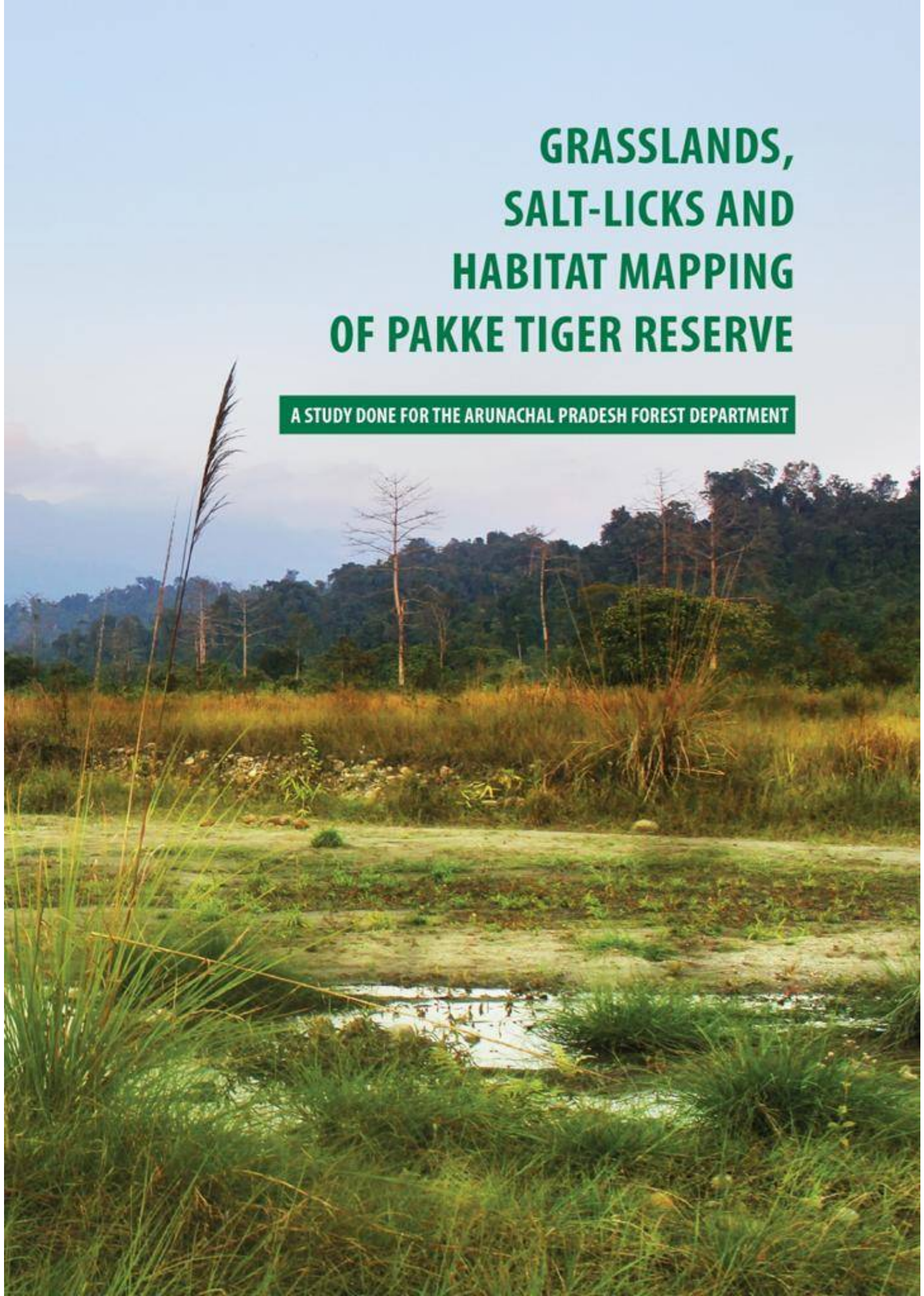
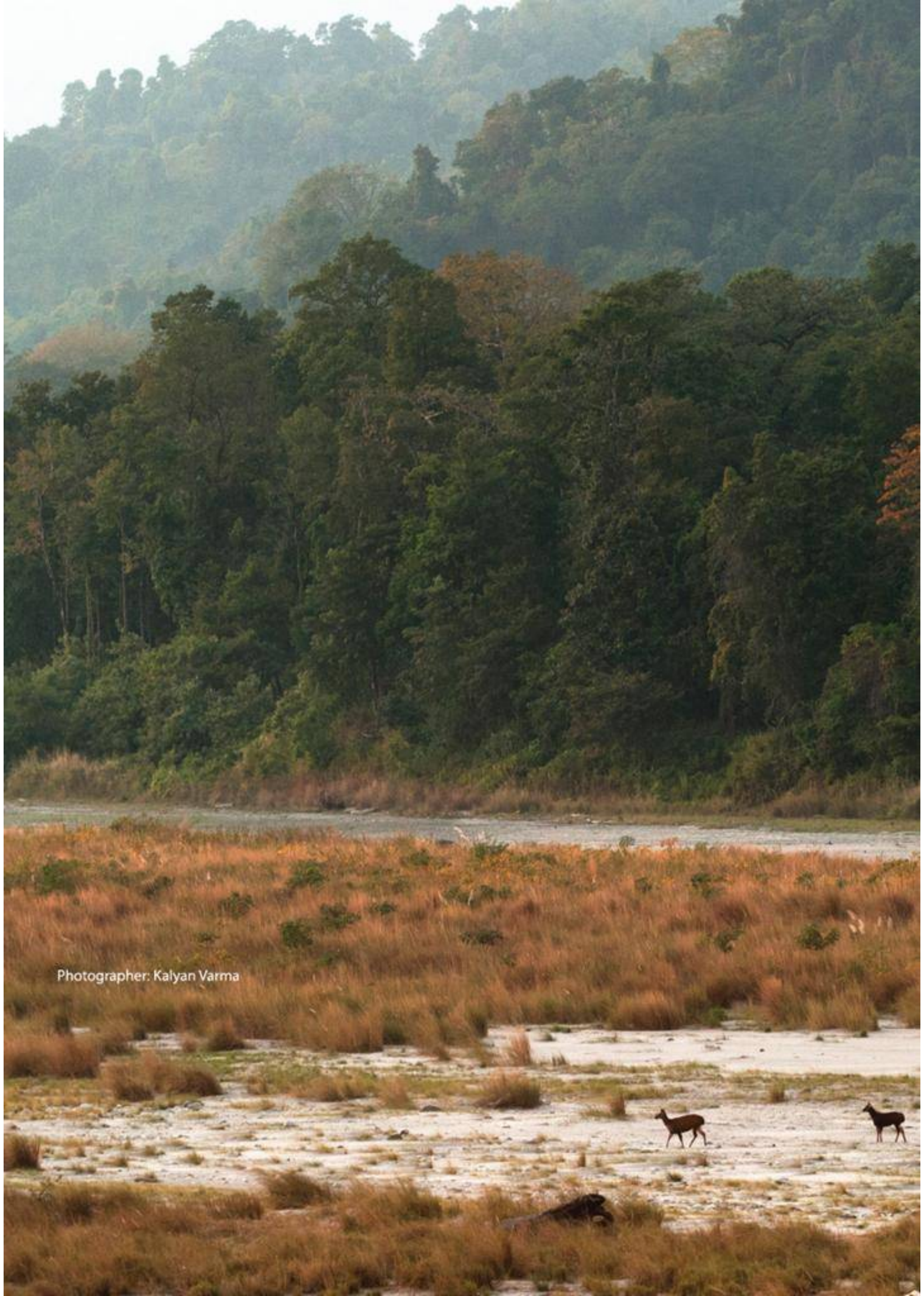
GRASSLANDS, SALT-LICKS AND HABITAT MAPPING OF PAKKE TIGER RESERVE

A STUDY DONE FOR THE ARUNACHAL PRADESH FOREST DEPARTMENT




Photographer: Kalyan Varma

Acknowledgements

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And finally we thank Shri Tana Tapi, Divisional Forest Officer for his enthusiasm and support towards improving the knowledge-base of Pakke Tiger Reserve and creating a model for management despite all the changes the area faces.

Executive Summary

The richness of the grasslands of Pakke cannot be understated. In our study we found the grasslands to be extremely rich with a mean estimate of 108 species that include grasses, ferns, shrubs and trees found in this area. This includes an estimated species richness of 30 grass species which are found in these grasslands, which cover about 1% of the total area. We found species diversity of all species (including grasses) to be highest in the grasslands of Khari, Nameri and Doigurung grasslands. The number of species in these grasslands could go up to152 species! However, a worrying sign was that these grasslands had many invasive species; Mikania micrantha was found in 17% of all plots. But we found that as canopy cover increased the percentage of invasives tended to decrease. This indicates that to control the spread of invasives in Pakke, closed-forests must not be cut down to try and create grasslands, as was tried in a small patch next to Khari in the 1980s. The existing grasslands are very important for many herbivore species and carnivores of global importance such as the tiger. The two species that we found most commonly in all grasslands were sambar (36% of all signs) and elephant (32.9%). However, we recorded the presence of the most number of herbivore species in the grasslands of Nameri within Pakke Tiger Reserve. From laboratory analysis of dung samples, we found that elephants had the highest percentage of grass in their diet (45%), although gaur (41%) and sambar (36%) were not far behind. We also calculated the mean palatability (on the basis of crude protein content) of the seven grasslands of PTR. We found that Khari grasslands had most to offer to herbivores, followed by Doigurung and Diji; Nameri and Dekorai did not perform as well. This could be because smaller grasslands and closer to camps, such as Khari and Doigurung, are cut and burned regularly. Larger grasslands such as Nameri, especially areas away from the camp, are not actively managed. Despite this, it should be noted that Nameri had the most number of herbivore species recorded per grassland and species richness of grasslands was highest here.

We also carried out soil sample analysis of salt-licks and analyzed the existing camera trap data to understand which species visit salt-licks the most. This is important from a patrolling point of view as studies from across the world show that poachers target animals that visit salt-licks. We found that elephants visited salt-licks the most (1.8 visits per salt-licks per day), followed by barking deer (1.4) and sambar (1.2). Preliminary analysis shows that sambar may visit salt-licks which had a higher concentration of copper; while elephants visited salt-licks which had a higher concentration of calcium in them. Further studies have to be done to investigate the relationship of macro and micro-nutrients on the well-being of animal species found in the reserve. Impressively, we recorded pictures of a total of 12 species at the salt-licks – sambar, gaur, elephant, barking deer, leopard, leopard cat, tiger, wild dog, Himalayan crestless porcupine, capped langur, Grey Peacock-pheasant and Khaleej pheasant.

Executive Summary

This study also contained important components of land-cover and habitat mapping that was done by the Foundation of Ecological Research, Advocacy and Learning (FERAL).

Land-cover mapping was done between 2002 when Pakke was declared a Tiger Reserve and 2014 (when our study was done). Between 2002-14, the percentage of area under grasslands in the core has remained between 07-1.2% of Pakke's area. Further the grasslands associated with rivers are also 0.2-1% of the total area. The changing course of the river makes these grasslands highly dynamic and inherently subjected to change. Coinciding with better protection and a sustained period of regeneration; secondary forests of the Assam valley – tropical evergreen type seem to be decreasing in the core area. In 2002, the area under secondary forests was 28.7% and it has now decreased to 15% in 2014. But in parallel, from 2002 onwards there has been an increase in the Assam valley-tropical evergreen primary forest from 24.3% to 38% (in 2014).

In the buffer area, area under grasslands has now shrunk to less than 1 sq. km. This may be because these areas are also suitable as agricultural areas. The buffer areas are also seeing a decrease in bamboo forests; in 2002 bamboo forests totalled 34.6 sq km (4.3% of the buffer area) and they have reduced to 1.2 sq km (0.2%). Several households fringing the Tiger Reserve are dependent on bamboo for house-building and the decrease in bamboo may be a source of concern. Further in the buffer Assam valley tropical evergreen primary forest has decreased the most. In 2002, these lowlands primary forests were 167.5 sq km (20.7%) and they have now decreased to 84.8 sq km (10.5%) of the total buffer area. In the higher altitudes, the good news is that subtropical broad leaved primary forest have increased over time, indicating that these areas hold good potential for conservation.

Contents

Chapter 1

NATURAL SALT-LICKS ARE WORTH THEIR SALT IN PAKKE TIGER RESERVE

Rhea Ganguly[1] and **Nandini Velho**[2]
1 Alumni of the Msc. Course of Wildlife Insitute of India – Dehradun
2 Doctoral candidate, James Cook University, Australia

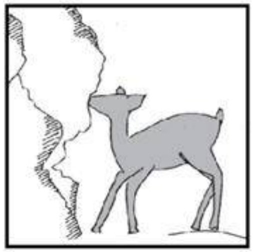
Corresponding person: **rheagang@gmail.com**

Rhea Ganguly and **Nandini Velho**
With inputs from Chandan Ri, Dr. Sumantha Bagchi, Manjunath R and Chengappa B

Introduction

The importance of natural salt-licks cannot be overstated in nutrient poor tropical landscapes (Matsubayashi et al. 2007). In these landscapes, soil is often leached and depleted of essential cations and vegetation has high levels of secondary compounds and variable concentrations of essential nutrients. As keystone resources, natural salt-licks are natural geological formations which are visited by a variety of species in an area because of their rich nutrient composition (Montenegro 2004). In sync with the diversity of species visiting the licks, the services that natural licks provide are also multifarious. While some studies reveal the use of licks to aid digestion and ingest antibiotics, others indicate the use of licks to buffer the effects of secondary plant compounds and to supplement diets poor in nutrients. Studies on use of natural licks by chimpanzees in Tanzania and mountain gorillas in Rwanda emphasize the role of licks in self medication and controlling dehydration (Mahaney et al. 1995, 1996).

Studies from over the world have reported the use of natural licks by elephants (Houston et al. 2001), musk-oxen (Klein & Thing 1989), sambar (Moe 1993), white-tailed deer (Atwood & Weeks 2003), Isle Royale moose (Risenhoover & Peterson 1986), mountain goats (Herbert & Cowan 1971), white-bellied spider monkeys (Blake et al. 2010), red howler monkeys (Blake et al. 2010), black howler monkeys (Behie & Pavelka 2012), Japanese macaques (Mahaney et al. 1993), mountain gorillas and even bats (Voigt et al. 2008).



But the mere presence of a lick is not reason enough for animals to visit. The factors that govern the visitation to a lick are more complex and depend on both site factors and the physiological conditions of the species that visit. For example, a study on comparative visits to salt-licks and their nutrient concentrations revealed that a lick rich in sodium, magnesium and copper was preferred to a lick rich in only sodium (Hebert & Cowan 1971; Henshaw & Ayeni 1971). The use of lick varies with season, time of day and the species. Some animals present in the area may choose not to visit it at all. A study in the Rocky Mountains found that mountain goats not only had preferences within licks but also between licks close to one another (Herbert & Cowan 1971). Similarly, pregnant and lactating animals tend to visit licks more often.

Nestled in the tropical landscape, with a complex mosaic of forest types predominated by semi evergreen forests, Pakke Tiger Reserve (PTR) has its share of licks both natural and man-made, locally called 'pungs.' In the past, these pungs have been used as a management tool. Sometimes table/ common salt was supplemented to particular places or existing natural salt-licks. However, as per the national directive of the National Tiger Conservation Authority, it was recommended to close artificial licks as poaching was common around these areas. But concrete information about these licks is still lacking. On ground, given that Pakke has had a history of prolonged hunting and thus poor prey densities, these natural salt-licks may play an important role in prey recovery. Information on the functional role of natural licks in PTR, the species that visit them, the frequency of their visits, and temporal patterns of lick use will help fill crucial gaps in the current knowledge that exists and could help inform management. Given the broader objective about developing information on the natural licks of PTR, we asked the following questions:

1. What are the levels of some essential nutrients in the natural licks?
2. Are visits by species linked to specific nutrients in the licks?
3. What is the frequency with which animals visit natural licks?
4. When do animals visit natural licks the most?

Study Area

Pakke Wildlife Sanctuary and Tiger Reserve, hereafter PTR; (26° 86' N, 92° 84' E) spans 861.95 km2. The main vegetation type is Assam Valley tropical semi-evergreen forest 2B/C1 (Champion & Seth 1968). The dominant canopy trees in grasslands and riverine areas are Bombax ceiba, Dillenia indica, Duabanga grandiflora, Albizzia lucida and Albizzia procera. The understorey is dominated by Clerodendrum viscosum, Alpinia allughas and Citrus sp. Panicum sp. and Oplismenis sp. are grass genera occuring under the forest canopy. In open grasslands, Imperata cylindrica and Saccharum rufipilum are common species.

Grasslands and riverine forests are a small (~ 62 km2; Varma et al. 2008) but important part of this vegetation mosaic, as they support several threatened herbivores such as the hog deer (Axis porcinus), Asian elephant (Elephas maximus), gaur (Bos gaurus) and sambar (Rusa unicolor), as well as globally endangered species such as the White-winged duck. In PTR, grasslands are mainly confined to the riverbanks and floodplains of smaller perennial rivers (Khari, Laling, Dekorai, Doigurung, Nameri, Diji and Denai) which drain into two main rivers (Pakke and Kameng).

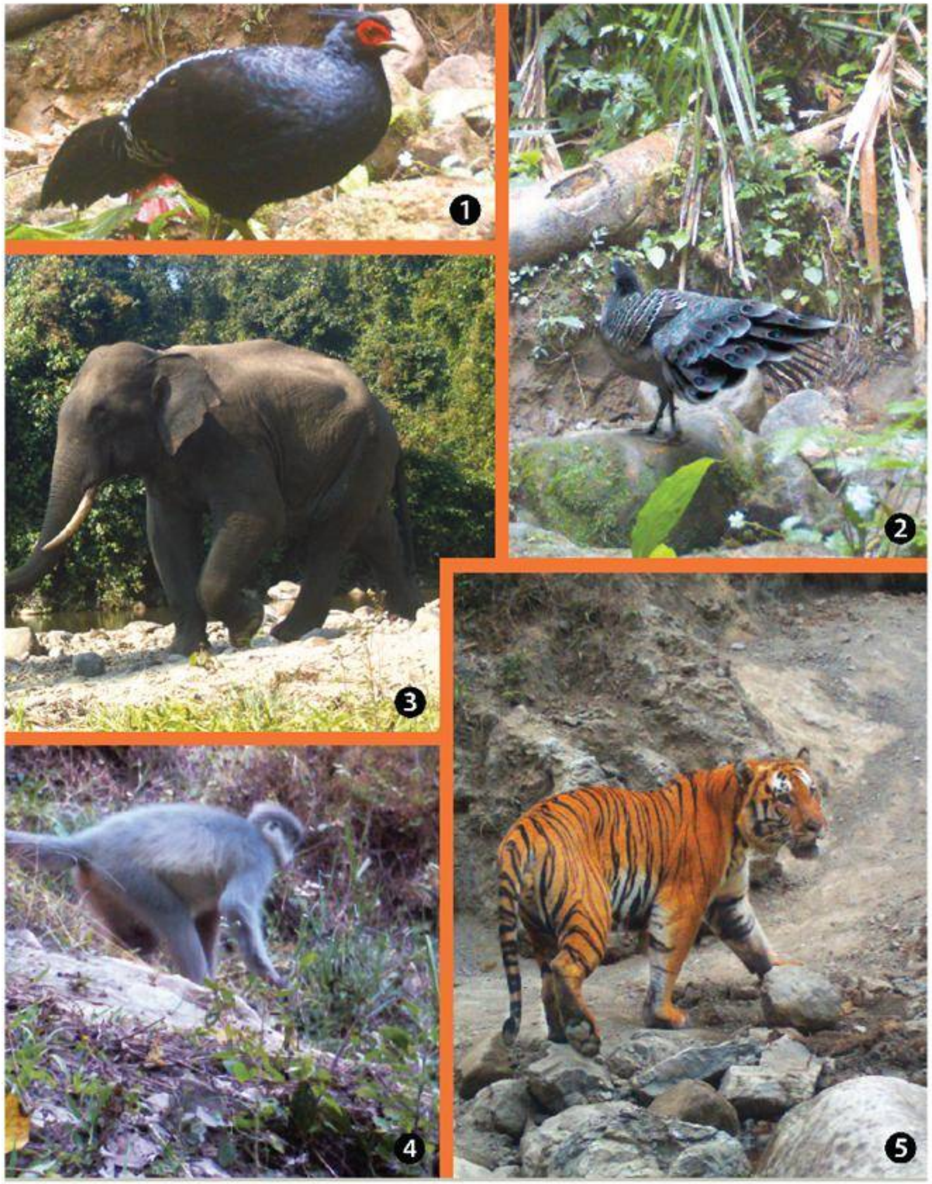


PLATE-1: Animals caught on camera traps in PTR: 1) Khalij Pheasant- *Lophura leuco melanos* | 2) Grey Peacock- *Polyplectron bicalcaratum* | 3) Elephant- *Elephas maximus* | 4) Langur- *Semnopithecus hector* | 5) Tiger- *Panthera tigris*

Photos courtesy Forest Department of Pakke Tiger Reserve

PLATE-2: Animals caught on camera traps at natural salt-licks in PTR: 6) Leopard- *Panthera pardus* | 7) Barking deer- *Muntiacus muntjak* | 8) Sambar- *Cervus unicolor* | 9) Leopard cat- *Prionailurus bengalensis* | 10) Wild dog- *Cuon alpines* | 11) Porcupine- *Hystrix indica*

Photos courtesy Forest Department of Pakke Tiger Reserve

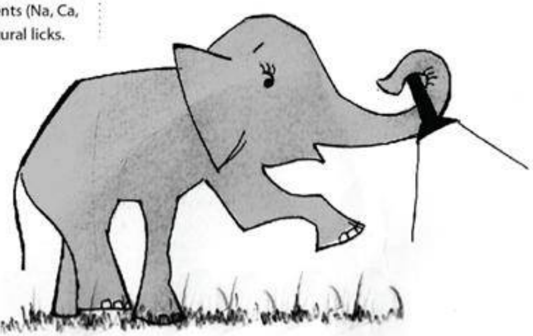
Materials and Methods

Based on past literature which highlights the deficiency of nutrients which cause severe impairment in the physiological activity of animals, we streamlined our analysis to understand the concentration levels of the seven most essential nutrients. A number of studies indicate that animals visit licks primarily for macro-nutrients such as sodium (Na), magnesium (Mg), calcium (Ca), and phosphorous (P and micro-nutrients such as iron (Fe), zinc (Zn) and copper (Cu) (ref). With this in mind, we tested for the concentration levels of these nutrients (Na, Ca, Mg, P, Zn, Cu, and Fe) in each of the natural licks.

We visited 12 natural lick sites across the Tiger Reserve and collected soil samples (each sample consisted of 4-5 sub samples) using a 10 inch galvanized steel soil sampler. The samples collected were thoroughly mixed and dried for laboratory analysis.

Indirect signs (dung, scrapes and foot-prints) of animals visiting each lick were also recorded. Apart from indirect evidences at salt-lick sites, we used data from the existing camera traps set up next to salt-licks by the forest department as part of the tiger estimation exercise.

There were altogether 7 trap locations at seven salt-licks for approximately 30 days (see Table 2). In the lab, the samples were dried overnight at 70˚C in an oven, ground and passed through a 2 mm mesh. One gram of the soil sample was taken and processed in an Inductively Coupled Plasma spectrophotometer (ICP) to arrive at nutrient concentration in parts per million (ppm).



Sn.	Grassland name	Time period of camera trap
1	Khari	1st Feb. to 1st Mar., 2014
2	Khari 1	31st Jan. to 28th Feb., 2014
3	Laling	1st Feb. to 1st Mar., 2014
4	Laling 1	1st Feb. to 1st Mar., 2014
5	Langbang	1st Feb. to 1st Mar., 2014
6	Langbang 1	15th Jan. to 15th Feb., 2014
7	Kimi	13th Dec. 2013 to 12th Jan., 2014

Table 1: The table given above represents the salt-licks at which the camera traps were places and the period during which data was collected.

Materials and Methods

Statistical methods

We used Program R and Microsoft Excel for all analysis in this chapter. We plotted the presence/absence of species as a function of nutrient concentrations present at salt-licks. From our camera trapping data, the number of independent captures of a species was considered as a photograph that was taken on an hourly basis. Visitation rates were compiled for species with more than 3 observations. Thus we were able to compute daily visitation rates for sambar, barking deer and elephants. The average visitation rate for each species was arrived at by pooling data from all salt-licks.

Table 2: The table below describes the key nutrients used in the study and their importance from literature. The concentration obtained from the soil analysis in parts per million is compared with nutrient values in comparable soil types.

Nutrient deficiencies	Importance from literature	Mean parts per million from PTR salt-licks (confidence intervals)
Iron (Fe)	Deficiency results in anemia, hypothyroidism, cardiac hypertrophy, and cognitive dysfunction	10.61(±4.08)
Magnesium (Mg)	Decreased milk production, effects lactating animals most, hypomagnesemic tetany	9.79(±3.11)
Calcium (Ca)	Decline in appetite, lethargy, Downer's disease	2.74(±1.77)
Sodium (Na)	Deficiency causes growth retardation, impairment of energy metabolism, decreased reproductive performance	1.17(±0.34)
Copper (Cu)	Decrease causes swayback, hypocuprosis (external symptoms: unthriftiness, diarrhoea and de-pigmentation of the hair)	0.52(±0.16)
Phosphorus (P)	Insufficient P leads to thriftiness, fragile bones, botulism, lowered fertility, peg leg	0.46(±0.19)
Zinc (Zn)	Facial eczema, lupinosis	0.19(±0.06)

PLATE-3: Materials and methods (salt-licks) 1) A well camouflaged camera trap placed in the vicinity of Khari saltlick to record animal presence in the area | 2) Indirect evidences (pug marks, hoof marks) that indicate animal presence at salt-licks (salt-lick at Khari)

PLATE-4: Materials and methods (salt-licks) 1) Soil being collected from Dekorai saltlick for analysis of mineral composition | 2) Soil corer being used to collect soil sample from saltlick

Results

Mineral concentration at salt-licks

Of the four macro and three micro nutrients essential for animals, we found that their concentrations were highly variable across pungs (Fig. 1).

The big pung at Dekorai had the highest magnesium and phosphorous concentrations. The small pung at Dekorai had the lowest concentration of these two elements. Further, this same small pung at Dekorai had lower concentrations of other essential nutrients (Ca, Na, Fe, Mg, and P), but it had the highest concentration of zinc. Interestingly, it was the only pung to be visited by serow.

The salt-lick richest in sodium was Laling pung. The big pung at Diji was richest in iron though poorest in zinc (Fig.1).

Magnesium and phosphorous were found to be positively correlated (Rho = 0.855). This means that in salt-licks where magnesium was found in high concentrations, phosphorous was also likely to be found in high concentrations. Zinc and copper had a negative correlation (Rho = -0.67). This means that in pungs were zinc concentrations were high, copper concentrations were likely to be low, or vice versa.

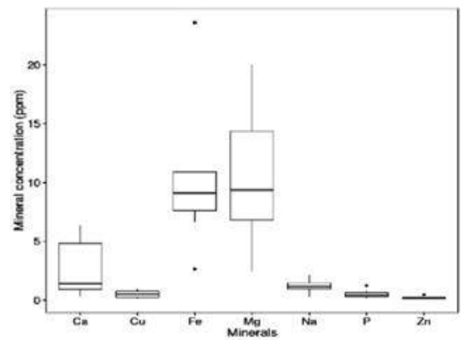


Fig.1: Concentration of essential nutrients compared. The concentration of magnesium and iron were highest across all pungs but also highly variable. The other nutrients were found in very low quantities.

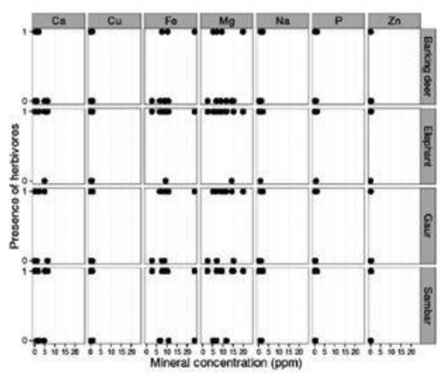
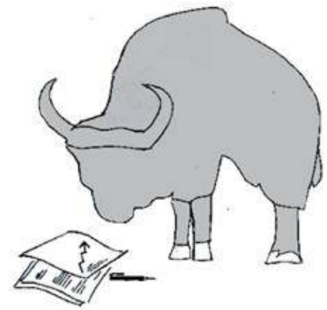


Fig. 2: Graphical representation of nutrient concentration (Ca, Cu, Fe, Mg, Na, P and Zn in ppm) and species absence/presence at that concentration. The species considered are barking deer, gaur, sambar and elephant. This graph shows that nutrient and herbivore signs were highly variable across pungs.

Results



Visitation rates

At the camera trap stations at salt-licks, a total of 12 species were recorded (sambar, gaur, elephant, barking deer, leopard, leopard cat, tiger, wild dog, Himalayan crestless porcupine, capped langur, Grey peacock-pheasant and Khaleej pheasant).

The species that visited pungs the most number of times were elephants, followed by barking deer and sambar (Fig. 3). Elephants visited a given pung within PTR at least 9 separate times every five days (visitation rate per day = 1.8 (0.24 SE), number of independent photographic captures = 25). Barking deer visited a given pung at least 7 separate times every five days (visitation rate per day = 1.43 (0.19 SE), number of independent photographic captures = 21). Sambar visited a given pung within PTR at least 6 times every 5 days (visitation rate per day = 1.2 (0.12 SE), number of independent photographic captures = 20).

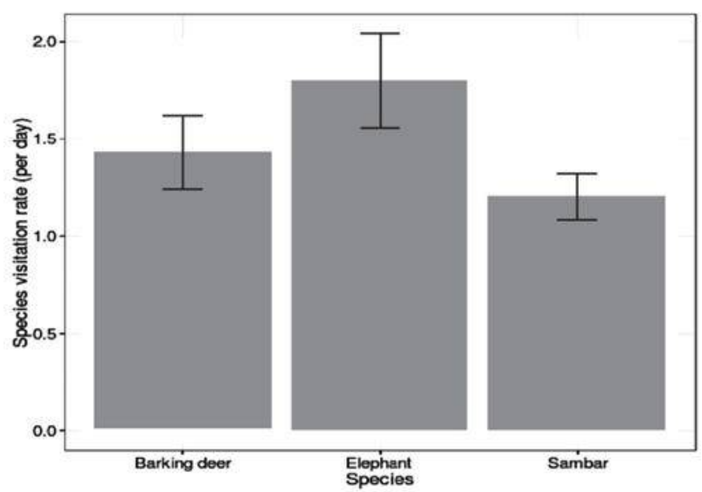


Fig.3: The figure given above indicates the mean visitation per day of elephant, sambar and barking deer to salt-licks. Elephants visited natural licks the most, followed by barking deer and sambar.

Results

Activity patterns

When data from all species was pooled together, we found high activity between 10:00 am and 11:00 am (Fig. 4). During the day, the other important peaks in activity at salt-licks were during (7:00 am to 9:00 am; 12 noon to 1 pm). Between 4:00 pm and 5:00 pm in the evening, again there was lots of activity at salt-licks. Late at night and early morning from 12:00 midnight to 1:00 am, was another important activity period for animals at salt-licks.

However, when the most frequent visitors (elephant, sambar and barking deer) were taken into consideration separately, we found that each species had specific temporal patterns when visiting salt-licks. We categorized the day into four intervals. Elephants visited salt-licks throughout the day and night, except between 4:00 am and 10:00 am where visitation by elephants was relatively low. The peak time of visiting salt-licks for elephants was in the evenings till night (4:00 pm to 10:00 pm). Barking deer visited salt-licks during the day (10:00 am to 4:00 pm). On the other hand, the peak time of sambar activity at salt-licks was late at night till the early hours of the morning (10:00 pm to 4:00 am). There was a minor peak in sambar activity from late-evenings till night (4:00 pm to 10:00 pm).

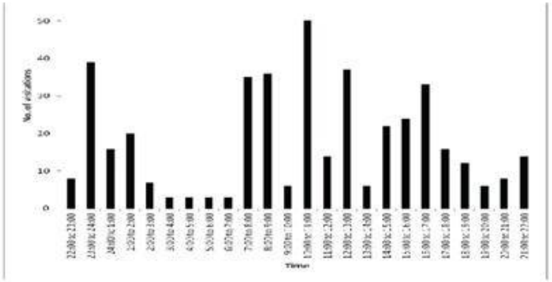


Fig. 4: The number of visitations made by all species collectively during different times of the day. Activity was high during these hourly intervals for all species:
a. 7:00 am to 9:00 am
b. 10:00 am to 11:00 am
c. 12 noon to1.00 pm
d. 4:00 pm to 5:00 pm
e. 12 midnight to 1.00 am

12:00 pm to 1:00 am

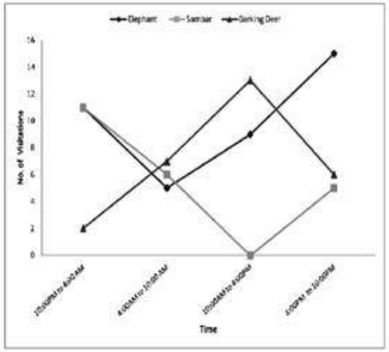


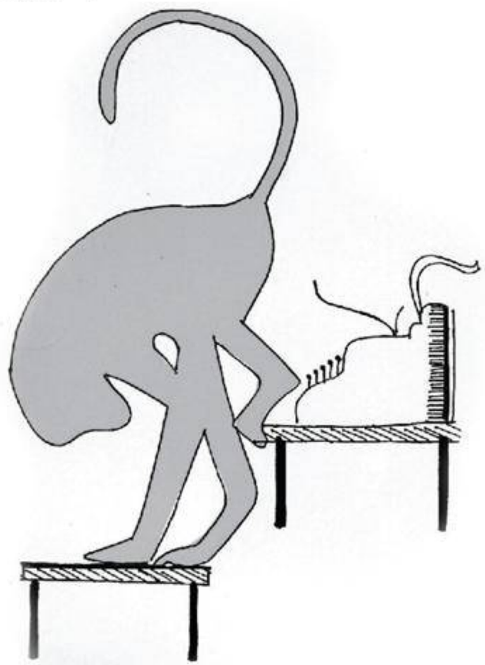
Fig.4: The activity pattern of sambar, elephant and barking deer during different times of the day. The three species showed different peaks in activity. Barking deer visited salt-licks the most during the day (10:00 am to 4:00 pm); elephants visited salt-licks the most during the evening till night (4:00 pm to 10:00 pm); and sambar visited salt-licks the most from late at night till the early hours of the morning (10:00 pm to 4:00 am)

Discussion

Even though natural licks are recognized as keystone resources, the need to have them in wildlife reserves/forests is often questioned. This is because just as waterholes attract animals across food habits and are areas where animals are forced to let their guard down and are easy prey for poachers, natural licks too suffer from the same problem (even though the diversity of animals may be much lower). Whereas the need for water is well understood, the need for essential trace and macro-nutrients is not. Episodes like the recent cyanide poisoning of 300 elephants in Hwange National Park in Zimbabwe (Telegraph, Oct 2013); convince park managers that the cost of having a natural lick in the reserve outweighs its benefit.

On the other hand, parks faced with minimal poaching risks use natural licks to promote "salt-lick tourism". One has to tread with caution though, as a study in New Hampshire recorded reduced use of a lick due to human presence (Chuan & Weng 2009, Chuan et al. 2012).

Our study gives some interesting insights into the nature of the salt-licks (in terms of nutrient concentration) and the activity revolving around it. While magnesium and calcium were macro-nutrients found in the greatest concentration, iron was the micro-nutrient with the highest concentration in the licks. Our study also shows that in salt-licks where zinc may be high, copper may be low, and vice versa. A combination of both these nutrients is important to prevent liver damage (lupinosis), lack of leg coordination (swayback) and hypocuprosis (external symptoms: unthriftiness, diarrhoea and hair de-pigmentation). A soil profile study from all across Pakke Tiger Reserve, including salt-licks and other areas, would build up on this baseline information to highlight the relative importance of salt-licks compared to non salt-lick areas.



Discussion

The temporal pattern that emerged from camera trap data brought to the fore some interesting points. Of the 12 species that visited salt-licks, while the gaur, capped langur and sambar are vulnerable, tiger and dhole are endangered. This highlights that salt-licks are used by a suite of species that are threatened and must be on constant vigil. All species taken together, activity around the natural licks peaked during the day. This is consistent with a study in Yankari Game Reserve which recorded greater use of lick during the day with activity greatest around 2:00 pm (Henshaw & Ayeni 1971).

Using time-activity patterns derived through camera trap data, it showed that elephants, sambar and barking deer had significantly different activity times, and salt-licks were used differentially throughout the day. This temporal segregation is only natural for multiple species using a common resource. From a natural history point of view, it is interesting to note that elephant and sambar were also the species that had a substantial proportion of grass in their diet. It has been observed earlier that in tropical forests, grasses are deficient in macro-nutrients and thus sambar and elephant might be visiting salt-licks for these macro-nutrients. More data on presence/absence of animals at licks with varied nutrient concentrations would present a clearer picture and perhaps throw light on the purpose of lick visit of each species.

Hunting non-randomly at salt-licks is not a new hunting tactic. PTR, spanning over a fairly large area, is an example of a reserve with rampant poaching in the past, still trying to break out of its clutches. In such a scenario, every additional animal death becomes a cause of concern. Park management could focus on incorporating this variability in animal activity, in the patrolling schedules of front-line anti-poaching staff. Night time patrols to salt-licks might be especially important for protection of sambar and elephants (including male-tuskers). The dynamics of salt-lick use and the comparative diversity at different licks is an interesting aspect that can be explored in the future. But there is no doubt that a natural lick is definitely worth its salt!

Casearia varica

Chapter 2

GRASSLANDS OF PAKKE TIGER RESERVE- VITAL HABITATS, STRIKINGLY DIVERSE

Rhea Ganguly1 and **Nandini Velho2**
1 Alumni of the Msc. Course of Wildlife Insitute of India – Dehradun
2 Doctoral candidate, James Cook University, Australia

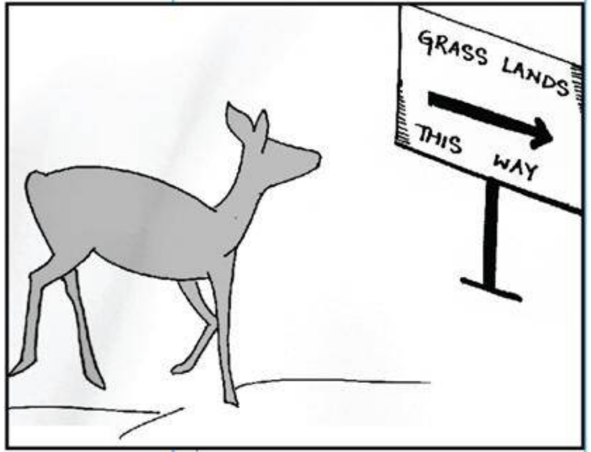
Corresponding person: **rheagang@gmail.com**

Rhea Ganguly and **Nandini Velho**
With inputs from Dr. Sumanta Bagchi, Dr. K. Haridasan, Dr. M. Khandal and B. Chengappa

Introduction

Indian grassland ecosystems face acute biotic pressure (Pemadasa 1990). But, as far as grasslands in protected areas are concerned, they are relatively isolated from biotic interference, subject only to the tools of management for enhancing wildlife conservation (Nangendo, Ter Steege et al. 2006). Even though grasslands may be found in a heterogenous patchwork along with forest ecosystems, their management entails treating them as separate entities. For example, if forage quality has to be enhanced for wild herbivores, controlled burning is carried out in grasslands only, even though they may be embedded in a broader tropical forest landscape.

In tropical forests, 'the green' though abundant, is often high in secondary compounds (Houston, Gilardi et al. 2001; Matsubayashi, Lagan et al. 2007) which may prove toxic for animals in greater quantities. Species tend to respond to these defence mechanisms of plants to herbivory either by evolution, constantly pushing up their levels of tolerances or by devising 'fixes' which may include ingesting soil from natural licks or shifting a portion of their diet to less frequently encountered but less toxic forage. It is in this context that less toxic grassland patches within tropical landscapes gain relevance (Underwood 1999 Minson 2012).



Studies indicate that grassland patches in these forest dominated landscapes are not a part of the climax community (Emanuel, Shugart et al. 1985) and are becoming prone to woody species invasion in the absence of management (Emanuel, Shugart et al. 1985; Archer, Scifres et al. 1988). This is true especially for many arid and semi-arid regions of the world (Wickens and White 1979) as well as India (Singh and Joshi 1979). The immediate reasons which are responsible for such a transformation are suppression of fire, change in climate and uncontrolled grazing (Hastings and Turner 1965; Archer 1989). It therefore becomes clear that active and balanced management may be required in grasslands to maintain species diversity (Crow and Perera 2004).

But to what extent are these anthropogenic interferences advisable? One of the major concerns today that plagues managers and ecologists both is the problem of invasives. Touted as an effective

Introduction

weed control tool, controlled burning has often been used to kill two birds- enhance forage quality for herbivores as well as control weed invasion. But a study in Western US demonstrates how fire can lead to a boom in the population of invasives (specially disturbance dependent annuals) (Keeley 2006). Invasives are known to adversely impact wildlife habitats and forage, deplete soil resources including water and have a negative effect on the overall diversity of the area (DiTomaso 2009). Thus, it becomes necessary to closely monitor areas which are artificially managed and put in a system of checks and balances if necessary.

Pakke Tiger Reserve (PTR) is an example of a grassland- tropical forest mosaic made unique by its plentifully bestrewn arteries of rivulets either seasonal or perennial in nature. The grasslands in the reserve broadly trace these river beds and expand into the adjoining forest flanks which may or may not come under the action of the river. Thus a part of the grasslands in PTR is subject to the annual onslaught of the rivers during monsoons and along with controlled burning becomes an important tool for stalling succession. Under normal circumstances, the unmanaged grasslands would have given way to woodlands and then to forests (van Straten 2003). So, in our study we hope to understand whether the grasslands in PTR are worth the time and effort that management involves.

To answer this question, we had to ask a few more:

1. What is the intrinsic value of the grasslands of PTR in terms of diversity?

- How rich are the grasslands in terms of both flora and fauna?
- How diverse are the grassland in terms of its florist composition?
- What is the level of invasion by weeds in these habitats?
- Which grasslands are more palatable?

2. Do the grasslands of PTR have any use value for any of the animal species? If so, how dependent are they on the grasslands?

Every grazing animal selects its food and selection depends upon certain factors, one of them being palatability (Heady 1964). Since palatability affects the choice of food that an animal ingests (Heady 1964), and animal presence indicates the use of a habitat by a particular species, both factors can together be used to estimate the level of dependence of an animal on a habitat.
We asked the following questions.

1. Which herbivores frequent the grasslands the most?

2. How much of the diet of herbivores consists of grass?

3. Is there any relation between the palatability of grasslands and the presence of herbivores?

Materials and Methods

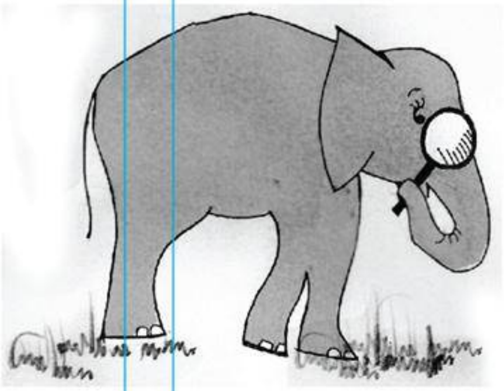
To identify potential sampling locations, we used remote sensing data from Landsat imagery to generate a map of grassland habitats in PTR using an unsupervised classification algorithm using GIS platforms that include ArcGIS and Quantum GIS. This mapping exercise preliminarily identified the extent and spatial arrangement of grasslands.

Over this grassland map of PTR, we overlaid a regular grid consisting of 100 x 100 m cells. Within a particular grassland patch, cells were selected randomly for sampling. The number of sampled cells was proportional to the size of the grassland (Table 1). Grid cells that had less than 50% grass cover were not sampled. Within a cell, we walked a single transect along the diagonal to record all interpretable animal signs (e.g. footprints, dung pellets, scrapes).

Vegetation sampling was conducted on two 0.5 x 0.5 m quadrats established in the corners of the sampled grid cell. In each quadrat, we ranked canopy cover (from 1 to 4, representing 25% increments in canopy cover), and visually estimated the proportion of ground covered by grasses, invasive species and soil. We also recorded the identity of grasses and invasive species, and identified the dominant grass species in each quadrat. Above-ground grass biomass was clipped from each quadrat for analysis of nitrogen content and digestibility.

Table 1: Grasslands sampled within PTR. The data in the table below is arranged in descending order in relation to the grassland size and hence number of quadrats sampled.

Sr No	Grassland	% area	Quadrats sampled
1	Khari	11	24
2	Dekorai	7.3	16
3	Doigurung	7.3	16
4	Nameri	29.4	64
5	Diji	11	24
6	Denai	7.3	16
7	Sukhanallah-1	0.9	2
TOTAL			162



Materials and Methods

Laboratory methods

Sample preparation

We oven-dried the dung, and grass samples overnight at 70˚C. The dung was then ground and sieved through a 2 mm mesh. Grass samples were chopped coarsely (using a coffee grinder) and then finely ground using Wiley's mini-mill.

Grass vs. browse estimation

In all, dung samples of 59 individuals were collected. We segregated these species wise. The samples were treated with a 9:1 ratio of hydrogen peroxide (30%) and aqueous solution of ammonia (25%) and left for 30 minutes. To identify the proportion of browse versus graze in the diet of herbivores, we used a microscope to observe leaf venation patterns in the treated dung samples. For each sample, we selected 100 dung fragments at random to observe under the microscope. Fragments with parallel venation leaf patterns were categorized as grass, while those with reticulate patterns were classified as browse. If fragments could not be categorized, they were recorded separately. On an average, each microscopic field (the visible area under a microscope) had 5 fragments, therefore 20 microscopic fields were observed to obtain the required number of 100 fragments.

Forage quality analysis

We estimated forage quality or palatability of the grasslands using crude protein content as an indicator. For the crude protein analysis, the sample (0.5 g) was treated with sulfurous acid (H_2SO_3), to remove inorganic carbonates. We weighed samples into silver capsules first, and then acidified them with multiple portions of H_2SO_3. After acidification, samples were placed in an oven at 60°C to dry completely before closing the silver capsule. After this, the capsules with sample were processed in the CHN auto analyser to obtain the nitrogen content in the plant samples. The nitrogen content (in percentage) was multiplied by a factor of 6.25 to obtain the crude protein content.

Statistical methods

Species diversity and richness

We estimated the species richness of each grassland using presence and absence data from our quadrats. The estimates were computed using program SPADE (Species Prediction and Diversity Estimation) (Chao and Shen 2003).

We estimated the species diversity index of six grasslands (excluding Sukhanallah) using Shannon's, Inverse Simpson's and Fisher's alpha indices. To get the exponent of Shannon's Index, we used Chao & Shen estimator which involves bootstrapping to 200 replications. In the case of Inverse Simpson's Index, Minimum Variance Unbiased Estimator (MVUE) was used. Identification of species was done using keys (Bor 1940; Shukla 1996) and assigning codes for unidentified individuals for off-field identification by experts (Dr. K Haridasan, Dr. Manish Khandal, Dr. B Tham and facilities granted by the Botanic Survey of India, Shillong).

Materials and Methods

Invasives

We selected the three most dominant invasive species (Eupatorium odoratum, Mikania micrantha and Aegaratum conyzoides) to examine the occurrence of invasives in grasslands. Aegaratum haustonianum was excluded from the analysis as there were only two records across all plots. For every sampled site, the means and standard deviations of the proportions of plots with invasives present was obtained through bootstrapping with 1000 iterations (with 50 random draws in each iteration)

Forage quality

We estimated the mean palatability of 9 main species encountered in the grassland, clubbing the rest as others. We also calculated the mean palatability per unit area by factoring in the species composition in each grassland.

Habitat use (dung samples and transect analysis)

We recorded signs of animal presence which included bite or grazing marks on vegetation, dung or pellets encountered, hoof or pug marks and direct sightings in the 81 transects that we walked to estimate animal presence in the grasslands of PTR. The number of transects walked in each grassland was directly proportional to the area of the grassland. We then estimated the mean values of animal presence in signs/unit area to compare across grasslands.

For grass vs. browse ratio, we calculated the mean proportion of grass in the diet of the eight herbivore species encountered (dung samples) along with the associated standard error and confidence values (95%).

We used Program R, Microsoft Excel and SPADE for all analysis.

PLATE-5: Methods for grassland analysis 1) Collection of grass specimens for identification | 2) A Wiley's mini mill: Grass specimens are crushed and ground to a fine powder of below 2 mm in size for chemical analysis | 3) Quadrats being laid out for sampling in grasslands of PTR

PLATE-6: Some of the salt-licks of Pakke Tiger Reserve 1) Elephants at a manmade salt-lick just below the Nameri Forest Camp | 2) Salt-lick at Diji | 3) An elephant visits a natural salt-lick at Nameri

Results

1. Species diversity and richness

Species richness is the basic measure of community or local diversity (Gotelli and Colwell 2001; Magurran 2004). In simplest terms, it is the number of different species represented in any ecological community or landscape. However, unlike species diversity, it does not indicate anything about the evenness of the community being sampled.

Our analysis of the quadrat data revealed varying species richness for different grassland patches in the reserve. We arrived at a species richness estimate using Incidence-based Coverage Estimator (ICE) which assumes that the detection probability of different species is heterogeneous (Chao and Shen 2003). The estimates for species richness of all species taken together are tabulated in Table 1 whereas grassland species richness estimates for only grass species is tabulated in Table 2.

The cut-off point for incidence occurrence separating a rare species from an abundant one was kept at 10. We also computed richness by pooling in data from all samples to obtain a species richness value for the grasslands as a whole. The grasslands were found to be extremely rich with a mean estimate of 108 species (ICE estimate, SE = 15.7). The number of species in the grasslands could range from 87 to 152 (CV = 0.829) indicating reasonable heterogeneity in species detection probability.

Additionally, we removed species other than grass from the analysis to arrive at diversity indices and richness estimates for the reserve with respect to grasses only. While, the number of observed species was 23, the species estimate was 29.6 (ACE 1 estimate, SE= 5.4) with the 95% CI range between 24 and 49 (CV= 0.68).

All species

Grassland	No. of observed species	Species richness estimate (ICE)	SE	Confidence interval (95%)
Khari	22	35.6	8.9	26.2- 65.8
Dekorai	19	25.2	5.0	20.5- 43.9
Doigurung	29	46.5	10.2	35.1- 79.7
Nameri	48	84.0	16.4	63.4- 132.4
Diji	22	35.6	8.9	26.2- 65.8
Denai	22	28.3	4.9	23.6- 46.1

Table 1: The ICE species richness estimates (non grass species included) for different grasslands within PTR are given above along with the associated standard error and the confidence interval. Nameri grasslands were found to be richest followed by Doigurung. Khari and Diji were similar in terms of species richness.

Only grass

Table 2: The ICE species richness estimates (for grass species only) for different grasslands within PTR are given on the next page along with the associated standard error and the confidence interval. Khari grasslands were found to be richest followed by Nameri and Doigurung. Denai and Diji were similar in terms of species richness.

Results

Grassland species	No. of observed estimate (ICE)	Species richness	SE	Confidence interval (95%)
Khari	16	29.2	10	19.5-65.6
Dekorai*	8	14.1	6.4	9.1- 41.0
Doigurung	9	11.2	2.7	9.3- 23.6
Nameri	13	16.7	3.9	13.7-33.3
Diji	9	12.1	3.7	9.5- 28.4
Denai	9	10.8	2.4	9.3-21.9

*ACE estimate used here

Similarity Indices

Two community pair wise similarity indices were also calculated after bootstrapping to 200 replications. Both Jaccard's and Sorenenson's indices were estimated. Results of both indices remained consistent on the degree of similarity among the six grasslands (Sukhanallah was not taken into account) taken two at a time.

Table 3: The following table is a matrix of species assemblages with the estimated indices of Jaccard's incidence and Sorenson's incidence along with their associated standard errors. Assemblage 2 and 6 are most similar whereas 1and 3 are the least similar. The assemblages denote a pair of grassland communities where 1 = Khari Grassland, 2 = Dekorai Grassland, 3 = Doigurung Grassland, 4 = Nameri Grassland, 6 = Diji Grassland and 7 = Denai Grassland.

Grassland assemblage	No. of shared species	Jaccard's incidence	SE	Sorenson's incidence	SE
1 and 2	13	0.28	0.04	0.43	0.05
1 and 3	12	0.22	0.03	0.36	0.05
1 and 4	20	0.29	0.03	0.45	0.04
1 and 6	12	0.23	0.03	0.37	0.05
1 and 7	14	0.28	0.04	0.44	0.05
2 and 3	12	0.36	0.05	0.53	0.06
2 and 4	16	0.31	0.04	0.48	0.05
2 and 6	13	0.44	0.06	0.62	0.07
2 and 7	12	0.40	0.05	0.57	0.06
3 and 4	18	0.32	0.04	0.49	0.05
3 and 6	12	0.32	0.05	0.49	0.05
3 and 7	10	0.26	0.04	0.41	0.05
4 and 6	18	0.34	0.04	0.50	0.05
4 and 7	17	0.31	0.04	0.48	0.04
6 and 7	12	0.35	0.05	0.52	0.06

Dekorai-Diji assemblage was found to be most similar followed by Dekorai-Denai, Dekorai-Doigurung and Nameri-Diji assemblages (see Table 3).

Results

Diversity of species

While species richness is a measure of species diversity, it does not account for evenness within the sample community. Diversity indices are based on both species richness values as well as evenness values. Shannon Index and Inverse of Simpson Index are often referred to as true diversity estimates.

All species

Table 4: Matrix of Grasslands of PTR along with three diversity indices (Exponential of Shannon's Index, Inverse of Simpson's Index and Fisher's alpha) for comparison. Khari grasslands were found to be most diverse (including non grass species) followed by Nameri and Doigurung.

Grassland	Exponential of Shannon Index (SE in paranthesis)	C.I. (95%)	Inverse of Simpson Index (SE in paranthesis)	C.I. (95%)	Fisher's alpha (SE in paranthesis)	95%
Khari	43.8 (6.4)	31.2- 56.3	24.1(0 .2)	23.7- 24.6	30.2 (4.7)	21.0-39.5
Dekorai	19.3 (3.5)	12.4-26.1	15.9 (0.2)	15.4-16.3	11.4 (2.6)	6.3- 16.5
Doigurung	30.9 (4.9)	21.4- 40.5	24.6 (0.2)	24.3-24.9	20.2 (3.9)	12.4-27.9
Nameri	35.9 (4.2)	27.7-44.2	21.5(0.1)	21.1-21.7	22.8(3.3)	16.4-29.3
Diji	16.0 (1.5)	13.0-19.0	14.7(0.2)	14.4-15.0	11.8(2.5)	7.0-16.6
Denai	27.5(3.5)	20.9-34.4	26.1(0.1)	17.2-17.6	16.5(3.4)	9.7-23.2
Entire Reserve	42.7(3.2)	36.4-48.9	21.7(0.1)	21.4-21.9	30.2(3.3)	23.8-36.6

All three indices calculated minimum diversity for both Diji and Dekorai (see Table 4). Shannon's and Fisher's alpha both estimated maximum diversity for Khari grassland followed by Nameri and Doigurng grasslands (see Table 4). Simpson's Index estimated maximum diversity for Denai grasslands followed by Khari and Doigurung.

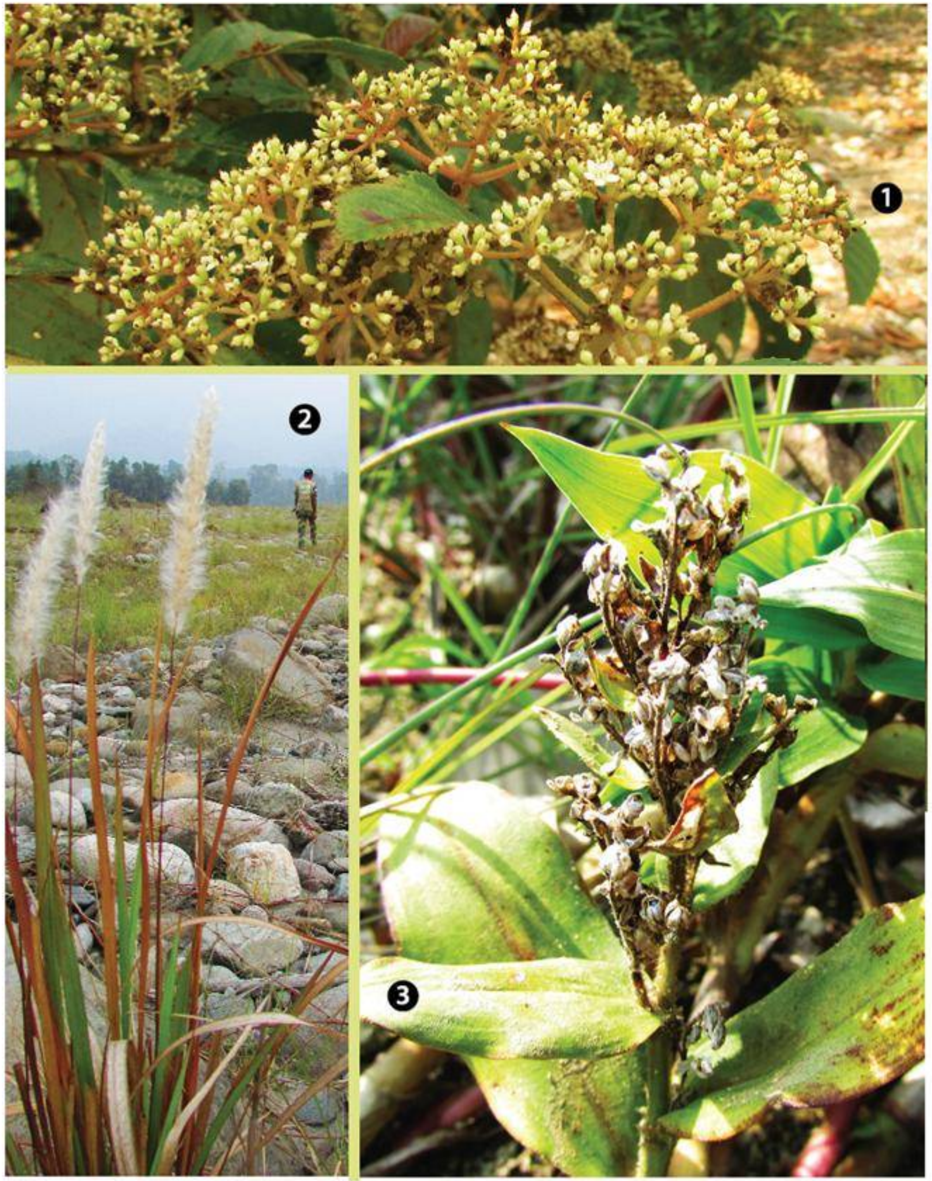


PLATE-7: Some common plants found in the grasslands of PTR 1) *Viburnum sp* L | 2) *Imperata cylindrica* (L.) P. Beauv | 3) *Floscopa scandens* J. de. Loureiro

PLATE-8: Some common plants found in the grasslands of PTR 1) *Casearia varica* | 2) *Piper* | 3) *Neyraudia reynaudiana* (Kunth) Keng ex A.S.Hitchc | 4) *Polygonum chinense var. avalifolium* Meisn

Results

Only grass

Table 5: Matrix of Grasslands of PTR along with three diversity indices (Exponential of Shannon's Index, Inverse of Simpson's Index and Fisher's alpha) for comparison. Khari grasslands were found to be most diverse (including non-grass species) followed by Nameri and Doigurung.

Grassland	Exponential of Shannon Index (SE paranthesis)	C.I. (95%)	Inverse of Simpson Index (SE in paranthesis)	C.I. (95%)	Fisher's alpha (SE in paranthesis)	C.I. (95%)
Khari	14.4(2.6)	9.2-19.5	8.7(0.2)	8.3-9.2	8.9(2.2)	4.5-13.2
Dekorai	7.3(1.7)	3.9-10.7	5.3(0.3)	4.7-5.9	4.2(1.5)	1.3-7.1
Doigurung	9.3(1.6)	6.2-12.3	8.1(0.2)	7.7-8.5	5.2(1.7)	1.8-8.6
Nameri	8.8(1.0)	6.8-10.8	6.8(0.2)	6.5-7.2	4.1(1.2)	1.8-6.5
Diji	7.5(1.2)	5.3-9.8	6.3(0.2)	5.8-6.7	3.6(1.2)	1.3-5.9
Denai	10.1(1.8)	6.6-13.9	9.5(0.2)	9.2-9.9	6.0(2.0)	2.1-9.9
Entire reserve	11.5(1.02)	9.5-13.4	7.5(0.2)	7.1-8.3	6.4(1.3)	3.8-8.9

Taking only grass species into account, Khari grasslands were most diverse. Nameri and Doigurung followed Khari whereas the least diverse grasslands were those of Dekorai.

Composition of grass species

Our quadrat data also comprised of ranks assigned to individual species present in quadrats according to their abundance. We computed percentage composition of individual species using DWR (Dry-Weight-Rank) method (Gillen and Smith 1986).

Imperata cylindrica or Cogon grass comprised of nearly 25% of all grass species (24.8%) followed by Saccharum rufipilum (19%) and Oplismenus composites (14%). 2% (in terms of percentage composition) of the species remained un-identified (excluding Jharu Kher).

It must be noted that cogon grass is among the 100 most invasive species (Lowe, Browne et al. 2000). Even so, field observations (bite marks) reveal that the grass is a source of food for herbivores. Neyraudia reynaudiana or Burma reed is another species which is considered to be an invasive (Langeland, Hall et al. 2007) which is abundant specially in some of the grasslands (Nameri and Diji).

Results

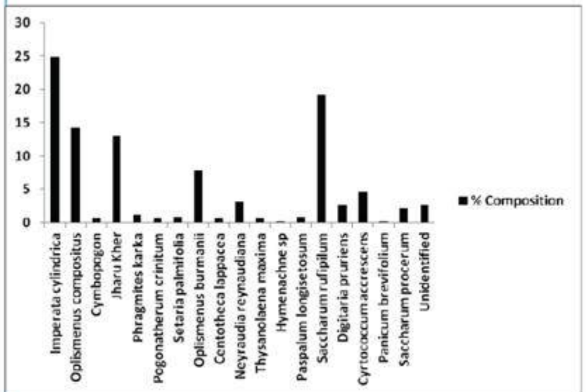


Fig.1: The figure given alongside is the graphical representation of the percentage composition in grasslands of each individual species. Imperata cylindrica and Sachharum rufipilum are the species that contribute most to the botanical composition of grasses.

Presence of invasives

In general, invasive cover was negatively related to canopy cover (Spearman's rho = -0.1015, p = 0.20). This means that as canopy cover increased there was a decrease in invasive cover. However, there were differences in invasive species across grasslands. M. micrantha was found in 17% of all plots, while E. odoratum and A. conyzoides were found in 7% of all sampled plots (Table 2). There was considerable variation in invasive presence across sampled sites (Fig. 1); M. micrantha was most common invasive species in Khari, Dekorai, Doigurung, Nameri and Denai, while E. odoratum was most common invasive found in Diji. A. conyzoides was generally the second most common invasive species, except in Doigurung, where E. odoratum was the second most common invasive species.

	Mikania micrantha	Eupatorium odoratum	Aegaratum conyzoides
Mean proportion of sites	0.17	0.07	0.07
Standard deviation	0.05	0.03	0.03

Table 2: The table below indicates the proportion of quadrats (n = 162) across all grasslands in PTR where invasive species were present. The mean proportion of sampled plots (and associated standard deviations) was obtained by bootstrapping (see statistical methods). M. micrantha was the most common invasive and E. odoratum and A. conyzoides also occurred.

PLATE-9: Some common plants found in the grasslands of PTR 1) *Spilanthes acmella* | 2) *Setaria palmifolia* (J.Koenig) Stapf | 3) *Crassocephalum crepidioides* (Benth.) S Moore

PLATE-10: Some common plants found in the grasslands of PTR 1) *Spilanthes acmella* | 2) *Setaria palmifolia* (J.Koenig) Stapf | 3) *Crassocephalum crepidioides* (Benth.) S Moore 1) *Saccharum spontaneum* L | 2) *Impatiens spp*

Results

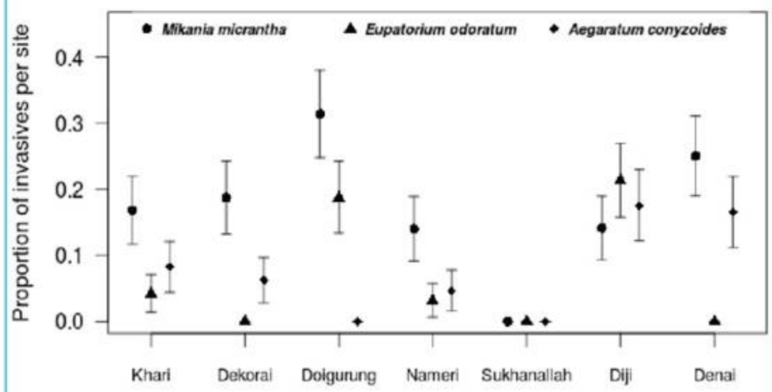
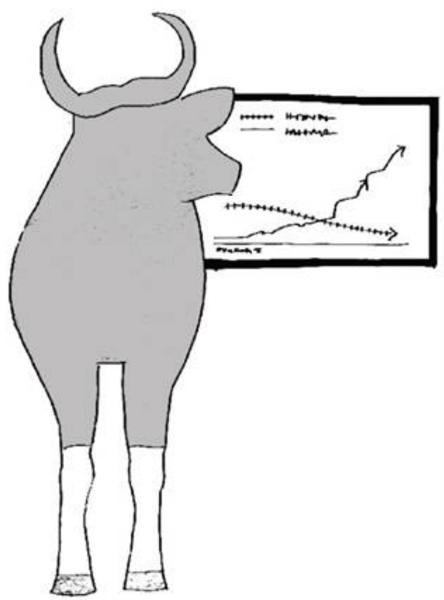


Fig. 2: Proportion of plots with three species of invasive plants across seven grassland (x-axis) sites in PTR. Error bars represent one standard deviation from bootstrapping. In general, M. micrantha was the most common invasive species, followed by E. odoratum and A. conyzoides.



Results

Forage quality analysis

The mere presence of any resource is not enough to ensure its use. Also, species occurring in similar habitats may utilize it in different ways. In terms of forage requirements, the extent of utilization may depend on the choice exercised by the species in question. This is more commonly known as selection, and the features of a plant that evoke selection, called palatability (Cowlishaw and Alder 1960; Heady 1964).

For the purpose of this study, we assessed the palatability of different grass species on the basis of their crude protein percent values (Hardison, Reid et al. 1954; Cook 1959; Heady 1964 (Westoby 1974).

We chose 9 major grasses which occurred at least three times in the grasslands for assessing palatability. These were further sub sampled proportionate to the number of occurrences for crude protein content analysis. The rest of the species were clubbed together as others, samples from this category were chosen randomly in accordance with their total pooled strength(Table 3).

Table 3: The palatability in terms of mean crude protein percent of 9 major grasses along with their associated confidence interval. The rest of the grasses occurring in PTR with occurrences less than two have been classified as others.

Species	Mean Crude Protein (%)	No. of occurrences	No. of samples selected	C.I. (95%)
Oplismenus compositus	11.36302083	27	6	3.91924
Saccharum procerum	4.598625	5	1	NA
Cyrtococcum accrescens	10.85520833	15	3	2.871716
Oplismenus burmanii	9.123541667	14	3	5.015055
Phragmites karka	5.2486875	4	1	NA
Jharu kher	5.317679688	32	8	1.285425
Neyraudia reynaudiana	10.65964583	11	3	17.1858
Saccharum rufipilum	4.338590909	45	11	0.746946
Imperata cylindrica	5.927740385	60	13	1.308125
Others	8.07703125	40	10	1.429509

Oplismenus compositus and Cyrtococcum accrescens were found to be highly palatable whereas Saccharum rufipilum and Saccharum proceerum were least palatable. It must be noted however, that certain grasses had a high degree of variability in their crude protein content (Neyraudia reynaudiana).

This variability can be attributed to phenological stage (Westoby 1974; Owen-Smith and Novellie 1982) of the plant.

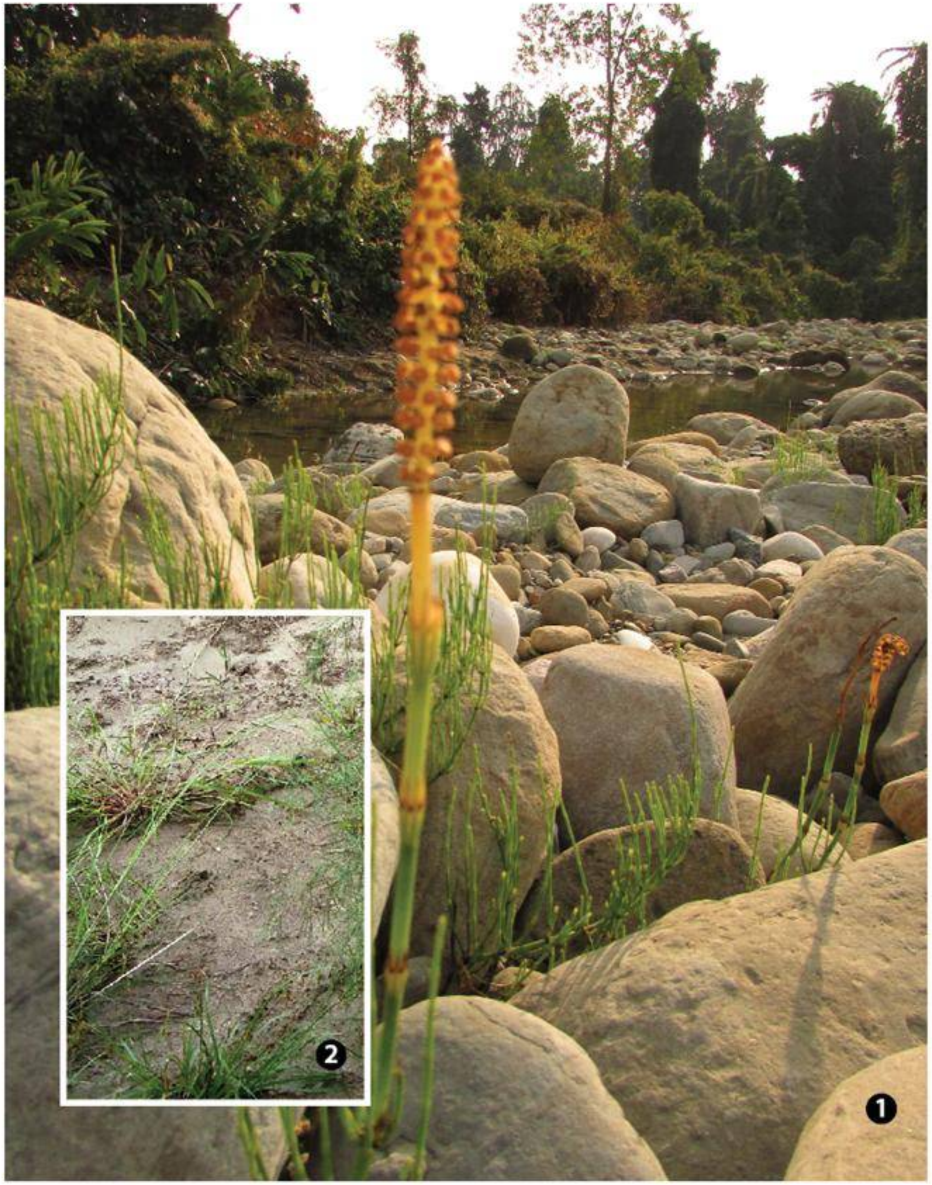


PLATE-11: Some common plants found in the grasslands of PTR 1) *Equisetum sp* | 2) *Saccharum rufipilum* Steud

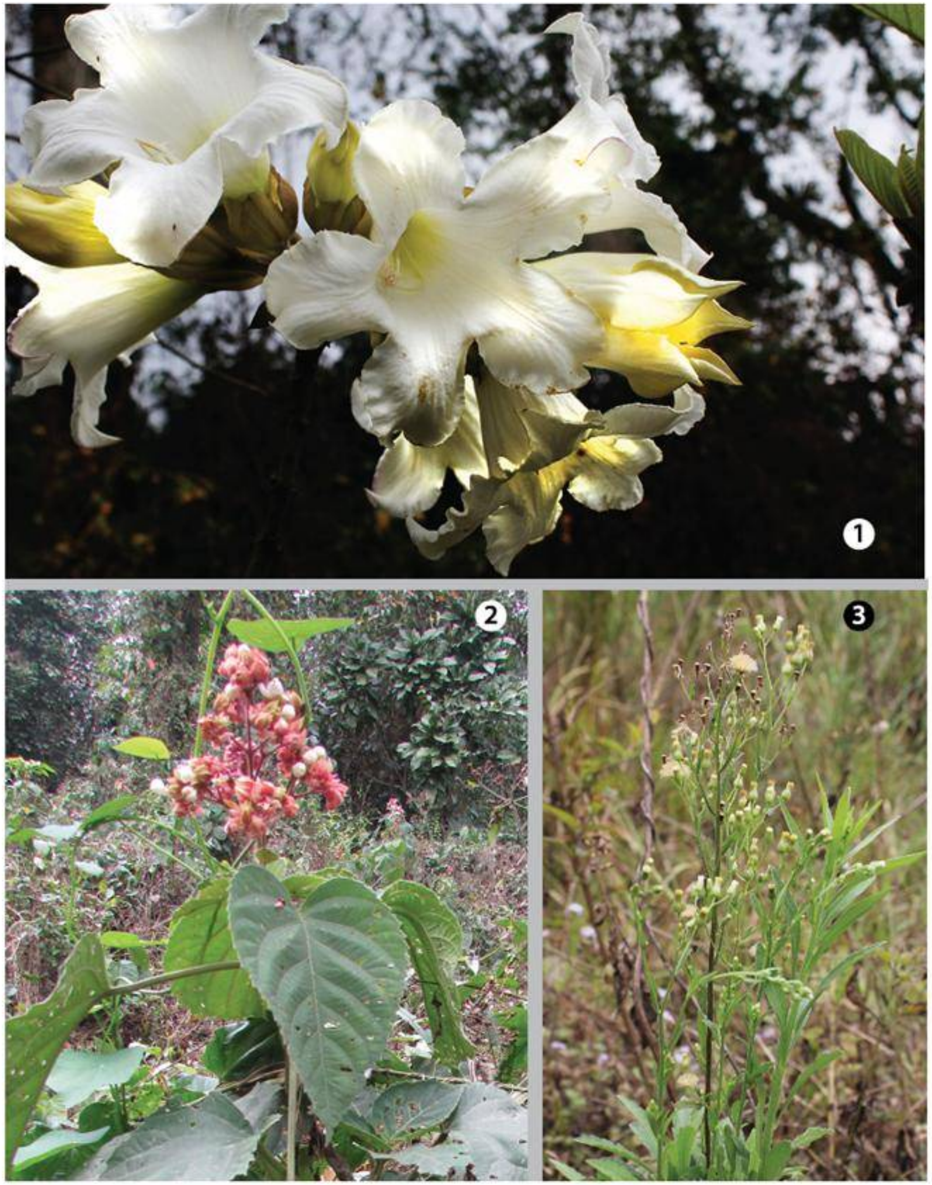


PLATE-12: Some common plants found in the grasslands of PTR 1) *Beaumontia grandiflora* | 2) *Clerodendrum viscosum* Vent | 3) *Erigeron sp*

Results

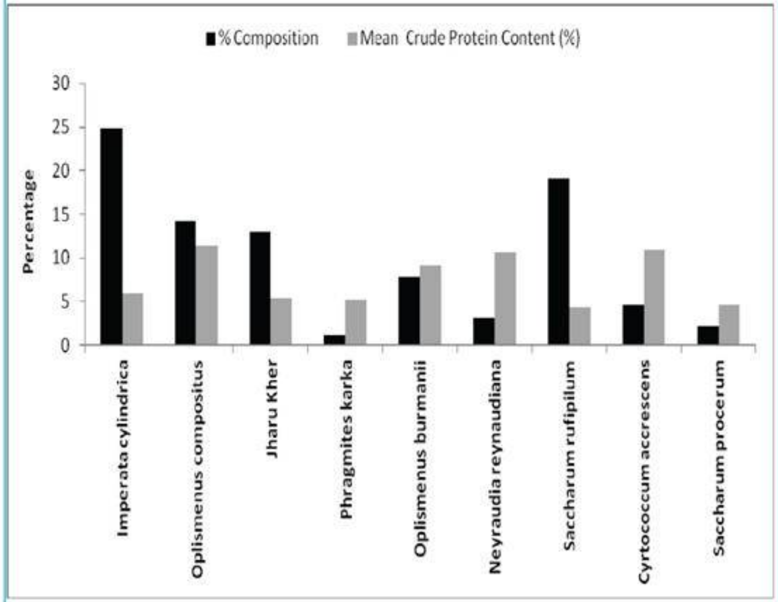


Fig.4: The graphical representation of the mean crude protein content of 9 frequently encountered grasses in PTR along with their percentage contribution to the composition of the grasslands.

Imperata cylindrica, contributes approximately 25% of the grasslands, but in terms of quality, it ranks among the lowest. Saccharum rufipilum follows similar trends. Oplismenus composites and Cyrtococcum accrescens have high crude protein content but their percentage contribution to the compostion of the grasslands is much lower (approximately 14% and 4% respectively) .On the basis of these two parameters (percentage composition, individual species palatability), we calculated the mean palatability of the seven grasslands of PTR. It was observed that in terms of crude protein content, Khari grasslands had most to offer to herbivores, followed by Doigurung and Diji whereas Nameri and Dekorai performed the worst (Fig.5). This could be attributed to the vastness of grasslands of Nameri and Dekorai, where there is no active-management (cutting and controlled burning) as distance from the anti-poaching camps increase.

Results

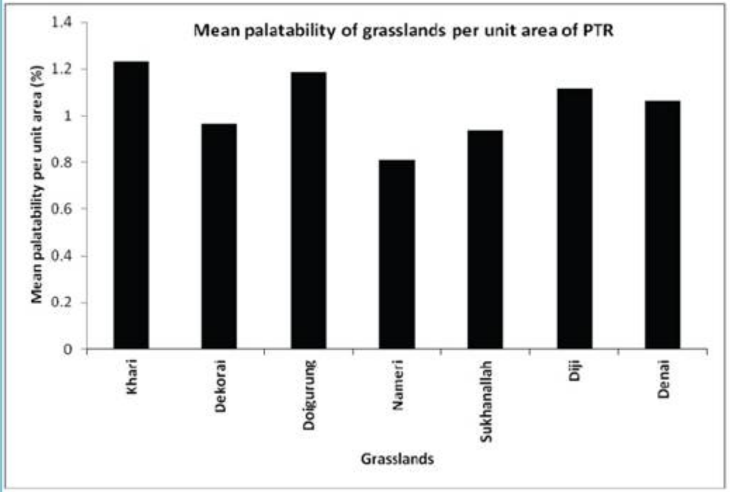


Fig.5: Mean palatability per unit area of the seven grasslands of PTR. Khari grasslands are most palatable (in terms of crude protein content) whereas Dekorai grasslands, the least.

Even though Sukhanallah grasslands were taken into account for the analysis, the number of quadrats laid (in proportion to its area) was too low to interpret results without bias.

Results

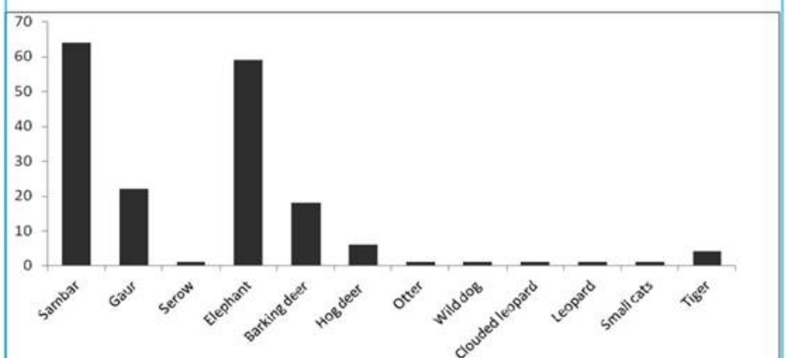
4. Transect analysis

In the 81 transects walked, we encountered signs belonging to 11 different species including sambar, barking deer, elephant, gaur, serow, hog deer, wild dog, otter, tiger, leopard and small Cats (which were clubbed together).

Of the total signs recorded, 64% were fresh signs (n=179). Denai (2.63) was observed to have the maximum number of fresh animal signs per transect, followed by Dekorai (2.22) and Nameri (1.78).Sukhanallah (0), Doigurung (0.67) and Khari (1.65) fared poorly with respect to recent animal presence in their grasslands.

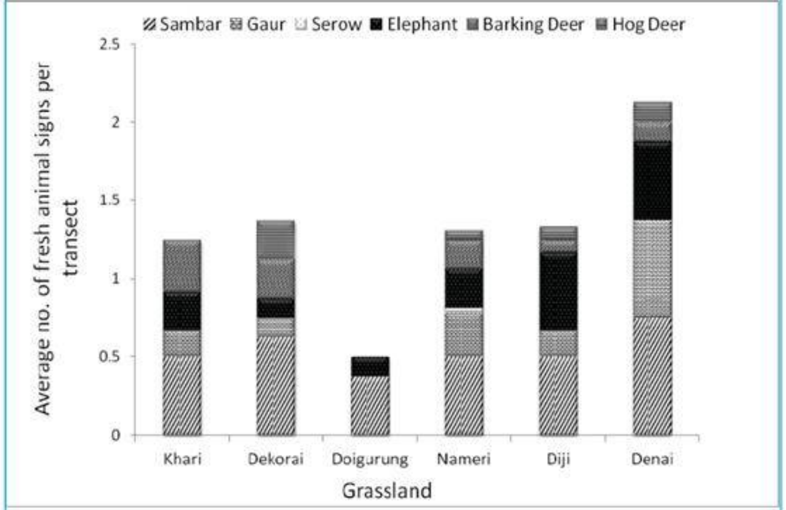
In general, the most frequently encountered signs were that of the sambar which accounted for 35.7% of all recorded signs. Elephant contributed 32.9% and gaur 12.3% to the total number of signs. Thus sambar, elephant and gaur are the most frequent users of grasslands. Amongst the carnivores, tiger was found to have the maximum presence in grasslands, accounting for 2.2% of all animal signs.

Fig.4: The bar graph below represents the number of animal signs encountered on transect across species (n=179).



Results

Fig.5: The bar graph below depicts the average number of fresh animal signs categorized species wise across six grassland sites. Only herbivores were taken into account. Sukhanallah was omitted from the analysis as no fresh signs were encountered



Only sambar and elephant were represented across all the sites and only Nameri had representatives of all the six herbivore species. Doigurung was the poorest in terms of animal diversity, though we caution that this may be a result of the construction and repair work that was going on the this anti-poaching camp during our study. Transect data indicated that grasslands were frequented least by the serow. However, off transect dung collection from grasslands yielded encounters with two other species, i.e. wild pig and porcupine, both with negligible grass content in their diet. The observed frequency was also very low (Wild pig=1, Porcupine =2).

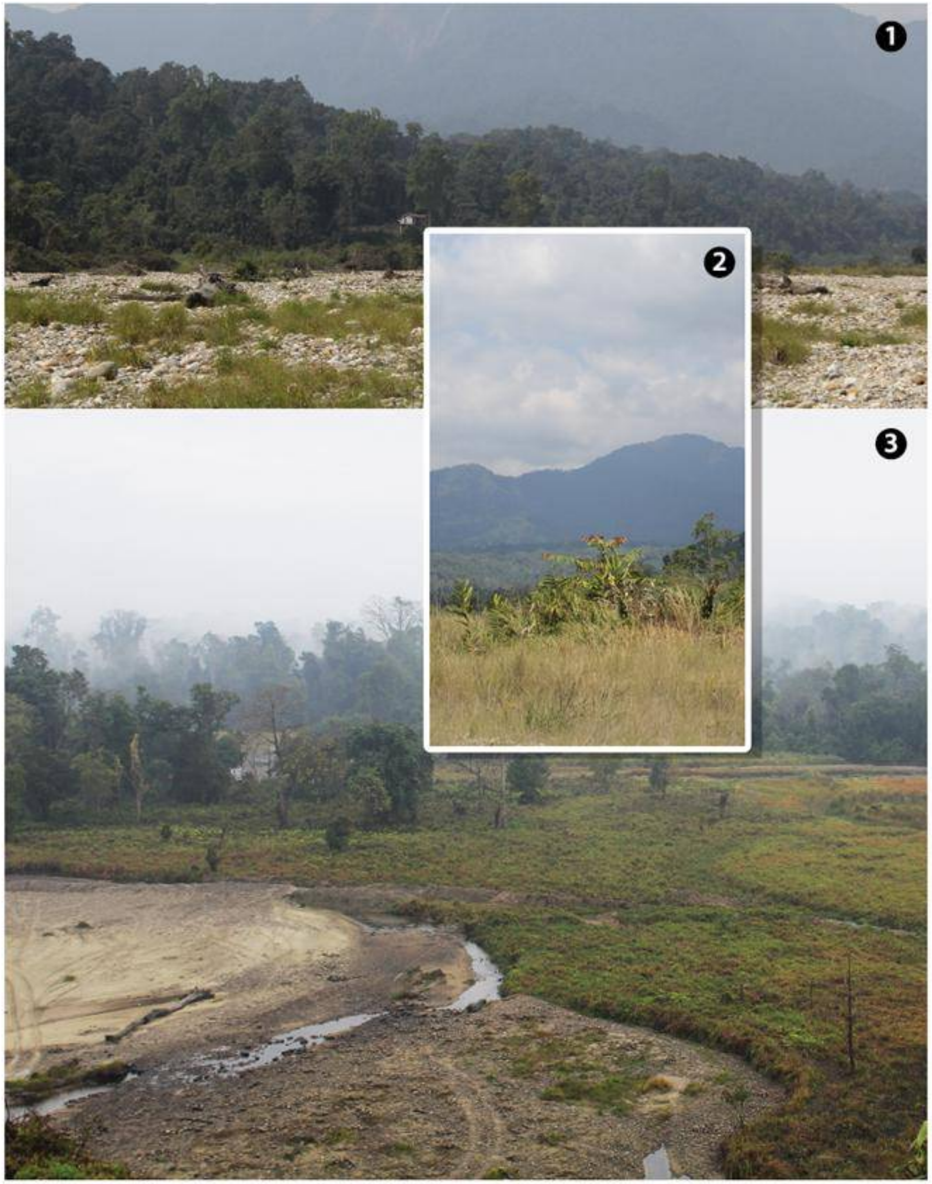


PLATE-13: An overview of the major grasslands in PTR 1) A part of Diji grasslands around Diji Forest Camp | 2) Doigurung Grasslands (unmanaged) | 3) A bird's eye view of the managed (control burnt) parts of Dekorai grasslands

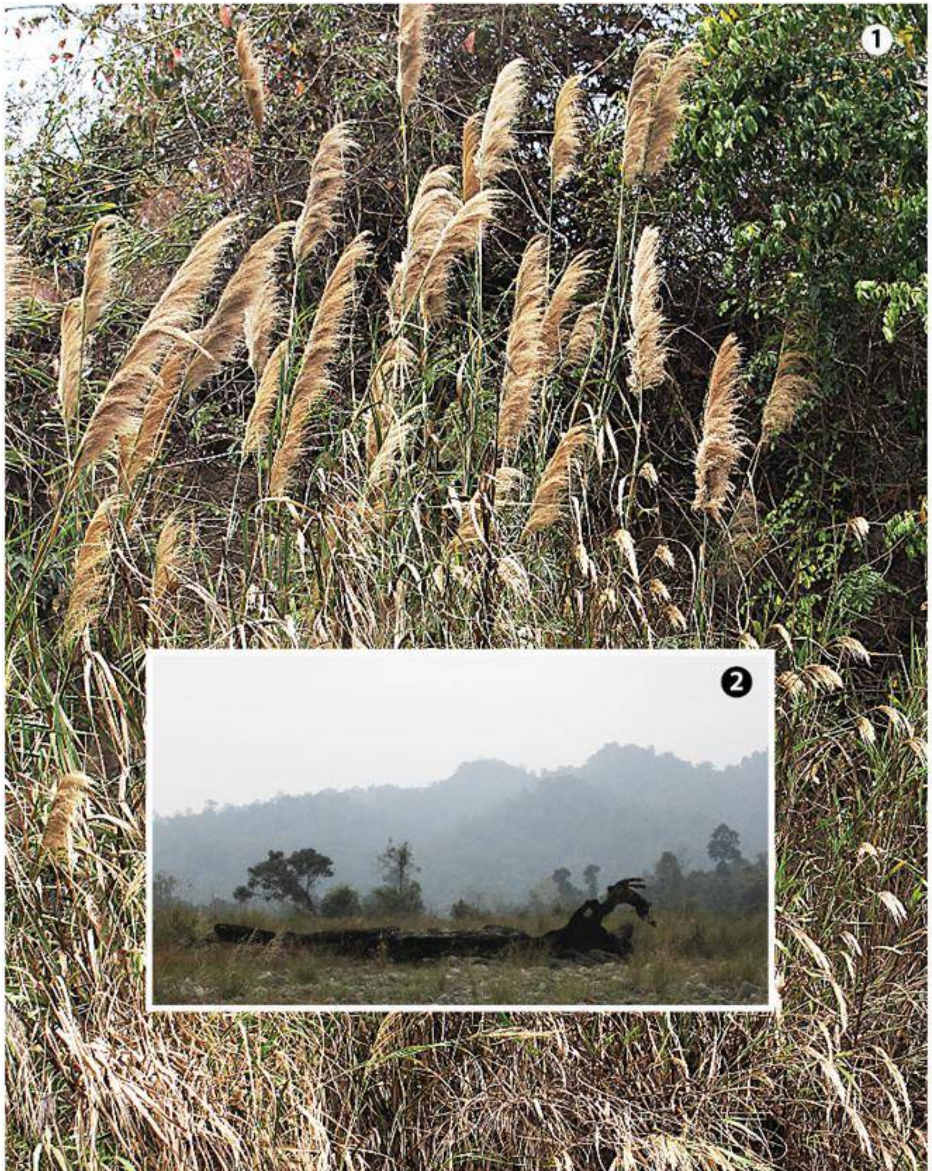


PLATE-14: An overview of the major grasslands in PTR 1) Neyraudia reynaudiana (Kunth) Keng ex A.S.Hitchc and Erianthus longisetosus Anderss on undulating terrain in Denai | 2) Grasslands of Nameri

Results

5. Grass vs. browse ratio

The proportion of grass as compared to browse was calculated taking into consideration the number of fragments that could not be classified as either. We then calculated the mean proportion of grass and browse in the diet across species as well as the standard error associated with each (see Table 3).

Table 3: The following table is indicative of the mean values of proportion of grass in the diet of select herbivore species (sambar, gaur, elephant, hog deer, barking deer, serow, porcupine and wild pig) with their associated standard error and confidence level (95%) values.

Species	Mean proportion of grass in diet	Standard Error	Confidence Level(95.0%)
Sambar (n*=360)	0.36	0.01	0.02
Gaur (n=240)	0.41	0.01	0.02
Elephant (n=180)	0.45	0.02	0.04
Hog Deer (n=140)	0.28	0.01	0.03
Barking Deer (n=100)	0.12	0.02	0.03
Serow (n=60)	0.07	0.01	0.02
Porcupine (n=40)	0.1	0.04	0.08
Wild Pig (n=20)	0.02	0.01	0.26

* denotes the number of microscopic fields observed

Results

The proportion of browse in diet remained higher than the proportion of grass across all species. However, grass forms a substantial part of the diet of large herbivores like elephant and gaur accounting for almost half of their diet. The diet of smaller herbivores like sambar and hog deer comprises of a lesser but significant proportion of grass matter.

Amongst the species sampled, the elephant had the largest proportion of grass in its diet, 0.45 (n=180, SE= 0.02) followed by gaur, 0.41 (n=240, SE= 0.01) and sambar, 0.36(n= 360, SE=0.01). Species with negligible grass intake were wild pig, 0.02(n=20, SE=0.01) Serow, 0.07(n=60, SE=0.01) and porcupine 0.1(n=40, SE=0.04). However, the number of dung samples encountered in and collected from the grasslands in these species was very low.

Fig.3: The box and whisker plot below is the proportion of grass and browse in the diet of sambar, gaur, elephant, hog deer, barking deer, serow, porcupine and wild pig.

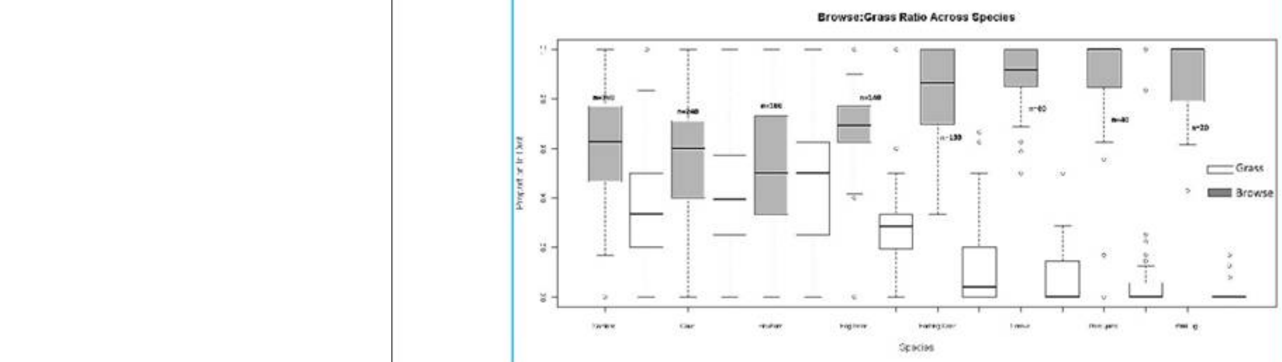


PLATE-15: An overview of the major grasslands in PTR 1) A section of Nameri grasslands currently being managed | 2) Denai grasslands | Doigurung grasslands in the vicinity of the Forest Camp

PLATE-16: An overview of the major grasslands in PTR 1) A foggy view of Khari grasslands | 2) Khari grasslands | 3) Khari grasslands

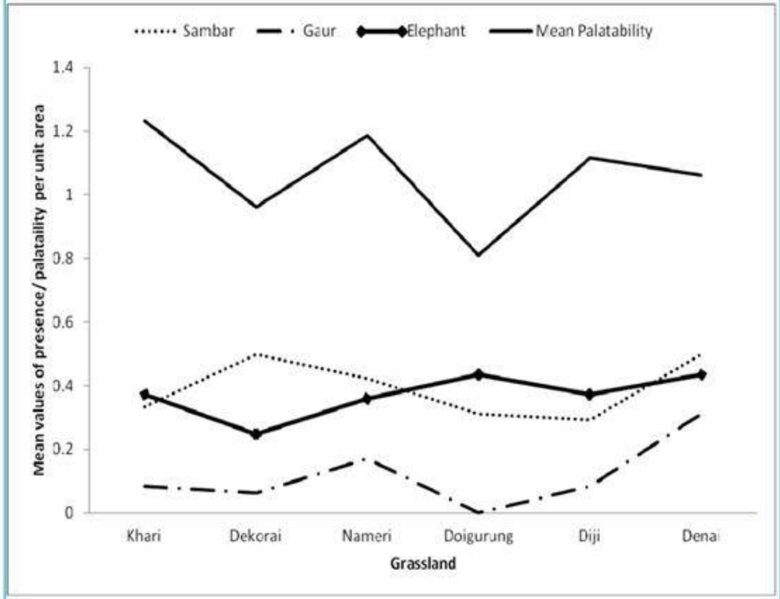
Results

6. Palatability and Animal Presence

Since grass constituted a significant portion of the diet of elephant, gaur and sambar, the presence of these species with respect to the mean palatability of each grassland was compared.

Fig.4: Presence of sambar, gaur and elephant compared with the mean palatability values across grasslands.

It was observed that while Sambar did not show increased presence with increased palatability, Elephant and Gaur presence responded positively to increased palatability. It must be noted that palatability here was indicated by the percentage of crude protein in the plant material. It has been found that a combination of factors like energy content, nutrient content, crude protein, is more likely to give true picture of palatability of any vegetation complex (Hardison, Reid et al. 1954; Heady 1964).



Discussion

On strength of its diversity alone, grasslands of PTR are important habitats rich in both flora and fauna. At least 30% of all mammal species in PTR use grasslands for different purposes. In terms of flora, Nameri grasslands were observed to be the richest while Khari grasslands the most diverse. The diversity of these grasslands is not surprising, given that research even shows that the overall diversity of grasslands may exceed that of the forests (Stott 1991). According to the diversity- stability hypothesis, the grasslands which are more diverse will also be the most stable (Tilman and Downing 1994). Dekorai and Diji fared comparatively poorly may be called the least stable grasslands of PTR.

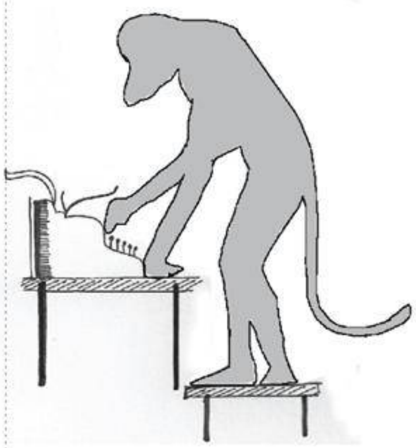
Of all grass species encountered, the percentage contribution of Imperata cylindrica to the grasslands was maximum, followed by Saccharum rufipilum, both species low in palatability. It must be noted that the phenology of the grass species contributed to the increased variation in data. The species which frequented the grasslands most were sambar (35.7%), elephant (32.7%) and gaur (12.3%), all large-herbivores. All three species has a substantial portion of their diet consisting of grass (0.36, 0.45 and 0.41 respectively). The study by Westoby supports this finding reinforcing that large generalist herbivores generally opt for forage which is abundantly available even though it may have low nutritive value (Westoby 1974).

In our study, we took crude protein content as an indicator of nutritive value and palatability. Studies have indicated that protein rich food can be successfully used as an indicator of palatability (Owen-Smith and Novellie 1982). In terms of palatability, we found that the mean palatability per unit area values were highest for Khari followed by Doigurung and Diji. It should be noted that both Khari and Diji were being managed in parts by controlled burning. Another interesting observation is that Diji was found to have the maximum invasive presence giving weight to the findings of Keeley's study which warned against invasive population doing well after prescribed burning.

While sambar occurrence did not respond to palatability values, elephant and gaur occurrence patterns indicated a positive trend with respect to grassland palatability values.

Fresh animal signs put Denai grasslands ahead of the rest in terms of animal presence. Nameri was the only grassland to have recorded signs (old and new) from all six major herbivore species (sambar, elephant, gaur, barking deer, serow and wild pig). Proportion of grass in the diet of the three major grassland users makes it obvious that these species are dependent on these habitats for their survival. Moreover, other species recorded in the grasslands just indicate that grasslands are important for them to fulfil their other functional needs.

PTR has had its share of problems- namely hunting. Therefore constant monitoring is required for creating favourable habitats for herbivores to ensure their steady recovery. In such a scenario, management of grasslands for diversity maintenance is not an option. It the need of the hour.



Chapter 3

GRASSLAND AND HABITAT MAPPING OF PAKKE TIGER RESERVE

FERAL

FOUNDATION FOR ECOLOGICAL RESEARCH, ADVOCACY AND LEARNING TAMIL NADU, INDIA

S.Sivakumar*, Rajat Ramakant Nayak, Srinivas Vaidyanathan
Foundation for Ecological Research Advocacy and learning
170/3 Morattandi, Auroville Post
Tamil Nadu – 605 101, India
Ph: +91413 2671566 Fax: +91413 2671567
Email: **feral@feralindia.org** Web: **http://www.feralindia.org**
*Corresponding person: **geosivakumar@gmail.com**

Bite marks of herbivores on Jharu kher in Nameri Grasslands

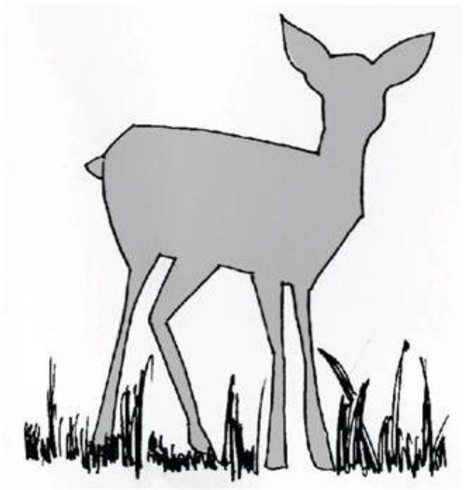
Introduction

Wildlife management often involves the management of their habitats. For effective wildlife management, it is important to understand different natural environments available for different species of flora and fauna in a protected area. In this study we used GIS tools and remotely sensed information along with field data to:

1. Map different habitats (land cover types) available in the Pakke Tiger Reserve (PTR). We also looked at changes in land-cover types over the years as a response to protection measures undertaken in the protected area.

2. Create fire frequency maps to provide information about areas that are susceptible to fire and suggest allocation of resources required during fire-prone seasons to manage it.

3. Develop a final map providing information on streams, villages, and different features such as anti-poaching camps in PTR.



Land-cover mapping (2014 and 2002)

Satellite remote sensing programs have produced an archive of images of the earth that are becoming an increasingly valuable source of data for the study of land cover types and the changes in them. The foremost example is the Landsat program, which has been in operation since 1972. The entire Landsat archive has become freely available, allowing public access to time-series data for most parts of the world. We used cloud free Landsat data for the year 2014 and 2002 to develop land-cover maps for these years. We then compared the changes in different land-cover features between 2002 and 2014.

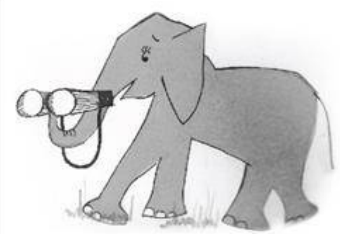
Materials and Methods

Land-cover mapping (2014 and 2002)

Image acquisition and pre-processing: The Landsat geo cover data set was downloaded from the global land cover facility (GLCF) (http://glcf.umd.edu) and USGS sites (http://earthexplorer.usgs.gov). Cloud free Landsat-ETM+ and Landsat-OLI8-TIRS images were collected for the years 2002 and 2014 respectively. The images were projected to UTM zone 46 (WGS 1984 datum) using a nearest neighbour algorithm with a cell size of 28.5 m resolution. The multi-temporal satellite data in the present large scale study poses a number of challenges, which include geometric correction error, noise erasing from atmospheric effect, and the errors due to changing in illumination geometry and instrument errors. These errors were rectified through image pre-processing techniques of the satellite data, which was carried out using image software GRASS GIS 7.0. This mainly included radiometric correction and geometric rectification which converted digital numbers (DN) to surface reflectance. The data was further corrected for shadow and scattering using dark object subtraction-1 (DOS-1) method.

Training site development: We generated the False Colour Composite (FCC) from the rectified Landsat images. FCC was then enhanced through the histogram equalization method to distinguish different land cover features. The ground-truth points collected from the field in the year 2013 were overlaid on the enhanced FCC for the year 2014. We used this to develop training sites for different land-cover types – tropical and sub-tropical primary and secondary forests, Assam valley evergreen and semi-evergreen primary and secondary forests, riverine forests, grasslands and bamboo forests, for the year 2014. Training sites for the year 2002 were developed using 2002 FCC along with 2002 True Colour Composite (TCC), unsupervised classification map and training points derived from 2014 land-cover classification. The generated training sites were analyzed for signature similarity for different classes between 2014 and 2002 and signature separability among different classes for 2002.

Image classification: The image classification of the satellite data was carried out using ENVI 4.7 image software. The supervised and unsupervised signature extraction techniques were used to classify the images in the present study. The supervised classification was carried out by using the maximum likelihood method.



Firefrequency mapping:

We used moderate resolution imaging spectrometer (MODIS) Collection 5 active fire products **(http://maps.geog.umd.edu)** and burned area products (MCD45) **(http://modis-fire.umd.edu)**, from January 2001 to May 2014, for identifying areas with different fire frequencies in the PTR. MODIS fire products are used extensively to detect and model the frequency and occurrence of fires worldwide, and have been found to be relatively accurate and reliable for open forests. However, in closed canopy forests low intensity ground fires could go undetected by the satellite sensors.

Results

Land-cover mapping (2014 and 2002)

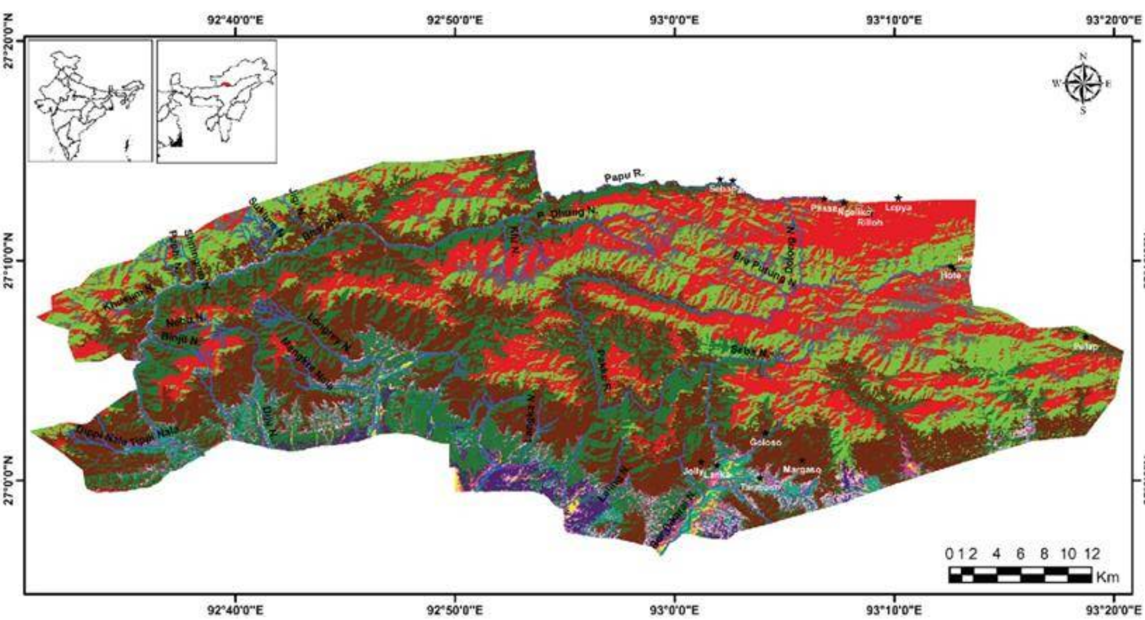
Figures 1 (a, b) and 2 (a, b) show land-cover classes for the years 2014 and 2002 respectively. An area wise comparison of different habitat features between the two years is given in table

Table 2. Comparison of land-cover features between the years 2014 and 2002

Land cover type	2014 Area (km2)			2002 Area (km2)		
	Core	Buffer	Total	Core	Buffer	Total
Grasslands	7.00 (0.7%)	0.7 (0.1%)	7.7 (0.4%)	10.9 (1.2%)	4.2 (0.5%)	15.1 (0.9%)
River	9.71 (1%)	2.3 (0.3%)	12.0 (0.7%)	1.5 (0.2%)	0.3 (0%)	1.9 (0.1%)
Riverine forest	8.69 (0.9%)	6.3 (0.8%)	15 (0.9%)	18.8 (2.0%)	8.3 (1%)	27.1 (1.5%)
Fallow/slash and burn	3.98 (0.4%)	11.7 (1.4%)	15.6 (0.9%)	26.6 (2.8%)	20.2 (2.5%)	46.8 (2.7%)
Secondary Bamboo forest	0	1.2 (0.2%)	1.2 (0.1%)	25.5 (2.7)	34.6 (4.3%)	60.0 (3.4%)
Assam valley tropical evergreen primary forest	358.09 (38%)	167.5 (20.7%)	525.6 (29.9%)	229.7 (24.3%)	84.8 (10.5%)	314.5 (17.9%)
Assam valley tropical evergreen secondary forest	142.6 (15%)	202.1 (24.9%)	344.7 (19.6%)	271.4 (28.7%)	219.1 (27.1%)	490.5 (28%)
Assam valley tropical semi-evergreen primary forest	74.34 (7%)	18.8 (2.3%)	93.1 (5.3%)	29.3 (3.1%)	6.3 (0.8%)	35.6 (2%)
Assam valley tropical semi-evergreen secondary forest	24.33 (2.5%)	12.0 (1.5%)	36.3 (2.1%)	18.4 (2.0%)	15.0 (1.9%)	33.5 (1.9%)
Subtropical broad leaved primary forest	271.87 (29%)	317.3 (39.2%)	589.2 (33.6%)	204.8 (21.7%)	203.6 (25.1%)	408.3 (23.3%)
Subtropical broad leaved secondary forest	44.63 (4.7%)	70.2 (8.7%)	114.9 (6.5%)	108.0 (11.4%)	213.3 (26.3%)	321.4 (18.3%)
TOTAL	**945**	**810**	**1755**	**945**	**810**	**1755**

The accuracy of the land-cover maps developed relies on training data (sites for which there are direct observations of land cover) that coincide temporally with the images used. Training data, however, was not available for the year 2002. Different methods and sources were used to develop training sites with higher accuracy. However, there is a possibility of few errors in the map for the year 2002.

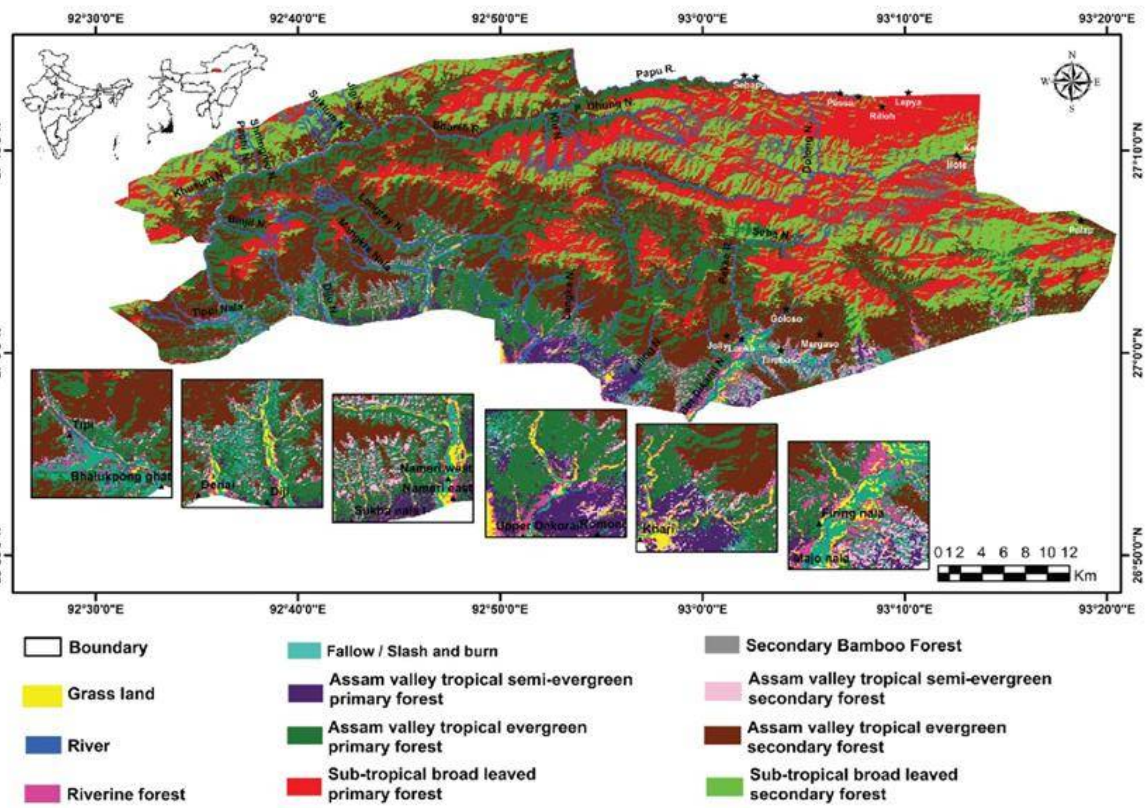
Land Cover Classification-PTR(2002)



Boundary	Fallow / Slash and burn	Secondary Bamboo Forest
Grass land	Assam valley tropical semi-evergreen primary forest	Assam valley tropical semi-evergreen secondary forest
River	Assam valley tropical evergreen primary forest	Assam valley tropical evergreen secondary forest
Riverine forest	Sub-tropical broad leaved primary forest	Sub-tropical broad leaved secondary forest

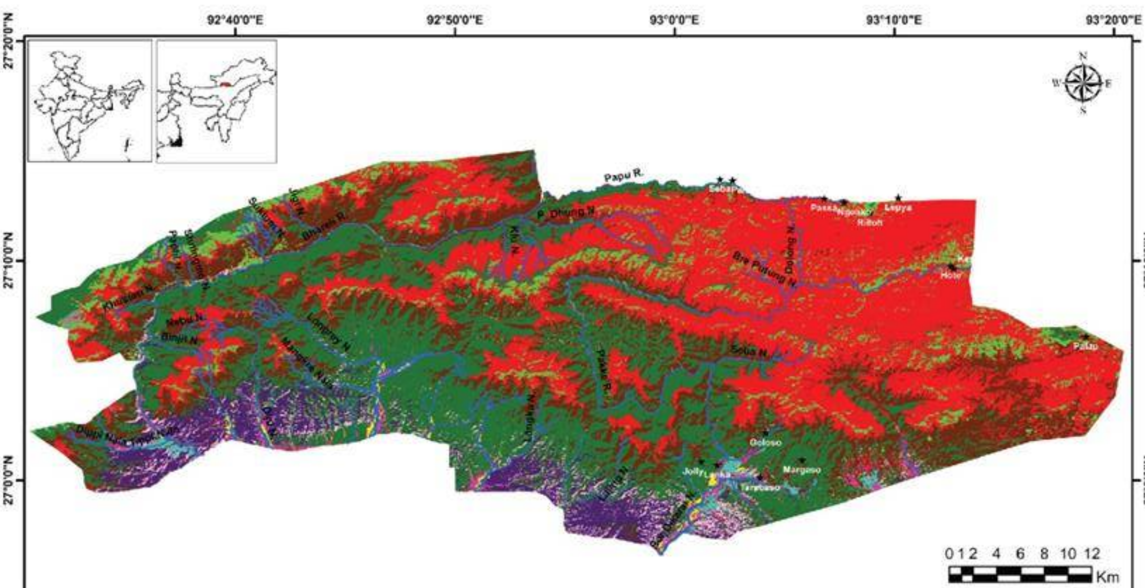
Grassland and Habitat Mapping Study FERAL , 2014

Land Cover Classification-PTR(2002)



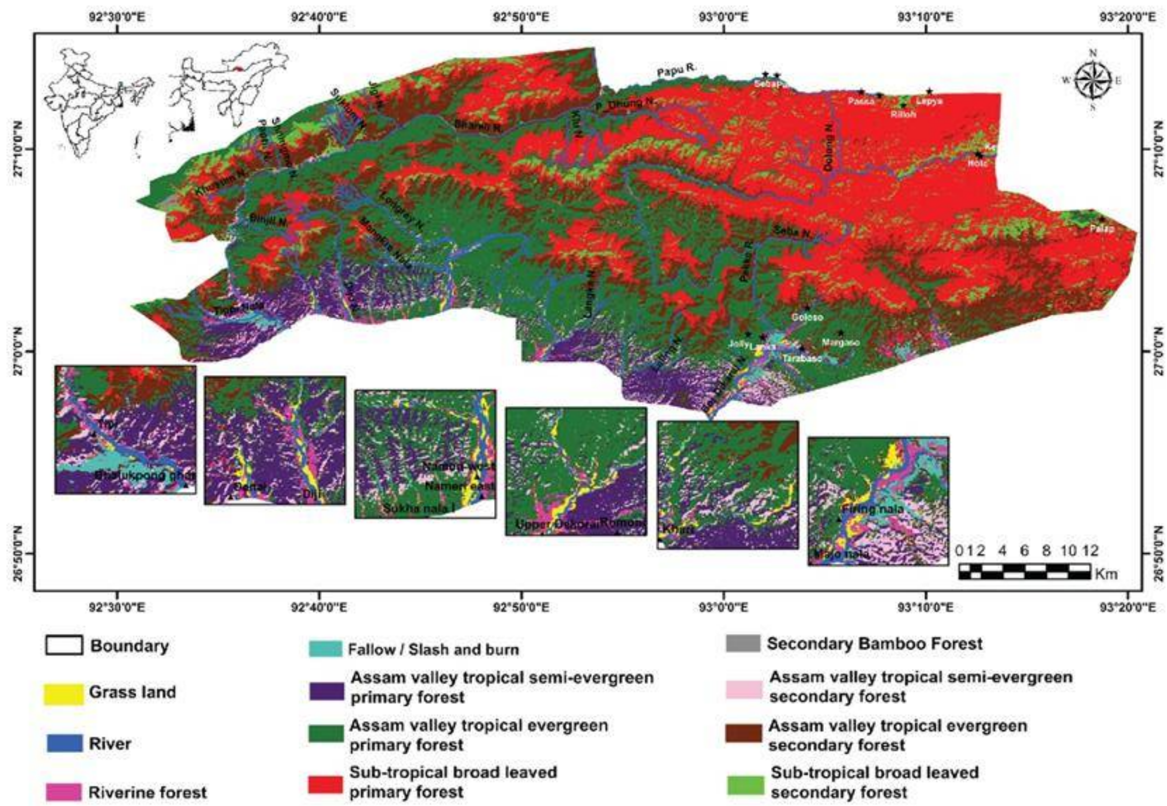
Grassland and Habitat Mapping Study FERAL , 2014

Land Cover Classification-PTR(2014)



Boundary	Fallow / Slash and burn	Secondary Bamboo Forest
Grass land	Assam valley tropical semi-evergreen primary forest	Assam valley tropical semi-evergreen secondary forest
River	Assam valley tropical evergreen primary forest	Assam valley tropical evergreen secondary forest
Riverine forest	Sub-tropical broad leaved primary forest	Sub-tropical broad leaved secondary forest

Land Cover Classification-PTR(2014)



Results

Fire frequency mapping:

Figure 3 shows trend in of forest fires between 2001 and 2014. Greater numbers of fires were detected near the northern boundary of the reserve. Table 2 provides information on fire frequency from 2001 to 2014.

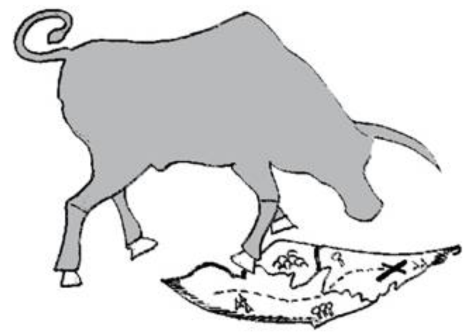
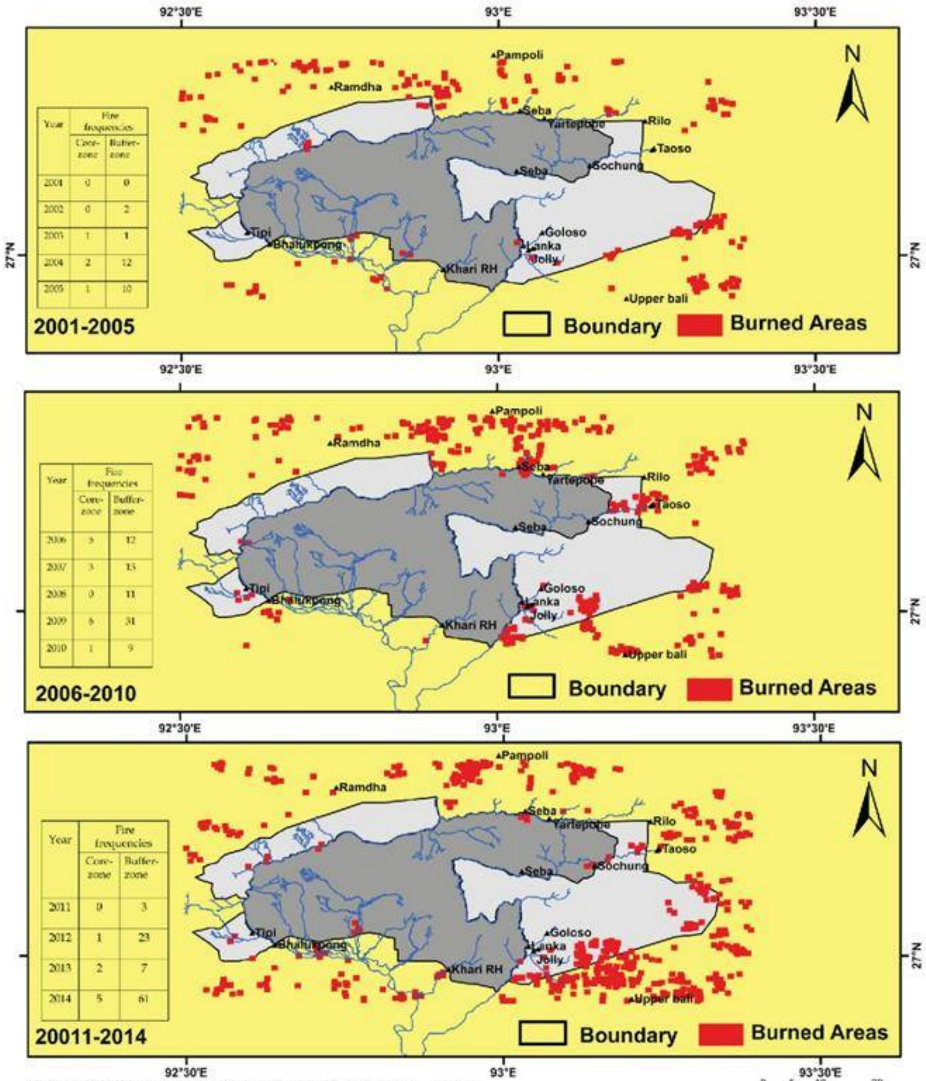


Table 3. Trend in fire frequencies in PTR from2001 to 2014

Year	Number of fires detected in core zone	Number of fires detected in buffer zone	Total
2001	0	0	0
2002	0	2	2
2003	1	1	2
2004	2	12	14
2005	1	10	11
2006	5	12	17
2007	3	13	16
2008	0	11	11
2009	6	31	37
2010	1	9	10
2011	0	3	3
2012	1	23	24
2013	2	7	9
2014	5	61	66
Total	**27**	**195**	**222**

Incidences of Fire in Pakke Tiger Reserve (2001-2014)



Year	Fire frequencies	
	Core-zone	Buffer-zone
2001	0	0
2002	0	2
2003	1	1
2004	2	12
2005	1	10

Year	Fire frequencies	
	Core-zone	Buffer-zone
2006	3	12
2007	3	13
2008	0	11
2009	6	31
2010	1	9

Year	Fire frequencies	
	Core-zone	Buffer-zone
2011	0	3
2012	1	23
2013	2	7
2014	5	61

Grassland and Habitat Mapping Study FERAL , 2014

0 5 10 20 Km

Results

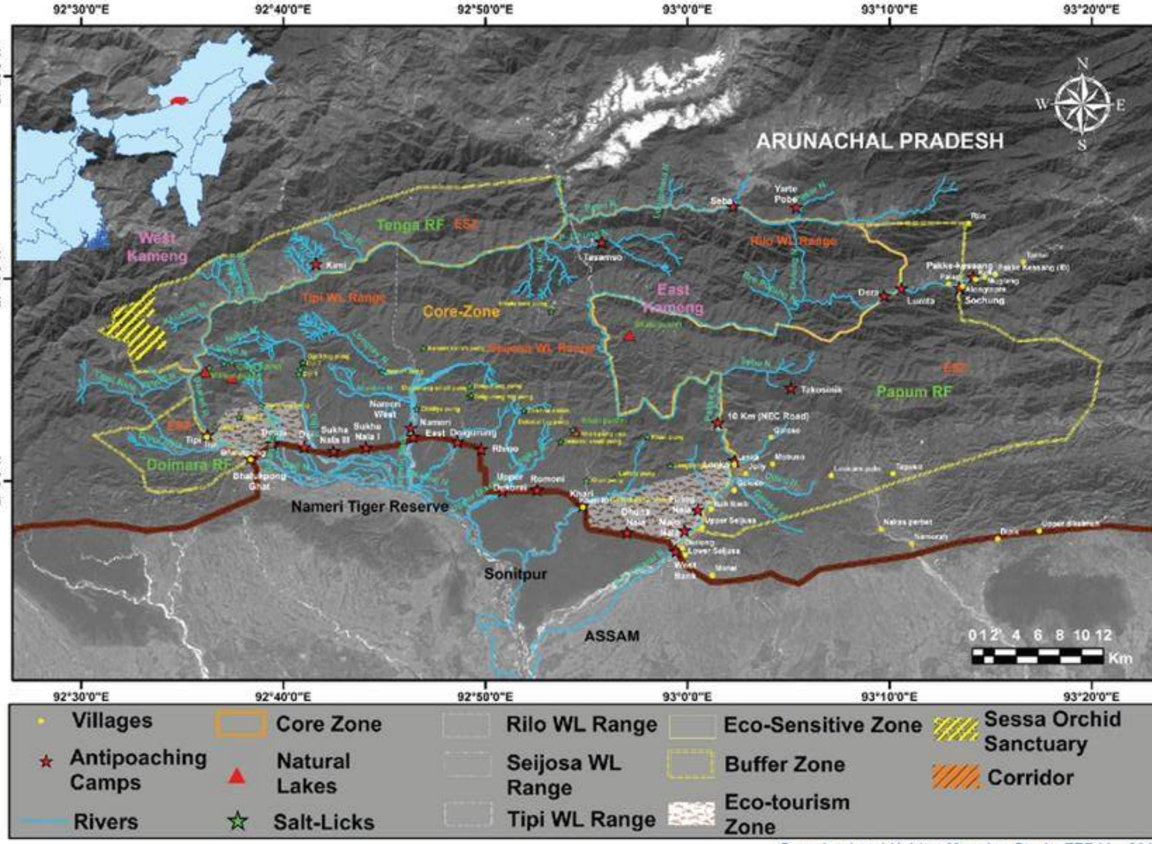
Pakke Tiger Reserve map

Figure 4 is a map of PTR giving information on administrative and management zones along with important features such as streams, anti-poaching camps (APCs), salt-licks, villages, watch-towers, corridors, etc. This map can be used as a reference by the forest department guards and watchers who will be patrolling this vast stretch of protected area.

Table 3. Areas of different administrative management zones in PTR:

Sr. no	Administrative/ Management Zones	Area (Sq.km)
1	Core-Zone	945
2	Buffer-Zone	810
3	Rilo Wildlife Range	235.67
4	Seijosa Wildlife Range	453.22
5	Tipi Wildlife Range	256.44
6	Papum Reserved Forest	547.74
7	Tenga Reserved Forest	209.65
8	Doimara Reserved Forest	52.71
9	Eco-Sensitive Zone	810
10	Eco-Tourism Zone	77.22
11	Sessa orchid sentuary	16.61

Pakke Tiger Reserve



Grassland and Habitat Mapping Study, FERAL , 2014

Appendix II: Qualitative Description of Grasslands Sampled Within PTR

Denai

In general the grassland meanders along the river. The grassland extent along the river is much narrower than others. This is because the river is in close proximity to hilly areas. In general along the river there are few overhanging rock faces, with *Pogonatherum crinitum* (khargosh gaas). The soil seems to be sandy, both in the grassland and the riverine forest. Perennial grasses such as *Neyraudia reynaudiana* were sparse; the grassland was dominated by *Imperata cylindrica* and Jhaadoo kher. Grasses found under the canopy were *Cyrtococcum accrescens* and *Oplismenus burmanii*. We recorded grazing marks on *Neyraudia reynaudiana, Imperata cylindrica.* Elephant trainers stated that Denai was not a suitable place to keep camp elephants due to the lack of good forage. *Aegaratum conyzoides* was the dominant invasive species. Other weedy species such as *Pteridium aquilinium* were also seen.

Diji

Diji had three major grass complexes. First complex was grass species such as *Saccharum rufipilum* and *Imperata cylindrica* that are found close to the river. *Phragmites karka* is a common species encountered close to the river. Second complex was of *Neyraudia reynaudiana*, Jaado Kher and *Imperata cylindrica* which was found with increasing distance away from the river. Second to Nameri, Diji has a fairly large area of permanent grasslands dominated by patches of *Neyraudia reynaudiana* and/or a mix of *Neyraudia reynaudiana* and *Imperata cylindrica*. *Oplismenus composites, Cyrtococcum accrescens* and *Oplismenus burmanii* are found closer to the forest and woody areas. Elephant trainers stated that Diji was a good place to keep elephants as it had sufficient forage for camp elephants. Close to the camp, few areas have been burnt and have been invaded by *Eupatorium sp* and *Mikania micrantha*. We recorded grazing marks on *Imperata cylindrica*. We also observed the pugmarks of two individual tigers walking together.

Nameri

The Nameri grassland has the largest grassland extent in PTR. This area may have the oldest grasslands in PTR. The tallest grasses were found here and there was mono-dominance in some grass stands along with near absence of invasives. Closest to the river *Saccharum rufipilum* was the most dominant grass species. *Phragmites karka*, Madhuri and sedges were encountered in water logged areas. Other areas both close and far away from the river had presence of *Imperata cylindrica, Saccharum rufipilum, Saccharum spontaneum* and Jhadoo kher. *Oplismenus composites, Cyrtococcum accrescens* and *Oplismenus burmanii* were commonly found under the canopy. Nameri is one of the few grasslands that has tall stands of *Neyraudia reynaudiana*. Along the pung nallah river, there were tall stands of this species that were heavily grazed at a height of approximately 2 m, which may indicate the importance of *Neyraudia reynaudiana* in the diet of elephants. We recorded numerous grazing marks on young *Saccharum procerum, Neyraudia reynaudiana*, young Imperata cylindrica and young *Saccharum rufipilum*.

Doigurung

This grassland is characterised by presence of *Imperata cylindrica* of varying age structure (called Uloo kher when small and Berenga kher when tall). The presence of numerous tall stands of *Imperata cylindrica* was particularly striking in this grassland. Similar to other grasslands, *Saccharum rufipilum* was a dominant species close to the river. *Pogonatherum crinitum* was comonly encountered on rock faces in pung nallah on the way to Doigurung pung.

Dekorai

The part that was managed in front mainly had *Imperata cylindrica* intersperesed with Jhadoo kher. The burnt areas had *Clerodendron* and other invasives, of which *Mikania micrantha* was the most common. The presence of thick undergrowth in some areas indicates that burning does not happen in the same patches regularly, but different patches may be burnt yearly. *Thysanolaena maxima* was encountered more in Dekorai and Khari, as compared to other grasslands.

Khari

A grassland was created in a gently undulating part of the forest on the way to Khari (N 26.93495; E 92.98736), a year after PTR was declared as a Widlife Sanctuary. The dominant grass species were *Imperata cylindrica. Eupatorium* and *Ageratum* were commonly encountered in the open areas. The tree species found in this patch were *Macaranga peltata, Bauhinia variegata, Prunus ceylanica, Tetrameles nudiflora* and *Duabanga grandiflora*.

Along the Laling and Khari river, the grasslands are dominated by *Imperata cylindrica* and *Saccharum rufipilum*. The rock faces have *Thysanolaena maxima*.

Ditchu

Cows were seen grazing on younger leaves of *Saccharum rufipilum*. There were graze marks on *Imperata cylindrica*. Sedges were more frequently encountered compared to other areas. In water logged areas Thorani *(Alpinia allughas)* was most frequently encountered along with a few strands of *Neyraudia reynaudiana. Erianthus longisetosus, Thysanolaena maxima* and *Neyraudia reynaudiana* were seen in association with each other on the rock faces overlooking the river. *Pogonatherum crinitum* was also observed on the rock faces though with no apparent association with the other three. Between Majo nala and Langbang camp part of the way under forest canopy was occupied by the various species like *Oplismenus compositus, O. burmanii, Panicum spp* and *Cyrtococcum accrescens*. The open canopied grasslands were dominated by *Imperata cylindrica* and *Saccharum rufipilum. Phragmites karka* was also encountered, the maximum across sites. Along the river 'Arali ghaas' and a number of sedges were also present. Elephant dung (old) was seen in multiple places and cattle presence was observed all along the grasslands. *Eupartorium sp, Mikania sp*, and *Ageratum sp* were present, *Eupatorium* being most dominant, followed by *Ageratum*.

Appendix III: Uses of some common plant species frequently encountered in grasslands of PTR

1. Madhuri
Used to make "gaadi" for elephants and as sleeping mats. Leaves are flattened after sun drying and weaved. Madhuri is preferred over cane and bamboo mats, as it can be folded quite easily.

2. *Alpinia allughas*
'Rapik' or tender 'thorani' *(Alpinia allughas)* ripens during March. Is fed to elephants and is a preferred food.

3. *Crassocephalum crepilioides*
Commonly called 'am saag' is used in chutnies.

4. *Pouzolzia bennettiana*
Young leaves of Laafa sag or Woikoa hairy leaf is used in dal in February-March and becomes soft and slippery when cooked.

5. *Clerodendrum viscosum*
Clerodendron leaves are dried and are mixed together in a ball with white rice and used to brew rice and millet wine.

6. *Stenochlaena palustris*
'Dhekia saag' is used in cooking from December to February.

7. *Pteridium aquilinium*
Pteridium aquilinium or 'bee dekia' is used to ward off mites in chicken coops.

8. Phutuka sweet to taste, fruits ripen by early April.

9. *Imperata cylindrica*
Kher *(Imperata cylindrica)* is used for thatching, about 3000 to 4000 leaves for roughly a 8 ft x 8 ft sized room, to be replaced every 7 years. But thatching is now not preferred as there is a tendency for rats to hide in the thatching made of this material. The quantity required in terms of bundles of grass (1ft circumference) would be 600-700 depending on craftsmanship. These are sold in the market for Rs. 5 per bundle.

Uloo kher (smaller sized *Imperata cylindrica*) lasts about 5 years, while Berenga kher (more mature, larger sized *Imperata cylindrica*) lasts 3-4 years in thatch.

Tokko and Beth are more popular as thatch material as compared to kher.

Kher is also used as fodder for animals, younger kher is preferred. Elephants eat both young and mature kher.

10. *Saccharum rufipilum*
It is preferred by elephants as food due to its sweet taste. The baby elephants prefer Phragmites karka and Khagri among grasses. Torani is also given to them.

11. *Cymbopogon sp.*
Gan birina or *Cymbopogon* sp is used for fencing. Bamboos aside, Ikra (did not come across this species during the study) is the most preferred fencing material. Is known to last for more than 20-25 years as long as it does not get wet. It is now not too commonly seen in the jungle or in markets.

12. *Thysanolaena maxima*
Brooms are made for commercial purposes. *Thysanolaena* is used for making phool jharu, about 60 culms in one jharu. It is sold for Rs. 30 in the market.

13. Jharu kher
Jhadoo kher is used to make adivasi jharu both for domestic use and selling in the market. 150- 200 culms with inflorescence are required for one jharu. It sells for Rs. 40 to Rs 50. in the market.

Those who made it happen!

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Montu Basumatary

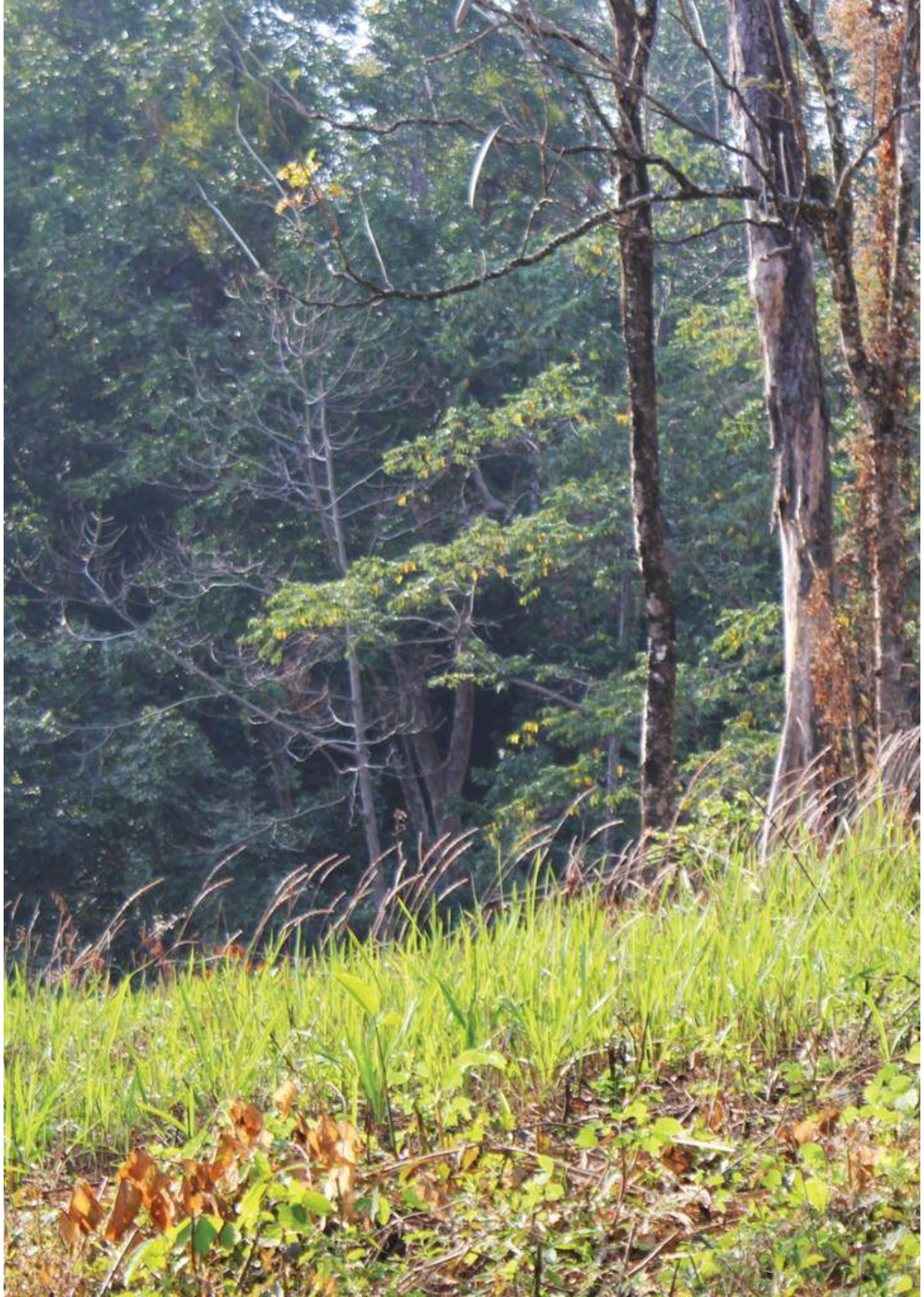
Elephants,Gulab singh, Raja, Manick and Bahadur with the indispensible haathi mahuts

Kishore

Sanjay Tissoo

Chandan Ri

Nandini Velho and Shivram Theron



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JAMES COOK UNIVERSITY AUSTRALIA

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