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Threats on Grassland Ecosystem Services: A Case from Shuklaphanta Wildlife Reserve

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Abstract

Change in ecosystem balance is increasing rapidly by means of humanly devised over and above natural activities to be precise land use change, deforestation, species invasion, and even the lack of sustainable management within and beyond protected area. Invasion of woody perennials and invasive alien species, human intervention together with improper management practices possibly generated substantial impacts on all major ecosystems of Shuklaphanta grassland. To acquire baseline information and understand ecosystem invasion, random line transects of 1000m were taken to get quadrats of $1m^2$, $25 m^2$ and $100 m^2$ in four different habitats within Shuklaphanta grassland. The result showed that the importance value index (IVI) and prominence value (PV) of woody perennials were high coupled with significant PV of invasive species. Ecosystem services change was prevalent in the study area and high possibility to change into forest vegetation. Invasive species, shrubs, and large trees encroachment consequently invited alteration challenge on preferable habitats formed on assemblage of major grass species. The disrupted ecosystem services amplified pressure on both prey and prey base species including swamp deer, antelope, one-horned rhinoceros, Asiatic elephant, royal Bengal tiger, Bengal florican and other threatened species.

Key words: biodiversity loss, ecosystem services, grassland, invasion.

Introduction

Ecosystem services ranging from provisioning services such as food, water, timber, fiber, habitat and genetic resources; regulating services such as the regulation of climate, floods, disease, and water quality as well as waste treatment; cultural services such as recreation, aesthetic enjoyment, and spiritual fulfillment; and to supporting services such as soil formation, pollination, and nutrient cycling (MEA 2005) are responsible to create unique opportunities for biological communities all over the world. These ecosystem processes including water, nitrogen, carbon, and phosphorus cycling, provide wide ranges of services to sustain natural as well as humanly devised environment. Fresh air, water, food, fodder, raw materials, etc. are free services given by nature. Without these services we with biotic communities would be devoid of all essential assistances obtained from our environment.

Globally, most of the ecosystems have been experiencing undue pressure as a result of natural causes in addition to anthropogenic activities. Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fiber, and fuel which has resulted in a substantial and largely irreversible loss in the diversity of life on earth (MEA 2005). Such problems are not only common on openly accessed ecosystems like ocean, cropland, private forest, rangeland but also in protected areas like national parks, wildlife reserves. However, the extent, magnitude, severity of alteration varies depending on illegal doings, topographical features, climatic factors and so on. The main threats to protected areas are (a) habitat loss and degradation due to conversion to pastureland and agriculture; and (b) overexploitation of natural resources, including logging, the collection

of non-timber forest products (NTFPs), overfishing, and overgrazing by livestock (Alers *et al.* 2007).

Wide-reaching problems like invasion of exotic species, climate change, overharvesting, pollution, along with loose management practices are some of the major challenges on ecosystems stability. Amongst upper mentioned problems, almost all have been observed in Terai landscape of Nepal. As for example, invasion of mile a minute (*Mikania micrantha*) is posing serious threat on hospitable habitat of endangered one-horned rhinoceros in Chitawan national park. The distribution of *M. micrantha* is common from central to eastern Nepal, particularly from Chitwan to Jhapa districts (Tiwari *et al.* 2005). Likewise, climate change could support for spreading new diseases as well for invasive species, occurrence of forest fire, flood and drought by which ecosystem processes are hindered in the long run. Although ecosys-tem services experience change due to natural causes, current change is dominated by anthropogenic indirect drivers (MEA 2005). In line with, Shuklaphanta grassland which is facing both natural and humanly devised threats as invasion of woody perennials and invasive alien species, intrusion by human being, together with improper management

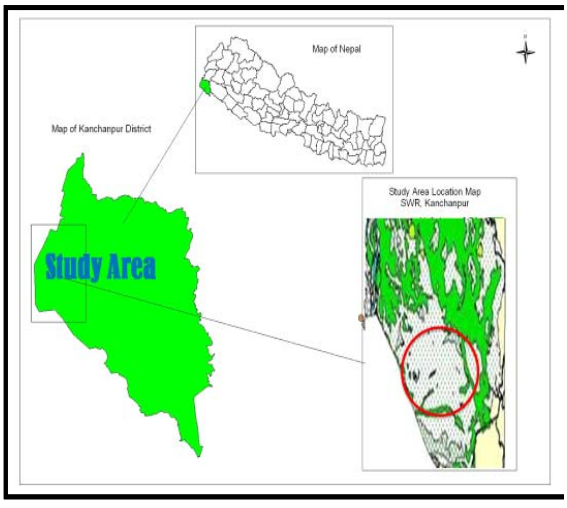

Fig.1. Study area with encircled Shuklaphanta grassland

practices. The study will explore the impact on grassland ecosystem services generated by woody perennials invasion, invasive alien plant species, and current management practices in Shuklaphanta grassland.

Methodology

Study area

Shuklaphanta wildlife reserve **(**SWR) is located in Kanchanpur district sharing southern border with India, west side with Mahakali river, east side with human settlements, and north side with foothills in Gangatic floodplain of farwestern lowland of Nepal. SWR is situated between $28^0$45'16"N and $28^0$57'23" and $80^0$06'04" and $80^0$21'40 E and was initially established as a royal hunting Reserve with an area of 131 km^2 (Yadav *et al.* 2000), which later was gazetted as the Shuklaphanta wildlife reserve (then royal shuklaphanta wildlife reserve) in 1976 increasing the area first to 155 km^2 and later to the present area of 305 km^2 in 1980 (DNPWC 2000).

The reserve is famous for large tracts of grasslands, among which Shuklaphanta is the largest. Shuklaphanta covers an area of 54km^2 south-west of the Bahuni river and south of the forest (Yadav *et al.* 2000). The grassland harbours herds of swamp deer, spotted deer, royal Bengal tiger, Bengal florican and notably one-horned rhinoceros. Abundant varieties of preferable grass species make this land favourable for various ungulates. For example, *Saccharum bengalensis, S. spontaneum, Imperata cylindrica, Narenga porphyrocoma, and Desmostachya bipinata* are the dominant grasses. In addition, ecologically vital section of Terai arc landscape (TAL) area and as well biological corridor, it has eminent significance. Its unique ecosystem not only maintains herbivore and carnivores populations but also exemplify the recreational value to observe their association.

Data collection

The study involved mainly three types of actions: i) extensive review of relevant literatures, ii) primary data collection from the field and iii) data analysis. Along with these actions, interaction with local people and experts were also the parts of study. The primary data were collected in between the last of November 2008 and January 2009. At first, the preliminary reconnaissance survey was executed to know the habitat condition and its diversity. According to expert view and survey, the grassland and its peripheral areas were alienated broadly into four habitat types, namely grassland, wetland, wooded grassland and riverine forest. Random line transects of 1000m were laid down to get the quadrats of 1m^2, 25 m^2 and 100 m^2 in these four habitats. Quadrats were taken on either side of

the transect lines. Altogether 31 transect lines and 305 quadrats were laid down. Among them, 194 quadrats in grassland, 51 in wooded grassland, 38 in wetland, and 22 in riverine forest. These quadrats were used for collecting the data of ground vegetation (herbs), shrubs, and trees respectively and calculating the vegetation cover and other essential factors. Global positioning system (GPS) was used to collect information regarding location from each quadrat which helped to analyse further in geographic information system (GIS) by a software, arcview 3.0. During data analysis, density, relative density, frequency, relative frequency, percentage cover and relative cover were calculated as the basis for importance value index (IVI), prominence value (PV), Shannon index of diversity (H), Sorenson's index of similarity (SI) and maturity index (MI). IVI was used for trees and PV for understorey vegetation (shrub and herb). Summation of the relative frequency, relative density, and relative cover provided the IVI. On the other hand, PV was obtained by using mean percentage cover of species with frequency. Microsoft Excels and SPSS.15 version played vital role in data processing.

Results and Discussion

Major Threats in Shuklaphanta grassland

Invasion of woody perennials and invasive alien species Total area of Shuklaphanta grassland was gradually decreasing as a result of various native shrubs and trees encroachment especially on northern and southern aspects of the grassland. The plant species widespread in and around the environment were the key encroachers of this ecosystem. *Bombax ceiba, Butea monsoperma, Sterculia villosa, Acacia catechu,* and *Dalbergia sissoo* were main tree species while shrub species were *Ficus palmata, Zizyphus mauritiania, Grewia sapida*. Some invasive alien plant species (IAPS) observed in both terrestrial and wetland ecosystems. Already listed as worst all over the world, *Lantana camara* was observed in two quadrats within the range of 100m near to the northeastern corner of wildlife monitoring center (WMC) based in the mid northern proximity of the Shuklaphanta grassland. Similarly, another notorious IAPS *Echhornia crassipes* was significantly high in wetland ecosystem causing serious impact in Shikari Lake, located on Southern aspect of the grassland.

Table 1. Prominence value (PV), and important value index (IVI) of major plant species

SN	Scientific Name	Importance Value Index (IVI) and Prominence Value (PV)			
		Grassland	Wetland	Riverine forest	Wooded grassland
Tree layer*					
1.	*Bombax ceiba*	85.23	40.93	15.64	64.91
2.	*Butea monsoperma*	55.9	18.61	5.3	24.99
3.	*Sterculia villosa*	26.99	-	5.57	14.73
4.	*Dalbergia sissoo*	15.1	-	3.77	80.39
5.	*Syzigium cumini*	12.44	49.25	82.33	4.26
6.	*Acacia catechu*	12.38	25.36	22.79	30.91
7.	*Murraya koenigii*	11.29	20.17	30.34	8.81
Shrub layer**					
8.	*Grewia sapida*	22.54	-	11.3	15.75
9.	*Zizyphus mauritiania*	11.94	2.02	15.07	8.75
10.	*Ficus palmata*	7.32	-	-	1.75
11.	*Colebroo oppositifolia*	5.38	-	15.07	1.75
12.	*Pogostemon bengalensis*	10.7	10.13	13.85	5.25
13.	*Clerodendrum viscosum*	4.68	-	-	-
14.	*Calotropis gigantea*	0.9	-	7.99	-
Invasive alien species**					
15.	*Echhornia crassipes*	-	28.39	-	-
16.	*Lantana camara*	6.35	-	-	-
Ground vegetation **					
17.	*Imperata cylindrica*	55.32	-	2.67	33.33
18.	*Saccharum bengalense*	23.14	-	-	42.58
19.	*Narenga porphyrocoma*	22.39	57.93	15.10	7.78
20.	*Cymbopogon pendulus*	17.65	-	2.67	8.75
21.	*Saccharum spontenum*	15.07	13.60	17.88	32.59
22.	*Vetivera zizanoides*	10.43	-	-	10.5
23.	*Desmostachya bipinnata*	10.08	10.13	11.30	10.5

* IVI for tree species only ** PV for shrub layer and invasive species

B. ceiba, B. monosperma and *S. villosa* have highest IVI with 85.23, 55.9 and 26.99 respectively in grassland compared to other ecosystems (Table 1). The same index of *D. sissoo* and *A. catechu* is high in wooded grassland while *S. cumini* and *M. koenigii* in riverine forest. These values signify that grassland was gradually affected by the invasion of native woody species. Similarly, *G. sapida, F. palmata,* and *C. viscosum* have highest PV with 22.54, 7.32 and 4.68 in grassland respectively. However, the presence of *Z. mauritania, C. oppositifolia, P. bengalesis,* and *C. giantea* was significant in riverine forest as well as in grassland ecosystem and it confirmed that shrubs of riverine forest are entering into the grassland. *P. bengalensis* has highest value (13.85) in wetland area. Significantly invasive alien plant species, *E. crassipes* has been observed only on wetland ecosystem while *Lantana* occupied the terrestrial ecosystem only. Major grassland vegetation comprised of *Imperata cylindrica* (55.32) followed by *Saccharum bengalense* (23.14), *Narenga porphyrocoma* (22.39), *Cymbopogon pendulus* (17.65) and *Saccharum spontenum* (15.07). Wooded grassland had significant values of all the grassland species while other two habitats had their own specific species like *N. porphyrocoma* (57.93) in wetland and *D. bipinnata* (11.30) in riverine Forest.

Sorenson's index of similarity (SIS)

This index helps to understand the similarity between two different habitats. Table 2 illustrates that highest SIS value (68.9) was observed in riverine and wooded grassland. It was clear there was 69% resemblance in species composition in these two habitat types. Nearly the same percentage of similarity was there in grassland and wooded grassland association which illustrated that grassland was influenced by woody perennials. Least SIS value (33.7) of grassland and wetland association explained that very few species were similar on those ecosystems. The relationship between wetland and wooded grassland in terms of similarity is also weak.

Table 2. Sorenson's index of similarity

Habitat	Grassland	Wetland	Riverine	Wooded grassland
Grassland	-	33.7	62.3	68.3
Wetland	33.7	-	54.1	46.2
Riverine	62.3	54.1	-	68.9
Wooded grassland	68.3	46.2	68.9	-

Diversity and Maturity Indices

The indices of diversity calculated for wooded grassland, riverine forest, grassland, and wetlands were 1.09, 1.01, 0.96, and 0.95 respectively (Table 3). Similarly, riverine forest, wooded grassland, grassland, and wetland had maturity indices of 0.16, 0.13, 0.07, and 0.03, respectively.

Table 3. Shanon's index of diversity and maturity index

Habitat	Shanon's Index	Maturity Index
Grassland	0.96	0.07
Wetland	0.95	0.03
Riverine	1.01	0.16
Wooded Grassland	1.09	0.13

Wooded grassland had the highest Shanon index, which indicated that it is the most diverse habitat among other types. It further hinted that grassland could change its status towards wooded grassland. It was obvious that riverine forest had the highest maturity index and signified for most matured vegetation type in the study area.

Human activity

Prohibited actions made by the local people were the major threats on Shuklaphanta grassland ecosystem though the grassland lied far from human settlement and was a core area of SWR. The illegal activities comprised of poaching of endangered and keystone species, grass cutting for roof thatching, letting livestock to graze in and around of grassland area, fishing in wetland ecosystem by using poisonous chemicals. Human activities outside the grassland also had negative impacts on the ecosystem. For example, chemical fertilizers used in agricultural land mix in wetland ecosystem could create problems like eutrophication. Local people used poison and electricity for catching the fish in water bodies which ultimately lost the aquatic diversity as well as adverse

impact on grassland dependent faunal species that used flowing water.

Management practices

Principally, management of grassland includes burning, cutting, ploughing, uprooting of shrub and tree saplings and so on. However, limited actions of management had been applied for the same in the study area. The management performed burning of grassland biannually. It was true that, burning of grassland helped for germination of new seeds, fresh sprout of grasses for all ungulates and also made favourable playing ground for herbivores. On the contrary, this practice is harmful for grassland birds like Hodgson's Bushchat, Bengal florican, a fowl in the category of critically endangered in the IUCN Red List. The present practice of chopping the tree saplings is detrimental and facilitates for the process of changing grassland into wooded grassland and eventually into forest.

Situation analysis

Invasion of Woody Perennials and Invasive Alien Species

I. cylindrica-dominated phantas, important habitats of the threatened swamp deer (Schaaf 1978), spotted deer and *nilgai* (Peet 1998) and the globally threatened Bengal florican (Inskipp & Inskipp 1983) are shrinking as a result of succession to tall grassland and forest species unpalatable to medium sized ungulates including swamp deer (Thapa & Mahato 2006). Primarily, the invasion was caused by native species. The impacts associated with the encroachment comprised of the loss of playground for swamp deer, loss of preferable habitat for grassland species including swamp deer, hog deer, Bengal florican; grassland ecosystem imbalance; and finally converted into forest. Gyawali and Jnawali (2005) explained that among the five different habitats used by swamp deer, short grassland was most preferred (HP value of 37.65%), followed by wooded grassland (HP value 27.14%) and the lowest HP values were for riverine forest (10.79%) and marsh (10.15%). It clearly indicated that encroachment invites negative impacts for the large herds of swamp deer. Preferred *I. cylindrica* and *S. spontenum*-dominated grassland losses its species composition and ecosystem services. Similarly, the hispid hare generally prefered to live in dry soil, and mostly near *Narenga* sp. with clumps of grasses more than 1m tall where they could easily move, see and play around (Yadav *et al.* 2008).

Wegge *et al.* (2006) revealed that one-horned rhino diet was dominated by graminoids (45.5%) followed by woody plants (33%) and others (3%); hog deer also subsisted mainly on graminoids (66.5%) and nine grass species, five species of woody plants and fruits of one shrub; swamp deer diet had the highest proportion of graminoids (74.5%), followed by woody plants (12.5%) and others (5%); and remarkably *S. spontaneum* was the most important forage plant (24%) for swamp deer, (18.5%) for rhino, and nearly one third for hog deer. However, another study (Bhatta 2008) found that *I. cylindrica* was the most preferred grass species of swamp deer. Hence the *S. spontaneum, I. cylindrica* grassland plant species, play vital role for the survival of herbivores including abovementioned species. Large patches of grassland become invaded by trees like *B. ceiba* and shrubs and it is becoming a major issue in Suklaphanta (Yadav *et al.* 2008). High value of *B. ceiba, B. monosperma,* and *S. villosa* at grassland as well in wooded grassland signify and authenticate that invasion by native species is continuous process in the study area. The highest similarity (as calculated using Sorensen's index of similarity 1948) was observed between the floodplain tall grassland and short grassland, while the least was between the moist riverine forest and tall grassland (Thapa & Mahato 2006). However, this study revealed that (by using the same index of similarity) the highest similarity occurred between riverine and wooded grassland followed by wooded grassland and grassland; and then riverine forest and grassland. This linkage clearly points to the succession of grassland to wooded grassland as well as invasion of riverine species in grassland.

IAPS, *L. camara* and *E. crassipes*, ranked within tenth position as most notorious plant all over the world, are spreading their area in terrestrial and wetland ecosystem respectively. The whole of *Shikari* Lake was covered in the invasive introduced *Eichhornia crassipes* (Baral 1996), the greatest danger faced by the wetlands is the dense and rapid growth of the same (Sharma 2006). *E. crassipes* is continuously encroaching the *Shikari* Lake significantly to the date. Along with this species *Arundo donax* is also extending its area from the outer bank of the same lake towards center. Similarly, *L. camara* is spreading slowly in grassland compared with outer skirt of the study area. Notably, *L. camara* was observed for the first time in core grassland. It has the capacity to subdue the growth of other native species and fast spreading.

Human activity

Human activities like poaching, illegal timber and grass cutting, usage of poisonous chemicals, causing forest fire, and livestock grazing have been destroying ecosystem balance in grassland. Poaching of prey species such as swamp deer, hog deer, barking deer, rabbit, and wild boar adversely affect to the prey base species like tiger and leopard and species composition. This reserve was famous for the densely populated tiger around the globe but this fame now is just in history because of untoward actions. With the illegal grazing and poaching the tigers and swamp deer are not safe in SWR and the swamp deer are not finding a safe haven to browse (Poudel 2007). Livestock grazing around the grassland, could transfer serious diseases like Tuberculosis to the wildlife. Interestingly, during the field study, a pet dog was roaming in grassland which signs for possibility of poachers or might encounter and spread the infectious disease like rabies. Notably, swamp deer avoids using areas grazed by livestock (Bhatta 2008). Additionally, a variety of direct and indirect effects of livestock grazing may interact to promote woody plant seedling establishment in grass communities (Archer 1995). These all activities are against the ecosystem balance and create undesirable impacts to obtain the ecosystem services.

Fishing at night time at Shikari Lake has been observed during the study period and came to know that it is continuous process which adversely impact for the movement of larger animals like elephant, tiger and disturb the night life. On the other hand, repeated usage of poisonous chemicals makes species vulnerable and could not prolong their offspring. Aquatic as well as water dependent species like deer species, Bengal florican, lesser adjunct, also predator species negatively affected and may lose their life as a result of poisonous chemicals in the water source.

Management practices

Practices like burning, cutting, ploughing, chopping down of shrubs and trees saplings have been continuously using as management approaches. Burning twice a year is in practice and helps for herbivores for fodder. Generally, a single fire favours invasion by increasing germination of certain plant species. However, two fires in close succession retard the invasion as the second fire destroys the seedling. After grassland burning new sprouts of grasses, which are preferred by ungulates instead of stiff, hard and rough parent grass species. In addition to that swamp deer, hog deer and other small animals get playing ground after burning. This activity not only helps for small and large wildlife, One-horned rhinoceros, wild elephant and other herbivores but also destroy the tree and shrub saplings. Most of the shrubs are seasonal and burn in fire therefore this management approach can control it in some extent. Entertainingly, many birds revolve just above the fire to catch insects which could be immediate benefit for them. Conversely, grassland birds like Bengal floricans, Hodgson's Bushchat lost their eggs, small herbivores loss their habitats by the fire. Burning, illegal or legal, has undoubtedly and catastrophically impacted the species-composition of grasslands and the survival of many small species, especially the Bengal Florican (MoEF 2011) and the impacts of repeated fire on small mammals like pygmy hog, which requires tall grassland, is completely unknown (Poudel 2007). The hispid hare's breeding season exactly coincides with the grass burning season and hence the burning practice has been playing a crucial role in the decline of the hispid hare in the SWR (Yadav *et al.* 2008). Small animals are compelled to change their habitat into the other places. While grassland burning, we should keep in mind the habitat, small fauna and avi-fauna to minimize the larger impact on them.

Instead of uprooting the tree and shrub saplings, present practice of uncontrolled burning and chopping is not wise management approach. Trees are also essential in grassland to provide shade for the wildlife but increasing the percentage of woody perennials is disadvantageous. It is also true that, grasslands are areas once level of disturbance (cutting, fire, or grazing) stop, plant succession leads to shrub encroachment and loss of grasslands and shrub encroachment is indeed a global problem affecting many of the world grasslands (Briggs *et al.* 2005). Controlled burning as well as careful management practices are utmost actions for the grassland conservation and to smoothen ecosystem services.

The study has identified the threat of grassland ecosystem alteration into shrub-land, wooded grassland, and forest as a result of invasion by woody perennials and invasive species along with human activities and present management practices. The prime impacts on Shuklaphanta grassland ecosystem ranges

from changes on food availability, habitat alteration, decrease the recreational value. Small to large herbivores dependent on grassland will face the problem of food scarcity or compelled to shift their habitat as adaptation measure. In addition the multiplied impacts of human intervention as poaching, illegal consumption of natural resources and adverse climatic anomalies create great toll on the ecosystem. The disrupted ecosystem services amplified pressure on both prey and prey base species including swamp deer, antelope, one-horned rhinoceros, Asiatic elephant, royal Bengal tiger, Bengal florican and other threatened species. As ecosystem is a cyclic phenomenon, impacts will diversify on all biotic and abiotic factors. The recreational beauty of this grassland accompanied by swamp deer and other animals will be lost as disappearance of these animals and increasing the number of woody perennial species. It signifies that the cultural service of grassland as aesthetic and recreational value will be adversely deteriorated.

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