Managing the *Terai* Grasslands in Nepal: Recent Research and Future Priorities

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Abstract
Recent research in the *Terai* grasslands of Nepal has provided important new information on their ecology and management. This paper briefly summarises key research and management priorities arising from this work.

Classification has revealed the structure, composition, and diversity of the grasslands within and between four protected areas. Maintaining the area and assemblage diversity of these grasslands will require further research into the effects of disturbance, particularly flooding, cutting, and burning, on grassland succession. In the absence of long-term data on the effects of fire, attempts should be made to leave areas of grassland unburned on a rotational basis.

Large mammal utilisation of the grasslands has been linked to particular grassland assemblages. Such associations need to be researched for other faunal groups and seasonal and management effects understood. For example, ungulates exploit the forage provided by grasslands resprouting after cutting and burning. However, widespread cutting and burning is deleterious to cover-dependent species. A management experiment in *Imperata cylindrica* grassland has indicated that patches of grassland can be left uncut and unburned on a rotational basis without causing major changes in species composition and abundance in the sward. These patches would then provide refugia for cover-dependent species.

Introduction

The tall grasslands of the *Terai* of Nepal and northern India are a unique habitat, dominated by dense stands of graminoids, up to six metres tall. They are host to a range of threatened fauna including the greater one-horned rhinoceros (*Rhinoceros unicornis*), tiger (*Panthera tigris*), swamp deer (*Cervus duvauceli*), and hispid hare (*Caprolagus hispidus*) (IUCN 1993).

In Nepal the grasslands are largely confined to four protected areas in the *Terai*: Koshi Tappu Wildlife Reserve, Royal Shukla Phanta Wildlife Reserve, Royal Chitwan National Park, and Royal Bardia National Park. Managers of these remaining grasslands face a number of management problems including harvesting of thatch, burning of grassland, grazing by domestic stock, loss of grassland area, and dam and irrigation schemes. In addition, key ecological data on the grasslands is limited as most studies have concentrated on the ecology of their fauna (Schaaf 1978; Laurie 1982; Mishra 1982; Smith 1984; Stoen and Wegge 1996). Relatively few studies have examined the structure and function of the grasslands themselves (Dinerstein 1979 a,b; Lehmkuhl 1989, 1994, Peet 1997; Peet *et al.* 1997, Peet *et al.* 1998).

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This paper briefly summarises some of the research, and conclusions on management priorities, arising from a recent research project in the *Terai* grasslands that investigated:

- botanical diversity across the protected areas;
- animal species - plant assemblage associations;
- the effects of cutting and burning on an *Imperata cylindrica* dominated grassland;
- the spatial and temporal responses of ungulates to cutting and burning; and
- the socioeconomics of grassland harvesting.

More detailed results and analysis and more complete management recommendations are given in Brown (1997); Peet (1997); Peet *et al.* (1997, 1998, in press). The results of the socioeconomic study are not given in this paper.

Grassland Organisation and Management

The complexity of the tall grasslands was first revealed by Lehmkuhl (1994) who identified eight grassland assemblages in Chitwan. Across the four *Terai* protected areas, nine grassland assemblages with eight phases have now been identified (Peet *et al.* 1998). These assemblages are characterised by a few highly dominant and structurally important grass species with the remaining species being of low abundance and frequency.

Early successional grasslands, maintained by annual flooding, are dominated by *Typha elephantina, Phragmites karka,* and *Saccharum spontaneum.* Assemblages on drier and better-developed soils are dominated by *Narenga porphyrocoma, Saccharum bengalense,* and *Themeda arundinacea* and are maintained, at least in the short-term, by fire, cutting, and grazing. *'Phanta'* grasslands are dominated by *Imperata cylindrica* and occur on old village sites and abandoned agricultural land within the protected areas. Assemblage diversity is highest in Chitwan, whilst Bardia and Shukla Phanta are of particular importance for their *Imperata cylindrica* grasslands. Assemblages in Koshi Tappu are limited to early successional grasslands maintained by flooding.

Whilst fire, cutting, and grazing are important in influencing the composition and structure of the grasslands on sites not maintained by flooding, the overall distribution and diversity of grasslands is primarily influenced by the action of rivers. Rivers can create new areas for grassland colonisation by depositing alluvium, leaving abandoned channels and ox-bow lakes, and removing areas of forest during floods. As rivers migrate across their floodplains they leave a variety of differently aged river terraces on which grasslands develop and are then maintained by disturbance. At the same time the mobile nature of the rivers feeding the protected areas means that existing grasslands are vulnerable to large-scale movements of the rivers either through the erosion of existing grassland or by leaving grassland isolated from fluvial disturbance and therefore open to succession to forest. Clearly regulation of the rivers that influence the protected areas, either for irrigation or hydro-electric schemes, would have severely deleterious effects on the area, distribution, and diversity of grasslands.

For protected area managers seeking to maintain the area and diversity of assemblages and the faunal species that utilise them, a research priority is to gain a better understanding of successional processes in the grasslands. This requires: i. investigating and predicting landscape dynamics, primarily controlled by rivers; ii. quantifying rates of succession between bare alluvium and early successional grassland, between early successional flooded grasslands and later successional dry grasslands, and between grassland and forest; and iii. gaining a clearer understanding of the role of fire, cutting, and grazing in the successional process.

Lehmkuhl (1989) developed exploratory models to predict changes in river course and alluvial deposition in Chitwan. These need to be further developed and extended to Bardia and Shukla Phanta so that protected area managers can predict likely changes in the spatial dynamics of flooding, erosion, and alluvial deposition, which has obvious consequences for the establishment of early successional grasslands.

A pre-requisite to investigating rates of succession between assemblages and changes in grassland area will be to identify the extent of grassland assemblages within each park. It should be possible to identify early successional grassland and later successional tall grassland from aerial photographs and to examine changes in area through time.

Rates of change between grassland types and between grassland and forest will be influenced by disturbance, particularly fire. In tall grassland assemblages, it would be expected that fire would retard succession to forest. Fuel loads are high as the grasslands are highly productive and little above-ground biomass is consumed by grazing herbivores (Lehmkuhl 1989). Under these conditions, high fire intensities would be expected, which should cause mortality in woody species or confine them to small individuals unable to escape the grass layer (Bond and van Wilgen 1996). However, Lehmkuhl (1989) suggests that fire cannot completely retard succession to forest as a result of spatial variation in fire occurrence and intensity. Long-term experiments should be used to examine the influence of fire and cutting on successional change in a variety of different assemblages. Identifying rates of successional change and changes in the area of grassland assemblages has obvious implications for the persistence and abundance of faunal species dependent on different grassland assemblages.

Whilst the impact of fire and cutting is poorly understood, cutting and burning of virtually the entire area of grassland within a protected area should be avoided. Instead, where possible, managers should seek to leave patches of grassland uncut and unburned on a rotational basis. This is of particular importance for grasslands that are not influenced by flooding.

Reaming *Imperata cylindrica* dominated 'phanta' grasslands are declining in area as a result of succession to tall grassland and forest. Immediate steps to monitor encroachment can be taken and invading tree saplings removed. The most suitable methods for maintaining patches of shorter grassland within the tall grasslands are currently unclear. Given the importance of these shorter grasslands for threatened species (Schaaf 1978; Dinerstein 1979b; Mishra 1982;

Inskipp and Inskipp 1983; Peet 1997), a priority should be to investigate experimentally methods of preventing succession to tall grassland.

Grassland Management and Faunal Conservation

Faunal associations with one or several grassland assemblages have been established for a range of species in the tall grasslands (Peet 1997; Peet *et al.* 1997). At this stage, research has concentrated primarily on larger mammals. For example, hog deer (*Axis porcinus*) and greater one-horned rhinoceros are associated with early successional assemblages dominated by *Phragmites karka* and *Saccharum spontaneum* (Peet 1997). There is a clear need to extend the present understanding of these associations to more faunal groups and to understand seasonal changes in assemblage utilisation.

Faunal species also respond to management of the grasslands, and the implications of annual cutting and burning for faunal utilisation of grassland needs to be more clearly understood. There are clear implications for faunal species conservation and reintroduction schemes. Cutting and burning of grasslands has been demonstrated to lead to temporary increases in the numbers of chital (*Axis axis*) and swamp deer (*Cervus duvauceli duvauceli*) utilising *Imperata cylindrica* grasslands (Dinerstein 1979b; Mishra 1982; Moe and Wegge 1997; Peet 1997). This appears to be a result of the high quality forage provided by the new grass shoots after cutting and burning (Moe and Wegge 1997; Peet 1997). The utilisation of burned grasslands by ungulates has led to widespread use of burning as a tool to maintain threatened ungulate populations and ungulate prey populations for threatened predators. However, it is not clear whether this ephemeral forage resource affects ungulate populations in the protected areas.

Whilst ungulates probably gain some benefit from widespread cutting and burning, studies of smaller cover-dependent species have indicated that they are deleteriously affected by the practice. Studies of hispid hare (*Caprolagus hispidus*) and pygmy hog (*Sus salvanius*) have shown that animals become confined to small patches of uncut and unburned grassland following fire where they are vulnerable to disturbance, predation, and hunting (Oliver 1980; Bell 1986; Bell *et al.* 1990; Oliver and Deb Roy 1993). Populations of both these species appear to have been affected deleteriously by widespread cutting and burning, and may indeed be limited by the extent of unburned habitat that remains in individual protected areas. Initial results of an ongoing study of small mammal communities in Bardia suggest that the abundance of animals in the grasslands declines dramatically after cutting and burning (T. Adhikari, personal communication). There is ample evidence from other systems that fire can influence species composition and species abundance in small mammal communities (Cheesman and Delany 1979; Fa and Sanchez-Cordero 1993; Friend 1993), herpetofauna (Fyfe 1980; Barbault 1983; Gillon 1983; Braithwaite 1987), and invertebrates (Gillon 1970, 1983; Ahlgren 1974; Majer 1984; Andersen 1991).

If management of the grasslands is to reflect the conservation of biodiversity other than ungulates and their predators, then it is important for managers to consider leaving uncut and unburned refugia. This would mean leaving patches of grassland unmanaged on a rotational basis. In Bardia, a management experiment has demonstrated that patches of *Imperata cylindrica* grassland can be left unmanaged for two to three years without a major turnover in species composition, or succession to tall grassland or forest, occurring more rapidly than in cut and burned grassland. *Imperata cylindrica,* dominant in the cut and burned grassland, remains the dominant grass species when grassland is left temporarily uncut and unburned for three years (Peet *et al.* 1997, in press). If an unmanaged patch was then cut and burned a forage resource would again be available to ungulates and a thatch resource available to local people. These results allow managers to consider rotational patch management of the phanta grasslands, thereby providing refugia for cover-dependent species. Leaving some areas uncut and unburned would be unlikely to impact on the available forage resource for ungulates as forage would remain abundant in cut and burned areas.

Conclusion

Recent research in the Nepalese *Terai* has raised a number of important research and management priorities. In particular, there is a need to understand better the successional processes within the grasslands and the effects of disturbance, particularly cutting and burning, on plant species composition and species abundance in the grasslands. In the case of *Imperata cylindrica* grasslands, it is important to investigate methods of maintaining areas of shorter grassland within tall grassland. The effects of management on faunal utilisation of the grasslands needs clarification, particularly for poorly known groups such as small mammals and herpetofauna.

With data lacking on the long-term effects of cutting and burning on the structure and composition of the vegetation, and the conservation of a range of faunal species being deleteriously affected by widespread cutting and burning, managers should consider adopting rotational patch management regimes in the grasslands.

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