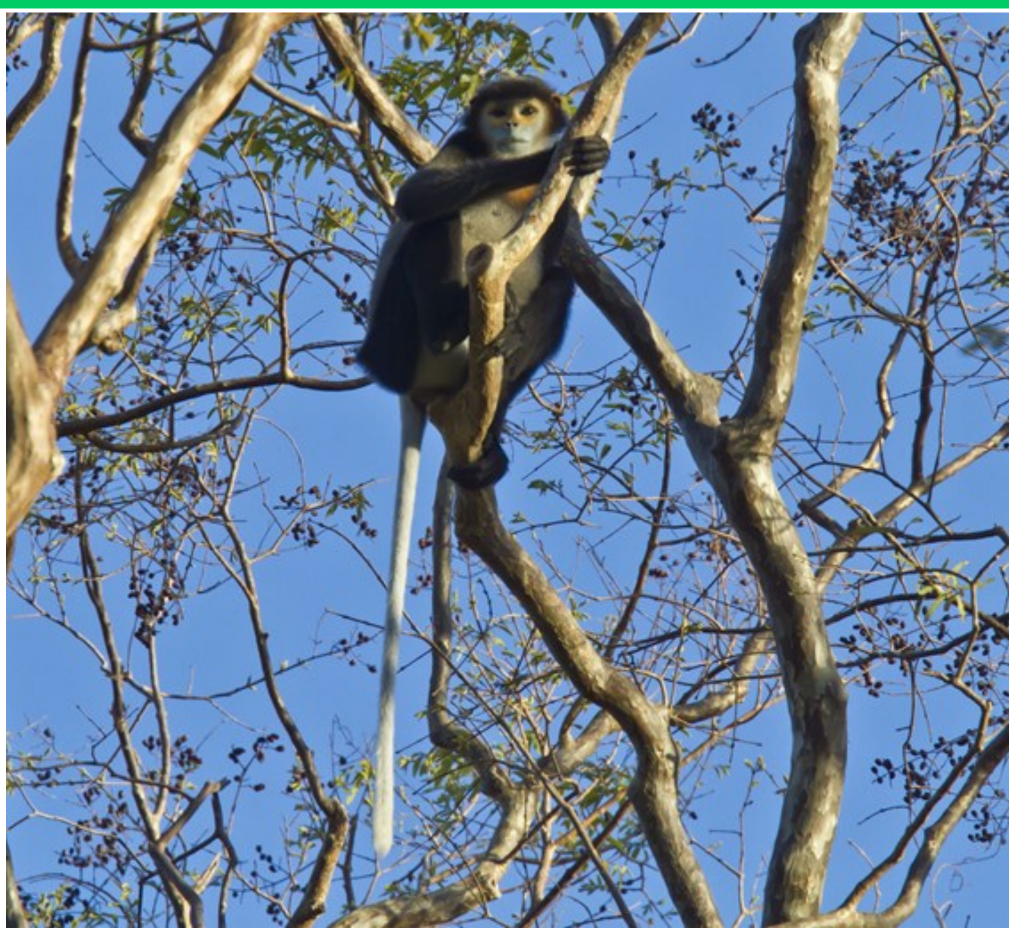
Information Brief – Monitoring Biodiversity Co-benefits in the Seima Protection Forest REDD+ Demonstration Site
Mondulkiri and Kratie Provinces, Cambodia



June 2015

Cambodia REDD+ Programme

Disclaimer

This information brief was prepared **Matt Nuttall, Alex Diment, Jeff Silverman, Donal Yeang** of the Wildlife Conservation Society (WCS), drawing on their experiences in developing and implementing the Seima Protection Forest REDD+ Project under voluntary carbon market. The work of producing the brief was funded by UNDP under the UN-REDD Programme. However, the views and recommendations reflected in the brief are not necessarily those of the Cambodia REDD+ Taskforce, the Forest Administration, the General Directorate for Administration of Nature Conservation and Protection (Ministry of Environment), UNDP or the UN-REDD Programme.

Contents

1. Introduction

Reducing Emissions from Deforestation and forest Degradation (REDD+) is a financial mechanism that provides incentives to developing countries to reduce forest-related greenhouse gases (GHG) emissions and to increase GHG removals from the atmosphere by forests. However, poor REDD+ program design may pose social and environmental risks which need to be guarded against through measures known collectively as "safeguards". The parties to the United Nations Framework Convention on Climate Change (UNFCCC) adopted the Cancun Agreements in the 16th Conference of the Parties (COP16) in Mexico. In term biodiversity conservation, the agreements state REDD+ activities should: take into account the multiple functions of forests and other ecosystems; be consistent with the conservation of natural forests and biological diversity; not be used for the conversion of natural forests but instead should be used to incentivize their protection; and be used to enhance other social and environmental benefits (UNFCCC, 2010). The parties to the Convention on Biological Diversity (CBD) noted that if REDD+ is well design and properly implemented, it would have unprecedented benefits for forest biodiversity. As a result, there is growing interest in biodiversity monitoring for REDD+ because it might help parties to the CBD to fulfil their commitments. Biodiversity monitoring is importance not only to assess how safeguards are adhered to but also guide the on-going planning and implementation of REDD+ (Dickson & Kapos, 2012). The implementation of REDD+ in Cambodia is expected to deliver significant benefits for both biodiversity conservation and local livelihoods while supporting Cambodia's commitments under the CBD (FA, 2011). Documenting the implementation and performance of safeguards requires standardized monitoring methods known as the Measurement, Reporting and Verification (MRV). The general principle of the Cambodia REDD+ Roadmap states that the development of Cambodia REDD+ MRV system should be developed for multi-purposes including monitoring biodiversity co-benefits (FA, 2011). However, there are a limited documents of lessons learnt on monitoring biodiversity co-benefits in the context of REDD+ implementation in Cambodia to support the national REDD+ process to develop critical aspects of REDD+ strategy and implementation. This information brief summarises the biodiversity monitoring system that exists in the Seima Protection Forest REDD+ demonstration site, and presents the baseline and subsequent data for biodiversity co-benefits. This monitoring system will be described in the context of the Climate, Community and Biodiversity (CCB) Standards for demonstrating biodiversity co-benefits. It is hoped that this monitoring system will demonstrate best practise biodiversity monitoring, and will prove useful for other REDD+ projects and sites in Cambodia when designing and implementing biodiversity monitoring programs.

2. CCB standards and Biodiversity Monitoring

The CCB standards do not mandate any particular monitoring or data collection methods. The Core Guidance manual (Richards & Panfil, 2011) recommend avoiding overly sophisticated monitoring methods which aim for high levels of precision, as these are not required by the standards and may not feel tangible to stakeholders (e.g. using technology or monitoring obscure taxa may not be as accessible to stakeholders as simple methods targeting easily observed species). It is also important to note that the standards require a *net* benefit, which in the case of biodiversity, the degree to which negative impacts are offset by positive ones will depend on the conservation value of the affected species or ecosystem. Estimation of net benefits must be done by comparing actual monitoring results to the "without-project" social and biodiversity projections done for Stage 2.

The standards require initial (pre-project) conditions to be described, which in the case of biodiversity will include summarising the biodiversity value of the Project Zone and any High Conservation Value present, followed by the threats to biodiversity.

3. Methods of biodiversity baseline assessment

The Seima Protection Forest is at an advantage to some other REDD+ sites in that it has been the focus of a long-term conservation project since 2002, and therefore has a wealth of existing biodiversity data. Since 2000, WCS in association with the Forestry Administration (FA) have conducted various exploratory and systematic biodiversity surveys within Seima using different methods. These have included rapid wildlife assessments and general surveys, species-specific population and distribution surveys, and forest cover / deforestation rate analyses using remote sensing.

There are a multitude of methods available for baseline biodiversity assessments (see reference list at the end of this document). Below is a brief outline describing some of these options, and the process by which decisions should be taken.

3.1. Habitat diversity assessment

The main reasons for assessing diversity above the level of species are (a) because the diversity of ecosystems and habitats is important in itself; and (b) as an indirect way of monitoring species, since it is not practical to monitor directly more than a fraction of species.

There are two main problems with assessing ecosystem diversity. First, many different entities and relationships are involved—layers of ecosystems within ecosystems, the pattern (type, size, and distribution) of communities in the landscape, their trophic structure, the pattern of habitats in each community, their species composition, the size and structure of component populations, and the connections and interactions among and within communities. Second, boundaries between these entities are ambiguous. Ecosystems and habitats are defined subjectively, depending on the objectives of the assessment and the scale at which it is working. Biomes (e.g., tropical rain forests, cold deserts) are not meaningful in a local assessment, just as detailed habitat mapping is not feasible in a national assessment.

The starting point is a classification and map of major ecosystems or habitats of the land. What qualifies as a major ecosystem or habitat depends on the size of the spatial level concerned (the area being assessed) and the resources available for the assessment.
Ecosystem classifications need to be:

· 'Mappable' at a convenient scale and observable using the most feasible means of monitoring.
· Ecologically meaningful, using entities that are useful for ecological analysis and biodiversity management.
· Linked to decision-making, showing boundaries of jurisdictions as well as ecosystems.

Because forests are, by definition, important for REDD+, it is useful to distinguish forest and non-forest ecosystems/habitats when assessing this and the other questions on the status and trends of land ecosystems and habitats.

3.2. Species assessment

How species assessments are conducted entirely depends on the specific questions that need to be answered. For example, if a study site has never been subject to a biodiversity survey before, then it is likely that the first step will be establishing a list of existing species in the shortest time possible. This kind of rapid assessment need not be statistically robust, or constrained by probabilistic survey design. Survey teams, ideally consisting of experienced biologists with prior knowledge of the species likely to be encountered in the area or region can simply survey the forest by covering as much ground as possible, ensuring that areas of likely animal presence (e.g. water sources, salt licks etc.) previously identified are visited. This kind of rapid survey can also be done with, or supplemented by, the use of camera traps, mist nets, pit-fall traps, small mammal traps, or any other device that can non-lethally catch an animal for identification purposes.

Building from the type of survey outlined above, species specific or multi-species surveys targeting a selection of species can be conducted with varying levels of rigour and precision. As above, the methodology used will depend on the desired outcome of the survey(s). It is recommended at this stage that qualified statisticians / ecologists / wildlife biologists are consulted and assist in the survey design to ensure reliable and meaningful results. The four most commonly sought outcomes of species specific surveys are 1) relative abundance / density; 2) absolute abundance / density; 3) presence/absence; and 4) distribution. It is worth noting that number 4 is often a by-product of numbers 1, 2, and 3. Broadly speaking, estimating relative indices are easier (and cheaper) than estimating absolute abundance or density, and are often sufficient if changes in these estimates or long-term trends are the desired metric – as is clearly the case for REDD+ projects.

3.3. Methods for biodiversity surveys in Seima Protection Forest

Much of the biodiversity data presented below was gathered between 2000 and 2010, using a variety of different methods. The biodiversity data that was collected in 2010 used line transect distance sampling to estimate the absolute abundance of key species within the core zone of Seima Protection Forest. Other baseline data were collected pre-2010 using faecal DNA capture-recapture (for elephants), and camera trapping (for multiple species). In the future there will be a possibility of using other monitoring methods such as occupancy. These methods are outlined below.

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 then used to calculate the perpendicular distance from the animal (or cluster of animals) to the transect. These distance data are then used by the program DISTANCE to calculate absolute densities.

Line transects are used to monitor the population densities of Banteng 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*, i.e. 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 (since 2010) systematically (with a random start) across the whole of the project area (Figure 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 1,300 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.

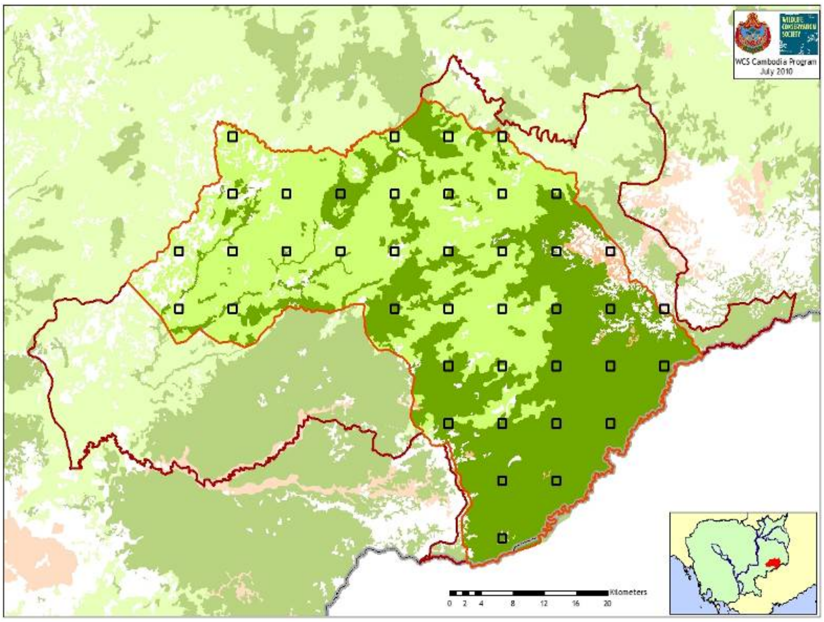


Figure 1. Line transect system in SPF. There are 40 transects, each 4km long. They were placed systematically with a random start point, ensuring distance sampling assumptions were met.

Faecal DNA capture-recapture

Faecal DNA is currently used to monitor the population of Asian Elephants in the project area. This method uses DNA extracted from small samples of faecal 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). 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, although this was not possible due to limited resources. This survey is scheduled for the 2015 dry season. 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 Illegal Killing of Elephants (MIKE) program and follows the global MIKE protocols.

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. Previously camera traps were not used to obtain quantitative estimates and no formal monitoring schedule was in place; rather it was seen as a supplementary tool for use at the discretion of the site managers. Generally camera-traps were 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 were examined to identify the species present, number of individuals, and if possible sex and age of the animal.

Due to the cryptic nature of some of the species within SPF (e.g. Wild cattle, Otters, Sambar, Elds' deer), and their low underlying density, it may be necessary to employ camera traps using a more quantitative approach, if line transects continue to yield unsatisfactory results.

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 particular 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 priorities and informing design of future monitoring efforts.

4. Seima Protection Forest biodiversity values

The Seima Protected Forest (SPF) is located in eastern Cambodia in Mondulkiri and Kratie provinces, along the border with Viet Nam. It was declared in 2002 as a Biodiversity Conservation Area. In recognition of its importance for biodiversity and environmental services the area was declared a Protected Forest by Prime Minister Hun Sen in 2009. The total size of the Protected Forest is 2,927 km^2 (292,690 ha). The Core Protected Forest is 1,879 km^2 (187,983 ha). The combined area of the Buffer Protected Forests east and west of the core is 1,047km^2 (104,707 ha).

The area is now managed for conservation of biodiversity, environmental services and livelihoods by the Department of Wildlife and Biodiversity of the Forestry Administration. Technical assistance is provided by the Wildlife Conservation Society (WCS), who have been working in Cambodia since 1999, and active in southern Mondulkiri since 2000.

Forest cover

The SPF remains almost entirely covered by natural vegetation and contains an unusually high diversity of forest types. These forests form a very complex mosaic that may be dependent on water availability, soil type, topography and other physical factors that are not fully understood. Four forest types are generally recognised in SPF:

- Evergreen forest. This forest is typical of the southern Annamite range, and is found in the hilly southern parts of the conservation area. It is characterised by being almost entirely evergreen, with a tall canopy (up to 40 m), three layers of vegetation and an understory that is rich is rattans and lianas.
- Semi-evergreen forest has a similar structure to evergreen forest but includes a varying proportion of deciduous trees that lose their leaves in the dry season. It is found throughout the conservation area often forming gallery forest along rivers and water courses through the more deciduous forest, or on isolated hills.
- Mixed deciduous forest, which in SPF is usually dominated by *Lagerstroemia* tree species. This can have a very open understory, or sometimes a dense bamboo understory.
- Deciduous dipterocarp forest, which is more widespread in the north and west of the conservation area. This forest is open with low canopy (20m) and only two strata. The tree flora is dominated by a few deciduous dipterocarp species. The understory is grassy or rich in short stemmed bamboo.

Other vegetation types that are found in SPF include dense patches of bamboo, areas of regenerating *chomkar* and the unusual grasslands of the Sen Monorom plateau. These areas do not have as many species as the major forest types, but are important habitat for some wildlife species. Bamboo, for example appears to be important for Elephants and Orange-necked Partridges.

Globally threatened species

The 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. This mosaic of forest types probably contributes to the high species richness in the area. To date 341 bird species, 88 confirmed mammal species (with a further 9 which are believed to occur but have not been confirmed) and over 72 reptile and amphibian species have been recorded in SPF. There are likely to be many more reptiles, amphibians and small mammals that have not yet been recorded. The flora and invertebrate life of the SPF have not been studied in detail and are very poorly known.

The SPF is particularly 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. Currently the area is likely to have at least five species of wild cat, with another two species suspected but not confirmed. SPF was previously notable for its small population of Tigers, however they are now believed to be locally extinct in the area, and very likely extinct from Cambodia. In 2007 the final camera trap photograph of a tiger in the Eastern Plain landscape was taken, and the last sign of their presence was believed to be a footprint found in 2009. Sadly, despite concerted efforts in recent years, no further evidence of their presence has been recorded.
- **Primates**: The semi-evergreen and evergreen forests of southern Mondulkiri are internationally important for the conservation of primates. The population of the Endangered Black-shanked Douc is estimated to be in the region of 20,000 individuals, probably the majority of the total world population. Between 1000 and 1400 Yellow-cheeked Crested Gibbons are also estimated to be present, a significant proportion of the world's population of this Endangered ape. In addition there are healthy populations of five other threatened primates including the Pygmy Loris and Germain's Silvered Langur. The latter is restricted to riparian forest in the deciduous dipterocarp forest, and is now highly threatened throughout its range.
- **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 survey in 2006 found the population of Asian Elephants in the SPF is around 116 animals, far larger than expected. 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 a key prey species for large carnivores such as Dhole and Leopard. Recent efforts to estimate the densities of these large ungulates have failed, partly due to the cryptic and shy nature of the animals. Despite signs of hunting pressure, it is still believed that viable populations of these species exist in SPF. Mondulkiri Province is thought to be home to one of the largest populations of Banteng in the world. Similarly when the contiguous network of protected areas in Mondulkiri is taken as a whole, it is believed that the Eastern Plains Landscape has one of the most important populations of wild cattle in Cambodia, and the region in general.
- **Galliforms**: SPF hosts globally significant numbers of three galliform birds. Monitoring of the Endangered Green Peafowl since 2002 suggests that numbers are stabilising, the species is now seen regularly in most parts of the conservation area especially in open areas near to permanent water. The SPF population is part of what may be the last stronghold of this species. 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 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 status of the species from Endangered to Near-threatened.
- **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. All of these species have all been seen in recent years, mainly in the open forests in the west of the SPF. This area is also known to be 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. Although this area has had relatively little survey effort, there have been multiple records of these species. This area may prove to be of global importance for these species.

As of 2013 74 vertebrate species that are Globally Threatened, Near-threatened or Data Deficient have been recorded in SPF[1] (**Table 1**).

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.

The southern, evergreen parts of SPF lie within the **South Viet Nam / Cambodia Lowlands Endemic Bird Area.** 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.

Table 1. All globally threatened, near-threatened, and data deficient species in SPF

Class	**Number of Globally threatened or near threatened species present in SPF** (number of species that are not yet confirmed, but suspected to occur, in brackets)					
	Critical	**Endangered**	**Vulnerable**	**Near Threatened**	**Data Deficient**	**Total**
Mammals		8 (2)	12 (2)	6	1	27 (4)
Birds	4	3(1)	6	8	-	21 (1)
Reptiles	(1)	2	2	2	-	6 (1)
Amphibians	-	-	4(2)	1	4	9(2)
Fish	1	(1)	2	4	4	11(1)
Total	5 (1)	13 (4)	26 (4)	21	9	74 (9)

The area also includes parts of **two Important Bird Areas** (IBA). 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

[1] Based on the IUCN 2013 Red List www.redlist.org

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 of 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". 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**. This is an area identified by the conservation NGO Conservation International as a *biodiversity hotspot* with high levels of biodiversity and endemism and under high threat of destruction.

There has been as little botanical work carried out in SPF. Inventories and studies have shown that SPF has at least ten tree species that are listed on the IUCN red list as Vulnerable, Endangered or Critically Endangered. In addition inferences on the importance of the SPF for the conservation of plants can be made from looking at studies of neighbouring areas. Cat Tien National Park in Viet Nam has semi-evergreen and evergreen forest that is similar to those in the south of SPF. These have been identified as a centre of plant diversity, with an estimated 2,500 species of vascular plants. 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. Yok Don 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 Yok Don and Cat Tien it is likely that SPF would also qualify as a **Centre of Plant Diversity.**

Line transect results

The line transect system that was set up in 2010 is the most statistically robust and comprehensive biodiversity monitoring program conducted in SPF, and arguably in Cambodia. Below are the results of the line transect surveys that were conducted in 2010, 2011, 2013, and 2014. These data represent excellent indicators for trends in biodiversity over the life of the project. The surveys produce reliable estimates both for primate species and ungulate species, as well as one species of galliforme.

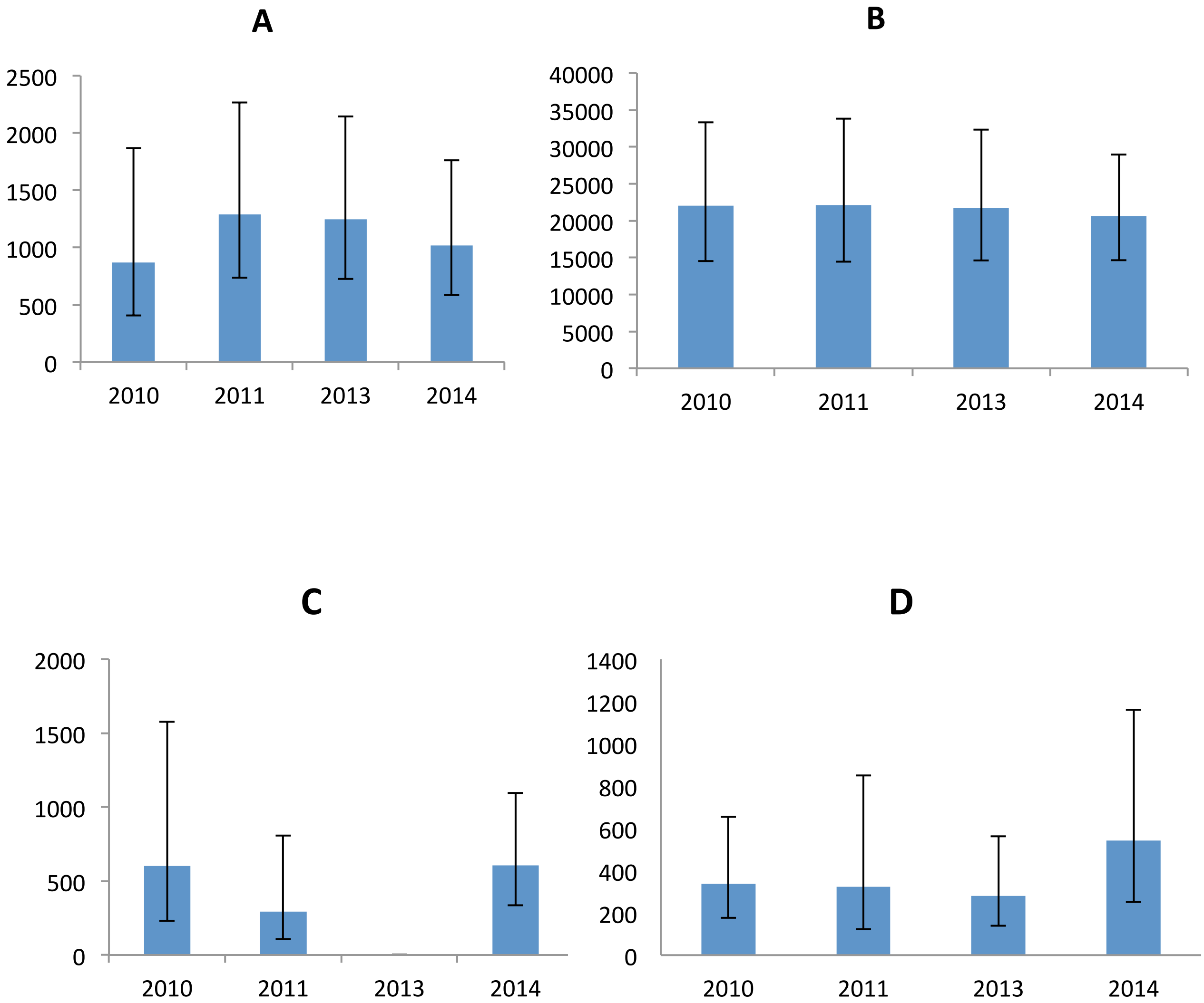


Figure 2. . Graphs showing the results of the line transects between 2010 and 2014 for ungulates and Green Peafowl. There is no estimate for wild cattle in 2013 due to a small number of observations which precludes analysis using distance sampling. Estimates are absolute abundance. A- Wild pig; B – Red muntjac; C – Wild cattle (Banteng and Gaur); D – Green peafowl

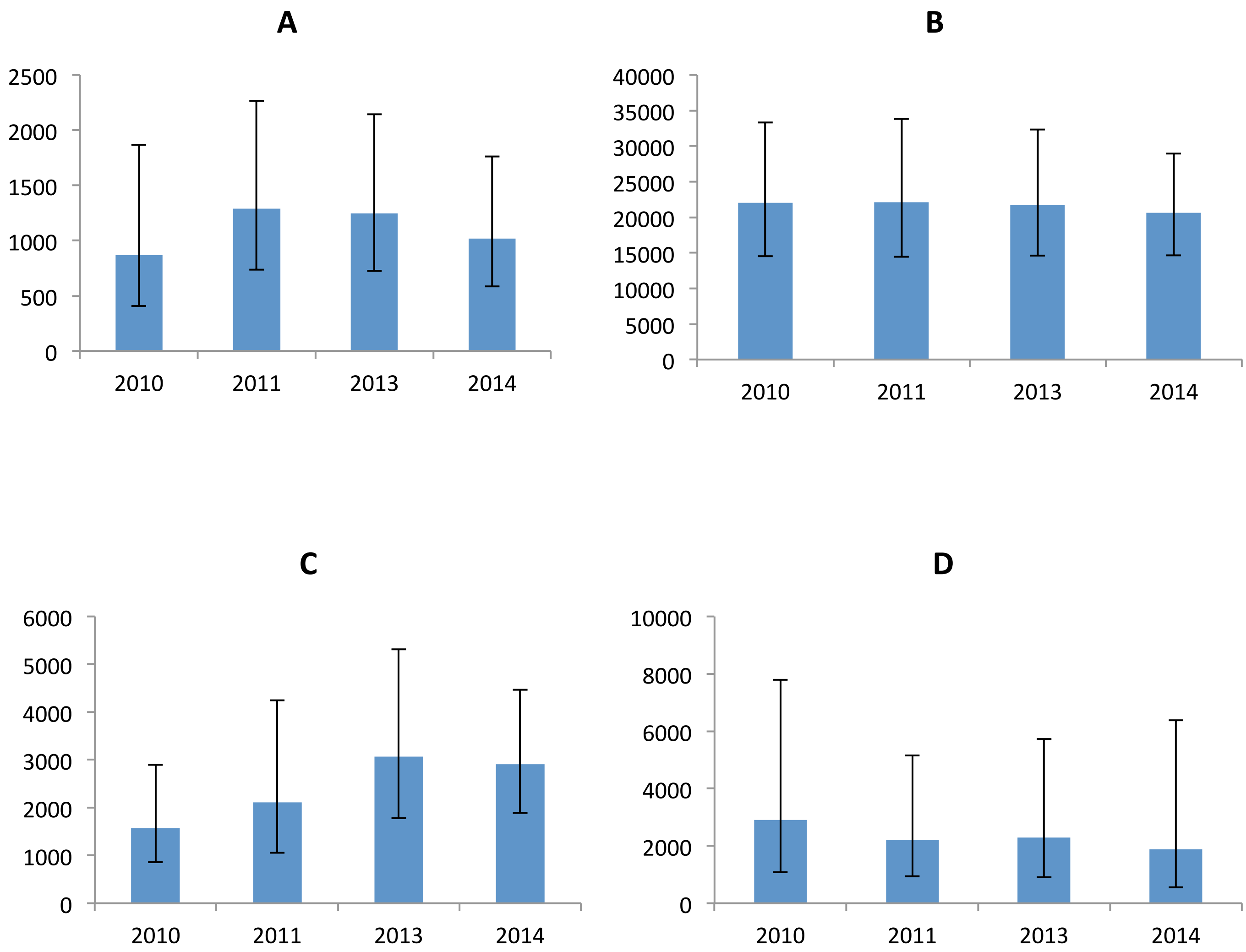


Figure 3. Graphs showing the results of the line transects between 2010 and 2014 for four primate species. Estimates are absolute abundance. A – Yellow-cheeked crested gibbon; B – Black-shanked douc; C – Pig-tailed macaque; D – Germain's silvered langur

The results of the biodiversity monitoring in Seima between 2010 and 2014 has shown that the wildlife populations are generally stable, and in some cases appear to be increasing. Only the species captured on the line transects can be assessed at this stage, but after the 2015 dry season elephant abundance between 2006 and 2015 will be compared.

5. Biodiversity monitoring in the context of REDD+ – lessons learned from Seima

As mentioned in the Social and Biodiversity Impact Assessment Manual, before biodiversity monitoring systems are designed and implemented for REDD+ landscapes, it is important to ask the following questions:

- How well known is the site's biodiversity?
- Have biologists studied the site before, or have they studies sites in the same region?
- Which taxonomic groups are considered well documented in the region?
- Do species lists or reference volumes exist for any taxonomic groups, and how complete are they?
- What types of terrestrial ecosystems are present?
- What sorts of plant and animal communities are particularly associated with each terrestrial ecosystem?
- What types of aquatic habitats (e.g., streams, lakes, coastal inlets) are present?
- What plant communities are associated with these aquatic habitats (e.g., gallery forest along streams, swamp forests, salt marshes)?
- What animal communities are associated with these aquatic habitats?
- Does the project zone contain landscape features that are especially important for the region's biodiversity (e.g., waterholes, salt licks, caves)?
- Which of the prominent biodiversity features of the ecoregion where the project is located, as described by ecoregional atlases (like Olson et al. 2001), are present in the project zone?

Technical skills required

Once these questions have been adequately answered, appropriate monitoring programs can be designed. **Criterion G4.2** of the CCB Standards asks project designers to describe the technical skills required to implement the biodiversity assessment and monitoring program successfully. While biodiversity assessment or inventory is a relatively quick and straightforward task, biodiversity monitoring is a long-term venture that requires careful planning, creative fine-tuning, and years of patient data collection. The key to a successful monitoring program is thus a team of dedicated, well-trained, and well-managed people.

In Seima Protection Forest, the biodiversity monitoring team has been built-up, developed, and continually trained for almost ten years. The investment in time and resources required to produce a professional monitoring team in Cambodia must not be underestimated. If insufficient time and energy is not invested in the development of a monitoring team, the data collected - and thus the results - will be of poor quality.

In most cases, designing a biodiversity monitoring program and evaluating the data it produces will require the assistance of a professional biologist. While non-specialists may be a good choice to actually collect monitoring data, a professional with formal training in experimental design should help ensure that the monitoring program will produce viable information. Likewise, it is wise to have at least one trained scientist oversee the monitoring (e.g., to clean and organize data as they are collected, to ensure that data are being collected correctly and on schedule, to meet regularly with data collectors to solve problems and take advantage of opportunities).

In Seima Protection Forest, there has been at least one Biodiversity Monitoring Advisor (employed by the Wildlife Conservation Society) who has been responsible for assisting / leading survey design, training the field teams on data collection and ensuring capacity is at the required level, supervising fieldwork, management and analysis of data, and reporting / presentation of results. Furthermore there has always been a Senior Technical Advisor, who is responsible for broader program development and direction, and is on hand to provide technical advice on all aspects of the project. This layered support structure reduces the likelihood of the biodiversity monitoring program failing to meet the requirements of the REDD+ project.

It is strongly recommended that field teams are not left for long periods of fieldwork unsupervised by a manager, senior staff member, technical advisor etc. unless the team in question is very experienced and well trained. This is simply because collecting biological and ecological data is almost entirely reliant on strict protocols, non-violation of assumptions, and changes or adaptations in methodology complying with the underlying statistics of the method. These aspects of data collection are often complex and can lead to poor quality data if not done correctly.

Selecting target species

Biodiversity variables or biodiversity indicators are ecosystem or community attributes that can serve as proxies for the health of natural systems. In the context of REDD+ projects, it is important to select indicators that have clear links to the biodiversity objectives described in the project document. Further, the selected indicators should have clear links to management interventions described in the project document. It is also sensible to choose multiple indicators that reflect the complexity of the ecosystem and the local ecological conditions. Finally, it is important to select species that are not overly complicated or difficult to monitor.

In Seima Protection Forest, a workshop was held to establish which species were to be considered the species of interest, and therefore the species that were to be monitored. A group of "landscape species" were selected, which represented various different taxa, each having different habitat associations, resilience, range size, and level of threat. It is important that the selection of target species at any site is thoroughly thought through, and discussed with a range of project stakeholders to ensure the most appropriate species are selected.

Monitoring methodology

The biodiversity monitoring program in Seima is large, robust, and long-term. However, it is important to note several points.

In the context of REDD+ and the CCB standards, it is not necessary to implement or maintain a monitoring program that produces precise absolute density and abundance estimates using advanced methods such as distance sampling or faecal DNA analysis. Seima is not only a REDD+ demonstration site, but a long-term conservation program, and therefore the REDD+ project has benefited from the availability of these data which were, and will be collected as part of the long-term program regardless of the REDD+ project. Other sites that simply want to monitor biodiversity for the purposes of REDD+, will not need to implement such methodologies. Methods that produce relative indices or track changes in presence/absence are perfectly sufficient, and often easier to implement and repeat.

There are caveats however. Even methods that monitor relative indices or changes in presence / absence need to be carefully designed in order to ensure ecologically meaningful, repeatable results are produced. As mentioned previously, it is strongly recommended that professional biologists or biological statisticians are consulted regarding survey design and intended analyses in order to avoid meaningless results.

Despite the scale and length of the Seima monitoring program, it has not been without problems. Two of the target species (Sambar, Eld's deer) have proved challenging to effectively monitor using line transects. This is surprisingly common with distance sampling, due to the relatively large number of required observations per survey to allow for robust analysis. Therefore distance sampling should only be considered if the species of interest are not overly shy, cryptic, or the underlying density is not too low.

References

Bussey, A., Ko, S., & Den, A. (2005). An evaluation of the mineral licks in the core area of the Seima Biodiversity Conservation Area Mondulkiri Province, Cambodia *Wildlife Conservation Society Cambodia Program, Phnom Penh*.

Dickson, B., & Kapos, V. (2012). Biodiversity monitoring for REDD+. *Current Opinion in Environmental Sustainability, 4*(6), 717-725.

FA. (2011). *Readiness Preparation Proposal (R-PP) Cambodia (Cambodia REDD+ Roadmap).Submitted to Forest Carbon Partnership Facility (FCPF) and United Nations REDD Programme (UN-REDD)*. Cambodia.

Olson, D. M., Dinerstein, E., Wikramanayake, E. D., Burgess, N. D., Powell, G. V., Underwood, E. C., . . . Morrison, J. C. (2001). Terrestrial Ecoregions of the World: A New Map of Life on Earth A new global map of terrestrial ecoregions provides an innovative tool for conserving biodiversity. *BioScience, 51*(11), 933-938.

Pollard, E., Eggert, L., Chanvibol, C., & Hedges, S. (2008). The status and conservation of Asianelephants in the Seima Biodiversity Conservation Area, Cambodia *WCS Cambodia Program, Phnom Penh*.

Richards, M., & Panfil, S. (2011). Social and Biodiversity Impact Assessment (SBIA) Manual for REDD+ Projects. Part I–Core Guidance for Project Proponents. Climate, Community & Biodiversity Alliance, Forest Trends *Fauna & Flora International, and Rainforest Alliance: Washington, DC*

Thomas, L., Buckland, S. T., Rexstad, E. A., Laake, J. L., Strindberg, S., Hedley, S. L., . . . Burnham, K. P. (2010). Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology, 47*(1), 5-14.

UNFCCC. (2010). *Decision 1/CP. 16, the Cancun Agreements: Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention*

Resources

1. CCB standards

Narasimhan, P., Starr, I., Hayward, J., Noponen, M. and Durbin, J. (2014). **Guidance for the use of the CCB Standards**. Washington, DC: Climate, Community and Biodiversity Alliance and the Rainforest Alliance. At: www.climate-standards.org/resources.

Pitman, N. 2011. **Social and Biodiversity Impact Assessment Manual for REDD+ Projects: Part 3 – Biodiversity Impact Assessment Toolbox**. Forest Trends, Climate, Community & Biodiversity Alliance, Rainforest Alliance and Fauna & Flora International. Washington, DC.

2. Designing project activities and estimating their biodiversity impacts

Tucker et al.'s (2005) guide to biodiversity monitoring in protected areas includes valuable advice on and examples of establishing biodiversity objectives, available online at **www.unepwcmc.org/collaborations/BCBMAN/PDF/PA_Guidelines_BMA.pdf.**

The CMP **Open Standards for the Practice of Conservation** (CMP 2007) include advice on identifying major biodiversity objectives (the term used in that document is "conservation targets"). The CMP standards are available online at **http://www.conservationmeasures.org/resources**.

Guidance on establishing biodiversity objectives is provided with the Conservation Action Planning tools, which are available online at **http://conserveonline.org/workspaces/cbdgateway/cap/index_html.**

3. Describing ecoregions and vegetation types

A map of Earth's terrestrial ecoregions (Olson et al. 2001) is available online at **http://www.worldwildlife.org/science/ecoregions/item1267.html.**

The United States Geological Service maintains interactive online maps to help users identify and download satellite images available for given areas of the world, available at **http://glovis.usgs.gov/ and http://edcsns17.cr.usgs.gov/NewEarthExplorer/**. The **University of Maryland's Global Land Cover Facility** maintains a similar site at **http://glcfapp.glcf.umd.edu:8080/esdi/index.jsp.**

Continental-scale panoramic aerial images are available online at **http://130.166.124.2/world_atlas/.**

Carbon projects in areas with significant wetlands should explore the **Ramsar Convention Handbooks**, available online at **http://www.ramsar.org/cda/en/ramsar-pubs-handbooks-handbooks4-e/main/ramsar/1-30-33^21323_4000_0__.**

4. Resources for assessing vegetation condition or quality

The Global Invasive Species Database and associated resources for assessing the extent to which invasive species have affected the project area are available online at **http://www.issg.org/database/welcome/.**

Table 7 in the **SBIA Manual – Part 3** lists variables that are commonly used to monitor vegetation condition or quality

5. Resources for describing biodiversity

The World Wildlife Fund maintains a useful online tool to identify species that are potentially present at any given site on Earth, available at **http://www.worldwildlife.org/wildfinder.**

Information on Earth's freshwater ecoregions (Abell et al. 2008) is available online at **http://www.worldwildlife.org/science/ecoregions/freshwater.html**

Information on internationally important wetland sites is available online at **http://ramsar.wetlands.org.** Carbon projects in areas with significant wetlands should explore the **Ramsar Convention Handbooks** for the wise use of wetlands, available online at **http://www.ramsar.org/cda/en/ramsar-pubs-handbooks-handbooks4-e/main/ramsar/1-30-33^21323_4000_0__.**

Information on global biodiversity hotspots is available online at **http://www.biodiversityhotspots.org/Pages/default.aspx.**

Information on globally important areas for bird conservation is available online at **http://www.birdlife.org/datazone/index.html.**

Guidance on describing biodiversity and current impacts is provided with the Conservation Action Planning tools, available online at **http://conserveonline.org/workspaces/cbdgateway/cap/index_html.**

Shapefiles and other resources for the global protected areas system are accessible on the online searchable site **http://protectedplanet.net.**

Contact address

Secretariat of Cambodia REDD+ Taskforce
No. 40 Preah Norodom Blvd
Sangkat Psar Kandal 2
Khan Daun Penh, Phnom Penh, Cambodia
Tel: +855 023 224 251
Email: redd.secretariat@cambodia-redd.org