Grassland Communities of Terai Conservation Landscape: Effects of Management Practices and Conservation Strategies

Abstract

Terai Conservation Landscape (TCL) was conceived as a system for landscape-scale conservation of large mammals, viz., tiger, one-horned rhino and Asian elephant along with their habitats, especially tall wet grasslands. This landscape encompasses a spatially heterogeneous landscape including two protected areas, viz., Dudhwa National Park, Kishanpur Wildlife Sanctuary, and two managed forests viz. North and South Kheri forest divisions, in the state of Uttar Pradesh. The landscape is characterized by a mosaic of moist deciduous sal (*Shorea robusta*) dominated forest interspersed with numerous swamps and tall, wet grasslands. We quantified the plant community structure and composition across major grasslands of TCL and assessed the effects of ongoing management practices on them. This paper highlights the need for adaptive management practices along with need for long term monitoring.

Key words: Burning; Harrowing; *Desmostachya bipinnata*; Terai grassland.

Introduction

Terai Conservation Landscape (TCL) was conceived as a vast extent of dynamic forest-grassland-wetland complex in flood plains of Sharada and Ghagara systems in Uttar Pradesh (UP), representing habitat for tiger, one-horned rhino and Asian elephant (Kumar, 1998, 2002, 2013, 2014; Kumar et al. 2002). Main features of this landscape are extensive tall wet grasslands which are among the home to a large number of threatened species. These grasslands represent successional continuum ranging from early seral stages established within new alluvial deposits to mixed wooded savanna like formations and climax forests dominated by gregarious sal (*Shorea robusta*). Sal occupies older, established and well drained alluvium while low lying and stream banks are areas that are replaced by riverine species such as *Syzygium cuminii* and *Trewia nudiflora* (Champion and Seth, 1968; Lemkuhl, 1994). In seasonally flooded alluvial flats, however, recurrence of early to mid seral communities represented by *Acacia catechu* and *Dalbargia sissoo* can be seen.

Several workers have studied structure and composition of grassland communities in Terai region of UP, e.g., Gupta and Shukla (1991); Pandey and Shukla (1999, 2003, 2005); Tripathi and Shukla (2007); Srivastava (1976); Shukla (2009); Biswas and Mathur (2003); Lahkar (2008); Khatri and Barua (2011). However, very few workers have conducted landscape level analysis of vegetation in relation to environmental changes in this region. Mathur et al. (2003) have identified nine different grassland communities in Dudhwa National Park which can be grouped into two categories, viz., the upland, dominated by short grasses upto 2m in height, e.g., *Imperata cylindrica, Desmostachya bipinnata* and the grasslands of lowlands characterized by tall (~ 6m) grasses dominated by *Sclerostachya fusca, Saccharum narenga* and *Themeda arundanacea*.

The grasslands in TCL have been extensively grazed, harvested, and annually burned since long time except in the Dudhwa National Park where livestock grazing and grass harvest have been officially banned for more than past 20 years. However, some level of illegal grazing and harvest of grasses in peripheral areas does take place and occasionally. Within Dudhwa, some grasslands were harrowed and burned to promote new grass growth during recent past. In order to assess the impacts of such management practices and to see the status of grasslands within the larger landscape, we initiated a study during 1998. The effect of different treatments and seasons on the above ground biomass and habitat use by two ungulates i.e. swamp deer and hog deer was measured to assess the effectiveness of different management practices by the park managers. The grassland management practices within the park were (1) grass cut and burned; (2) grass cut, removed, and burned; (3) grass harrowed and burned; and (4) grass burned for assessing the impact of different treatments on the above ground biomass and relative pellet occurrence of two ungulate species i.e. hog deer and swamp deer in in the short upland and tall lowland grassland types.

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Materials and Methods

Site description

The Terai Conservation Lanscape (TCL) is spread across four districts viz., Lakhimpur Kheri, Pilibhit, Shahjahanpur and Bahraich in the state of UP between 27° 49' and 28°43' N Latitudes and 81° 01' and 81° 18' E Longitudes. The TCL constitutes a spatially heterogeneous landscape of PAs, including Dudhwa National Park (DNP) and Kishanpur Wildlife Sanctuary (KWS), and managed forests (MFs) of North Kheri and South Kheri Forest Divisions within a matrix of private agricultural lands. The major portion of the TCL (~97%) comes under Lakhimpur Kheri with altitude ranging from 150 m in the south-east to 182 m in the north. The alluvial soils range from sandy in elevated areas and along the high banks of river to loamy in the level uplands, and clays in depressions. The climate of Terai region is typically tropical monsoon type with three distinct seasons: winter (mid October to mid March), summer (mid March to mid June), and monsoon (mid June to mid October). Temperature and humidity extremes occur in different seasons; heavy dew fall during winter, frequent frosts in December to mid February with January as the coldest month (mean maximum 19.6°C; mean minimum 8.8°C). May and June are the hottest months with mean maximum 42.7°C.

Grassland Sampling

The grasslands of TCL were stratified into two categories, viz., Upland and Lowland types. The former is characterized by sparse trees and shorter grasses while the latter is devoid of trees, mainly due to their annual flooding and burning. A total of 293 plots of 10m x 10m were laid covering 24 different patches in the upland and lowland grasslands. Cover and abundance were estimated for grasses, shrubs, herbs, and sedges. Data collection in grasslands was carried out in the post-rainy season i.e. October-December, 1999 and 2000, when the majority of grasses and other herbs were flowering, aiding identification, and also just before grasses were ready to be burnt in January-February. Lowland grasslands were inaccessible on foot due to surrounding swamps. Here plots of (10m x 10m) were marked and quantified from the elephant back. Cover/abundance for each species was rated on the Domin scale (1-10, or a "+" for solitary plants). This was done as described by Mueller-Dombois and Ellenberg (1974). Unknown species were described, numbered, and collected for later identification.

Treatments, Sampling and Data Analysis

Representative areas of the upland (*I. cylindrica – D. bipinnata*) and Lowland (*S. fusca – S. spontaneum*) grasslands in the Madria and Sathiana areas of the DNP were selected to test the effects of burning. Plots of 100 x 260 m (replicated three times) were laid out in each grassland type and split into five 100 x 50 m treatment sub-plots for the four burning treatment plus a control block which was separated by 10m fire-break. Before the burning treatments were applied, quadrats were sampled to establish a baseline for plant composition; phenology, grass height, above-ground total biomass and pellet count (swamp deer and hog deer) were done in January 1998. The different treatments (i.e., grass cutting, removal, harrowing) were completed by 25 January followed by burning on 28 January, 3 February, and 5 February for three consecutive years i.e. 1998, 1999, and 2000, respectively.

Standing biomass was assessed in 10 random 1 x 1m quadrats in each treatment plot. Standing biomass (live and dead) was cut at the ground level with sickles and weighed in the field. Biomass was sorted and fresh weight for each species recorded. Sub-samples (about 100g) were chopped, transferred to separate paper bags, weighed, dried in a hot-air oven at 800 C and weighed to determine dry weight. The values for the 10 plots were averaged to provide a biomass estimate for treatment plots at each sample date. The grassland classification analysis was carried out using the polythetic divisive clustering technique TWINSPAN (Hill, 1979). Pseudo-species cut levels were set at 2%, 5%, 25%, 50%, and 75% cover, whilst all other options were set to default levels. The groups resulting from the TWINSPAN analysis are summarized in the present study by including only indicator species and strongly preferential species for each group to avoid producing long lists of species (Peet et al., 1997).

Aboveground biomass and relative pellet occurrence data were initially analyzed using 2-way Analysis of Variance (ANOVA) to investigate the effect of treatments and seasons individually. Subsequently multiple range comparisons were done for each grassland type using Tamhane's T2 Test to detect effect of interactions among different treatments and seasons. SPSS/PC+ based software was used for all analyses (Norusis, 1994).

Results

In all, nine species assemblages were identified through TWINSPAN analysis in the present study. These assemblages include only indicator species and strongly preferential species. The first division of samples separated the outlying *Typha elephantina* assemblage at 81%, which generally occurs in water logged areas. The second split divided the Upland and Lowland communities at 75% dissimilarity, and further separated out at different level of dissimilarity. These assemblages along with their habitat specificity are as follows:

1. *Typha elephantina* (TE) assemblage - Permanently water logged sites.
2. *Vetiveria zizanioides -Saccharum spontaneum* (VZSS) assemblage – Upland grassland well developed soils heavily grazed.
3. *Cymbopogon jwarancusa – Saccharum bangalense* (CJSB) assemblage - Upland grassland, dry sites frequently burned, least grazing
4. *Imperata cyclindrica – Desmostachya bipinnata – Saccharum spontaneum* (ICDBSS) assemblage - upland grassland, dry sites well developed soils.
5. *Themeda arundinacea – Saccharum narenga- Apluda mutica* (TASSAM) assemblage -Tall dense grassland, often at forest edge, well developed soils influenced by fire.
6. *Saccharum narenga – Apluda mutica* (SNAM) assemblage - Flood plain grassland alluvial soils influenced by fire
7. *Saccharum narenga – Saccharum spontaneum – Apluda mutica* (SNSSAM) assemblage – tall dense grassland, old river terraces and wetter soils influenced by fire
8. *Sclerostachya fusca – Saccharum spontaneum – Apluda mutica* (SFSSAM) assemblage - seasonally inundated tall dense grassland.
9. *Phragmites karka – Arundo donax* (PKAD) assemblage - Tall dense grassland, seasonal and marsh.

Dabadghao and Shankarnarayan (1973) in their classification of Indian grasslands had recognized just one cover type from Terai region, i.e., *Phragmites – Saccharum – Imperata*. However, they had identified 19 principal grass species as constituents of this cover type all across Gangetic and Brahmaputra flood plains. However, their classification does not account for the diversity of plant species assemblages in the Terai grasslands as have been identified by Lehmkuhl (1994), Peet et al., (1997), and the present study.

The effect of the four burning treatments on the above-ground biomass (AGB) revealed that three grasses formed the bulk of cover and standing biomass i.e., *I. cylindrica, D. bipinnata* and *V. zizanoides* in the Upland grassland. Similarly, *S.fusca , S. narenga and S. spontaneum* formed largest proportion of the standing biomass in the Lowland grassland. The dominance of these species was maintained under all the treatments. The only exception was the harrowed-burned treatment in the lowland grasslands that were invaded by *Desmostachya bipinnata* and persisted for more than 3 years.

The managed (burned) plots showed an increase in the number of shrubs, herbs, sedges and ferns. Thus, treated plots were heterogeneous in composition and structure, whereas the unmanaged plots were more homogeneous. The increase in number of herbaceous and other species was a result of disturbance by different burning regimes. These disturbances resulted in decreased canopy density and an increase in gaps in the managed grassland swards into which other species invaded. Earlier studies have reported a general principle that herbaceous species have a greater capacity than the dominant inferior competitors to colonize gaps in disturbed communities (Horn and MacArthur, 1972; Crawly and May, 1987; Peet et al., 1997). Different burning regimes substantially reduced standing biomass immediately after each of the treatments. However, at the end of three consecutive years of different burning treatments, only a marginal difference in AGB values was registered in each case. Lowest AGB (16%) was under the harrowed-burned treatment given to the Upland grassland. The Lowland grassland also responded similarly to the four treatments over the three years and there was a maximum decline of AGB to the extent of 14%. Thus marked negative effect of the harrowed-burned treatment on AGB was evident in both the type of grasslands and also at all stages of the experiment.

There were significant differences between the AGB for the four treatments. However, the multiple comparisons using Tamhane's T2 Test showed that there was no significant difference between (1) cut-burned and cut – removed - burned; (2) cut-burned and burned; and (3) Cut-removed - burned and burned alone treatments on their corresponding values of AGB in the Upland grassland. Likewise, the cut-burned and cut-removed-burned treatments in the Lowland grassland also had no significant difference. This result supports earlier findings of Peet et al. (1997) which showed that there was no difference ($p < 0.001$) in cutting alone, burning alone and cutting and burning combined.

The Null hypothesis that there is no effect of treatments and seasons on the above ground biomass in both the type of grasslands was rejected. Multiple comparisons performed using Tamhane's T2 test showed that there were no significant differences between (i) cut-burned and cut-removed-burned; (ii) cut-burned and burned; (iii) cut-removed-burned and burned treatments in the Upland grassland on the basis of their corresponding AGB values (Table 5.1). Likewise, the cut-burned and cut-removed-burned treatments in the Lowland grassland had no significant difference. All other comparisons among treatments in the both grassland types were highly significant at the 0.05 level.

Table 5.1. Multiple comparisons for the above ground biomass among different treatments in the Upland and Lowland grasslands using Tamhane's T2 Test

Treatment (I)	Treatment (J)	Upland Grassland Mean Difference (I-J)	Upland Grassland Significance (P)	Lowland Grassland Mean Difference (I-J)	Lowland Grassland Significance (P)
Control	Cut-Burn	340.0	.000***	994.6	.000***
	Cut-Removed	356.0	.000***	1055.8	.000***
	Harrowed-Burned	455.7	.000***	1311.3	.000***
	Burned	302.4	.000***	471.7	.000***
Cut-Burned	Cut-Removed -Burned	16.0	.998NS	61.2	.961NS
	Harrowed-Burned	115.7	.000***	316.7	.000***
	Burned	-37.6	.510 NS	-422.9	.000***
Cut-Removed-Burned	Harrowed-Burned	99.6	.000***	255.5	.000***
	Burned	-53.6	.099 NS	-484.1	.000***
Harrowed-Burned	Burned	-153.3	.000***	-739.6	.000***

****- Significant at the 0.001 level; NS – Non-Significant.*

Nevertheless, the effect of four burning treatments on the species composition and standing biomass of major grass species was prominent in both the grasslands. *I. cylindrica*, the major contributor to the standing biomass in the Upland grassland declined considerable (40-53%) in its AGB in all treatments at the end of three years. The maximum loss (53%) was in the harrowed-burned treatment while the minimal loss (40%) was in burned alone treatment. The opposite effect was evident in the control block where *I. cylindrica* AGB increased by 10% by the end of experiment. In contrast to *I. cylindrica, D. bipinnata* increased its contribution to AGB from 1% to 37% in three treatments (cut-burned; cut-removed-burned; and cut-burned) and the control. The maximum gain was in the harrowed-burned treatment which favoured *D. bipinnata* at the expense of *I. cylindrica*.

The burned only treatment was the exception in which *D. bipinnata* declined by 4% in its AGB at the end of three years. The decrease of *I. cylindrica* and the increase of D. bipinnata can be attributed to the fact that the *I. cylindrica* is a sod-forming species that grows in dense swards (Lehmkuhl, 1989) whereas *D. bipinnata* and other grasses such as *V. zizanoides, S. spontaneum* and *S. narenga* have a clumped habit, often with wide spacing between clumps. *I. cylindrica* is also known to be very susceptible to shading; perhaps the dead material on the unburned (control) plots and burned alone treatment with remnant unburned portions shaded the surface sufficiently to depress surface temperature, nitrogen mineralization and growth from basal meristems (Weaver and Rowlands, 1952; Lehmkuhl, 1989). Thus, on one hand the shading effect must have influenced new growth and AGB, whereas on the other hand, intense grazing and utilization of new growth by wild ungulates in the four burned treatments may explain the reduction in I. cylindrica AGB. *D. bipinnata* was definitely favoured by the open conditions created in the Upland grassland by different burning treatments except the burned alone treatment. *D. bipinnata* which was otherwise absent in the Lowland grassland prior to the commencement of experiment in January 1998 abruptly emerged and established in the harrowed-burned treatment. In contrast, *S. fusca and S. narenga* were adversely affected in the harrowed-burned treatment with AGB of both species significantly reduced by 47% and 53%, respectively by the end of three years. The managed Upland and Lowland grassland plots distinctly favoured wild ungulates, particularly immediately after the treatments were applied and during summer. Thus, the management objective of promoting new growth and palatable grass during the lean season was achieved. The swamp and hog deer had greater relative pellet occurrence in the harrowed-burned and burned alone treatments in the Upland grassland. In the Lowland grassland, the harrowed-burned and cut-burned treatments were most favorable, while the burned alone treatment was for the most part avoided. The relative pellet occurrence of swamp deer and hog deer substantially increased in the four managed Lowland grassland plots than the control plot immediately after they were treated. The values of relative pellet density ranged from 58.3 pellet groups/ha to 172.5 pellet groups/ha in the burned alone and cut-burned treatments, respectively in April (1998-2000). This was followed by a considerable decline in the ungulate use in all the four managed Lowland grassland plots. Gradual decline further continued in all the cases even in the month of October (1998-2000) and finally the lowest values were recorded in January, 2001 after the three years of repeated treatments. The open ground situation due to the cut-burned, cut-

removed-burned, and harrowed-burned treatments was more selected than the burned alone treatment. Both the ungulates used open areas for resting while new tender shoots for foraging. In all the cases, the values of pellet counts in the unmanaged plot (control) remained low. These low values can be attributed to the fact that the unmanaged grassland continued to have tall, dense coarse grass, which could not attract swamp deer and hog deer. It is also possible that the dense grass situation might have also affected an efficient counting of pellets while it was easier to locate pellet groups and count them in the four managed grassland plots.

The *Imperata cylindrica–Vetiveria zizanoides* community in the Upland grassland supported grazing throughout the year, particularly in the harrowed-burned and burned alone treatments. Hog deer grazed more heavily in the harrowed-burned and burned alone treatments, but selected plots subjected to burning alone since this type of treatment left more cover to hide in. Hog deer selected relatively much less two other treated areas. Swamp deer also used more the harrowed-burned and burned alone treatments than the two other treatments.

ANOVA results showed a highly significant difference between all the treatments and seasonal use of managed Upland grassland by swamp deer and hog deer (Table 5.2). The multiple comparisons among treatments revealed a highly significant difference in use of the control vs. treatment plots. The ANOVA results showed a highly significant difference in the pellet counts of swamp deer and hog deer under the four different treatments given to the Lowland grassland.

Table 5.2. Effect of different burning practices on the relative pellet occurrence of swamp deer and hog deer in the upland grassland in a full factorial ANOVA design

Source of Variation	Degree of freedom (df)	F-Ratio*
Model	24	24.257
Treatments	4	28.477
Seasons	4	72.112
Treatment seasons	12	6.366
Total	**366**	

Discussion

Studies by Karki (1997), Mishra (1984), Brown (1997) and Peet et al. (1997) have indicated that the Terai grasslands are maintained in part through human intervention. This study also corroborates the earlier observations and reveals that current rates of biomass removal are not adversely affecting the condition of the tall grasslands. Rather, the current practices bring benefits to both local communities and to wildlife. However, whether the practices are sustainable, and in what way they can be regulated, is open to question. Present study showed that there was no significant difference in the overall standing biomass among the four treatments when compared to the control plot. At the same time, earlier studies (e.g. Peet et al. 1997; Kumar et al., 2002) and data presented here all report the increases in abundance and AGB of *D. bipinnata* (a species of relatively poor value to wildlife and local people) and a decrease in preferred grass species in the managed plots, particularly the harrowed-burned treatment. The resultant change of the Upland grassland dominated by *I. cylindrica* and the Lowland grassland dominated by *S. fusca, S. narenga* and *S. spontaneum* to a homogenized grassland dominated by *D. bipinnata* due to repeated harrowed-burned treatment is a major management concern unless regular monitoring of species composition and abundance is instituted.

It is also clear that ending the current practices of cutting and burning would remove the real benefit of the availability of new growth of palatable grasses to ungulates during the lean period. Grass removal by local communities and periodic burning are also helping in controlling hotter and destructive summer fires by reducing fuel loads which has a positive effect on the ecology of these grassland systems. Therefore, maintaining the status quo, by annual cutting and burning would provide ungulates with summer forage from the regenerating grassland also well provide important subsistence resource to local communities. Most studies have confirmed that biomass removal of whatever form (including grazing; Lehmkuhl, 1989) resulted in a similar species composition, abundance, structure, and standing biomass at the time of termination of experiment. However, the harrowed-burned treatment has marked influence on the species composition, standing biomass, phenology, and ungulate use. In view of the above, it is evident that some sort of patch cutting and burning of both the grassland types would produce a mosaic of suitable habitats for the persistence of diverse faunal species in Terai (Plate 5.1 - 5.3). Staggered cutting and burning would also create different patches providing varying forage and cover conditions. However, patch size would be critical for success; a patch too large would be hard for

herbivores to crop fast enough to keep the grass short, and a patch too small might be overgrazed and may not provide adequate benefits to warrant management.

Conclusion

It was found that harrowing as a management practice did not result in the improvement of grassland quality and rather it resulted in the proliferation of coarse and poor quality grasses such as *D. bipinnata*. This implies that this practice should not be continued for the management of grasslands within Terai PAs. While the other management practices, such as burning, cutting and removing of dry biomass, and grazing helped in regeneration of desirable species. Hence judicious use of these tools could help in maintenance of grassland quality. Creating mosaics of different successional stages and creation of different grassland patches proved to be better for ensuring spatial distribution of grazing ungulates.

Recommendations

(a) Most of the hygrophilous (tall wet) grasslands in the TCL are highly threatened. All such grasslands outside the PAs form important corridors for threatened grassland fauna. Hence, such patches need to be given high priority for conservation.

(b) Several grassland patches are degrading rapidly due to over grazing by domestic livestock and infestation by alien invasive species and encroachment by woody species. There is a need to manage such degraded grasslands especially outside the PAs.

(c) Ideal season to burn Terai grasslands is peak winter i.e, before February 15, because the nesting of the birds starts after that. Moisture regime of the grasslands should be taken into cons detain before burning.

(d) In recent years, the Terai of U.P. has become prone to highly destructive flash floods which affect the grasslands. These grasslands are managed by burning and the effects of flooding, therefore monitoring protocols need to be developed.

(e) Intensive research work by Kumar et al. (2002) on tall grasslands of Dudhwa Tiger Reserve and the adjoining North Kheri and South Kheri Forest Divisions should be replicated for the entire Terai ecosystem, from Rajaji National Park to the Brahmaputra floodplains.

(f) Adaptive management is very important for the grassland patches which support species of conservation concern, e.g., Bengal Florican, because if these patches experience succession from short grasslands to tall grasslands these endangered species will also disappear.

Plate 5.1: Dudhwa Reed Frog

Plate 5.2: Pied bushchat

Plate 5.3: Use of fire for habitat improvement © Karma C. Bhutia

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