International Journal of Ecology and Environmental Sciences 43 (1): 55-60, 2017
ISSN: 2320-5199 (Online)

Biodiversity in Indian Tropical Grazing Lands

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ABSTRACT

The grazing land ecosystems in Indian tropics can be recognized as Steppe formation under semi-arid climate, Dry savanna dominating central and eastern parts of Rajasthan (with 500 mm/a rainfall and 6-8 months dry spell), Shrub savanna in Deccan plateau, and *Arundinella – Themeda* tall savanna on wet slopes of low to medium elevations in the north India at the borders of the tropics. Among these, the Shrub savanna of Deccan plateau are rich in herbaceous and ligneous biodiversity. This contribution describes status of biodiversity in these grazing land ecosystems and growing threats to biodiversity in the post-liberalization economy. Evidently, during the past two decades, the alarmingly high neglect of ethno-scientific principles and incentive of a market economy, besides the conventional pressure of sedentary and migratory graziers, burning and agricultural extension have resulted in decline of phytodiversity, both in composition and herbage quality, leading to loss of faunal diversity and alteration in ecosystem functioning. Niches of livestock-friendly forage species like *Dichanthium, Bothriochloa, Cenchrus* and *Chrysopogon* have been occupied by non-palatable species, such as, *Heteropogon contortus* (L.) Beauv. ex Roemer & Schultes and *Themeda quadrivalvis* (L.) Kuntze, and weedy flora like *Agrostis*, *Aerva*, *Eragrostis* and *Euphorbia*. At places, these grazing land ecosystems have been used for development of human settlements and commercial orchards.

In Protected Areas like Kanha National Park in Madhya Pradesh, the rich nutritious herbage sites are fully occupied by non-palatable species *Saccharum sponteneum* L. in particular, thus, posing a threat of decline of foraging resources for swamp deer (*Rucervus duvaucelii* G. Cuvier). The Great Indian Bustard (*Ardeotis nigriceps* Vigors) conservation areas have deteriorated rapidly due to overgrazing by Blackbuck (*Antilope cervicapra* L.). At sites, growth of bushes and deformed coppices of tree species have resulted in increased population of predators like fox (*Volpes vulpes*) that are danger to eggs and chicks of bustard. The "pockmark" sites, such as, leftover quarrying sites have been turned into market use (industrial areas), fragmenting the continuity of faunal diversity sites. It is suggested that survey of grazing lands should be continued at selected locations on long-term basis as done for silvicultural operations (using protected and marked preservation plots) in forestry. Habitat alteration activities, especially affecting RET species, must be regulated. Establishing a network of local people and experts for regular monitoring of migratory herds and wild fauna like Great Indian Burtard would help greatly in conservation of biodiversity and RET species in particular, of the tropical grazing lands at ecosystem level.

Key Words: Biodiversity; Tropical Grasslands; India

INTRODUCTION

Grazing lands offer carrier support functionally to agri-culture, animal husbandry and forestry. These also serve as habitat to most of the wild fauna and breeding ground to birds. In tropics, they support livelihood needs of human-beings, such as, semi-nomadic pastoral tribes *Raika* and *Rabari* of *Marwar* (Rajasthan); *Bharwad* and *Rabbari* of Gujarat; *Danger* of Maharashtra; and *Golla, Kuruba* and *Lambada* of Andhra Pradesh and Karnataka. The partial nomads, viz., *Gadariya, Ahir* and *Gujjar* of Madhya Pradesh and Rajasthan, *Bhil* of Madhya

Pradesh, *Idaiyan* of coastal lowland, *Toda* of Nilgiris and *Gauda* of Orissa are also dependent on grazing lands for rearing milch animals. Central Arid Zone Research Institute (CAZRI), Jodhpur has recorded diverse types of nomads dependent on semi-arid and arid grazing lands as:

- the pastoral nomads (mainly *Raika, Sindhi, Barihar* and *Billock*),
- the trader normads (*Banjara, Gheltiwalajogi* and *Gowariea*),
- the artisan nomads (*Godoliya, Lohar, Sansi*and *Sattia*), and
- the miscellaneous nomads (*Nat* and *Balbeliya jogi*).

Due to the availability of age-old luxuriant grazing lands, the arid western Rajasthan has been the home of excellent cattle breeds, viz., *Rathi, Tharparkar, Nagouri* and *Kankrej,* and sheep breeds, viz., *Nali, Pugal, Magra, Chokla, Marwari* and *Jaisalmeri* (Lal and Melkania 1994) and the Great Indian Bustard. Thus, grazing land services are link between socio-economic and ecological systems (Table 1).

Table 1.Grazing lands services are a link between socio-economic and ecological systems

Key Functions			
Production	Regulatory	Carrying	Information
Domestic livestock	Soil & water conservation	Grazing	Aesthetics
Humans food	Carbon sequestration	Breeding ground	Tourism
Forage	Flood mitigation		Spiritual & Cultural
Biofuel	Riparian area rejuvenation		Historical & Archaeological
Fibre	Clean environment		Scientific
Fish/Meat fauna			
Genetic & bio-chemical materials			

ORIGIN, TYPES AND DISTRIBUTION

The tropical grazing lands in India are either edaphic climax or sub-climax resulting from continued biotic influences (disclimax) in the form of deforestation and abandoned cultivation. Grazing lands in Nilgiris have come into existence on account of the forest clearing as their re-colonization by ligneous species is prevented by repeated firesand continual grazing in forest and open areas (Legris and Blasco 1969). The true tropical grazing lands occur between 8° to 28° N, 68° and 87° E, and 300-1200 m altitude in Gujarat, Maharashtra, Rajasthan, Madhya Pradesh, Orissa, Andhra Pradesh, Karnataka, Tamil Nadu and Kerala. Central Indian Plateau and Aravali ranges with gently undulating to hilly topography receive 300-600mm rainfall annually. Ironically, specifically identified and regulated grazing lands are virtually non-existent in India. The official record of grazing lands (13 million ha) implies neither biological and management status nor suitability for recording, but only traditional usage. Neither these grazing lands are demarcated on the ground nor any definite agency exists for their management.

Dabadghao and Shankarnarayan (1973) identified *Sehima-Dichanthium* type as true Indian tropical grazing land in semi-arid and arid zones. The *Dichanthium-Cenchrus-Lasiurus* type, *Phragmites-Saccharum-Imperata* type and *Themeda-Arundinella* type represent, respectively, sub-tropical dry sub-humid, moist sub-humid and sub-humid to humid zone (Misra 1983). Most of these grazing lands are interrupted by woody vegetation, hence, better called as savanna (Misra 1983, Singh et al. 1984). Gadgil and Meher-Homjii (1984) pointed out that almost all the Indian savannas are result of human interference and that they are replaced by a variety of natural forest types ranging from tropical rain forests (rainfall >5000 mm yr^{-1}) to thorny scrub (rainfall <400 mm yr^{-1}). UNESCO/UNEP/FAO (1979) classified tropical grazing lands in India broadly into four types:

(a) Steppe formations in semi-aid climate (<200 mm yr^{-1}) in western Rajasthan – Dominant species are *Aerva, Calligonum, Aristida* and Eragrostis

(b) Dry savanna in central and eastern Rajasthan under rainfall 500 mm yr^{-1} - Dominant species include *Cenchrus ciliaris, C. setigerus, Dichanthium annulatum, Lasiurus sindicus, Panicum antidotale* and *P. targidum*

(c) Shrub-savanna- the largest savanna of Deccan plateau under rainfall 700-1200 mm yr^{-1} - Dominanat species are *Cymbopogon* spp., *Panicum maximum* and *Themeda cymbaria*

(d) *Arundinella-Themeda* dominated tall savanna in north India at the borders of tropics on wet slopes at low and medium altitude.

ECOLOGY AND BIODIVERSITY

Studies on the ecology of Indian grasslands have been reviewed by Singh and Krishnamurthy (1981) and Melkania and Singh (1989). The tropical grazing lands are dominated by therophytes due to strong grazing pressure and climatic periodicity. The major floral components include:

Aristida setacea Retz., *Bothriochloa pertusa* (L.) A. Camus, *Dichanthium annulatum* (Forsk.) Stapf, *D. caricosum* (L.) A. Camus, *Sehima nervosum* (Rottler) Stapf. as major graminaceous species; *Cassia auriculata* L., *Mimosa rubicaulis* Lam., *Zizyphus nummularia* (Burm. f.) Weight and Am as major shrub species, and *Acacia catechu* (L. f.) Willd., *A. sundra* (Roxb.) DC., *Anogeissus latifolia* (Roxb. Ex DC.), *Dalbergia latifolia* Roxb., *Hardwickia binata* Roxb., *Tectona grandis* L. f. and *Terminalia tomentosa* W. and A. as major tree species.

The tropical grazing lands support relatively lower biomass because of limited availability of water. The phytomass supports a wide variety of secondary producers. The invertebrates include grasshoppers and moths, ants, termites, spiders and ticks, and other microarthopods. The soil fauna is represented by protozoans, rotifiers and nematodes; microarthropods and earthworms; and burrowing animals. Termites serve grazing lands as significant detritus feeder. Ants have marked influence on staggered and aggregated distribution of autotrophs as they store grass seeds in burrows. Aneura are distinct amphibians during rainy season in particular. Reptiles, viz., snakes and lizards exercise control over other herbivores. The graminaceousavifauna consume an appreciable amount of grass seeds, and the insectivorous birds regulate the insect population. The mixed species foragers (e.g., Indian Peafowl - *Pavo cristata* L.; Peacock) are also common. Rodents and legomorphs contribute significantly both as consumers and modifiers of the habitat. The mammals are represented by impoverished ungulates of generalist browsing species in particular. Intense use of grazing lands by humans and cattle arrest specialist or large generalist grazers from achieving a permanent place in the ungulate community.

Studies conducted by the State Forest Research Institute, Jabalpur (cited in Melkania and Singh 1989) in Kanha National Park reported Chital (*Axis axis*) Erxleben as grazer and browser of wide range of grass species, forbs and tree species while barasingha (*Cervus duvauceli brandri* G. Cuvier) and black buck (*Antilope clevicarpa* L.) are exclusively graminivorous. Chital and langur (*Presbytes eutellus* Dufresne) are widely distributed in all mid-successional grazing lands. Gaur (*Bos gaurus* C.H. Smith) and samber (*Cervus unicolor* Kerr) are frequent dwellers of early-to mid-successional grazing lands whereas barking dear (*Muntiacus muntzak* Zimmermann) and four-horned antilope (*Tetracerus quadricornis* de Blainville) frequently occupy the plateau grasslands. Chital is reported to prefer maximum *Chrysopogon fulvus* (Spreng.) Chivov, *Cynodon dactylon* L., *Dichanthium annulatum, Heteropogon contortus* (L.) Beauv. ex Romer and Schultes and *Themeda triandra* Forsskal, and flowers and fruits of *Madhuca indica* (L.) J.F.Macbride. The barasingha prefers *Saccharum spontaneum* L. while *Panicum montanum* Roxb., and *Iseilema prostatum* (L.) Anderson are preferred forages of gaur.

THREATS TO GRAZINGLANDS AND THEIR BIODIVERSITY

During the last three decades, the tropical grazing lands have reduced greatly in extent, got fragmented and degraded by large-scale expansion of agriculture, faced conversion to other kinds of the land uses, and experienced pressure of drainage, overgrazing, trampling and fires. Graziers' encroachment has also increased in the protected areas. Large increases in livestock have led to widespread overgrazing; the problem has exacerbated as more and more grazing lands have been converted to other land uses. The agro-chemicals-supported agriculture has intensified in recent years in tropics leading to increased production with damaging impact on avifauna. The vultures have attained highly threatened status due to poisoning by dichofenac, a drug used to treat livestock ailments.

Increased bovine pressure and drought-led forage shortage have compelled the nomadic pastoralists of Rajasthan to make indiscriminate use of grazing resources. Further, the settled rural communities do not welcome the nomadic groups due to opening-up of communication in interior villages, thus, making their lives measurable. The normadicgraziers depending on highly hot desert adapted *Lasiurus sindicus* Henr. grass of "psammophytic scrub desert" (Meher-Homji 1977) native grazing lands for sheep and goat grazing now experience crisis of profuse growth of *L. sindicus* as in many areas in *Marwar* region in Rajasthan, this grass in loosing ground due to increase in soil moisture regime on account of irrigation and seepage from Indira Gandhi

Canal (villagers in the area of Chadan and Jaisalmer; selected *Marwari* Graziers, personal communication). The availability of water for irrigation has promoted interest of landowners for agriculture over forage resource development. Many of these nomads who suffered alarmingly high hardship of grazing resources have forcefully established houses and are searching for alternate economic activities for their livelihood.

In South India, the deforestation-led change of forests to savannas has accelerated rapidly the dual use of savannas as a source of fuelwood and communal grazing resulting in increased degradation of the latter (Gadgil and Meher-Homji 1984). Srinivasan (1984) reported greater use of savannas in Peninsular (South) India for cultivation of agronomic and plantation crops, compared to their use for forage production and animal husbandry in Tenali, Guntur region of Andhra Pradesh. Market incentives, such as, cultivation of lemon (*Citrus* spp.) has ledconversion of grazing land into fruit orchards. The Chennai-Kolkata railway makes it possible for them to export their production to Kolkata. Introduction of ligneous species in wastelands in semi-arid and arid regions as afforestation and/or reforestation activity has led to reduced herbage production due to direct and indirect influences of planted species.

In aquatic ecosystems, including wetlands, fertilizer-led nutrient enrichment has been harmful to aquatic forages and birds. The build-up of persistent pesticides, e.g., DDT and aldrinin food chain is affecting adversely the birds of prey particularly. Natural habitats outside the protected areas have been encroached by the adjacent communities, converted to agronomic land and/or led to deterioration of habitat and decline of bird's species and their population. In Birdlife International's 2010 Assessment, 1240 avifauna have been considered threatened by extinction (12.5% of the world's avifauna) including 78 species of regular occurrence in India.

Overgrazing (at times increased intensification of agriculture and/or conversion of grazing lands to agrarian systems) have threatened wildlife of these forage resources. The maltreatment of arboreal species for woodfuel and top feed has reduced their seed output and ultimately poor regeneration in grazing lands.Rapid coppicers, e.g., *Butea monosperma* (Lamk.) Taubert with thorny species, such as, *Zizyphus nummularia* and weedy flora, e.g., *Cassia tora, Themeda quadrivulvis*, etc., have occupied successfully the heavily grazed sites. The *Lantana camara* L.-rich degraded grazing lands have now been occupied by striped hyena (*Hyaena hyaena* L.) population as they can stay in concealed state by day time in *Lantana* thickets and shelter places as small caves among rocks and boulders, thus, causing additional threat to herbivore diversity.

The selective grazing habit of grazers has led to loss of palatable species and predominance of opportunistic therophytes of non-forage value. Severe browsing of *Salvadora oleoides* Decne and Z. *nummularia* in arid environ-ments has forced these species to stay in "low-canopied bush form" and *Anogeissus pendula* Edgew and *Prosopis cineraria* (L.) Druce to "pillow-cushion form". Trampling together with low availability of moisture has altered mechanical composition of soils, thus, promoting growth of ephemeral weeds, finally followed by desertification if the bovine pressure continues. The human-induced most common surface fires (either as head or back fire), together with crown fire (developed from surface fire due to favourable weather and low moisture biomass availability) destroy the juvenile coppice shoots of ligneous species, thus, deteriorate the health of savannas and higher order seral community formation. Excessively burnt sites are occupied by annual weeds and half-burned regrowth of *Clero-dendrum, Costus,* etc.

Wildboar (*Sus scrofa* L.) is now widely distributed in busy areas and degraded forests with lopped trees. In Central India, majority of young wild boar are borne at two periods, shortly before and shortly after the rains, thus, damage grazing lands significantly. No animal is more destructive to crops than the wild boar. In cultivated areas of originally grazing lands, it has now become impossible to make plea for crops protection. The highly prolific tendency (all weather breeding) togetherwith high sense of smell have led change in landuse from cultivated area with crop to cultivated areas unsown but ploughed only.

Most of the Peninsular region grazing lands' endemic birds are now at serious risk, including Lesser Florican *Sypheotides indicus* Miller and Great Indian Bustard (GIB) *Ardeotis nigriceps* Vigors due to habitat degradation and loss. Among grazing lands' birds, omni-vorous GIB has suffered significantly. It preferably inhabits short grass plains in semi-arid and arid tropics with scattered low shrub (Rahmani 1989). Fragmen-tation, modification and finally loss of such grass plains as a result of widespread agricultural development and land use changes (on account of quarrying and industrial development), irrigation schemes (to convert areas to paddy cultivation), increased use of pesticides in agriculture, livestock grazing, high level disturbance due

to widespread hunting for sport and food, accelerated vehicular access to remote areas are reported as key threats to GIB which belongs to Schedule 1 of the Wildlife Protection Act, 1972 and CITES Appendix 1 (Rahmani 2002). Increasing instances of nest trampling and egg loss, disturbances caused by farmers and inappropriate protected area management have added to the problem further. Growth of bushes and small trees in stone-wall-cum-hedge fenced areas have resulted in increased population of black buck (*Antilope cervicarpa* L.) and natural predators like fox (*Volpes vulpes* L.) that are danger to GIB's eggs and chicks. It is hoped that some GIB's sanctuaries like Ghatigaon (Maharashtra) would totally lose their bustard population in couple of years if agricultural expansion continues (Rahmani 2006). Karena, Sorson and Ranibennur sanctuaries have already lost their bustards (Rahmani 1997).

In desert of Jaisalmer (Rajasthan), while changing life style and unregulated human activities (prominently tourism) have endangered the GIB, thousands of windmills around the Park are posing serious threat to the GIB. The surveys conducted by the State Forest Department reveal that the population of GIB in 2014 has come down to less than 50 from 154 in 2012 and 103 in 2013 (Dhar 2015).

Invasion of alien species and woody perennials in tropical grazing lands is yet another emerging biotic threat to structure and function of these ecosystems. *Prosopis juliflora* introduced into Indian hot desert as early as 1913 mainly to stabilize sand dunes for stopping desert spread (Muthana and Arora 1983) has now found roots in the sprawling grazing lands of Jamnagar district in coastal Gujarat. Kumar et al. (2006) revealed that 24% of grazing land area in Jamnagar has been invaded by *P. juliflora* (Swartz) DC. resulting in change in species composition and forage biomass decline drastically. Sites invaded by *P. juliflora* have dominance of lower order seral weedy species. Even among the protected and undisturbed sites, dominance of late successional species, e.g., *Acacia nilotica*, *A. senegal* and *Z. nummularia* are recorded less at sites with *P. juliflora* than at sites without it. Invasion of *P. juliflora* has influenced density of an endangered species *Commiphora wightii* L. negatively (Kumar and Mathur 2014) which may lead to its complete loss over decades.

TASK AHEAD

The foregoing account evidently illustrates that the grazing lands in Indian tropics are now resources under seize. The grazing land-forest interface is changing rapidly. As the pastoralists and marginalized human population and wild fauna especially depend on the grazing lands, India needs a definite and well-identified agency to manage and demarcate these grazing land resources clearly on the ground. The much needed grazing policy for utilization and management of these resources is yet awaited. Regular survey of the grazing lands similar to the forest survey in India for status, population dynamics, productivity, biodiversity and pattern of movement of grazing land fauna, such as, GIB, chital, etc., using remote sensing and established permanent plots in each grazing land type is the need of the hour. The Forest Department personnel, revenue authorities and village *panchayat/Gram sabha* should be motivated for effective improvement and conservation of the grazing lands and forest floor vegetation management, especially in peri-rural areas. Habitat alteration and developmental activities must be regulated through legal measures and/or awareness generation programmes as the case may be. multi-stakeholder monitoring involving concerned public sector's line departments, non-governmental organizations, experts and user groups (community) should be practiced by measuring the health and use of grazing lands instead of single department-centric monitoring to promote participation and concern of all the stakeholders. In formal tertiary level education, the grazing land management must be included as a key chapter/course in agriculture, forestry and environmental science. In the development planning, grassland management should be positioned as an integral part of overall land use and natural resource development action plan, forest management, eco-development, ecotourism and rural development.

In rural landscape, efforts need be strengthened further to reduce dependency of people on natural (forest) resources by promoting alternate energy sources, efficient (wood) energy utilization devices, managed private and community forage husbandry, reducing bovine population and promoting forage cultivation. Development of fuelwood and fodder reserves and resources, and habitat management for avifauna and RET species are the urgent necessities. Creating conducive habitat for grazing land fauna, especially GIB, can help significantly for reviving the declining population of such threatened species. Selection of Important Bird Areas (IBAs) for conservation of grassland birds in their entirety can be an effective way of habitat management as a part of Protected Area Networks (PANs). Birds living in marginal agricultural areas, such as, GIB, partridge, etc., need support of local people necessarily

for long-term conservation. Thus, community resources or community conservation recovery programmes suggested under the Wildlife Act 1972 (amended in 2013) could help in survival of the species.

ACKNOWLEDGEMENTS

Apart from the published studies, interaction and discussions with scientists of Central Arid Zone Research Institute, Jodhpur, selected pastoralists of *Marwar* and *Kutchh* region, forest officials and pastoral and peasant community individuals and author's own field surveys have been much useful in presenting the subject to the users. The author extents grateful thanks to all those who facilitated surveys and collection of information on tropical grazing lands.

REFERENCES

Dabadghao, P.M. and Shankarnarayana, K.A. 1973. The Grasscover of India. Indian Council of Aagricultural Research, New Delhi. 713 pages.

Dhar, A. 2015. Windmills spell doom for Great Indian Burtard. The Hindu, March 08, 2015, p. 03.

Gadgil, M. and Mehar-Homji, V.M. .1984. Land use and productive potential of Indian savannas. pages 106-113. In: Tothill, J.C. and Mott, J.C. (Editors) Ecology and Management of the World's Savannas, Commonwealth Agricultural Bureaux, London, U.K.

Kumar, S. and Mathur, M. 2014. Impact of invasion by *Prosopis juliflora* on plant communities in arid grazing lands. Tropical Ecology 55(1): 33-46.

Kumar, S.; Mathur, M.; Thakkar, P.S. and Jadha, R.N..2006. Spatial distribution of grasslands through remote sensing with implications in their yield management in a coastal arid part of India. Range Management and Agroforestry 27: 35-39.

Lal, J.B. and Melkania, N.P. 1994. India's Grasslands: Ecology and Management. Status Paper, National Workshop on Grassland Management in India: New Opportunities and Challenges, Indian Institute of Forest Management, Bhopal, 38 pages. (Mimeo).

*Legris, P. and Blasco, F. 1969. Variabilité des facteurs du Climat: Cas des montagns du sud de l'Inde et de Ceylon. Institut Français de Pondichéry, Travaux de la section scientifique et technique 8: 1-95.

Melkania, N.P. and Singh, J.S. 1989, Ecology of Indian grasslands. pages 67-103. In: Singh, J.S. and Gopal, B. (Editors) Perspectives in Ecology. Jagmander Book Agency, New Delhi.

Misra, R. 1983. Indian savannas. psges 151-166, In: Bourliére, F. (Editor) Tropical Savannas, Elsevier Scientific Publication, Amsterdam.

Meher-Homji, V.M. 1977. The arid zones of India: Bioclimatic and vegetational aspect. pages 160-175, In: Desertification and Its Control. Indian Council of Agricultural Research, New Delhi.

Muthana, K.D. and Arora, G.D. 1983. *Prosopis juliflora* (Swartz) D.C., A Fast Growing Tree to Bloom the Desert. CAZRI Monograph No. 22. Central Arid Zone Research Institute, Jodhpur. 48 pages

Rahmani, A. 1989.The Great Indian Bustard. Final Report. Bombay Natural History Society, Mumbai. 234 pages.

Rahmani, A.R. 1997. Great Indian bustard in Ranibennur. Newsletter for Birdwatchers 37: 44-45.

Rahmani, A.R. 2002. Protection of Nankaj Bustard Area, Solapur, Maharashtra. Report. Bombay Natural History Society, Mumbai. 9 pages.

Rahmani, A. 2006. Need to Start Project Bustards. Bombay Natural History Society, Mumbai. 20 pages.

Singh, J.S. and Krishnamurthy, L. 1981. Analysis of structure and function of tropical grassland vegetation of India. Indian Review of Life Science 1: 225-270.

Singh, J.S.; Hanxi, Y. and Sajise, P.E. 1984 Structural and functional aspects of Indian and south east Asian savanna ecosystems. pages 34-51, In: Tothill, J.C. and Mott, J.C. (Editors) Ecology and Management of the World's Savannas. Commonwealth Agricultural Bureaux, London, U.K.

Sreenivasan, P.S. 1984. Crops and cropping pattern in savanna of peninsular India. pages. 265-269, In: Tothill, J.C. and Mott, J.C. (Editors) Ecology and Management of the World's Savannas. Commonwealth Agricultural Bureaux, London, U.K.

UNESCO/UNEP/FAO. 1979. Tropical Grazing Land Ecosystems, UNESCO, Paris. 1650 pages.

* Original not seen

Received 16 October 2016
Accepted 8 February 2017