



## THE SERENGETI OF ASIA: CONSERVATION IN TWO MAJOR PROTECTED AREAS OF THE EASTERN PLAINS LANDSCAPE PROTECTED AREA COMPLEX, CAMBODIA

Rohit Singh<sup>1\*</sup>, Phan Channa<sup>2</sup>, Prum Sovanna<sup>3</sup>, Pin Chanratana<sup>4</sup>, Gerard Ryan<sup>5</sup> and Mark Wright<sup>6</sup>

\* Corresponding author, [rsingh@wwf.org.my](mailto:rsingh@wwf.org.my)

<sup>1</sup> WWF-Tigers Alive Initiative, Kuala Lumpur, Malaysia

<sup>2</sup> Project Officer, Flora & Fauna International, Cambodia

<sup>3</sup> Project Officer, WWF Eastern Plains Landscape, Cambodia

<sup>4</sup> Project Assistant, WWF Eastern Plains Landscape, Cambodia

<sup>5</sup> Research Technical Advisor, Kratie Province, Cambodia

<sup>6</sup> Conservation Director, WWF-Suriname

### ABSTRACT

The Eastern Plains landscape of Cambodia still has extremely good forest cover over a large area but wildlife populations remain low after many years of civil unrest and hunting pressure. Over the past decade concerted conservation efforts of WWF in collaboration with the Royal Government of Cambodia in the Mondulkiri Protected Forest and Phnom Prich Wildlife Sanctuary, the two major protected areas in the landscape, have demonstrated modest successes in curbing illegal activities and gaining community support for forest protection. These conservation efforts include rigorous and regular monitoring of biological diversity, effective law enforcement monitoring using latest tools, gaining community support for forest protection through awareness and livelihood interventions. This programme shows the different aspects of management which need to be considered for protected areas to be effective and at the same time reflects the need for long-term investment in conservation in order to see progress and the requirement to address policy, social, economic in addition to biological factors to ensure sustainability.

**KEYWORDS:** monitoring, tigers, law enforcement, Mondulkiri Protected Forest, Phnom Prich Wildlife Sanctuary, Eastern Plains Cambodia, protected area management

### INTRODUCTION

Heralded in the 1950s as the ‘Serengeti of Asia’, the dry forests of Eastern Cambodia once supported some of the greatest aggregations of large mammals in South-East Asia (Wharton, 1957). This area, known as the Eastern Plains Landscape, saw considerable turmoil over the last four decades of the 20th century as Cambodia struggled through civil war, the Pol Pot regime and invasion by Vietnam. During this dark period, biodiversity and natural resources declined at a frightening rate (Global Witness, 2007). Though protected areas were unofficially designated before forest protection legislation came into existence in early 2000, easy availability of guns, absence of any environmental law enforcement and civil unrest resulted in the widespread hunting of wildlife for food and trade, and large-scale logging of many forests (Loucks et al., 2008). The first protection legislation, the Forestry Law, was approved in 2002 to protect the

Kingdom’s forests and wildlife. Shortly after, the Protected Area Law (2003) came into force, to provide a means of legally designating and protecting land for biodiversity, such as National Parks and Wildlife Sanctuaries. After a decade of concerted efforts from a range of government agencies and conservation partners, some wildlife populations now appear to be recovering in parts of Cambodia, including in the Eastern Plains.

The Eastern Plains spreads over approximately 1.6 million hectares at the core of the Lower Mekong Dry Forest Ecoregion in Mondulkiri, Ratanakiri and Kratie Provinces in Cambodia, and Dak Lak Province in Vietnam. The Lower Mekong Dry Forest is considered one of the 200 most important Ecoregions for global biodiversity by WWF (Olson & Dinerstein, 1998; Wikramnyake et al., 2002). The Eastern Plains Landscape is a complex of five protected areas—

**Table 1: Details of the protected areas in the Eastern Plains Landscape**

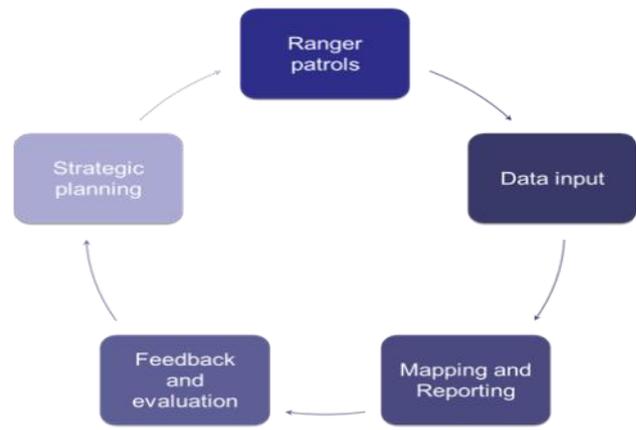
| Protected Area                 | Size (ha) |
|--------------------------------|-----------|
| Mondulkiri Protected Forest    | 372,971   |
| Seima Protected Forest         | 301,867   |
| Phnom Prich Wildlife Sanctuary | 222,500   |
| Lumphat Wildlife Sanctuary     | 252,525   |
| Yok Don National Park          | 115,545   |

Mondulkiri Protected Forest, Phnom Prich Wildlife Sanctuary, Lumphat Wildlife Sanctuary, Seima Protected Forest, in Cambodia, and Yok Don National Park in Vietnam (Table 1; Figures 1 and 2). It supports the largest extant of lowland dry deciduous forest in Southeast Asia (Tordoff et al., 2005).

The Eastern Plains Landscape is home to many globally endangered and critically endangered mammals including Asian elephant (*Elephas maximus*), banteng (*Bos javanicus*), wild water buffalo (*Bulalus arnee*), Siamese crocodile (*Crocodylus siamensis*) and Eld’s deer (*Cervus eldii*); critically endangered water birds like the giant ibis (*Thaumatibis gigantea*), white-shouldered ibis (*Pseudibis davisoni*) and white winged duck (*Cairina scutulata*) and three critically endangered vulture species - the red headed vulture (*Sarcogyps calvus*), slender-billed vulture (*Gyps tenuirostris*) and white-rumped vulture (*Gyps bengalensis*).

Around 50,000 people of multiple ethnic groups live in Mondulkiri Province with 59 per cent of them living below the poverty line (WWF, 2008). Many of these communities depend directly or indirectly on natural resources to support their livelihoods and subsistence needs.

While some conservation gains have been made over the last ten years, the rich biodiversity of the landscape remains under threat due to illegal logging, hunting, land clearing and other unsustainable uses of natural resources. On-going protection is thus vital. Continued granting of large economic land concessions within and around the protected areas, as well as mining and hydropower development create additional large-scale and serious threats to both forest and wildlife. The kouprey (*Bos sauveli*), Cambodia’s national animal, and the Indochinese tiger (*Panthera tigris corbetti*) which



**Figure 1: Basic adaptive feedback management model of law enforcement monitoring used in the EPL**

once thrived in this landscape are almost certainly extirpated (Timmins et al., 2008; Gray et al., 2012) and the status and immediate future of many other species is uncertain unless immediate action is taken to reduce these threats.

**INITIATIVES TO SUPPORT THE BIODIVERSITY**

This paper focuses on two protected areas in the Eastern Plains Landscape, Mondulkiri Protected Forest (MPF) and Phnom Prich Wildlife Sanctuary (PPWS), where WWF works in collaboration with the Cambodian government for the protection of wildlife and their habitat. MPF is of particular national significance as it is the only Tiger priority source site identified in the National Tiger Recovery Plan of Cambodia (MAFF, 2010). Based on early biodiversity survey work, the areas were identified as priority sites for biodiversity conservation. WWF is providing both financial and technical support to the Ministry of Environment, Ministry of Agriculture, Forestry and Fisheries and the Provincial Government. Conservation actions are directed through a landscape strategic plan (see Lessons Learned, below), developed by those working in the area. The conservation strategy focuses around law enforcement, governance and policy development, community engagement, and biodiversity monitoring.

**BIODIVERSITY MONITORING**

WWF carried out the first biological survey in MPF and PPWS in 2000 and then regular biological surveys were conducted between 2000-2008 (Timmins & Ou, 2001; Claassen & Ou, 2006). A detailed baseline survey was conducted in 2009 as a basis for regular monitoring for priority species including large carnivores and their prey, Asian elephants and yellow-cheeked crested gibbons (*Nomascus gabriellae*) in the MPF and PPWS (Gray & Phan, 2011; Gray & Prum, 2011; Gray et al., 2011a; 2011b;

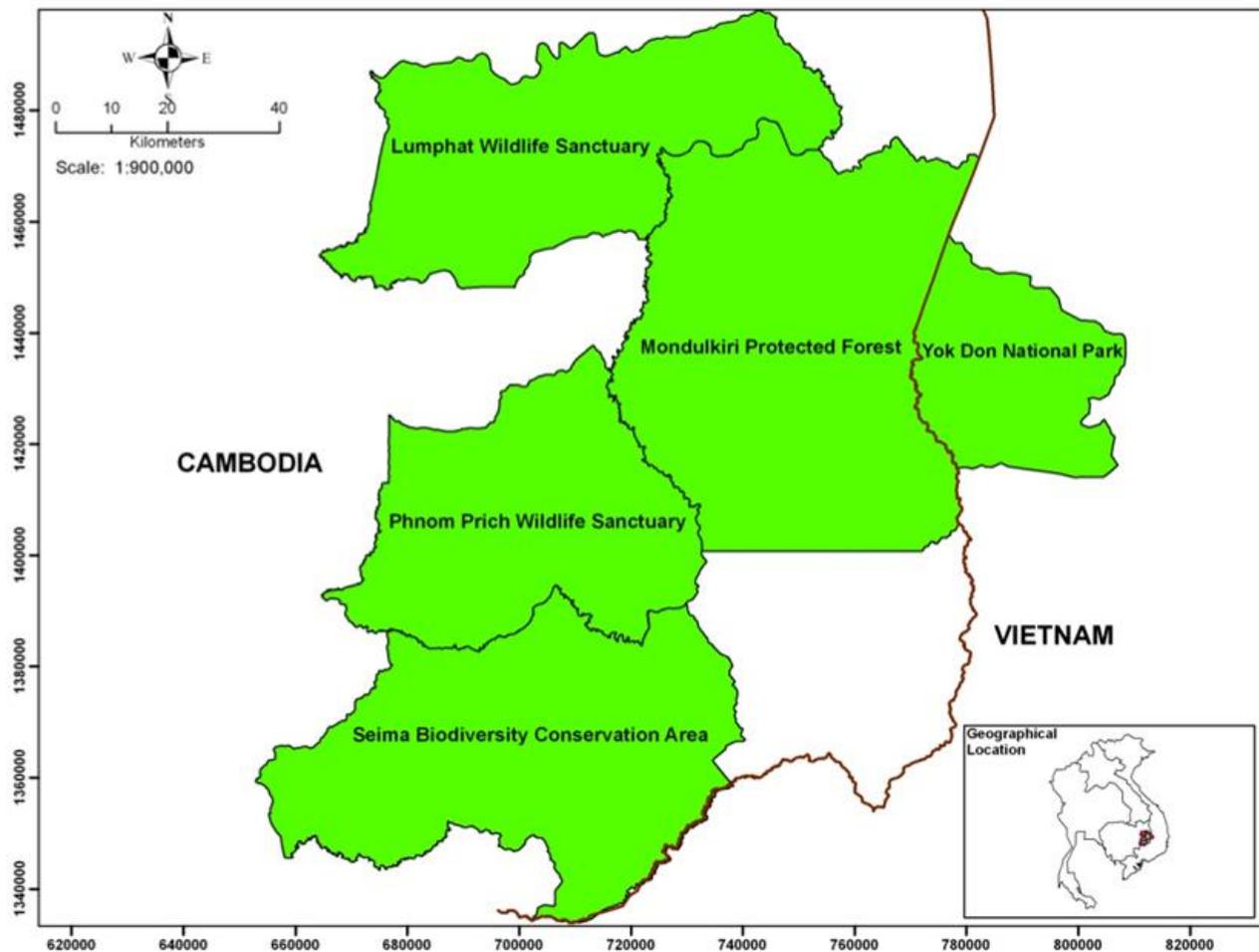


Figure 2: Protected area complex in the Eastern Plains Landscape, inset – mainland South-East Asia

Phan & Gray, 2009). Standard distance-based line transect sampling and camera trapping are used for monitoring ungulates and a range of other species, whilst new innovative techniques such as the use of scat detection dogs and DNA identification from faeces have been used to survey low density species such as Indochinese Tiger and Asian elephant (WWF-internal unpublished data; Gray et al., 2011b). Similar studies have also been conducted in the Seima Biodiversity Conservation Area (SBCA), an adjacent protected area in the landscape (WCS/FA internal data). Populations of large ungulates remain in the landscape, including Banteng, Eld's deer, sambar (*Cervus unicolor*), gaur (*Bos gaurus*), red muntjac (*Muntiacus muntjac*) and wild pig (*Sus scrofa*). Surveys suggest that these populations may be slowly recovering from earlier hunting pressure (Gray et al., 2011a) and the landscape is now home to globally significant populations of some species. For example, it supports world's largest banteng population (Gray et al., 2012), and is an important regional stronghold for Eld's deer, Asian elephant, yellow-cheeked crested gibbon, giant ibis and white-shouldered ibis (*Pseudibis davisoni*).

The presence of the landscape's arguably most charismatic species, the tiger, remains doubtful. A camera trap photograph from the MPF taken in November 2007 is the most recent confirmed evidence of tiger presence in Cambodia (Lynam, 2010). Despite extensive targeted camera trapping in PPWS and MPF and surveys using tiger scat detection dogs there has been no further concrete evidence of tigers in MPF and PPWS since then (WWF internal unpublished data). Similar studies have been conducted in Seima Protected Forest (WCS/FA internal data) with the same result. There have been reports of tiger footprints in MPF and PPWS respectively in 2008 and 2010 (unpublished ranger reports) but this evidence is inconclusive. This suggests that, if tigers persist in the landscape, there may be only one or two individuals.

Another globally important species, the Asian elephant, still remains in reasonable numbers in the landscape. The faecal-DNA based capture-mark-recapture method was used to establish a base line for the Asian elephant populations in MPF and PPWS. The results indicate



**A herd of banteng in the core zone of Mondulkiri Protected Forest © Fletcher & Baylis**

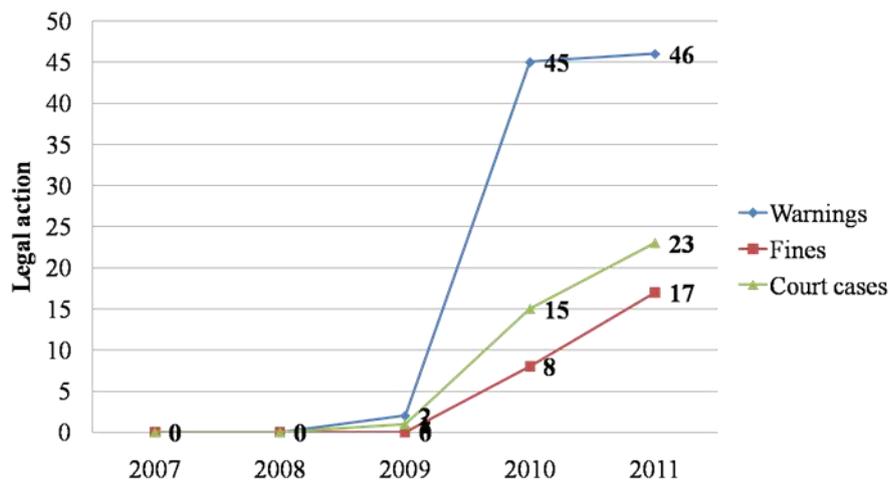
between 101 to 175 (mean 154) individuals in PPWS and a minimum of 21 individuals in MPF (Gray et al., 2011b). Movement of elephants between the two protected areas was observed over the 2009 dry season (Gray et al., 2011b), demonstrating the importance of a landscape approach and the need to maintain biological corridors for conserving viable populations of large, wide-ranging species such as elephant.

Biodiversity monitoring has demonstrated that the landscape has huge potential for wildlife conservation, and if adequately protected, wildlife populations can recover; however further research is required to determine the carrying capacity of the landscape.

### **LAW ENFORCEMENT**

Law enforcement is the single most critical conservation action needed to protect the biodiversity of the landscape. Uncontrolled hunting, logging, land clearing and other unsustainable uses of natural resources threaten the landscape's rich biodiversity. WWF has been actively supporting enforcement activities in the landscape since 2006. Currently three major enforcement teams work in the landscape; ranger teams in MPF and PPWS for enforcement within the protected areas and a Mobile Enforcement Unit (MEU). The protected area teams conduct regular enforcement

patrols within the park boundaries and gather basic but vital information on key species. The MEU is responsible for monitoring international border transit points, checking markets and restaurants for wildlife products as well as gathering intelligence on wildlife and forest crime. It has been highly effective in responding to tip offs of wildlife crime and illegal logging activity within the province. A total of 64 rangers make up these three teams although, for two protected areas of this size, at least 90 would be more appropriate. Rangers patrol on foot, and by motorbike, elephant and boat. During the dry season, the majority of the patrols are done on motorbikes, however during the monsoon elephants are used as they provide greater access to remote areas. MIST—Management Information System—is an electronically based system used to monitor the patrol efforts and to gather information on key species' distribution and habitat quality (Stokes, 2010). Other monitoring tools are used for the systematic recording of enforcement data are the Informant Monitoring Tool and Wildlife Crime Database (WWF, 2012a). The Informant Monitoring Tool is designed to store all the information gathered by informants as a means of measuring their effectiveness. The tool has details of all informants, their target areas, information received from them and incentive provided to them. It also records the outcomes of the actions taken by law enforcement agencies, based



**Figure 3. Legal action taken against forest and wildlife crime in the Eastern Plains Landscape, 2007–2011, including warning letters (blue), fines (red), and court cases (green)**

on the information provided. The Protected Area Law and Forestry Law of Cambodia offer three types of legal action against forest and wildlife offences i.e. written warning, fines and court cases. The law also allows sanctions to become stronger for repeat offenders. However, in the past, neither the Provincial level Forestry Administration (FA) nor the Department of Environment (DoE) had a system for recording crimes and repeat offenders which made it difficult to track what legal action had been taken, and against whom, for forest and wildlife crime offences. To address this issue the Wildlife Crime Database was created in 2011 to manage the information on legal actions taken by FA and DoE against offenders in the Mondulakiri Province. The database is now managed by the provincial FA and DoE.

The protected area teams conduct monthly patrol planning to ensure effective patrolling and adapt strategies as appropriate. Patrol planning meetings are held in the forest at the ranger stations and are led by the protected area managers. A variety of information sources are used for patrol planning purpose, e.g. reviewing patrol block coverage and patrol routes, as well as information received from the communities or informants to ensure that, within a given time, the whole of the respective protected area has been patrolled and that hotspots of illegal activity are prioritized. Every enforcement ranger spends 16 days patrolling the forest, as well as seven days at their ranger outposts each month.

Between 2006 and 2011, the enforcement teams undertook 8,848 day patrols and 3,062 night patrols. Teams have confiscated a huge amount of wildlife articles and luxury timber. Around 359 m<sup>3</sup> of luxury timber and 133 chainsaws were confiscated by the enforcement teams over this period (WWF, 2012a). Notable species seizures include wild water buffalo, leopard (*Prionailurus pardus*), sun bear (*Ursus*

*malayanus*), Eld's deer (*Cervus eldi eldi*), Asian elephant (*Elephas maximus*) and pangolin (*Manis javanica*), mostly hunted for wild meat, trophies or medicinal purposes. A few wildlife species that have been confiscated were destined for the pet trade or were being kept in captivity, including leopard cats (*Prionailurus bengalensis*) and green peafowl (*Pavo munticus*), but this is not common. According to the Forestry and Protected Area Law, only common species can be kept as pets and only with due approval from the concerned Ministries. The MEU is responsible for curbing such illegal activities. Over 250 animals that were fit for release were returned to the wild, while 10 in poor condition were sent to the Forestry Administration's Phnom Tamao wildlife rescue centre near Phnom Penh.

During any enforcement work, it is important that proper legal action is taken against the offenders. In the Cambodian context, legal action is especially important because sanctions under the law become more severe if the wildlife offender repeats their crime. Previously, very few court cases were filed by the enforcement agencies. Since 2010, however, due to the improvement in knowledge of the legal procedures by the enforcement teams, there has been a significant increase in legal action concerning wildlife and forest offences; 40 court cases were filed, 93 warning letters were issued and 25 offenders have been charged fines (Figure 3).

## COMMUNITY ENGAGEMENT

There is broad recognition that community engagement is a key element of conservation management. In least developed countries such as Cambodia (UNCTAD, 2012), support for livelihoods is critical to help offset the restricted access to natural resources that can come with the designation of protected areas. Without these interventions it can be difficult to maintain community support for conservation. In the Eastern Plains, there



**A tiger photographed in the core zone of Mondulkiri Protected Forest in 2007. This photograph is the most recent unequivocal evidence of Tigers in Cambodia ©FA-WWF-Cambodia**

have been four major foci: awareness and education, community forestry, improving livelihoods through sustainable harvesting of non-timber forest products (NTFP) and ecotourism (WWF, 2012b). A socio-economic survey was conducted in 2007 and 2008 to target and better understand those communities depending on forest resources such as hunters, resin collectors and honey collectors (Mailing, 2007; WWF, 2008). Working in the area since then, the first three years of the project focused on building relationships with communities living in and around the MPF; with the same model being replicated later for PPWS. A key aim of the project was to improve the capacity of the local communities as de facto resource managers.

Under a parallel initiative, six Community Protected Areas, three Community Conservation Forests and two Community Fisheries have been established over the past six years (Figure 4). These areas are managed and monitored by the communities, with legal mandates under the Protected Areas, Forestry and Fishery Laws, respectively. Thirty-four patrol teams, consisting of local community members, cover 22,931 ha of forests in these areas (as of September 2012). Community patrol teams use MOMS (Management Oriented Monitoring System) to record information on illegal activities and wildlife in their area (Diggle, 2006; WWF, 2012b) which is then shared with relevant authorities for them to take action. Communities are allowed to manage and extract NTFPs in a sustainable manner within these areas, however hunting, land clearing and illegal fishing is banned. In community fisheries areas communities are allowed to

harvest fish sustainably for their own subsistence needs while protecting their areas from illegal fishing. Another activity initiated is sustainable harvesting of honey and supporting the communities in processing and marketing. Fifty-four of the poorest forest-dependent families have benefited through the programme and their annual income has increased on average from US\$ 150 in 2008 to US\$ 400 per family in 2012.

Ecotourism is another means of improving community livelihoods and strengthening the link between local communities and the forests. A community-based ecotourism feasibility study was done in the year 2007 (Bauld, 2007) and an ecotourism initiative was started in early 2009, resulting in the establishment of a community home stay at Dei Ey in the MPF. The homestay is a purpose-built building, managed by the community. In addition to providing income to the community, part of the resources earned from the tourism activities are used for supporting community patrol teams. Beside this, regular awareness programmes are conducted in villages as well in the schools. WWF also played an important role in building ecoclubs in local schools.

## GOVERNMENT ENGAGEMENT

It is very important to engage with concerned government agencies from all levels to achieve the protected area management and landscape goals. WWF's strategy to achieve this includes; a full-time person for government liaison both at national and provincial level, monthly meetings and annual workshops with all stakeholders, and involvement in land use planning activities.

## LESSONS LEARNED

As a result of a long-term engagement in these two protected areas in the Eastern Plains Landscape it is possible to draw out some key elements that helped to foster success.

- 1. Clear conservation strategy:** a clear overall conservation strategy with constituent goals based on assessments of threats to the key biodiversity values of the landscape helps define and frame the work programme. Ideally, this should be reviewed throughout the project lifetime. In the Eastern Plains Landscape this was achieved through following the WWF Global Programme Standards Framework in MIRADI (Conservation Measures Partnership, 2009).
- 2. Identification of all stakeholders:** it is important to identify the full spectrum of stakeholders right at the beginning of the project including those likely to be for or against some or all project activities. The role



Mondulkiri Protected Forest enforcement team © WWF

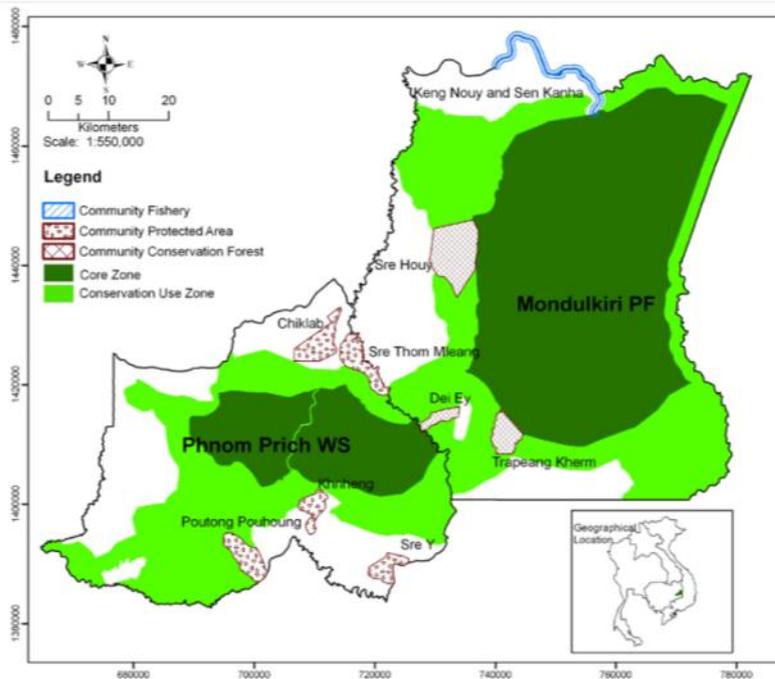
and impact of stakeholders needs to be reviewed on a regular basis and new stakeholders may need to be engaged as the situation develops. This was done early through social-economic surveys, threat analysis for both the protected areas and through government engagement. Based on the role of different stakeholders and threats the first landscape strategy was developed in 2007. As the situation may change rapidly in the landscape, it is beneficial to repeat this exercise intermittently. In the Eastern Plains Landscape the exercise was repeated in 2012 (WWF, 2012c).

**3. Full government engagement from the start:** it is very important to engage all the concerned government agencies continually from the beginning of the project. This includes ‘target’ ministries such as Ministry of the Environment but should also include other departments such as Roads and Transportation, Industry and Mines which may not be directly involved with conservation and protected area management but whose activities and plans impact on conservation.

This also improves the protected area management through participatory discussion as well as strengthening links between government and NGOs. In the Eastern Plains Landscape project a position titled government liaison officer is supported to ensure this work.

**4. Commit for the long term:** protected area management needs committed long-term intervention and support particularly in developing countries like Cambodia. This includes both financial and technical support. WWF has been supporting conservation in the Eastern Plains Landscape since 2000 and will need to continue to do so for the foreseeable future. However it is equally important for NGOs to have a clear exit strategy in place to ensure that protected area management can continue once this support is withdrawn.

**5. Work at the right scale:** this may be especially true for community and livelihoods engagement where benefits have to be sufficiently widespread and fit within the broader socio-economic context of the community in order for true conservation buy-in to be achieved.



**Figure 4: Community Conservation Forests, Community Protected Areas and Community Fisheries in Mondulkiri Protected Forest and Phnom Prich Wildlife Sanctuary**

**6. Need to engage with the political framework and understand the political context:** it is as important to understand and address the political framework as it is to understand the biological elements within a protected area as regards its impact on management. The same is also true of understanding the socio-economic context of communities who impact the protected area – directly or indirectly and the motivations underlying people’s decision making.

**7. Be selective in fundraising:** it is very easy to ‘chase the money’, which can result in shifting objectives, not necessarily related to good protected area management or protection. It is important for both government and NGOs to prioritize actions source funding accordingly.

**8. Basic biological and enforcement monitoring tools:** in any protected areas it is necessary to have a system in place to monitor the effectiveness of the law enforcement activities. These tools provide regular information on magnitude of threats and their distribution which is very important for developing enforcement strategies. The project has been using the MIST system for past six years and has recently started using the Spatial Monitoring And Reporting Tool—SMART (Conservation Software, 2013). Biodiversity monitoring is also important; however it requires sufficiently trained personnel and can be expensive. Ensuring a proportion of all funding goes to monitoring is critical to assess impact and measure success.

**9. Nurture and retain the right skills base:** identify skill and knowledge gaps, and ensure complementarity of technical skills across the landscape is an important contribution to effective management.

Regular training need assessments and capacity building programmes have been conducted in the Eastern Plains Landscape to ensure the correct skill base in the protected areas.

**10. Raise the profile of the area through awareness:** it is very important to keep the profile of the protected areas high to help get, and maintain, both financial and especially political support.

**11. Communication plan:** establish how the work – and the importance of the protected area – will be communicated and through which medium. Understand how best to ‘sell’ the landscape or the wildlife it contains to maximize external interest.

**12. Balance land use:** there is the need to balance the requirements of local communities and emerging business with that of the natural world. This is best captured through appropriate allocation of land for development and formalizing ownership of land through land titles.

## THE FUTURE OF THE EASTERN PLAINS

In keeping with many protected areas in the tropics, those in the Eastern Plains of Cambodia suffer from very limited management resources, low levels of funding and little systematic planning. Protected areas are inherently complex and, to be effective, have to address simultaneously biological, economic and social issues whilst prioritizing resource uses to where they are most needed. Conservation efforts in the two protected areas of Eastern Plains discussed here give one example of where this is being put in to practice. The work is still at a relatively early stage but lessons can be learned from the experiences to date. Enforcement activities are critical to

protecting protected areas and their natural resources but these must be coupled with strong laws and a legal system that offers true deterrents to illegal activity. The policy environment must recognize the full value of the protected areas (financial and non-financial) and the contribution they make at local, national and international levels. This must be reflected in appropriate large scale land-use planning that designates areas primarily for conservation. It is also reflected in fostering a greater understanding of the range and importance of ecosystem services and the development of sustainable harvesting systems for natural products. Science and research is helping underpin much of the decision making, for example around quota setting for NTFPs and fisheries, identifying core conservation areas and indicating how resilient a given habitat is likely to be to change. However, research findings alone cannot provide the whole answer and decisions about land use must also incorporate social and traditional land use considerations.

In Cambodia all these requirements have not yet been fully met, but significant progress and some success has been achieved. With long-term commitment from the responsible government agencies and, for now, the donor community there is no reason why all of these requirements for ensuring truly effective protected areas should not be realized. Many stakeholders will need to be involved and many competing and conflicting demands will need to be considered. It is impossible that every interest group will be satisfied with the outcome and a key role of government will be to ensure that decisions lead to the protection of these globally important forests. With strong leadership and real commitment to protecting Cambodia's natural heritage there is room for optimism that this landscape can once again become the Serengeti of Asia.

#### ABOUT THE AUTHORS

**Rohit Singh** is Trainer- Tactical Protection and Law Enforcement Monitoring with WWF-Tigers Alive Initiative.

**Phan Channa** is Project Officer with Flora & Fauna International-Cambodia Programme and counterpart with the Ministry of Environment.

**Prum Sovanna** is a Project Officer in the Eastern Plains Landscape and counterpart with the Forestry Administration.

**Pin Chanratana** is a Project Assistant in the Eastern Plains Landscape.

**Gerard Ryan** is a Research Technical Advisor based in Kratie province.

**Mark Wright** is Conservation Director with WWF-Suriname.

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## RESUMEN

El paisaje de los Llanos Orientales de Camboya aún tiene una buena cobertura forestal en una área extensa, pero el nivel de las poblaciones silvestres continúa siendo bajo tras tantos años de guerra civil y la presión de la cacería. Durante la última década, los esfuerzos de conservación de WWF en colaboración con el Gobierno Real de Camboya en el Bosque Protegido Monduliri y el Santuario de Vida Silvestre Phnom Prich, las dos principales áreas protegidas en el paisaje, han demostrado éxitos modestos en la reducción de actividades ilegales y la obtención de apoyo comunitario para la protección de los bosques. Estos esfuerzos de conservación incluyen el monitoreo riguroso y periódico de la biodiversidad, la vigilancia efectiva de la aplicación de la ley mediante el uso de modernas herramientas, y la obtención de apoyo comunitario para la protección de los bosques a través de campañas de sensibilización e intervenciones para asegurar los medios de subsistencia. Este programa muestra los diferentes aspectos en materia de gestión que deben tenerse en cuenta para asegurar la eficacia de las áreas protegidas, al tiempo que refleja la necesidad de inversión a largo plazo en la conservación para avanzar en este sentido y la necesidad de abordar factores de carácter político, social, económico y biológico para garantizar la sostenibilidad.

## RÉSUMÉ

Le paysage des plaines orientales au Cambodge possède encore un excellent couvert forestier sur une vaste superficie, mais les années de chasse et les troubles civils ont drastiquement réduit les populations à l'état sauvage. Depuis dix ans, les efforts de conservation concertés du WWF et du gouvernement royal du Cambodge, dans la forêt protégée de Monduliri et le sanctuaire de vie sauvage de Phnom Prich, les deux principales aires protégées du paysage, connaissent un succès modeste et sont parvenus à réduire les activités illégales et à gagner le soutien des communautés pour améliorer la protection des forêts. Ces efforts de conservation incluent un suivi rigoureux et régulier de la diversité biologique ; un suivi efficace de l'application de la loi grâce aux outils les plus modernes ; et un soutien aux communautés pour protéger les forêts grâce à des campagnes de prise de conscience et à une amélioration des moyens d'existence. Ce programme montre les différents aspects de la gestion devant être pris en compte pour optimiser l'efficacité des aires protégées, et reflète parallèlement le besoin d'investissement à long terme dans le secteur de la conservation, afin de voir les progrès et les exigences des questions politiques, sociales, économiques et biologiques pour garantir la durabilité.