Cutting trees in a secondary forest to increase gaur *Bos gaurus* numbers in Khao Phaeng Ma Reforestation area, Nakhon Ratchasima Province, Thailand

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SUMMARY

The value of tourism for gaur *Bos gaurus* in the Khao Phang Ma reforestation area, which borders Khao Yai – Dong Phaya Yen World Heritage Site, decreased when a large number of gaurs moved away from the watching area of the former grassland in the middle of the secondary forest. A major cause appeared to be an increase in the number and size of pioneer trees *Macaranga siamensis* that overshadowed gaurs' food patches. We constructed a 5.7 ha pilot plot where 407 pioneer trees were cut down in an attempt to attract gaurs back to the area. Since tree cutting was a controversial practice, especially with local people, we engaged with, and were supported by, a local non-governmental organization throughout the process. We monitored the density of gaurs using the total counts of dung piles. The estimated density of gaurs was significantly higher in the pilot plot compared with an adjacent control plot (8.62 individuals/km^2/day versus 3.95 individuals/km^2/day), demonstrating a positive impact of tree felling in attracting this species back to an area.

BACKGROUND

Though Thailand is located in a tropical zone, habitat management for large herbivores is generally based on that of their traditional rangelands in temperate zones. Populations of large herbivores in some areas of Thailand have increased continuously and are expanding into secondary forests at the edge of protected areas. Appropriate management designed specifically for each area is necessary in order to strike a balance between tourism and conservation. Some management approaches, such as tree cutting to reduce shade and increase the ground layer vegetation that is important in the diet of large herbivores, is quite a shift from conventional rangeland management. Such practices are unfamiliar and may be considered destructive and contrary to conservation by local communities.

Gaur *Bos gaurus* is the largest Asian wild cattle, categorized as Vulnerable by IUCN (Duckworth *et al*. 2016). In Thailand, their population has declined in the past, mainly due to trophy hunting, and the gaur population was estimated as only 915 individuals in 1995 (Srikosamatara & Suteethorn 1995). But, recently their numbers have increased in several protected areas, partly due to better legal regulation on trophy hunting.

Khao Phaeng Ma reforestation area (KPM) is one of a few secondary forests that provides habitat for gaurs, due to abundant food sources in the early successional stage of tropical forest. KPM has an area of 8 km^2 and is located at the edge of the World Heritage Site, Khao Yai – Dong Phaya Yen forest complex, in Wang Nam Khiao District, Nakhon Ratchasima Province, Thailand (Figure 1). KPM was formerly a bare area resulting from past deforestation. A KPM reforestation project began in 1994, through a collaboration between local communities, the non-governmental organization Wildlife Fund Thailand and the government sector of the Royal Forest Department. This was part of a national reforestation programme throughout Thailand to honour the King. Not only was the forest restoration a success (Lamb 2011), but gaurs that immigrated from the nearby Khao Yai National Park to the area after 1995 became a wildlife tourism highlight. Between 1995 and 2009, through immigration and births, the number of gaurs rose from 6 to 100 and the area became known as "the land of gaur". After the reforestation project was completed in 2002, local residents who were involved in the project continued to preserve and manage KPM, establishing the Khao Phaeng Ma Conservation Group (KPMCG). Between 2002 and 2011, KPMCG was a voluntary arrangement, with no official status or financial support from the government. Conservation activities, including educational and recreational projects, relied on small grants from the corporate social responsibility initiatives of private companies.

After 15 years of the continuous reforestation project, a secondary forest dominated by the pioneer tree *Macaranga siamensis* had expanded in area, canopy height and cover. Trees of the genus *Macaranga* are typical of the early successional phase of tropical forests of Southeast Asia. They are fast growing, soft-wooded and reach heights of up to 20 m (Davies *et al*. 1998). For *M. siamensis*, its large leaves and broad canopy limit light to plants on the ground. These include food sources for gaurs, especially ground-covering vine *Pueraria thomsonii*, cogon grass *Imperata cylindrica* and wild banana *Musa acuminata* which contributed up to 60% of gaurs' diet during the early succession stage of KPM (Bidayabha 2001). The significant decline in food plant abundance for gaurs (Pothong 2009) caused them to move away from the core area of KPM where the gaur watching viewpoint for tourists was located. This movement reduced the tourism and conservation value of the area. It was thought that the gaur had moved away from a prime tourist viewing area because their food supply there had been shaded out by pioneer tree species. In collaboration with local stakeholders and protected area managers, we therefore conducted a pilot removal of trees to attempt to attract gaur back to an area of forest.

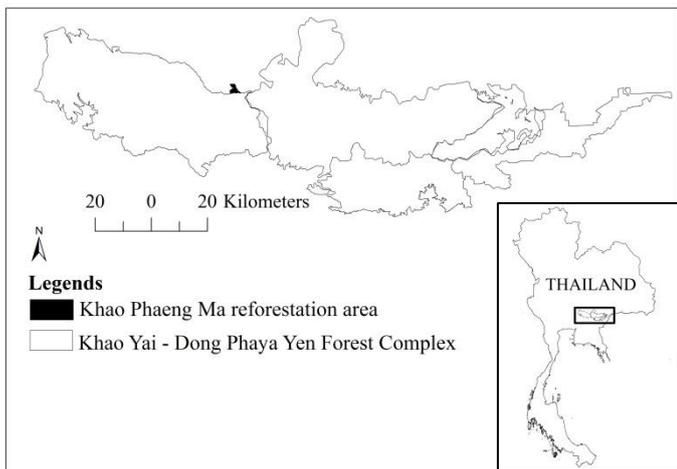* To whom correspondence should be addressed: n.prayong@gmail.com

Figure 1. Location of Khao Phaeng Ma Reforestation area at the edge of the World Heritage site, Khao Yai – Dong Phaya Yen Forest Complex, Wang Nam Khiao District, Nakhon Ratchasima Province, Thailand.

An informal discussion between the local KPMCG and Mahidol University about this altered situation began in 2009. A proposed solution was to cut down the pioneer trees, which both parties agreed were causing the problem. Though it was a destructive intervention, it was considered necessary to maintain the conservation value of the site for gaurs, the flagship species in KPM. The locals, however, were hard to convince. They were concerned about cutting down trees, especially in this reforestation area that is known for its tree planting. Tree felling appeared to be contrary to other conservation measures used by the locals, such as planting trees and maintaining fire protection trails. Thus, tree cutting to resolve the problem of secondary forest could potentially cause local conflicts and public controversy. For these reasons we decided that a pilot study was a crucial step to assess the effectiveness of this unfamiliar and apparently destructive intervention.

We partnered with KPMCG to cut *M. siamensis* in order to create open space in the secondary forest, and attract gaurs back to the area. We monitored the effectiveness of this approach by estimating gaur density by counting dung piles in this cleared space compared with a nearby control area. It was expected that the resulting open space in the pilot plot would attract more gaurs. A positive outcome would increase the confidence of wildlife managers in adopting this tree felling intervention and allow the expansion of the practice to larger areas.

ACTION

Designing a pilot plot and felling the pioneer trees *Macaranga siamensis*: Following a survey in 2010, a 5.7 ha pilot plot was set up within Chang Pa valley (Figure 2). The key factors in selecting this area included visibility from the tourist viewpoint, accessibility, and a suitable size for management by the tree felling team. The pilot plot had a limited open space seen by the public so as to minimize possible controversy during the tree cutting phase. A 4.7 ha control plot was identified nearby (Figure 2a). The smaller size of the control was limited by the difficulty of monitoring forest on steep slopes in difficult terrain.

The tree felling process was collaboratively planned with KPMCG for May - September 2010, during the low tourism season. The work was performed primarily on weekdays and not long weekends, in order to minimize the effects on tourists. Felling of *M. siamensis* with chainsaws (STIHL model MS 381 with a standard guide bar of 50 cm) in the 5.7 ha managed plot was done by local skilled personnel who aimed to minimize damage to neighbouring vegetation. We started in a low elevation zone, cutting trees into small pieces and clearing them immediately; trees at higher elevation were then cut and cleared. A total of 407 *M. siamensis* trees were felled (Figure 3). The ground within both the plots was cleared twice annually using a tractor, in June and December 2011, in order to set back succession and remove dense ground cover.
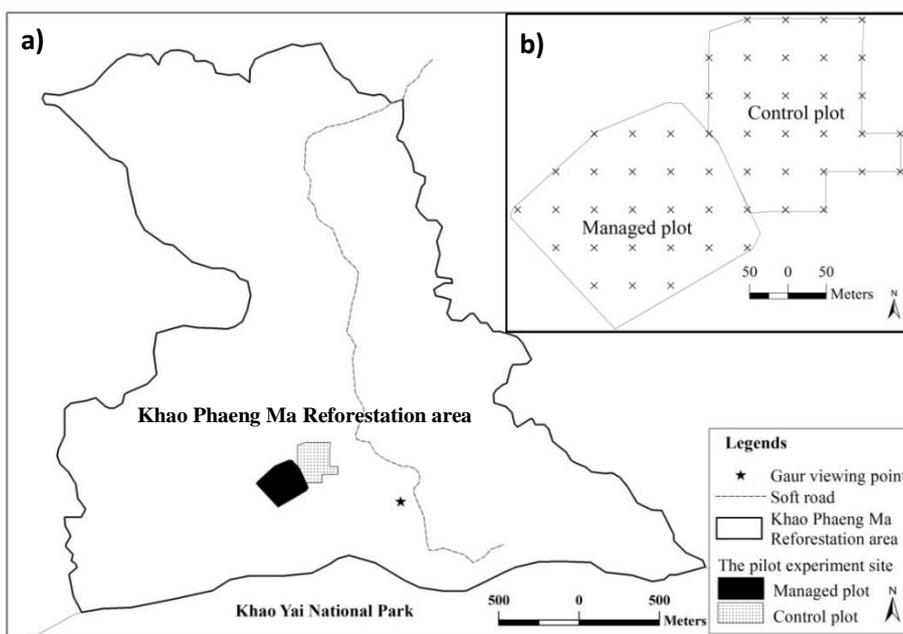

Figure 2. **a)** Location of the managed plot, in which *M. siamensis* trees were felled, and nearby control plot within Chang Pa valley of Khao Phaeng Ma reforestation area. **b)** Wooden poles (x) distributed over managed and control plots were used as reference points while counting gaur dung piles. The distance between each pole was 50 m.

Figure 3. Characteristics of the two plots in the experiment. a) Managed plot, cleared of the pioneer tree *M. siamensis*. b) Control plot with a canopy cover of *M. siamensis*.

Monitoring gaurs: We started monitoring in February 2011, four months after the *M. siamensis* trees had been felled. We estimated gaur density by systematic counts of their dung piles. Wooden poles were laid out systematically 50 m apart to use as reference points in both managed and control plots (Figure 2b). A team of 9-10 local volunteers counted dung piles. The observers lined up 5 m apart between two wooden poles, and walked parallel to each other, guided by a compass, to the next row of wooden poles, recording all dung piles that they found. This was repeated until all areas in both plots were covered. To avoid repeating counts from the preceding month, we covered all detected dung piles with soil after they were recorded. Dung pile counts were conducted once a month for one year from February 2011 to March 2012, with the exception of June and December 2011. This was because of the ground clearing for the rainy and the dry season was carried out by tractor in these months, which disturbed the accumulated dung piles and may also disturb gaurs visitation. To avoid data errors in these months, all dung piles in both managed and control plots were not recorded and were covered with soil before the next observation month.

Data analysis: Based on dung pile density and a defecation rate for the gaur of 9.5 /day (Srikosamatara 1993), we estimated gaur density (individuals/km²/day) as:

$$\frac{[\text{Number of dung piles/ha}] \times 100}{\text{Defecation rate} \times \text{Number of days}}$$

The relative gaur density in the managed area compared with that in the controlled area was also calculated.

CONSEQUENCES

In our managed plot of 5.7 ha, approximately 1.63 ha (28%) was covered by canopies of *M. siamensis* before tree-felling occurred. This was the area of open space gained once the trees were felled.

Over the year of monitoring, approximately twice as many gaurs used the managed plot compared to the controlled plot. Mean density of gaurs using the managed area was 8.62 ± 1.32 (S.E.) individuals/km²/day, compared with 3.96 ± 0.69 (S.E) individuals/km²/day in the control plot (t = 3.13, d.f. = 22, p = 0.006) (Table 1). In addition the range of gaur densities in the managed plot was higher than in the control plot (1.97 to 15.02 individuals/km²/day compared with 0.75 and 8.21) (Figure 4). The higher variance in the managed plot may have been the effect of an unstable succession following an opening of the space, which was not seen in the control plot.

The number of gaurs using the managed plot was higher than that in the control plot in all months except for January 2012 (Table 1). This suggested that there was a positive effect of cutting and managing pioneer trees on the local density of gaurs. Additionally, the density of gaurs appeared to be inversely proportional to the length of time following a ground clearing process, with the exception of the month immediately after the clearing. Thus, density was highest in August (following ground clearing in June) and declined until November. Similar effects were observed after the ground clearing in December.

The relative local gaur density in the managed compared to the controlled plot varied between months. It was greatest in July 2011 at 5.85 times, followed by September 2011 (3.46 times), and March 2012 (3.26 times).

DISCUSSION

Secondary forest is a preferred habitat for gaurs in tropical forests. For example, a study in Malaysia showed that gaur

Table 1. Density of gaurs using the managed and control plots each month for a year after tree cutting in the managed plot.

| Month	Gaurs density (individuals/km²/day)		Relative density (managed/ control plots)
	Managed plot	**Control plot**	
Feb 2011	4.99	2.54	1.96
Mar 2011	8.43	4.93	1.70
Apr 2011	2.65	1.34	1.98
May 2011	1.97	0.75	2.63
Jun 2011	Ground clearing for the rainy season		
Jul 2011	5.66	0.97	5.83
Aug 2011	15.02	5.67	2.64
Sep 2011	14.10	4.07	3.46
Oct 2011	12.20	7.53	1.62
Nov 2011	5.54	3.14	1.76
Dec 2011	Ground clearing for the dry season		
Jan 2012	7.49	8.21	0.91
Feb 2012	13.18	4.56	2.89
Mar 2012	12.23	3.75	3.26
Mean (+S.E)	**8.62 (+1.32)**	**3.96 (+0.69)**	**2.18**
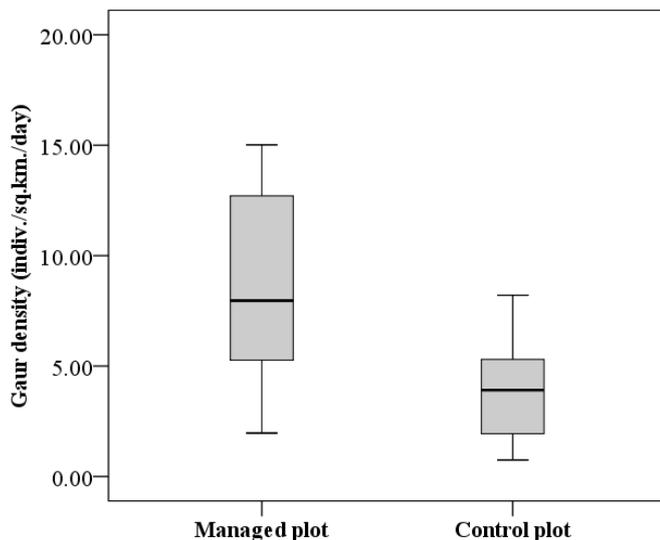
Figure 4. Gaur density in the managed and control plots over a one-year monitoring period. Boxplot show medians (horizontal line), interquartile range (boxes) and minimum/maximum values (whiskers).

preferred to settle in secondary forest and agricultural areas rather than dense pristine forest; this was attributed to the higher biomass of food plants in the former (Conry 1989). In the early stage of KPM reforestation, there were at least 54 food plants in the area (Bidayabha 2001). Large pioneer trees, an early stage in the successional development of secondary forest, reduced the abundance of food plants. In order to maintain favourable habitat for gaurs felling pioneer trees was deemed necessary, if potentially controversial. Our experimental results demonstrated the effectiveness of removing large pioneer trees in attracting gaur back to a once favoured area that they had largely abandoned. The high abundance of gaur dung piles in the managed plot may reflect several behavioural responses, either a temporary visitation of a large group of gaurs, a frequent visit by a small number of gaurs each month, or a long-term settling in the area. Regardless of the activities, the outcome was a restoration of opportunities for tourists to see gaur.

The challenge in this study included not only attracting gaurs back into the area but also initiating the tree felling. Our pilot area was key for the management of the park stakeholder, KPMCG, to further implement this controversial intervention. Due to the transitional period of KPM management from the local to the government, we designed the experiment as a managed-controlled area comparison rather than a before-and-after experiment.

Even with the approval of KPMCG, cutting trees remained a concern for many local residents. The results proved the effectiveness of the practice of cutting trees in secondary forest for large herbivores. The collaboration of local KPMCG in the small setting of our pilot area was an effective process to convince the locals of this alternative intervention, before extending it to a larger scale.

The positive results of this study led to an unofficial meeting in 2011 where a project to increase the cleared area to 16 ha by felling *M. siamensis* was agreed. Approximately 700 *M. siamensis* would be cut, gaining about 10 ha of new open ground. At this time, KPM was established as a protected area, named "Khao Phaeng Ma non-hunting area". The expanded project was then transferred from the local NGO to the government. The project was later approved by the officials of the KPM non-hunting area and forwarded to the Department of National Parks, Wildlife and Plant Conservation, which gave permission in March 2012. However, before the project was put into action, the KPM non-hunting area chose instead conventional grassland management, growing grass after eliminating large forest patches, without considering colonisation by *M. siamensis* trees.

Although there have been difficulties in expanding the scale of this pilot project, it has provided evidence of the effectiveness of an alternative, controversial intervention. Such small-scale actions with specific stakeholders may be currently suitable for alternative management in Thailand. Other examples include the success of restoring gibbons with non-timber forest product collectors (Kolasartsanee & Srikosamatara 2014) and the reduction of elephant-human conflict with local people (Noonto 2009). Cumulative evidence of the effectiveness of various types of alternative intervention is still useful, even at a small scale, to help in solving various problems of wildlife management in Thailand.

ACKNOWLEDGEMENTS

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