

REVIEW ARTICLE

Distribution and Conservation Status of the Red-Shanked Douc (*Pygathrix nemaeus*) in Lao PDR: An UpdateCAMILLE N. Z. COUDRAT^{1*}, JOHN W. DUCKWORTH², AND ROBERT J. TIMMINS²¹Department of Anthropology and Geography, Oxford Brookes University, Oxford, United Kingdom²Wildlife Conservation Society, Vientiane, Lao PDR

The endangered red-shanked douc (*Pygathrix nemaeus*), endemic to Lao PDR, Vietnam, and perhaps Cambodia, remains little known. The Lao population is highly threatened. To improve conservation prospects of the species there, we here update a status review from 1999. Subsequent literature (mostly not readily available to the outside scientific community) was reviewed critically. Doucs and their habitat in Lao PDR faced continuous, increasing threats in the past 10 years through large development projects and heavy hunting. Many locations with records from the 1990s were not surveyed in the last decade, so douc persistence remains uncertain in them. Given the poor status of the species in Vietnam and Cambodia, the Lao population is surely the world's largest and the best hope for the species' global conservation. Resources for conserving species are very limited in the country, urging prioritization of populations, so available resources have maximum effect. Nakai–Nam Theun and Hin Namno National Protected Areas hold the largest populations of *P. nemaeus*, but face great threats from hunting. Management of these areas (and secondary priority areas) should focus on control of this illegal activity. *Am. J. Primatol.* 74:874–889, 2012. © 2012 Wiley Periodicals, Inc.

Key words: colobine; douc langur; hunting; Laos; trade

INTRODUCTION

Doucs (*Pygathrix*) are members of the Old World monkey subfamily Colobinae and belong to the odd-nosed monkey group—*Pygathrix*, *Nasalis*, *Rhinopithecus*, and *Simias*—of parts of China and South-east Asia [Sternler et al., 2006]. Three douc species are recognized by most contemporary authors: the red-shanked douc (*P. nemaeus*), the gray-shanked douc (*P. cinerea*), and the black-shanked douc (*P. nigripes*). They are endemic to Indochina (here defined as Lao PDR [Lao People's Democratic Republic/Laos], Cambodia, and Vietnam) east of the Mekong River, each with a relatively small geographic range. Information on their distribution, population status and ecology is limited [e.g. *P. nigripes*: Hoang & Baxter, 2006a,b; Houang & Baxter, 2007; Hoang et al., 2009; Nadler, 2008; Nadler et al., 2003; O'Brien et al., 2008; Phan Duy Thuc et al., 2005; Rawson, 2006, 2009; *P. cinerea*: Ha Thang Long, 2004, 2007, 2009; Nadler et al., 2003; *P. nemaeus*: Lippold, 1977, 1995, 1998; Kirkpatrick, 1998; Timmins and Duckworth, 1999; Nadler et al., 2003; Lippold & Vu Ngoc Thanh 2008; Lippold et al., 2008; Rawson & Roos, 2008; Phiapalath, 2009; Phiapalath & Suwanwaree, 2010; Phiapalath et al., 2011].

The red-shanked douc is the only douc recorded in (possibly) all three countries. It is classed internationally on *The IUCN Red List of Threatened*

Species as Endangered, because its global population is thought to have declined by over 50% in the past 30–40 years (= three generations), a trend predicted to continue [Vu Ngoc Thanh et al., 2008]. In Vietnam *P. nemaeus* ranges from Pu Mat National Park (NP; 19°02'N) in the north to Chu Mom Ray NP (14°22'N) in the south [Ha Thang Long, 2007, 2009],

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but it may not occur in Kon Ka Kinh NP, *contra* Nadler et al. [2003]. Animals in Ratanakiri Province, north-east Cambodia, were recently considered by Rawson and Roos [2008] to include both pure *P. nemaeus* and *P. nemaeus* × *P. cinerea* hybrids, based on the genetic analysis of several animals. These individuals were not characterized by morphology typical of red-shanked doucs, however, and the mixed genetic content is not proof of recent hybridization; further information is needed to confirm the taxonomic identity of this population. In Lao PDR, doucs have been confirmed from Nam Theun Extension proposed National Protected Area (NPA; 18°38'N) in the north to Nam Ghong Provincial Protected Area (PPA) on the Cambodian border (14°25'N) [Timmins & Duckworth, 1999]. Animals in most of this range are typical red-shanked doucs, with red leg-patches extensive and bright. In, and south of, Phou Ahyon (15°43'N 105°11'E), these patches become smaller and duller, so that in the far south, in Nam Ghong PPA, the few animals observed had only narrow red anklets, with most of the dark shank-patch blackish. Typical red-shanked animals were however observed in Houay Pen Production Forest Area (PFA), south of Phou Ahyon, in 2009 [RJT, personal observation]. Only a few animals have been observed closely in each Lao area where these populations are present, and the level of intrapopulation variation remains unknown. The available descriptions of animals from Phou Ahyon through Dong Ampham NPA and Nam Ghong PPA to north-east Cambodia are consistent with a gradual, perhaps clinal, dilution of brightness and extent of red in the shank patch, with decreasing latitude.

Animals of mixed phenotype are known to occur at these similar latitudes in the area of southeast Lao PDR, northeast Cambodia, and Vietnam [Nadler, 1997; Timmins & Duckworth, 1999; Minh Hoang et al., 2005; Nadler, 2008; Rawson & Roos, 2008; Lippold et al., 2011]. With the apparently complex situation and the paucity of detailed observations (particularly of many animals at one site), claims of hybridization and/or sympatry of two or more douc species need to be seen as provisional with further work needed.

Given the, at best, small range of *P. nemaeus* in Cambodia, and its dramatic population decline in Vietnam [Nadler et al., 2003], Lao PDR has by far the world's largest population and thus is most important for its conservation. Yet, it has received little attention, with only one published study on *P. nemaeus* ecology: in Hin Namno NPA [Phiapalath, 2009]. Timmins and Duckworth [1999] reviewed *P. nemaeus* distribution in Lao PDR and highlighted threats (mainly hunting, predicted to intensify strongly with increase in accessibility to the species' habitat) compromising the species' future viability in many areas throughout the entire country. Numbers of *P. nemaeus* in Lao PDR are unknown but the Nam Kading basin ("Nam Theun basin" in Timmins and

Duckworth [1999]) was once considered to harbor the largest contiguous Lao population [Timmins & Duckworth, 1999].

Lao PDR was one of the least explored countries in the world, biologically, until the 1990s when many wildlife surveys were conducted [reviewed in Duckworth et al., 1999; Duckworth, 2008]. Few analyses have focused on Lao nonhuman primates [since 1999: Johnson et al., 2004, 2005; Geissmann, 2007; Duckworth, 2008; Brown, 2009; Phiapalath & Suwanwaree, 2010; Duckworth et al., 2010a; Steinmetz et al. 2011; Timmins et al., in press a, b; Boonratana et al. in press; Timmins & Duckworth, in press]. Thus, much remains to be clarified concerning their distribution and taxonomy, especially among colobines and gibbons (*Nomascus* and *Hylobates*). Primates in Lao PDR, particularly colobines and gibbons, are highly threatened by hunting, which has already extirpated them locally [Duckworth et al. 1999; Timmins & Duckworth 1999; Johnson et al., 2004; Duckworth 2008; Brown, 2009; Duckworth et al., 2010a; Boonratana et al. in press; Timmins et al. in press a, b]. Rapid infrastructure development in Lao PDR is easing access to many of the most remote natural habitats, thereby stimulating unsustainable exploitation and additional threats to the survival of *P. nemaeus*.

Given its globally threatened status, its restricted global range, and paucity of resources available, the best strategy to conserve *P. nemaeus* in Lao PDR is to focus conservation attention on priority populations, maximizing chances of their survival. Rapid changes in Lao PDR since 1999 means that conclusions of Timmins and Duckworth [1999] may not remain relevant. We present here an update of red-shanked douc distribution in Lao PDR, and discuss its conservation status.

METHODS

We reviewed reports of mammal surveys conducted in Lao PDR subsequent to Timmins and Duckworth [1999], that is, from 1999 to early 2012. Most of these reports are internal to nongovernmental organizations, governmental bodies, and commercial companies and not easily available to the scientific community. Their wildlife information varies greatly in credibility, so statements concerning doucs were viewed in the context of the overall content reliability. Following the principles in Duckworth [2008, p 29–32], records were rejected (and not repeated here) where triangulation exposed errors, or where in the report claims of any species presence significantly extended its contemporary known range and were listed without contextual comment or where there were multiple errors (such as incorrect matching of scientific and common names) indicating a careless approach to detail. Most documents without these flaws involved at least one of the authors of this article and/or their close colleagues. The use of

interview data is a great challenge in Lao PDR [e.g. Timmins et al in press a, b], and many reviewed literature sources paid inadequate critical attention to inherent problems using this information. Interview-only claims of doucs were assessed particularly carefully.

No data from the review period exist for many survey areas in Timmins and Duckworth [1999]. The small list of sites with 1999 to early 2012 information reflects general paucity of wildlife surveys in Lao PDR after 1999, when conservation projects increasingly changed from documenting the situation to trying to change it. Permission to undertake the surveys included in this review was obtained from various bodies appropriate to the individual surveys, mostly from the Department of Forestry of the Ministry of Agriculture and Forestry of the Lao PDR. This body has responsibility for the management of NPAs and oversight of national wildlife laws.

Field surveys reviewed lasted from a week (occasionally less) to a few months of direct observation. Village interviews were diverse in length, depth and purpose, as well as credibility. Surveys and interviews were conducted near and in NPAs, PPAs, PFAs, or other wildlife habitat under development project influence. Most surveys had few or no direct douc records, allowing only the coarsest extrapolated status assessment to the management unit. No survey covered a whole management unit, and heavy hunting has reduced monkey population densities almost everywhere, and made animals evasive. Therefore a lack of douc records does not necessarily indicate absence from the management unit in question. In the Lao language, *P. nemaus* is known as “*khadeng*” (literally, “red leg”), apparently universally throughout Lao-speaking communities. This name is documented for no other species; Deuve’s [1972] assignment of *ling khadeng* to the bear macaque (*Macaca arctoides*) was surely in error [Duckworth et al., 2010a]. Given its diurnal behavior and distinctive appearance, village interview information could be expected to be more reliable than for most other mammal species. Surprisingly, however, errors do occur (see below). The following original Lao words appear commonly in location names: *Ban* = Village; *Dong* = forest, *Houay* = stream; *Nam* = River, *Phou* = Mountain, *Xe* = River.

Research adhered to the American Society of Primatologist’s principles for the ethical treatment of primates and the laws of the country in which the research was conducted (Lao PDR).

RESULTS

Since 1999, *P. nemaus* has been confirmed in five areas and reported in ten more (Table I; Fig. 1). The lack of on-going survey directly north and northwest of its known range (as given in Timmins & Duckworth [1999]) means that the species’ exact northern limit remains unknown. Altitude was not

specified for all post-1999 records (Appendix I); but no records were known to fall outside the known Lao range of 200–1,600 m a.s.l. [Timmins & Duckworth 1999]. Limited survey above 1,600 m means that the true upper limit of occurrence remains unknown.

Area Accounts

Records and reports are compiled in Table I and precise date, coordinates, and altitudes of sightings are, where known, given in Appendix I.

Areas Where *P. nemaus* Was Confirmed during 1999 to Early 2012

Confirmed records are sightings by wildlife surveyors; reported information is also included here for sites with such records. Photographic documentation from rural development or large infrastructure projects, would also have been included here, but none was traced.

Nakai–Nam Theun NPA

From January 2001 to February 2003, some NPA staff were trained for monthly biodiversity monitoring in three zones of the NPA within Nakai district. A total of 67 sightings of doucs was made in Navang zone, 149 in Thapaiban zone, and 85 in Teung zone; field effort per zone was between 76 and 111 days [Boonratana, 2001, 2002, 2003]. Johnson and Johnston [2007] documented surveys in 2006–2007 along 78 forest transects (totalling 526 km discounting replication) in a 200-km² block within the Nam Chae zone, giving 152 detections of *P. nemaus*. A hunter was camera-trapped with a dead douc in Khamkeut district in May 2006. In 2007, adult doucs were camera-trapped on three occasions in the Nam Chae zone [WMPA, Unpublished data]. Transect walks in a 200-km² block within the Nam On zone in 2007–2008 generated 37 douc sightings along 72 transects, each approximately 1½ km and walked four times [WMPA, Unpublished data].

Three further records came from the Nakai plateau and its edge in 2009–2010 [RJT, personal observation] indicating regular but low-density occurrence in the hilly margins of the plateau. Timmins and Duckworth [1999] presented no records from the Nakai plateau, but consideration of pre-1999 survey patterns suggests that doucs were simply overlooked then; there is no reason to invoke any expansion of their range.

The most recent visits to this NPA (randomly selected: Ban Xeuk, Maka, Tong Xet, Nam Chae, Nam On, upper Nam Theun, Houay Tong, Tongkacheng, and upper Nam Mon; cf. Fig. 2) confirmed the presence of the species [Coudrat, unpublished data]. Three sightings were made in Nam Chae (two–three groups), two at Ban Xeuk site (one group), two at Maka site (one–two groups), seven at Tong Xet site

TABLE I. Sites Visited from 1999 to Early 2012

Areas (and provinces) ^a	Site no.	Dates of field work	References
Areas where <i>P. nemaeus</i> was confirmed			
Nakai–Nam Theun NPA and Nakai plateau (Khammouan)	4	March 2001–February 2003; December 2006–June 2007; 2006–2007; October 2009 (18 days); January–February (13 days), and August 2010 (13 days); January (14 days), February–March (30 days), May–June (21 days), July (13 days), and October 2011 (16 days); January 2012 (10 days); February 2012 (18 days); March–April 2012 (21 days)	Boonratana [2001, 2002, 2003]; Johnson and Johnston [2007]; Dersu [2008]; RJT personal observation; Coudrat [unpublished data]
Him Namno NPA (Khammouan)	7	March 2007–June 2008	Phiapalath [2009]
Laving–Laveun PPA, Vilabouli district (Savannakhet)	10	June–July (~20 days) 2009	Duckworth et al. [2010b]
Houay Pen PFA (Xekong)	25	May–June (20 days) 2009	Timmins [2009]
Dong Phou Vieng	13	7–9 April 2012	Eames [unpublished data]
Xe Sap NPA	17	16 May–3 June 2012	Timmins RJ pers. data
Areas where <i>P. nemaeus</i> was reported from village interviews			
Nam Kading NPA (Bolikhambxai)	1	January–February (~26 days) 2005	Timmins and Robichaud [1999]
Dong Phouxoy PFA (Khammouan)	5	June 2002; April–July (15 days) 2005	Robichaud et al. [2002]; Poulsen et al. [2005]
Nongkapat PFA (Khammouan)	6	April (3 days) 2005	Poulsen et al. [2005]
Central Muang Vilabouli (Savannakhet)	9	November–December (~30 days) 2008	Duckworth et al. [submitted].
Dong Kapho PFA (Savannakhet)	11	March–July (13 days) 2005	Poulsen et al. [2005]
Dong Sithouan PFA (Savannakhet)	12	January (16 days) 2000; March (3 days) 2005	Boonratana [2000]; Poulsen et al. [2005]
Phou Talava PFA (Salavan)	16	June 2002; March–June (13 days) 2005	Robichaud et al. [2002]; Poulsen et al. [2005]
Xe Sap NPA (Salavan)	17	February–April (~40 days) 1999	Steinmetz et al., 1999
Dong Hua Sao NPA (Champasak and Attapu)	18	March–July (4 days) 2005	Poulsen et al. [2005]
Nam Pa PFA (Attapu)	24	February 2010 (8 days)	Suford [in press]

^aAreas surveyed but without credible records or reports of doucs are omitted.

(two–five groups), 15 in the Nam On zone (three–five groups), five in upper Nam Theun (three groups), 16 in Houay Tong (three–five groups), 10 in Tongkagheng (one–two groups), and 16 in Upper Nam Mon (two–three groups). A douc dead in a snare was seen in Teung zone (Phou Vang) in March 2011 [Robichaud WG, personal communication, 2011] and a douc skin was found in Nam Chae zone in January 2012 [Coudrat, unpublished data].

Douc groups were sighted twice in primary hill forest above the Nam Gnala river in 2007 in the NNT-Phou Hinpoun NPAs corridor [Dersu, 2008]. Specific areas mentioned above are represented in Figure 2.

Him Namno NPA

From January to December 2007, 142.8 km walked along 25 transects in the northern and central NPA gave almost daily douc sightings [Phi-

apalath P, personal communication, 2011]. From March 2007 to June 2008, groups (of 17 and 39 individuals) were assessed to have home range of about 3 km² [Phiapalath, 2009]. Informants from eight villages reported 495 hunted doucs (many probably for cross-border trade with Vietnam) between March 2007 and February 2008 [Phiapalath, 2009]. This is certainly only a small proportion of douc offtake from the entire NPA during that period.

Laving–Laveun PPA

Five sightings, involving several groups, of two to ~15 individuals (probably not complete group counts) were made during June–July 2009 [Duckworth et al., 2010]. Also, a snared adult was seen in the adjacent village of Ban Klay and one villager claimed to snare the species with some regularity. The local population of *P. nemaeus* remains healthy. This may be due to the fact that projectile-hunting

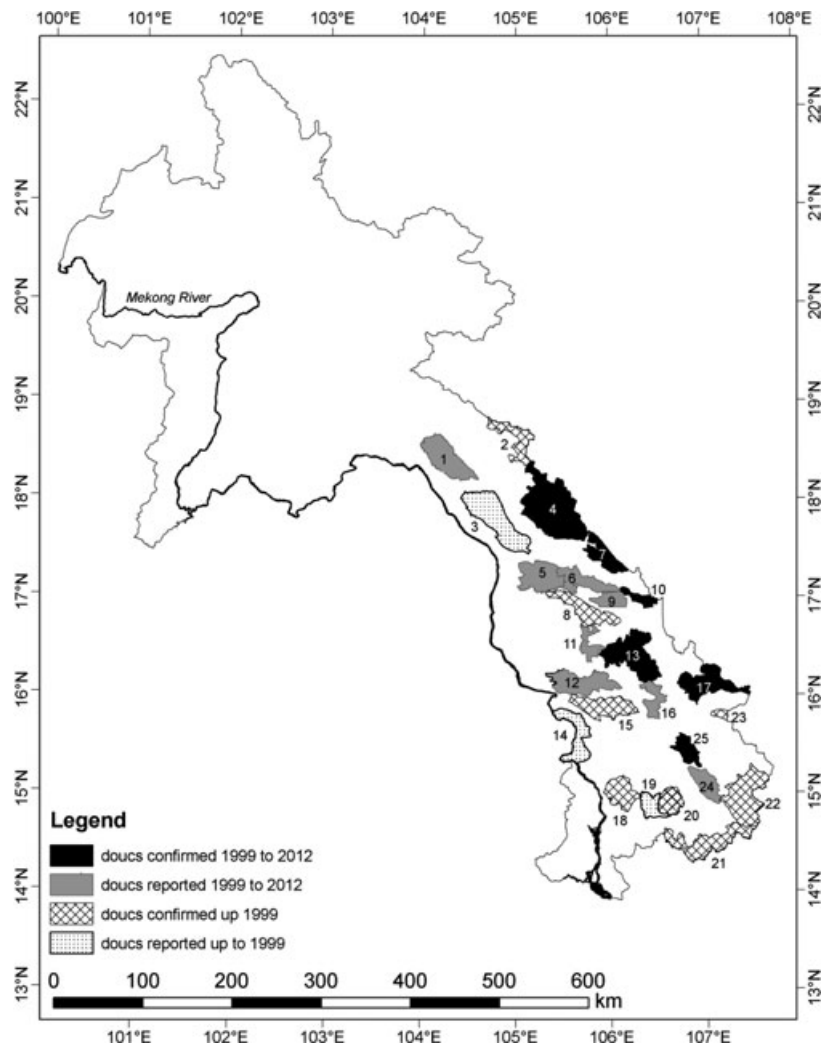


Fig. 1. Distribution of red-shanked douc records in Lao PDR up to early 2012. Note: areas represent management area boundaries, not the potential extent of doucs in each. Pre-1999 information status is not shown for areas with 1999 to early 2012 confirmation and reports. The white area on the map within the overall geographic range of red-shanked douc should not be taken as lacking the species; most of it has not been surveyed. Areas: 1: Nam Kading NPA; 2: Nam Theun Extension pNPA; 3: Phou Hinpoun NPA; 4: Nakai–Nam Theun NPA; 5: Dong Phouxy PFA; 6: Nongkapat PFA; 7: Hin Namno NPA; 8: Phou Xang He NPA; 9: Central Muang Vilabouli; 10: Laving–Laveun PPA; 11: Dong Khapo PFA; 12: Dong Sithouan PFA; 13: Dong Phou Vieng NPA; 14: Phou Xiang Thong NPA; 15: Xe Bang-Nouan NPA; 16: Phou Talava PFA; 17: Xe Sap NPA; 18: Dong Hua Sao NPA; 19: Bolaven Southwest pNPA; 20: Xe Namnoy catchment; 21: Nam Ghong PPA; 22: Dong Ampham NPA; 23: Phou Ahyon; 24: Nam Pa PFA; 25: Houay Pen PFA.

pressure on arboreal mammals seems low given that animals did not flee far when encountering people [Duckworth et al., 2010b].

Houay Pen PFA

Two groups were observed in May 2009 on the Phou Theung plateau, the only suitable part of the PFA for doucs surveyed [Timmins, 2009]. Credible reports from villagers in 2006 and 2009 indicated the species to be locally present on the plateau [Poulsen et al., 2006; Timmins, 2009]. The species has been effectively hunted out from a significant proportion of this isolated plateau [Timmins, 2009; personal observation].

Dong Phou Vieng NPA

Three red-shanked doucs were seen on April 8, 2012 in the semievergreen (amid deciduous) 180-ha

Dong Sakee Sacred Forest (located N 16°23'34.0' E 106°03'28.6') during a 3-day visit [Eames, unpublished data]. The NPA is being illegally logged and villagers from Ban Vongsikeo reported that Vietnamese regularly visit the area's villages to request monkey bones [Coudrat, 2011a,b; Eames, unpublished data]. The species had only been confirmed before in 1997 on a remote part of Phou Lapeung [Steinmetz, 1998].

Xe Sap NPA

The species was encountered on four occasions during a 3-week survey of the western third of the NPA in May–June 2012 by one of the authors (Timmins RJ). The encounter rate was relatively low given the size and remoteness of the survey area, in the light of the surveyor's prior experience. Densities

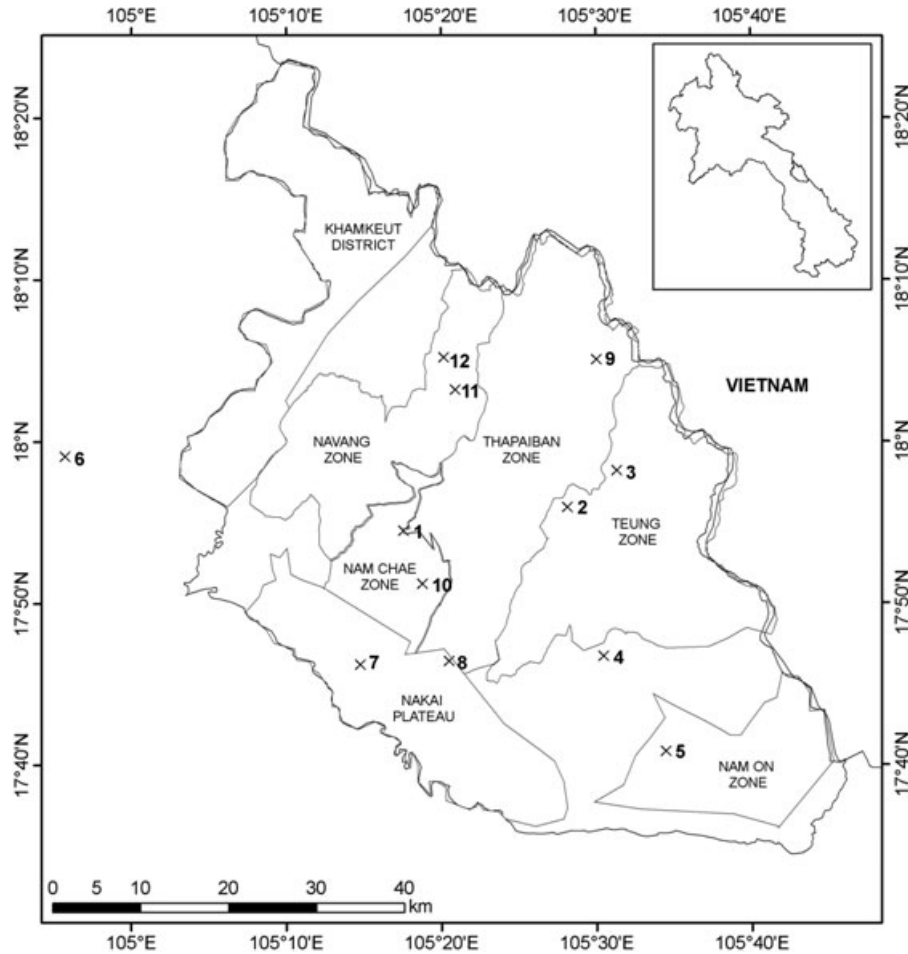


Fig. 2. Nakai-Nam Theun NPA with management zones and spot localities where doucs were recorded during 1999 to early 2012 (cf. Appendix I). Sites: 1: Nam Chae; 2: Ban Xeuk; 3: Maka; 4: Tong Xet; 5: Nam On; 6: above Nam Gnala (NNT-PHP Corridor); 7: Nakai Plateau; 8: Dividing hills; 9: upper Nam Theun; 10: Houay Tong 11: Tongkacheng; 12: upper Nam Mon. Note: Only management zones with douc records during the review period are named.

however may in part be relatively low due to habitat characteristics. Much of western Xe Sap NPA being a mosaic of an often relatively stunted forest type with a high conifer content, characterized by a pine *Pinus* cf. *P. dalatensis*, and tall broadleaf forest. All douc encounters were in tall broadleaf forest patches. However, years of hunting also appear to have left many large mammal and other quarry species populations depressed (as accords with the interview findings of Steinmetz et al. 1999, see below), even though at present gun hunting appears to be relatively minor, as suggested by the general behavioral response to human observer presence; two of the groups either failed to detect the observer, or showed no visible response. Individuals in two of the groups that were seen reasonably well were typical *P. nemaeus* (s.s.) on the basis of pelage characteristics.

Doucs were also reported in all 15 villages visited in 1999 [Steinmetz et al., 1999]. Some villages reported them along the Xe Kong, south of the NPA and in Phou Ma Nai within the NPA. Villagers from

south and north of the NPA reported strong declines, attributing them, in part, to their own subsistence hunting but mostly to hunting by Vietnamese crossing the border. Groups of up to 40 individuals were reported to be typical [Steinmetz et al., 1999].

Areas Where *P. nemaeus* Was Reported during 1999 to Early 2012

Reports are from interviews of villagers living alongside or within the areas.

Nam Kading NPA

In 2005, villagers reported doucs as persisting in the Sayphou Phapet sector (in the southwest of the NPA), but not in the other sectors of the NPA, consistent with previous information [Timmins and Robichaud, 1999]. Timmins and Robichaud [1999] noted that since their 1995 visit to the area, armed hunters (Hmong and Vietnamese) were more commonly encountered. Hunters stated that they

increasingly came into Nam Kading NPA as the more accessible areas were already depleted of prey species [Timmins and Robichaud, 1999]. The Nam Kading seems to represent the northern limit of the species in this NPA [Timmins & Robichaud, 1999]. Doucs were already assessed to be scarce in the NPA, and the only confirmation of occurrence remains a single hunted specimen, photographed [Timmins & Duckworth, 1999; Duckworth et al., 1999].

Central Muang Vilabouli, Savannakhet province

Pygathrix nemaeus was reported in the remaining forests in this largely encroached area (west of Laving–Laveun PPA), but the population is at best localized. Most of the area is zoned for economic development (notably with road construction) and this douc population is probably not practicably conservable [Duckworth et al., submitted].

Dong Hua Sao NPA

In 2005, 32 villages from Pathoumphon PFA reported douc presence, mostly just north of the PFA, in Dong Hua Sao NPA [Poulsen et al., 2005]. The species was confirmed in this NPA in 1993 [Timmins & Duckworth 1999].

Nongkaphat PFA

One of two village interviews reported doucs as still present in the area [Poulsen et al., 2005].

Dong Sithouan PFA

In 2000, all 20 villages interviewed reported doucs as present [Boonratana, 2000]. In 2005, two villages interviewed reported doucs [Poulsen et al., 2005].

Dong Phouxoy PFA

In 2002, three villages in the southeast of the area and one in the northwest of the area were visited. Villagers reported that doucs had occurred 10–20 years previously but were now largely gone. Only Ban Nakhamchouang-Tai, in the east, indicated that doucs still occurred northeast of the village boundary [Robichaud et al., 2002]. In 2005, 46% of 56 village interviews reported the species as still present in the PFA, and 32% of the interviews reported it as extinct; a distribution map depicts douc presence as reported by villagers in the south, west, and north of the area [Poulsen et al., 2005]. The 2002 and 2005 studies' provide results that are incompatible (see further discussion below).

Dong Kapho PFA

Of 22 village interviews in 2005, 27% reported the species as gone while 55% reported it as persisting [Poulsen et al., 2005].

Phou Talava PFA

Doucs were reported by villagers as still present in 2002 [Robichaud et al., 2002]. Consistent with this were the 20 village interviews conducted in 2005 with 85% reporting doucs present [Poulsen et al., 2005].

Nam Pa PFA

In 2010, doucs were reported as still common in remote evergreen interior of the PFA but a new road built here will increase illegal hunting of the species [Suford, in press].

Areas Where *P. nemaeus* Was Reported during the 1990s but No Subsequent Information was Traced

Areas where *P. nemaeus* was confirmed or reported by Timmins and Duckworth [1999] but with no post-1999 data are presented in Table II and Figure 1.

DISCUSSION

Recent taxonomies [e.g. Groves, 2005] indicate that Lao PDR has at least 15 species of primates, of which 13 are threatened with extinction [IUCN, 2011] including the endangered red-shanked douc. In Lao PDR, doucs occur from Nam Ghong PPA on the southern border north to the central-north of the country, and are restricted to east of the Mekong. This river is a geographical marker for the distribution of several other primate species [Meijaard and Groves 2006], but the river itself may not act as a barrier for doucs because of their apparent absence from much of the area to its east, the Mekong plain and the adjacent low hills of Lao PDR [e.g. Xe Pian NPA; Timmins & Duckworth, 1999]. Climatic features probably limit their western range, as they presumably do for their northern range. The precise northern limit of *P. nemaeus* in Lao PDR east of Nam Kading NPA is unknown, falling either in the latitude of the Nam Theun Extension pNPA or the contiguous Nam Chouan pNPA to its north, and areas west of these. The southern limit of *P. nemaeus* (sensu stricto) in Lao PDR also remains unknown, given the evident dilution in pelage characters that distinguish it from congeners in the southern part of the country. It seems unlikely that there is a hard boundary between red-shanked doucs and other douc species.

Lao records come mostly from evergreen and semievergreen forest, and from the lower foothills into the montane zone. The upper altitudinal limit remains unclear. Two Nakai plateau records came from a habitat not previously recorded as used in Lao, pine (*Pinus*) dominated semievergreen forest. On October 10, 2009, at least four animals were seen in a broad-leaf patch within a mosaic of open and

TABLE II. Areas Where *P. nemaeus* Was Confirmed or Reported Up To 1999 and for Which Updated Surveys Were not Available. After Timmins and Duckworth [1999]

		Site no	Details
Areas where <i>P. nemaeus</i> was confirmed up to 1999	Nam Theun Extension proposed NPA	2	Sighted ("groups")
	Phou Xang He NPA	8	Sighted (2 groups)
	Xe Bang-Nouan NPA	15	Sighted (4-5 groups)
	Phou Ahyon	23	Sighted ^a (1 group)
	Xe Namnoy drainage basin (Bolaven Plateau)	20	Sighted ^a (1 individual); and 1 captive youngster [Timmins et al., in press a]
	Dong Ampham NPA	22	Sighted ^a ("uncommon")
	Nam Ghong PPA	21	Sighted ^a (1 group)
Areas where <i>P. nemaeus</i> was reported up to 1999	Phou Hinpoun NPA (formerly: Khammouan Limestone)	3	May only be distributed locally—mostly not suitable habitat
	Phou Xiang Thong NPA	14	May only be distributed locally—mostly not suitable habitat
	Bolaven Southwest proposed NPA	19	May only be distributed locally—mostly not suitable habitat

^aSightings were treated as *P. nemaeus* by Timmins and Duckworth [1999] who considered all doucs conspecific. If (as here) *P. nigripes* and *P. cinerea* are considered distinct species, these sightings should be considered as of *Pygathrix* sp.

closed pine forest. On February 2, 2010, five–six animals were seen in a mosaic of dense broad-leaf and more open tall pine forest, with at one point at least three of the animals sitting in the crown of a pine tree.

Although *P. nemaeus* is among the most morphologically distinctive Lao mammals, village reports need be viewed with caution. At the national scale, reconnaissance interviews during 1988–1992 proved a good predictor of the confirmed distribution of *P. nemaeus* [Timmins & Duckworth, 1999]. But on a more local scale, few areas have had field surveys to allow comparison with interview results, or multiple independent interview surveys to check for consistency. In one case, these show a good fit, from Nam Kading NPA in 1994–1995 and 2005 (see site account, above). But in other cases (e.g. Dong Phouxy PFA; see site account, above), there were major inconsistencies in the reports such that nothing more precise could be concluded other than that doucs probably occur somewhere in the general area, or at least did so until recently. Interviews may result in misleading information for many reasons [e.g. Baird 2007] and therefore can only provisionally indicate the presence (let alone precise distribution) of doucs in those areas.

Conservation Status of *P. nemaeus* in Lao PDR

Within its Lao distribution, *P. nemaeus* evidently still occurs widely. This is based on the fact that no competent survey of extensive suitable habitat within the doucs known range failed to contain the species. However, this should not lead to complacency. In the past 20 years, Lao PDR has realized several large-scale development projects

[Singh, 2008], including hydroelectric dams and large mining projects. With about 70% of Lao people relying on natural resources for their livelihood and on wildlife as a protein resource [Krahn & Johnson, 2007; UNDP, 2010], such projects, which may involve movement of villagers into areas with lower agricultural potential [McNeely, 1987], increase the risk of overhunting. In formerly remote areas, the overexploitation of wildlife, exacerbated by a lack of resources to control hunting, is a major problem [e.g. Dersu, 2008; McDowell et al. 2009, 2010].

Given the limited data on doucs in Lao PDR since 1999, conclusions regarding the conservation status are tentative. "Proxies," such as status trends in similar species especially gibbons [Duckworth, 2008], waves of increasing natural resource extraction, including illegal hunting [e.g. Johnson & Johnston, 2007; Krahn & Johnson, 2007; Robichaud et al., 2009], the dispersed, rural, nature of the human population (about 10% of the country's villages lie inside NPAs [Southammakot, 1999, cited in Chape, 2001]), and a much improved road network, all suggest that severe declines in primate populations are likely to occur in many areas. The most serious threat appears to be overhunting, for both in-village consumption and, at least in some areas, for outside trade. This statement is based on the rarity with which monkeys and apes are encountered even in the interior of large blocks of suitable habitat (mostly well below daily encounters; although most surveys presented here and in the 1990s did not focus on monkeys and apes, thereby surely reducing sighting rates), compared with those few areas surveyed in the 1990s before trade-driven hunting had penetrated the interior [e.g. parts of interior Nakai-Nam Theun NPA; Duckworth, 1998]. Moreover,

encounter rates with *P. nemaesus* are low compared with general encounter rates of monkeys and apes in various well-protected forest areas elsewhere in Southeast Asia. Within NPAs, commercial wildlife extraction is prohibited but local villagers may take some species for subsistence use [National Assembly Lao PDR, 2007]. Doucs are classified under the *Prohibition* category of the Lao hunting regulation, which groups species “rare, near extinct, high value and are of special importance in the development of social-economic, environmental, educational, scientific research” [National Assembly Lao PDR, 2007: Article 11; p 4]. Species in this category should be “managed, inspected, preserved” [National Assembly Lao PDR, 2007: Article 11; p 4], and their hunting is not permitted. However, this has had little effect in most rural areas. Davidson et al. [1997] reported that *P. nemaesus* was intensively hunted in Dong Ampham NPA with approximately 50 doucs killed per year according to local hunters (geographic area not specified, but certainly not the total for the whole NPA). Recent figures for Hin Namno NPA (again for only a part of the NPA) are even higher (see above). In sum, the species must have been reduced to very low densities, even to local extinction, in some forest areas in Lao PDR. This is especially true in smaller and/or more fragmented and/or easily reached habitat blocks. These descriptions increasingly typify forest areas in the country and this trend is likely to continue if no action is taken.

Recent records of snared doucs in Laving-Laveun PPA and Nakai-Nam Theun NPA (see above), and (in March 2011) in Thua Thien-Hue Nature Reserve, Vietnam (contiguous with Xe Sap in Lao PDR) [Robichaud WG, personal communication], raise the possibility that snares might represent important threats to doucs in Lao PDR. In addition, snares set in trees targeting arboreal animals including primates are already common in Vietnam [Vu Ngoc Thanh, personal communication]. For example, villagers near Chu Mom Ray NP reported using tree snares to catch doucs and gibbons. One villager claimed he had caught seven doucs with this technique in the year 2007 [Lippold et al., 2011]. This practice is likely to become widely used in Lao PDR, given the extent to which Vietnamese nationals are involved in wildlife trade, as buyers, transporters, and in some cases as actual hunters [e.g. Nooren & Claridge 2001]. Most doucs hunted are, however, still obtained with guns. Despite governmental gun-collection programs in much of Lao PDR since the mid-1990s, villagers can still easily and inexpensively make guns or adapt existing guns for use [Robichaud et al., 2001; Hansel, 2004]. Shots were heard during visits in Nakai-Nam Theun NPA [Coudrat, unpublished data], as is still typical in many remote forested areas of Lao PDR today. In addition, *P. nemaesus* exhibits a behavioral pattern of initially hid-

ing in trees in the presence of people prior to fleeing [Coudrat, personal observation; Phiapalath, 2009], making it an easy target for hunters using guns.

That dead doucs are heavily traded in Vietnam [Tran Thu Hang, 2010] suggests that in Lao villages hunting doucs for trade with Vietnam may be or become a lucrative activity. This has been assessed at too few sites for authoritative comment. However in March 2001, the density of (ground-level) snares in Nakai-Nam Theun NPA was found to be higher as one approached to the Vietnam border [Coudrat, unpublished data]. This same pattern was commonly found in Lao PDR due to a lucrative trade with Vietnam and then China [e.g. Hardcastle et al., 2004; Robichaud, 2005]. *Pygathrix nemaesus* is hunted for its meat, which has been reported as a favorite food in Dong Ampham NPA [Davidson et al., 1997]. It also is sought after for medicinal use, and (probably at only insignificant levels) for the pet trade [Nooren & Claridge, 2001]. The species often has been reported in the Lao wildlife trade (mostly in areas bordering Vietnam or Thailand) [Compton et al., 1999; Nooren & Claridge, 2001]. Most of the Lao wildlife trade is driven by outside demand from Vietnam, Thailand, and China [Srikosamatara et al., 1992; Compton et al., 1999; Nooren & Claridge, 2001; Phantavong et al., 2003]. In central-eastern Lao PDR, at the Lao-Vietnamese border, Vietnamese hunters and traders have been encountered for over two decades and pose the greatest threat to marketed wildlife species [Tobias et al., 1998; Robichaud & Stuart 1999; Robichaud et al., 2009]. Because much optimal douc range and surviving habitat in Lao PDR is in the eastern half of the country, it is at particular risk of Vietnamese-driven hunting, and this is likely to increase as more favored species (e.g. otters [Lutriane], turtles [Chelonia], pangolins [*Manis*], tiger [*Panthera tigris*]) are reduced to negligible densities over most of the country. Specifically, Nakai-Nam Theun NPA and Hin Namno NPA have the largest red-shanked douc population, both have a long border with Vietnam and both are heavily impacted by Vietnamese hunters. Both Vietnamese and local villagers hunt in these areas: the Lao villagers hunt either for local consumption or for trade with the Vietnamese in exchange for various day-to-day goods [Phiapalath, 2009; Johnston, 2011; Coudrat, unpublished data].

Global Importance of the Lao Population

The Lao population of *P. nemaesus* evidently remains the largest in the world. Lao PDR contains most of remaining habitat for red-shanked doucs, and (albeit based on fewer surveys than desirable) the species survives, although at generally low densities, across at least most of its Lao range. The great decline in Vietnamese red-shanked doucs and the preliminary taxonomic status of Cambodian animals

gives the Lao population the strongest, most diverse options for conserving the genetic and ecological diversity of red-shanked doucs. In the absence of intervention, steep declines in *P. nemaeus* population size are likely to intensify. In Vietnam, widespread deforestation and the increased use of wildlife for diverse purposes leave few refuges for the species, and the increasingly isolated populations remain highly threatened by illegal hunting and deforestation. Since the last overview of *P. nemaeus* distribution in Vietnam in 2002 [Nadler et al., 2003], no additional sites holding *P. nemaeus* have been discovered [Nadler, 2010]. The largest known population in Vietnam is in Phong Nha–Ke Bang NP, contiguous with Hin Namno NPA. A recent survey found the species is still abundant there (although the quantification of 445–2,187 individuals is based on extrapolation from only 13 encounters, from nonrandom survey trails, clustered in one small part of the area for which the population was extrapolated) [Haus et al., 2009]. Another survey encountered at least 10 groups (130–168 individuals) in nonlimestone Ubo forest and buffer zones (~7,700 ha) within this NP [Le Trong Dat et al., 2009]. The park is mostly impenetrable karst habitat, which is highly atypical of Vietnamese sites maintaining (or formerly holding) this species. The other populations considered large for the country are found in Son Tra NP (~200 individuals) and Bach Ma NP (~30 individuals) [Nadler, 2010]. There is no recent evidence of red-shanked doucs in other areas in Vietnam, where they were recorded from the mid 1990s to 2002. They may have been extirpated from Pu Mat NP, and have highly decreased in Vu Quang NP [Nadler et al., 2003]. Although not focusing on doucs, gibbon surveys in Pu Mat NP's core area in 2007 [Ruppell, 2008] and 2011 [Luu Tuong Bach & Rawson, 2011] found none. The last confirmed douc in Pu Mat NP was in 2004, when one was seen in one of six study areas surveyed for diurnal primates [Grieser Johns et al., 2004]. The most recent survey of diurnal primates in Quang Nam Province, central Vietnam, confirmed *P. nemaeus* in only two communes (in Dong Giang and Nam Giang districts) of the 28 visited, and the authors expressed their "doubts on the viability of some areas for douc conservation" [Minh Hoang et al., 2005; p 22]. Thus, presently, while there is little evidence for such eradications in Lao PDR (itself probably a function of the propensity for wildlife surveys to focus on the best available areas, and to spend too little time in heavily encroached areas to determine what is absent, rather than a true indication of a genuine lack of such eradications), there is in Vietnam. Hunting is the major threat to primates in Vietnam [Nadler et al., 2003]. In 2007, 44 hunted *P. nigripes* destined for medicinal use were confiscated. Similar events occurred several times in 2009 [BirdLife International, 2010], and 25 *P. cinerea* were hunted with guns or snares in 2010 in Quang Ngai Province

[Nguyen Thanh Tuan et al., 2010]. These numbers (certainly underestimates) show the dramatic situation of doucs in Lao PDR's neighboring country. The factors responsible for this situation in Vietnam exist in Lao PDR but at a lower level, as least for now. With increased human density and high dispersion, increased human access to forests with development projects, increasingly lucrative national and international trade, and the paucity of effective management and law enforcement capabilities, the situation for doucs is only likely to become worse. Thus, present-day Vietnam predicts the future of doucs in Lao PDR if wildlife management is not improved. Some douc populations in Lao PDR seem viable only if hunting is effectively controlled, such as in Houay Pen PFA [Timmins, 2009], and this assessment probably applies to all Lao forest within single-day access from villages, roads (including motor-cycle trails), or navigable bodies of water.

Identification and Current Status of Priority Areas

Despite the uneven direct information on douc status across Lao PDR, some areas can be identified as conservation priorities based on area size and, particularly, the extent of habitat more than half a day's walk from vehicular access. Resources being inadequate to conserve all populations, the best conservation strategy for *P. nemaeus* in Lao PDR is to prioritize populations to receive the available resources, and only when these populations are secured and protected, will it be prudent to expand to other populations. Survey of further areas is not a priority because many NPAs and PPAs with potentially conservable douc populations were found in the 1990s–2000s, yet none is effectively protected. Moreover, surveys have already been sufficiently widespread that there is no chance of finding larger or more remote areas of prime habitat within which doucs stand markedly higher unassisted chances of survival. Therefore, the priority needs to be effective field conservation of some populations (it may not particularly matter which ones), specifically the sustained suppression of illegal hunting in these areas over a time-scale well in excess of the typical conservation donor cycle [e.g. Leisher, 2001]. Factors affecting success are as much or more related to human activity, attitudes, and intentions as to the current status of douc populations. Timmins and Duckworth [1999] concluded that "inaccessibility" of remote forest areas was the best protection for *P. nemaeus* in Lao PDR but this is being eroded in all areas. Thus, we need immediate identification of where active conservation programs and policies stand the highest chances of success. The presence of villages within wildlife areas makes the control of illegal hunting even more challenging, as each acts as a base for hunting.

As for now, Nakai–Nam Theun and Hin Namno NPAs offer the best hopes for conservation of large populations in the short–mid term. This is because the former is by far the largest block of forest in Lao douc range, and the latter, although much smaller, is so rugged that much of it is difficult of access and is close to large douc populations in Vietnam (Phong Nha–Ke Bang NP) and Lao PDR (Nakai–Nam Theun NPA, to the north). The contiguous Nam Ghong PPA–Dong Ampham NPA–Nam Pa PFA landscape probably retains at least a fairly large population of doucs and, given the phenotypic variability of the population, may be characterized by relatively high genetic diversity. Xe Sap NPA must still hold one of the largest populations of *P. nemaesus* in Lao PDR, likely ranking third to NNT and HNN. Although it is perhaps not as large as previously hoped, it must surely number thousands rather than hundreds of animals given that doucs were found widely over the surveyed area of western Xe Sap NPA with no indication of absence from significant portions of the area, suggestive of a very large area of potentially occupied habitat. Further strengthened by the even larger area of habitat not explored, especially in the central and eastern portions where tall broadleaf forest probably predominates and is as or more remote from likely sources of hunting pressure.

These areas correspond to those prioritized by Timmins and Duckworth [1999], but the conservation status of each has deteriorated over time. Lao PDR's largest hydroelectric dam, Nam Theun 2, recently constructed beside Nakai–Nam Theun NPA, has fuelled massive increases in wildlife removal from the NPA due to the expansion of the road network resulting in more trading opportunities. In addition, the flooding of rapids that formerly hindered upstream access into the NPA's hills has led to increased hunting opportunities and more efficient removal to markets. Although the NPA has received funds for wildlife conservation, through the Nam Theun 2 project, control of illegal activities is proving a great challenge [Johnston, 2010, McDowell et al., 2010]. In Hin Namno NPA, the limestone habitat hampers entry, but the more accessible sites are heavily illegally hunted [Phiapalath, 2009]. Since 2006, Hin Namno NPA receives no external financial support [Phiapalath, 2009] and there is no effective management in the NPA. However, international assistance is due shortly to resume. Management of Xe Sap NPA is currently being supported by a large 3-year grant administered by a collaboration between GoL and WWF Greater Mekong Programme. But many challenges still remain, and the future funding of management activities is far from certain. At the same time, road infrastructure in and around Xe Sap NPA is being upgraded at a rapid pace, and trade in natural resources with Vietnam is showing signs of dramatic increase. Furthermore, the area also appears to be rich in minerals especially gold, and has

many potential opportunities for hydropower development, with two projects already underway within the immediately adjacent Xe Kong catchment, suggesting a future replication of the changes in Nakai–Nam Theun NPA. The recent Nature Reserves contiguous with Xe Sap NPA created in Vietnam, in Quang Nam and Thua Tien Hue Provinces, to protect the Saola (*Pseudoryx nghetinhensis*), if effectively managed, are likely to benefit any *P. nemaesus* in the adjacent easternmost subsection of Xe Sap NPA, an area unvisited by wildlife surveyors, but presumed to still have doucs. Although two of the three contiguous areas in Nam Ghong PPA–Dong Ampham NPA–Nam Pa PFA are recognized as NPA or PPA, no significant conservation management current takes place. A new access road through interior of Nam Pa PFA will certainly increase illegal hunting in the area [Suford, in press]. The effects of the construction of the Xe Kaman 1 dam at the border of Dong Ampham NPA on wildlife hunting and trade, is likely to resemble those in Nakai–Nam Theun NPA, given that there are no active protection programs to counter them. Dong Ampham NPA was considered a “source area” for wildlife products by Nooren and Claridge [2001; p 202], and doucs were reportedly hunted at a high level even in 1997 [Davidson et al., 1997]. Dam construction is led by Vietnamese companies and personnel who may continue hunting the doucs, suggesting the possibility that doucs may only remain in the most remote parts of these areas. Thus, the security of douc populations in any of the four priority areas remains threatened.

General Recommendations for Priority Areas

From the mid 1980s to 2005, the Government of Sweden provided support to the Lao Department of Forestry to “Improve . . . productivity and sustainable use of forest and agricultural land in combination with conservation and protection of target areas” [NAFES, 2005; p 37]. However, this was insufficient to prevent major habitat loss. Although the following recommendations apply to most of the many threatened species in Lao PDR, and are not new to wildlife management in Lao PDR or elsewhere, the chances of survival of *P. nemaesus* populations of conservation priority will be enhanced by an (1) increasing trained and motivated management staff; (2) ensuring the primacy of biodiversity conservation in management aims and practices in areas where land has been declared to be protected areas (e.g. NPAs); (3) enforcing the laws against illegal wildlife collection and habitat conversion with application of relevant deterrents such as penalties; (4) increasing the number of patrols throughout the protected areas; (5) in the short term, designating priority management zones where a maximum of resources should be allocated (progressively expanding them as the cores are secured); (6) enforcing and maintaining careful

control at strategic trading points and routes; (7) discussing species conservation with local people. It also may be possible to educate the population to the globally unique features and conservation status of *P. nemaeus* and thereby elevate it as a flagship species [Timmins and Duckworth, 1999]. In addition, (8) a greater effort needs to be made to train national students from the universities of Lao PDR in conservation biology, in order to increase the number of conservationists in the country and the involvement of the universities in conservation. Finally, we urge (9) facilitation of internationally collaborative scientific research in Lao PDR, to aid the establishment of conservation plans and publications on Lao wildlife. This will serve to raise the awareness of the scientific community and to obtain funding for research and conservation project implementation. The three first recommendations are of particular importance for all the priority conservation areas identified and should be implemented immediately and strategically established in the long term. Precise needs at each site need to be determined during project formulation and start-up, and this must include the people who will undertake project execution and local residents. The past 15 years in Lao PDR have shown that remotely prepared management guidelines, no matter how technically sound, stand little chance of effective local implementation.

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APPENDIX I. Geographic coordinates available for some recent sightings of *P. nemaeus* in Lao PDR.

Area	Date	Coordinates	Altitude	Reference	
Nakai–Nam Theun NPA					
	Nam Chae	23 Jan 2011	17° 53' 42.342" N 105° 16' 11.325" E	722 m	Coudrat, unpublished data
		30 Jan 2011	17° 55' 46.076" N 105° 17' 48.969" E	814 m	Coudrat, unpublished data
	1 Feb 2011	17° 29' 19.129" N 105° 18' 43.059" E	938 m	Coudrat, unpublished data	
Ban Xeuk	20 Feb 2011	17° 56' 2.753" N 105° 27' 13.181" E	1063 m	Coudrat, unpublished data	
	28 Feb 2011	17° 55' 59.812" N 105° 27' 18.578" E	1043 m	Coudrat, unpublished data	
Maka	17 Mar 2011	17° 59' 8.006" N 105° 31' 14.460" E	1255 m	Coudrat, unpublished data	
	28 Mar 2011	17° 58' 16.989" N 105° 31' 13.290" E	770 m	Coudrat, unpublished data	
Tong Xet	23 July 2011	17° 47' 21.793" N 105° 31' 12.317" E	739 m	Coudrat, unpublished data	
	23 July 2011	17° 47' 53.272" N 105° 31' 26.782" E	807 m	Coudrat, unpublished data	
	24 July 2011	17° 47' 30.905" N 105° 30' 46.904" E	665 m	Coudrat, unpublished data	
	25 July 2011	17° 48' 4.831" N 105° 30' 56.945" E	718 m	Coudrat, unpublished data	
	26 July 2011	17° 46' 50.282" N 105° 30' 56.459" E	999 m	Coudrat, unpublished data	
	26 July 2011	17° 46' 21.540" N 105° 31' 20.158" E	916 m	Coudrat, unpublished data	
	28 July 2011	17° 46' 10.477" N 105° 30' 41.735" E	927 m	Coudrat, unpublished data	
	Upper Nam On	24 Oct 2011	17° 41' 28.752" N 105° 34' 33.319" E	761 m	Coudrat, unpublished data
	24 Oct 2011	17° 41' 57.347" N 105° 34' 11.863" E	943 m	Coudrat, unpublished data	
	24 Oct 2011	17° 41' 32.402" N 105° 34' 14.927" E	881 m	Coudrat, unpublished data	
	25 Oct 2011	17° 41' 26.110" N 105° 34' 30.216" E	750 m	Coudrat, unpublished data	

APPENDIX I. Continued.

Area	Date	Coordinates	Altitude	Reference
	26 Oct 2011	17° 41' 45.629" N 105° 33' 55.480" E	835 m	Coudrat, unpublished data
	26 Oct 2011	17° 41' 30.725" N 105° 34' 23.149" E	841 m	Coudrat, unpublished data
	31 Oct 2011	17° 40' 28.114" N 105° 34' 35.865" E	715 m	Coudrat, unpublished data
	31 Oct 2011	17° 40' 33.143" N 105° 34' 25.655" E	746 m	Coudrat, unpublished data
	1 Nov 2011	17° 41' 19.518" N 105° 33' 30.132" E	806 m	Coudrat, unpublished data
	1 Nov 2011	17° 41' 16.174" N 105° 33' 36.810" E	798 m	Coudrat, unpublished data
	1 Nov 2011	17° 41' 6.309" N 105° 33' 55.868" E	799 m	Coudrat, unpublished data
	3 Nov 2011	17° 41' 27.964" N 105° 33' 57.848" E	860 m	Coudrat, unpublished data
	3 Nov 2011	17° 41' 35.369" N 105° 33' 38.491" E	843 m	Coudrat, unpublished data
	3 Nov 2011	17° 41' 12.394" N 105° 33' 44.230" E	847 m	Coudrat, unpublished data
	3 Nov 2011	17° 41' 3.509" N 105° 33' 58.738" E	780 m	Coudrat, unpublished data
Upper Nam Theun	14 Jan 2012	18° 4' 15.981" N 105° 28' 23.527" E	1105 m	Coudrat, unpublished data
	14 Jan 2012	18° 4' 37.679" N 105° 28' 25.496" E	1155 m	Coudrat, unpublished data
	17 Jan 2012	18° 6' 48.586" N 105° 30' 7.513" E	1132 m	Coudrat, unpublished data
	17 Jan 2012	18° 6' 30.312" N 105° 29' 56.393" E	1105 m	Coudrat, unpublished data
Houay Tong	20 Jan 2012	18° 6' 47.538" N 105° 30' 6.915" E	1122 m	Coudrat, unpublished data
	13 Feb 2012	17° 51' 12.974" N 105° 19' 16.370" E	758 m	Coudrat, unpublished data
	15 Feb 2012	17° 50' 36.834" N 105° 19' 38.438" E	838 m	Coudrat, unpublished data
	16 Feb 2012	17° 50' 51.338" N 105° 18' 15.595" E	754 m	Coudrat, unpublished data
	16 Feb 2012	17° 50' 51.101" N 105° 18' 10.980" E	797 m	Coudrat, unpublished data
	17 Feb 2012	17° 51' 28.663" N 105° 19' 9.739" E	766 m	Coudrat, unpublished data
	18 Feb 2012	17° 51' 37.685" N 105° 18' 30.935" E	731 m	Coudrat, unpublished data
	18 Feb 2012	17° 51' 35.075" N 105° 17' 49.308" E	863 m	Coudrat, unpublished data
	18 Feb 2012	17° 51' 25.549" N 105° 17' 50.921" E	980 m	Coudrat, unpublished data
	20 Feb 2012	17° 51' 9.306" N 105° 18' 11.732" E	827 m	Coudrat, unpublished data
	22 Feb 2012	17° 51' 29.452" N 105° 19' 3.266" E	737 m	Coudrat, unpublished data
	22 Feb 2012	17° 51' 27.302" N 105° 19' 20.618" E	798 m	Coudrat, unpublished data
	22 Feb 2012	17° 51' 11.318" N 105° 19' 23.290" E	747 m	Coudrat, unpublished data
	23 Feb 2012	17° 51' 40.536" N 105° 18' 7.862" E	877 m	Coudrat, unpublished data
	23 Feb 2012	17° 51' 25.675" N 105° 17' 49.913" E	992 m	Coudrat, unpublished data
	26 Feb 2012	17° 52' 9.822" N 105° 18' 37.433" E	836 m	Coudrat, unpublished data
	26 Feb 2012	17° 52' 16.907" N 105° 18' 6.116" E	772 m	Coudrat, unpublished data
Tongkacheng	15 Mar 2012	18° 3' 11.513" N 105° 20' 52.346" E	1257 m	Coudrat, unpublished data
	15 Mar 2012	18° 2' 55.514" N 105° 21' 4.954" E	1322 m	Coudrat, unpublished data
	19 Mar 2012	18° 3' 11.588" N 105° 20' 52.314" E	1262 m	Coudrat, unpublished data
	19 Mar 2012	18° 2' 50.874" N 105° 20' 35.905" E	1152 m	Coudrat, unpublished data
	20 Mar 2012	18° 3' 46.303" N 105° 20' 55.046" E	1261 m	Coudrat, unpublished data
	20 Mar 2012	18° 3' 28.217" N 105° 20' 17.516" E	1023 m	Coudrat, unpublished data
	20 Mar 2012	18° 3' 30.557" N 105° 20' 29.558" E	1090 m	Coudrat, unpublished data
	20 Mar 2012	18° 3' 29.452" N 105° 20' 48.959" E	1283 m	Coudrat, unpublished data
	24 Mar 2012	18° 3' 28.994" N 105° 20' 40.574" E	1175 m	Coudrat, unpublished data
	24 Mar 2012	18° 3' 27.112" N 105° 20' 27.596" E	1106 m	Coudrat, unpublished data
Upper Nam Mon	26 Mar 2012	18° 5' 23.708" N 105° 20' 0.265" E	1246 m	Coudrat, unpublished data
	26 Mar 2012	18° 5' 43.296" N 105° 19' 45.721" E	1436 m	Coudrat, unpublished data
	27 Mar 2012	18° 5' 5.230" N 105° 19' 17.285" E	1429 m	Coudrat, unpublished data
	27 Mar 2012	18° 5' 6.688" N 105° 19' 26.015" E	1310 m	Coudrat, unpublished data
	27 Mar 2012	18° 5' 8.318" N 105° 19' 38.665" E	1179 m	Coudrat, unpublished data
	28 Mar 2012	18° 5' 22.859" N 105° 21' 12.719" E	1484 m	Coudrat, unpublished data
	29 Mar 2012	18° 5' 35.174" N 105° 19' 19.625" E	1419 m	Coudrat, unpublished data
	29 Mar 2012	18° 5' 39.667" N 105° 19' 22.195" E	1342 m	Coudrat, unpublished data
	31 Mar 2012	18° 5' 39.671" N 105° 21' 31.118" E	1529 m	Coudrat, unpublished data
	01 Apr 2012	18° 5' 19.752" N 105° 20' 20.749" E	1070 m	Coudrat, unpublished data
	01 Apr 2012	18° 5' 24.328" N 105° 20' 16.490" E	1134 m	Coudrat, unpublished data
	01 Apr 2012	18° 5' 43.202" N 105° 19' 47.298" E	1390 m	Coudrat, unpublished data
	02 Apr 2012	18° 5' 5.788" N 105° 19' 16.111" E	1439 m	Coudrat, unpublished data
	02 Apr 2012	18° 5' 9.172" N 105° 19' 44.335" E	1159 m	Coudrat, unpublished data
	03 Apr 2012	18° 5' 17.171" N 105° 20' 36.982" E	1222 m	Coudrat, unpublished data
	03 Apr 2012	18° 4' 49.004" N 105° 20' 17.736" E	1004 m	Coudrat, unpublished data
above Nam Gnala	17 Mar 2007	17° 59' 15.807" N 104° 55' 29.192" E	c.600 m	Dersu 2008

APPENDIX I. Continued.

Area	Date	Coordinates	Altitude	Reference
above Nam Gnala (NNT-Phou Hinpoun NPAs Corridor)	17 Mar 2007	17° 58' 35.390" N 104° 55' 21.491" E	c.600 m	Dersu 2008
Nakai plateau	10 Oct 2009	17° 46' 25.03"N 105° 14' 32.72" E	c.555 m	RJT
Dividing Hills (Nam Theun valley)	1 Feb 2010	17° 46' 38.56"N 105° 20' 15.84" E	c.570 m	RJT
Nakai plateau	2 Feb 2010	17° 45' 55.26"N 105° 14' 14.68" E	c.555 m	RJT
Laving-Laveun	23 June 2009	17° 01' 05.5" N 106° 18' 01.8" E	-	Duckworth et al., 2010b
	23 June 2009	17° 00' 57.6"N 106° 18' 50.3" E	-	Duckworth et al., 2010b
	23 June 2009	17° 00' 45.8"N 106° 18' 41.3" E	-	Duckworth et al., 2010b
	30 June 2009	17° 01' 10"N 106° 17' 25" E	550 m	Duckworth et al., 2010b; JWD
	1 July 2009	17° 01' 15"N 106° 17' 25" E	420 m	Duckworth et al., 2010b; JWD
Phou Theung plateau, Houay Pen PFA	29 May 2009	15° 32' 1.04"N 106° 41' 7.514" E	450 m	Timmins, 2009
	29 May 2009	15° 31' 5.141"N 106° 41' 15.11" E	400 m	Timmins, 2009
Xe Sap NPA (western third only)	16 May 2012	16° 09' 00"N 106° 49' 00" E	1200 m	Timmins RJ, pers data
	20 May 2012	16° 06' 26"N 106° 49' 54" E	1200 m	Timmins RJ, pers data
	24 May 2012	16° 04' 38"N 106° 51' 15" E	1600 m	Timmins RJ, pers data
	2 June 2012	16° 04' 38"N 106° 54' 48" E	1400 m	Timmins RJ, pers data

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