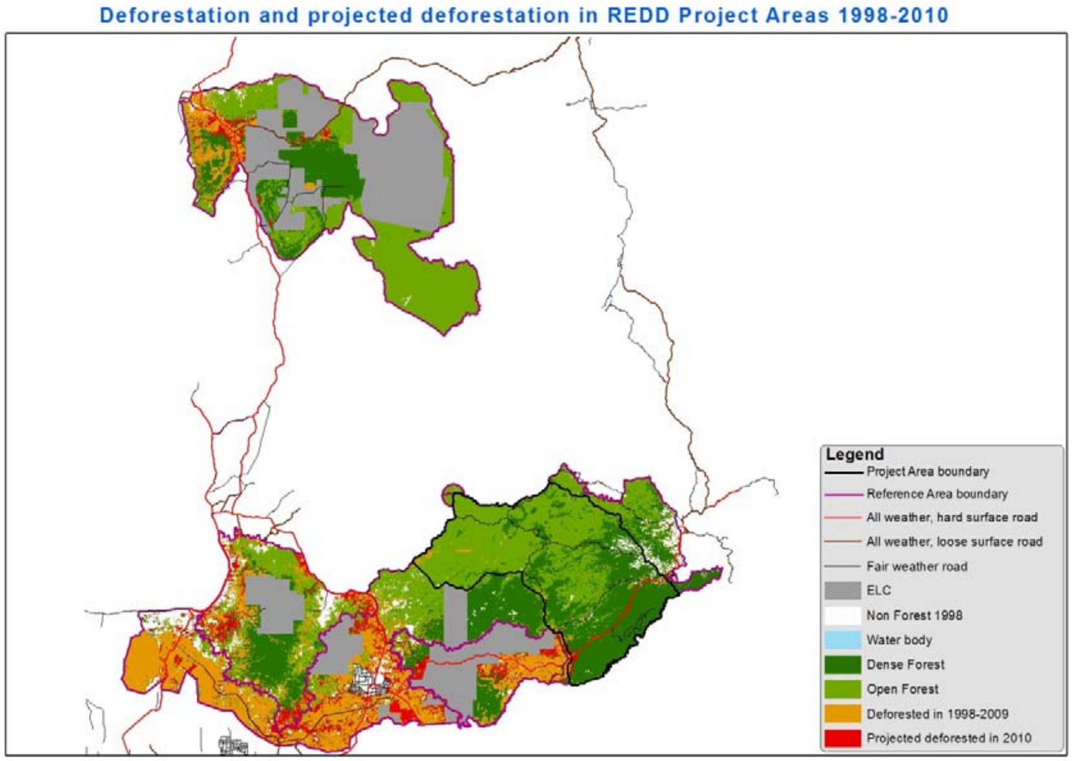


Figure 3 Total projected deforestation 2010-2019

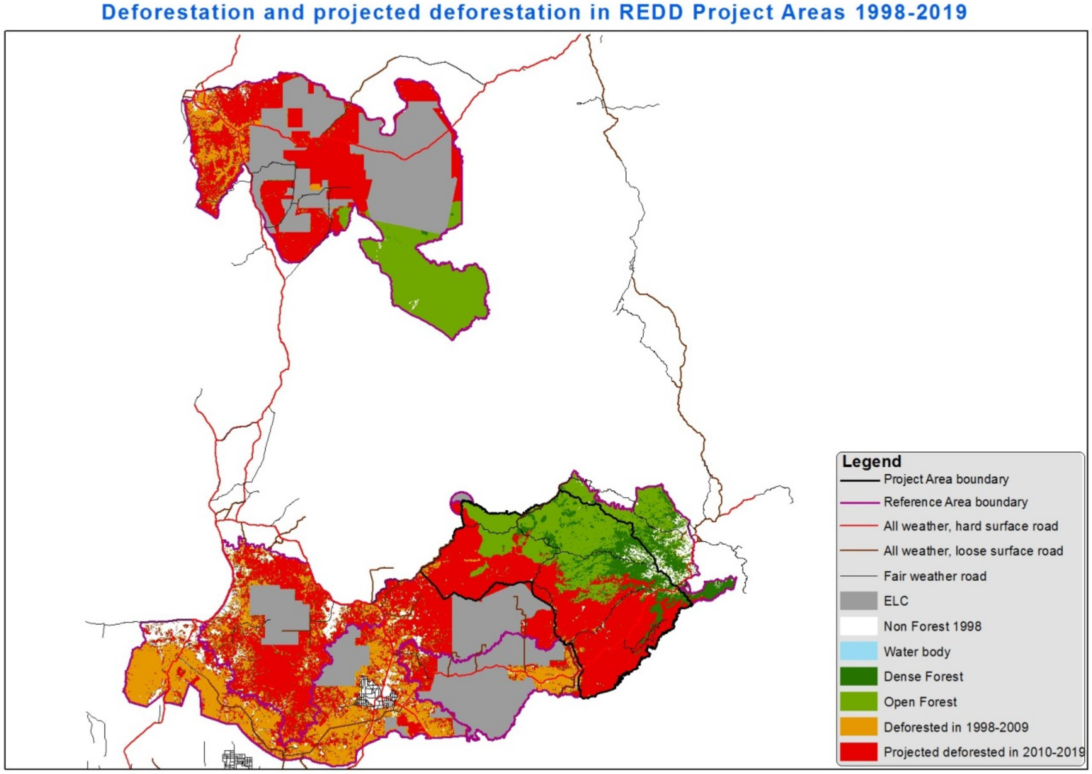
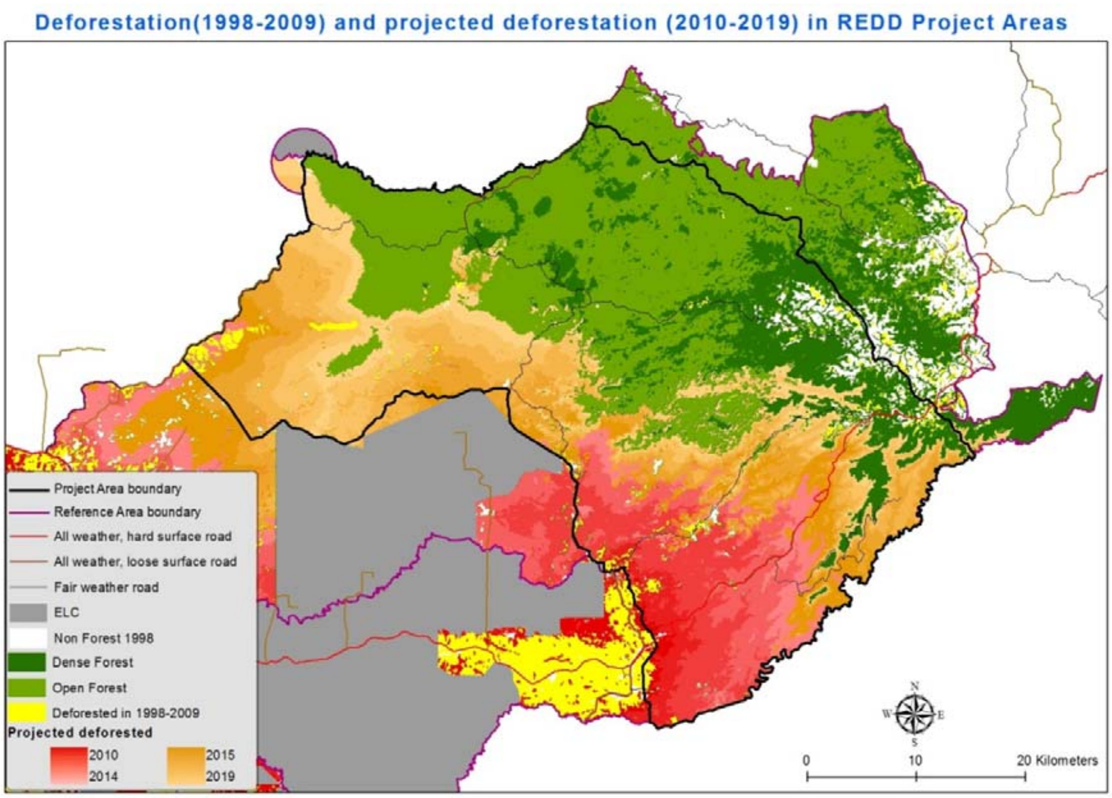


Figure 4 Projected annual deforestation in the project area, 2010-2019



Appendix 1 Detailed list of variables, maps and factor maps (= Table 10 of the methodology)

ID	File name	Source	Units	Description	Range	Meaning of the categories/pixel values	Other maps and variables used to create the factor maps*	Algorithm or equation used
t2p	SEIMAproject.gdb	Derived by authors from other data products	h	Travel time to Phnom Penh	6-74.2 h	See description	WCS/JICA road map 2005 (on road); NASA SRTM Digital Elevation Model (DEM) (off road)	Path distance generator in spatial analyst ArcGIS 10.0 using a friction map based on travel speeds from Verburg *et al.* (2004).
t2t	SEIMAproject.gdb	Derived by authors from other data products	h	Travel time to the nearest market town	0-63.1 h	See description	WCS/JICA road map 2005 (on road); NASA SRTM Digital Elevation Model (DEM) (off road)	Path distance generator in spatial analyst ArcGIS 10.0 using a friction map based on travel speeds from Verburg *et al.* (2004).
d2mekong	SEIMAproject.gdb	Derived by authors from other data products	km	Distance from the Mekong River	0-182.6 km	See description	standard ArcGIS library Basemap files	Straight-line distance using the Euclidean Distance generator in spatial analyst of ArcGIS 10.0
d2deall	SEIMAproject.gdb	Derived by authors from other data products	km	Distance from post-1998 deforestation	0-62.7 km	See description	Analysis of historical land use and land-use change reported in PD Section 4.5	Straight-line distance using the Euclidean Distance generator in spatial analyst of ArcGIS 10.0
d2degt10	SEIMAproject.gdb	Derived by authors from other data products	km	Distance from post-1998 deforestation patches >10 ha in extent	0-69.3 km	See description	Analysis of historical land use and land-use change reported in PD Section 4.5	Straight-line distance using the Euclidean Distance generator in spatial analyst of ArcGIS 10.0
soilf	SEIMAproject.gdb	Derived by authors from other data products	-	Soil fertility	L, M or H	Low, medium or high	Derived by grouping classes of the standard national dataset (Crocker 1963) georectified to the project area.	Soil fertility classes follow SCW (2006)

lmc05	SEIMAproject.gdb	Derived by authors from other data products	-	Land management category in 2005	-	Boundaries of conservation areas of different status and of logging concessions as of year 2005.	Compilation of official GIS layers of protected areas and logging concessions obtained from various government departments	Aligned to shared natural features by project team to avoid slight overlaps
d2awhro05	SEIMAproject.gdb	Derived by authors from other data products	km	Distance from all-weather, hard-surfaced roads in 2005	0-88.9 km	See description	WCS/JICA road map 2005	Straight-line distance using the Euclidean Distance generator in spatial analyst of ArcGIS 10.0
d2awlro05	SEIMAproject.gdb	Derived by authors from other data products	km	Distance from all-weather, loose-surfaced roads in 2005	0-86.0 km	See description	WCS/JICA road map 2005	Straight-line distance using the Euclidean Distance generator in spatial analyst of ArcGIS 10.0
d2fwro05	SEIMAproject.gdb	Derived by authors from other data products	km	Distance from fair-weather roads in 2005	0-67.9 km	See description	WCS/JICA road map 2005	Straight-line distance using the Euclidean Distance generator in spatial analyst of ArcGIS 10.0
d2tracks	SEIMAproject.gdb	Derived by authors from other data products	km	Distance from cart-tracks in 2002	0-62.7 km	See description	WCS/JICA road map 2005. Refers to 2002 in this case as no later data are available	Straight-line distance using the Euclidean Distance generator in spatial analyst of ArcGIS 10.0
natveg	final_classification_utm48n_indian1960_nodata_filtered_13feb2011.img	Analysis of historical land use and land-use change reported in PD Section 4.5	-	Natural vegetation cover	DEF, DFOF or clear in 1998	Dense or open forest	-	-
elev	srtmdem_utm48n_indian1960_2.img	NASA SRTM Digital Elevation Model (DEM)	m asl	Elevation above sea level	0-1081 m	See description	-	-
slope	srtmdem_utm48n_indian1960_2.img	Derived by authors from other data products	%	Slope of terrain	0-100 %	See description	NASA SRTM Digital Elevation Model (DEM)	-

* '*WCS/JICA road map 2005*' is 'Roads_master_4Toby.shp' the standard national road dataset from JICA/MoPW (2002) updated with field data from WCS/FA

Appendix 2 Specifications of the 16 model combinations

Model #	Road variables	Travel time variable	Deforestation variable	Other variables (same for all models)
1	d2awhro05+d2tracks	t2p	d2deall	d2mekong+elev+slope+soilf+lmc05+natveg
2	d2awlro05+d2tracks	t2p	d2deall	d2mekong+elev+slope+soilf+lmc05+natveg
3	d2fwro05+d2tracks	t2p	d2deall	d2mekong+elev+slope+soilf+lmc05+natveg
4	d2awhro05+d2awlro05+d2fwro05+d2tracks	t2p	d2deall	d2mekong+elev+slope+soilf+lmc05+natveg
5	d2awhro05+d2tracks	t2t	d2deall	d2mekong+elev+slope+soilf+lmc05+natveg
6	d2awlro05+d2tracks	t2t	d2deall	d2mekong+elev+slope+soilf+lmc05+natveg
7	d2fwro05+d2tracks	t2t	d2deall	d2mekong+elev+slope+soilf+lmc05+natveg
8	d2awhro05+d2awlro05 d2fwro05+d2tracks	t2t	d2deall	d2mekong+elev+slope+soilf+lmc05+natveg
9	d2awhro05+d2tracks	t2p	d2degt10	d2mekong+elev+slope+soilf+lmc05+natveg
10	d2awlro05+d2tracks	t2p	d2degt10	d2mekong+elev+slope+soilf+lmc05+natveg
11	d2fwro05+d2tracks	t2p	d2degt10	d2mekong+elev+slope+soilf+lmc05+natveg
12	d2awhro05+d2awlro05+d2fwro05+d2tracks	t2p	d2degt10	d2mekong+elev+slope+soilf+lmc05+natveg
13	d2awhro05+d2tracks	t2t	d2degt10	d2mekong+elev+slope+soilf+lmc05+natveg
14	d2awlro05+d2tracks	t2t	d2degt10	d2mekong+elev+slope+soilf+lmc05+natveg
15	d2fwro05+d2tracks	t2t	d2degt10	d2mekong+elev+slope+soilf+lmc05+natveg
16	d2awhro05+d2awlro05+d2fwro05+d2tracks	t2t	d2degt10	d2mekong+elev+slope+soilf+lmc05+natveg

Appendix 3 Variables and stratum boundaries used for projecting the location of baseline unplanned deforestation 2010-2019

The first table summarizes the dynamic treatment of stratum boundaries during the early years of the first fixed baseline period.

	2010	2011	2012	2013 onwards
Stratum boundaries	Updated to the observed situation in 2010-2011*	Updated to the observed situation in 2010-2011*	Updated to the observed situation in 2012	As 2012

*The boundaries of Stratum 2 are defined by the location of active economic land concessions, for which one necessary source of evidence is the analysis of satellite imagery to determine how active they are. Due to the availability of imagery and other constraints no analysis was conducted at the end of 2010 so the same stratum boundaries are applied for both 2010 and 2011. No updates are possible beyond the end of 2012 due to uncertainties about the future locations of concessions. This is conservative as data on additional concessions would be likely to increase the relative risk of deforestation in non-concession areas such as Seima, by reducing the pool of land available for unplanned deforestation.

The second table summarizes the treatment of the risk variables (both dynamic and static) during the early years of the first fixed baseline period. Please see Appendix 1 for further information on these variables.

ID	Description	Type	2010	2011	2012	2013 onwards
t2t	Travel time to the nearest market town	Dynamic	Updated to observed situation in 2010	Updated to observed situation in 2011	Updated to observed situation in 2012	No further updates. 2012 values apply.
d2degt10	Distance from post-1998 deforestation patches >10 ha in extent	Dynamic	Updated to observed situation at start of 2010	Updated to projected situation at start of 2011	Updated to projected situation at start of 2012	Updated to projected situation at start of each subsequent year
lmc05	Land management category in 2005	Static^	Coding unchanged since calibration period. Parameter coefficient adjusted to reflect variation in funding^	Coding unchanged since calibration period. Parameter coefficient adjusted to reflect variation in funding^	Coding unchanged since calibration period. Parameter coefficient adjusted to reflect variation in funding^	No further updates. 2012 values apply.
d2mekong	Distance from the Mekong River	Static	Unchanged since calibration period	Unchanged since calibration period	Unchanged since calibration period	Unchanged since calibration period
natveg	Natural vegetation cover	Static	Unchanged since calibration period	Unchanged since calibration period	Unchanged since calibration period	Unchanged since calibration period
elev	Elevation above sea level	Static	Unchanged since calibration period	Unchanged since calibration period	Unchanged since calibration period	Unchanged since calibration period

* The methodology only allows predictive updates of infrastructure maps based on clearly documented evidence, which is not available in the current case

^ While the legal designations of all management units remain unchanged from the calibration period, Appendix 4.4 demonstrates major observed and predicted declines in funding for key activities in the baseline scenario due to changes in donor policies. These declines would weaken the protective impact of the Seima Biodiversity Conservation Area relative to the historical reference period through a proportional reduction in the staffing and activity budgets for core activities, above all law enforcement patrolling and threat monitoring. These declines have been reflected in the projections by reducing the coefficient of the Seima-specific parameter in the model in proportion to the decline in funding, relative to the 2006-2009 average.

Annex 5.3 Estimation of baseline carbon stocks in the forest classes found in SPF

Summary

This report summarises the results of a survey of carbon stocks in the forests of the Seima Protection Forest Core Area, the site of a REDD project. It forms a methodological annex to the Seima Protection Forest REDD Project Document. A systematic random sample of 104 plot clusters was enumerated across the whole Project Area. Carbon pools measured were living and dead trees and lying dead wood, whilst root biomass was estimated using standard conversion factors. Formal quality control measurements showed very low levels of error.

Two forest strata, dense and open, were mapped from satellite analysis. The dense forest stratum comprises evergreen, semi-evergreen and bamboo stands - it has an above and below ground carbon stock of 298.62 tC/ha (+/- 7.4% at the 90% confidence level). The open forest stratum comprises mixed deciduous forest, deciduous dipterocarp forest and open woodland - it has a stock of 150.72 tC/ha (+/- 15.6%). These figures are relatively high compared to IPCC defaults values but consistent with previous studies in the landscape and published predictive regional maps. Hence this part of eastern Cambodia is confirmed to support forest with high carbon stocks by regional standards, despite some past selective logging.

Introduction

A conservation finance project is being developed in the Core Area of the Seima Protection Forest (SPF), Cambodia under the REDD framework (Reduced Emissions from avoided Deforestation and Degradation). The project will follow a carbon accounting methodology validated against the Verified Carbon Standard. The chosen methodology is the Unplanned Deforestation Methodology, VM0015. (hereafter 'the methodology').

Among other steps, this methodology requires an estimation of the carbon stocks in forests in the project area. This report summarises the numerical results of the estimation of forest carbon stocks in the SPF Project Area[26].

Study area and methods

Study area

The study area was the Core Area of the Seima Protection Forest (SPF), which lies mainly in Mondulkiri Province, eastern Cambodia. The altitudinal range is about 100-750 m, with 93% of the area lying below 500 m. The climate is tropical monsoonal. At the SPF headquarters (106° 55 E 12° 06 N, 160 m above sea level) recorded rainfall is 2200-2800 mm/year with up to 5 dry[27] months per year from December to April (WCS/FA and Nomad RSI unpublished data). Total rainfall is believed to be lower, with a somewhat more intense dry season of similar duration, in the low-lying north and west of the Core Area, and higher (>3000 mm/year), with a shorter but still strongly marked dry season at higher altitudes in the south-east of the Core Area. Hence the whole landscape lies in the 'Moist' climate category as defined by Chavé *et al.* (2005) and the Moist Tropical biome of IPCC (2006; Table 4.1).

The forests of SPF mostly fall within four of the broad classes used by the 2006 National Forest Cover Assessment (FA 2007), namely Deciduous, Semi-evergreen, Evergreen and Bamboo Forests. Appendix 1 provides a summary of the main forest types recognised by FA (2007) as they relate to SPF. However, defining forest 'types' requires caution in Cambodia, as in many other places, since there is often a continuum without sharp boundaries, and many intermediates can be found across the landscape. The various complex typologies proposed for Cambodian forests are discussed by many authors (e.g Rundel 1999, Tani *et al.* 2007). In SPF studies have found a spectrum of forest

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[26] We acknowledge the assistance of Sarah Walker, Erin Swails, Scott Stanley and Jeff Chatellier in the development of this Annex

[27] Defined as a month with <100 mm precipitation

types from fully deciduous to almost fully evergreen (e.g Walston *et al.* 2001, Zimmermann and Clements 2003, Tani *et al.* 2007), forming a complex mosaic believed to reflect climate, altitude, edaphic factors and varying history of human disturbance.

Alternative typologies can be imposed on this variation, with different systems and different degrees of complexity appropriate for different purposes. In this study we identify a simple set of classes that can be objectively mapped by remote sensing across the whole landscape and correlate with varying carbon stocks to an adequate degree. It has been found that two broad forest classes are sufficient to represent the variation in carbon stocks with sufficient precision.

Methodology

The surveys described here were consistent with the requirements of the methodology, although at the time of the first part of the survey they were conducted based on a draft version of the Avoided Deforestation Partners Modular REDD Methodology, which is very similar in these aspects.

The requirements are described in Part 2 Section 6.1.1 of the methodology and are not repeated in full here. In essence the approach requires the project developer to define the forest classes occurring in the project area and leakage belt, collect existing carbon-stock data from the literature or existing unpublished studies and then to conduct additional field measurements where necessary.

Methods

Assessment of existing data and literature estimates

No existing data were found that met the criteria set out by the methodology (Section 6.1.1a). A number of small high quality datasets existed (e.g. McKenney *et al.* 2004, Tani *et al.* 2007, both of which overlap the project area) but these did not have adequate spatial coverage or sample sizes to be applicable in estimating landscape-wide averages. Raw inventory data were available from the period when the site was an active logging concession (approx. 1996-2000) but the strategic-level inventory data had already been found to be of insufficient quality for forest management planning in a formal review (Y. Petrucci *in litt.* to B. McKenney 2004) and our own analysis of the harvest planning inventory dataset also revealed methodological problems (for example declining tree density with distance from transect lines in the '100%' inventory blocks, suggesting that many trees had been missed). Therefore the concession data were not used. A few other studies exist from comparable forest types elsewhere in North-east Cambodia (e.g. Rollet 1962), but none could be shown to be representative of the conditions in SPF. Therefore it was decided to obtain all the necessary data from field measurements.

Identification of forest boundaries, selection of forest types and carbon pools for measurement

The chosen forest definition is discussed in detail in the Project Document. It was used in the analysis of historical deforestation in the Reference Region, which culminated in the Forest Cover Benchmark map for the Project Area at the project start date. The benchmark map classifies the forest area into two strata, dense and open, which are readily distinguishable by their spectral signatures and correlate well with other national forest classifications and field observations. The survey data presented below were analysed with respect to those two forest strata.

Selection of carbon pools followed guidance in the methodology, and was informed by the results of the pilot survey described below. The choices are discussed in detail in the project document. The following carbon pools were measured in the forest plots:

- above ground living trees ≥5 cm dbh
- standing dead wood ≥5 cm dbh and lying dead wood ≥5 cm diameter.

Below ground living biomass was included in the analysis based on conservative literature values alone, with no additional field data collection.

Data were also collected on the main elements of the non-tree living biomass pool - saplings and bamboo. However, this pool is now considered negligible and the data are not presented here. Litter was considered negligible from the outset and not measured. Soil carbon was conservatively not measured as VCS guidance suggested it was unlikely to change significantly in significant parts of the expected post-deforestation class. The rate of degradation from logging has been shown to be negligible in the Project Area from a carbon accounting perspective (Annex 4.3). Therefore the Long-lived Wood Products pool can also be treated as negligible.

Field measurements

The required steps are detailed in Appendix 3 of the methodology.

Staff training took place mainly in March-April 2009 and included the customisation of generic SOPs for local conditions, the development of Khmer language SOPs and the implementation of a pilot survey. Fieldwork took place during two main periods. During Phase 1, March-July 2009 76 clusters of plots were enumerated across both strata. During Phase 2, December 2011-January 2012 a further 28 clusters were enumerated in the dense forest stratum.

Sampling framework

Determination of sampling frame

Sampling was conducted across the whole Project Area. The sampling frame was the extent of forest within the Project Area, based on the Forest Benchmark Map for the project start date. A draft forest benchmark map was used for the sampling in 2009, which showed negligible differences from the final version. None of the sampling points changed their classification between the draft and final versions.

The methodology states that it is preferable, but not required, that sampling is in locations expected to be deforested according to baseline projections. Such projections were not in hand at the time of the sampling but a qualitative assessment of the distribution of accessibility, threats and recent past deforestation indicated that no part of the project area was wholly free of the risk of deforestation during the life of the project. Hence sampling was applied to all parts of the area and the results can be considered applicable to any area where deforestation is projected under the baseline model.

Collection of preliminary data

In March 2009 a pilot survey was conducted. A total of 44 plots was surveyed during this pilot phase, including several in clusters. The pilot survey assisted in the selection of carbon pools, allowed an evaluation of different sampling designs (e.g. cluster layout, plot nests and tree size classes), provided data for estimation of required sample sizes and consolidated the skills of the field measurement teams. Plot results from the pilot survey were not used directly in the final analysis of carbon stocks.

Sample size

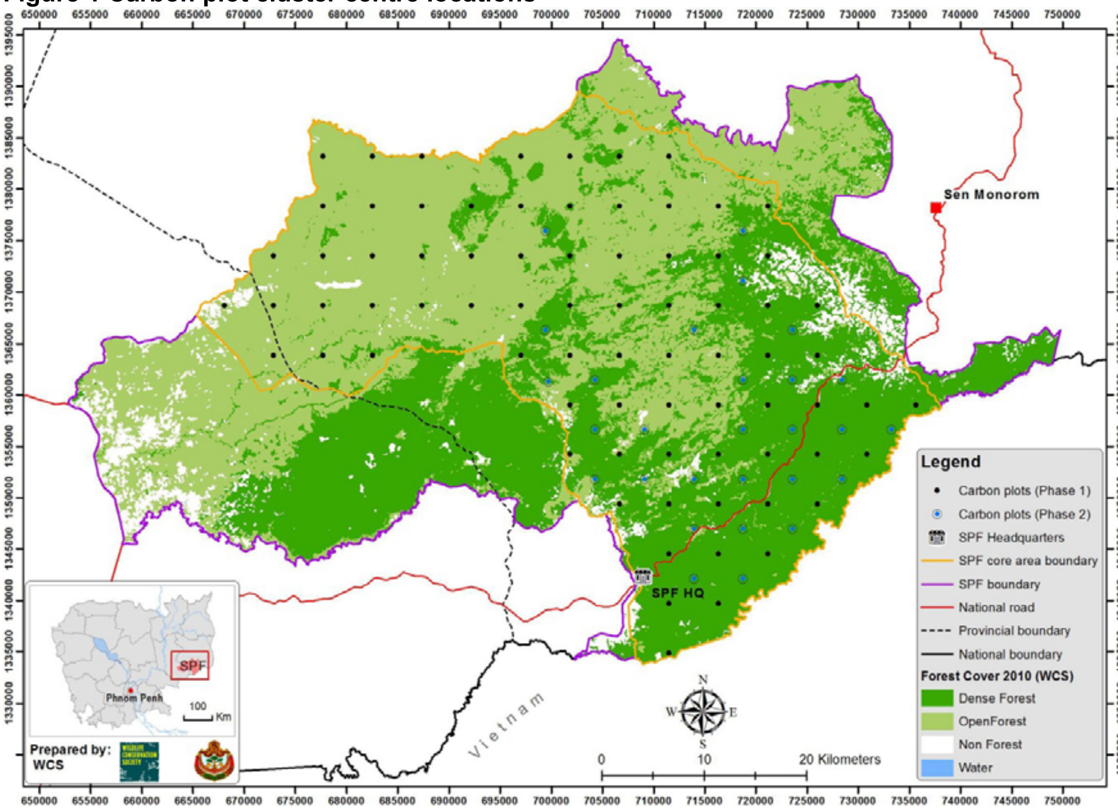
The required sample size was estimated from the Sample Size Calculation Tool from Winrock International, which incorporates standard equations consistent with those in the methodology, Appendix 3. Pilot survey data suggested the need for 76 clusters for an expected overall standard error of 8%, including a default 10% surplus of plots to provide a margin for error. The eventual precision was somewhat poorer than this, necessitating the additional sampling of 28 further clusters in Phase 2. In Phase 1 the same sample intensity was chosen for both strata, so they formed part of a single systematic layout. All Phase 2 plots were in the dense forest stratum.

Sample design

The distribution of plots is shown in Figure 1. Plot locations are listed in Appendix 2. In Phase 1 systematic sampling with random start point was used, assigning centre points using the program DISTANCE, with buffer settings that ensured edge areas were sampled as fully as the forest interior. A few sub-plots falling wholly outside the project area were discarded. In Phase 2 the additional clusters were all placed in the dense forest stratum, on the same systematic grid, offset east and south by exactly half the distance between the plots in Phase 1. Data from the dense forest stratum in Phase 1 and Phase 2 were pooled for analysis.

At each sample point a cluster of three plots was enumerated with one centred on the sample point itself and the centres of the two satellite plots being placed 150 m from the sample point along two random bearings (in order to avoid any systematic bias). Pilot surveys showed that three plots in one cluster can typically be completed in one day, allowing efficient use of travel times between clusters, which dominated the time costs of the survey.

Figure 1 Carbon plot cluster centre locations



Plot design

Three sets of nested circular plots were enumerated in each cluster, one at the cluster centre and two at the satellite points (Table 1). Additionally, a line-intersect transect for lying dead wood was measured, starting from the margin of the central nest. The largest nest had an effective area of 0.094 ha (3 subplots each of 20 m radius). In the pilots this was found to be a suitable size to sample the chosen target of at least 10 trees on each subplot. Haglof laser Digital Measuring Equipment (DME) made the use of circular plots very time-efficient despite the dense vegetation.

Table 1 Nested plot design for measurement of carbon stocks

Plot	Parameters measured
20 m circle	Live trees ≥30 cm DBH, standing dead wood ≥30 cm DBH
15 m circle	Live trees 15-29 cm DBH, standing dead wood 15-29 cm DBH
5 m circle	Live trees and standing dead wood ≥5 cm dbh
3 m circle	Saplings (<1.3 m tall) and bamboo (<1.3 m tall) (this pool was later disregarded)
100 m transect	Lying dead wood ≥10 cm diameter

All plot centres were marked to facilitate re-measurement. The methodology permits the use of temporary plots, but on some of the later plots in this study individual trees were given permanent marks, to provide a resource for future studies. Physical demarcation of the plots is summarised in Table 2.

Table 2 Physical demarcation of plots

Means of marking	Phase 1	Phase 2
Metal bar sunk at the central point to facilitate plot relocation by GPS and metal detector	All subplots in all clusters	All subplots in all clusters
Painted numbers and point of measurement	All subplots in 8 clusters in open forest	All subplots in all clusters
Numbered metal tree tags (trees > 15 cm dbh)	All subplots in 8 clusters in open forest	Central subplot of each cluster

Plot measurement protocols

Plot survey protocols were based closely on the Winrock Standard Operating Procedures (SOPs; Walker *et al.* 2009). Tree heights were not required for the chosen biomass equation.

The methods varied from the SOPs only in the case of slope. Plots that encompass varying degrees of slopes were not moved to areas of uniform slope as suggested by the SOPs, as this was expected to risk introducing bias by under-sampling certain vegetation types. Instead the dominant slope was determined and recorded. Due to the small size of plots and the generally flat nature of the terrain, slope of >5% was present in only a small proportion of plots. Ultimately slope was disregarded during analysis, to simplify the mathematics. This slightly over-estimates the projected horizontal area of the few plots affected, which leads to a slight and conservative under-estimation of carbon density per hectare.

Estimation of carbon stocks in each plot

Plot calculations were performed in spreadsheets adapted from the Carbon Plot Calculation Tool created by Winrock International. The calculations took a stepwise approach. The biomass of each individual plant or standing dead tree was calculated using the appropriate equations, then these were expanded to equivalent per hectare values using expansion factors derived from the area of the relevant subplot for an individual of that size class. Expanded values for each individual were then summed across the three subplots in a cluster to form a single sample estimate, following standard forestry practice. Calculations were conducted separately for each carbon pool across all clusters within a stratum, and then the pools within a stratum were combined using standard error propagation formulae. Root biomass was calculated using total biomass for each cluster.

Above ground tree biomass was estimated by the height-only allometric equations provided by Chavé *et al.* (2005) for moist tropical forests;

Above Ground Biomass = wood density(in g/cm3) x exp(-1.499 + 2.148ln(DBH) + 0.207(ln(DBH))^2 – 0.0281(ln(DBH))^3)

The use of this equation has been validated for the site by destructive sampling of a range of large and small trees from both strata in accordance with the methodology (see Annex 5.4 of the Project Document) and it was found to be conservative in both forest strata.

The biomass of standing dead wood was calculated according to formulae presented in the SOPs and the abundance of lying dead wood along the transects was calculated according to the method set out by Harmao and Sexton (1996). The density of lying dead wood in each of the three soundness classes defined by the methodology was estimated from ten randomly chosen samples from each class in each forest stratum.

The below-ground living biomass was calculated at the plot level, rather than for individual trees, following Cairns *et al*. (1997) Equation 3:

Root biomass density (t/ha) = exp(-1.0587+0.8836*ln(Above Ground Biomass))
`

Key conversion factors are shown in Table 3.

Table 3 Standard conversion factors used in calculations

Standard values used in plot calculations		
Carbon fraction of dry biomass	0.5	IPCC 2003

Live wood density g/cm3	0.57	Reyes *et al.* 1992*
Dead wood density (g/cm3): Sound class	0.77	SPF core area destructive sampling
Dead wood density (g/cm3): Intermediate class	0.62	SPF core area destructive sampling
Dead wood density (g/cm3): Rotten class	0.40	SPF core area destructive sampling

* The destructive sampling found this to be a conservative assumption (Annex 5.4).

Quality assurance/quality control

To ensure the data collected are of consistently high quality, it is essential that field teams are meticulous in their measurements and adhere rigidly to the survey protocols. We invested heavily in training, and had the advantage of a group of team leaders who already had high personal standards for data quality as shown by their record of performance during several years of quantitative wildlife surveys in the area (e.g O Kelly and Nut Meng Hor 2010). A scientifically-trained expatriate advisor was also on hand throughout the process to provide oversight and trouble-shooting assistance.

The SOPs define various quality assurance mechanisms, including “hot checks” to correct errors in data collection and “blind checks” to estimate the final field measurement error. Hot checks were carried out by the team coordinator, who checked all measurements by each team member at periodic intervals during the data collection. These were carried out continuously at the commencement of the survey and at less frequent intervals throughout the duration of the fieldwork.

Blind checks were used to quantify variance in measurements and required a sub-sample of plots to be re-measured by a second team. Ideally this would an independent audit team, experienced in all field measurements techniques. As it was not possible to find to find such a team in this context, the field teams were rotated and different team members/leaders accompanied the expatriate team coordinator to assist with re-measuring plots. The re-measurements included both some permanently marked plots and some unmarked temporary plots. Lying dead wood was not remeasured since slight variation in the placement of the transect was expected to dominate comparisons. Estimated root biomass is a direct function of living tree biomass so was not compared.

Extensive checking was also conducted during the data entry process, including a 100% review of all data entered, a rechecking of 10% of plots datasheets, selected at random, and further checking of any suspected outliers. All edits during this process were documented.

Results

The estimated carbon stocks for each stratum are shown in Table 5. Table 6 shows the same data in CO_2 equivalents, which corresponds to a part of Table 15a of the methodology. The notation system follows the methodology, for ease of reference.

Table 5 Estimated carbon stocks in the forest strata of SPF

		Cab[cl]		Cbb[cl]		Cdw[cl]		Ctot]cl]	
		ave. stock	+/- 90% CI	ave. stock	+/- 90% CI	ave. stock	+/- 90% CI	ave. stock	+/- 90% CI
ID[cl]	LU/LC Class	$tCha^{-1}$	$tCha^{-1}$	$tCha^{-1}$	$tCha^{-1}$	$tCha^{-1}$	$tCha^{-1}$	$tCha^{-1}$	$tCha^{-1}$
1	Dense forest	207.46	20.75	70.55	6.28	20.61	3.71	298.62	21.99
2	Open forest	119.63	20.09	21.56	3.15	9.87	2.34	151.06	20.47

Cab[cl]: *Average carbon stock per hectare in the above-ground biomass carbon pool of class cl*
Cbb[cl]: *Average carbon stock per hectare in the below-ground biomass carbon pool of class cl*
Cdw[cl]: *Average carbon stock per hectare in the dead wood biomass carbon pool of class cl*
Ctot[cl]: *Average carbon stock per hectare n all accounted carbon pools cl*

Table 6 Estimated equivalent CO_2 stocks in the forest strata of SPF (for codes see Table 5)

		Cab[cl]		Cbb[cl]		Cdw[cl]		Ctot]cl]	
		ave. stock	+/- 90% CI	ave. stock	+/- 90% CI	ave. stock	+/- 90% CI	ave. stock	+/- 90% CI
ID[cl]	LU/LC Class	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}
1	Dense forest	760.69	76.07	258.68	23.02	75.57	13.62	1094.94	80.63
2	Open forest	438.64	73.65	79.05	11.54	36.19	8.58	553.89	75.04

Quality control/quality assurance

Ten clusters were re-measured in full, 10% of the total sample (Table 7). The overall measurement error was -1.1 %, i.e. the total above ground carbon was 1.1% lower on the first survey visit compared to the quality assurance survey. The methodology does not set a threshold level for this comparison, but this is evidently a very high level of repeatability, with the original survey being slightly conservative.

Table 7 Results of the quality control survey of carbon plots

QC plots		Main survey		Difference
Cluster	Biomass (t/ha)	Cluster	Biomass (t/ha)	Biomass (t/ha)
103_1	466.09	103	458.5	7.59
12_1	234.33	12	227.35	6.98
13_1	332.96	13	299.08	33.88
42_1	220.44	42	208.29	12.15
53_1	179.42	53	170.69	8.73
7_1	142.67	7	143.17	-0.50
86_1	652.38	86	657.52	-5.14
90_1	235.65	90	252.13	-16.48
94_1	383.96	94	376.32	7.64
99_1	338.13	99	358.32	-20.19
Grand Total	3186.04		3151.37	34.67
			Overall error	1.1%

Discussion

This is one of the first systematic landscape-scale surveys of carbon stock to have been completed in Cambodia. The results show high carbon stocks. Table 8 compares the results of the present survey to Tier 1 estimates of typical carbon stocks from IPCC (2006; Table 4.7). SPF figures are within the default range of values for the region, but well above the median default values. Analysis of the literature shows that these results are fully consistent with other studies (Appendices 3 and 4). A regional model of carbon stocks excluding dead wood but taking account of likely recent patterns of degradation, predicted that much of SPF and some nearby areas would fall into the 200-250 tC/ha (400-500 t biomass/ha) category (Brown *et al.* 1993; Figure 2), which is closely consistent with our findings (Tables 3, 5 and 7).

In conclusion, SPF is confirmed to support high carbon stocks over large areas, with high densities of large trees over much of the site in both open and dense forest types. The contribution of the gregarious, fast-growing and often tall deciduous tree *Lagerstroemia calyculata* (Lythraceae; local name 'sralao') to current carbon stocks is especially notable, since it occurs commonly across a wide range of forest sub-types. It represented more than 20% of the carbon stock in many of the clusters.

Careful checking of the SPF estimates suggests that in fact the results may be slight under-estimates of the true figures. As noted earlier, the biomass equations were validated (and found to be conservative) by destructive sampling, the default timber density value is thought to be an under-estimate and the quality control plots also indicated an average slight under-estimation. Further work on biomass equations and density estimates for Cambodian forests would be worthwhile.

Table 8 SPF biomass in comparison to IPCC default values

SPF Stratum	Above ground live biomass (t/ha) +/- 90% CI	IPCC (2006) nearest equivalent	IPCC (2006) default values (t/ha) (range)
Dense Forest	414.9 (+/-41.4)	Tropical rain forest (Asia continental)	280 (120-680)
Open Forest	239.3 (+/-40.2)	Tropical moist deciduous forest (Asia continental)	180 (10-560)
-	-	Tropical dry forest (Asia continental)	130 (100-160)

Appendix 1 Notes on the broad forest types present in SPF

The following notes are drawn from FA (2007) with additional comments relating to the SPF from Walston *et al.* (2001) and the authors' own observations. See also Rundel (1999). Overall, the Evergreen, Semi-evergreen and Bamboo forests in SPF each have high tree species diversity with a wide overlap in species lists and a generally similar range of tree forms, including many tall canopy and emergent species, often bearing buttresses. Trees heights of 40-55 m are common. Mixed deciduous forests are often of similar stature but have a lower species diversity and are almost wholly deciduous. Deciduous Dipterocarp Forests have a small number of dominant species and tend to be of lower stature (typically 20-35 m).

Evergreen forest: Evergreen forests are usually multi-storied forests where trees maintain their leaves during the whole year. They comprise the lowland tropical rain forests, the hill evergreen forests and the dry evergreen forest and along streams and rivers (gallery forests).

Semi-evergreen forest: Semi-evergreen forests contain variable percentages of evergreen and deciduous trees, the percentage of evergreen trees varying from 30% to 70%. Semi-evergreen forests continue to appear evergreen throughout the year, even when the percentage of deciduous trees is high. In SPF this type is often dominated by the tall, pale-barked deciduous tree *Lagerstroemia calyculata* (Lythraceae). Another significant species is the massive evergreen emergent *Dipterocarpus alatus* (Dipterocarpaceae).

Deciduous forest: Deciduous forests comprise the Mixed Deciduous forests and Deciduous Dipterocarp forests. Deciduous forests drop their leaves more or less completely during the dry season. Human impact such as fire is usually much higher compared to other forest types. Mixed Deciduous forest are floristically a depauperate version of semi-evergreen forest, often dominated by *Lagerstroemia calyculata*, with an understorey dominated by bamboo and rattan but rarely much grass. Dry Deciduous Dipterocarp forests naturally have an open character and are often described as savanna forest. Individual stands usually have rather uniform structure dominated by just 2-3 species in any one location, but several different stand types can be found across the landscape. An undisturbed Deciduous Dipterocarp forests may have a crown cover of only 20-40%, an open understorey dominated by grass or herbaceous bamboos and no middle storey except along drainage lines. Soil and grass may have a significant impact on reflectance from these forests and as a result, it is difficult to separate low-density Deciduous Dipterocarp forests from shrub land during the dry season using satellite imagery.

Other forests: This land cover type includes regrowth, stunted forests, mangrove forests, inundated forests, and forest plantations. Regrowth of secondary forests is representative of a continuous, usually dense, layer of smaller trees. Stunted forests grow very slowly because of poor site conditions on hydromorphic soils and rock outcrops. Heavily disturbed forest like mosaics of forest, regrowth, and cropping, corresponding to shifting agriculture in which the percentage of forest is more than 40%, and areas of old regrowth and young secondary forest in the process of regenerating after clear cutting, are also included in this category.

Bamboo: Areas dominated by tall tree bamboos, with or without trees. Bamboo areas taller than 5 m are included in the national definition of forest under the Marrakech Accords. In SPF the bamboo forests often contain a significant number of large trees and have quite high carbon stocks. Some bamboo stands in SPF are evidently signs of recent disturbance but others were already present on topographic maps from the 1960s and appear to represent long-term stable communities. Large areas of dense bamboo are usually discernible on satellite imagery due to their pink and orange color and their typical texture. A sparse bamboo coverage or small bamboo will not be discernible and will remain in one of the other classes.

Wood and shrub land evergreen/dry: Wood and shrubland is a mixture of shrubs, grass and trees, the trees cover remaining below 20 percent. As the national forest definition includes land with a crown cover above 10%, some land in this category must be classed as forest for purposes of a REDD project. This class can be found mainly on shallow soils, on the top of mountains under climax conditions or as a result of non sustainable land use. Theoretically there is a chance of becoming forest again in some cases. The signature remains light red during the whole year. Young regrowth after shifting cultivation is also included in this class when the shifting cultivation mosaic becomes invisible. There is usually a dense layer of shrub and grass with some trees.

Appendix 2 Sample plot locations

Phase 1

Cluster	Plot ID	UTMx	UTMy
1	1	711549	1334882
1	1A	711417	1334952
1	1B	711682	1334812
2	2	711549	1339712
2	2A	711404	1339751
2	2B	711694	1339673
3	3	716379	1339712
3	3A	716377	1339562
3	3B	716382	1339862
4	4	711549	1344542
4	4A	711407	1344496
4	4B	711692	1344588
5	5	716379	1344542
5	5A	716361	1344691
5	5B	716398	1344393
6	6	721209	1344542
6	6A	721178	1344689
6	6B	721240	1344395
7	7	706719	1349372
7	7A	706633	1349249
7	7B	706805	1349495
8	8	711549	1349372
8	8A	711453	1349487
8	8B	711646	1349257
9	9	716379	1349372
9	9A	716364	1349521
9	9B	716395	1349223
10	10	721209	1349372
10	10A	721100	1349270
10	10B	721319	1349474
11	11	726039	1349372
11	11A	726058	1349223
11	11B	726020	1349521
12	12	701889	1354202
12	12A	701739	1354192
12	12B	702039	1354213
13	13	706719	1354202
13	13A	706617	1354092
13	13B	706821	1354312
14	14	711549	1354202
14	14A	711405	1354161
14	14B	711693	1354243
15	15	716379	1354202
15	15A	716358	1354054
15	15B	716400	1354351
16	16	721209	1354202
16	16A	721076	1354270
16	16B	721343	1354134
17	17	726039	1354202
17	17A	725923	1354108
17	17B	726156	1354297
18	18	730869	1354202
18	18A	730730	1354146
18	18B	731008	1354258
19	19	701889	1359032
19	19A	701807	1358906
19	19B	701971	1359158
20	20	706719	1359032
20	20A	706869	1359030
20	20B	706569	1359035
21	21	711549	1359032
21	21A	711693	1358991
21	21B	711405	1359073
22	22	716379	1359032
22	22A	716513	1358964
22	22B	716246	1359100
23	23	721209	1359032
23	23A	721261	1358891
23	23B	721158	1359173
24	24	726039	1359032
24	24A	726175	1359096
24	24B	725903	1358969
25	25	730869	1359032
25	25A	730916	1359175
25	25B	730823	1358889
26	26	735699	1359032
26	26A	735603	1358917
26	26B	735796	1359147
27	27	672909	1363862
27	27A	673037	1363939
27	27B	672780	1363785
28	28	677739	1363862
28	28A	677765	1363714
28	28B	677713	1364010
29	29	682569	1363862
29	29A	682420	1363844
29	29B	682718	1363880
30	30	697059	1363862
30	30A	697070	1364012
30	30B	697049	1363713
31	31	701889	1363862
31	31A	701925	1363717
31	31B	701853	1364008
32	32	706719	1363862
32	32A	706796	1363991
32	32B	706642	1363734
33	33	711549	1363862
33	33A	711646	1363977
33	33B	711453	1363747
34	34	716379	1363862
34	34A	716509	1363937
34	34B	716249	1363787
35	35	721209	1363862
35	35A	721358	1363844
35	35B	721060	1363880
36	36	726039	1363862
36	36A	725971	1363996
36	36B	726107	1363729
37	37	668079	1368692
37	37A	668135	1368553
37	37B	668023	1368831
38	38	672909	1368692
38	38A	672759	1368695
38	38B	673059	1368690
39	39	677739	1368692
39	39A	677805	1368827
39	39B	677673	1368557
40	40	682569	1368692
40	40A	682703	1368624
40	40B	682435	1368760
41	41	687399	1368692
41	41A	687485	1368569
41	41B	687313	1368815
42	42	692229	1368692
42	42A	692219	1368543
42	42B	692240	1368842
43	43	697059	1368692
43	43A	697192	1368622
43	43B	696927	1368763
44	44	701889	1368692
44	44A	701991	1368802
44	44B	701787	1368583
45	45	706719	1368692
45	45A	706719	1368842
45	45B	706719	1368542
46	46	711549	1368692
46	46A	711697	1368718
46	46B	711401	1368666

47	47	716379	1368692
47	47A	716463	1368568
47	47B	716295	1368817
48	48	721209	1368692
48	48A	721321	1368592
48	48B	721098	1368793
49	49	726039	1368692
49	49A	726086	1368835
49	49B	725993	1368550
50	50	672909	1373522
50	50A	672868	1373378
50	50B	672950	1373666
51	51	677739	1373522
51	51A	677857	1373615
51	51B	677621	1373430
52	52	682569	1373522
52	52A	682717	1373546
52	52B	682421	1373499
53	53	687399	1373522
53	53A	687286	1373424
53	53B	687512	1373621
54	54	692229	1373522
54	54A	692369	1373576
54	54B	692089	1373468
55	55	697059	1373522
55	55A	697206	1373494
55	55B	696912	1373551
56	56	701889	1373522
56	56A	701833	1373661
56	56B	701945	1373383
57	57	706719	1373522
57	57A	706852	1373452
57	57B	706587	1373593
58	58	711549	1373522
58	58A	711693	1373566
58	58B	711406	1373478
59	59	716379	1373522
59	59A	716467	1373644
59	59B	716291	1373401
60	60	721209	1373522
60	60A	721310	1373634
60	60B	721109	1373411
61	61	677739	1378352
61	61A	677591	1378326
61	61B	677887	1378378
62	62	682569	1378352
62	62A	682506	1378488
62	62B	682632	1378216
63	63	687399	1378352
63	63A	687355	1378209
63	63B	687443	1378496
64	64	692229	1378352
64	64A	692193	1378498
64	64B	692265	1378207
65	65	697059	1378352
65	65A	696918	1378301
65	65B	697200	1378404
66	66	701889	1378352
66	66A	701753	1378289
66	66B	702025	1378416
67	67	706719	1378352
67	67A	706763	1378209
67	67B	706675	1378496
68	68	711549	1378352
68	68A	711411	1378411
68	68B	711687	1378294
69	69	716379	1378352
69	69A	716335	1378496
69	69B	716423	1378209
70	70	721209	1378352
70	70A	721336	1378273
70	70B	721082	1378432
71	71	677739	1383182
71	71A	677637	1383073
71	71B	677841	1383292
72	72	682569	1383182
72	72A	682506	1383046
72	72B	682632	1383318
73	73	687399	1383182
73	73A	687458	1383044
73	73B	687340	1383320
74	74	697059	1383182
74	74A	696996	1383318
74	74B	697122	1383046
75	75	701889	1383182
75	75A	701925	1383037
75	75B	701853	1383328
76	76	706719	1383182
76	76A	706868	1383203
76	76B	706571	1383161
77	77	711549	1383182
77	77A	711631	1383057
77	77B	711468	1383308

Phase 2

78	78	713964	1342127
78	78A	713968	1341977
78	78B	713961	1342277
79	79	718794	1342127
79	79A	718868	1342257
79	79B	718720	1341997
80	80	713964	1346957
80	80A	714010	1346814
80	80B	713919	1347100
81	81	718794	1346957
81	81A	718697	1347071
81	81B	718891	1346843
82	82	723624	1346957
82	82A	723718	1346840
82	82B	723531	1347074
83	83	704304	1351787
83	83A	704174	1351713
83	83B	704434	1351861
84	84	709134	1351787
84	84A	709282	1351810
84	84B	708986	1351764
85	85	713964	1351787
85	85A	713815	1351801
85	85B	714114	1351773
86	86	718794	1351787
86	86A	718697	1351901
86	86B	718892	1351673
87	87	723624	1351787
87	87A	723712	1351666
87	87B	723536	1351908
88	88	728454	1351787
88	88A	728339	1351691
88	88B	728570	1351883
89	89	704304	1356617
89	89A	704199	1356724
89	89B	704409	1356510
90	90	709134	1356617
90	90A	709239	1356724
90	90B	709029	1356510
91	91	718794	1356617
91	91A	718645	1356635
91	91B	718943	1356599
92	92	723624	1356617
92	92A	723721	1356503
92	92B	723527	1356731
93	93	728454	1356617
93	93A	728574	1356527

93	93B	728335	1356707
94	94	733284	1356617
94	94A	733134	1356614
94	94B	733434	1356620
95	95	699764	1361263
95	95A	699677	1361141
95	95B	699851	1361386
96	96	704304	1361447
96	96A	704246	1361585
96	96B	704362	1361309
97	97	718794	1361447
97	97A	718746	1361305
97	97B	718843	1361589
98	98	723624	1361447
98	98A	723526	1361334
98	98B	723723	1361560
99	99	728454	1361447
99	99A	728393	1361584
99	99B	728516	1361310
100	100	699474	1366277
100	100A	699343	1366204
100	100B	699605	1366350
101	101	713964	1366277
101	101A	713848	1366182
101	101B	714080	1366372
102	102	723624	1366277
102	102A	723636	1366427
102	102B	723612	1366127
103	103	718794	1371107
103	103A	718684	1371208
103	103B	718905	1371006
104	104	699474	1375937
104	104A	699437	1376082
104	104B	699511	1375792
105	105	718794	1375937
105	105A	718859	1376072
105	105B	718730	1375802

Appendix 3 Comparative data reported from other dense forests in the region

Location	Forest type(s)	Above ground biomass (t/ha)	Basal area m^2/ha	Notes	Source
SPF Core Area	**Dense Forest (Evergreen, semi-evergreen and bamboo)**	**414.9 (90% CI +/- 41.4)**	**34.0 (90% CI +/- 3.7)**		**This survey**
SPF Core Area	Dense Forest (Evergreen/semi-evergreen)	438.5 (90% CI+/- 101.5)	39.5 (90% CI +/-8.2)	9 randomly sited 0.5 ha plots surveyed in 2004 in little-logged semi-evergreen forest. NB *includes only trees ≥20 cm* DBH and no other pools	Reanalysis of data used by McKenney *et al.* (2004)
SPF Buffer Zone	Logged semi-evergreen forest	377.4 (90% CI +/- 68.9)	24.4 (90% CI +/- 4.1)	Systematic sample of 60 variable area 6-tree plots; trees ≥ 10 cm and other carbon pools as in the Core Area	Evans *et al.* (in prep.)
SPF and nearby areas	Secondary Evergreen Forest Type 1	-	38.9 (range 30.1-46.3)	Mean of 3 plots. Trees ≥ 10 cm.	Tani *et al.* (2007) Plots 20 m diam.
	Secondary Evergreen Forest Type 2	-	28.2, 37.8	2 plots. Trees ≥ 10 cm.	
	Mixed Deciduous Forest	-	20.9 (range 11.0-32.0)	Mean of 4 plots. Trees ≥ 10 cm	
Oddar Meanchey REDD Project	Evergreen forest	c.210	-	Estimated for our purposes by subtracting 20% for below ground portion	FA *et al.* (2009)
Cat Tien Nat. Park, Viet Nam	Evergreen and semi-evergreen forest	-	29.3, 31.3, 31.7, 54.9, 69.4	5 subjectively placed 1 ha plots, trees ≥ 10 cm. 2 plots with highest BA dominated by *L. calyculata*	Blanc *et al.* (2000)
West Cambodia	Old growth (but logged) wet forest	321	23.9, 32.5. 32.5	Methods unclear as source not seen.	Hozumi *et al.* (1969) cited by Murali *et al.* (2005)
Preah Vihear	Unlogged and logged evergreen forest		13.5 (90% CI 0.0) 11.0 (90% CI 0.0)	60 randomly located 0.12 ha plots in each type; trees ≥ 10 cm	Kao (2006)
North-east Thailand	Dry evergreen forest	237.6	-	1 plot, unknown size. All above ground pools.	Sabhasri *et al.* (1968)
North-east Thailand	Dry evergreen forest	291	-	Sample details not available. All above ground pools.	Ogawa *et al.* (1965) cited by Sabahsri *et al.*
Kolli Hills, Eastern Ghats of India	Evergreen forest	412		Around 2000 mm rainfall per year, similar to SPF	Mohanraj *et al.* (2011)
Indonesian Borneo	Lowland evergreen rainforest	508.7	36.8	1 ha plot, all above ground pools.	Yamakura *et al.* (1986)

Appendix 4 Comparative data reported from other open forests in Cambodia

Location	Forest type(s)	Above ground biomass (t/ha)	Basal area m^2/ha	Notes	Source
SPF Core Area Open Forest	**Mixed deciduous and deciduous dipterocarp**	**239.3 (90% CI +/- 40.2)**	**20.8 (90% CI +/- 2.6)**		**This survey**
SPF Buffer Zone	Deciduous dipterocarp forest	139.8 (90% CI +/- 27.4)	15.2	Systematic sample of 10 variable area 6-tree plots; trees ≥ 10 cm and other carbon pools as in the Core Area	Evans *et al.* (in prep.)
SPF Buffer Zone	Deciduous dipterocarp forest	147.4 (90% CI +/- 14.6)	-		Khun Vathana (2010)
SPF	Deciduous Dipterocarp Forest Type 2	-	19,4, 21.5	2 plots. Trees ≥ 10 cm	Tani *et al.* (2007)
Oddar Meanchey REDD Project	Mixed deciduous and deciduous dipterocarp	c.100		Deciduous/ mixed forest class. Estimated for our purposes by subtracting 20% for below ground portion	FA *et al.* (2009)

Annex 5.4 Validation of the biomass equation used for the Seima REDD Project

Summary

Evidence is presented that the biomass equation selected for use in the Seima Protection Forest REDD project meets the requirements of the relevant carbon accounting methodology. The equation is conservative for both Deciduous and Evergreen/Semi-evergreen Forest types, giving overall errors in total biomass of the sampled trees of -10.8% (n=6) and -6% (n=6) respectively. Some suggestions are given for further work to improve biomass predictions in national-level carbon accounting.

Introduction

A conservation finance project is being developed in the Seima Protection Forest (SPF), Cambodia under the REDD framework (Reduced Emissions from avoided Deforestation and Degradation). The project will follow a carbon accounting methodology validated against the Verified Carbon Standard. The chosen methodology is the Unplanned Deforestation Methodology, VM0015. (Thereafter referred to as 'the methodology').

Among other steps, this methodology requires an estimation of the carbon stocks in standing forests in the project area. This is based on the measurement of trees on sample plots. The carbon stock is estimated from tree diameter using allometric equations for individual stems (the option chosen in the SPF project) or stand-level biomass expansion factors. If the chosen allometric equation(s) are not locally-derived, the methodology (Appendix 3 p146) requires that they be validated by destructively sampling a number of trees from the site. This report summarises the results of the validation conducted in SPF.

Study area and methods

Study area

The study area was the Core Area of the Seima Protection Forest (SPF), which lies mainly in Mondulkiri Province, eastern Cambodia. The altitudinal range is about 100-750 m, with 93% of the area lying below 500 m. The climate is tropical monsoonal. At the SPF headquarters (106^{o} 55 E 12^{o} 06 N, 160 m above sea level) recorded rainfall is 2200-2800 mm/year with up to 5 dry[28] months per year from December to April (WCS/FA and Nomad RSI unpublished data). Total rainfall is believed to be lower, with a somewhat more intense dry season of similar duration, in the north and west of the Core Area, and higher (>3000 mm/year), with a shorter but still strongly marked dry season at higher altitudes in the south-east of the Core Area. Hence the whole landscape is believed to lie in the 'Moist' climate category as defined by Chave *et al.* (2005). For the purposes of REDD, two forest strata have been recognised in the area, dense and open. These are discussed in more detail in the main Project Document.

Methods

In the absence of any applicable equations developed nationally or locally, for SPF it was decided to focus on the family of allometric equations developed by Chave *et al.* (2005). These provide estimates of tree above ground biomass (AGB) using diameter at breast height (D, in cm) and, optionally, total height (H, in m) as well. The carbon fraction of this biomass was taken as 0.50, following IPCC (2003). The Chave *et al.* (2005) study is perhaps the most comprehensive synthesis of its kind, combining biomass data from over 2500 trees throughout the tropics. As noted above, SPF falls in the 'Moist' category. For comparison the performance of the following equations was tested in SPF:

- Chave *et al.* (2005) Moist forest, equation using D alone ('Chave D') and D and H together ('Chave D*H')
- Chave *et al.* (2005) Dry forest, equations using D alone ('Chave Dry D') and D and H together ('Chave Dry D*H')

[28] Defined as a month with <100 mm precipitation

Specialist advice indicated that Chave D was expected to perform well (S Walker pers. comm.), and by not requiring H measurements would also minimise inventory costs. This equation is as follows:

$$AGB = \rho \exp(-1.499 + 2.1481 \ln(D) + 0.207 [\ln(D)]2 - 0.0281 [\ln(D)]3)$$

Where ρ = wood density, g/cm3 dry weight

The other Chave et al. equations are of similar structure.

For interest one other allometric equations was assessed in this paper, as follows:

- IPCC (2003) Equation for tropical moist hardwoods using D alone, Annex 4.A.2, Table 4.A.1 ('IPCC TMH')

The methodology requires that 'a few trees of different species and sizes' are sampled 'within the project area but outside the sample plots'. Guidance from specialists indicated that about 5-6 trees per carbon stratum would be acceptable in this case (S. Walker, Winrock International, pers. comm.). For the validation of biomass equations trees were selected from these two carbon strata (Table 1), with equal numbers of trees selected from the Open Forest (n=6) and from Dense Forest (n=6). Trees were selected subjectively, aiming for fairly typical individuals of dominant species in locations where the destructive sampling was logistically feasible, and a range of larger and smaller individuals in each stratum. The work was conducted from mid 2009-early 2010.

A default value of 0.57 g/cm^3 was used for ρ (Reyes *et al.* 1992). Measured densities were available for the sampled trees, but will not be available in the main carbon stock survey, so this is the appropriate figure to use in this analysis.

The standard operating procedures used for the destructive sampling are presented in Walker *et al.* (2009). Smaller parts of the tree, including leaves, are wet-weighed in their entirety, and then samples are taken for drying to allow estimation of the total dry weight. For the bole and outsize branches volume is estimated from measurements and then the dry weight is estimated using a density derived from oven dried disc samples. The stump and buttresses are treated separately.

Table 1 Sampled trees*

Code	Species (Khmer/Scientific)	D/cm	H/m
	Deciduous Forest		
4	Chhlik/*Terminalia alata* Roth	13	10.7
12	Trach /*Dipterocarpus intricatus* Dyer	14	10.65
3	Rang Phnom/*Shorea siamensis* Miq.	22	14.75
2	Pchek/*Shorea obtusa* Wall.	24	16.6
5	Sokrom/*Xylia dolabriformis* Benth.	44	19.12
1	Khlong/*Dipterocarpus tuberculatus* Roxb.	52	23.8
	Evergreen/Semi-evergreen Forest		
7	Onsoy/ [unidentified species]	19	9.13
9	Troseak/*Peltophorum* sp.	22	12.8
11	Koki/*Hopea* sp.	34	25
8	Chambok/*Irvingia malayana* Oliver ex A. Benn.	49	18.85
10	Sralao/*Lagerstroemia calyculata* Kurz	89	34.25
6	Chheuteal/*Dipterocarpus alatus* Roxb.	93	44

* Names follow MAFF Prakas 089 (2005) where relevant

Results

The results for the two forest strata are presented in Tables 2 and 3 and Figures 1 and 2. The observed biomass is given along with the estimated biomass using the preferred equation. Errors between estimates and observations are then presented for this equation and all other equations listed in the Methods section, to allow comparison on their performance.

Table 2 Observed and estimated biomass values in Deciduous Forest

	Biomass/kg		Error in estimates/kg				
Tree	Observed	Estimated (Chave D)	Chave D	Chave D*H	Chave Dry D	Chave Dry D*H	IPCC TMH
4	63	76	13	-10.5	6	2	15.8
12	81	93	12	-20.4	1	-7	14.2
3	220	307	87	-12.7	9	7	78.4
2	390	385	-5	-112.3	-112	-93	-18.5
5	1865	1825	-40	-790.1	-808	-839	-171.4
1	3489	2765	-724	-1620.2	-1981	-1786	-923.3
Total	**6108**	**5452**	**-656**	**-2566.2**	**-2885**	**-2716**	**-1004.8**
Total %			**-10.8%**	**-42.0%**	**-47.2%**	**-44.5%**	**-16.5%**

Table 3 Observed and estimated biomass values in Evergreen/Semi-evergreen Forest

	Biomass/kg		Error in estimates/kg				
Tree	Observed	Estimated (Chave D)	Chave D	Chave D*H	Chave Dry D	Chave Dry D*H	IPCC TMH
7	98	209	111	-2.3	66	14	108.2
9	257	307	50	-77.1	-28	-57	41.4
11	986	949	-37	-146.8	-382	-168	-96.0
8	1396	2387	991	-81.7	-66	-162	817.6
10	9765	9999	234	-1886.9	-5282	-3403	-80.4
6	14016	11063	-2953	-2965.1	-9135	-5342	-3225.5
Total	**26518**	**24915**	**-1603**	**-5159.9**	**-14828**	**-9118**	**-2434.7**
Total %			**-6%**	**-19.5%**	**-55.9%**	**-34.4%**	**-9%**

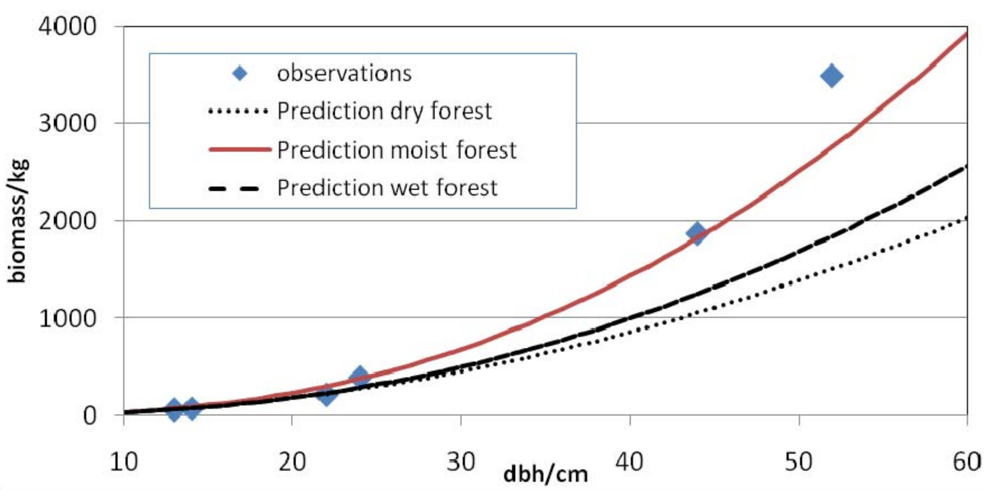


Figure 1 Observed biomass compared to predictions : Deciduous Forest

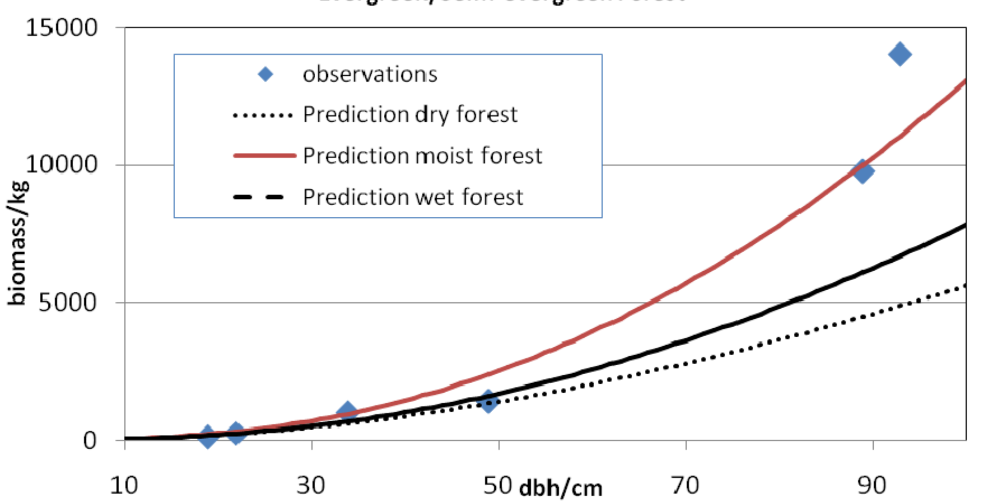


Figure 2 Observed biomass compared to predictions : Evergreen/Semi-evergreen Forest

Discussion

The performance target set in the methodology is as follows:

'If the biomass estimated from the harvested trees is within about ±10% of that predicted by the equation, then it can be assumed that the selected equation is suitable for the project. If

this is not the case, it is recommended to develop local allometric equations for the project use.'

By this standard the preferred allometric equation (Chave D) is considered acceptable for both Deciduous Forest (overall error -10.8%) and Evergreen/Semi-evergreen Forest (overall error -6.0%). The former figure is borderline acceptable according to the methodology ('about +/- 10%'), and given that it represents an underestimate of the total biomass, is also conservative. Figures 1 and 2 support the idea that the observed values are consistent with the Chave D estimates across a wide range of values, and show how widely the results diverge from the dry forest equation, especially for the larger trees, which are those containing the majority of the carbon.

Of the other equations IPCC TMH met the required standard for Evergreen/Semi-evergreen forest (-9%) and marginally failed for Deciduous Forest (-16.5%), but performed better than the others and might be found to have acceptable performance given increased sampling. All other combinations of equation and forest type gave more severe under-estimates in biomass, ranging from - 19.5% to - 55.5%. Predictions from the wet forest equations of Chave *et al.* (2005) were also serious under-estimates (data not shown here), intermediate between the moist and dry curves.

It is notable that all of the equations under-estimated biomass, which suggests that the individual trees in both these broad forest types may have unusually high biomass for the climate zone that they are found in. Further study would be required to clarify the reason for this.

The estimates are sensitive to the figure used for wood density. The regional default value chosen in this study is lower than observed for the dominant wood type (bole timber) in the particular samples from both Deciduous Forest (0.70 g/cm^3, n=6) and Evergreen/Semi-evergreen Forest (0.65 g/cm^3, n=6). If these figures are used the error in estimated biomass becomes +9.6% in Deciduous Forest and +7.0% in Evergreen/Semi-evergreen Forest - both still within the acceptable tolerance but no longer conservative. If the observed bole densities of individual stems are used in the allometric equations then the errors increase to 15.2% and 17% respectively. In the absence of a site-specific estimate of volume weighted average density, applicable across all species, it is appropriate to continue using the default value of 0.57 g/cm^3. The issue of wood density deserves further study during the development of Cambodia's national REDD+ programme.

Annex 5.5 Estimation of baseline carbon stocks in post-deforestation/agricultural land classes around SPF

Summary

This report summarises the process of estimating carbon stocks in the post-deforestation land-use class surrounding the Seima Protection Forest Core Area, the site of a REDD project. This document forms part of a methodological annex to the Seima Protection Forest Core Area REDD Project Document.

The methodology employed by the project requires an estimation of the carbon stocks in the post-deforestation scenario. This estimation was undertaken in Seima using a historical area-weighted average approach. This approach is based on the assumption that land in and around the project area which has been deforested in the past is representative of likely future land-use in areas yet to be deforested in the project area itself. A local study was conducted to obtain post-deforestation carbon stocks of selected agro-ecological zones. Sample sites were selected on the basis of land management practices identified as the most likely post-deforestation baseline scenario. Field measurements at these sites were combined with additional data obtained from credible literature sources to produce conservative estimates of carbon stocks in the post-deforestation landscape.

Introduction

A conservation finance project is being developed in the Core Area of the Seima Protection Forest (SPF), Cambodia under the REDD framework (Reduced Emissions from avoided Deforestation and Degradation). The project will follow a carbon accounting methodology validated against the Verified Carbon Standard. The chosen methodology is the Unplanned Deforestation Methodology, VM0015. (hereafter 'the methodology').

Among other steps, the methodology requires an estimation of the carbon stocks on the land following deforestation. Deforestation is all attributed to one group of agents, namely small-holder farmers, as described in the driver analysis. Estimation of post-deforestation carbon stocks is based on a study of stocks in current well-established agricultural land use systems observed in the reference region. This report summarises the numerical results of this study.

Study area and methods

Study area

The study area was the Core Area of the SPF, which lies mainly in Mondulkiri Province, eastern Cambodia. The altitudinal range is about 100-750 m, with 93% of the area lying below 500 m. The climate is tropical monsoonal. At the SPF headquarters (106^{o} 55 E 12^{o} 06 N, 160 m above sea level) recorded rainfall is 2200-2800 mm/year with up to 5 dry[29] months per year from December to April (WCS/FA and Nomad RSI unpublished data). Total rainfall is believed to be lower, with a somewhat more intense dry season of similar duration, in the low-lying north and west of the Core Area, and higher (>3000 mm/year), with a shorter but still strongly marked dry season at higher altitudes in the south-east of the Core Area. Hence the whole landscape lies in the 'Moist' climate category as defined by Chavé *et al.* (2005) and the Moist Tropical biome of IPCC (2006; Table 4.1).

Methodology

The crops planted by farmers vary across the landscape depending on a variety of factors. Rather than attempt to model this complex and dynamic situation, we opt to estimate a historical area-weighted average stock. The approach can be summarized as follows;

Step 1

- Divide the non-forest landscape into one or more agro-ecological sectors, with each sector being characterized by the dominant agricultural practices of the communities in that area.

[29] Defined as a month with <100 mm precipitation

- Select representative sampling areas within blocks of land which constitute long-established examples of each of these sectors.
- Conduct systematic point sampling in the selected sample areas in order to determine the proportional composition of each sector by area in terms of crop/vegetation classes
- Select the carbon pools to be estimated to enable a comparison with stock values from forest classes.

Step 2

- Estimate the carbon stock values for each of the crop/vegetation classes, using local data supplemented with values from the literature. Stocks must be 20-year averages, to allow for the cyclical variation in longer lived crops.
- Calculate the mean weighted carbon stock for each agro-ecological sector using the carbon stock value of each crop/vegetation class and the proportional contribution of each to the sector as a whole.

Step 3

- Combine the means from each sector, in proportion to their contribution to deforestation during the historical deforestation period, to produce an overall area-weighted average for deforested land across the whole landscape.

The steps are set out in detail below.

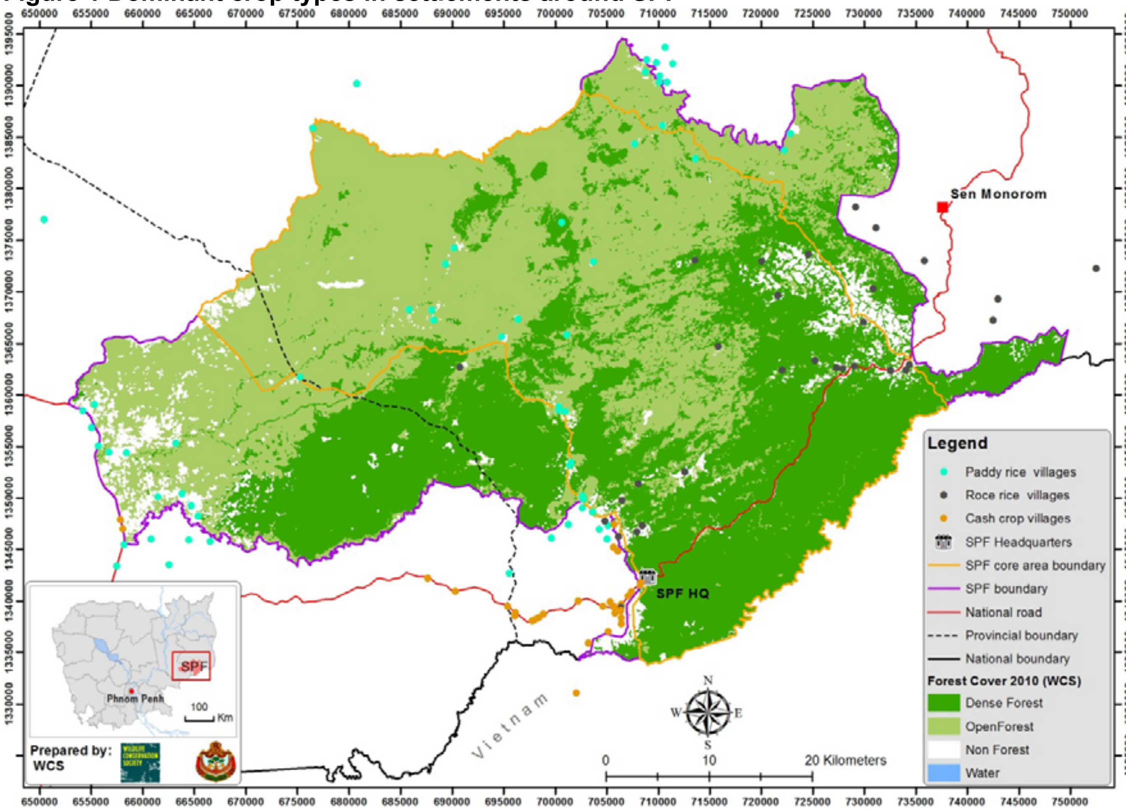
Step 1

<u>Characterization of existing post-deforestation areas</u>

Data from demographic surveys (Evans 2007, Pollard and Evans 2009) and expert knowledge of the project area were used to partition smallholder farmed areas into three broad agro-ecological types, according to the dominant agricultural livelihood types reported in nearby settlements. An examination of the data reveals a relatively simple and consistent spatial pattern and three broad agro-ecological sectors can be clearly distinguished (See Map 1). The prevailing type of agricultural land use in a given sector is evidently correlated with factors such as the suitability of the land, market conditions, the ethnicity and traditions of the residents and length of time they have been resident in the area.

These three sectors are dominated respectively by 1) cash crops, 2) paddy rice, and, 3) hill rice. Cash crop cultivation is generally preferred, where soils and market access permit it, with rice dominant elsewhere. The prevalence of paddy rice is determined by availability of suitable flat land. Hill rice dominates where the paddy rice and cash crops are not feasible. Cash crop cultivation currently predominates in ethnic Khmer settlements, and these are often newer villages, established by recent in-migrants and situated in close proximity to roads and local markets.

Figure 1 Dominant crop types in settlements around SPF



Selection of representative areas for point sampling

The project-generated forest cover map for 2002 was examined and candidate polygons of non-forest were identified in which to sample during 2009. These candidate polygons represented areas that were deforested prior to 2002 and so had been incorporated into agricultural land use systems for a minimum of 7 years, and sometimes longer than 10 at the time of the sampling. This is sufficient time for the proportions of different crops and vegetation types in the landscape to have stabilized following initial deforestation. Plots deforested more recently are excluded because they are not representative of the expected mixture of long-term vegetation/crop types in a zone. Appendix 3 of the methodology recommends choosing areas deforested 10-30 years earlier, but the frontier nature of this area meant that very few older areas were available for sampling. As the main carbon stock in the sampled areas was found in remnant forest trees, which are likely to be fewer in older areas of deforestation, this is a conservative approach.

One large polygon was selected to represent the cash crop system and one to represent the paddy rice system. Each polygon covered over 100 ha and included parts of the agricultural land of at least two villages. No comparable block of land could be identified to represent the hill rice system because even seven years ago the extent of this system was small and highly fragmented. Therefore we applied the figure for cash crop farming (which was the higher of the two) to the hill rice areas.

Systematic point sampling

A set of sample points was created for each land use polygon in a systematic layout with a random start. The cash crop polygon contained 148 points and the paddy rice polygon 110 points. The precise geographic locations of points were uploaded into Garmin GPS units for field surveys.

Field teams surveyed all points and recorded the vegetation/crop types present within a 3 meter radius of each point. Training was conducted prior to the surveys to ensure that all field teams were consistent in their definition of vegetation/crop types. Pre-defined classes were agreed upon during this training but where new vegetation/crop types were encountered during the point survey they were

added to the list. If points occurred in areas with no vegetation/crop, such as on roads, buildings and water bodies, this was also recorded.
The results of this intensive sampling were used to identify the principal vegetation/crop classes and their relative abundance by area.

Selection of the carbon pools

As in the forest strata, the following carbon pools were considered:

- above ground living trees ≥5 cm dbh
- standing dead wood ≥5 cm dbh and lying dead wood ≥5 cm diameter.
- Below ground living biomass was included in the analysis based on conservative literature values alone, with no additional field data collection.
-

Data were also collated, and measurements taken, for non-tree woody species (e.g. cassava and saplings) and for herbaceous species (e.g. non-woody vegetables, grass). However this pool is considered negligible in both forest and non-forest strata and so the results are not presented here.

Soil carbon was not measured as VCS guidance, repeated in the methodology, suggested there would be little significant difference between forest and post-deforestation classes (since a proportion of the post-deforestation landscape supports perennial crops, grassland and scrub). Ignoring any difference that may occur was conservative.

Step 2

Estimates of carbon stock for each vegetation/crop type

Mature rubber plantations do not exist in the area analysed so a 20 year average stock was estimated from the growth curves presented by Wauters *et al.* (2008), conservatively using only the results from their more fertile site (Western Ghana). Sample plots were measured for the other three key vegetation/crop types, as show in Table 1. This included the two vegetation/crop types with the highest carbon stocks (semi-natural woody cover and cashew plantations) and a cross-section of non-woody vegetation/crop types. Plots were placed within all three of the agro-ecological zones.

Table 1 Number of plots sampled in each vegetation/crop type

Crop/vegetation type	Plots	Includes
Semi-natural woody cover	7	Various types of degraded woody vegetation derived from forest or fallow regrowth (woodland, shrubland, wooded field boundaries, bamboo stands)
Mature cashew stands	7	Includes inter-cropping with banana, cassava and jack-fruit
Other crop types - Elephant grass - Mixed vegetable fields - Cassava	 2 2 2	
	20	

The results from the three 'other crop types' were pooled to provide an average value that was also applicable across the remaining non-tree crop types that were not directly sampled. The results are conservative, since substantial amounts of lying and standing deadwood currently remain in these areas, relics of the deforestation process, and these were measured in this survey but seem likely to decline substantially as the time since deforestation increases. The proportion of carbon-rich patches of semi-natural woody vegetation and the number of remannt forest trees per hectare of farmland also seems likely to decline over time as farming intensifies.

Plot surveys in non-forest areas

Sampling Design

Purposeful sampling was used and plot locations were selected on the basis of being representative of a particular vegetation/crop type. Local knowledge was used to identify areas of mature cropland, fallows and scrub in which to situate plots. Where possible, plots sampled mature crops to ensure conservative estimation of long-term average stocks.

Field measurement protocols

Plot survey protocols followed the Standard Operating Procedures (SOPs) of Walker *et al.* (2009) with some adaptations to the local project context. Survey protocols and the modifications made to them in order to sample stocks in deforested strata are summarized below. No destructive sampling was required for trees.

At each selected location a nested set of temporary circular plots was combined with a line-intersect transect for lying dead wood, as summarised in Table 2[30].

Table 2 Nested plot design for measurement of carbon stocks

Plot	Parameters measured
20 m circle	Live trees and standing dead wood ≥5 cm dbh
40 m circle	Live trees ≥30 cm DBH, standing dead wood ≥30 cm DBH
100 m transect	Lying dead wood ≥5 cm diameter

Protocols differed from those used to survey forest plots in the following instances;

- Nest sizes and DBH classes were adjusted to reflect the fact that smaller DBH trees were likely to occur at high densities in some areas but that larger DBH trees were likely to occur at very low densities (occasional large forest trees left in the fields).
- For multi-stemmed trees, such those found in fruit and nut orchards, diameter at the base of the tree was measured (10cm above ground) rather than diameter at breast height.

Estimation of carbon stocks in post-deforestation landscape

Plot calculations

Plot calculations were performed in a slightly modified and corrected version of the Carbon Plot Calculation Tool created by Winrock International. The key assumptions underlying this calculator are as follows:

- Biomass of wild trees was estimated by the height-only allometric equations provided by Chavé *et al.* (2005) for moist tropical forests, as validated for this landscape in Annex 5.4 of the project document:

  Above Ground Biomass = wood density(in g/cm3) x exp(-1.499 + 2.148ln(DBH) + 0.207(ln(DBH))^2 – 0.0281(ln(DBH))^3)
- The allometric equation provided by Schroth *et al.* (2002) for multi-stemmed citrus trees was used for both cashew and fruit trees.
- Living wood density is assumed to equal the default value for tropical Asia (Reyes *et al.* 1992). The destructive sampling found this to be a conservative assumption (Annex 5.4).
- The carbon fraction of dry biomass is 0.50 (IPCC 2003).
- The ratio of below-ground to above-ground living biomass for trees is calculated following Cairns *et al*. (1997) (Equation 3):

  Root biomass density (t/ha) = exp(-1.0587+0.8836*ln(Above Ground Biomass))

- The stock of lying dead wood can be calculated following Harmon and Sexton (1996).

Values for each carbon pool for each plot were then combined on another Excel spreadsheet to allow further analysis.

Sector Calculations

[30] In addition, a 3 m circle was used to estimate saplings and other woody non-tree vegetation, and clip plots were used for herbaceous species, but as noted above these data are not presented here.

The data from Steps 1 and 2 were combined to calculate the weighted mean above and below ground carbon stock in each of the agro-ecological sectors. The stocks differed very little between the two sectors studied.

Step 3 Calculation of the mean across strata

The proportion of deforested land attributable to each sector was estimated using GIS. Each pixel of deforestation during 1998-2008 in the project area was assigned to one of the three sectors according to the dominant farming system in the nearest settlement in 2008, following the dataset provided by Pollard and Evans (2009).

An area-weighted mean carbon stock across the three zones was then calculated.

Results

The results are show in Table 3. The stock values are derived from the stepwise analysis shown in Appendices 1, 2 and 3. These data correspond to a part of Table 16 in the methodology.

Table 3 Estimated carbon stocks(CO_2e) in the forest strata of SPF

		Cab[cl]		Cbb[cl]		Cdw[cl]		Ctot]cl]	
		ave. stock	+/-90% CI	ave. stock	+/- 90% CI	ave. stock	+/- 90% CI	ave. stock	+/- 90% CI
ID[cl]	LU/LC Class	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}	tCO_2eha^{-1}
Nf	Non-forest	28.87	0.00	6.34	0.00	11.34	0.00	46.55	0.00

As these results have been shown by the methods used to be conservative, they can be used without further quantification of uncertainty.

Appendix 1 Summary results from sample plots

PlotID	Vegetation/crop type	Trees >5 cm (t C/ha)	Standing Dead Wood (t C/ha)	Lying Dead Wood (t C/ha)	Total above ground carbon stock (tC/ha)
	Cashew				
OA10	Cashew	9.8	0.1	0.0	10.0
OA14	Cashew	11.4	0.0	0.0	11.4
OA11	Cashew	10.6	0.0	0.0	10.6
PC05	cashew (overgrown)	7.8	6.1	0.0	13.9
OA13	Cassava and cashew	8.0	0.0	0.0	9.5
PC04	cashew/banana	9.7	1.3	7.2	18.2
PC03	cashew/banana/jackfruit	26.0	2.0	10.7	38.7
	Mean	**11.9**	**1.4**	**2.6**	**16.0**
	Other crops				
OA15	Tall grass	0.0	0.0	0.0	0.0
OA07	Tall grass	8.6	2.0	5.0	15.6
SP021	Mix Vegetables	2.9	0.0	1.1	4.0
OA12	Mix vegetables	4.4	0.0	0.0	4.4
OA16	Cassava/grass	0	0.0	0.0	0.7
OA08	Cassava/Vegetables	0	8.5	0.3	8.8
	Mean	**2.7**	**1.7**	**1.1**	**5.6**
	Semi-natural woody cover				
SP024	Partially cleared forest	60.8	1.2	2.1	64.0
SP020	Scrub	1.8	0.1	0.0	1.9
SP018	Scrub	40.2	2.9	0.0	43.1
SP022	Scrub	16.9	0.0	0.0	16.9
PC01	Scrub/fallow	29.5	2.8	11.8	44.0
PC02	Scrub/fallow	33.3	1.9	23.2	59.3
PC06	Scrub/fallow	93.2	0.8	3.1	97.0
	Mean	**39.4**	**1.4**	**5.7**	**46.6**

Appendix 2 Area-weighted calculations for each agro-ecological sector

Vegetation/crop	Secondary crop	Count of points	% of points	CARBON POOL (tC/ha) Trees >5 cm	Below ground	Standing Dead Wood	Lying Dead Wood	Total	Weighted stock	Source
PADDY RICE SECTOR				**6.35**	**1.51**	**1.65**	**1.55**		***11.1***	
semi-natural woody cover		11	10.0%	39.40	8.22	1.40	5.70	54.72	*5.5*	woody cover plots
paddy rice		91	82.7%	0.77	1.70	1.10	6.27	*5.2*	*7.5*	other crop type plots
grassland		5	4.5%	0.77	1.70	1.10	6.27	*0.3*	*0.4*	other crop type plots
empty paddy		2	1.8%	0.77	1.70	1.10	6.27	*0.1*	*0.2*	other crop type plots
road/trail		1	0.9%	0.00	0.00	0.00	0.00	*0.0*	*0.0*	
		110	100.0%							
CASH CROP SECTOR				**9.62**	**1.98**	**1.18**	**1.78**		**14.6**	
rubber		3	2.1%	52.00				52.00	*1.1*	Wauters *et al.* 2008
semi-natural woody cover		9	6.2%	39.40	8.22	1.40	5.70	54.72	*3.4*	woody cover plots
mango		3	2.1%	8.22	1.40	5.70	54.72	*1.1*	*1.1*	woody cover plots
cassava	mango	1	0.7%	8.22	1.40	5.70	54.72	*0.4*	*0.4*	woody cover plots
cashew	cassava/ banana	50	34.5%	2.85	1.40	2.60	18.75	*6.5*	*6.7*	cashew plots
cassava	banana	5	3.4%	0.77	1.70	1.10	6.27	*0.2*	*0.3*	other crop type plots
cassava		21	14.5%	0.77	1.70	1.10	6.27	*0.9*	*1.3*	other crop type plots
elephant grass		9	6.2%	0.77	1.70	1.10	6.27	*0.4*	*0.6*	other crop type plots
corn		1	0.7%	0.77	1.70	1.10	6.27	*0.0*	*0.1*	other crop type plots
soya		1	0.7%	0.77	1.70	1.10	6.27	*0.0*	*0.1*	other crop type plots
eggplant		1	0.7%	0.77	1.70	1.10	6.27	*0.0*	*0.1*	other crop type plots
pepper		2	1.4%	0.77	1.70	1.10	6.27	*0.1*	*0.1*	other crop type plots
banana		3	2.1%	0.77	1.70	1.10	6.27	*0.1*	*0.2*	other crop type plots
paddy rice		5	3.4%	0.77	1.70	1.10	6.27	*0.2*	*0.3*	other crop type plots
grassland		1	0.7%	0.77	1.70	1.10	6.33	*0.0*	*0.1*	other crop type plots
bare field		17	11.7%	0.00	0.00	0.00	0.00	*0.0*	*0.0*	
bare land		16	11.0%	0.00	0.00	0.00	0.00	*0.0*	*0.0*	
		145	100.0%							

Appendix 3 Calculation of area-weighted carbon stocks in the post-deforestation land-use class

Sector	Deforestation from 1998 to 2008 (ha)	% of landscape	Trees >5 cm (t C/ha)	Below ground (tC/ha)	Standing Dead Wood (t C/ha)	Lying Dead Wood (t C/ha)	Stock in relevant pools tC/ha	Weighted stock tC/ha
Cash Crops-dominated	1152.8	22.4%	9.62	1.98	1.18	1.78	14.57	
Paddy Rice-dominated	2746.1	53.4%	6.35	1.51	1.65	1.55	11.06	
Hill Rice-dominated	1247.8	24.2%	9.62	1.98	1.18	1.78	14.57	
Overall area-weighted average			**7.87**	**1.73**	**1.43**	**1.66**		**12.70**

Annex 6.1 Review of potential negative project impacts on communities and proposed mitigation measures

	Expected positive impacts	Potential negative impacts	Most vulnerable stakeholders	Assessment and mitigation of threats
Sub-Objective #1: Key legal and planning documents for the Seima Protection Forest and surrounding landscape are approved and implemented				
Action #1: Support for sub-decree maintained among senior levels of government and general public	recognition and protection of traditional/existing livelihoods, reduced risk from concessions, infrastructure, migration etc, improved status of key natural resources, REDD finance for livelihood improvement	**restriction of development options**	poorest, women, IP	in fact there is no significant restriction on options for community development beyond those in national law mitigation of any possible restriction of options comes from increased investment in alternative and improved livelihoods
Action #2: Management plan approved and implemented (including zonation and regulations)	clearer definition of existing rights and responsibilities, strengthen capacity of FA to implement activities/manage threats, improved status of key natural resources	**zonation will exclude traditional harvest activities in certain areas (to be defined through consultation)**	IP, forest-dependent Kh users	this is best considered voluntary displacement of customary uses,: further FPIC will be sought for this step, risks will be countered by careful design and piloting, compensation for resin tree users, targeted provision of alternative livelihoods
Action #3: Mondulkiri Provincial Corridors strategy implemented (maintaining links to other forests)	increased involvement of provincial authorities in supporting SPF management and controlling threats	none	-	
Action #4: Develop partnerships with the private sector (to reduce impacts by companies)	reduced negative impacts from company activities	none	-	
Action #5: Develop international cross-border dialogue	reduced cross-border impacts (esp logging, illegal hunting)	none	-	
Action #6: Adaptive Management system (regular public reviews and workplans)	SPF management responds to changes in community needs/attitudes	undue representation of certain groups	-	structured, balanced forum for participation
Sub-Objective #2: To reduce forest and wildlife crime by direct law enforcement				
Action #1: Enforce wildlife, forest and	effective control and deterrence of	**inappropriate prevention**	IP, poor Kh	legal awareness, monitoring,

protected area laws and sub-decree through patrols	illegal activities by outsiders and community members; improved security of land and forest resources; improved general law and order situation	**of legal uses, selective enforcement, over-harsh punishment, unclear rules**	users	training, enforcement strategies, demarcation/regulations, grievance system, regular staff reviews, strong responses to any corruption found
Action #2: Establish and implement law enforcement monitoring framework	increased effectiveness of Action#1	**physical risks to informants from criminals**	non-powerful people	voluntary participation, incentives not enough to motivate undue personal risk taking, confidentiality rules, adaptive management, grievance system
Action #3: Ensure sufficient patrol buildings, equipment and staffing	increased effectiveness of Action#1	buildings on community land		obtain community approval before building or seek other locations
Action #4: Ensure sufficient patrol personnel capacity	increased effectiveness of Action#1	none	-	
Action #5: Liaise with Provincial, National and other authorities	increased effectiveness of Action#1	none	-	
Action #6: Establish Community-based Patrolling and/or monitoring system	additional control and deterrence of illegal activities by outsiders and community members; improved security of land and forest resources; improved general law and order situation; jobs for community members	**risk from offenders; conflict within community; legal liability**	IP, poor Kh users	manage through community groups; voluntary participation, participatory approaches; coordinate with local government; adaptive management; develop cautiously to resolve legal issues
Sub-Objective #3: Land and resource use by all core zone communities is sustainable				
Action #1: Form and maintain land-use agreements with communities	increase tenure security, improve management of threats, build community cooperation/strengthen traditional systems and cultural norms	**communities allocated too little land; process causes/revives conflicts or changes social dynamics; marginalised groups not accounted for**	IP, poor Kh users	participatory process, safeguards for all village members; grievance process; local gov. oversight
Action #2: Legally register communities and users	increase tenure security, improve management of threats, build community cooperation/strengthen traditional systems and cultural norms	**CBO formation gives too much power to some groups; individual registration excludes some users unfairly**	IP, poor Kh users	participatory process (= national process for ICC, local process for user cards), safeguards for all village members; grievance process; local gov oversight
Action #3: Indigenous land titling in appropriate communities	further increase tenure security and define boundaries of carbon ownership	**communities allocated too little land; process causes/revives conflicts or changes social dynamics; marginalised groups not accounted for**	IP, poor Kh users	participatory process, safeguards for all village members; grievance process; local gov oversight
Action #4: Demarcation of the Forest	improve management of threats, clarify	**communities allocated too**	IP, poor Kh	participatory process (see

Estate; reforestation of recent clearance	extent of rights (reduce risk of conflict with the law); reforestation sequesters carbon, increases supply of forest products/biodiversity and	**little land; process causes/revives conflicts or changes social dynamics; marginalised groups not accounted for; reforestation in wrong areas**	users	WCS/FA/MoE 2009), safeguards for all village members; grievance process; local gov oversight
Action #5: Conduct extension and communication activities	support all other activities	none	-	
Action #6: Liaise with Commune Council and other agencies	support all other activities	none	-	
Action #7: Engage with civil society organisations operating in the Project area	support all other activities	none	-	
Action #8: Ensure the capacity of Project staff is sufficient	support all other activities	none	-	
Sub-Objective #4: Support for alternative livelihoods that reduce deforestation				
Action #1: Establish sustainable timber harvests in buffer zone areas	bring forest under sustainable management, control threats, alternative and improved livelihoods	**damage from logging, corruption/social conflict, inequitable benefit-sharing; business liabilities**	IP, women, elderly	FA approval of management plan/ESIA; financial safeguards; participatory approach, oversight by local authorities
Action #2: Establish community-based ecotourism	alternative and improved livelihoods; incentives to change behaviour and control threats	**environmental and social impacts from tourists, corruption/ social conflict, inequitable benefit-sharing; business liabilities**	IP, women, elderly	environmental screening/monitoring; code of conduct for tourists and agents; participatory approach, oversight by local authorities
Action #3: Support agricultural extension activities	alternative and improved livelihoods, incentives to change behaviour and control threats	**inequitable benefit-sharing, corruption**	IP, women, elderly	participatory approach, oversight by local authorities
Action #4: Provide infrastructure support linked to conservation activities	alternative and improved livelihoods, incentives to change behaviour and control threats	**inequitable benefit-sharing, corruption**	IP, women, elderly	participatory approach, oversight by local authorities
Action #5: Develop NTFP-based livelihood projects	bring forest under sustainable management, control threats, alternative and improved livelihoods	**over-harvest, corruption/social conflict, inequitable benefit-sharing; business liabilities**	IP, women, elderly	FA approval of management plan/ESIA; participatory approach, oversight by local authorities
Action #6: Develop and manage a	alternative and improved livelihoods,	**corruption/social conflict,**	IP, women,	participatory approach, oversight by

system to share carbon benefits	incentives to change behaviour	**inequitable benefit-sharing**	elderly	local and national authorities
Action #7: Improve literacy and numeracy	increase capacity to participate in other activities; increase off-farm livelihood opportunities	inequitable benefit-sharing	IP, women, elderly	participatory approach, oversight by local authorities
Sub-Objective #5: Collect information on long-term ecological and social trends				
Action #1: Monitoring of trends in forest cover	assess threats, measure success	none		
Action #2: Monitoring of key wildlife species	assess threats, measure success	none		
Action #3: Socio-economic and demography monitoring	assess threats, measure success/negative impacts	none		
Action #4: Facilitate research that will benefit the management of the SPF	inform adaptive management	unethical research		ensure ethical review by source institution
Action #5: Ensure sufficient staff capacity is available	support other activities	none		
Sub-Objective #6: Effective administrative, accounting and logistical procedures are in place				
Action #1: Evaluation and feedback on staff capacity, effectiveness and training needs	support other activities	none		
Action #2: Develop and maintain effective management, administrative and accounting systems	support other activities	none		
Sub-Objective #7: Long-term financial security				
Action #1: Develop and Implement REDD project	ensure documentation, consent and approvals to allow sale of carbon credits	covered elsewhere		
Action #2: Establish Eastern Plains Trust Fund	ensure transparent long-term sustainable management of funds	none		
Action #3: Continued support of a wide range of donor partners	maintain funding for baseline levels of protection	none		
Action #4: Increase use of commune development funds for project activities	reduce need for external funding	none		system already has many safeguards