Grasslands of Anshi-Dandeli Tiger Reserve

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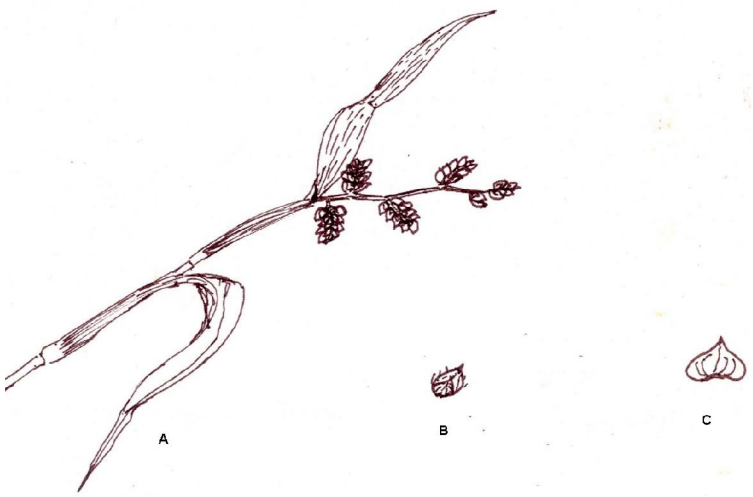

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Chapter 1: INTRODUCTION

During the last century, there were over 40,000 tigers in India. This number has dwindled to 1827 by 1972 due to poaching, illegal hunting, fragmentation and destruction of habitat, making them an endangered species. The Government of India started "Project Tiger" on April 1st, 1973 to protect the tigers from extinction. Uttara Kannada district was exceptionally rich in tigers almost until late 19th century. British chronicles show hundreds were hunted down in the district during late 19th century, and such hunting was even sponsored by the government. Presence of numerous tigers in the district until the close of 19th century highlights the richness of forests interspersed with grasslands, abundance of water resources and richness of wildlife in general, especially the grazing mammals, constituting the prey stock of the wild carnivores.

Dandeli Wildlife Sanctuary with the extent of 206.75 sq kms was first notified as Game Sanctuary in the year 1956 (vide Bombay Govt. Resolution WLP.1957 dated 10-05-1956). This was extended to 5729.07 sq kms (vide Government of Karnataka Notification No. AFD 52 FWL 74 dated 08-01-1975) and subsequently reduced to 834.157 sq kms (vide FFD 150 FWL 81 dated 01-09-1987) and 475.018 sq kms. (vide draft Notification no. FEE 172 FWL 93, on 29-04-1994), which was finally notified as Dandeli Wildlife Sanctuary (vide FEE 58 FWL 96/09-03-1998). The draft notification of Anshi National Park was done covering an area of 250 sq kms (vide AHFF 77 FWL 87 / 02-09-1987) and the final area notified is 339.866 sq kms (vide Notification No. FEE 221 FWL 99 dated 18.08.2003). Both the Protected Areas with the spatial extent of 814.884 sq km was declared as Tiger Reserve on 4th January 2007 (GO No. FEE 254 FWL 2006). This along with the Mahaveer Wildlife Sanctuary of Goa covers an area of over 2,000 sq.km.

Anshi-Dandeli Tiger Reserve-Study area

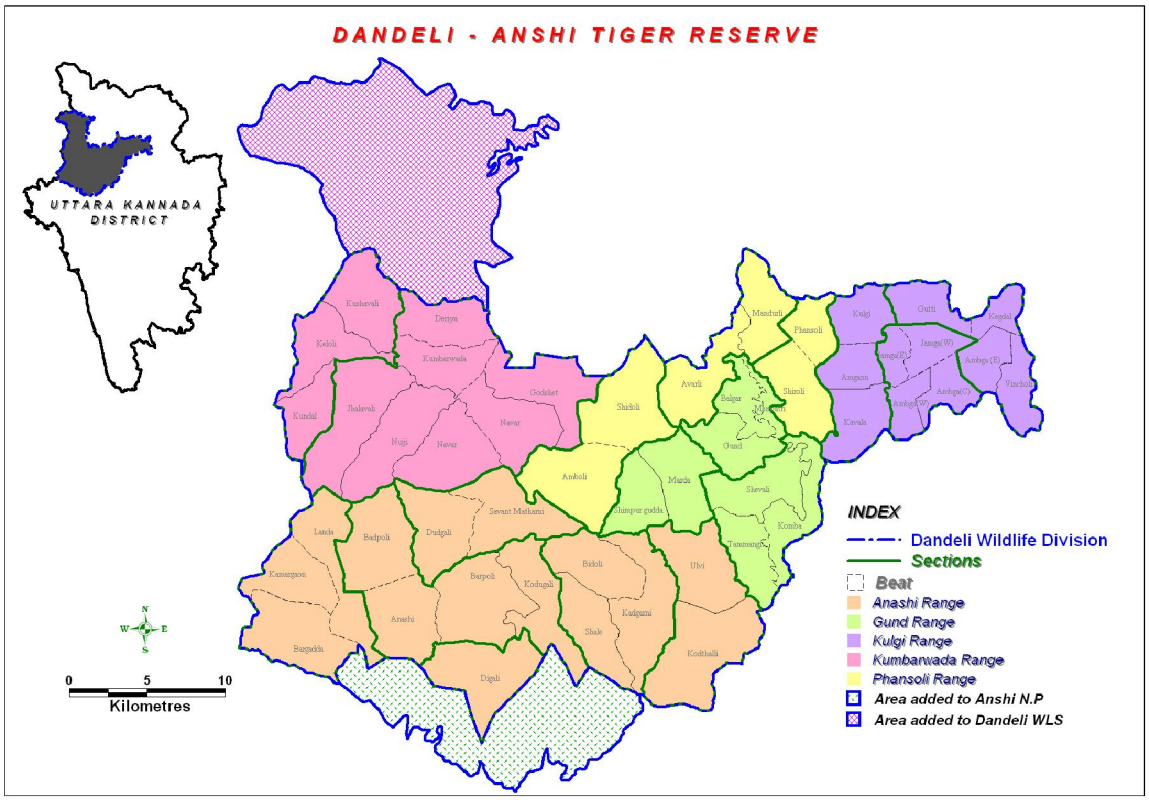

Figure 1.1: Dandeli-Anshi Tiger Reserve

The Anshi-Dandeli Tiger Reserve (ADTR) covers the hill ranges of northern Uttara Kannada district in the taluks of Joida and Haliyal (Figure 1.1). The western side of the Tiger Reserve, receive seasonal heavy rainfall from the South-West Monsoon to the tune of 3000-6000 mm. Tropical evergreen forest is the climax vegetation here. However, human factors through millennia have transformed bulk of these forests into semi-evergreen types, interspersed with savannas and agricultural areas. Progressive decline in rainfall towards the east, which gradually merges with the Deccan Plateau in the rain-shadow region, is responsible for moist and dry deciduous forests. Long history of forest burning in the past and wholesale transformations of the forests into teak plantations, beginning with the British period have acted as powerful factors that modified natural vegetation. Places such as Kumbarwada, Diggi, Terali, and Kundal have large expanse of grasslands, due to the slash and burn cultivation practices earlier by shifting cultivators consisting communities such as Kunbis and Kumri Marathis. *Gavli* pastoral tribes and *Siddi* forest dwellers live in this area. Many village settlements are present in the reserve and the surrounding areas where the wild animals move.

Faunal diversity of Anshi and Dandeli Tiger reserve

This Tiger- Reserve is habitat for large mammals, which include bonnet macaque, spotted deer, barking deer, mouse deer, gaur, civet, Malabar giant squirrel, pangolin and sloth bear. Besides, the black panther, elephants and tigers are rare species found in the park. Reptiles spotted in the park include the king cobra, krait, python, rat snake and viper. Around 200 species of birds are reported from the park. These include the adjutant stork, ashy woodswallow, black-crested bulbul, blue-headed pitta, brahminy kite, broad-billed roller, crested serpent eagle, and yellow-footed green pigeon (Source: Karnataka Forest Department, Dandeli).

IMPORTANCE OF GRASSLANDS FOR TIGER CONSERVATION

The tiger is internationally recognized as an endangered animal destined to be extinct in the wild if the forces causing its decline continue. Many small tiger populations are completely isolated and critically endangered. Entire subspecies from Bali, Java and areas adjacent to the Caspian Sea have not survived. The South China tiger is down to a few individuals and is slipping away. There has been much anxiety for the tiger and its future. Some predict the tiger's demise, with some isolated populations expected to blink out in the near future (Seidensticker et al., 1999). The resonating theme of the excellent work *Riding the Tiger*, has been the importance of the tiger's prey, mainly the large mammal. "…this great cat evolved as the predator of the largest deer, wild cattle and wild pig, and where this essential prey has been extirpated, the tiger does not survive. However, where large prey are abundant, the tiger survives and has a robust reproductive output" (Seidensticker et al., 1999).

If we examine the important prey animals throughout Asia, where the tiger survives in many pockets, there are many kinds of deer among them such as the chital, sambar, chousingha, muntjac etc. and other ungulates like gaur, wild pig, nilgai and domestic cattle; they sometimes even feed on langurs and porcupines. By and large the tiger's prey are herbivores that depend substantially on grasslands. Yet we cannot underestimate other landscape elements such as forests, scrub, riverine habitats and even mangroves as harbouring tigers and their prey. Diverse kinds of landscape elements are preferred by tigers. Even their prey, deer for example, not only feed on grasses but also browse on the leaves of trees and fallen fruits of many trees. Water bodies are visited by almost all animals. Therefore the Tiger Reserve should be a healthy combination of different landscape elements, including the grasslands that provide bulk of the fodder needs of the ungulates.

UNDERSTANDING GRASSLANDS

Grasslands are the grass-dominated areas with few trees. Global grasslands even though widespread are shrinking alarmingly and merit consideration as one of the most endangered ecosystems, even more so than tropical rainforests. Though the grasses form an easily identifiable natural group of plants they have remarkable diversity. Grass belongs to family Poaceae, the fourth largest family of flowering plants, has over 700 genera and probably 10,000 species (Sreekumar and Nair, 1991). Civilizations flourished in and around grasslands as grasses meet most of the basic human needs - bulk of the food, fodder, thatching materials, medicines etc. Livestock constitutes the backbone of agricultural economy and its sustenance depends on the grasslands. In grasslands worldwide are found maximum numbers of large herbivore animals. They also hold the key to the richness of wildlife as most wild herbivores survive on grasslands. In the grassland ecosystems we find high levels of productivity and energy utilization. A forest cannot support such large populations of grazing animals since the herb layer is less luxuriant and deficient in grasses, and the forest shrubs and trees cannot withstand heavy browsing, nor are most of them palatable. In such situations, even the forest living animals come out into open grasslands and clearances for grazing. The rapid decline of natural grasslands is due to several reasons. Grasslands being relatively open areas with low-stature vegetation receiving higher light intensity, they are easily vulnerable to invasive species, more so following disturbance (Wagner, 1989). They are sensitive to various human impacts such as conversions to agriculture and rangelands, spread of invasive species introduced by humans, road making, alterations in natural fire cycles and pollution that alters soil fertility and rates of plant growth. Their structure and function make them one of the most vulnerable land ecosystems to global climate change (Schlesinger, 1997; Mooney and Hobbs, 2000; Lejeune and Seastedt, 2001). Grassland studies are of paramount importance and pre-requisite for conservation and management of wildlife (Panwar, 1986; Rodgers and Sawarkar, 1988 Rahmani, 1992). Many studies are found on grasslands of India, including of the Western Ghats (Lele et al., 1997; Bhat et al. 2005; Misra and Misra 1981; Kotwal and Pandey, 1981; Rawat et al. 1997*;* Lehmkuhl, 1989; Rodgers, 1990).

Evolution and spread of grasslands: Grasses appear in the fossil records of the Earth from the late Cretaceous Era about 100 million years ago. The early grasses probably evolved at high altitudes, above the tree line in the mountains, because all grasses have one common attribute; they cannot tolerate shady conditions. As dense forests covered most of the land surface the deep shade of the trees did not favour grasses underneath. Pollen of grass species is notable for its absence beneath all types of forests but as soon

as tree pollen begins to decline, grass pollen makes a sudden appearance in the pollen profile. There is also the unexplainable fact that pollen from grasses has been observed at the same time in many different parts of the globe. This probably is correlated to increased aridity in climate unfavourable for forests (http://www.bcgrasslands.org/library/world.htm.).

Grasses and Adaptability: Although grasses do not thrive underneath the canopy of forests they belong to a vegetation type that actually thrives on being eaten, burnt, and trampled upon. They can grow at sites ranging from sea level up to the edges of high altitude glaciers and tolerate salinity, acidity and alkalinity. Many grow submerged partly or fully in water, yet others colonize deserts. They are successful invaders capable of colonizing diverse habitats due to their various adaptations. Their remarkable genetic adaptability equips them to adapt to such varied environmental conditions. By means of sexual reproduction they can quickly evolve new varieties to suite new growing environments. Perennial grasses spread fast by vegetative methods as well. Close to their nodes are tender spots packed with actively dividing cells constituting meristematic tissue. Stems elongate and new shoots sprout from these meristems (Misra, 1980; http://www.bcgrasslands.org/library/world.htm.).

Grasses of wetter conditions (Figure 1.2) are softer and delicate than land grasses. They have less of fibrous tissues in them. Their leaves are bright green, thinner and broader than land grasses. *Hubbardia heptaneuron*, a grass feared to have gone extinct from the spray zone of Jog water falls in Uttara Kannada is very delicate with almost translucent thin leaves and soft tissues. The grass has been rediscovered in some waterfall areas of Maharashtra Ghats. The plant parts of aquatic grasses are spongy due to air spaces that enable to them to keep their floating. However, because of silica crystal deposit even aquatic grasses like the rice plants can have rough and sharp leaves. Grasses of the other extreme, in water scarcity areas, have xerophytic adaptations. They look duller and many are with hairy surfaces. Some have water storage tissues in their leaves, which enable them to survive drought. These grasses are stronger with lot of fiber tissues. Most desert grasses have stomata on the upper epidermis which also has special cells that help in rolling of leaves into a hollow tube. Therefore the stomata are protected from the desiccating conditions during the hot hours of the day. Not only in deserts in most other drier habitats like sandy sea shores, rocky places, and other open dry areas, grasses tend to have similar adaptations.

Figure 1.2: Grasses and sedges (grass like plants) along with water-lilies

The trailing habit of many grasses (e.g., *Cynodon dactylon, Oplismenus burmanii etc.*) helps them to withstand grazing pressure, trampling and even fires. Taller grasses tend to dominate areas where they have to compete with dicot herbs. Bamboos though woody and tree like are also grasses. For them the height is of advantage in competing with trees of the forest. Grasses are prolific seed producers. Their smaller seeds have enabled them to spread widely. Most grasses also reproduce vegetatively, so that even if their shoots are browsed by animals or destroyed in fire, they produce fresh shoots from underground rhizomes or from nodes at ground level. Some grass species can survive in diverse ecological conditions; for instance the Bermuda grass (*Cynodon dactylon*), commonly found in Anshi- Dandeli Tiger Reserve can grow in submerged habitats as well as on drier soils. Tiny, wind dispersed seeds of many grasses and their light loving nature enable them to be the pioneer colonizers of freshly created open habitats. Elasticity of grass internodes confer on them survival value in windy conditions and resist trampling. Another reason for the success of grasses is wind pollination and their non dependence on animals as pollinators. All such characters of grasses provide them with greater plasticity to grow in situations not favorable for many other flowering plants.

Grasslands constitute a critical resource, as the grasses constitute bulk of the diet of herbivorous mammals, especially ungulates, which constitute bulk of the prey for the big cats, the tiger and the panther. Ecological history of the Western Ghats, especially of Uttara Kannada district, and the recent studies highlight that the number of tigers in any reserve is correlated to the number of prey animals and prey animals depends on grasslands. Therefore grasslands deserve prime attention in the management plans of ADTR. The work on grasses of ADTR is scanty and this work constitutes preliminary work which help in understanding grassland ecology. Tigers are part of a landscape of varied elements and grasslands cannot be treated in isolation, but in combination with forests, savanna, scrub, streams and rivers, gorges, ravines and cliff, which in a mosaic constitute homes for the deer, sambar, gaur and pig which are among the important preys of the tiger.

This report is based on a short term study conducted on the grasslands of ADTR keeping above objectives in view. Here we try to understand and place the grasslands of ADTR in the backdrop of the world of grasses. Not only large grasslands, but various microhabitats of grasses have bee identified and their characteristic flora catalogued. The results are discussed at length and many useful recommendations are arrived at with the tiger in the focus. Though apparently digressions from grasslands are many in this report, efforts are made to harmonise them into the holistic concern for conservation. We have also provided here locations of grasslands and other openings in the forest canopy based on Google Earth, and made efforts at estimating the forest Range-wise area under grasslands. This report carries a useful guide of pictures and descriptions of a good number of grasses of the Reserve. The use of technical terminology cannot be easily dispensed with while describing grasses, since they are plants with very subtle features. We have provided a glossary of technical terms used in taxonomic descriptions. This report is more of a preliminary study and constant efforts have to be carried out in the coming years to understand the dynamics of the grassy habitats, evaluating them in sustaining a good prey population critical for increasing the number of tigers to the potential carrying capacity of the Reserve.

CHAPTER 2: GRASSLANDS OF THE WORLD

Grasslands are of many types, and are associated with all the continents of the world, barring the Antarctica. Latitude, soil and local climates for the most part determine what kinds of plants grow in particular grassland. Natural grassland is a formation in low rainfall areas where the average annual precipitation is normally just enough to support grasses, and in some areas a few trees. The precipitation is so erratic that drought and fire prevent large forests from growing. Grasses can survive fires because they grow from the bottom instead of the top. Their stems can grow again after being burnt off. The soils of most natural grasslands are also too thin and dry for trees to survive.

The Grasslands in the southern hemisphere receive more precipitation and support taller grasses than those in the northern hemisphere. In Argentina of South America, with a humid climate, the grasslands are known as **Pampas.** A large area of grassland that stretches from the Ukraine of Russia all the way to Siberia is known as the Russian and Asian **Steppes**. The climate in this region is very cold and dry because there is no nearby ocean to get moisture from; winds from the Arctic aren't blocked by any mountains either (www.blueplanetbiomes.org/grasslands). In the Miocene and Pliocene Epochs, which spanned a period of about 25 million years, mountains rose in western North America creating a continental climate favoring the spread of grasslands and decline of ancient forests in the interior plains. Following the Pleistocene Ice Ages, grasslands expanded in range as hotter and drier climates prevailed worldwide. But natural grasslands today have highly decreased; for instance the tall grass prairie of Ontario is only three percent of the original extent (www.ucmp.berkely.edu/exhibits/biomes/grasslands). Grasslands can be broadly divided into Temperate grasslands and Tropical grasslands or savannas (Figure 2.1).

Temperate grasslands: Temperate grasslands are characterized by the general absence of trees and large shrubs. The '**Veldts**' of South Africa, the '**Puszta**' of Hungary, the '**Pampas'** (Figure 2.2) of Argentina and Uruguay, the and the '**Prairies**' (Figure 2.3) of Central North America '**Steppes**' (Figure 2.4) of the former Soviet Union, belong to this category. Summers here are hot, winters cold and rainfall moderate, lower indeed than in tropical savanna grasslands. Summers here are hot, winters cold and rainfall moderate, lower indeed than in tropical savanna grasslands (http://www.hamiltonnature.org/habitats/grasslands). The grasses attain greater heights in

wetter than in drier regions. Seasonal drought and occasional fires have decisive influence on biodiversity.

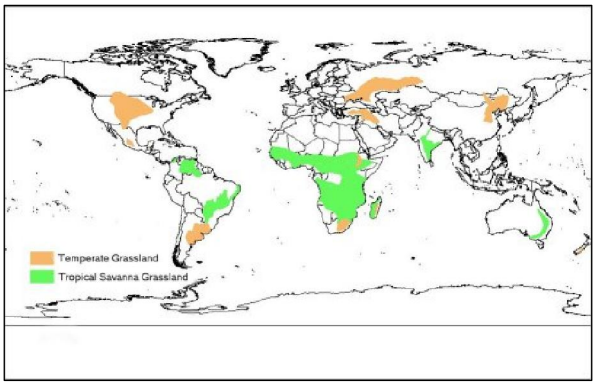

Figure 2.1: Grasslands of the world (Source: **www.bcgrasslands.org/library/world.htm)**

Figure 2.2: Pampa grasslands of Argentina

Figure 2.3: Bisons grazing in Prairies of North America

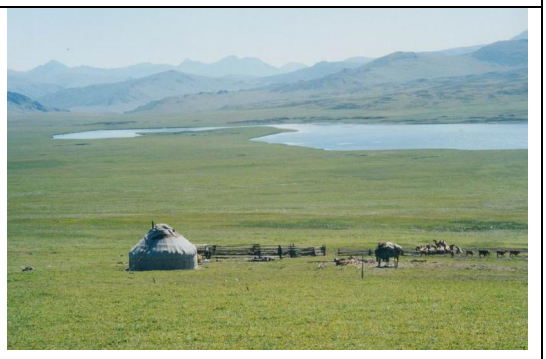

Figure 2.4: Short grasses of Steppe grassland

Figure 2.5: Savanna grassland

Tropical Grasslands (Savannas): The word 'Savanna' is derived from the Caribbean Indian language in which Sabana means forest clearings. (Savannas are grass dominated lands with scattered individual trees). Savannas of one sort or other cover almost half the surface of Africa (about eight million square kilometers, generally in Central Africa), large areas of Australia, South America, and India. Climate is the most important factor in creating a savanna, always found in warm or hot climates where the annual rainfall ranges from 51-127 cm (www.ucmp.berkely.edu/exhibits/biomes/grasslands). The rainfall here is confined to four to eight months a year, followed by a spell of drought punctuated with fires. If the rains were to be well distributed throughout the year, many such savannas would turn into tropical forest.

Savannas can be in general divided into:

- ***Climatic savannas*:** These savannas are derived from climatic conditions. Their change into other forms depends on climatic variations.
- ***Edaphic savannas***: Savannas resulting mainly from soil conditions such as hill soil, clayey water logged soil etc.
- ***Derived savannas***: Most of the Indian grasslands of plains and low altitude hills belong to this category. They are considered to be derived from slashing and burning of forests and other human impacts. Variations in rainfall and soil conditions between different savannas maintain different grass species of which some become dominant.

Indian Grasslands: The climax vegetation of India is either forests or desert vegetation (Misra, 1980). These grasslands exist solely due to the anthropogenic activities such as lopping, burning, shifting cultivation and grazing for the last several thousand years. The tropical grasslands of India are often referred as savanna. Maximum growth rates are found at about 35°C, about 10°C warmer than the optimum for temperate grasses, and at light intensity twice the optimum. The reason for this is that most tropical grasses have a different photosynthetic mechanism compared to temperate grasses. These biochemical reactions have given rise to C4 and C3 plants (Misra, 1980). During the last few thousand years, the Indian grasslands have undergone many changes. The West Indian desert (Thar) of Rajasthan today is characterized by a hot and dry summer followed by a cold winter. Historical evidence indicates that the area was under forests some 2000 years ago

but was gradually destroyed by man for agricultural practices and became desert due to excessive dryness. In the North-Eastern region, under a hot and humid climate, where rainfall exceeds 1,000 cm (world's highest), there has been development of dense evergreen forests of rich biodiversity. Over a long period of time, tribes and local peoples in this region have cleared forests and practiced Jhum (shifting) cultivation leading to the conversion of primary forests to secondary forests to grasslands (www.pages-igbp.org.; Ramakrishnan, 1992). Indian savannas during the past four centuries are stated to have changed from moderately moist (mesic) to arid (xeric) conditions favoring common woody elements like *Acacia nilotica, A. senegal, A. catechu, Calotropis gigantea, Mimosa sp., Phoenix sylvestris and Ziziphus nummularia*. Indian grasslands are tentatively divided into eight major types (Whyte R.O., 1954, 1957):

Many of the hilly forested areas of Western Ghats were under shifting cultivation by forest dwelling people, such as the Kunbis, Kumri Marattis etc. of Uttara Kannada. Patches of forests were cleared by cutting and burning, and cultivated the cleared lands for two or three years. As prolonged cultivation would cause soil erosion, decrease soil fertility and increase pest pressures the shifting cultivators would repeat this process in another patch of forest. After many years when forest had regrown on abandoned lands the cycle would be repeated (Chandran, 1998). In India, this system of cultivation is widespread to this day in the Northeastern states. It was banned in most of the South Indian Western Ghats by the British, during late 19th Century. Considerable part of the Anshi Dandeli Tiger Reserve (ADTR) was affected by this system. Whereas forests have re-grown in old shifting cultivation areas, there are very good stretches of savanna grasslands still within the Reserve. These are good examples of derived savannas. The periodic firing of these savanna grasslands keep them in their present state. If fire factor is stopped these savannas have chance to revert to forest if the ground is not rocky or severely eroded. Grasslands associated with wind exposed medium altitude of 1000-1600 m (eg. Kudremukh, Bababudan) and higher altitudes of >1600 m (eg: Anamalais and Nilgiris) are known as 'shola' grasslands. These grasslands alternate with stunted evergreen forests in the wind sheltered folds of hills (Figures 2.6 & 2.7) The species found here are *Andropogon pertusus, Ischaemum pilosum, Themeda imberbis, Cymbopogon polynuros, Eragrostis nigra* etc. Extensive areas of temperate, subalpine and alpine grasslands occur in the higher altitudes of the Himalayas (Figures 2.8 and 2.9)

Indian grasslands are broadly grouped into eight major types (Whyte, 1954, 1957) as in Table 2.1:

Table 2.1 Major types of Indian grasslands and their distribution

Sl	type	Dominant grasses	Associated grass sp.	States occurring
1	*Sehima-Dichanthium*	*Sehima sulcatum, S. nervosum, Dichanthium annulatum, Chrysopogon montanus* and *Themeda quadrivalvis*.	*Ischaemum rugosum, Eulalia trispicata, Isilema laxum* and *Heteropogon contortus*. *Themeda* and *Heteropogon* are more extensive on hilly tracks.	Black soils of Maharastra, Madhya Pradesh, south-western Uttar Pradesh and parts of Tamilnadu and Karnataka.
2	*Dichanthium-Cenchrus*	*Dichanthium annulatum* and *Cenchrus ciliaris* are very important fodder grasses	Perennials like *Bothriochloa pertusa*, *Heteropogon contortus, Cynodon dactylon* and the annuals, *Eragrostis tennela, E. tremula, E.viscosa, E.ciliaris, Aristidia adscensionis* and *Dactyloctenium aegyptium*. Well drained wet soils are characterized by *Desmostachya bipinnata* and *Dichanthium annulatum*.	Sandy loam soils of the plains of Punjab, Haryana, Delhi, Rajasthan, Saurashtra, eastern Uttar Pradesh, Bihar, Bengal, eastern Madhya Pradesh., coastal Maharastra and Tamilnadu. In dry areas of Rajasthan, Saurastra and Western Madhya Pradesh, after severe grazing these are replaced by sparse population of annuals.
3	*Phragmitis-Saccharum*	*Phragmitis karka, Saccharum spontaneum, Imperata cylindrica and Bothriochloa*		Terai areas of northern Uttar Pradesh, Bihar, Bengal, and Assam. Swamps of Sundarbans and Cauvery delta of Tamilnadu.
4	*Bothriochloa*	*Bothriochloa odorata*		high rainfall paddy areas of Lonavala track of Maharastra is only with dense growth of *Bothriochloa odorata*
5	*Cymbopogon*	*Cymbopogon spp.*	*Themeda, Heteropogon* and *Aristida*.	Low hills of the Western Ghats, Vindhyas, Satpuras, Aravali and Chota Nagpur
6	*Arundinella*	*Arundinella nepalensis, A.setosa* with *Themeda anathera* form extensive stands with sporadic growth of *Chrysopogon* spp.		High hills of the Western Ghats, Nilgiris, and throughout on lower Himalayas from east in Assam to west in Kashmir. On the Himalayas, between 1500 m to 2000 m

7	*Deyeuxia-Arundinella*	*Deyeuxia, Arundinella, Brachypodium, Bromus and Festuca sp.*		Temperate regions of the upper Himalayas between 2000 m. to 3000 m. from Assam, Bengal through Uttar Pradesh to Punjab and Himachal Pradesh
8	*Deschampsia-Deyeuxia*	*Deyeuxia, Deschampsia, Poa, Stipa, Glyceria* and *Festuca. Deschampsia* and *Trisetum spicatum* extend even beyond 5000 m.		Restricted to the Himalayas above 2500 m in the alpine to subartic region.

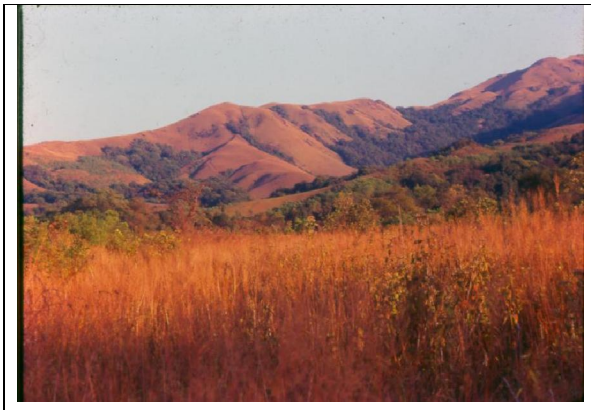

Figure 2.6: Medium altitude shola grasslands of Kudremukh

Fig: 2.7. High altitude shola grassland of Anamalais

Figure 2.8: High altitude subalpine grasslands in Western Himalayas

Figure 2.9: High altitude temperate grasslands in Western Himalayas

CHAPTER 3: GRASSLANDS OF UTTARA KANNADA

Uttara Kannada district (74^0 9'-75^0 10' E and 13^0 55'-15^0 31' N), having 10,327 sq km area is bordered by the Arabian Sea to the west. Most of the district is covered by the low altitude (<800 m) hills of Central Western Ghats. The South-west Monsoon brings to the western parts of the district, up to the crestline, copious rainfall ranging from 3000-5000 mm per annum. As the Ghats cause most of the clouds to precipitate towards the west, there is dramatic decline in rainfall towards the rain-shadow eastern portions; just 40 km east of the crestline the rainfall would be less than 1500 mm. The rainfall over the district is highly seasonal, with more than 90% occurring in June-November. Mean monthly temperature range from 20-27^0 C. The net result is an effective dry season of almost six to seven months. The western portions of the district with higher rainfall tend to have evergreen to semi-evergreen forests as the natural climax vegetation, in the absence of human interference. The eastern undulating landscape merging with the Deccan Plateau, in the taluks of Mundgod and Haliyal tend to have moist deciduous to dry deciduous forests as the climax forests. The grasslands in the district are mainly due to the forest clearance by humans carried out through centuries of shifting cultivation and cattle grazing. Specially maintained 'bena' grasslands (Figure 3.1) of farmers as well as many grassy blanks within forests and closer to villages are the result of arresting the natural succession of forest vegetation because of periodic burning of woody growth by the people. Savanna vegetation (Figure 3.2) is very common element of landscape in every taluk of the district. It is a mixture of isolated trees or clumps of dwarf trees amidst a general matrix of grasses. In the absence of fire these savannas often tend to progress towards forest, through recruitment of more trees, which shade the grasses, giving not much scope for their multiplication.

Man-made savanna grasslands: Pollen grain deposits in swamps and marshes and in the seabed along the coastline are often indicators of the past vegetation and the changes that happened in the course of time. We do not have much of pollen deposit studies from Uttara Kannada. However, one outstanding study by Caratini et al. (1991) based on a soil core sample from the sea bottom off the Karwar coast shows that the land was covered until 3,500 years ago by forests dominated by evergreen trees. Thereafter the pollen deposit from savanna plants such as grasses and herbs increased. Such change would indicate the human impact on the forests of Uttara Kannada by slash and burn method or shifting cultivation or *kumri* cultivation (Chandran, 1998). Climatic conditions would still favour return of the forests on fallow or abandoned agricultural lands. Cattle rearing also contributed to savanna formation; as humid weather promoted the growth of forests in savannas and grasslands, the farmers were forced to keep forests away by periodical burning of woody outgrowth.

Figure 3.1: A 'bena' grassland in coastal Uttara Kannada

Figure 3.2: A hill top savanna element in the forest landscape

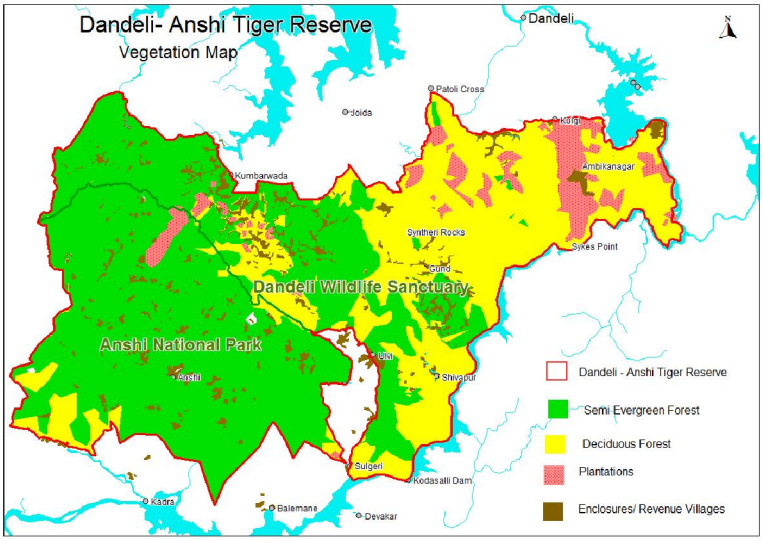

Figure 7: Vegetation map of ADTR

Grassland types in Uttara Kannada: The savanna grasslands can be mainly categorized into two types:

- **Dry to mesophilous grasslands** occur along the rocky plateau, open hill tops and slopes, scrub jungles, forest undergrowth and openings, uncultivated lands, fallow fields etc. The mesophyllous grasslands occur in more moist conditions than the dry land grasses. Those in gardens, rice field bunds, wet meadows etc. are of this type.
- **Hygrophilous grasslands** are more water-loving and seen along the margins of water courses like pools, puddles, back waters, along marshy places, low lying areas etc.

In both these grassland categories, depending upon human pressures, topography, soil nature and grazing pressure short or long type grass species would occur. Human factor is decisive factor governing the permanency of grasslands, but for which vegetation would change in most cases according to the principles of ecological succession. Based on Sarmiento, 1984on these factors Savannas can be differentiated as:

1. Savannas without woody species taller than the herbaceous stratum: *Grass savannas or grasslands.*(e.g., Benas; Figure 3.1)
2. Savannas with low (less than 8 m) woody species forming a more or less open layer.
    (a) Shrubs and/or trees isolated or in groups; total cover of woody species less than 2%: *Tree and shrub savanna* (e.g., Coastal scrub savannas)
    (b) Total tree/shrub cover between 2% and 15%: *Savanna woodland, wooded grassland, or bush savanna*
    (c) Tree cover greater than 15 %: *Woodland* (e.g., Interior Coastal scrub savannas, and hill top grasslands)
3. Savannas with trees over 8 m
    (a) Isolated trees with less than 2% cover: *Tall- tree savanna* (Lands near agricultural fields)
    (b) Tree cover 2-15%: *Tall savanna woodland* (Eg.,Scrub lands)
    (c) Tree cover 15-30%: *Tall wooded grassland* (Highly degraded deciduous forests, Soppina Bettas)
4. Savannas with tall trees in small groups: *Park savanna*
5. *Mosaic of savanna units and forests: Park* (Forest hill slope grassland, forest openings, etc.).

Figure 9: A coastal wetland grassy area mixed with the sedge *Cyperus pedunculatus*

CHAPTER 4: GRASSLANDS OF ANSHI-DANDELI TIGER RESERVE - Study method

The grasslands of the ADTR were mapping through the IRS P6 - remote sensing data (Google Earth etc.) and field survey. Representative patches for all types of grasslands or rather grass growing areas, including marshes, puddles, forest underneath etc. were studied using ecological sampling technique 'transect cum quadrat method'. In each selected grassland 5 plots (quadrats), each 1 m x 1m (Figure 4.1), were laid along a straight line (transect line) leaving a distance of 10 m between any two plots (Figure 13). We have characterized grasslands as short (<15 cm height), medium (16-30 cm) and tall (>30 cm). In each plot, grasses and other herbs were noted and their numbers counted. Data on their habit (clumps, trailing, erect etc.) and notable field characters were also recorded. Searches were made outside the sample plots to document other species. Rare and unidentified specimens were pressed for herbaria. Geographical co-ordinates of study localities were recorded using global positioning system (GPS). Fresh specimens were identified with the help of floras and our own herbarium specimens. Experts were consulted for unidentified collections; some of the specimens were also taken to the BSI herbarium at Pune. Bamboos and reeds, though also grasses, have not been included in this study as they do not form part of grasslands. The locations of sampling are given in Figure 4.2. The grasslands studied in different localities have been characterized and the details are given in Table 4.1. A typical grassy blank in the forest is shown in Figure 4.3.

Sl.	Transect locality	Grassland type	Dry/Wet
1	Goyar-Savadi	Forest underneath*	Dry
2	Kailwada-Dongrewada	Grassland adjacent to fields	Dry
3	Kailwada – Kailwada	Fallow fields	Dry
4	Kailwada-Madgaon	Grassland adjacent to fields	Dry
5	Thayamaddi-Barpoli Cross (Anshi)	Hill slope grassland	Dry
6	Burpalli (Anshi)	Open grassland	Dry
7	Shiroli-near Bamnia (Kumbarwada)	Wet grassland	Wet
8	Terali	Forest opening grassland	Dry
9	Kundal	Forest opening grassland	Dry
10	Kaneri dam site	Forest opening grassland	Dry
11	Virnoli safari route	Forest underneath*	Dry
12	Shiroli mining area (Kulagi)	Wet grassland	Wet
13	Mandurlli (Kulagi)	Wet grassland	Wet
14	Bommanahalli Reservoir	Reservoir side grassland	Dry
15	Lande	Forest opening grassland	Dry
16	Anshi	Forest opening grassland	Wet

*Forest underneath: Sparse growth of certain grasses occurs beneath forest canopies.

Table 4.1: Transect locations in Anshi and Dandeli Tiger Reserve and grassland type

Figure 4.1: Laying quadrat in *Dimeria* and *Arundinella* dominated grassland in Kundal

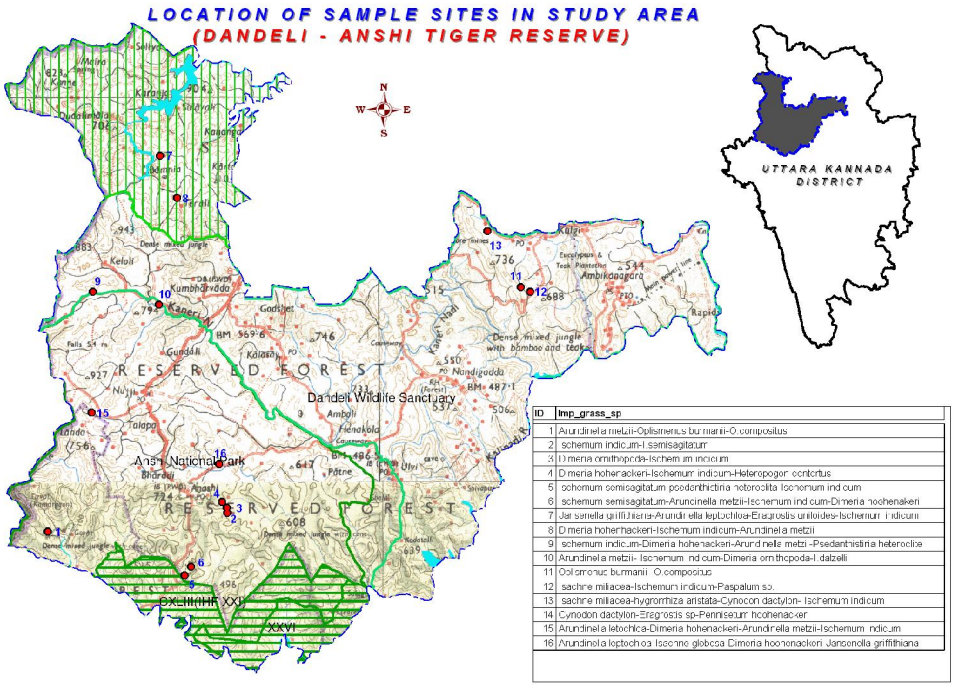

Figure 4.2: Grasslands study locations in ADTR

Opportunistic surveys: Grasses occurring in many minor habitats other than grasslands such as old walls, alongside water courses, wastelands, cultivations, crevices in rocks etc., were also listed.

- ***Wall grasses*:** The monsoon rains promote a flourish of seasonal grasses on mud walls, stone fences, old compound walls, abandoned houses etc. The commonest among these wall grasses are *Arthraxon lancifolius, Dimeria ornithopoda, Arundinella pumilla* etc.

- ***Grasses along water courses*:** *Paspalum conjugatum, Hygrorrhiza aristata, Leersia hexandra, Sacciolepis interrupta, Isachne miliaceae*, etc. occur along water courses.
- ***Fallow land grasses:*** The fallow lands of the village areas are dominated by grasses like *Panicum repens, Dactyloctenium aegyptium, Eragrostis uniloides, Paspalum scrobiculatum* etc.
- ***Grasses as weeds*:** Several grasses occur as weeds in fields and gardens. Notable of them are *Echinochloa colona, E. crusgalli, Oryza rufipogon, Sacciolepis interrupta* etc., associated with rice fields. Weeds in gardens and other croplands include *Panicum repens, Dactyloctenium aegyptium, Centotheca lappacea* and *Ischemum indicum.*

Results (using sample plots)

Based on 16 transects and 80 plots (each of one sq.m) we recorded 116 flowering plant species, belonging to 109 genera and 36 families There were 100 herb species belonging to Poaceae (grasses) and its close relative Cyperaceae (sedges). Eight shrub species, seedlings of six tree species and two climber species were also recorded. Poaceae with 32 species was the largest and dominating family followed by Cyperaceae (13 sp.), Scrophulariaceae (8), Asteraceae (6), and Acanthaceae (5) and others in smaller numbers. The notable grasses of different grasslands sampled are given in Table- 4.2

Population: Terali grassland (Figure 4.4) had the highest number of individuals (3800/transect) followed by Kailwada-Kailwada (3022) (Figure 4.5) and others. Terali has many grasslands, rich in fodder grasses dominated by *Dimeria hoohenackeri, Ischemum indicum*, and *Arundinella metzii*, all these endemic to Peninsular India. The fallow fields of Kailwada-Kailwada under heavy grazing pressure from cattle, are dominated by weedy species of sunflower family, Asteraceae. If fallow period continues and grazing pressure reduced this area could be transformed into good grasslands. Most fallow fields of the ADTR are of similar kind. The fenced *bena* lands near paddy fields are naturally having tall grasses cherished as good fodder by villagers.

Table 4.2: Grassland study locations and notable grass species.

Sl.	LOCATION	Important grass species
1	Anshi	*Arundinella leptochloa-Isachne globosa-Dimeria hoohenackeri-Jansenella griffithiana*
2	Bommanahalli reservoir	*Cynodon dactylon-Eragrostis sp-Pennisetum hoohenackeri*
3	Burpalli-Anshi	*Ischemum semisagitatum-Arundinella metzii-Ischemum indicum-Dimeria hoohenakeri*
4	Goyar-Savadi	*Arundinella metzii-Oplismenus burmanii-O.compositus*
5	Kailwada – Kailwada	*Dimeria ornithopoda-Ischemum indicum*
6	Kailwada-Dongrewada	*Ischemum indicum-I.semisagitatum*
7	Kailwada-Madgaon	*Dimeria hohenackeri-Ischemum indicum-Heteropogon contortus*
8	Kaneri damsite	*Arundinella metzii- Ischemum indicum-Dimeria ornithopoda-I.dalzelli*
9	Kundal	*Ischemum indicum-Dimeria hohenackeri-Arundinella metzii-Psedanthistiria heteroclite*
10	Lande	*Arundinella letochloa-Dimeria hohenackeri-Arundinella metzii-Ischemum indicum*
11	Mandurlli (Kulagi)	*Isachne miliacea-hygrorrhiza aristata-Cynodon dactylon- Ischemum indicum*
12	Shiroli mining area	*Isachne miliacea-Ischemum indicum-Paspalum sp.*
13	Shiroli-near Bamnia	*Jansenella griffithiana-Arundinella leptochloa-Eragrostis uniloides-Ischemum indicum*
14	Terali	*Dimeria hohenhackeri-Ischemum indicum-Arundinella Metzii*
15	Thayamaddi-Barpoli Cross	*Ischemum semisagitatum-psedanthistiria heteroclita-Ischemum indicum*
16	Virnoli safari route	*Oplismenus burmanii- O.compositus*

Figure 4.3: A typical hill slope grassland

Figure 4.4: *Dimeria hohenakeri* dominated grassland in Terali

Species richness: Figure 4.6 shows species richness of different transects. Shiroli-Bamnia had the highest number of species (43). Marshy spots with characteristic herbs contribute to its species richness. Drier highlands of Shiroli-Bamnia had perennial grasses like *Arundinella leptochloa* and seasonal *Dimeria hoohenackeri, Ischaemum indicum* etc. all of fodder value. Diggie area, newly added to ADTR, has some good and large grasslands, followed by Anshi transect (39 species), also with marshy plots. Anshi region is mostly clad in evergreen to semievergreen forests. There are fairly large agricultural areas cum grassy blanks, within these forests.

Figure 4.5: Kailwada–Kailwada grassland & fields (from Google Earth)

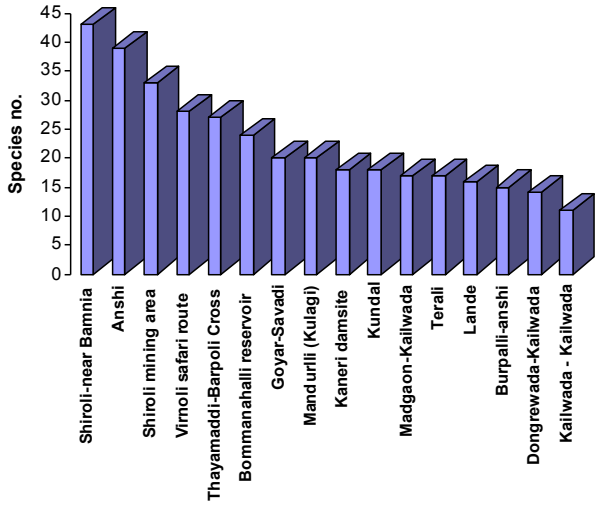

Figure 4.6: Transect-wise species richness in ADTR.

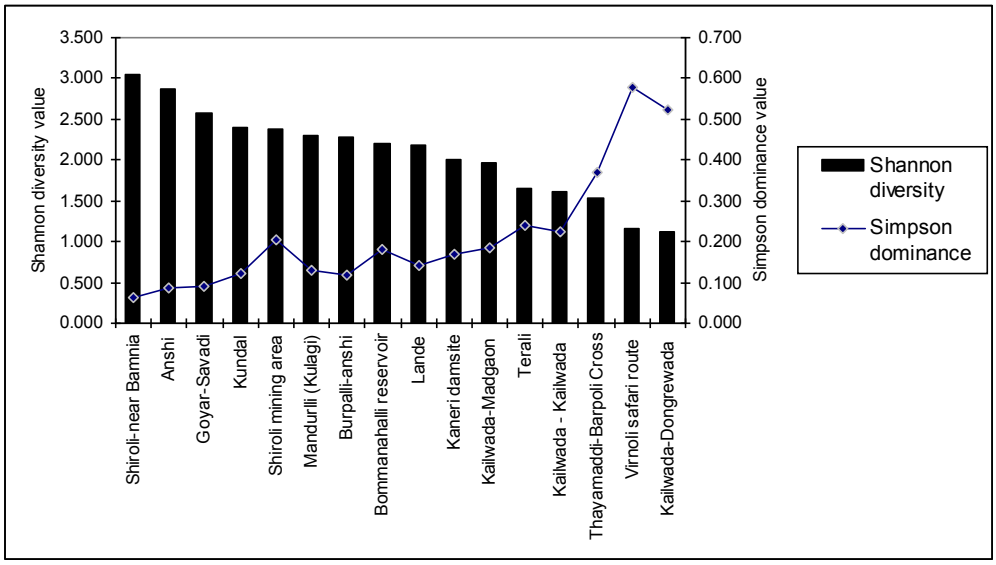

Figure 4.7: Transect-wise Shannon diversity and Simpson dominance in ADTR

Details regarding Shannon diversity and Simpson dominance of the grasslands are given in Figure 4.7. Terali open grassland though low in Shannon diversity index (1.65) was dominated by fodder grasses. Shannon diversity was higher in forest underneath grassland of Goyar (2.5), open grassland (Figure 4.6) of Kundal (2.4), wet grasslands of Shiroli- old mines area (2.4) and Mandurli near Kulgi (2.3).

Figure 4.8: Kundal forest opening and nearby large fields

Figure 4.9. Kailwada-Dongrewada – highly fragmented landscape

In Goyar though species number was high (20) grasses constitute only 40%, and that too of not much fodder significance such as *Oplismenus burmanii* and *O. compositus,* which by habit creep on the forest floor amidst other non grass herbs. The same was the case with Shiroli old mines area. Forest transect along Virnolli (safari route), and fallow fields of Kailwada-Dongrewada study area (Figure 4.9) had the lowest Shannon diversity indices at 1.166 and 1.129 respectively. Bommanahalli reservoir grassland had a moderate Shannon diversity of 2.21. The number of grass species here was poor and their fodder significance less, understandably due to constant fluctuation of water level in the dam. Diversity was very poor and dominance very high in Virnolli (safari route) with 75% of population constituted by single short grass species of *Oplismenus burmanii*. Kailwada-Dongrewada also had very high dominance with *Ischaemum indicum* but this grass has good fodder value. Percentage of grass species versus non-grass species for different study sites are given in Figure 4.10. It was observed that habitat heterogeneity at the micro-level within the grassland causes increase in the number of species, but need not be reflecting the pasturage value of the grassland.

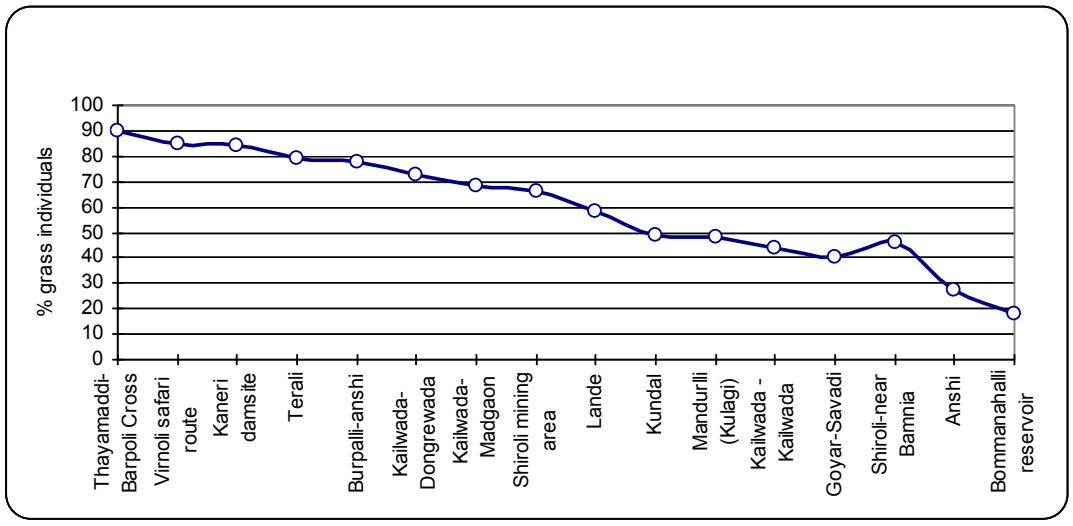

Figure 4.10. Grass individuals (%) compared to non-grass individuals (%) in the samples.

CHAPTER 5: GRASSLANDS AND TIGERS

The primeval grasslands played major role in sustaining large mammals than other ecosystems almost anywhere in the world where they occur. The Great Plains of North America was once teeming with vast herds of bison, deer, elk and pronghorns. The gray wolf, cougar, bears, gray fox and badger were common predators. Today the large mammals have become extremely rare or extinct in most of their former ranges because of hunting and habitat destruction. The savanna grasslands of Serengeti Plains of Kenya and Tanzania are home to the highest density of hoofed grazing animals in the world. Over 1.5 million wild beasts, which include antelopes, gazelles, black rhinoceros, zebras, impalas and giraffes graze on the savanna. The herbivores in turn support lions and a variety of predators and scavengers, such as leopards, hyenas, cheetahs and wild dogs. Rapidly growing human populations, herds of domestic cattle competing with wild animals for grazing and agriculturists clamoring for farmlands are major threats to wildlife here. Threat from hunters is a major problem for African wildlife (Cunningham and Saigo,1990).

There are several accounts of the rich and varied wildlife that Uttara Kannada had in the past, as described by many visitors and officers to Uttara Kannada, even before one thought of sanctuaries and national parks. Francis Buchanan, as early as 1801, mentioned about the tiger infested forests of Kanara. The *Kanara Gazetteer* (Campbell, 1883) has a rich account of Uttara Kannada's wildlife. As early as 1676 an English traveler Fryer and in 1690 Ovington commented upon the abundance of wild animals in the forests close to Karwar. The British residents of Karwar went to the woods regularly for hunting and could bring home for meat spotted deer, sambar, wild hogs and gaurs "without any further expense than that of powder and shot".

The hunting spree continued more intensified, both by native shikaris and the British sportsmen, during the 19th century. That was the period when the British consolidated their hold on Uttara Kannada. Wildlife was plentiful in the district until the mid-19th century. Tigers, panthers and bears had proliferated. Incidents of human and cattle kills had increased so much so that was taken as the reason for launching a massive programme for eliminating most of these animals of prey and other dangerous animals by the British. Rewards were paid to the shikaris for every animal killed.

Colonel Peyton, Conservator of Forests had made graphic account on the hunting of tigers, panthers and bears in Uttara Kannada. For a period of 22 years from 1855, 510 tigers were officially reported to be killed in the district. Between 1878 and 1882, yet another 130 tigers

were hunted down. During the same five year period 214 panthers were hunted. Between 1844 and 1861, 51 bears were hunted down. Hunting for sport became a very common feature under the British rule until the animals became scarce. Among the prolifically hunted animals for meat purpose were sambar, gaur, antelopes, spotted deer, barking deer, mouse deer etc. So much so there was a precipitous decline in the population of many wild mammals by the close of the 19th century. Colonel Peyton wrote on the hunting of spotted deer (chital): "Chittal was at one time numerous over the whole of Kanara…. Ten of fifteen years ago the spotted deer was abundant throughout the valleys of the Kalinadi, Bedtihalla, Gangavali, and Tadri, as well along the east of the district….. At Dandeli in 1867 from a herd of not less than 150 to 200, three splendid stags were picked out and shot in a few moments. Now, about same place, the sportsman has had a lucky morning if he sees a small herd or two."

Regarding gaur Col. Peyton stated: "The Bison…. is found over the greater part of Kanara, but being so much shot at and from being subject to the disease which prevail among domestic cattle …. it is disappearing from many parts where it abounded fifteen or sixteen years ago …. They were especially common about sixteen years ago in the Gund forests, and between Gund and Anshi, as well as along the Kaneri river." The Sambar and barking deer were also quite widespread in the district (Campbell, 1883). What made Uttara Kannada such a special place for the abundance of tigers and panthers as well as so many kinds of herbivores, at a time when there were no sanctuaries or National Parks? That was also a time when the Forest Department, under the British, was acquiring and settling forests. The animals like tigers were in such excess that every year dozens were eliminated. Hunting was wantonly carried out for sport than for subsistence. To find answer to these questions, we need to look into the forest history and learn some lessons crucial for wildlife management. At the time of British take over of Uttara Kannada in 1799 the land was a mosaic of primeval evergreen forests, secondary forests in different stages of succession and extensive grassy blanks, the results of forest clearance for shifting cultivation. Many times the shifting cultivators did not return to the same spot for repeating the slashing and burning resulting in late successional stages of secondary forests. Where the grasslands were fired systematically during summers for fresh growth during rains, by the local farmers, the climax vegetation remained as grasslands or savanna grassland complex, as is found in many parts of the Anshi-Dandeli Tiger Reserve to this day. The period of shifting cultivation was one of landscape heterogeneity ideal for wildlife. The forests on both sides of the district's rivers were already of a secondary kind, dominated by deciduous trees, during the early British period itself (early 19th century). This could have been the result of shifting cultivation, as well as due to timber logging for commercial purposes (Chandran, 1998). Anshi-Dandeli Tiger Reserve area has perhaps the largest concentration of the descendents of shifting cultivators of the past.

HABITAT SUITABILITY FOR LARGE UNGULATES

Prey-Predator: their relation with habitat -

Unlike lions or cheetah which need vast grasslands for their prey capture, tigers rely on surprising a prey and capturing it. Hence tigers prefer to inhabit mosaic kind of landscape elements such as dense forest, grasslands, scrub, ravines, wetlands etc. According to Karanth (2003) tigers have the ability to live in very diverse natural habitats and they can tolerate wide range of temperatures and rainfall regimes. They produce relatively large litters with relatively short inter-birth intervals. They can take prey differing considerably in size and their hunting tactics will vary based on prey size, prey species and habitat. ADTR hosting large number of these landscape elements would have been ideal as tiger habitats, as is obvious from the historical records. The tiger population largely vanished from Uttara Kannada itself mainly due to hunting (both tigers as well as its prey animals), and large scale conversion of forests into monoculture of mainly teak (about 1000 sq km of forests have been converted into teak plantations in the district) and other forms of intensified habitat degradation due to commercial working of forests for timber and industrial raw materials. Weeds like *Lantana* and *Eupatorium* proliferated in the canopy openings and inside the teak plantations adversely affecting native species, and therefore understandably, with adverse consequences on the rich wildlife that the region had once. Increase in human and cattle population, the growth of Dandeli as an industrial city, from an obscure village prior to independence and the execution of a chain of hydel projects in the river Kali and associated disturbances such as the setting up of new colonies for project employees at Ambikanagar and Ganeshgudi etc. would have obviously reduced wildlife areas and affected habitat quality. Evacuees from the submersion areas of Supa dam were resettled in the newly created Ramnagar township. Moreover several mining leases were given inside the forest areas damaging forests and grasslands as well as converting the region into a transportation hub. The stoppage of shifting cultivation in the late 19th century witnessed the erstwhile shifting cultivators like Kunbis, Kumri Marattis etc. taking to permanent cultivation. With settled cultivation these historically nomadic cultivators, who were earlier not associated with pastoralism, took to cattle rearing for manure and milk. Therefore, naturally, the pressure on the grazing resources from the domestic cattle would have increased substantially, with telling consequences on the ungulate preys of the tiger and panther. Shifting cultivation today is a thing of the past. Working of reserved forests for timber and firewood and industrial raw materials is no more in the reserved forests, from mid 1980's, and more so in the Protected Areas. There are strict rules regarding forest and wildlife conservation. As such we could expect an increase in the prey population favouring the multiplication of tigers.

In contrast to the earlier approach in tiger conservation, relying on large unbroken habitats new approaches are emerging. Tigers are visulalised to living in large, dynamic landscapes. Tiger conservationists know that it is impossible to isolate and protect tigers from human influences (Seidensticker et al., 1999). Karanth and Smith (1999), looking at the ecological history tiger, propose that prey depletion is a major factor driving the current decline of wild tigers. If depressed prey is a significant negative factor, reducing poaching pressure on tigers alone is not an adequate conservation response. A model proposed based on several studies on prey depletion in recent years postulates strongly that prey depletion has a strong effect on tiger population dynamics. Prey scarcity will affect nutrition of adults forcing them to move into unstable habitats. Juvenile tigers, nutritionally dependent on their mothers are also affected. Cub survival is reduced and the tiger population size declines rapidly (–ibid-).

CURRENT WILDLIFE SCENARIO IN ADTR

Wildlife census was carried out in 1997 and 2002. The census covers only selected mammals. In due course more detailed and accurate census details may be expected. Latest census details are yet to be obtained. The data reveals that the tiger population had remained static at 13 during this period. Of these 13 tigers, 11 were reported from Dandeli Wildlife Sanctuary and only two from Anshi National Park. As the latest census report is awaited there is cause for concern. Moreover the prey population leaving the (monkeys s.n. 9 & 10) in the Table has not improved. Most alarming is the decline of gaur (*Bos frontalis*) from 1817 in 1997 to 1376 in 2002. This could be due to sampling error, habitat destruction or poaching or a combination of these. In Schaller's (1967) estimate of adult tiger's food the gaur's share was only 7% (0.5 animal/year). In the Nagarahole National Park, in the Western Ghats, which is closest to ADTR in vegetational comparison the number of gaurs killed by tigers, based on scat analysis, constituted 11.4% of the total prey animals (Karanth and Sunquist, 1995). It was 4.8% in Kanha National Park (Schaller, 1967).

The decline of the spotted deer or chital (*Axis axis*) is still more alarming. Its number in the Dandeli Wildlife Sanctuary declined from 1667 in 1997 to 1252 in 2002. In 2002 the total number was 1429 because of adding the population of Anshi National park. Considering the fact in the conservancies of the Indian subcontinent the spotted deer was one of the predominant prey killed by tigers, 27.8% in Chitwan National Park, Nepal, 50.3%, in Kanha and 22.8% in Nagarahole, (Schaller, 1967, Mcdougal, 1977 and Karanth and Sunquist, 1995), this decline of one of the commonest forest animals has to be considered seriously. The consolation, however, comes from the significant increase in sambar deer. However, for the sheer size of the ADTR the total estimated number of sambar deer at 722, is not satisfactory. Overall the census methods for

the animals have to be streamlined to project reasonably good pictures. Although the pig (*Sus crofa*) is one of the notable preys of the tiger its enumeration has not been carried out, may be due to the understandable difficulties in counting this animal of varied habitats. The barking deer (*Muntiacus muntjac*), though an important prey, 6.4% of numbers killed in Chitwan, 34.8% in Huai Kha Khaeng Wildlife Sanctuary, Thailand and 8.4% in Nagarahole (Sunquist et al., 1999), the total estimated for ADTR is only 592.

Table 5.1: Details of wildlife census carried out in 1997 and 2002

(Source: Karnataka Forest Department, Wildlife Division, Dandeli)

Census Details for the year 1997 and 2002

Sl. No.	Name	1997 Census			2002 Census		
		Dandeli Wildlife Sanctuary	Anashi National Park **(#)**	Total Dandeli Wildlife Division	Dandeli Wildlife Sanctuary	Anashi National Park	Total Dandeli Wildlife Division
1	2	3	4	5	6	7	8
1	Tiger	11	2	13	Census work is	Census work is	
2	Leopard	9	-	9	to be done	to be done	
3	Elephant	45	-	45	45	-	45
4	Gaur	907	910	1817	1376	216	1592
5	Spotted Deer	1667	-	1667	1252	177	1429
6	Barking Deer	423	28	451	470	122	592
7	Sambar Deer	217	87	304	348	374	722
8	Sloth Bear	390	293	683	43	39 **(o)**	82 **(o)**
9	Common Langur	7690	6620	14310	27019 *	11118 *	38137
10	Bonnet Macaque	2726	146	2872	2914	1386	4300
11	Malabar Squirrel	2741	1870	4611	7448	2182	9630

Source: Deputy Conservator of Forests, Wildlife, Dandeli Division

(#) File not available in this office (DCF Wildlife)

*This is quite a high number

(0) Possibly an overestimate due to sampling error/insufficient sampling

Fodder needs: Sunquist et al. (1999) estimated the mean mass (kg) of prey killed by tiger in the Nagarahole National Park ar 65.5 kg. We may assume the case in ADTR to be similar. Sunquist (1981) recorded that a tigress needs 5-6 kg of meat a day for a maintenance diet. This amounts to 1825-2190 kg/year of meat; but as 30% of each carcass is inedible (due bones, hoof, hair etc.), a

tigress needs to kill some 2373-2847 kg/year of meat. Using the above example we may attempt to arrive at the annual meat requirements of 13 adult tigers in the ADTR. At a modest maintenance diet of 2610 kg meat/tiger/year the total meat requirement for 13 tigers would be 33930 kg/year. For meeting this requirement the tigers need to kill 518 prey animals of mean weight 65.5 kg. The meat requirement of a tigress feeding two large cubs is estimated to be 50% more. This meat would also come from pigs, and monkeys and other miscellaneous prey to a smaller extent. At the generally accepted energy flow models of 10% of biomass energy reaching successive levels of consumers in the food chain, to produce harvestable 33930 kg/year of harvestable meat for tigers the food needs of the herbivorous prey animals would be 3393000 kg/year (3393 tons of fodder). Considering the fact that there were only 4335 important prey animals (all deer spp. and gaur together) in the ADTR in 2002 the future of the tiger depends on how best we can increase the prey resources. We should also bear in mind that there are panthers, hyena, and some minor carnivores which have a share in the major and minor prey population of ADTR. As most of the ungulate prey mainly depends on grasslands for their fodder the management of these grasslands is of paramount importance.

Competition with domestic cattle: Good number of grasslands and savanna woodlands with grassy ground cover are in the vicinity of villages, where the wild animals will have to compete with them for fodder. At a modest rate of 10 kg of grass/other plant resources as fodder, the 6000 plus cattle would need annually about 22,000 tonnes of fodder. As ADTR has forest as climax vegetation, and large areas already covered with monoculture plantations. Many village grasslands grasslands are in eroded and poor state where again the cattle become competitors for wild herbivores. Unless this situation changes tiger population is not likely to improve significantly. Most of the deer and gaur usually come to grasslands only after dusk hours to escape humans. As villages, at least in the core areas, will be resettled outside the pressure from domestic cattle on these grasslands is bound to decline in the coming few years. The range-wise details cattle number are given in the Table 5.2.

Table 5.2: Range-wise cattle population in the ADTR

Sl No.	Range	Number of Cattle
1	Kulgi	2202
2	Phansoli	260
3	Gund	952
4	Kumbarwada	1342
5	Anshi	1414
	Total	**6170**

Grazing and productivity: In the largely forested district of Uttara Kannada, it has been traditional practice of the agriculturists to leave the cattle for foraging freely. The cattle often enter into the adjoining forests. They browse upon any edible herb and sapling and enter the grassy blanks even in the interior of forests. Village cattle can be found roaming in many places even inside the ADTR. They come from the villages within as well as from peripheral villages. An experimental study carried out in the grasslands of Uttara Kannada by Lele and Hegde (1997) shows that heavy grazing in the open grasslands lead to 40% drop in production relative to the control which was ungrazed. The above ground herb layer biomass (AGHB) was 3-6 t/ha/yr in ungrazed areas, compared to heavily grazed ones with 1 t/ha/yr. However initial months of grazing in monsoon and avoiding in non rainfall growing months also lead to higher AGHB. This shows that late monsoon grazing is deleterious to AGHB. Bhat et al. (2005) observed that the herb biomass productivity (HBP) in a completely open area adjoining a forest in Uttara Kannada was 4.5 t/ha compared to 0.0524 t/ha within the forest. Here, however, the herb layer does not mean all grasses or other palatable plants. If we consider 4.5 tons/ha/yr as mean productivity of good grasslands, hypothetically, nearly 800 ha of such grasslands have to be conserved as such for exclusive use by ungulate prey animals of tigers only. It also implies that the production should be only of edible grasses. It is not practicable to delimit the grasslands to only 800 ha., as, understandably, there are no chance at all of all the potential prey animals ending up as tiger's food. If we consider that about 10% of the wild ungulates are captured every year by the tigers, and the rest are not, we would require about 8000 ha of good quality grasslands to feed exclusively the potential prey stock of the ADTR. The actual demand would be much more, as there are currently about 6000 domestic cattle and many other herbivorous wild animals in the ADTR and all the herbs/other plants growing in grasslands/savanna grasslands are not necessarily palatable.

Traditional fodder management in hilly areas and wildlife fodder crisis: Different types of historical grassland management practices create different plant diversity patterns (Gustavsson, 2007). The open grasslands with long history of maintenance either by humans (by mowing, grazing by domestic animals, fire etc) or from wild animals (by grazing) tend to be more species rich with more fodder species. The grasslands in high rainfall hilly regions are exposed to varying levels of grazing such as in *benas* and *soppinabettas*. Some are temporarily fenced off and harvested by hand at the end of growing season. These management practices have co-evolved with the local agrarian system, which is a combination of Areca-spice orchards and paddy fields. Productivity depends critically on the continuous input of organic matter and nutrients in the form of livestock dung (along with leafy mater), and on the availability of draught animal power for ploughing. Milk is an important additional benefit. Livestock, almost all cattle and buffalo, are thus an integral part of the agrarian system. This has lead to the serious competition with wild life

animals for natural grasslands as cattle population has increased. The grasslands areas are dwindling because of the need for land for housing, agriculture, roads and various other developmental activities

Fodder rich and poor areas in ADTR: Larger grassland areas such as Thayamaddi-Barpoli cross, Kaneri dam site, Terali, Burpali-Anshi, Kumbarwada-Diggi areas etc., are old grasslands having not only highly palatable, high yielding grass species but also good number of other fodder dicot species.

Most of the highly exploited, overgrazed, lands will have species very different from those they had earlier. Virnoli safari route forest grassland though showing high percentage grass individuals have only two low yielding fodder grasses (*Oplismenus burmanii* and *O.compositus*) dominating (Table 3). Same is the case with Goyar forest grassland which had also very low fodder value grass species. It also had low density of dicot herbs.

Areas underneath the forest canopy having low density dicot forage herbs along with sparsely occurring grasses as in the Virnolli-safari route, Goyar etc., cannot sustain any significant number of herbivores. On the other hand open grasslands interspersed with wetlands are more important in sustaining herbivores. In the ranges with dense forests and/or monoculture plantations such as at Anshi, Phansoli, Gund and Kulgi, the wildlife mostly depend on openings within the forest, on wetlands and on the sparse growth of grasses underneath the forest canopy. Hardly any grasses grow in the teak plantations and inside dense evergreen-semievergreen forests (as in Anshi Range) therefore these ranges do not have as much potential to support wildlife unlike Kumbarwada and Diggie Ranges. The entire forest region especially along the deciduous zone is dotted with teak plantations which are not congenial for grasses. Phansolli, and Kulgi forests are also largely planted with teak.

Management recommendations

- Grassland enrichment is to be thought of for selected grasslands. Very degraded grasslands may be closed to grazing facilitating revival of the grasses.
- The practice of afforestation of grassy blanks has to be discontinued unless there is need for recreation of resource patches (fruit trees and keystone plant resources favouring life of herbivores). These resource patches have to be in block planting or in linear forms facilitating corridors for movements, for animal movements. A combination of both may be also carried out, after planning and deliberations. A list of species that can nurture by their products the fauna of the ADTR is given in Table 5.3.

- Afforestation of grassy blanks to be limited to very unproductive areas only. While selecting tree species for planting the animal community should be borne in mind. Patches have been observed where instead of raising natural vegetation the exotic industrial cum pulpwood species *Acacia auriculiformis* has been planted (Figure 5.2). For example Acacia was planted up in Thayamaddi-Barpoli Cross and few other places.
- Controlled fire to be used in grasslands in transition such as under dicot weeds and woody vegetation. Such grasslands to be divided into blocks and alternate blocks to be set on fire. Volunteers may be trained and their services used in meticulous use of fire so as to promote grasses
- Since legumes are nitrogen rich and good as fodder, leguminous fodder herbs may be planted in abandoned agricultural fields to promote wildlife. Herbaceous climbers of legumes, that provide forage for wildlife may be promoted experimentally in some of the poor grade mono-culture plantations.
- Natural succession inside monoculture plantations may be directed towards enhancing the food resources of the ADTR for wildlife.
- Herbaceous forage legumes may be considered experimentally for planting along the sides of some of the forest roads.
- Priority to be given for resettlement of villages with large number of cattle. Some of the good pastures of importance to wild herbivores need to be spared from grazing by domestic cattle. In the peripheral villages the concept of village fodder farms, to meet the fodder requirements of domestic cattle, needs to be promoted, so as to prevent those cattle from entering the ADTR.

Table 5.3: Wild woody plants that provide food for wildlife and recommended for selective planting in grasslands

Sl.	Species	Local/common Name	Parts eaten and wild animals feeding on them	Remarks
1	*Acacia concinna*	Seege	Pods-Deer*, Sambar, Gaur	
2	*Acacia ferruginea*	Banni	Pods-Deer*, Sambar,	
3	*Artocarpus integrifolia*	Halasu, Jack	Fruits-Monkeys, Bear Leaves- fodder	Fallen fruits of *A.integrifolia* and *A.hirsutus* are relished by many ungulates
4	*Bauhinia sp.*	Basavanapada	Pods- Gaur, Sambar, Deer*	
5	*Bombax ceiba*	Buraga, Silk cotton	Flowers-Monkeys, Sambar, Deer*, Wild pig. Nectar for many birds	

6	*Careya arborea*	Kumbia, Kaul	Bark-Sambar, Fruits-Elephant, Monkey, Porcupine, Sambar	
7	*Cassia fistula*	Kakke	Pods-Bear, Monkeys	
8	*Cordia macleodii*	Hadang	Fruits- Deer*, Gaur, birds	
9	*Cordia myxa*	Challe	Friuits-Deer*, Sambar, Bear, birds	
10	*Dillenia pentagyna*	Kanagalu	Fruits-Deer*, Sambar, Gaur, birds	
11	*Ficus* spp.	Atti	Fruit- Birds, including Hornbills, bats etc., and ungulates such as Deer*, Sambar, etc. Leaves- fodder for herbivores	Keystone species with one or the other tree flowering throughout the year and eaten by large number of wild animals, both big and small
12	*Grewia tiliaefolia*	Dhaman; Dadaslu	Leaves-Sambar, Deer*,Fruits-Monkey, birds	
13	*Hydnocarpus laurifolia*	Suranti; Toratte	Fruit-Porcupine	
14	*Spondias acuminate*	*Kaadmate*	Fruits: Sambar, Porcupine, Deer*	
15	*Kydia calycina*	Bende	Leaves –Ungulates	Seems to be eaten by ungulates as they are eaten by cattle.
16	*Moullava spicata*	Hulibarka	Fruits-Deer*, Sambar	Flowering spike is also eaten
17	*Mucuna pruriens*	Nasagunni kai	Leaves-Deer*	
18	*Phyllanthus emblica*	Nelli; Gooseberry	Fruits-Sambar, Deer*	
19	*Strychnos nux-vomica*	Kasarka	Fruits- pulp eaten by monkeys, Hornbills	
20	*Syzygium cumini*	Nerale	Fruits- wild Pig, Deer*, Bear and several birds	
21	*Tectona grandis*	Saaguvani; Teak	Bark- Elephants.	Elephants debark the tree in long strips and consume it.
22	*Terminalia belerica*	Tare	Fruits-Deer, Sambar	
23	*Tetrameles nudiflora*	Kadu bende	Bark-Elephants	Favourite tree for bees to make hives
24	*Xylia Xylocarpa*	Jamba	Seeds-Gaint Squirrel, Monkeys	
25	*Zizhiphus oenoplia*		Fruits-Jackels, Procupine, Deer*, Pangolin, birds	
26	*Ziziphus rugosa*	Kaare	Fruits-Bear, birds	

***Deer includes Mouse deer, Barking deer, Spotted deer**

Figure 5.1: Larger grasslands of Diggie region

Figure 5.2: Wet grassland drained, ploughed and being planted with *Acacia Auriculiformis*

CHAPTER 6: GRASSLAND DENSITY IN THE WILDLIFE RANGES

Grasslands can be visually identified in the field during actual field work. Satellite imageries provide good overall idea about the grasslands in a specified area. In the Anshi-Dandeli Tiger Reserve, it is actually a difficult task to count exactly the number of grasslands. There are small grasslands, less than one hectare larger ones over six sq. km each. In addition are savanna grasslands everywhere where trees are sparse to closer ones which almost would appear like forest. Moreover, often fallow fields overgrown with various herbs and grasses also appear as grasslands. In general, a grassland can be defined as "Grass and other herbs dominating a landscape from which trees are scarce or absent" (Brewer, 1988). Using Google Earth imagery we have listed easily identifiable grasslands/forest openings/rice fields (including even fallow fields overgrown with herbs) of one sq. km and above in size occurring in the different Wild Life ranges of the ADTR (Table 6-1).

Sl.	Range	1-3 Sq.km	3-6 Sq.km	6-9 Sq.km	>9 Sq.km
1	Diggi	25	3	1	
2	Kumbarwada	20	7	3	2
3	Phansoli	8	3		
4	Kulgi	5	2	0	
5	Gund	15	1		
6	Anshi	59	13	4	3
7	Kadra	4	1		

Table 6.1: Grassland/forest opening density in different Wild Life Ranges of ADTR

Anshi and Kumbarwada Ranges have some very large grasslands. Higher number of grasslands seen in Anshi range may be due to its larger range size and anthropogenic causes such as fields, either used or disused. Also the number of very small grasslands less than 1 sq km are more, although we have not listed them here. Details of forest Beats, Range-wise, having good grasslands are given in the Table 6-2.

Total number of beats having large number of grasslands are more in Anshi owing to, may be, its larger size. This is followed by Kumbarwada with 5 beats having large grasslands. Phansoli and Kulgi have the least (Table 6-2).

Beats	Diggi	Kumbarwada	Phansoli	Kulgi	Gund	Anashi
1	Kartoli	Gundali	Shidoli	Ambga(W	Kalane	Tirval
2	Kanangaon	Teloli	Chandrali	Ambga(C)	Tamange	Nanevada
3	Vageli	Nujji			Komba	Anashi
4		Kundal				Kelimala
5		Savant Matkarni				Bhakhi
6						Kailvada
7						Kodugali
8						Ulvi

Table 6-2: Range-wise names of Beats having good grasslands/forest openings

1. **Anshi Range:** This Range with its vast area and diverse habitats contributes substantially towards the safety of wildlife. The Kali River towards its east runs in southerly direction and turns westwards; its course is quite near the southern boundary of the Anshi Range. Rise of water in the river due to the construction of Kodsalli dam has submerged good tiger habitats of rugged rocks and pockets of tall grass and other wild growth. Several small openings can be seen in the satellite imagery (Google), most of them are human inhabited areas and fields with bits and pieces of grasslands adjoining agriculture. There are also grassy blanks in the otherwise largely forest covered Range. Evergreen forest areas are not very suitable for grazing animals. Naturally, we cannot expect the tiger population to increase in this Range (Anshi National Park has only three tigers estimated). Nevertheless the grasslands here are very critical for ungulates and their predators. They need to be protected from forest succession, nor any plantation activities to be carried out in the grassy blanks. Grasslands require more management interventions, including the use of controlled fire and restriction of grazing by domestic animals. The resettlement of villages will turn many fields into grasslands, meadows and marshes enhancing landscape heterogeniety favouring wildlife.

2. **Diggie range:** Kalinadi originates from near a 900 m peak in Diggi Range. As the river has been dammed at Supa, towards the east of the Range is a vast water body, the Supa reservoir. This Range has good grassland areas with less of human population. These grasslands have to be properly managed by periodical use of fire as otherwise most them would revert back to forest with high rainfall and no fire. There should be no raising of monoculture plantations in these grassland areas.

3. **Kumbarwada Range:** Kumbarwada range has more hill top and slope grasslands (Figure 6.3). North western areas also have some larger flat grassland areas with meager human population. Some areas of Khushavali and Keloli beat are sparsely habituated and have more grassland plains. In the 19th century Kalsai and Amboli (a small part of the village in this Range) had fine deciduous forests as well as good evergreen forests as well. Shifting cultivation was widespread in this Range and therefore we can see fine grasslands, savannas and secondary forests. The region has good potential for wildlife.

4. **Kadra Range:** This is a very hilly forested area with very less of grasslands and other openings However the Kali River flowing by the side, and the Kadra reservoir add considerable habitat heterogeneity to the region. There are also steep barren hill slopes that enhance such heterogeniety. During the 19th century, the forest stretch along the Kalinadi had good deciduous forests mixed with natural teak. There were also good evergreen forest patches. Teak plantation was started here as early as 1859. The presence of deciduous forests here is evidence of past fires and shifting cultivation. Today the evergreen species are dominating this Range and grasslands are hardly present.

5. **Kulgi Range:** This Range is also thickly forested with dry deciduous to moist deciduous forest mostly dominated by planted teak and monoculture plantations of teak (Figure 34). Hence it has very less of natural grasslands and the grasses occurring are forest grasses such as *Oplismenus compositus* or *Oplismenus burmanii*, along with *Leptuca radicans* which because of their low density, and less area can support very less wild life. To promote grass in this Range various kinds of openings including edges of water bodies, abandoned fields, forest clearance etc are to be preserved and managed without any further raising plantations inside them. Succession in forest plantations may be directed by promoting fruit and fodder trees natural to the region as well as through introduction of suitable species.

6. **Phansoli Range:** Virnolli and eastern Phansoli areas are highly populated places. Being in lower rainfall zone the most of vegetation consists of deciduous forests and savanna woodlands. Avurli-Mandorli area, on the north side of the Kaneri river had excellent teak forests in the 19th century. The Kasai-Usode forest covering Kalsai, Ambodi, Gangoda, Potoli, Virnoli etc. had not much natural teak, but there were fine mixed deciduous forests. Kalsai had good patches of evergreen forests also. Wildlife-human conflicts

seem to be more here because of the larger number of cattle kills. Such conflicts can be minimized by promoting better vegetation supportive of wildlife, including grasslands.

7. **Gund Range:** The Gund-Shivapur forests, on the plateau of the river Kali in the south-east, was, in the 19th century well known for its forests- "great teak forests of Gund and splendid evergreen forests of Shivapur" (Campbell, 1883). The Range does not have many grasslands and other open areas suitable for ungulate wildlife. (Figure 6.7). The forests of the Range along with the water bodies provide good habitat heterogeneity for wildlife. Table 6.3 lists the grasslands visited during the field investigations.

Table 6.3: Grassland study in Anshi and Dandeli W L Santuary

Sl.	Transect location		Lat	long	Alt
1	Goyar-Savadi		14.96731	74.28001	96
2	Kailwada-Dongrewada		14.97914	74.39934	480
3	Kailwada - Kailwada		14.98257	74.39884	466
4	Kailwada-Madgaon		14.98644	74.39588	467
5	Thayamaddi-Barpoli Cross		14.93885	74.3707	485
6	Burpalli-anshi		14.94459	74.37508	494
7	Shiroli-near Bamnia		15.21059	74.35571	589
8	Terali		15.18345	74.36704	693
9	Kundal		15.12269	74.31069	647
10	Kaneri damsite		15.1141	74.3544	638
11	Virnoli safari route		15.12485	74.59537	584
12	Shiroli mining area		15.12153	74.60146	587
13	Mandurlli (Kulagi)		15.16115	74.57316	578
14	Bommanahalli reservoir		15.16617	74.67917	441
15	Lande		15.04452	74.30956	652
16	Anshi		15.01100	74.39397	633

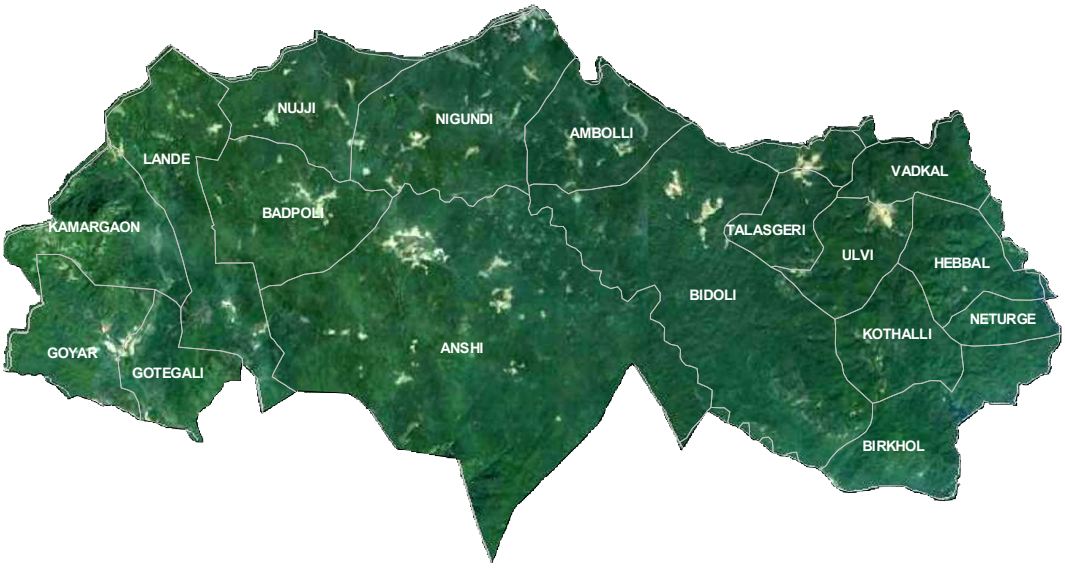

Figure 6.1: Anshi Range with village boundaries and land cover (source: Google Earth)

Figure 6.2: Diggie Range satellite imagery (Source: Google Earth)

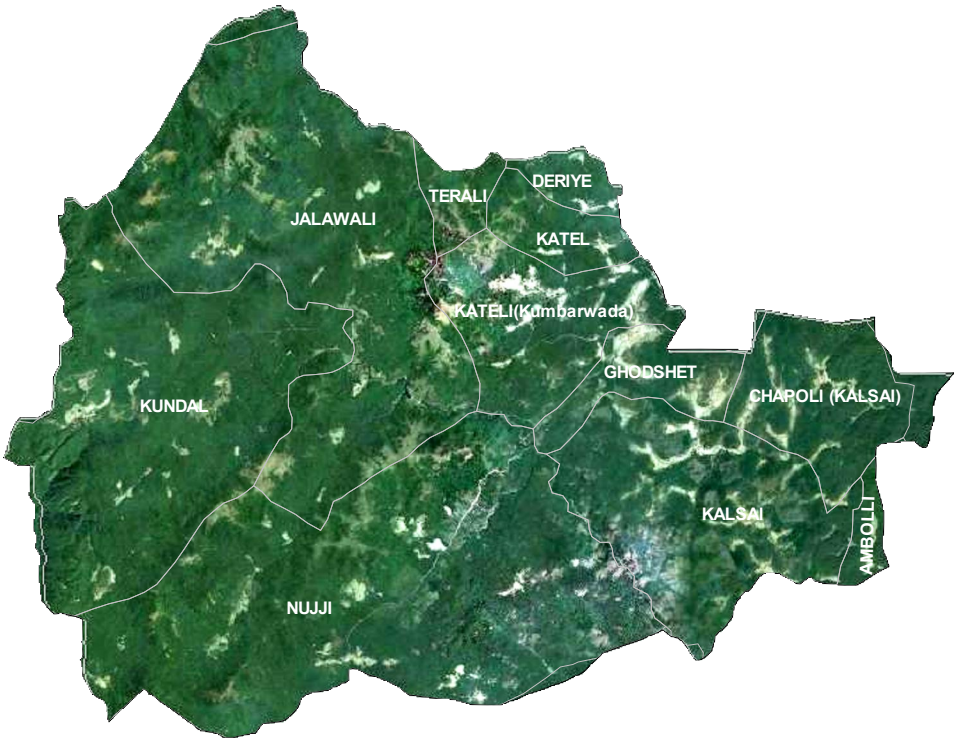

Figure 6.3: Kumbarwada Range with village boundaries (based on Google Earth)

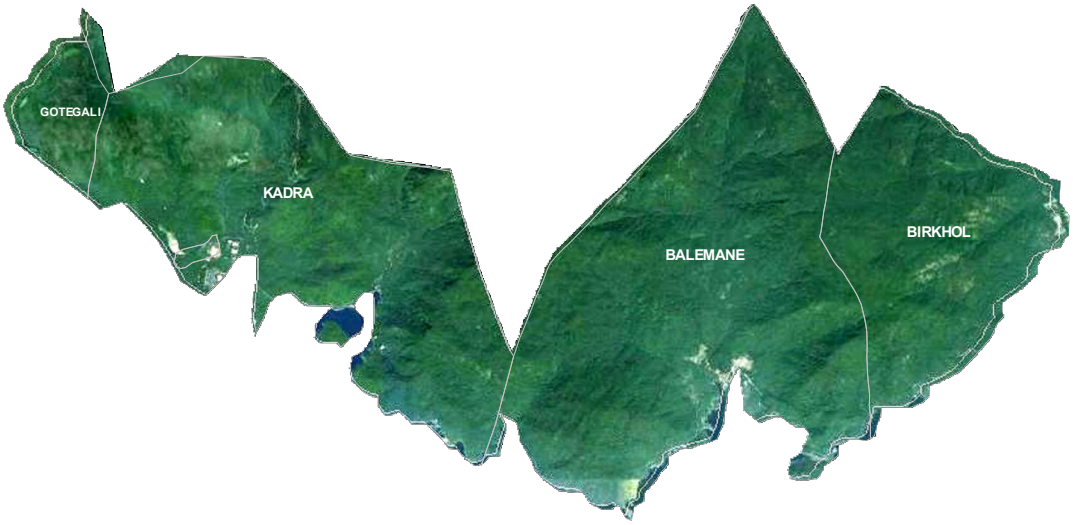

Figure 6.4: Kadra Range with village boundaries (based on Google Earth)

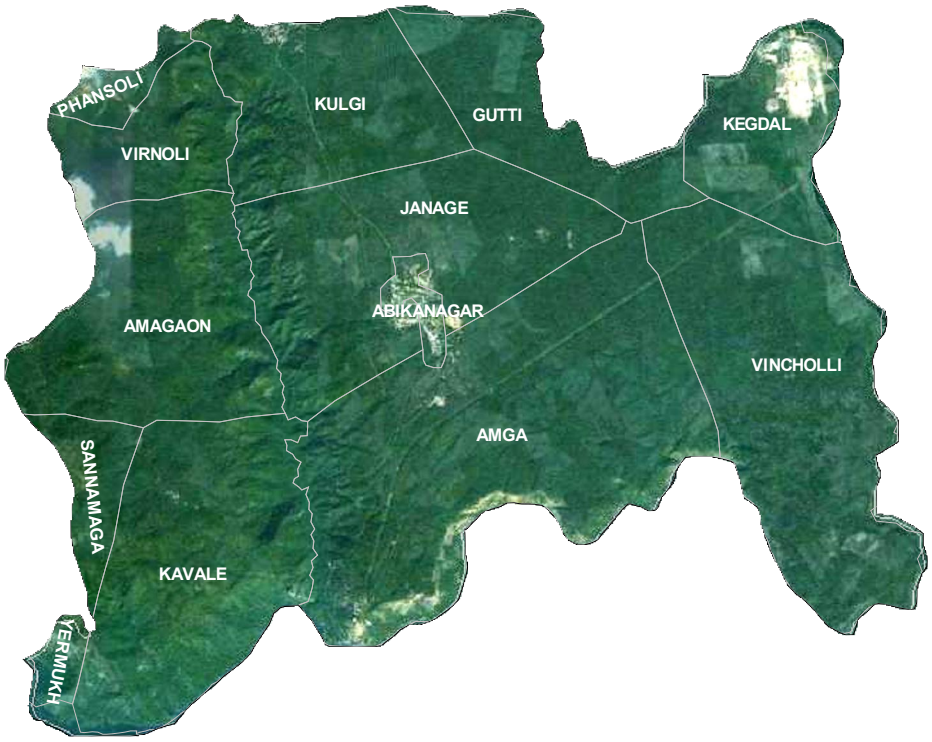

Figure 6.5: Kulgi Range with village boundaries (based on Google Earth)

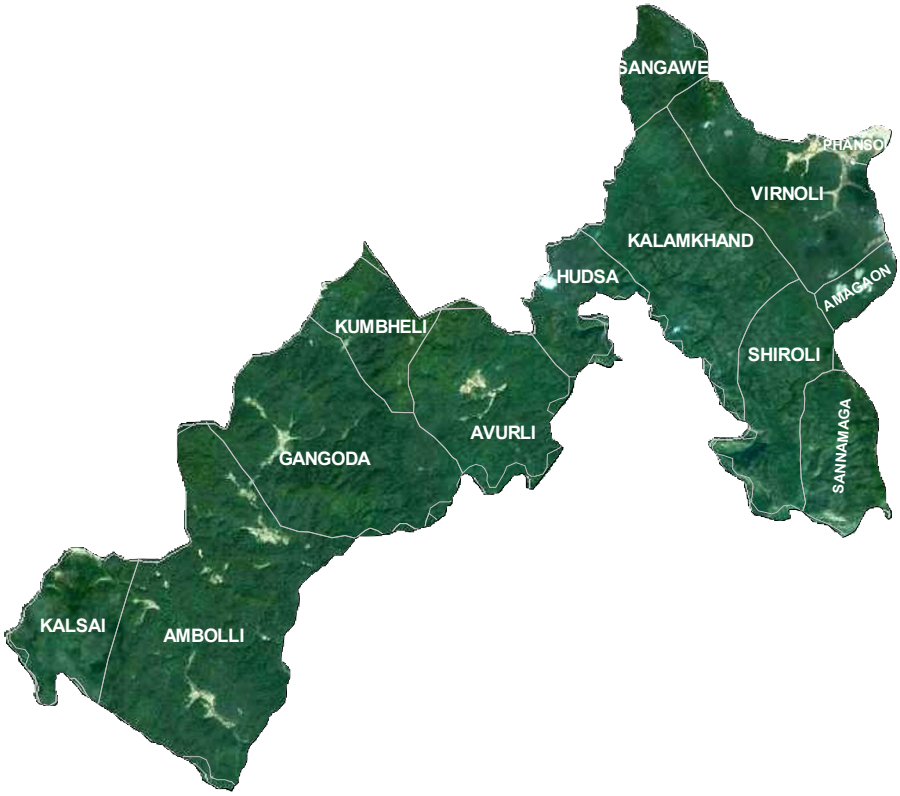

Figure 6.6: Phansoli Range with village boundaries (based on Google Earth)

Figure 6.7: Gund Range with village boundaries

Figure 6.8: Khadra region with some wetland areas

Chapter 7: ECOSYSTEM MANAGEMENT IN ADTR FOCUSSING ON GRASSLANDS

LESSONS FROM HISTORY FOR TIGER CONSERVATION

A Land rich in tigers: The earliest official accounts of Uttara Kannada, and some of the adjoining places in neigbouring districts, covering mostly the 19th century, provides pictures of the richness of tigers and the chilling details of their largescale elimination. According to Colonel Peyton, Conservator of Forests for Kanara during late 19th century, and a great wildlife expert, the tiger's favourite haunts were near the Sahyadris where they breed in the wildest and most difficult parts. They love to rest in densely wooded river banks and safe cool spots in islands thick with thorns, rank grass, and creepers. According to present day tiger ecologists of tiger is a specilised predator of large ungulates. It is never found far from water. In Asia, the ungulate species diversity and biomass reach maximum where grasslands and forests form a mosaic and where many vegetation types mingle together. In such areas tiger density reaches its maximum. In these relatively closed habitats the tiger lives and hunts these large ungulates alone. On the other hand the lion is group living animal in open habitats and hunt in packs (Campbell, 1883; Seidensticker et al., 1999).

Uttara Kannada of pre-British period was one of pristine sacred groves in almost every village, large stretches of secondary and pre-climax forests, shifting cultivation areas in different stages of vegetational succession, *benas* or grasslands, maintained by farmers using fire periodically to eliminate woody plants and weeds. The valleys with perennial water sources were associated with rice fields and arecanut cum spice gardens. These were in addition to the natural topographical features of rugged terrain of mounts, and steep hillsides, gorges of rivers, densely wooded ravines and narrow valleys, innumerable streams that merged to form few important rivers, water falls and springs. Such landscape favoured the rich wildlife the district had (Chandran and Gadgil, 1993).

For the early inhabitants of the district hunting was never a sport, but carried out mainly for subsistence and crop protection. The British arrival in the district, first as traders and later as rulers, saw setting in of a new era of wanton hunting of wildlife, more for sport than for subsistence. The chilling statistics of tiger killing in the district as furnished in the *Kanara Gazetteer* (Campbell, 1883) are given in Tables 8-1 and 8.2.

Table 81: Incidents of tiger killing in Uttara Kannada and adjoining districts

No. of tigers/cubs killed	Year of kill	Place of kill
31 tigers	1840-41	Belgaum
1 tiger	3 April 1875	Supa
1 tigress, 1 cub	5 April 1875	Supa
1 tigress & 5 cubs	1878	Tinaighat
1 tiger	1881	Yellapur
1 tiger & 1 tigress	1882 march	Yellapur
2 killed, 1 wounded	?	Yellapur
1 tigress, 5 cubs	1882 April	Potoli, Supa

Source: Based on Campbell, 1883

Consolidated numbers of tigers killed in Uttara Kannada, during some years of 19th century, as is officially reported in the *Kanara Gazetteer* (Campbell, 1883) are given in (Table 8-2)

Table 8-2: Statistics of tigers killed in Kanara during 1856-1882

Year	Tigers killed (male, female)
1856-1877	510 (average 23/year)
1867-1877	352 (average 32/year)
1878	23
1879	18
1880	39
1881	28
1882	22
Total for 27 years	**992 (37 tigers/year)**

Source: Based on Campbell, 1883

The reasons for tiger decline: From the 19th century records it appears that the reasons for the great fall in the tiger numbers are:

i. ***For protection of humans from tigers:*** 22 persons were killed between 1856 and 1877. Rewards were paid to the hunters for each tiger and cub killed. Probably, such human kills, could have been due to widespread and intensified hunting of the ungulate animals by British sportsmen and local *shikaris*.

ii. ***For protection of cattle*:** 4041 cattle were killed during five years, 1878-1882 by tigers and 1617 by panthers. Instead of correlating the high number of cattle kills to the depletion of prey in the wild, it was made a reason for tiger hunting.

iii. ***Sports hunting*:** Hunting developed as a sport during the British period. Graphic descriptions on the growth of hunting 'technology' are found in the British records.

iv. ***Decline of fire as an ecological factor*:** The British saw *kumri* cultivation as a threat to the timber rich forests and failed to note that use of fire for clearing evergreen forests by the *kumri* cultivators was the reason for enrichment of the rainforests with deciduous timber species, leading with teak, which had great demand nationally and internationally. Fire-swept landscapes where grass grew plentifully in early successional stages of forests could have been significant in wildlife enrichment. The ban on shifting cultivation reduced the role of fire substantially, and itself would have reduced the carrying capacity of the landscape for ungulates, with adverse effects on tiger population.

v. ***Increase in human population:*** The general increase in human population increased pressure on forests and wildlife. Increase in forest based industries, forest logging related human influx, mining in forest areas, construction of a chain of hydel projects in Kali river, submersion of Supa town by the reservoir and resettlement of people in the newly created township of Ramnagar, growth of Dandeli as an important industrial town, the Karnataka Power Corporation settlements in Ambiganagar and Ganeshgudi etc. would have created spillover effects on the ADTR. Linear intrusions in the forests would have increased manifold due to newly developed road networks and power lines. However, in the ADTR Ranges the population growth curve appears to have leveled off or declined during 1991 and 2001 census (from total of 20805 in 1981 to 21496 in 1991 and 21293 in 2001). Except in Kumbarwada Range in the other Ranges the population has stabilized or is showing marginal decline (Table 8-3 and Figures 8.1 and 8.2).

Table: 8-3: Range-wise human population details for 1961-2001

Range	**1961**	**1971**	**1981**	**1991**	**2001**
Anshi Range	2815	3421	4385	5156	4784
Gund Range	987	1321	2145	1583	1686
Joida Range	1777	1803	2382	2904	2425
Kadra Range	775	564	1252	1252	1252
Kulgi Range	2850	3070	3423	3547	3487
Kumbarwada Range	2365	2802	4015	3982	4566
Phansoli Range	3777	3261	3203	3072	3093
Total	**15346**	**16242**	**20805**	**21496**	**21293**

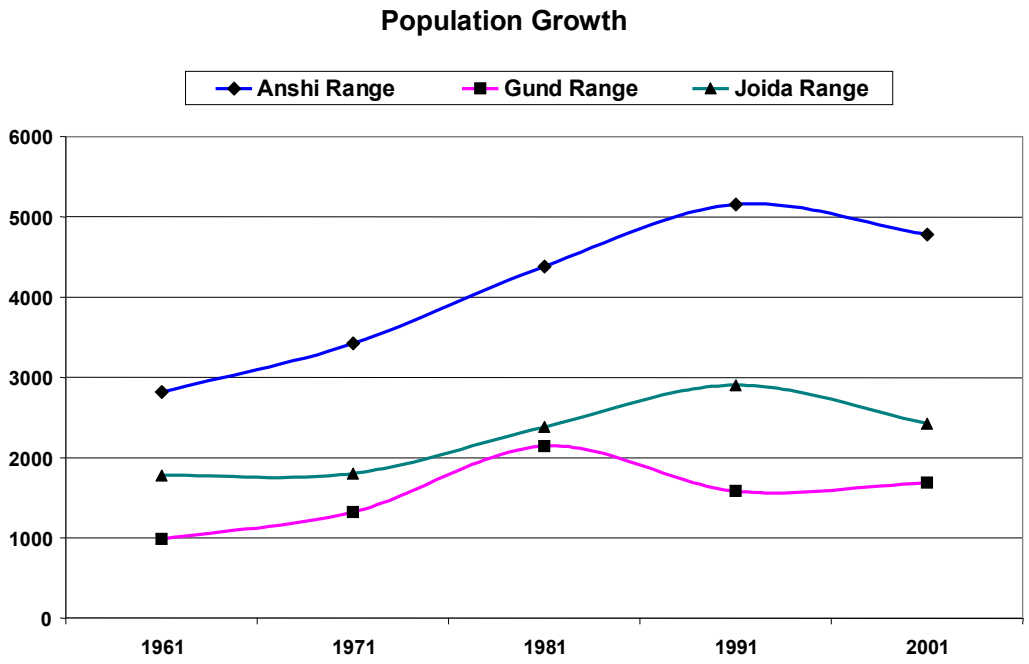

Figure 8.1: Range-wise human population growth in ADTR

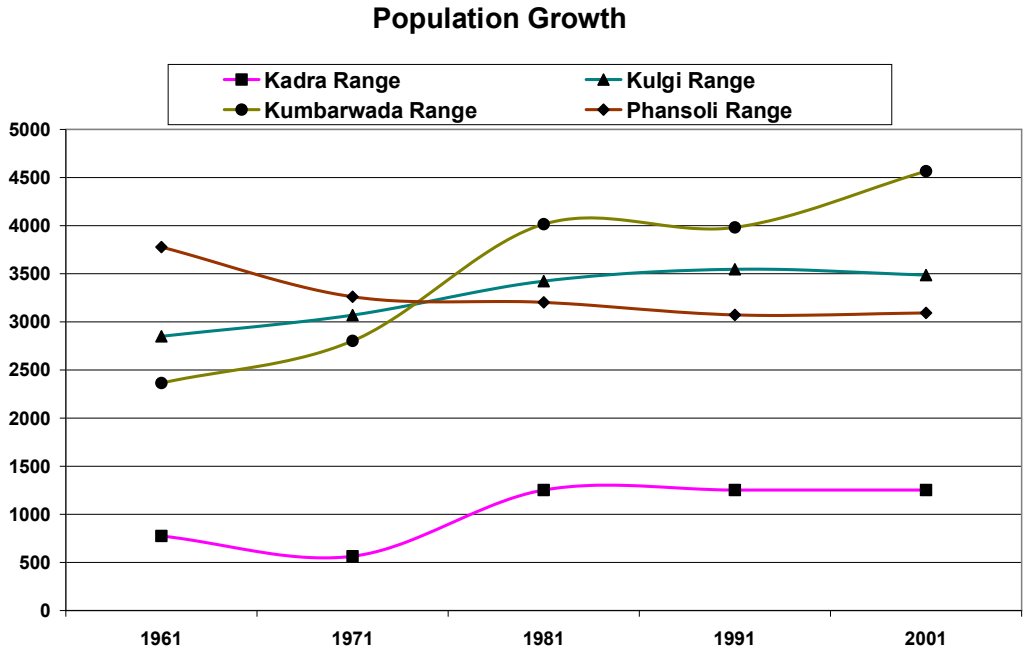

Figure: 8.2: Range-wise human population growth in ADTR

vi. ***Increase in cattle population*:** The prohibition on shifting cultivation necessitated more permanent cultivation in the valleys. As plant ash could not be added to hill soils, because of decline in the use of fire, the farmers had to keep more number of cattle, mainly for manure. Cattle obviously became competitors for wild ungulates in sharing the fodder resources. At the same time, during the latter half of 19th century, when there was drastic decline of prey animals due to over-hunting, cattle became important prey.

vii. ***Impoverishment of grasslands***: The stoppage of shifting cultivation gave prominence to settled cultivation and permanent grasslands along hill tops and slopes. Many of the nomadic cultivators, who had not maintained cattle earlier, were compelled to keep them for manure purpose. Constant grazing in the grasslands perpetually maintained by use of periodic fire, to eliminate rank growth, would have caused soil erosion and laterization. Such extensive laterite areas are seen all over the Joida taluk.

viii. ***Excess of teak monoculture:*** Intensive commercial working of forests for hardwood timbers from 19th century unleashed a saga of new wave interference into habitats teeming with wildlife. Timber extraction was followed by often clear-felling of forests to raise teak monoculture plantations. Some of the earliest plantations in the Western Ghats, dating back to 1859, were started in the Kadra Range. With systematic extraction of marketable timbers, according to the forest working plans, from the dawn of the 20th century, teak plantations were raised in portions of the worked forests almost in every coupe. The ecology of natural teak was altogether neglected and nothing was done to maintain a sustainable system of natural forests enriched with teak (Gadgil and Chandran, 1989). In fact the Gund plateau (part of the ADTR) was one of the three well known natural teak forests of the Western Ghats along with the Anamalais and the Wynad-Hegdedevankote forests (Cleghorn, 1861). Raising of teak in large scale impoverished the forest ecosystem as a whole because of: a. forest fragmentation and steep decline of forest biodiversity; b. conversion of healthy grasslands and successional forests into monoculture; c. intense erosion of soil, especially on steep slopes, as protection of the spongy soil mantle from teak canopy during the monsoon months would be insufficient, as compared to the denser canopy of natural forests; d. increased incidence of ground fires due to thick deposit of fallen leaves of teak during the summer months; e. weed invasion (mainly *Lantana* and *Eupatorium*) that replaced more benign ground vegetation of native species dominated by *Strobialanthus* and other native species prior to monoculturing; f. Impoverishment of watersheds and drying up of streams in the teak areas.

ix. ***Destruction of micro-habitats due to flooding****:* As Col. Peyton, Conservator of Forests for Kanara noted: the tiger's favourite haunts were near the Sahyadris where they breed in the wildest and most difficult parts. They love to rest in densely wooded river banks and safe cool spots in islands thick with thorns, rank grass, and creepers (Campbell, 1883). The rise of

water level in the Kali and its tributaries due to construction of a series of hydel reservoirs would have submerges lot of tiger microhabitats alongside the rugged banks of the river in the Western Ghats and the small islands strewn with rocks and overgrown with vegetation.

REQUIREMENTS OF THE TIGER

Habitats and home ranges: A single tiger's home ranges may be anything from 20 to over 400 km², depending on the density and availability of the prey. Therefore protecting large populations will require extensive areas of habitat for conservation. The ecological requirements of tigers and their prey can be effectively used to design landscape-level land use options. Such options include conservation of core areas coupled with restoration of degraded lands, and sustainable natural resource use plans to meet the needs of the local people (Wikramnayake et al., 1998). Tiger can adapt to a variety of habitats. ADTR, receiving a range of rainfall regimes from western portions with extremely heavy seasonal rainfalls (up to 5000 mm) to much lower (barely over 1000 mm) towards the east has habitats ranging from tropical evergreen and semi-evergreen to moist deciduous and dry deciduous forests. Human impacts in these forests through ages have created a variety of derived habitats such as grasslands, savanna and scrub which, enmeshed in a matrix of forests, created the needed heterogeneity for the proliferation of tigers and their prey.

Prey animals and food needs: Mean weight of prey killed by tigers can vary from 15 to 65 kg, down to sometimes 5 kg in some protected areas. The low value perhaps reflects the scarcity of large prey animals (Sunquist et al., 1999). A tigress requires 5-6 kg of meat a day as its maintenance diet (Sunquist, 1981). It was estimated that the tigress' need of meat would be 1825-2190 kg/year; but as 30% of each carcass is inedible a tigress needs gross quantity of 2373-2847 kg/year of meat. The range of animals killed by tigress may range from 20 kg barking deer every 2-3 days or one 200 kg sambar every few weeks. Based on a study of three National Parks (two in India and one in Nepal) and one Sanctuary in Thailand, it was estimated that the mean mass of prey killed was 14.7 kg in Thailand to 65.5 kg in Nagarahole and 66 kg in Kanha (Sunquist et al., 1999). Details regarding the frequency of mammalian species in the food of tigers in the Nagarahole National Park, based on scat analysis is given in the Table 8-4 (ibid. 1999)

Table 8-4: Details regarding the frequency of mammalian species in the food of tigers in the Nagarahole National Park (based on Sunquist et al., 1999)

Species name	**Common name**	**Mean body mass, kg**	Relative no. killed
Axis axis	Chital, Spotted deer	55	22.8
Cervus unicolor	Sambar deer	212	11.4
Bos frontalis		287	7.5
Sus scrofa	Pig	38	8.4
Muntiacus muntjac	Barking deer	20	8.4
Semnopithecus entellus	Hanuman langur	9	11.3
Moschiola meminna	Indian chevrotain	8	13.6
Lepus nigricolis	Black-naped hare	3	1.5
Hystrix indica	Indian porcupine	8	0.6
Cuon alpinus	Asiatic wild dog	15	1.0
Unidentified items			13.5
Mean mass (kg) of prey killed =65.5 kg			

Nagarahole being more similar to ADTR than any other tiger reserve in India, we expect as well the same prey animals in the latter. We need to see how to increase the numbers of these animals. Most of these depend on grasslands and savannas for their food. Different other habitats also contribute towards the food of these animals; for instance, the langurs are mainly arboreal. Therefore, we need to work out in detail, the ideal combination of landscape elements to maintain and enhance the number of a spectrum of prey animals, from the smallest hare to the largest gaur. Grassland forms the base of the ecological pyramids of all the large prey animals, which are also part of forests and water bodies.

Ideal habitats: Unlike lions or cheetah which need vast grasslands for their prey capture, tigers rely on surprising a prey and capturing it. Hence tigers prefer to inhabit mosaic kind of landscape elements such as dense forest, grasslands, scrub, ravines, wetlands etc. Hence ADTR hosting large number of these landscape elements has good potential to be an ideal place for tiger conservation. In fact the tiger population was very good in the past and the reasons for its decline also have been discussed. According to Karanth (1993), tigers have the ability to live in very diverse natural habitats, where they tolerate a wide range of temperatures and rainfall regimes. They produce relatively large litters with relatively short inter-birth intervals. They can take prey differing considerably in size and their hunting tactics will vary based on prey size, prey species and habitat. Hence due to their diverse selection of prey and larger territorial activities, larger intact diverse habitats are required. However, tiger needs for its prey good population of large sized herbivorous mammals, mostly ungulates. To sustain these herbivores large and healthy grasslands are very essential. Good tiger population in a preserve would reflect good grasslands

and large number of ungulate preys. Wildlife managers need to assess habitat requirements of different species, and bring the grasslands under careful management system, particularly with reference to their strategic locations, palatability of grasses and herbs, vegetational succession, willful alterations of them and about their vulnerability to weed menace.

Need for minimizing grazing pressure from domestic cattle: Overgrazed areas near many villages are dominated by weedy species and it is necessary to minimize the number of cattle. This objective could be fully achieved only when such villages are prioritized for rehabilitation of the inhabitants, at least towards reducing the present levels of pressure. Range-wise details of cattle population in the ADTR are furnished in the Table 8-5. Though apparently the cattle number (6170) is not that high for the ADTR, considering that the grasslands here are secondary and created from the forests in the past during the peak period of shifting cultivation, through slashing and burning natural vegetation, grass growth is poor in most of them. Because of the heavy rainfall the region receives, the grasslands, tend to revert to woody vegetation and are also subject to invasion to tall weeds like *Chromolaena.* Moreover, the substratum of many grasslands is rocky being abandoned *kumri* areas, and old pastures exposed to alternate intensive rainy season followed by prolonged dry period of six to seven months. These rocky area grasslands produce very less grasses, compared to genuine dry area grasslands of relatively lower rainfall, elsewhere. The protected *bena* grasslands of individual farmers are better in terms of height and density of grasses, although the grasses there die during the dry season.

Table 8-5: Range-wise details of cattle population in the ADTR

Sl No.	**Range**	**Number of Cattle**
1	Kulgi	2202
2	Phansoli	260
3	Gund	952
4	Kumbarwada	1342
5	Anshi	1414
	Total	**6170**

Because of heavy seasonal rainfall exceeding 4000-5000 mm per annum towards the western portions of the ADTR, evergreen-semi-evergreen forests not much favoured by the tigers, constitute the major vegetation types here. There are fairly large agricultural areas within this region and some of them need to be prioritized for rehabilitation of families. These villages can turn into very good secure habitats for tigers, especially during the drier months, due to better availability of water and reduced competition from domestic cattle, which are presently in good numbers. However, more efforts are to be made for maintenance of grasslands in all the heavy

rainfall regions. If villages are shifted are entirely there will be no check on the succession of woody forest species and non grass weeds in the grasslands and fallow fields. Through regulated use of fire, involving the local population in such exercises, the succession of forests in abandoned grasslands and fallow fields can be checked.

FOOD NEEDS OF THE TIGER

Promoting plant species for faunal richness: Many kinds of habitats within the ADTR, presently not so favourable for or of below optimum utility for faunal richness can be selectively managed to increase the population of major and minor mammals, birds and bats and various invertebrates like butterflies and bees which add to the attractiveness of ADTR and render various ecosystem services. A list of forest trees, shrubs and climbers which provide food in various forms for the wildlife are given in the Table 8-6. The species can be planted in all the suitable habitats without destroying the existing vegetation. Such habitats to be considered include numerous monoculture plantations within the ADTR, barren rims of reservoirs of hydel projects, roadsides, rocky places with scanty growth of grasses etc.

Table 8-6: Wild woody plants of food value for wildlife

Sl.	Species	Local/common Name	Parts eaten and wild animals feeding on them	Remarks
1	*Acacia concinna*	Seege	Pods-Deer*, Sambar, Gaur	
2	*Acacia ferruginea*	Banni	Pods-Deer*, Sambar,	
3	*Artocarpus integrifolia*	Halasu, Jack	Fruits-Monkeys, Bear Leaves- fodder	Fallen fruits of *A.integrifolia* and *A.hirsutus* are relished by many ungulates
4	*Bauhinia sp.*	Basavanapada	Pods- Gaur, Sambar, Deer*	
5	*Bombax ceiba*	Buraga, Silk cotton	Flowers-Monkeys, Sambar, Deer*, Wild pig. Nectar for many birds	
6	*Careya arborea*	Kumbia, Kaul	Bark-Sambar, Fruits-Elephant, Monkey, Porcupine, Sambar	
7	*Cassia fistula*	Kakke	Pods-Bear, Monkeys	
8	*Cordia macleodii*	Hadang	Fruits- Deer*, Gaur, birds	
9	*Cordia myxa*	Challe	Friuits-Deer*, Sambar, Bear, birds	
10	*Dillenia pentagyna*	Kanagalu	Fruits-Deer*, Sambar, Gaur, birds	

11	*Ficus* spp.	Atti	Fruit- Birds, including Hornbills, bats etc., and ungulates such as Deer*, Sambar, etc. Leaves- fodder for herbivores	Keystone species with one or the other tree flowering throughout the year and eaten by large number of wild animals, both big and small
12	*Grewia tiliaefolia*	Dhaman; Dadaslu	Leaves-Sambar, Deer*,Fruits-Monkey, birds	
13	*Hydnocarpus laurifolia*	Suranti; Toratte	Fruit-Porcupine	
14	*Spondias acuminate*	*Kaadmate*	Fruits: Sambar, Porcupine, Deer*	
15	*Kydia calycina*	Bende	Leaves –Ungulates	Seems to be eaten by ungulates as they are eaten by cattle.
16	*Moullava spicata*	Hulibarka	Fruits-Deer*, Sambar	Flowering spike is also eaten
17	*Mucuna pruriens*	Nasagunni kai	Leaves-Deer*	
18	*Phyllanthus emblica*	Nelli; Gooseberry	Fruits-Sambar, Deer*	
19	*Strychnos nux-vomica*	Kasarka	Fruits- pulp eaten by monkeys, Hornbills	
20	*Syzygium cumini*	Nerale	Fruits- wild Pig, Deer*, Bear and several birds	
21	*Tectona grandis*	Saaguvani; Teak	Bark- Elephants.	Elephants debark the tree in long strips and consume it.
22	*Terminalia belerica*	Tare	Fruits-Deer, Sambar	
23	*Tetrameles nudiflora*	Kadu bende	Bark-Elephants	Favourite tree for bees to make hives
24	*Xylia Xylocarpa*	Jamba	Seeds-Gaint Squirrel, Monkeys	
25	*Zizhiphus oenoplia*		Fruits-Jackels, Procupine, Deer*, Pangolin, birds	
26	*Ziziphus rugosa*	Kaare	Fruits-Bear, birds	

*Deer includes Mouse deer, Barking deer, Spotted deer

Several kinds of grasses are associated with the ADTR; of them many are known as good or very good fodder grasses. The list of fodder grasses in general are given in the Table 8-7. Grasslands with such grasses need to be given special attention in management programmes. List of grasses for planting in Kulgi and Dandeli wild life Sanctuary is given in Tables 8.8 to Table 8.10.

NEED FOR STRICT PROTECTION OF PRIME HABITATS

Tigers are sensitive to high levels of human disturbance. In landscape management programme large core areas are to be earmarked for strict protection. Relocation/rehabilitation of villages, preferably should begin with these identified core areas. The core areas may be identified by abundance of wildlife in general, good water resources and reasonably large sized elements in natural landscapes. Good grasslands need to be linked to large patches of multi-species forests and perennial water bodies.

***Control on poaching*:** Tiger populations were severely depleted in Uttara Kannada due to heavy poaching/hunting during the latter part of 19th century. Panwar et al. (1987) state that tiger populations can recover relatively rapidly, with the sustained availability of food and water alongwith reduced or complete elimination of poaching. Tigers, in favourable situations, are considered to breed faster than their prey. Karanth and Smith (1999) consider prey depletion as a critical determinant of tiger population viability. This fact was not given much attention earlier in conservation circles, which highlighted poaching and habitat loss as the major causes for tiger decline. Their study results suggest that tiger populations can persist in relatively small reserves (300-3000 km²), even if there is low level of poaching, provided prey base is maintained at adequate density. Karanth and Sunquist (1992) and Seidensticker and McDougal (1993) affirm that in high prey-density habitats like the alluvial grasslands and deciduous forests of southern Asia, the necessary protected areas could be as small as 300 km², whereas in prey-poor habitats such as mangrove, evergreen or temperate forests, they may exceed 3000 km².

Suggestions: Core areas and corridors are to be identified on the basis of field studies, animal censuses/observations hitherto carried out and remote sensing data. Corridors to be devised and existing ones have to be strengthened/widened using suitable plant species.

Table 8-7: List of grasses of ADTR , noting those of fodder value

	Grasses of Anshi-Dandeli Tiger Reserve			
Sl	**Genus**	**Species**	**Distribution**	**Remarks as fodder**
1	Aristidia	Setacea	India, Sri Lanks, Mascsrene	Good
2	Arthraxon	Lancifolius	Paleotropics	Good
3	Arundinella	Leptochloa	Peninsular India, Sri Lanka	
4	Arundinella	nepalense	Oriental-Indomalaysia	
5	Arundinella	Metzii	Oriental-Western Ghats	Good
6	Bracharia	Miliiformis	Oriental-Indomalaysia, Sri Lanka	Good
7	Centotheca	Lappacea	Indo-Malaysia, China, Tropical Africa, Polynesia	Good

8	Chloris	Barbata	Tropics	
9	Coelachne	simpliciuscula	India, Sri Lanka, China, South East Asia	
10	Coix	Lacryma-Jobi	Tropics	
11	Cyanodon	Dactylon	India, Sri Lanka, Pantropics	Good
12	Cymbopogon	Caesius	Oriental-India, Sri Lanka, South West Asia, Africa	
13	Cyrtococcum	Muricatum	India, South East Asia	
14	Cyrtococcum	Oxyphyllum	Oriental-Indomalaysia	
15	Cyrtococum	Patense	Oriental-Indomalaysia, Pacific Islands	
16	Dactyloctenium	Aegyptium	Oriental-India, Sri Lanka	
17	Digitaria	Bicornis	Tropical Asia, Africa	Very Good
18	Dimeria	ornithopoda	India, Malaysia, Japan, Tropical Australia	
19	Dimeria	hohenackeri	Oriental-Peninsular India	Very Good
20	Echinochloa	Colona	Most warm countries	Very Good
21	Eleusine	Indica	Oriental and Paleotropic	Good
22	Elytrophorus	Spicatus	Oriental-India, Sri Lanka, old tropics	
23	Eragrostis	Uniloides	Asian Tropics	
24	Eulalia	Trispicata	Oriental-Indomalaysia, Australia	
25	Heteropogon	Contortus	Pantropics	
26	Hygrorhiza	Aristata	Oriental-India, Sri Lanka	Good
27	Isachne	Miliacea	Oriental-Indomalaysia	
28	Isacne	Globosa	Oriental-Indomalaysia	
29	Ischaemum	thomsonianum	Oriental-Western Ghats	
30	Ischaemum	Dalzelli		
31	Ischaemum	Indicum	South India	Good
32	Ischemum	semisagittatum	Oriental-India, Sri Lanka	
33	Jansenella	griffithiana	Oriental-India, Sri Lanka	
34	Leersia	hexandra	Tropics	
35	Oplismenus	Burmanii	Oriental and Paleotropic	
36	Oplismenus	Compositus	Pantropics	
37	Oryza	rufipogon	Oriental-India	
38	Panicum	Auritum	Oriental-Indomalaysia, China	
39	Echinochloa	crus-galli	India, S E Asia and Africa	Very Good
40	Panicum	Repens	Pantropics	Very Good
41	Paspalidium	Flavidum	S Asia	Very Good
42	Paspalum	Canarae	Peninsular India	
43	Paspalum	Conjugatum	India, Sri Lanka, old world world tropics	
44	Paspalum	scrobiculatum	Oriental-India	
45	Pennisetum	hoohanackeri	India, Pakistan, Tropical africa, Madagascar	
46	Pennisetum	pedicellatum	India, Tropical Africa	
47	Pseudanthistiria	umbellata	Oriental-India	
48	Pseudanthistiria	Heteroclite	Oriental-Western Ghats	Good
49	Pseudanthistiria	Hispida	Oriental-Western Ghats	
50	Sacciolepis	Indica	Oriental-Indomalaysia	Good
51	Sacciolepis	interrupta	Oriental-Indomalaysia	

52	Setaria	Pumila	Oriental-India, Sri Lanka, Old world Tropics	Good
53	Spodiopogon	rhizophorus	Oriental-Western Ghats	
54	Themeda	Tremula	Oriental-India, Sri Lanka	Good

RESTORATION OF DEGRADED HABITATS IN BUFFER ZONE

Buffer zone management is very critical in tiger conservation efforts. The buffer zone should not be one with intense human activities and grazing pressures from domestic cattle. The human activities here should be regulated and development guided towards complementing the objectives of ADTR. Activities suggested for the buffer zone are listed below:

- Formation of Village Forest Committees and Biodiversity Management Committees among all the peripheral villages
- Raising firewood and NTFP species to make peripheral villages self sufficient so as to take pressure of the ADTR core and buffer zones
- Starting village fodder farms, under Social Forestry schemes, especially in villages having numerous cattle and insufficient fodder resources
- Training enthusiastic youngsters as tourist guides, volunteers and communicators
- Fencing of small blocks of lands for three to five years from human impact and grazing by domestic cattle, will have very positive impact on forest succession and healthy growth of grasses in overgrazed areas. Once tall saplings are naturally established, the forest will flourish on its own. The protection may be shifted to other unprotected areas after the three to five year period. The forest lands thus protected may be named "Regeneration Blocks". The vegetational succession in such blocks to be monitored and recorded, preferably by local volunteers. Seeds of suitable tree and shrub species may be disseminated in such areas to promote diversity.

Suggestions: Application of GIS on wildlife distribution within ADTR is critical. Distribution data, to begin with, should cover primary and secondary reports on tigers, panthers and major herbivorous mammals. From existing and freshly collected data bird distribution details can be prepared as well. Birds are also good indicators of habitat quality. From distribution maps thus prepared, areas of importance for tigers and their prey may be demarcated. This would help in understanding ecosystem processes for preparing guidelines of future management of the Reserve. As it is difficult to get exact details of the very few tigers reported from the ADTR, it is very important to track their associate species and use them as proxy for demarcating likely tiger preference habitats within the Reserve.

GRASSLAND MANAGEMENT

It is necessary to maintain different kinds of grasslands within the Reserve as some grazing wild animals prefer short grass areas while others prefer tall grass areas. Mixed savanna-grasslands are favourites of yet others.

Controlled use of fire: ADTR receives high to moderate rainfall and the natural climax vegetation here is forest. Gradual vegetational succession in grasslands towards forest would effectively reduce carrying capacity for grazing animals and thereby affect prey supply for the carnivores. Therefore maintenance and management of grasslands would play a crucial role in sustaining wild fauna. Fire has been an important tool in grassland management in the humid Western Ghat regions. In the grasslands fire burns down the harsh, fibrous old bases and promotes a flush of new growth of fodder grasses. As it is time consuming and expensive to manage the large areas and keep the ecosystems in a dynamic stage to sustain maximum of the tiger population, with the available staff of the Forest Department, trained volunteers, NGOs and wildlife enthusiasts may be used in grassland management with regulated use of fire according to specifically prepared, site-centred management plans. Fire is to be used with caution as repeated fires can dry out a habitat, cause soil erosion and destroy many sensitive species.

Many tree species of food importance for herbivore prey animals of the tiger are associated with burnt savannas. These include *Acacia* spp., *Bombax ceiba, Careya arborea, Cordia* spp., *Dillenia pentagyna, Kydia calycina, Phyllanthus emblica* etc.

Afforestation in grasslands: Grassland within the Reserve, including fallow fields, should not be used for tree planting under normal conditions. The practice of raising block plantations in such grassy blanks is to be altogether dispensed with. Block plantations, and that too of fodder tree species and those trees that provide food for wildlife can be considered in rocky areas with scanty growth of grasses and other herbs. Providing designed corridors (using area specific trees and other life forms) for animal migration through such areas would be a good exercise for keeping the integrity of the ADTR by keeping the ecosystem processes alive. Dinerstein *et al.* (1999) consider the restoration of habitat integrity in wildlife, a prerequisite for effective dispersal of tigers.

THE PROBLEM OF MONOCULTURE PLANTATIONS

Ever-since commercial forestry began in the ADTR region, over one hundred years ago, during the British period, raising of teak plantations became an accepted practice, almost in every block of forest, after clear-felling the natural tree growth. We do not know exactly how much area has been brought under teak plantations in the ADTR. Teak plantations in general are low diversity areas, with scanty undergrowth of grass. The plantations are drier places than the natural forests, often subjected to soil erosion and ground fires. Despite the fact teak timber fetches fabulous market prices, there has been a moratorium on tree felling within the ADTR. With the objective of increasing the prey population of tigers, the food resources have to be increased. Without in anyway tampering with good teak plantations, the others can be subjected to enrichment planting with various fruit and fodder species, mainly the trees.

Adopting landscape level approach: In small and isolated protected areas the chances for long term survival of megafauna are slim, unless they are linked by natural habitat corridors to permit dispersal of tigers and their prey and are provided with buffer zones to minimize impacts from other land uses. Therefore landscape level approach is essential for tiger conservation (Karanth and Sunquist, 1995).

Suggestions: Evaluation of habitat quality in different parts of the ADTR with their suitability for wildlife in general and tiger in particular needs to be carried out. In such evaluation grassland quality and connectivity with different other landscape elements are important. Management plans have to be prepared to upgrade landscape elements, particularly poor quality grasslands.

GETTING PUBLIC SUPPORT

Tiger in India is a symbol of pride, power and strength. In Indian tradition it is both feared and respected animal and treated at par with the lion. In the local cultures associated with the wooded highlands tiger has been a worshipped animal. This holds good for the hilly terrain of Karnataka as well. In the Uttara Kannada district most villages and even towns have icons of tigers or *Hulidevaru* inside sacred forests, under sacred trees or in recently constructed small shrines. Tiger is famed as the *vahana* of the goddess Kali/Durga and Lord Aiyappa. Such incredible sentimental attachment among the public towards this magnificent animal needs to be appropriately utilized for gaining public support for tiger conservation in ADTR. Such support has to come from not only from outside but more so from the people living within the ADTR and its peripheral villages. Volunteers from among the youth, especially from these villages have to be enlisted to work for activities related to tiger conservation, and to develop a positive attitude among the local population. As the too few staff of the Forest Department are insufficient to manage and maintain the ADTR, especially in fire control, regulated use of fire, in grassland

maintenance, tree planting, nursery activities, awareness creation, as local guides etc. it will be ideal to have a core group of such volunteers to assist the Department. If trained in bird watching, plant identification, and in disseminating wildlife related information to the visitors, ADTR can gain much from this reposition of confidence in the local population. In the words of wildlife conservationist Peter Jackson (1999): "if tigers are to be conserved, local people's feelings and needs must be a paramount consideration. Unless they support conservation, the tiger is doomed. They are not necessarily hostile to the tiger; they have greater problems with the deer and wild boar, which ravage their crops. A local tiger can even be seen as a protector against these pests. But people resent being excluded from forests and grasslands, which have been set aside for tigers and other wildlife, and which could provide them with basic necessities….If people's hostility is to be eliminated so that they can co-exist with tigers and other wild animals, they must be ensured the resources they need from land outside reserves….The tiger is still alive in the consciousness of the Asian peoples, many of whom retain respect for its place in culture and religion. This should be a powerful factor in enlisting public support, and should be used to convince political leaders that it should not be allowed to become extinct in their countries."

Table 8.8: List of grasses for planting in Kulgi and Dandeli wild life Santuary

{note: to be implemented under technical supervision]

S.No	Genus	Species	Best habitat	Common names
1	Arundinella	metzii	Open slopes	
2	Arundinella	leptochloa	slopes	
3	Brachiaria	mutica	moist	Para grass (cultivated)
4	Centotheca	lappacea	slight shades	
5	Chloris	gayana		Rhodes grass (cultivated)
6	Chrysopogon	hackelii	slopes	
7	Chrysopogon	fulvus	slopes	Ganjigorikahullu, Karada (Kan)
8	Coix	lachrymal-jobi	Wet, marshy areas	Job's tear grass
9	Cymbopogon	caesius	Open dry slopes	
10	Cymbopogon sp		Open dry slopes	
11	Dichanthium	annulatum	Open moist	
12	Digitaria	ciliaris	moist shady	
14	Eleusine	coracana	Open moist places, abandoned fields	Ragi
15	Eulalia	trispicata	slopes	
16	Heteropogon	contortus	Open slopes	Spear grass
17	Panicum	maximum	moist	Guinea grass (cultivated)
18	Panicum	auritum	river side, moist slopes	
19	Pennisetum	purpureum	Banks of rivers, moist places	Napier grass (cultivated)
20	Saccharum	spontaneum	Banks and wet places	Kan-kabbu
21	Sporobolus	indicus	Dry	
22	Themeda	tremula	Open slopes	
23	Themeda	triandra	Open slopes	

Notes on some important grasses

- ✓ ***Brachiaria mutica*** (Para grass) is a very tall (up to 2.5 m) grass native to South America and West Africa. The grass is a good fodder grass suitable for moist, swampy, open areas. Grass planting is to be done during the onset of monsoon or in cool months. The plants are raised from rooted, mature stem cuttings of 20-30 cm long having 2-3 nodes or from rooted runners. The cuttings root in about six days and begin to spread out. If this grass is to be maintained the soil has to be moist during dry months. The unirrigated grass though dries up sprouts with the beginning of rains. The grass is highly succulent, palatable and nutritious.
- ✓ ***Centotheca lappacea*** prolifically branched, perennial grass that attains up to 1.5 m height. It is found in open, dry stony regions, especially on laterite soils. If the soil is stony the grass remains stunted. The grass is a good fodder and can be stored as hay. The fodder value is high before flowering.
- ✓ ***Chloris gayana*** (Rhodes grass) is a fine stemmed, annual or perennial grass introduced as a fodder grass into India from South Africa. It is ideally suited for dryer part of the ADTR, where the rainfall does not exceed 125 cm. It is drought tolerant and good for light loamy soils than stiff clay or water logged areas. Seeds or rooted cuttings are used for propagation. It attains height of 1-1.5 m. Sowing of seeds to be done with the onset of monsoon. While sowing fine soil has to be mixed with seeds so as to have uniform spread. Rooted cuttings can also be planted in rows 60 cm apart. Below power lines with light soils would be ideal. The grass is nutritious and withstands grazing and trampling.
- ✓ ***Chrysopogon fulvus***: Perennial tufted grass up to 1.8 m.
- ✓ ***Eleucine coracana***: Ragi seeds can be dispersed in all suitable areas to promote growth of wildlings in due course of time. The plants, though seasonal, make good forage. Ragi was grown widely once by the shifting cultivators of ADTR in patches of forests cleared and burnt. Ragi plant is a nutritious fodder.

Table-8.9 : List of Leguminous plants for planting in Kulgi and Dandeli wild life Santuary			
Sl.No.	**Genus**	**Species**	
1	Bauhinia	purpurea	Basavanapada
2	Bauhinia	Racemosa	Banne
3	Bauhinia	variegata	Arisinatige
4	Cassia	fistula	Kakke
5	Crotolaria	juncea	Sunhemp
6	Desmodium	triflorum	
7	Entada	scandens	Hallekayiballi
8	Erythrina	spp.	Harivana
9	Indigofera	cassioides	
10	Pithecellobium	dulce	
11	Saraca	asoca	
12	Sesbania	grandiflora	Agase
13	Smithia	conferta	
14	Smithia	sensitiva	
15	Tephrosia	purpurea	
16	Tamarindus	Indicus	Tamarind

Some notable legumes

- ✓ ***Cassia fistula*** leaves have fodder value though the cattle are not fond of it. It is likely that some wild ungulates would feed on the leaves. Bears and monkey feed on the fruit pulp according to Talbot (1909), and therefore the tree renders good ecosystem services. Moreover the beautiful, golden yellow bunches of flowers are great attraction during the summer months. The tree can be extensively raised on roadsides and other open, even lateritic areas with poor grass growth. The seedlings are routinely raised in forest nurseries using well-established silvicultural practices.
- ✓ ***Desmodium triflorum:*** A small, trailing, perennial herb it is a good fodder. It spreads on the ground and forms a close mat; good for nitrogen enrichment and soil conservation.
- ✓ ***Entada scandens:*** A giant woody climber associated with deciduous and semi-evergreen forests. The leaves are fodder for elephants. Plants can be multiplied by layering or from seeds.
- ✓ ***Erythrina*** spp. Leaves make good fodder. The tree is good for deciduous forests, roadsides and open places. Stem cuttings are ideal for propagation. The flowers are visited by many birds for nectar.

PULSES FOR INTRODUCTION

Pulses are leguminous herbs and climbers the seeds of a great variety of which have been used as protein rich food by humans from ancient times. Not only are the seeds rich in proteins but the forage also is rich in proteins, mainly because of the association of the roots of these plants with nitrogen fixing bacteria. The very growth of the legumes enriches soils with nitrogen and they are ideal for reclaiming impoverished soils. Dispersing the seeds of relatively low cost pulses selectively, especially along roadsides, as well as raising them in small protected patches, and in canopy gaps of plantations, underneath power lines etc., in due course can increase the stock of these useful plants, as wildlings in the ADTR. The plants will provide excellent forage for many herbivores which constitute the prey stock of tigers. A list of these forage legumes are given below:

- ✓ ***Dolichos biflorus*** (Eng: Horse-gram; Kan: Kulthi): It grows on a variety of soils, including poor soils, and is hardy and drought resistant. It is considered a valuable green fodder crop and a good protienaceous substitute for grasses. The plants improve soil fertility, which is very necessary for many parts of ADTR where shifting cultivation was widely practiced leaving behind thin layer of poor soils impoverished of nutrients. Underneath poor grade plantations also the species can be raised.
- ✓ ***Dolichos lablab* var. *typicus*** (Kan: *Avare*). It is a good climber, cultivated for the tender pods and seeds used as human food. The plants, both fresh and dry, make good protein rich fodder for herbivores.
- ✓ The seeds of various pulses such as of blackgram, green gram, cowpea (alsande) etc may be dispersed in suitable localities so as to increase their number through natural propagation as wildlings.

Table -8.10 : Nonl-leguminous fodder trees and climbers

1	Artocarpus	integrifloia	Jackfruit
2	Caryota	Urens	Palm
3	Dillennia	pentagyna	Kanigala (Kan)
4	Emblica	officinalis	Nelli (Kan); gooseberry (Eng)
5	Ficus	religiosa	Pipal
6	Ficus	bengalensis	Banyan
7	Mallotus	phillippensis	Kumkumadamara (Kan)
8	Mangifera	Indica	Mango
9	Mimusops	elengi	Bakula (Kan)
10	Sygygium	Cumini	Jamun
11	Zizhiphus	Rhugosa	Mulla hannu

Note: Artocarpus integrifolia: The jack fruit tree can be raised in forest openings, roadsides, field bunds etc. The evergreen tee requires protection for some years from

browsing by animals. There is good scope for raising thousands of trees in the ADTR. The leaves are eaten by elephants and most ungulates. The large fruits also make ideal food for many herbivores during summer months and early part of rainy season.

Bauhinia purpurea: A medium sized, tree suitable for savanna with hardened surface and roadsides especially in the ADTR. Apart from having ornamental value due to its deep pink to white, fragrant flowers the leaves have fodder value as well. The leaves contain 3.6% protein and 9.7% carbohydrates and are rich in minerals, especially calcium and phosphorus. It is raised from seeds and the seedlings are transplanted. It can be raised at site by line sowing. Light demand being moderate, should not be planted in fully open places (Talbot II, 1976; Wealth of India, vol. 2, 1988).

Bauhinia racemosa is a small, crooked bushy leguminous tree of moist and dry deciduous forests; useful for filling blanks in forest plantations. Propagation is done by line sowings. The young plants are kept weeded and the soil is loosened from time to time. The tree is a light demander. It produces root suckers and coppices well.

Bauhinia variegata: The tree is not natural to the ADTR. However, being indigenous tree present throughout India it is ideal for introduction, particularly along the roadsides. While the leaves are good fodder the showy flowers provide ornamental value. The leaves have by dry weight 3.58% digestible protein and 14.3% digestible starch and are rich in minerals. The flowers and flower buds have food value even for humans. Known as *Kovidara* in Sanskrit the plant is also reputed medicinally (Wealth of India, Vol. 2, 1988).

Caryota urens: Elephants are fond of the leaves and starchy pith of the palm that is often associated with evergreen-semi-evergreen forests. Fire protected moist deciduous forests can be planted with this species, especially in gullies and ravines and along the water courses. The palm is propagated through seeds. Self-sown seeds germinate in 150-180 days. Pre-soaking of seeds in cold water for 24 hours ensures the maximum germination in a minimum period. The palm lives for 20-25 years (Wealth of India, vol.3- 1992).

Dillenia pentagyna: Deciduous tree of deciduous forests and burnt savanna. Deer is fond of fruits; many birds also feed on fruits. The tree reproduces by seeds, and is ideal for planting in places subjected to fire. The species also produces coppice shoots.

***Dioscorea* spp.;** Tuber producing climbers. The tuber is eaten by deer. The plans can be raised from tubers.

***Emblica officinalis*:** Fruits eaten by a variety of wildlife. Leaves make fodder for wildlife. There is good scope for raising thousands of trees in ADTR using nursery raised saplings.

Ficus religiosa: The tree can be introduced in unproductive, open, non-grassy areas (as good grasslands should not be brought under any tree plantations). Elephants are fond of pipal leaves. *Ficus* sp. are considered keystone resources of ecosystems by providing food, in the form of ripe fruits, to birds and many herbivores, during times of scarcity of other seasonal fruits.

Ficus bengalensis: Same habitats as the previous one. Prolific producer of fruits for birds, monkeys and minor mammals. Elephants and ungulates feed on the leaves

Ficus racemosa: The wild fig grows in ravines, gullies, banks of water courses and different other habitats. Being a prolific producer of fruits a-seasonally, there is good scope for raising thousands of trees of this species in ADTR, which can benefit a variety of herbivores, including birds.

Mallotus phillippensis: A small tree that prefers partial shade. The leaves have fodder value. Seldom any importance has been given to this tree, that is also medicinally important, in forest planting. The tree can be propagated by seeds.

Mangifera indica: The mango trees, especially of the wild or semi-wild Appe-midi varieties can be propagated in the forest. The fruits are eaten by several herbivores, and the leaves, though not a good fodder, are sparingly eaten by many animals. The tree will have a great role in ecosystem enrichment.

Madhuca indica and M. longifolia : These are large trees associated with deciduous forests. Leaves make excellent fodder. The fruits are eaten by monkeys, large birds such as hornbills and also bats. The trees are raised from seeds. Even fallen flowers are eaten by herbivores. There is tremendous scope for increasing the population of this useful tree which is a light demander.

Mimusops elengi: Large evergreen tree suitable for planting in evergreen-semievergreen forest areas, in haps and openings. Leaves make medium quality fodder. Fruits constitute food for many birds, bats and other wildlife. The tee is propagated by nursery grown seedlings.

Odina wodier: Moderate to large sized deciduous tree. Leaves are readily browsed by ungulates and fruits eaten by birds. The light demanding and fire tolerant tree produces root suckers as well as coppices well. The tree can be grown from cuttings as well as seeds.

Spondias mangifera: Ctuttings and seeds, light demander.

Bamboos: Different species of bamboos need to be propagated in poor grade plantations. Young shoots and tender leaves of bamboos constitute good fodder for elephants and ungulates.

Appendix-1

Differentiating sedges (Cyperaceae members) and grasses: Grasses can be easily differentiated from other families, particularly in habit and in character of leaves, fruits, seeds and embryos. They are predominantly herbaceous, the woody bamboos being exceptions. Members of Cyperaceae share some of the common characteristics of grasses as they are their nearest relatives. Both are having herbaceous habit, with small flowers without sepals and petals. The flowers arise from the axils of boat shaped scales called glumes. The glumes are arranged in small units called spikelets. Each such spikelet may have a single flower as in rice, two in sugarcane or numerous as in many other grasses. However table 8.11 below shows the dissimilarities between sedges and grasses.

Table 8.11: Sedges vs. grasses

Sl no.	Character	Sedges	Grasses
1	Habitat	Relatively more primitive than the grasses and are mostly associated with wet places.	Occur in most habitats.
2	Stem	Triangular and solid stems.	Rounded and often hollow outline.
3	Leaves	Three rows of leaves	Only two rows.
4	Flower	Subtended by a single bract (glume).	Single concave glume or lemma is closed by another boat shaped scale called palea. The grass flower therefore is concealed within these two scales.
5	Fruit	An achene or a nut having a dry wall and seed remaining free from fruit wall.	Caryopsis type fruit with thin fruit wall, commonly known as bran, is fused with the seed itself.
6	Embryo	Embedded in the endosperm.	Attached outside endosperm.

Vegetative and floral morphology of grasses - The vegetative parts:

Habit: Grasses vary very much in their habit. Some grasses grow erect forming tufts and others form cushions with their branches creeping along the ground. Some grasses are annual while others are perennial. It is often difficult to determine whether a certain grass is annual or perennial. But by examining the shoot system this can be ascertained easily. In an annual all the stems and branches usually end in inflorescences and they will be of the same year. If, on the other hand, both young leafy branches and old branches ending

in inflorescence are found mixed, it is a perennial grass. The presence of the remains of old leaves, underground stolons and rhizomes are also signs of perennial grasses.

Roots: Grasses being monocots do not produce tap roots. Their roots are tufts of fibrous structures from base of stems or from nodes of creeping stem. Grasses also might produce from nodes of horizontal branches aerial roots. Stilt like aerial roots from basal nodes of stout, tall stems are characteristic of *Andropogon, Sorghum* (Jowar)*, Zea* (maize)*, Saccharum* (sugarcane) etc. The root systems of the most grasses are superficial on the soil and so are best adapted for absorbing water and nutrients from top soils.

Stem: In annual grasses stems in most cases are erect or even if they are not entirely so they become erect at the time of flowering. But in perennials in addition to erect branches, creeping branches, stolons, and rhizomes may occur. The internodes in most cases are usually hollow. The younger parts of stems especially are protected sheathing base of leaves. Nodes may be pale or colored, glabrous, hairy or bearded with long hairs.

Leaf: Leaves are in two rows alternating left and right on the nodes of the stem. Leaves may be crowded towards stem base forming tufts, in many perennial grasses. The leaves are reduced to non-green scaly structures in the lower nodes in some of the grasses. The normal foliage leaves of grasses consist of two parts, the flat expanded portion called the blade and the lower part called the sheath that encircles the stem above the node. At the junction of sheath and blade is a scaly outgrowth called ligule. The ligule may be reduced to a tuft or fringe of hairs. The function of the ligule is probably to facilitate the shedding of water which may run down the leaf, and thus lessen the danger of rotting of the stem. The veins in the leaf blade can usually be seen running closely parallel from base to tip.

Inflorescence and flower: The flowers of grasses are reduced to just their reproductive parts the stamens (male) and pistil or gynoecium (female reproductive). The ovary of the pistil matures into the fruit containing the seed inside it. The flowers are aggregated together on distinct shoots constituting the inflorescence. Sooner or later all the branches of a grass-plant terminate in inflorescences which usually stand far above the foliage leaves. Inflorescences are of different types but its basic unit is called spikelet. In a spike inflorescence, as in ragi, spikelets are directly attached to the axis without a stalk. Raceme is like a spike but the spikelets are attached by stalks as in wheat. A branched

inflorescence axis as in rice is a panicle. The spectacular, silken and fluffy white sugarcane inflorescence, for instance, is a large panicle.

The spikelet may be considered as a specialized branch consisting of a short axis, the rachilla bearing a series of scaly bracts, the glumes, the lowest pair being empty but the others bearing flowers in their axils (Figure 9.1). The lower two bracts are empty and are called glumes; above the glumes are one or more boat shaped bracts called lemma, arranged alternately towards right and left of the axis. The flower in the axil of lemma is closed by yet another bract like structure called 'palea'.

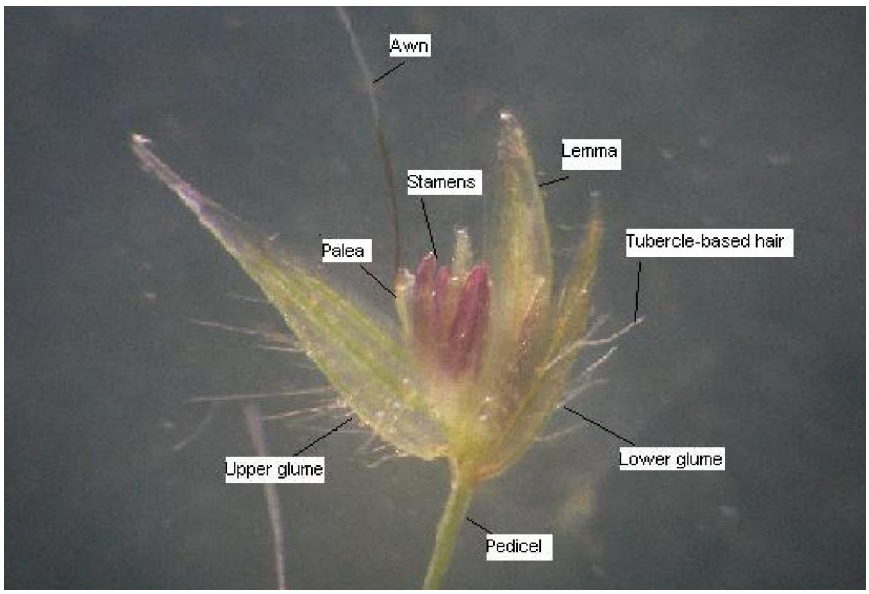

Figure 9.1: Dissected spikelet of *Arundinella metzii* showing different parts.

The grasses are self pollinated or wind pollinated and therefore they have no necessity of producing colorful flowers or nectar to attract butterflies or bees. Probably grasses were once, in their early stages of evolution attractive flowers. Today, most grasses still have two or three tiny 'lodicules' at the base of the ovary, which represent vestigial perianth. The stamens are three in number in majority of grasses and six are in rice*, Hygroryza* and bamboos. In mature flowers the stamens protrude out of the glumes and oscillate in the wind on their delicate stalks called filaments. The anthers produce plenty of pollen which are carried away by wind, the pollinating agency. The pistil consists of a bulged ovary topped with two delicate styles ending in feathery stigmas that are suited for capturing wind borne pollen. Ovary has just one chamber and a single ovule attached to its base.

Fruit: Typical fruit is usually a caryopsis, a dry one, where the seed cover is fused with the thin fruit wall constituting what is known as bran. The fruit covered by the husk which consists of two scaly and concave glumes, which were the original protective cover of the flower. Fruit is sometimes a nut, if the hard fruit wall is free from seed coat; fruit is a utricle if the fruit wall is membrane like and free from seed coat; in rare cases fruit may be a tiny, fleshy berry. The seed is with starchy endosperm and small embryo at base of it.

Pollination: Grasses in general are wind pollinated, though in few cases like rice self pollination occurs. Jowar has a combination of self and cross pollination. The terminal position of the inflorescence, its protrusion far above the level of the foliage leaves, the swinging and dangling anthers, the abundance of non-sticking pollen and the plumose stigmas are all intended to facilitate pollination by wind.

General aspects of flowering and fruiting: The beginning of monsoon in early June triggers germination and luxuriant growth of grasses and the Tiger Reserve in many places turn into green carpet of rolling grasslands. For most annual grasses of the Reserve flowering and fruiting start from late August, with some decline in the intensity of South West Monsoon. Flowering and fruiting are profuse from September and go on almost to January. Some of the perennials and wetland species in favorable moisture conditions, flowering and fruiting occur almost throughout the year.

Grassland communities: Although grasses are dominant, the grassland community includes also large number of other herbs from dicot and monocot families. The fodder quality of these herb communities also count in judging the forage importance of the grasslands. In many overgrazed pastures weedy and unpalatable herbs such as members of Asteraceae viz. *Chromolaena, Ageratum, Parthenium* etc., multiply at the expense of the original palatable herbs such as sedges, *Justicia*, *Rungia, Phyllanthus, Desmodium, Alysicarpus, Crotolaria* etc. This brings down the overall quality of the grasslands to support herbivores. Hence grasslands need to be managed to their best combinations of species diversity and biomass, in the interest of wildlife promotion, through periodic surveys and management interventions. Details regarding the other herbs noticed in the transect studies in the grasslands of ADTR are given in the Appendix 2 and 3 respectively.

Appendix II:

ILLUSTRATED MANUAL OF THE GRASSES OF ANSHI-DANDELI TIGER RESERVE

The grass family, Poaeae is one of the largest families of flowering plants in the number of genera, species, sub-species and varieties. Although many grasses, for example the ones that supply us with our staple food – the cereals and millets- such as rice, wheat, maize, jowar, ragi etc. and some others like sugarcane, lemon grass etc. are easier to identify bulk of the others requires specialised knowledge of taxonomy, grass taxonomy in particular. On very subtle floral features, with the help of good microscopes only, we can distinguish between many closely related grasses. Grasslands are of paramount importance in the management of any tiger reserve, because bulk of tiger's prey animals feed on grasses. There are grasses which are very palatable and of high nutritional value; and there also ones which are sparingly eaten or never eaten by these animals.

Within the ADTR there are several grasslands and microhabitats such as rocky crevices, roadsides, stream and rive banks, marshes etc where specialized grasses grow. There are common grasses universally present in vast areas. We have described in this manual most of the grasses of the ADTR to the species level. Since it is not an exhaustive taxonomic work on the grasses of ADTR we have not furnished here any keys for identification. A simple taxonomic description of grasses is given here and the scientific words are explained in the glossary of terms. Hand-drawn sketches or photographs are given for easy identification in the field of most of the grasses described here, at least to the generic level.

Aristida setacea Retz. (Figure 9.2)

A coarse perennial grass. Culms stout, erect from woody root stock, up to 120 cm high; nodes without hairs; ligule a fringe of hairs. Flowering panicle very narrow, 8-38 cm long; Spikelets 12-17 mm long. Glumes linear –lanceolate, 1-nerved, awned, up to 20 mm long; lemma 3-nerved, awned, 3-partite.

Occurrence: Common along road sides and road cuttings, hill slopes, waste lands, rocky places.

Figure 9.2: ***Aristidia setacea.*** **A. Habit with inflorescence; B. Spikelet; C. Lower glume**

Arthraxon lancifolius (Trin.) Hochst. (Figure 9.3) (*Andropogon lancifolius* Trin.)

Annual; culms very slender, trailing, short hairy below flowering branch. Leaves linear to lance shaped or ovate, 1-4 x 0.3-1 cm hairy, margins with short hairs which are bulged at base. Sheaths glabrous. Inflorescence of 2-6 branches, unequal, 0.7-2.5 cm long spikes; joints and pedicels with long hairs or cilia. Spikelets generally stalkless, 2.5-5 mm long, linear-lanceolate, laterally compressed. Lower glume or lemma with two narrow points towards tip and rounded at back; it has no central nerve (keel) and is feebly nerved. Upper glume equals the lower and ends in a narrow point up to 2.5 mm long. It has a bristle or awn, up to 10 mm long from near the base; Stamens 2; Some spikelets may be pedicelled.

Occurrence: Common along hill slopes, raised bunds, rocky places, and on compound walls, and fences; in moist situation

Figure 9.3: ***Arthraxon lancifolius*** **A. Habit with inflorescence; B. Spikelet; C. Upper glume**

Arundinella leptochloa(Nees ex Steud.) Hook. (Figure 9.4)

(*Panicum leptochloa* Nees ex Steud; *Arundinella gigantia* Dalz.; *A.lawsonii* Hook.)

Tall perennial; culms up to 2 m, not hairy; root stock hairy.; nodes not hairy. Leaves up to 60 x 3.5 cm, linear-lanceolate, rounded or heart-shaped (cordate) at base. Leaf sheaths striate, poorly hairy with tubercle based hairs; ligule a very narrow membrane. Panicle variable in size, up to 45 x 20 cm. Spikelets 2.5-3.5 mm long, Lower glume 2 mm long, ovate-acute, glabrous except on scabrid nerves. Upper glume not bearded. Lower glume with male of bisexual flower in the axil, broadly elliptic acute, 5-nerved. Upper lemma 1 mm long, bisexual, without awn.)

Occurrence: Rice field bunds, hill slopes, road cuttings, waste lands etc.; usually in shady places. Note: Very similar to *A.metzii* but can be differentiated by its robust and taller growth, purplish flowering branches unawned.

Figure 9.4: ***Arundinella leptochloa*- inflorescence**

Arundinella nepalensis Trin. (Figure 9.5), (*A.brasiliensis* Raddi, *A.hispida* Blatt.)

Perennials along stream courses, 1-1.5 m tall; culms stout with hard root stock. Leaves 10-25 x 0.4-1.0 cm, linear lanceolate, hairy. Panicles pyramidal, 10-16 cm long. Spikelets 0.4-0.5 cm long, ovate-laceolate, glabrous; lower glumes to 0.3 cm long, ovate. Upper glume to 0.5 cm long, ovate-lanceolate; lower lemma obtuse, bifid at apex.

Note: Grows in large population near streams and moist grasslands confused with *A.leptochloa* but can be distinguished by the large reed-like softly hairy culms below the inflorescence, distinctly awned spikelets.

Figure 9.5: ***Arundinella nepalensis.*** **A. Habit with inflorescence; B. Spikelet; C. Lower glume**

Arundinella metzii Hochst. (Figure 9.6), (*A.pygmaea* Hook; *A.lawii* Hook)

Annual; culms erect, 30-60 cm high, tufted, rounded with striations. Leaves 40 x 0.9 cm, linear, base rounded, softly hairy on both surfaces with tubercle-based hairs, densely ciliate on one margin. Floral panicle up to 50 x 25 cm. Spikelets in pairs, one short and one long pedicelled, 3-4.5 mm long. Lower glume 2-2.5 mm long, lanceolate or elliptic, 3-nerved, Upper glume 2.75 -4.25 mm long, elliptic, narrowing and ending in an abrupt tip. Lower lemma with male and upper lemma with bisexual flowers, 1 mm long, with 3 mm long awn.	
Occurrence: Common in open grassland, cultivated fields, and other moist places.	

Figure 9.6: Inflorescence of *Arundinella metzii*

Brachiaria miliiformis (J.S. ex C.B.Presl) A.Chase (Figure 9.7)

(*Panicum miliiforme* J.S. ex C.B.Presl)

Annual to perennial grasses. Culms slender, erect or creeping and rooting at lower nodes, 30-75 cm high. Leaves up to 17 x 1 cm, lanceolate, base cordate; sheaths glabrous, margin ciliate; ligule a fringe of hairs. Panicle consists of 4-6, horizontally spreading racemes up to 6.5 cm long; rachis flattened. Spikelets crowded, arranged on one side of axis, 3.25-3.75 mm long, oblong-ovate, tapering rather abruptly to a short point. Lower glume with margins overlapping at base, 5-7 nerved.	
Occurrence: Common along roadsides, waste lands, bunds of paddy field, banks of rivers, usually in shade.	

Figure 9.7: *Brachiaria miliiformis.* A. Habit with inflorescence; B. Spikelet

Centotheca lappacea(L.) Desvaux (Figure 9.8)

(*Cenchrus lappaceus L.; Holcus latifolius* Osbeck; *Centotheca latifolia* (Osbeck)Trin.)

Culms stout erect, 30-100 cm high. Leaves 5-25 x 1-3.5 cm, oblong-lanceolate, acute or acuminate, glabrous or sparsely hairy, many nerved, base narrowed with asymmetrical sides; ligule a lacerate membrane. Panicle up to 30 cm long. Spikelets 4-6 mm long, green, oblong-lanceolate. Glumes distant; lower 2.5-3 mm long, ovate, 3-nerved; Lemmas 7-nerved, lower lemma 4-5 mm long.	
Seen in margins of forests, or in shades of trees and bushes.	

Figure 9.8: ***Centotheca lappacea.*** **A. Habit with inflorescence (partly shown); B. Spikelet**

Chloris barbata Sw.
A perennial grass. Culms tufted, up to 90 cm high; nodes glabrous. Leaves 5-30 x 0.2-0.5 cm, flat, linear acuminate, sheaths compressed, junction of sheath and blade hairy. Inflorescence spike type 4-20 in number, each up to 10 cm long. Spikelets green or purplish, each 2.5 mm long; 3-awned; the spikelet axis bearded at base. Glumes translucent, the lower shorter than the upper. Fertile lemma 2-2.5 mm long, obovate concave, back sparsely hairy, margins densely ciliate above the middle, its awn up to 4 mm long. Empty lemmas 2; lower obovate, awned, ciliate above the middle; upper subglobose, awned, glabrous.
Occurrence: Very common along roadsides and in disturbed areas; in wetlands; a weed in cultivated fields

Coelachne simpliciuscula (Wight and Arn. ex Steud.) Munro ex Bth (Figure 9.9)

(*Panicum simpliciusculum* Wight and Arn. ex Steud.; *Ceolachne pulchella* sensu Hook.)

Annuals or perennials, 15-20 cm long, delicate, erect or prostrate with upper parts rising vertical. Leaves 1.0-3.0 x 0.1-0.3 cm, linear-lanceolate, somewhat rough, apex acute. Inflorescence, 2-5 cm long, of short spikes in panicles arranged on the axis with gaps in between. Individual spikelets ovoid, 0.15-0.2 cm long; upper glume suborbicular; lower lemma longer than glumes.

Occurrence: Fairly common in marshes and paddy fields, ditches and other wetlands.

Figure 9.9: ***Coelachne simpliciuscula***

Coix lacryma-jobi L. (Figure 9.10)

Annual herbs, up to 1.5 m high, erect rooting at lower nodes. Leaves 15-40 x 0.8-1.6 cm, linear-lanceolate. Racemes 1-many with flat axis. Male and female spikelets relatively large; the latter in singles, 1 cm long; male 1.2 cm long. Grains flat, reddish-brown.

Occurrence: Found growing near wet places and in standing waters. The hardened involucres surrounding female spikelets called, "job's tears", used for ornaments

Figure 9.10: ***Coix lacryma-jobi***

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Cynodon dactylon (L.) Pers. (Figure 9.11)

(*Panicum dactylon* L.)

Weak, creeping perennials, rooting at nodes, with branches rising 5-40 cm into the air; Inflorescence of spikes 1.5-5.5 cm long. Spikelets *c* 0.2 cm long, stalkless; lemmas silken hairy on keels.	
Occurrence: Common grass; *Garike* in Kannada.	

Figure 9.11: ***Cynodon dactylon***

Cymbopogon caesius (Nees ex Hook. & Arn) Stapf (Figure 9.12)

(*Andropogon caesius* Nees ex Hook; *A.schoenanthus var caesius* (Nees ex Hook. & Arn.); *A. schoenanthus var. gracillimus* Hook)

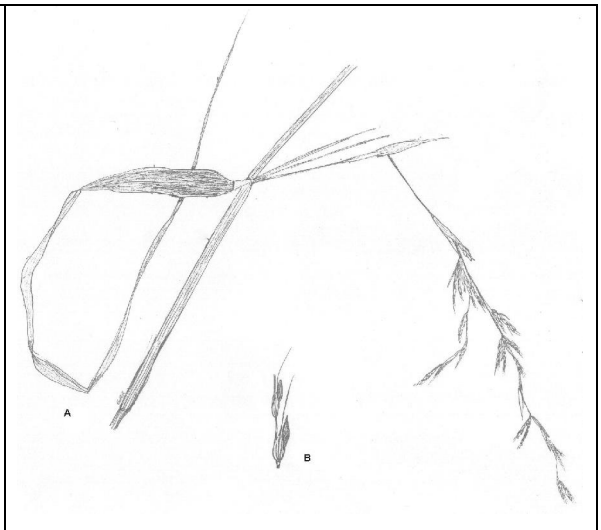
Perennials. Culms 50-200 cm high. Nodes glabrous. Leaves linear-lanceolate, 10-30 x 0.3-0.8 cm acuminate. Ligules ovate, acute, membranous, 3-5 cm long; Panicles narrow, contracted, 15-40 cm long; joints densely villous. Sessile spikelets linear-oblong, 3-4 x 0.75 mm, callus hairy; keels of lower and upper glumes narrowly winged in the upper half. Palea absent. Pedicelled spikelets elliptic, 3-4 x 1 mm, glabrous; pedicels 1-2 mm long, densely long villous. Stamens 3.	
Occurrence: Seen in hill slopes and fringes of forests.	

Figure 9.12: ***Cymbopogon caesius.*** **A. Habit with inflorescence (partly shown); B. Spikelet**

Cyrtococcum muricatum (Retz.)Bor (Figure 9.13) (*Panicum muricatum* Retz.)

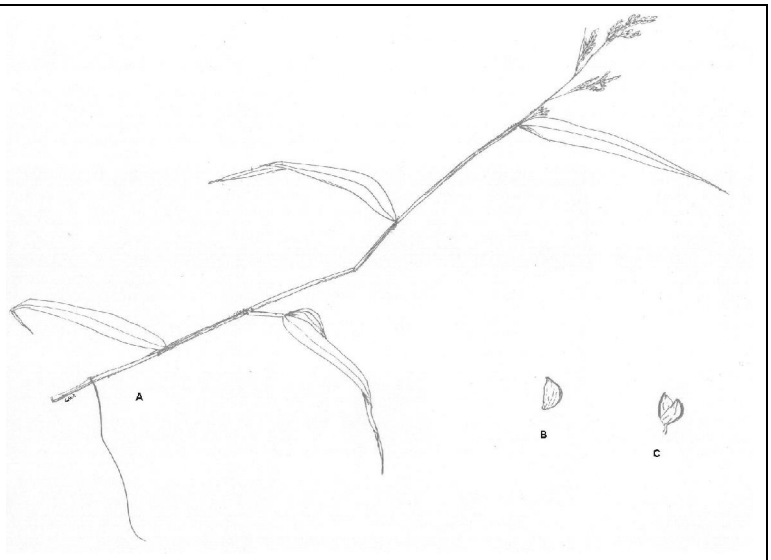
Annuals. Culms 10-75 cm long, creeping or trailing, rooting at lower nodes, rarely upper parts rising; nodes glabrous. Leaves ovate-lanceolate, elliptic or elliptic-lanceolate, 1-10 x 0.4-1.8 cm, acuminate, softly hairy from minute tubercled bases, base conical and fringed with hairs; sheaths also fringed with hairs. Panicles 5-20 cm long lax. Spikelets obovate, 1.5-2 mm, brown or purplish. Lower glume ovate; upper glume boat shaped or ovate-oblong, 3-nerved, softly hairy with a few brown wart like outgrowths. Stamens 3, pale yellow.

Occurrence: Frequent along shaded margins of forests

Figure 9.13: ***Cyrtococcum muricatum***

Cyrtococcum oxyphyllum (Steud.) Stapf. (Figure 9.14)

Perennials, ascending; culms slender, 30-60 cm long, rooting below. Panicles 4-6 cm long, branches slender. Spikelets *c* 0.15 cm long; lower glume elliptic-oblong, brown; upper glume elliptic.



Occurrence: Frequent in forest edges and openings.

Figure 9.14: ***Cyrtococcum oxyphyllum.*** **A. Habit with inflorescence; B. Upper lemma; C. Spikelet**

Cyrtococcum patens (L.) A. Camus (*Panicum patens* L.)

Perennials, trailing; culms reclining with upper parts rising, branching, interlaced below, branches erect. Leaves 2.5 -5.0 cm long, linear-lanceolate. Panicles 2.5-4.0 cm long, contracted. Spikelets *c* 0.15 cm long, elliptic shortly pedicelled, glumes and lemmas dissimilar; lower glume half the length of lemmas, 3-nerved, pale-brown, so also upper one; lower lemma 5-nerved, pale brown, upper naked or bearded at tip.
Occurrence: Along forest margins, scrub jungles and moist shady places.

Dactyloctenium aegyptium . Willd. (*Cynosurus aegyptius* (L.) Desf.

Tufted annuals, erect, suberect or geniculately rising, 15-45 cm high. Leaves 2.5 -12.0 x 0.1 -0.5 cm, linear. Spikes 2-6, bearded at base, digitately radiating, 1-4.5 cm long. Spikelets 3- 0.4 cm long.
Occurrence: Common in open areas, field bunds.

Digitaria bicornis (Lamk.) Roem. & Schult ex Loud
(*Paspalum bicorne* Lamk. *Digitaria biformis* Willd.)

Annual with culms up to 80 cm high, ascending from a geniculate or prostrate branched base; nodes glabrous. Leaves 5-15 x 0.4-0.9 cm, linear-lanceolate, glabrous, or sparsely hairy; sheaths glabrous or pilose; ligule a short membrane. Racemes 2-8, from the tip of a short common axis, each up to 15 cm long; raceme axis (rachis?) flat, margins winged. Spikelets in dissimilar pairs, one stalked and the other stalkless. Former glabrous to slightly hairy, the stalked one softly hairy may or may not be pectinate (where?), 2.5 -3.5 mm long, oblong. Lower glume a minute scale. Upper glume fringed with hairs. Lower lemma 5-7 nerved, densely bearded with soft spreading hairs.
Occurrence: Very common in open places, as weeds in arecanut gardens.

Dimeria hohenackeri Hochst. ex miq. (Figures 9.15-9.16)

A slender annual grass to 60 cm high; nodes bearded. Leaves short, forming a rosette at base, 3-6 x 0.2-0.4 cm, linear-acute, covered with bulbous based hairs, margins hairy; sheaths glabrous in the lower half but pilose in upper half, keeled margins translucent. Racemes 2-9, sub-digitately arranged, up to 12 cm long. Spikelets 3-3.5 mm long, very narrow, compressed, with a short bearded callus. Upper glume not winged, margins translucent, with stiff hairs at apex. Lower lemma margins ciliate at apex. Upper lemma forked at apex and awned from the sinus.

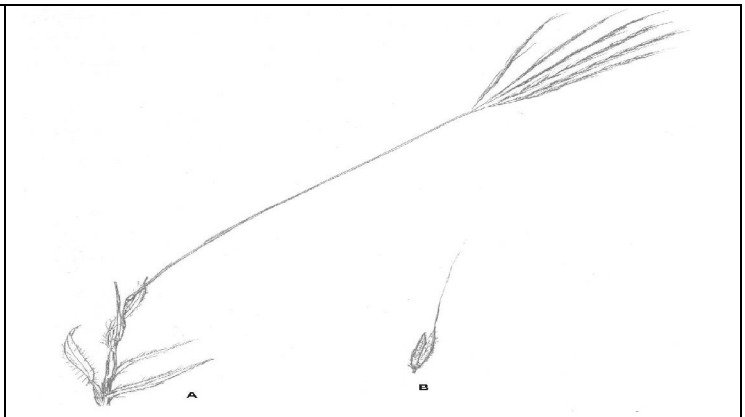


Figure 9.15: ***Dimeria hohenackeri.*** **A. Habit with inflorescence; B. Spikelet**

Figure 9.16: Inflorescence of ***Dimeria hohenackeri***

Occurrence: Common grass in open areas.

Dimeria ornithopoda Trin. (Figure 9.17) (*Dimeria tenera* Trin.)

An annual grass, up to 40 cm high, slender; nodes bearded. Leaves 2-7 x 0.1-0.2 cm, linear-acuminate, covered with bulbous based hairs, especially in midrib and margins, midrib prominent. Racemes 2, rarely 3; erect or spreading rachis triangular in section. Spikelets linear, compressed; callus bearded. Upper glume not keeled, softly hairy, sometimes with stiff hairs towards apex. Upper lemma awned from sinus; awn 4-10 mm long.

Occurrence: Very common in wet places, uncultivated paddy fields etc.

Figure 9.17: ***Dimeria ornithopoda.*** **A. Habit with inflorescence; B. Spikelet**

Echinochloa colona (L.) Link (Figure 9.18) (*Panicum colonum* L.)

Slender annual grass, prostrate to shortly creeping with branches rising to 60 cm. Leaves 5-20 x 0.3 -1 cm, linear-lanceolate; ligule absent. Racemes 8-20, simple, up to 3 cm long; rachis angular. Spikelets ovoid, 2.5-3 mm long with rough hairs. Upper glume as long as lower, ending in sharp point, concave, 5-7-nerved, with rough hairs. Lower lemma broadly ovate or sub-orbicular, 3-nerved.	
Occurrence: A common weed of paddy fields, and in wet places.	

Figure 9.18: *Echinochloa colona* A. Habit with inflorescence; B. Spikelet; C. Upper glume

Echinochloa crusgalli (L.) P.Beauv.
Panicum crusgalli L.

An annual grass. Culms tufted, up to 1 m high, nodes glabrous. Leaves 10-50 x 0.6-1.2 cm, linear-lanceolate, acuminate, glabrous; sheaths keeled; ligule absent. Panicle up to 20 cm long; contracted and pyramidal; racemes many. Spikelets 3-4 mm long, subglobose or ovoid, hairy with tubercled based hairs. Upper glume cuspidate or shortly awned, hispidulous. Lower lemma short- or long awned.
Occurrence: In wet and marshy areas.

Eleusine indica (L.) Gaertn.
(*Cynosurus indicus* L.)

Culms tufted, 15-75 cm high, erect, slightly compressed. Leaves 8-50 x 0.2-0.6 cm, flat or folded, linear, acuminate, sparsely hairy. Spikes 2-9, up to 14 cm long 5 mm wide. Spikelets 2-5 mm long, 3-6-flowered, closely overlapping in two rows, pointing upwards at an acute angle with the rachis. Upper glume longer than the lower.
Occurrence: Very common in damp places.

Elytrophorus spicatus (Willd.) A. Camus (Figure 9.19)
(*Dactylis spicata* Willd.; *Elytrophorus articulatus* P.Beauv.)

Annual herbs, 12-35 cm tall; Leaves 5-17 x 0.15-0.5 cm, linear, acute, smooth. Inflorescence 1.5-3.0 cm long, interrupted spikate. Spikelets 0.5 cm long, ovoid.
Occurrence: In paddy fields and other wet places.

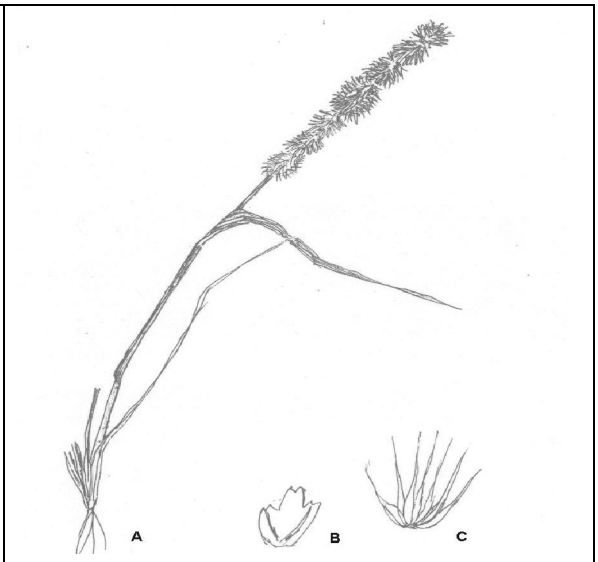


Figure 9.19: ***Elytrophorus spicatus.*** **A. Habit with inflorescence; B. Palea; C. Spike with awned glumes.**

Eragrostis unioloides (Retz.) Nees ex Steud. (Figure 9.20)
(*Poa unioloides* Retz.; *Eragrostis amabilis* Stapf)

Tufted annual herbs to 25 cm high; culms erect or geniculately ascending. Leaves 3-7 x 0.2-0.4 cm, linear or linear-lanceolate; ligules absent or obscure. Panicles 4-8 cm long. Spikelets 0.2-0.7 cm long, straw colored, tinged with purple.

Occurrence: Common in wet places, dry or open

Figure 9.20: ***Eragrostis unioloides***

Eulalia trispicata (Retz.) Nees ex Steud. (Figure 9.21)
(*Poa unioloides* Retz; *Eragrostis amabilis* Stapf)

Stout, tufted perennials, 60-150 cm tall, erect or geniculate. Leaves 10-25 cm long, linear, soft textured; sheaths bearded at sides; ligules short, membranous, fringed with long hairs. Racemes 6-12, 4-6 cm long. Spikelets 0.3-0.4 cm long, elliptic-oblong, densely clothed with white hairs. Upper lemma hardly wider than its awn, bifid into 2 subulate lobes; awn up to 20 mm long.

Occurrence: In open grasslands, with some disturbances like repeated fire, digging etc., and in wastelands.

Figure 9.21: Inflorescence tip of *Eulalia trispicata* grass

Heteropogon contortus (L.) P. Beauv. Ex R. & S. (Figure 9.22)
(*Andropogon contortus* L.)

Densely tufted, perennials; culms 10-90 cm tall, creeping below. Leaves 5-14 x 0.2-0.3 cm, linear, acuminate, flat; sheaths compressed. Racemes 3-7.5 cm long. Spikelets closely overlapping. Sessile female spikelets 0.4-0.6 cm long, callus bearded with reddish brown hairs; upper lemma reduced to an awn up to 7.5 cm long or more, awns often twisted about each other. Pedicelled male spikelet *c* 0.8 cm long.

Occurrence: Common on open hill slopes and in waste lands.

Figure 9.22: *Heteropogon contortus*

Hygroryza aristata (Retz.) Nees ex Wight & Arn (Figure 9.23)
(*Pharus aristatus* Retz.)

A floating aquatic grass. Floating culms up to 30 cm long; branches short, erect and leafy. Leaves 2-8 x 0.5-1.8 cm, ovate to ovate-oblong, obtuse, subcordate; sheaths glabrous, inflated, compressed, margin hairy. Panicle up to 5 cm long and broad; branches slender, smooth. Spikelets few, sessile or pedicelled. Lemma 6-8 mm long, narrowly lanceolate; awn up to 14 mm long.	
Occurrence: Common in ponds and slow moving streams forming dense floating masses.	

Figure 9.23: *Hygroryza aristata*-Habit

Isachne globosa (Thunb.) Kuntze (Figure 9.24)
Milium globosum Thunb

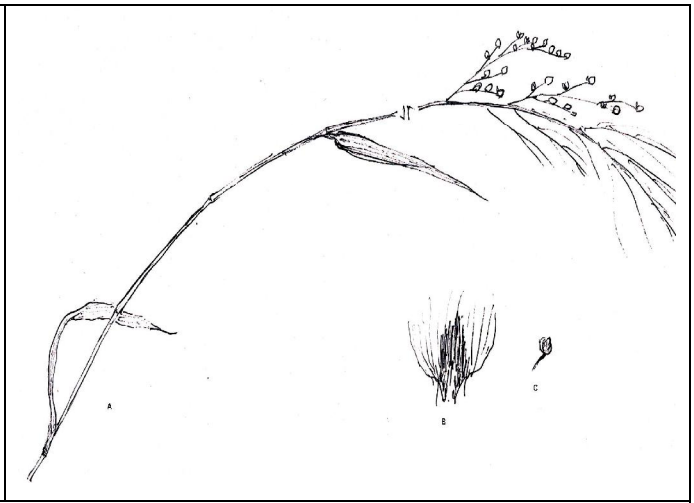
A slender grass to 45 cm high, erect or ascending from a creeping base; nodes glabrous. Leaves narrowly lanceolate, 2-10 x 0.4-0.8 cm acuminate, base rounded; ligule a fringe of long hairs. Panicle up to 12 cm long, lax. Spikelets 2-2.5 mm long, subglobose. Glumes subequal, equal to or slightly shorter than lemmas, broadly ovate or suborbicular. Lemmas unequal.	
Occurrence: Very common in marshes; a weed in paddy fields.	

Figure 9.24: Isachne globosa. A. Habit with inflorescence B. Leaf with ligule. C. Spikelet.

Isachne miliacea Roth
A slender grass to 30 cm high, ascending from a creeping and branched base; nodes glabrous or ciliate. Leaves 2.5-5 x 0.3-0.8 cm, ovate-lanceolate to lanceolate, base rounded; ligule a fringe of hairs. Panicle lax. Spikelets 1.4-1.8 mm long, globose. Glumes subequal, as long as or slightly shorter than lemmas, suborbicular. Lower lemma longer than the upper.
Occurrence: Common in marshes; a weed in paddy fields.

Ischaemum thomsonianum Stapf
Perennial herbs, to 1 m high. Leaves lanceolate, 7-15 x 0.9-1.3 cm, lower leaves sessile. Racemes to 5 cm long. Sessile in pairs, one stalked and other stalkless. Lower glume *c* 0.4 cm long, awned; upper glume oblong, keeled and rounded above, with tufts of hairs in middle. Pedicelled spikelets oblong-lanceolate, 5-6 mm long, awned.
Occurrence: Rare along bunds of paddy fields, wet waste lands and banks of rivers.

Ischaemum dalzellii Stapf ex Bor (Figure 9.25)

Annuals or perennials. Culms 3-60 cm or more long, creeping or trailing, rarely erect; nodes glabrous or sparsely bearded. Leaves lanceolate or linear lanceolate, 4-15 x 0.8-1.5 cm, long acuminate, deeply cordate or hastate at base, lower ones distinctly petiolate. Racemes 2, slender, 3-6 cm long; joints linear-clavate, 3-4 mm long, densely ciliate along margins. Sessile spikelets linear-oblong 5-6 x 1mm, densely villous in the upper half of the spikelet and glabrous on the lower; awned; callus densely bearded. Pedicelled spikelets oblong-lanceolate, *c* 6 mm long, awned or awnless.	
Occurrence: Along rocky hill slopes, shades and near wetlands.	

Figure 9.25: Inflorescence of *Ischaemum dalzellii*; note lower glabrous and upper hairy Spikelets

Ischaemum indicum (Houtt.) Merrill (Figure 9.26)
Phleum indicum Houtt
Ischaemum ciliare Retz
I.aristatum auct. Non L.

A perennial grass. Culms up to 70 cm high, slender, erect or often creeping at base. Leaves up to 15 x 1.2 cm, linear-lanceolate, sparsely to densely hairy. Sheaths compressed. Racemes 2, rarely 3, up to 8 cm long. Sessile spikelets ovate-oblong, green, reddish or splashed with violet, up to 6 mm long; callus bearded. Lower glume papyraceous towards top, apex 2-toothed or cuspidate, margins inflexed, auricled at base, sides broadly winged at apex, wings often auriculate. Upper lemma bifid with a geniculate awn from sinus; awn up to 12 mm long. Pedicelled spikelets rather smaller than sessile. Upper lemma awned.

Occurrence: Common grass found in more drier situation such as waste lands, roadsides, common lands, grasslands etc.

Figure 9.26: ***Ischaemum indicum grass***

Ischaemum semisagittatum Roxb. (Figure 9.27, 9.28)

Ischaemum conjugatum Roxb.

An annual grass. Culms slender, often decumbent at base, than ascending up to 50 cm high or more. Leaves 2.2-9.5 x 0.5-2.0 cm, oblong-lanceolate, base deeply cordate to acutely sagittate. Lower leaves long petioled. Racemes 2, very rarely 1. Sessile spikelets 4-8 mm long. Lower glume ovate or oblong, lower half cartilaginous, with 3-6 marginal nodules, usually connected by irregular and shallow transverse ridges, the upper half with green veins with ciliolate margins, tip usually bifid. Upper lemma 2-fid with a geniculate awn from the sinus, sometimes awnless. Pedicelled spikelet shorter than sessile and almost awnless.

Figure 9.27: ***Ischaemum semisagittatum***

Occurrence: Forest openings, edges and other shady places.

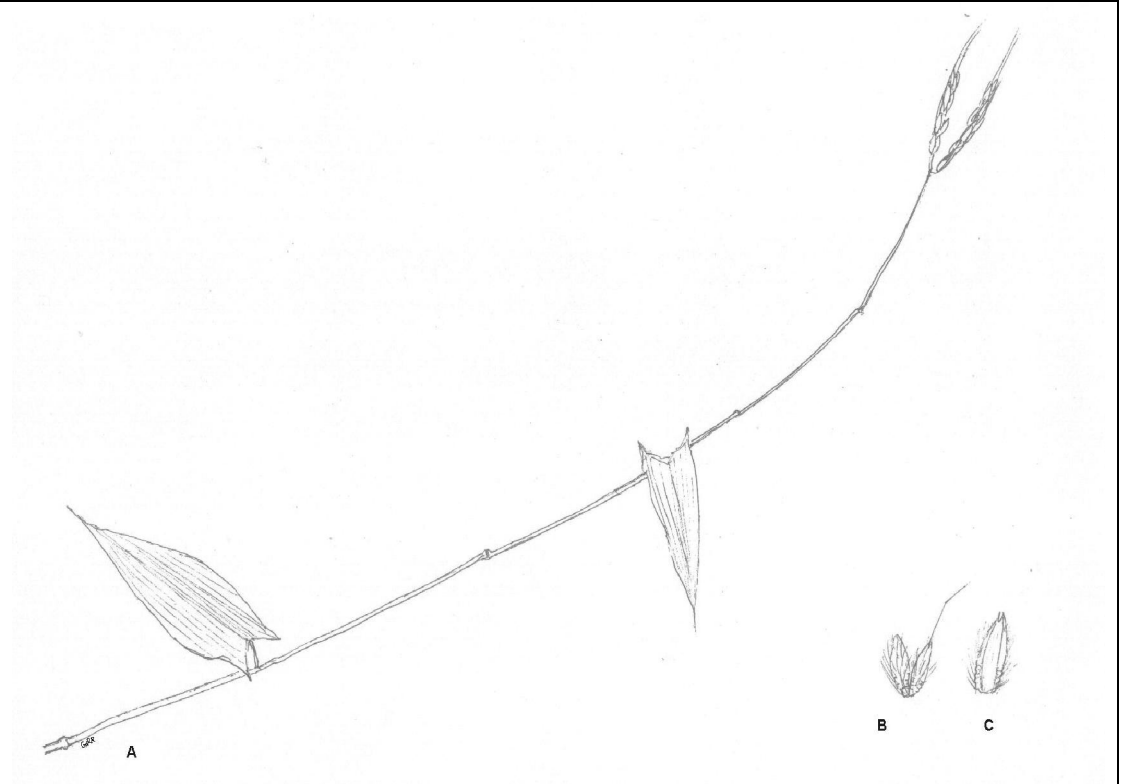


Figure 9.28: ***Ischaemum semisagittatum.*** **A. Habit with inflorescence; B. Pedicelled and sessile spikelet; C. Lower glume of sessile spikelet.**

Jansenella griffithiana (C.Muell.) Bor (Figure 9.29, 9.30)
Danthonia griffithiana C.
Arundinella avenacea Munro ex Thw.

Herbs, slender, erect, 15 cm high, rooting at lower nodes. Leaves 2.5-4.5 x 0.4-0.5 cm, ovate-lanceolate; ligules linear. Inflorescence a compact panicle of crowded spikelets. Spikelets subsessile, 4-6 mm long. Upper lemma with 4-5.5 mm long, oblong, with 2 lateral tufts of white hairs above the middle; median awn up to 9 mm long.

Figure 9.29: ***Jansenella griffithiana***

Occurrence: This grass is common in grassy hill slopes, marshy areas and along small irrigation canals.

Figure 9.30: ***Jansenella griffithiana.*** **A. Habit with inflorescence; B. Spikelet; C. upper lemma**

Leersia hexandra Swartz. (Figure 9.31)

Homacenchrus hexandrus (Swartz) O.Kuntze

A slender, perennial grasses. Culms up to 1.2 m high, geniculate and ascending, rooting at lower nodes; nodes hairy with deflexed hairs. Leaves 7-20 x 0.2-1 cm, linear; ligule a short obliquely truncate or two lobed membrane. Panicle up to 13 cm long. Spikelets *ca*. 4 mm long. Lemma strongly keeled, keel ciliate.

Occurrence: Common in ponds, swamps and in paddy fields.

Figure 9.31: ***Leersia hexandra***. **A. Habit B. with inflorescence C. Spikelet**

Lepturus radicans (Steud.) A. Camus (Figure 9.32)
Ophiurus radicans Steud.

A perennial, slender grass. Culms branched and widely creeping below; branches ascending; nodes glabrous. Leaves flat, linear-lanceolate, acuminate, glabrous, 12 x 0.4 cm. Spike 3-5 cm long, 1-flowered. Lower glume absent.

Grasses common as undergrowth in moist to dry deciduous forests.

Figure 9.32: ***Leptuca radicans***

Oplismenus burmannii (Retz.) P.Beauv.
Panicum burmannii Retz.

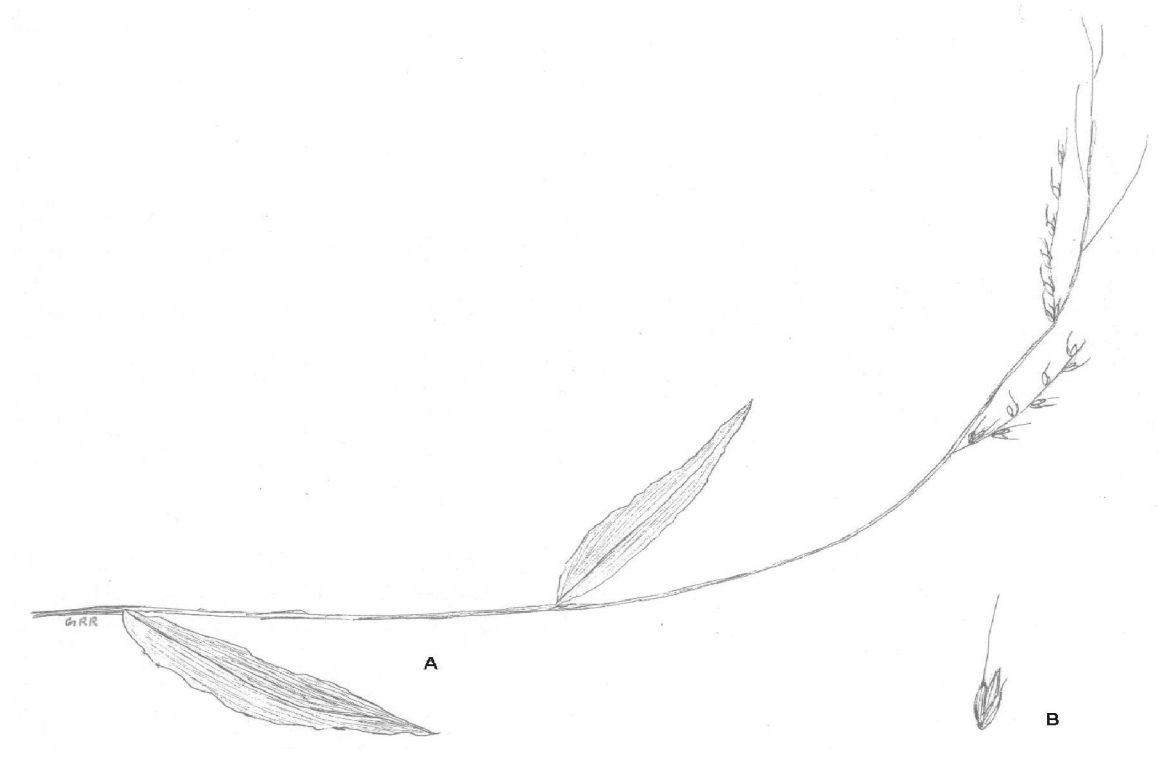
A slender annual grass. Culms slender, creeping and rooting below. Panicle up to 10 cm long; peduncle very long, up to 1.8 cm long. Spikelets up to 2.5 mm long, second. Lower glume ovate, awned, barbellate. Upper glume awned. Lower lemma shortly awned, ciliate.

Occurrence: Common undergrowth in semievergreen to deciduous forests, and other open areas.

Oplismenus compositus (L.) P.Beauv. (Figure 9.33)

Panicum compositum L.

A perennial grass. Culms rather robust, creeping and rooting below; branches ascending. Leaves 2-16 x 0.5-2.5 cm, ovate to ovate-lanceolate, acuminate; sheaths with ciliate margins. Panicles up to 30 cm long, racemes distant, up to 7.5 cm long; rachis angular. Spikelets, lanceolate, awned; awn to 11 mm long, stout and viscid. Upper glume mucronate or shortly awned.



Occurrence: Common in open shady places.

Figure 9.33: ***Oplismenus compositus.*** **A. Habit with inflorescence (partly shown); B. Spikelet**

Oryza rufipogon Griff.

An aquatic grasses. Culms rooting in mud and the floating branches up to 80 cm long. Leaves up to 50 x 1.1 cm, linear-lanceolate, acuminate, striated; ligule long membranous, 2-partite. Panicle compound, up to 25 cm long. Spikelets *ca.* 9 mm long, oblong, long awned. Fertile lemma dorsally spinescently ciliate.

Occurrence: Seen in ponds, paddy fields and other small water bodies.

Panicum auritum Presl. (Figure 9.34)

A perennial, tall, erect grass. Culms up to 1.5 m high. Leaves linear-lanceolate, up to 35 x 3 cm, base broadly cordate; sheaths glabrous or sparsely hairy with bearded mouth. Panicle contracted or more or less open, up to 45 cm long. Spikelets 2-3 mm long, oblong or ovate-oblong, sessile or shortly pedicelled. Lower glume broadly ovate, one third to half the length of lower lemma, 3-nerved.

Occurrence: Found in marshy areas.

Figure 9.34: ***Panicum auritum*** Presl. **A. Habit with inflorescence B. Spikelet**

Panicum repens L. (Figure 9.35)

A perennial grass. Culms creeping and stoloniferous at base, up to 1.3 m high; nodes glabrous, lower nodes rooting. Leaves distichous, glacous, lanceolate, 5-25 x 0.2-0.8 cm, margin finely serrate, glabrous or hairy on upper surface, base rounded and ciliate; sheaths with ciliate margins; ligule a short thin membrane with a very short cilia on free margin. Panicle up to 20 cm long. Spikelets oblong-lanceolate, 2-5-3.3 mm long, glabrous; pedicels long with copular tips. Lower glume suborbicular, hyaline.	
Occurrence: Common in sandy soils, field bunds and tank margins.	

Figure 9.35: Inflorescence of *Panicum repens* grass

Paspalidium flavidum (Retz.)A. Camus *Panicum flavidum* Retz.
Annual with tufted culms, rising from a reclining base, up to 1 m high. Leaves 2.5-20 x 0.2-1 cm, flat, linear-lanceolate, base rounded or slightly cordate with long white hairs on the small basal lobes; sheaths compressed, ligule a fringe of hairs. Racemes few to many, distant, one sided on the axis, shorter than internodes, up to 3 cm long. Spikelets 2.5-3.2 mm long, ovoid or subglobose, obtuse or acute, hardly compressed. Lower glume suborbicular, about half the length of the spikelet.
Occurrence: Common in wet situations.

Paspalum conjugatum Berg
A perennial grass. Culms up to 90 cm high, creeping and branching below. Leaves up to 20 x 1.5 cm, linear-lanceolate, acuminate; sheaths glabrous, margins ciliate. Racemes 2, up to 15 cm long, usually divergent; rachis flat. Spikelets in two rows, subsessile, imbricate, plano-convex, 1.4-2 mm long. Lower glume absent. Upper glume hyaline, fringed with fine white hairs from margins.
Occurrence: Grows in moist and shady situation.

Paspalum canarae (Steud.) Veldkamp (Figure 9.36)
Paspalum compactum Roth.

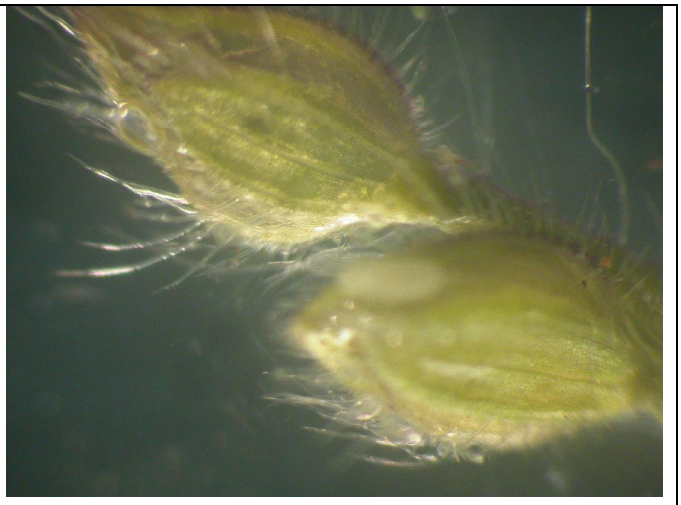
Annual slender grasses. Culms 5-30 cm tall. Decumbent and branched below. Leaves 1.5-7.5 x 0.5-1.6 cm, elliptic-lanceolate, acute, hairy on both sides; sheaths densely covered with bulbous based hairs. Racemes 6-many, alternate, spreading; rachis triquetrous, setose. Spikelets closely arranged up to 1.25 mm long, obtuse. Lower glume absent.	
Occurrence: In open grasslands and in wet situation.	

Figure 9.36: *Paspalum canarae*; setose spikelets.

Paspalum scrobiculatum L. (Figure 9.37)
P.orbiculare Forst.
P.commersonii Lamk.
P.cartilagineum J.S.Presl ex. C.B.Presl.

An annual or a perennial grass. Culms up to 90 cm high, tufted, erect or creeping and rooting below; nodes glabrous. Leaves 10-45 x 0.2-0.8 cm, linear-lanceolate, acuminate, margin serrulate, glabrous; leaf sheaths, compressed, glabrous, keeled. Racemes 2-6, alternating, spreading, 2-15 cm long; rachis, broad, winged, with a median keel. Spikelets in 2-rows, orbicular or ovate-oblong, 1.8-2.8 mm long. Lower glume absent. Upper glume 5-nerved.	
Occurrence: Common in wet and waste places.	

Figure 9.37: *Paspalum scrobiculatum*

Pennisetum hohoenackeri Hochst. ex Steud (Figure 9.38)
P.alopecuros Nees ex Steud

Perennials. Culms 30-150 cm high, erect, densely tufted; nodes glabrous. Leaves narrowly linear, acuminate, 10-60 x 0.2-0.8 cm narrow or rounded at base, convolute, glaucous. Sheaths keeled, distichous. Panicles spiciform, 5-25 cm long, involucre enclosing one sessile spikelet, bristles glabrous or scaberulous, 3-20 cm long. Spikelet elliptic-lanceolate or lanceolate, 6-8 mm long. Lower glume ovate. Upper glume ovate-lanceolate, 5-7 nerved.	
Occasional along the banks of streams and other water-courses, paddy field bunds and on river beds etc.	

Figure 9.38: *Pennisetum hohoenackeri* grass

Pennisetum pedicellatum Trin. (Figure 9.39)

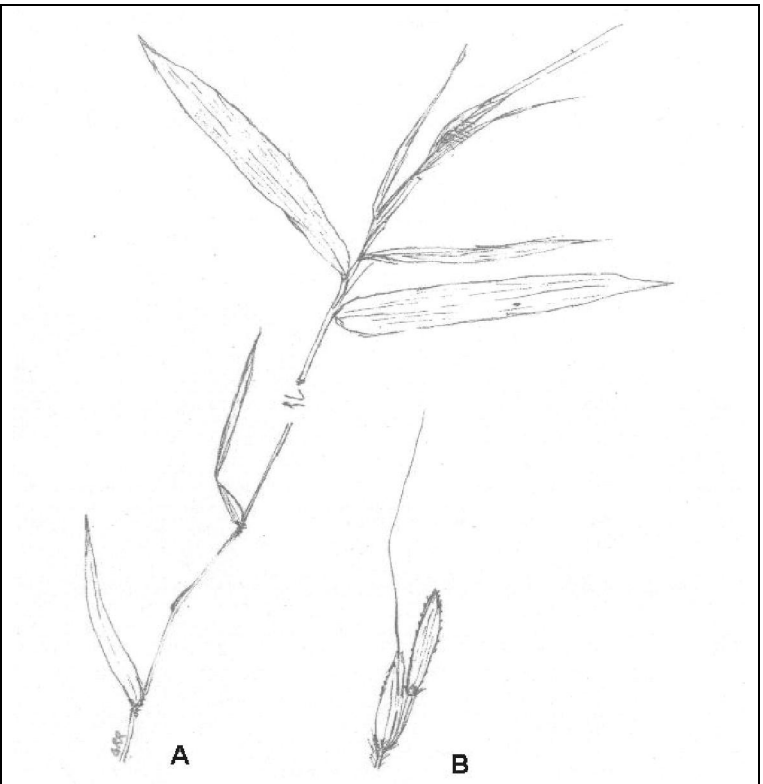
An annual grass. Culms up to 1 m high, branched from base. Leaves flat, up to 35 x 1.5 cm; sheaths glabrous. Panicle up to 20 cm long; involucres sessile; outer bristles few, inner bristles numerous, longest up to 16 mm long; densely villous below middle. Spikelet solitary and pedicelled, or in groups of 2-5, with one sessile and other pedicelled, or in groups of 2-5, with 1 sessile and other pedicelled, up to 4.25 mm long. Lower glume very small, wooly.	
Occurrence: Seen in hill slope grasslands, roadsides etc.	

Figure 9.39: Inflorescence of *Pennisetum pedicellatum* grass

Pseudanthistiria umbellata (Hack.) Hook (Figure 9.40)

Andropogon umbellatus Hack.

A very slender grass. Culms very weak, straggling, creeping and rooting at nodes. Leaves up to 6 x 0.75 cm, lanceolate, glabrous on both sides, rounded at base, primary and secondary nerves indistinguishable; sheaths shorter than blade. Panicle leafy, very lax, interrupted, 12-20 cm long; fascicles of spikelets few, axillary, 6-12 mm wide, raceme 3-6 in a fascicle; proper spathes 8-15 mm long, margins finely ciliate from minute tubercles. Sessile spikelets 3.5-4.5 mm long; lower glume 7-nerved. Awn up to 20 mm long. Pedicelled spikelets lanceolate, 4-6 mm long.



Occurrence: Common in shady places.

Figure 9.40: ***Pseudanthistiria umbellata.*** **A. Habit with inflorescence (partly shown); B. Spikelet**

Pseudanthistiria hispida Hook.

Annuals. Culms 30-100 cm high, tufted, nodes glabrous. Leaves lanceolate or linear-lanceolate 5-20 x 0.2-0.8 cm, acuminate, rounded at base. Panicles oblong, 2-3 mm long, awned. Lower glume oblong or elliptic-oblong, 2-3 mm long. Upper glume linear-oblong, upper lemma awn up to 3 cm long. Pedicelled spikelets lanceolate, sparsely setose at apex. 0-25 cm long,

Occurrence: Seen in hill slope grassland.

Pseudanthistiria heteroclita (Roxb.) Hook. (Figure 9.41)
Anthistiria heteroclita Roxb.

Annuals, culms up to 70 cm high, erect or geniculate at base. Leaves linear, 15-30 x 0.3-0.5 cm, more or less hairy from tubercles on both sides. Panicles 20-30 cm long, leafy, compound with many shortly peduncled fascicles; proper spathes 7-10 mm long, margin setose, usually from minute tubercles; racemes 6-8 mm long. Sessile spikelets 3-4 mm long, linear-oblong, hispid. Upper glume as long as the lower; upper lemma awn up to 20 mm long. Pedicelled spikelets 2.5-3 mm long.

Occurrence: Occasional in grassy hill slopes, open grasslands etc.

Figure 9.41: ***Pseudanthistiria heteroclita.*** **A. Habit with inflorescence (partly shown); B. Raceme with lower pair of sessile and pedicelled spikelet, and upper group of 3 spikelets with 1 sessile awned and 2 pedicelled unawned spikelets**

Sacciolepis indica (L.) A. Chase (Figure 9.42)
Panicum indicum Mill
Panicum indicum L.

A slender grass. Culms erect, up to 60 cm high. Leaves 2.5-15 x 0.2-0.5 cm, linear. Panicle 1-14 cm long, continuous, cylindric, spiciform; branches very short. Spikelets ovate-lanceolate, acute, usually curved, 2.5-3.5 mm long. Lower glume half as long as spikelet. Upper glume 7-9 nerved.	
Occurrence: Very common in marshes and as a weed in paddy fields.	

Figure 9.42: Inflorescence of *Sacciolepis indica* grass

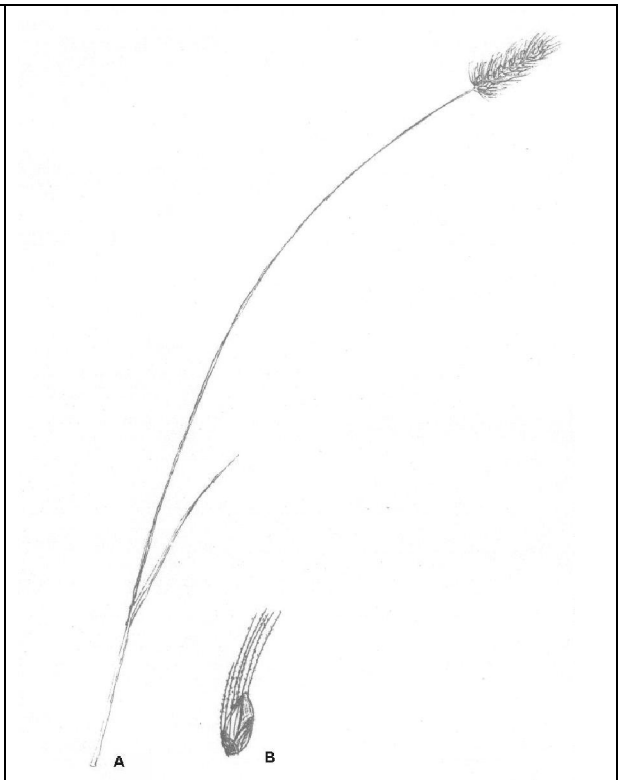
Sacciolepis interrupta (Willd.)Stapf. (Figure 9.43)
Panicum interruptum Willd.

A large, perennial aquatic grass. Culms up to 1.8 m high, stout and spongy below, ascending from a creeping and rooting or floating root stock. Leaves 15-35 x 0.5-1.3 cm, linear, acuminate, base rounded or subcordate. Panicle 10-30 cm long, cylindric, interrupted below. Spikelets 4-5 mm long, ovoid-lanceolate, subsessile or shortly pedicelled. Lower glume hyaline, less than half the length of spikelet, broadly ovate. Upper glume 9-nerve	
Occurrence: This grass is frequent in swampy situations.	

Figure 9.43: Habit of *Sacciolepis interrupta* grass

Setaria pumila (Poir.) Roem. & Schult (Figure 9.44)
Panicum pumilum Poir.
Setaria pallide-fusca (Schumach.) Stapf & C. E. Hubb.
Panicum pallide-fuscum Schumach.

An annual grass. Culms tufted, simple or branched, erect or ascending, up to 1 m high. Leaves 6-32 x 0.3-1 cm, linear-lanceolate, base rounded; ligule a ridge of hairs. Panicle cylindric, continuous, sometimes almost capitate with few spikelets, up to 16 cm long., Involucral bristles 6-12, usually yellow, rarely reddish-brown, up to 9 mm long, antorsely barbed. Spikelets *ca*. 2.25 mm long, ellipsoid. Lower glume less than half the length of the lower lemma, broadly ovate, hyaline. Upper lemma dorsally gently curved.



Occurrence: Seen in wetlands, bunds of paddy fields, roadsides, along the margin of forest, open grassland and waste places.

Figure 9.44: ***Setaria pumilla.*** **A. Habit with inflorescence; B. Spikelet**

Spodiopogon rhizophorus(Steud.) Pilger (Figure 9.45)
Andropogon rhizophorus Steud.
Spodiopogon albidus Benth.

Annuals or perennial straggling grass. Culms tufted, much branched, rooted at lower nodes, up to 1.25 m tall. Leaves flat, up to 25 x 3 cm, oblong-lanceolate, acuminate, base narrowed into a slender petiole up to 8 cm long; sheaths glabrous, ligule oblong. Panicle at first enclosed in a long spathaceous sheath; rachis and pedicels compressed, ciliate. Spikelets up to 10 mm long, lanceolate, densely covered with white hairs. Lower glume 7-9 mm long, ovate-lanceolate, minutely 2-mucronate or aristate, densely ciliate. Upper lemma 5-7 mm long, its palea broad, awn up to 2.5 cm long.

Occurrence: Occasional on old fort walls and on road cuts in Ghats.

Figure 9.45: ***Spodiopogon rhizophorus.*** **A. Habit with inflorescence; B. Sessile and pedicelled Spikelet; C. Anther; D. Palea enclosing nut and anther; E. Palea opened; F. Upper lemma**

Themeda tremula (Nees ex. Steud.) Hack. (Figure 9.46)
Anthistiria tremula Nees ex Steud.

A perennial grass. Culms erect or ascending from a creeping root stock, up to 1.25 m high, leafy, smooth, brown. Leaves up to 50 x 1.4 cm, finely acuminate, rigid, suberect, glabrous or nearly so, margins scabrid; sheaths compressed. Panicle 30-60 cm long, racemiform; fascicles of racemes rather subflabelliform, 1-3.5 cm wide, on flexuous capillary peduncles; outer spathes 1-3.5 cm long, more or less hairy with simple or tubercle based hairs; proper spathes 1-2 cm long, compressed, finely setose from large tubercles, margins scarious. Involucral pairs in superposed pairs, up to 8 mm long. Lower glume 6.5-8 mm long, linear-lanceolate. Pedicelled spikelets lanceolate, smaller than involucral spikelets and similar to them. Bisexual spikelets 2, sessile, bearded with reddish hairs. Upper lemma with awn up to 3 cm long.

Occurrence: In open grassland, hill slopes, road cuttings etc.

Figure 9.46: ***Themeda tremula*** Presl. **A. Habit with inflorescence**

Appendix III

Herb species (grass not included) in transect plots in Anshi and Dandeli wild life santuary

Sl	Family	Genus	Species	Habit	Geographical distribution
1	Fabaceae	Acacia	sinuata	Shrub	Oriental-Indomalaysia, China
2	Asteraceae	Ageratum	conyzoides	Herb	Pantropical
3	Amaranthaceae	Alternanthera	sessilis	Herb	Paleotropics
4	Fabaceae	Alysicarpus	bupleurifolius	Herb	Oriental-Indomalaysia, China, Polynesia, Pakistan
5	Euphorbiaceae	Aporosa	lindleyana	Tree	Oriental-Peninsular India, Sri Lanka
6	Scrophulariaceae	Bacopa	monnieri	Herb	Tropics
7	Elatinaceae	Bergia	ammanioides	Herb	Warmer and Tropical regions of Africa, Asia and Australia
8	Oxalidaceae	Biophytum	sensitivum	Herb	India, Sri Lanka, Tropical Asia, Africa, America
9	Acanthaceae	Blepharis	asperrima	Herb	Oriental-Western Ghats
10	Gentianaceae	Canscora	decussata	Herb	Tropical Africa, Madagascar, India
11	Lecythidaceae	Careya	arborea	Tree	Oriental-Himalayas to Sri Lanka
12	Caesalpinieae	Cassia	tora	Herb	Oriental-Asia
13	Apiaceae	Centella	asiatica	Herb	Tropics
14	Scrophulariaceae	Centranthera	indica	Herb	Oriental-Indomalaysia
15	Papilionaceae	Crotalaria	filipes	Herb	Oriental-Western Ghats
16	Liliaceae	Curculigo	orchioides	Herb	India, Java
17	Zingiberaceae	Curcuma	neilgherrensis	Herb	Oriental-Wester Ghats
18	Cyperaceae	Cyperus	rotundus	Herb	Almost cosmopilitan
19	Cyperaceae	Cyperus	pilosus	Herb	Old World tropics
20	Cyperaceae	Cyperus	tenuispica	Herb	Old World tropics
21	Faboideae	Desmodium	triflorum	Herb	Tropics
22	Cyperaceae	Diplacrum	caricinum	Herb	Tropical Asia and Australia
23	Droseraceae	Drosera	burmanii	Herb	West Africa to North east Africa
24	Cyperaceae	Eleocharis	dulcis	Herb	Old World tropics
25	Cyperaceae	Eleocharis	retroflexa	Herb	Tropics of old Worlds
26	Cyperaceae	Eleocharis	spiralis	Herb	Tropics of old Worlds
27	Asteraceae	Elephantopus	scaber	Herb	Pantropical
28	Asteraceae	Emilia	sonchifolia	Herb	Pantropical
29	Asteraceae	Epaltes	divaricata	Herb	W Peninsular India, China, Myanmar
30	Eriocaulaceae	Eriocaulon	xeranthemum	Herb	Oriental-India
31	Eriocaulaceae	Eriocaulon	truncatum	Herb	S and S E Asia
32	Eriocaulaceae	Eriocaulon	heterolepis	Herb	West India
33	Asteraceae	Eupatorium	odoratum	Shrub	Neotropical
34	Convolvulaceae	Evolvulus	nummularius	Herb	Neotropics
35	Cyperaceae	Fimbristylis	acuminata	Herb	Indomalaysia to Philippines
36	Cyperaceae	Fimbristylis	tetragona	Herb	Tropical Asia and

					Australia
37	Cyperaceae	Fimbristylis	dichotoma	Herb	Tropical and warm temperate regions
38	Faboideae	Flemingia	strobilifera	Shrub	Oriental-Indomalaysia
39	Papilionaceae	Geissaspis	cristata	Herb	South West India to Indo-China
40	Thymeliaceae	Gnidia	glauca	Shrub	Paleotropics, Oriental-India, Sri Lanka
41	Rubiaceae	Hedyotis	corymbosa	Herb	Oriental,Tropical Africa, America
42	Sterculiaceae	Helicteres	isora	Shrub	Paleotropics, India to Australia
43	Asclepiadaceae	Hemidesmus	indicus	Climber	Oriental-Peninsular India, Sri Lanka
44	Gentianaceae	Hoppea	fastigiata	Herb	Oriental-India, Sri Lanka, Myanmar
45	Balsaminaceae	Impatiens	lawii	Herb	Oriental-Western Ghats
46	Acanthaceae	Justica	simplex	Herb	India,Abyssinia,Malay Islands
47	Cyperaceae	Kyllinga	melanosperma	Herb	Old world tropics and subtropics
48	Anacardiaceae	Lannea	coromandelica	Tree	Oriental-South Asia, Indomalaysia
49	Leeaceae	Leea	indica	Shrub	Oriental to Australia
50	Acanthaceae	Lepidagathis	prostrata	Herb	Oriental-India
51	Lamiaceae	Leucas	lavandulifolia	Herb	India, Mauritius, Malay Islands
52	Scrophulariaceae	Limnophila	indica	Herb	Palaeotropics
53	Scrophulariaceae	Limnophila	repens	Herb	Tropical Asia
54	Scrophulariaceae	Lindernia	ciliata	Herb	Oriental-Indomalaysia
55	Scrophulariaceae	Lindernia	crustacea	Herb	Palaeotropics
56	Campanulaceae	Lobelia	alsinoides	Herb	Oriental-Indomalaysia
57	Onagraceae	Ludwigia	perennis	Herb	Oriental-Indomalaysia
58	Sterculiaceae	Melochia	corchorifolia	Shrub	Tropics
59	Convolvulaceae	Meremia	tridentata	Herb	Oriental-Indomalaysia, Tropical Africa
60	Scrophulariaceae	Microcarpae	minima	Herb	Tropical Asia and Australia
61	Fabaceae	Mimosa	pudica	Herb	Neotropics
62	Loganiaceae	Mitrasacme	pygmaea	Herb	India to Japan
63	Caesalpiniaceae	Moullava	spicata	Climber	Oriental-South India
64	Commelinaceae	Murdannia	spirata	Herb	Indomalesia
65	Melastomaceae	Osbeckia	truncata	Herb	Oriental-Western Ghats
66	Acanthaceae	Phaulopsis	imbricata	Herb	India, Africa, Sri Lanka, Madagascar
67	Euphorbiaceae	Phyllanthus	debilis	Herb	Western Peninsula, Tropical Africa
68	Portulacaceae	Portulaca	oleracea	Herb	Pantropics
69	Cyperaceae	Pycreus	sanguinolentus	Herb	Old world tropics and subtropics
70	Rubiaceae	Randia	dumetorum	Tree	Paleotropics
71	Cyperaceae	Rhynchospora	wightiana	Herb	Oriental-Indomalaysia
72	Lythraceae	Rotala	densiflora	Herb	Oriental-Indomalaysia
73	Lythraceae	Rotala	indica	Herb	India, Korea, Sri Lanka
74	Acanthaceae	Rungia	pectinata	Herb	India, Burma, Srilanka

75	Asteraceae	Senecio	belgaumensis	Herb	Oriental-Western Ghats
76	Malvaceae	Sida	rhombifolia	Herb	Oriental-Indomalaysia
77	Rubiaceae	Spermacoce	mauritiana	Herb	Indomalaysia, Tropical America and Africa
78	Rubiaceae	Spermacoce	articularis	Herb	Oriental-Indomalaysia
79	Scrophulariaceae	Striga	lutea	Herb	Palaeotropics
80	Euphorbiaceae	Trewia	nudiflora	Tree	Oriental-Indomalaysia, Myanmar, China
81	Tiliaceae	Triumpheta	rhomboidea	Herb	Tropical Africa, Asia
82	Fabaceae	Xylia	xylocarpa	Tree	Oriental-Indomalaysia
83	Xyridaceae	Xyris	pauciflora	Herb	Oriental-Indomalaysia
84	Rhamnaceae	Ziziphus	rugosa	Shrub	Oriental-India, Sri Lanka

Acuminate … … applied to the apex of a leaf having a gradually diminishing point.

Acute … … applied to the apex of a leaf distinctly and sharply pointed but not drawn out.

Adventitious roots roots which do not arise from the radicle or its subdivision, but from parts other than these.

Amplexicaul … applied to the base of the leaf when it embraces the stem.

Apiculate … … said of the apex when it has a sharp, short point.

Appressed … … lying flat for the whole length of the part or organ.

Articulate … … jointed.

Auricle … … outgrowth at the sides close to the region.

Awned … … having an own, that is, a bristle-like appendage, especially on the glumes of grasses .

Bifarious… … disposed in two rows or ranks on the sides.

Binate … … in pairs.

Blade … … the expanded portion of a leaf.

Bristles … … stiff hairs.

Bulbous based … having an inflated base.

Callus … … the projecting part or an extention of the flowering glume below its point of insertion.

Caryopsis … a one-celled, one- seeded superior fruit in which the pericarp has fused with hairs.

Chartaceous … papery, i e., thin and somewhat rough.

Ciliate … … fringed with hairs.

Ciliolate … … very sparsely fringed with hairs.

Clavate … … club-shaped.

Clavellate … thickened towards the apex.

Collar … … the white or colorless band at the base of the blade of a grass leaf just where it joins the sheath.

Conduplicate … folded together lengthwise.

Convolute … rolled round from the margin to the other ,so that one margin

is inside , and the other outside.

Coriaceous … leathery.

Corymbosely … arranged in corymbs, i.e., flat- topped flower clusters.

Crisped … … Curled.

Cuneate … … wedge-shaped or triangular.

Cuspidate … tipped with a small triangular piece at the apex.

Decumbent … reclining but with the upper part ascending.

Digitate … … fingered, arranged at the end of the stalk.

Dioecious … having the sexes separated on two distinct individuals.

Distichous … two ranked or two-rowed.

Endodermis … the innermost layer of the cortex abutting on and forming a sheathing layer round the stele.

Extra vaginal … applied to shoots branches that come out piercing the leaf sheath in grasses.

Fascicle … … a cluster or bundle.

Filiform … … thread shaped, slender and thin.

Flexuous… … bent alternately in opposite directions.

Foveolate … marked with small pits.

Geniculately … bent abruptly so as to resemble a knee-joint.

Geminate … … in pairs.

Gibbous … … convex or rounded.

Glabrescent … slightly hairy but becoming glabrous.

Glabrous … quite smooth without hairs.

Glaucous … covered with a bloom.

Glume … the chaffy two-ranked members found in the inflorescence of grasses.

Hispid… … Rough hairs.

Hirsute … … covered with fairly long distinct hairs.

Hyaline … … colorless or translucent.

Imbricate … overlapping.

Internode … portion of a stem between two nodes.

Intravaginal … growing out from inside the sheath.

Involucel … a ring of bracts surrounding several spikelets.

Keeled … … having a ridge along the length.

Lemma … … the flowering glume of a grass.

Ligule … … the thin scarious projection found at the leaf sheath. Where it joins the blade in grasses.

Lodicule … … a small scale outside the stamens in the flower of grasses.

Membranous … thin and semi-transparent.

Mucronate … possessing a short and a straight point.

Node … … the part of the stem which has a leaf, or the knot in the grass stem.

Palea … … the inner glume in the spikelet of grasses.

Pectinate … … pinnatifid with narrow segments which are close like the teeth of a comb.

Pistil … … the female organ of a flower, consisting of the ovary, style and Stigma.

Plumose … … feathered.

Prophyllum … the first scale-like leaf of a branch found where it joins the main stem.

Puberulous … slightly hairy.

Pubescent … … clothed with soft hair.

Punctuate … … marked with dots pits or glands.

Pungent … … ending in a rigid and sharp point.

Raceme … … a centrifugal or indeterminate inflorescence with stalked flowers.

Rachilla … … a secondary axis in the inflorescence of the grasses, the axis of the spikelet.

Rachis … … axis of an inflorescence.

Retuse … … with a shallow notch at the apex.

Rhizome … … root-stock or under ground stem prostrate on the ground.

Rugulose … somewhat wrinkled.

Scaberulous … slightly rough due to the presence of short hairs.

Scabrid … … somewhat rough.

Scale … … a reduced leaf.

Secund … … directed to one side only.

Serrate … … beset with small teeth on the margin.

Setose … … beset with bristles.

Spathaceous… … having a large bract enclosing a flower cluster.

Spiciform … … Spike-like.

Spike … … an inflorescence with sessile flowers on an elongated axis, the older flower being lower down and the younger towards the top.

Squarrose … … rough with outstanding processes.

Stipe … … a short stalk of gynaecium

Stipitate … … having a short stalk.

Stolon … … any basal branch which is disposed to root.

Sub-coriaceous … some what leathery.

Subulate … … finely pointed.

Truncated … … as if cut off at the end

Turbinate… … cone shaped or top shaped.

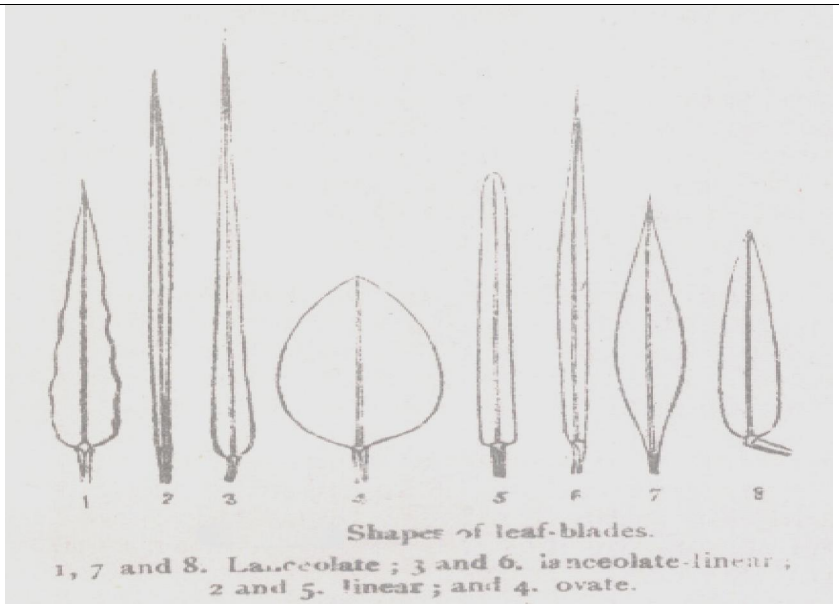
Villous… … with long hairs

References

1. Achariyar, Ranga K Bahdur Rai. 1921. A Handbook of some south Indian Grasses. Bishen Singh Mahendra Pal Singh. Dehra Dun. India.
2. Bhat, K. G and C.R. Nagendran. (2001). Sedges and grasses of Dakshina Kannada and Udupi districts. Bishen Singh Mahendra Pal Singh, Dehra Dun.
3. Bhat, K. G. (2003). Flora of Udupi. Indian Naturalist, Udupi.
4. Cook, C.D.K. (1996). Aquatic and wetland plants of India. Oxford University Press. New York.
5. Cooke, T. 1903: The Flora of the Presidency of Bombay Vol. 1; Tailor and Francis, London. (Bishen Singh Mahendra Pal Singh, Dehradun.
6. Gamble, J. S. 1915-1936. Flora of the Presidency of Madras, Adlard and Son, London.
7. http://www.berkeley.edu/exhibits/biomes/grasslands.php#savan
8. http://www.pages-igbp.org
9. http://www.hamiltonnature.org/habitats/grasslands
10. http://www.ucmp.berkely.edu/exhibits/biomes/grasslands
11. http://www.blueplanetbiomes.org/grasslands
12. Sreekumar, P. V., & V. J. Nair. 1991. FLORA OF KERALA – GRASSES. Botanical Survey Of India, Calcutta.
13. Gustavsson, Eva, Tommy Lennartsson, Marie Emanuelsson. 2007. *BIOLOGICAL CONSERVATION* 138 (2007) 47 –59

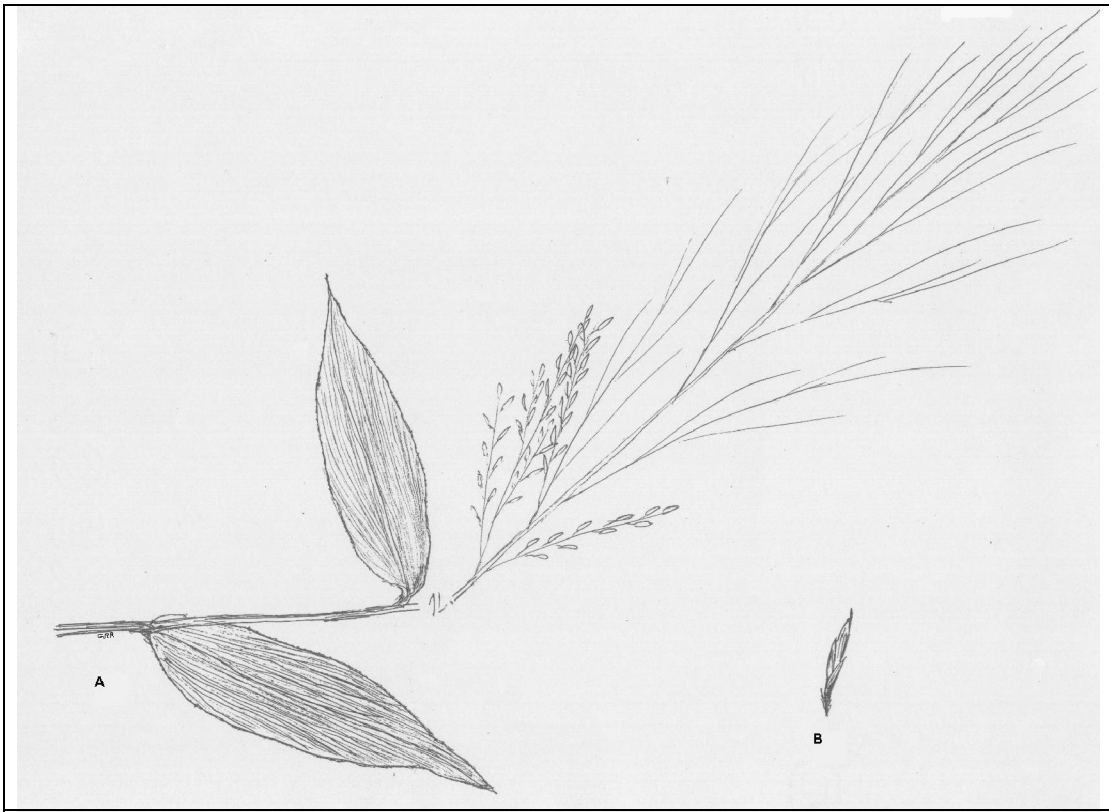
14. Misra, K. C. 1980. MANUAL OF PLANT ECOLOGY (second edition). Oxford and IBH Publishing co. New Delhi.
15. Nayar, T. S., A. Rasiya Beegam, N. Mohanan, G. Rajkumar. 2006. Flowering plants of KERALA-A handbook. TBGRI, Thiruvanathapuram. Kerala.
16. Saldanha, C. J. 1984: Flora of Karnataka (2 volumes). Oxford & IBH Publishing Co. New Delhi.
17. Mukherjee Biswarup. 1996. ENVIRONMENTAL BIOLOGY. Tata McGraw-Hill Publishing Company Limited. New Delhi.
18. *Gelbard L..Jonathan*. 2003. Grasslands at a Crossroads: Protecting and Enhancing Resilience to Climate Change. *In* L. S. Hansen, J.L.Biringer, and J.R. Hoffman. (Eds.). BUYING TIME: A user's Manual for Building Resistance and Resilience to Climatic Change in Natural Systems. WWF.
19. Misra M. K., and B. N. Misra. 1981. Species diversity and dominance in a tropical grassland community. *Folia Geobotanica*. Volume 16, Number 3 / September, 1981. Springer Netherlands.
20. Rawat, G.S., Goyal S.P. (1989) & Johnsingh, A.J.T. (1997). Ecological Observations on the Grasslands of Corbett Tiger Reserve, India. *Indian Forester*, 958-963.
21. Kotwal P.C and R.K. Pandey (1981) Dynamics of Grass Production and Consumption by wild Herbivores in Kanha National Park, (M.P) *Paper presented in Silver jubilee Symposium*, international Society for Tropical Ecology, Bhopal.
22. Lehmkuhl . J.F. (1989) .The ecology of South Asian tall –grass community (*unpub.Ph.D. Thesis*) university of Washington .195p.p.
23. Rodgers W.A (1990) Grasslands production and Natural Implications for wild grazing Herbivores in Rajaji National Park India. *Tropical Ecology* .**31**(2): 41-49.
24. Rawat, G.S., Goyal, S.P. and Johnsingh, A.J.T. 1997. Ecological observations on the grasslands of Corbett Tiger Reserve, India. *Indian Forester*. Vol.123(10): 958-963.
25. Rahmani A.R.(1992) threatened fauna of Indian Grasslands K.P.Singh and J.S. Singh (eds) *Tropical Ecosystems :Ecology and Management* . Wiley Eastern Limited, New Delhi. pp Rodgers 143-151.
26. Panwar H.C (1986) A study of management requirements in Corbett National Park, *Proc. 25th working Session IUCN's Commission on National Parks and Protected Areas*. Corbett National Park, India, 4-8 Feb, pp. 169-176
27. Rodgers W.A. and V.B.Sawarkar (1988) Vegetation Management in wildlife Protected Area in India Aspects of Applied Biology **16**: 407-422.
28. Wagner, F.H. 1989. Grazers, past and present. Pages 151-162 *In* L.F. Huenneke and H. Mooney (Eds.). Grassland structure and function: California annual grassland. Kluwer Academic Publishers, Dordrect, The Netherlands.
29. Sala, O. E., F. S. Chapin III, J. J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L. F. Huenneke, R. B. Jackson, A. Kinzig, R. Leemans, D. M. Lodge, H. A. Mooney, M. Oesterheld, N. LeRoy Poff,

30. M. T. Sykes, B. H. Walker, M. Walker, and D. H. Wall. 2000. Global biodiversity scenarios for the year 2100. Science **287**:1770-1774.
31. Lele, Sharachchandra., and Gurupada, T. Hegde. 1997. Potential herb layer production and grazing effects in anthopogenic savanna-grasslands in the moist tropical forests of the Western Ghats of India. *Tropical grasslands*. Vol.31, 574-587.
32. Bhat, D. M., K. S. Murali., and Ravindranath, N. H . 2005. Herb layer productuctivity under different light gaps in the forests of Western Ghats of Karnataka, India. *Int.J.Agricultural Resources,* Governance and Ecology, Vol. 4. No.1. pp. 93-100(8).
33. Schlesinger, W. H. 1997. Biogeochemistry: an analysis of global change. Academic Press, San Diego. 588 pp.
34. Lejune, K. D., and T. R. Seastedt. 2001. *Centaurea* species: the forb that won the west. Conservation Biology **15**:1568-1574.
35. Mooney, H. A. and R. J. Hobbs. 2000. Invasive species in a changing world. Island Press, Washington D. C. 457 pp.
36. Sarmiento, G. (1984) The Ecology of Neotropical Savannas. Harward University Press, Cambridge, MA.
37. Dandeli-Anshi Tiger Reserve Core/Critical Tiger Habitat. Proposal on Delineation/Identification of Core/Critical Tiger Habitat. Wild life division. Karnataka forest department. Dandeli. Karnataka.
38. Wikramanayake, Eric., Meghan McKnight, Eric Dinerstein, Anup Joshi, Bhim Gurung, and David Smith. 2004. Designing a Conservation Landscape for Tigers in Human-Dominated Environments. *Conservation Biology*, Vol.18. No.3. PP-839-844.
39. Whyte, R.O., 1955, Grasslands in soil conservation, *Journ. Soil and Water Cons. India* 3 : pp. 70-71; !957, The grassland and fodder resources of India, ICAR. Monogr. No. 22; 1968, Grasslands of the monsoons, Faber and Faber, London.
40. Chandran MDS (1997) Shifting cultivation, Sacred groves and conflicts in colonial forest policy in the Western Ghats. In *Nature and the Orient: The environmental History of South and Southeast Asia.* (eds. Grove, R. H., Damodaran, V. and Sangwan, S.). Oxford University Press, New Delhi, PP.674-707.



Shapes of leaf-blades.

1, 7 and 8. Lanceolate ; 3 and 6. lanceolate-linear ; 2 and 5. linear ; and 4. ovate.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