# Importance of Tall Grasslands in Megaherbivore Conservation

*Shant Raj Jnawali [9] and Per Wegge [10]*

**Abstract**

In the lowlands of Nepal, tall grasslands once stretched throughout the southern alluvial floodplains, but now they are restricted to the river basins of protected areas. These tall grasslands provide refuge for a large number of wild mammals, including greater one-horned rhinoceros, wild elephant, tiger, swamp deer, hispid hare, hog deer, and wild water buffalo. The main objective of this paper is to assess the importance of the tall grassland ecosystem in megaherbivore conservation, with special emphasis on greater one-horned rhinoceros. In this study, which was carried out in Royal Chitwan National Park (RCNP) and Royal Bardia National Park (RBNP), microhistological analyses of animal faeces were used to assess the importance of grasses in conserving rhinoceros. Feeding data of rhinoceros clearly indicated that both the annual and the seasonal diets of rhinoceros in Bardia and Chitwan are dominated by the grass species growing primarily in the tall alluvial floodplain grasslands, which in these protected areas suffer encroachment from woody vegetation. Although the park authority in RBNP has recently initiated programmes of uprooting of woody bushes from phantas and wooded grasslands, which will help to create more open space for the large populations of medium sized ungulates that primarily graze on these habitats, no such interventions have been introduced so far to manage the tall floodplain grasslands. These grasslands are needed to accommodate an increasing number of megaherbivores as well as floodplain-dependent ungulates in both areas. Ironically, the dynamics of the floodplain ecosystem is still poorly understood, since no long-term scientific research has been conducted on its ecological processes. A comprehensive scientific research effort is needed before any management prescription can be made.

## Introduction

The tall grasslands originating from fluvial action and monsoon floods are unique natural ecosystems. Theye are regarded as prime sites for biodiversity conservation. Previously, tall grasslands were distributed throughout the floodplains of the Ganges and Brahmaputra river systems of the northern Indian sub-continent including the southern lowland (*Terai*) of Nepal (Bell and Oliver 1992). Mainly as a result of lack of effective measures to control grazing by domestic stock, these habitats are now confined within the boundaries of protected areas in both Nepal and India.

In Nepal, tall grasslands once stretched throughout the southern alluvial floodplains of the perennial river systems, mainly the Mechi and Koshi river systems in the east; the Rapti, Rew, and Narayani river systems in the centre; and the Babai, Orai, Karnali, and Sarada river systems in the west. As a result of intensive rice cultivation and grazing, tall grasslands are now restricted to the

[9] King Mahendra Trust for Nature Conservation, Kathmandu, Nepal
[10] Agricultural University of Norway, As, Norway

river basins of four protected areas: Koshi Tappu Wildlife Reserve in the east, Royal Chitwan National Park in the central region, Royal Bardia National Park in the west, and Royal Shukla Phanta Wildlife Reserve in the far western *Terai*.

The tall grasslands are composed of a mosaic of a number of different tall grasses with a few sparsely scattered tree species. Dominant graminoids include *Saccharum spontaneum*, *Narenga porphyrocoma*, *Saccharum bengalensis*, *Themeda sp.*, *Phragmites karka*, *Arundo donax*, and *Imperata cylindrica*. Important scattered tree species include *Dalbergia sissoo*, *Trewia nudiflora*, and *Acacia catechu* .

The tall grasslands provide refuge for a large number of wild mammals, including greater one-horned rhinoceros, *Rhinoceros unicornis* (Laurie 1978; Dinerstein and Price 1991; Jnawali 1995), wild elephant, *Elephas maximus* (Sukumar 1989), tiger, *Panthera tigris tigris* (Tamang 1982; Smith 1984), swamp deer, *Cervus duvauceli duvauceli* (Schaaf 1978; Pokharal 1996), hispid hare, *Caprolagus hispidus* (Bell *et al.* 1990; IUCN 1993), hog deer, *Axix porcinus* (Dhungel 1985), and wild water buffalo, *Bubalus bubalis* (Heinen 1993). In addition, a remarkable number of smaller mammals, birds, and reptilian species, refuge in this ecosystem.

The main objective of this paper is to assess the importance of the tall grassland ecosystem in megaherbivore conservation with special emphasis on the greater one-horned rhinoceros (henceforth referred to as rhinoceros).

**Study Area**

Data presented in this paper were collected from two national parks, Royal Chitwan National Park (RCNP) in the east and Royal Bardia National Park (RBNP), which is located ca 500 km west of RCNP. In Chitwan, a study area of ca 20 sq.km was selected in the northern floodplain (84° 20' E and 27° 30' N) along the Rapti river near Sauraha. In Bardia, the study area consisted of a narrow strip of ca 70 sq.km in the southwestern corner of the park (81° 20' E and 28° 35' N) along the Geruwa river, the eastern branch of the Karnali river system.

The climate of both study areas is subtropical monsoonal type. More than 80% of the precipitation occurs within the relatively short monsoon period. May and June are quite hot with average maximum temperatures around 40°C. Winter is chilly and the temperature drops below 5°C.

Vegetation in both areas is of subtropical type, ranging from a mosaic of early successional riparian vegetation on newly established riverbeds to the climax sal *(Shorea robusta)* dominated forest established on the dry uplands and slopes of the Churia ranges. There are five major types of vegetation in Chitwan: riverine; sal forests; khair-sissoo (*Acacia catechu-Dalbergia sissoo*) forests; bushy pasture; and tall floodplain grasslands—and seven in Bardia: riverine; sal; mixed hardwood forests; khair-sissoo forests; wooded grassland; tall floodplain grassland; and phanta.

Among the habitat types common to both areas, sal forest, tall grassland, and bushy pasture are similar floristically. The riverine forests in the two areas differ

in species composition with *Trewia nudiflora* dominating in Chitwan and *Mallotus phillippinensis* in Bardia. The tall floodplain grasslands in both areas are dominated by *Saccharum spontaneum*, *Saccharum bengalensis*, and *Phragmites karka*. *Themeda arundinaceum* does not grow in Bardia's floodplain. In Chitwan, this species grows in large tracts between the Churia foothills and the Rapti river where surface water remains available all year round. *Arundo donax* is more common in Bardia's floodplain than in Chitwan. Furthermore, *Narenga pophyrocoma* is one of the dominant tall grass species in Chitwan, whereas in Bardia it is localised in the northern section of the floodplain. Detailed descriptions of the habitat types in both areas are given for Bardia in Dinerstein (1979) and Jnawali and Wegge (1993); and for Chitwan in Laurie (1978) and Mishra (1982).

The fauna in both parks is similar, except that some species are confined to one or other of the areas. Bardia has a small sub-population of rhinoceros translocated from Chitwan during 1986 (13 animals) and 1991 (25 animals). This newly-established population has increased gradually and has now reached a total of about 50 individuals (chief warden, personal communication). Other important wild mammals include Asian wild elephant (*Elephas maximus*), tiger (*Panthera tigris*), common leopard (*Panthera pardus*), sloth bear (*Melursus ursinus*), four species of deer (*Axis axis, A. porcinus, Muntiacus muntjack,* and *Cervus unicolor*), and wild dog (*Cuon alpinus*). The uncommon mammals include nilgai (*Boselephus tragocamalus*) and barasingha or swamp deer (*Cervus duvauceli duvauceli*) in RBNP, and gaur (*Bos gaurus*) in RCNP.

**Methods**

Microhistological analyses of faeces of Bardia and Chitwan rhinoceroses were used to assess the importance of grasses in conservation of this species (Jnawali 1995). For this, fresh dung samples were collected from both areas, sun dried, ground, and pooled. Every month, five microscopic slides were prepared from a pooled fecal sample. Identification of plant fragments was done using the morphological features observed by microscopic examination. Volumetric estimations of each food plant species were made for each month and later combined for three seasons–summer, monsoon and winter.

Above ground parts (leaf, flower, fruit, twigs, bark) of ca 200 plant species were collected to prepare reference slides. Microscopic structures observed on the reference slides were sketched to allow matching with the faecal plant fragments. A detailed description of the method is given in Jnawali (1995).

The relative importance value (RIV) of each plant species observed in the fecal samples was calculated as follows:

$$RIV_x = D_x(\sqrt{\varphi f_x})$$

Where,

$RIV_x$ = Relative importance value for species x
$D_x$ = Mean percentage of species x in fecal sample
$f_x$ = Frequency of species x in fecal sample

**Results and Discussion**

The rhinoceroses foraged a wide range of wild food plants, but >70% of the volume in the diet was contributed by less than ten species in both areas (Table 3). In Bardia, nine species (five grasses: *Saccharum spontaneum*, *Arundo donax*, *Cyanodon dactylon*, *Saccharum bengalensis*, and *Erianthus ravennae*—and four browse species: *Mallotus phillipinensis*, *Dalbergia sissoo*, *Callicarpa macrophylla*, and *Calamus tenuis*) contributed more than 70% of the total volume in the annual diet. In Chitwan, seven species (four grasses: *Saccharum spontaneum*, *Saccharum bengalensis*, *Cyanodon dactylon*, and *Narenga porphyrocoma*—and three browse species: *Coffea bengalensis*, *Murraya paniculata*, and *Litsea monopatela*) made up 85% of the total volume in the annual diet.

The diet of rhinoceros in both areas was dominated by grass species basically found in tall grasslands. Their proportion was higher in Chitwan (73%) than in Bardia (63%).

Browse species made up about 20%, and agricultural crop plants more than 6% of the diet in both areas. Other food plants, mainly herbs, forbs, climbers, horsetails, and pteridophytes, constituted ca 8%, with a slightly higher proportion in Bardia.

Of the different wild food plants recorded in the annual diet in both areas, the highest proportion was contributed by *Saccharum spontaneum*, with RIVs of 28.5 and 36.9 in Bardia and Chitwan, respectively. The other important grass species common in the annual diet were *Saccharum bengalensis* and *Cyanodon dactylon*. Uncommon species included *Arundo donax* and *Erianthus ravennae* in Bardia and *Themeda species* in Chitwan. The proportion of *Narenga pophyrocoma* in the annual diet was higher in Chitwan (RIV = 6.1) than in Bardia (RIV = 1.0). The higher proportion of this species in Chitwan was related to its availability. In Chitwan, this species is distributed in large patches throughout the tall floodplain grassland, whereas in Bardia *Narenga* is localised in the northern part of the floodplain.

The proportion of the different plant groups varied considerably between seasons, but the pattern was different in the two areas. Grass species constituted the highest proportion of the diet during the monsoon in Bardia (ca 92%) and during the hot season in Chitwan (ca 86%). They constituted the lowest proportion during the winter in both areas, about 42% in Bardia and about 57% in Chitwan. The higher proportion of grass species in the diet in Chitwan during the winter and hot seasons was probably related to the higher availability of water during these seasons. In Chitwan, substrate moisture is available for plant growth all year round. The most dominant grass species, *Saccharum spontaneum*, sprouts soon after grass cutting and grazing (Dinerstein and Price 1991) and burning (Laurie 1978) in winter, and a new flush becomes available early in the hot season. Hence, this species , is foraged during the dry season although to a lesser extent.

In Bardia, rhinoceros compensate scarcity of grasses during the winter season by foraging on the leaves of browse species. Laurie (1978) also recorded the highest proportion of browse species in the diet during the winter season.

Table 3. **Relative importance values of main wild food plants in the diet of rhinoceros in Royal Bardia and Royal Chitwan National Park**

| Species | Relative Importance Value | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Winter | | Hot | | Monsoon | | All year | |
| | RBNP | RCNP | RBNP | RCNP | RBNP | RCNP | RBNP | RCNP |
| **Grasses** | | | | | | | | |
| *Saccharum spontaneum* | 18.9 | 25.7 | 21.2 | 43.1 | 45.4 | 41.9 | 28.5 | 36.9 |
| *Saccharum bengalensis* | 0.8 | 14.9 | 3.2 | 13.8 | 8.7 | 8.2 | 4.2 | 12.3 |
| *Narenga porphyrocoma* | - | 1.6 | 0.7 | 8.4 | 2.3 | 8.4 | 1.0 | 6.1 |
| *Erianthus ravennae* | 2.1 | - | 3.8 | - | 4.7 | - | 3.5 | - |
| *Cyanodon dactylon* | 4.4 | 4.3 | 4.7 | 7.6 | 3.1 | 8.2 | 4.1 | 6.7 |
| *Imperata cylindrica* | - | 0.4 | 4.4 | 2.3 | 1.2 | 2.6 | 1.9 | 1.8 |
| *Themeda sp.* | - | 3.1 | - | 2.2 | - | 2.8 | - | 2.7 |
| *Cymbopogon sp.* | 0.7 | 2.3 | 2.0 | 3.2 | 3.8 | 0.5 | 2.2 | 2.0 |
| *Phragmites karka* | 1.9 | 0.7 | 1.5 | 1.2 | 2.2 | 0.8 | 1.9 | 0.9 |
| *Arundo donax* | 5.6 | - | 5.4 | - | 4.5 | - | 5.2 | - |
| **Browse** | | | | | | | | |
| *Callicarpa macrophylla* | 3.9 | 3.7 | 4.5 | 1.0 | 3.2 | 2.0 | 3.9 | 2.2 |
| *Litsea monopatala* | - | 5.0 | - | 0.1 | - | 0.6 | - | 2.0 |
| *Coffea bengalensis* | - | 6.5 | - | 0.4 | - | 3.0 | - | 4.1 |
| *Murraya paniculata* | - | 5.8 | - | 2.8 | - | 4.0 | - | 3.9 |
| *Malllotus phillippinensis* | 7.9 | 2.6 | 5.9 | 2.1 | 0.6 | 0.4 | 4.8 | 1.1 |
| *Dalbergia sissoo* | - | - | 7.9 | 0.3 | 0.7 | - | 2.9 | - |
| *Trewia nudiflora* | - | 0.2 | - | - | 0.1 | 11.2 | 0.03 | 3.8 |
| *Calamus tenuis* | 4.4 | - | 5.0 | - | 0.9 | - | 3.4 | - |
| *Bombax ceiba* | 1.2 | 0.2 | 0.6 | - | - | - | 0.6 | 0.1 |
| *Colebrookia oppositifolia* | 1.6 | 0.1 | 0.8 | 0.1 | 0.1 | 0.2 | 0.8 | 0.1 |
| *Ehretia laevis* | 1.1 | - | 0.3 | - | 0.1 | 0.2 | 0.5 | 0.1 |
| *Ficus glomarata* | 1.7 | - | 0.1 | - | 0.3 | - | 0.7 | - |
| *Ziziphus mauritiana* | 1.0 | - | 0.1 | - | - | - | 0.4 | - |
| *Acacia concinna* | 1.3 | 0.1 | 0.4 | - | 0.2 | - | 0.6 | 0.03 |
| **Others** | | | | | | | | |
| *Triumfetta sp.* | 0.4 | 0.4 | 0.1 | - | 0.1 | 0.2 | 0.2 | 0.2 |
| *Urena lobata* | 0.9 | 0.1 | 1.8 | 0.1 | 0.6 | 0.1 | 1.1 | 0.1 |
| *Circium wallichii* | 4.2 | 0.1 | 3.1 | 1.5 | 1.3 | - | 2.9 | 0.5 |

Important browse species in the annual diet included *Mallotus phillipinensis* (RIV = 4.8), *Callicarpa macrophylla* (RIV = 3.9), and *Calamus tenuis* (RIV = 3.4) in Bardia, and *Coffea bengalensis* (RIV = 4.1), *Murraya paniculata* (RIV = 3.9), *Trewia nudiflora* (RIV=3.8), *Callicarpa macrophylla* (RIV=2.2), and *Litsea monopatela* (RIV = 2.0) in Chitwan. *Coffea bengalensis* and *Murraya paniculata* were not recorded in Bardia animals as these species do not occur in the Bardia study area.

**Conclusions and Management Implications**

The tall floodplain grasslands created by fluvial action and monsoon flood are prime habitats for bio-diversity conservation including megaherbivores like the greater one-horned rhinoceros. Once common throughout the floodplain of the Ganges and Brahmaputra river systems, the tall floodplain grasslands are now restricted to river basins within protected areas of the northern Indian sub-continent.

The feeding data from Chitwan and Bardia rhinoceros clearly indicated that graminoids make up the bulk of rhinoceros food. Both the annual and the seasonal diets of rhinoceros in both areas were dominated by grass species primarily growing in the tall alluvial floodplain grassland. Of the different wild food plants *Saccharum spontaneum*, a dominant grass species in the floodplain, contributed the greatest volume to the diet of both populations. Grasses become coarse and less palatable during the winter season. Rhinoceros compensate scarcity of green grass by foraging on green leaves of browse species: in winter mainly *Callicarpa macrophylla*, *Calamus tenuis*, and *Mallotus phillippinensis* in Bardia, and *Murraya paniculata*, *Coffea bengalensis*, and *Litsea monopatela* in Chitwan.

Within protected areas, tall floodplain grasslands (particularly old ones) suffer encroachment from woody vegetation. In Chitwan, *Trewia nudiflora* is aggressively invading grasslands where inundation by monsoon floods is not a regular phenomenon. *Trewia* seeds dispersed mainly by rhinoceros are easily established in open floodplains where substrate moisture is accessible (Dinerstein and Wemmer 1988). In Bardia, *Dalbergia sissoo* is a primary invader in newly-established *Saccharum spontaneum* dominated grassland, whereas *Murraya koinigii*, *Callicarpa macrophylla*, *Lantana camara* in association with *Dalbergia sissoo*, and *Acacia catechu* encroach the older tall grasslands.

In Bardia, the park authority has recently initiated a programme of uprooting woody bushes from phantas and wooded grasslands. This will help to create more open space for the large populations of medium-sized ungulates that primarily graze on these habitats. However, these habitats are far less important for rhinoceros, since their preferred food plants are not available there. So far, no such interventions have been made to manage the tall floodplain grasslands. But these are needed in both park areas to accommodate an increasing number of megaherbivores as well as floodplain-dependant ungulates.

Regular burning of grassland is regarded as an effective tool to control the invasion of woody vegetation. Today, burning of floodplain grassland is limited to areas with grass left over after grass cutting. Both parks are opened for local people to collect thatch grass (*Imperata cylindrica*) and grass reeds (mainly *Saccharum spontaneum*, *Narenga porphyrocoma*, and *Arundo donax*, needed for making the walls of traditional Tharu houses). In Chitwan, local people burn a few patches of the *Narenga porphyrocoma* growing on the dry uplands to remove the upper leafy part before the grass is cut off. This practice helps to some extent to control the invasion of woody vegetation into *Narenga*-dominated patches. In Bardia, the lower section of the floodplain is dominated

by *Saccharum spontaneum*, which is cleared by local people during grass cutting. Burning therefore has very little effect. Furthermore, fire has a very limited effect on *Saccharum* dominated floodplains with enough substrate moisture, as this species sprouts all year round in such areas.

The dynamics of the floodplain ecosystem are still poorly understood since no long-term scientific research has been conducted on the ecological processes. A comprehensive scientific research effort is needed before any management prescription can be made.

**References**

Bell, D.J. and Oliver, W.L.R. (1992) 'Northern Indian Tall Grasslands: Management and Species Conservation with Special Reference to Fire'. In K.P. Singh and J. S. Singh (eds.), *Tropical Ecosystems: Ecology and Management*. New Delhi: Wiley Eastern Limited.

Bell, D.J.; Oliver, W.L.R.; and Ghose, R.K. (1990) 'The Hispid Hare *Caprolagus Hispidus*'. In Chapman, J.A. and Flux, J.E.C (eds) *Rabbits, Hares and Pikas. Status Survey and Conservation Action*, pp128-136. Gland: IUCN.

Dhungel, S.K. (1985) *Ecology of the Hog Deer in Royal Chitwan National Park*. Ph.D Dissertation. Montana: University of Montana.

Dinerstein, E. (1979) 'An Ecological Survey of the Royal Karnali-Bardia Wildlife Reserve, Nepal. Part 2: Habitat/Animal Interactions'. *Biological Conservation*, 16: 265-300.

Dinerstein, E. and Price, L. (1991) 'Demography and Habitat Use by a Greater One-horned Rhinoceros in Nepal'. *J. Wildl. Manage.*, 55: 401-411.

Dinerstein, E. and Wemmer. C.M. (1988) 'Fruits Rhinoceros Eat: Dispersal of *Trewia Nudiflora* (Euphorbaceae) in Lowland Nepal'. *Ecology*, 69: 1768-1774.

Heinen, J.T. (1993) 'Population Viability and Management Recommendations for Wild Water Buffalo in Koshi Tappu Wildlife Reserve, Nepal'. *Biol. Cons.* 65: 9-34.

IUCN (1993) *Nature Reserves of the Himalaya and the Mountains of Central Asia*. Gland: IUCN/World Conservation Monitoring Centre.

Jnawali, S.R. (1995) *Population Ecology of Greater One-horned Rhinoceros (Rhinoceros Unicornis) with Particular Emphasis on Habitat Preference, Food Ecology and Ranging Behaviour of a Reintroduced Population in Royal Bardia National Park in Lowland Nepal*. Ph.D dissertation. Ås: Agricultural University of Norway.

Jnawali, S.R. and Wegge, P. (1993) 'Space and Habitat Use by a Small Re-introduced Population of Greater One-horned Rhinoceros (*Rhinoceros Unicornis*) in Royal Bardia National Park in Nepal, A Preliminary Report'. In Ryder O. A. (ed) *Proceedings of an International Conference: Rhinoceros Biology and Conservation*, pp 208-217. San Diego: Zoological Society of San Diego.

Laurie, W.A. (1978) 'Behavioral Ecology of the Greater One-horned Rhinoceros (*Rhinoceros Unicornis*)'. *J. Zool. Lond.* 196: 307-341.

Mishra, H.R. (1982) *The Ecology and Behaviour of Chital (Axis axis) in the Royal Chitwan National Park, Nepal.* Ph.D Dissertation. Edinburgh: University of Edinburgh.

Pokharel, C.P. (1996) 'Food Habit and Habitat Utilization of Swamp Deer *Cervus Duvauceli Duvauceli Cuvier* in the Royal Bardia National Park Nepal'. Kathmandu: DNPWC.

Schaaf, C.D. (1978) *Population Size and Structure and Habitat Relation of the Barasingha (Cervus d. Duvauceli) in Shukla Phanta Wildlife Reserve, Nepal.* Ph.D Dissertation. Michigan: Michigan State University.

Smith, J.L.D. (1984) *Dispersal, Communication, and Conservation Strategies for the Tiger (Panthera Tigris) in Royal Chitwan National Park, Nepal.* Ph.D Dissertation. Minneapolis: University of Minnesota.

Sukumar, R. (1989) *The Asian Elephant: Ecology and Management.* Cambridge: Cambridge University Press.

Tamang, K. (1982) *Dynamics of Tiger Prey Population in Royal Chitwan National Park.* Ph.D dissertation. East Lansing: Michigan State University.