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ESTIMATES OF STANDING BIOMASS AND PRODUCTIVITY OF TROPICAL MOIST FORESTS OF UTTARA KANNADA DISTRICT, KARNATAKA, INDIA

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January 1987

CES Technical Report 19

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Running Title: Primary production of tropical forests

Key Words: Biomass, Productivity, Tropical Forests, Landuse

ABSTRACT

The two important categories of land use namely, the reserve and minor forests in Uttara Kannada district of Karnataka in Peninsular India were investigated for standing biomass of tree, shrub and herb layers. In addition, estimates of net annual above ground primary productivity (NPP) were obtained for tree and herb layers.

The average estimate of total biomass including that of below ground, for reserve and minor forests was 248.68 and 142.54 t/ha., respectively. In the former category nearly 98% of total biomass was concentrated in trees and their seedlings; while, the remaining 2% was distributed among shrub and herb layers. In minor forests, on the contrary, 91% of the biomass was concentrated in trees and their seedlings while the shrub and herb layers together ccontributed to 9% of the total biomass. The net annual above ground productivity estimate of tree layer in the reserve and minor forests were found to be 5.395 and 2.956 t/ha/yr respectivley, while those of herb layers in these two categories were 3.150 and 8.016 t/ha/yr. respectively. The differences in biomass and NPP in the two categories is attributed mainly to selective prevalence of anthropogenic pressures on these forests.

INTRODUCTION

The tropical moist forests of Uttara Kannada district in Peninsular India have, for a long time been exploited by the local population as well as by the state to meet the requirements for timber, railway sleepers, bamboos, fuelwood, fodder and for a host of other uses. The forests have been accordingly, categorized as 1)reserve forests for use by the state, and 2) protected or minor forest for use by the local population. Although, the management of these forests were sought to be done on a sustained yield basis, in practice, however, it was more often neglected: consequently, there has been a steady erosion of these natural resource base symptomatic of other places in India (Gadgil et al., 1983). The forests of Uttara Kannada, not only contribute substantial revenue to the exchequer but also form an inseparable component of the traditional agroforest ecosystem peculiar to this region (Prasad, 1984). However, due to unplanned exploitation and dwindling resources combined with a near absence of a programme to enhance the plant resources, a conflict of interest has arisen among the major beneficiaries of these resources (Mani, 1984). There is, thus, an urgent felt need to provide a data base on the total standing biomass, its productivity and the impact of human activity on these forests. Although there have been, in the past, some attempts at estimating the biomass and productivity of deciduous (Prasad and Sharatchandra, 1984) and evergreen forests (Rai 1981) of Peninsular India, there have been no published investigations on, the moist deciduous and semievergreen forests of Uttara Kannada district, except, the routine data as exploitable tree volume data of the forest department. Hence, as a part of the programme on ecological studies in this district, we attempt to estimate the standing biomass of tree, and shrub layers as well as the net annual above ground productivity of tree and herb layer in a number of localities of reserve and minor forests of Uttara Kannada district.

MATERIALS AND METHODS

Location of the study area

The studies were carried out in Sirsi and Kumta taluks of uttara Kannada district (lat. $13^{o}55'$ to $15^{o}31'$N; long. $74^{o}9'$ to $75^{o}10'$ E) of Karnataka in peninsular India during October 1983 to January 1985.

The eight study sites, each of one hectare in extent, were selected to represent the reserve and minor forests. Of these eight plots, four each were loated in the reserve and minor forests (Table I). In addition to these eight plots, two more were selected in the barren lateretic out crops entirely devoid of tree and shrub growth in Kumta taluk to study herb layer biomass during the wet season of June to December in 1984. During the dry season, this habitat is almost totally devoid of higher plant growth. No attempt has been made to include the so called leaf manure (Betta) forests as they were functionally similar to minor forests; although, the levels of productivity of herb layer could be higher in areas protected from cattle grazing. Since most of these betta lands are degraded to a very high degree (Mani 1984), we are unlikely to lose information by not including them in the present study.

Topography and geology

The terrain is hilly with gentle slopes and broad valleys. The maximum altitude is 900 m. The underlying rock is gneisses and the soils are shallow on exposed slopes, while in the valleys they are loamy laterites. Details of soils are given in Tippeswamy (1958) and Shanmukhappa (1979).

Rainfall

Mean annual rainfall in Sirsi and Kunmta are 2510 and 3277 mm respectively. There is a pronounced dry season lasting for a period of five months from December to April during which the total amount of rainfall is only 30-48 mm. The southwest monsoon which brings copious amount of rainfall is highly unevenly distributed even among these six months. The month of July for example, receives almost half of the total annual rainfall.

Estimation of standing biomass of tree layer

All woody individuals of 10 cm and above in circumference at 132 cm., height from ground level were enumerated in one hectare plot at eight sites and their GBH was taken during November 1983 to May 1984. Heights were also measured with an improvised multimeteter for the entire one hectare plot at Bidrahalli reserve forest. Since it was found that general canopy height was similar in all localities and since the process of height measurement was very tedious and time consuming, for the remainning seven plots, it was assumed that heights would be similar. Admittedly, this procedure would not give us precise heights of individuals. Based on his studies on evergreen forests of Karnataka, Rai (1981) found out that GBH was as good an estimator of tree volume as the combined parameters of GBH and height. Hence our observation of GBH and number of individuals in one hectare plot would give us a reasonably accurate (~ 95%) (Rai 1981) estimate of tree volume/biomass. The heights were categorised into two natural classes corresponding to overwood and underwood species. These two height classes were (a) > 5 m and (b) < 5 m respectively for overwood and underwood species. The percentage of plant population falling into those two as mean classes were calculated. The standing biomass was estimated by two methods. In the first method, allometric relationship obtained between volume (y), diameter and height (x) for the overwood and underwood evergreen tree species of Karnataka by Rai (1981) was used. The regression equation is as follows

$$V = 0.0790 + 0.4149\ D^2H$$

where V is volume of stemwood over bark, D is the diameter at breast height and H is the stand height. The above regression was used to compute species wise biomass by taking an average basal area for a given species, number of individuals in a given species, an average stand height and a species specific wood weight/volume ratio (Nazma et al., 1981). Since the weight so obtained would pertain only to stem wood biomass, an estimate of total biomass (including below ground) could be obtained by multiplying the value of stem wood biomass, with a ratio of total biomass to stem wood biomass obtained by a recent study of tropical forests by Brown and Lugo (1984). This ratio was found to be 1.6.

The details of computations are as follows:

$$V_i = 0.079 + 0.4149 \, (x_i / \pi \times 100)^2 \times H$$

$$B_{t1} = \sum_{i=1}^{K} w_i \times v_i \times N_i \times R$$

where

B - total basal area (in cm.)

b_i - the basal area for i^{th} species

B_{t1} total biomass (including root) as estimated by three means of regression analysis (tons)

f - form factor (ratio of actual volume of tree/volume of cylinder

H - average height of tree being 13.96 m)

K - total number of species

N_i - number of individuals in the i^{th} species

R - ratio of total biomass to stem wood biomass (being 1.6)

V - estimated volume

W_i - ratio of weight of wood/unit volume for i^{th} species

X - B/N (average basal area, in cm)

x_i - average basal area (in cm) for i^{th} species

In the second method, volume computation has been based on the measurements of girth and mean height by using $\pi \times r^2 \times h$. Since trees are not cylindrical in shape, a factor of actual volume/cylinder volume derived for forest trees of Western Ghats by Rai (1981, 1983, 1984), here called form-factor, was used. The volume so obtained was converted to weights from the wood weight/unit volume ratios of Nazama *et al.* (1981). The details of computation are as follows:

$$V_i = \pi \times (x_i / 2 \cdot \pi \times 100)^2 H \times f$$

$$B_{t2} = \sum_{i=1}^{K} v_i \times W_i \times N_i \times R$$

where B_{t2} is the total biomass as estimated by the second method.

Estimation of net annual above ground producitivity (t/ha.)

Based on measurements of basal area of four preservation plots in Uttar Kannada district, Rai (1984) has arrived at an annual basal area increment of 2%. We have used this factor to compute the productivity, as the study areas are representative of these four plots and the rates of increments are based on a very long period of observation. Hence our estimates are unlikely to be inaccurate.

Estimation of standing biomass of shrub layer

Ten individuals of each shrub species have been randomly slected in the surrounding one hectare plot and measurement of diameter at the ground level and the total height were taken. The individuals were harvested and separated into leaf, and stem components, and their fresh weights were obtained in the field itself. A sample of it was utilized to obtain the oven dry weights.

Allometric relationships between the total dry weight of the individual (y) and diameter (x_1) and height (x_2) were obtained by multiple linear regression.

Total dry weight (y) = $a + bx_1 + cx^2_2$

where x_1 and x_2 are diameter in (cm) and height (cm) respectively). The combined parameter of diameter and height (D^2H) was also used in a linear regression.

$$y = a+b \quad D^2 \; H$$

where

y = total dry weight

D = diameter

H = height,

a is the intercept, b and c being the coefficients of regression. In order to obtain a better relationship, the sample size has been increased by pooling data of all individuals from a plot. From the pooled data, the height and diameter frequency classes as well as the proportion of individuals in these classes was computed. Enumeration of the individuals of shrub species in quadrats of size 10 m x 10 m was carried in 10 randomly selected areas in the one hectare plot. The size frequency distribution obtained earlier has been used to categorize the enumerated individuals for the one hectare plot. The standing biomass was arrived at using the relationship explained above.

In one of the localities namely Mirzan, the sampling has been made difficult by the impentrable shrub layer, caused mainly due to overgrazing and excessive lopping. The shrub biomass estimates are thus, likely to be underestimates, in this particular locality.

Estimation of herb layer biomass

In each of the eight localities, herb layer biomass has been sampled at monthly intervals during November 1983 to January 1985. In addition, two more localities without any tree cover have been selected. The biomass has been harvested in twenty quadrats of size 50 cm x 50 cm. No sampling has been carried during the months of February to May as there was only standing dead. Further details of harvest method and computation of productivity are given in Prasad and Sharatchandra (1984).

RESULTS

Estimates of total tree biomass (including that of seedlings)

The results of total standing tree biomass indicate that reserve forests have, on an average, a higher amount of biomass than minor forests. The average biomass of 243.25 t/ha. of reserve forests of Bidrahalli, Nagur, Santgal and Sonda is thus 1.87 times higher than that of minor forests of Bengle, Bhairumbe, Chandavar and Mirzan (average 129.92 t/ha.). The difference was found to be statistically significant (t 3.17 df 6, $p < 0.02$). Table II gives the details of biomass.

The total biomass among reserve forest localities, in decreasing order were found to be in Nagur, Santgal, Sonda and Bidrahalli. In minor forest localities, the ranking in decreasing order is Bengle, Chandavar, Bhairumbe and Mirzan. The differences in standing biomass appears to be a function of number of individuals as well as the degree of anthropogenic pressures. This interaction appears to be of special importance in minor forests, which by definition, are meant for use by local population. In contrast, the reserve forests, are largely utilized by the state for periodic felling and are legally out of bounds to local population and hence, the observed high values of biomass.

Biomass distribution among different species

The number of species with three percent or more of total biomass varied from a minimum of 3 (Bidrahalli) to 9 in Bengle. These dominant species constituted more than 65 of the total biomass while the remaining 35% was comprised of a large number (25-44) of species (Figs. 1 and 2). Thus a few species alone appear to determine the physiognomy of these forests. In the reserve forests, this category seem to be *Xylia xylocarpa*, *Terminalia tomentosa*, *T.paniculata*, *T. bellerica* which is a climax association for this locality (Pascal et al. 1983). In disturbed minor forest locality of Chandavar, poioneer and understory tree species such as *Aporosa lindleyana*, *Careya arborea*, *Ixora brachiata*, *Strychnos nux-vomica*, *Ervatamia heyneana*, contribute a substantial amount of biomass to the total (Figs. 3 and 4).

It is interesting to note that, although, the climax association appears to be intact from the point of biomass, the dominance of understory and pioneer species in overall composition of reserve forest is very remarkable. This would mean that climax species have a few large individuals, which appear to contribute to the bulk of biomass. The implication then, is that a transition of biomass dominated by climax species into one that is dominated by pioneer species and underwood species appears to be round the corner!

Net annual above ground productivity (t/ha.) of tree layer

The NPP estimates for reserve forests varied from a maximum of 7.25 t/ha/yr to 3.946 t/ha/yr and those of minor forests from a maximum of 3.476 t/ha/yr to minimum of 1.501 t/ha/yr (Table III). It appears that NPP is higher on sites with large population size and with minimum biotic disturbances. Since reserve forest localities are relatively less disturbed than those of minor forests, the NPP in reserve forests on an average, is about twice that of minor forests. These differences are statistically significant ($t=2.905$, $df=6$, $p<.05$).

Estimates of shrub biomass

Regression of above ground shrub biomass on D^2H

It was found that D^2H in a linear regression was a better estimator of dry weights of shrubs rather than a multiple linear regression of weight on diameter and height. It was also found that pooling of all individuals of all species in a given site has given a more reliable linear regression rather than by considering the individuals of a given species alone as indicated by low standard errors of the regression coefficient in the former. Moreover such a generalized relationship could be useful in estimating the biomass of saplings of trees as well (below 10 cm girth limit) since, in the young stages these sapling have similar growth from. Table IV gives sample sizes, intercept, regresssion and correlation coefficients as well as T values and their significance. It can be seen from the table that a high positive correlation exists between biomass and D^2H in the plot at Bidrahalli, Bengle, Bhairumbe, Nagur, Santgal. In the case of Chandavar and Mirzan, low correlation values could perhaps be due to change in form caused by excessive lopping of shrubs by local population to meet their requirements for leaf manure and fuel. Similar trend is seen in the Sonda reserve forest also.

The above ground shrub biomass estimated by taking mean diameter and mean height was found to be on a little higher side compared to the estimate obtained by grouping individuals into height classes and considering their mean diameters. The difference, however, appears to be marginal only. The average of two estimates are given in Table V. While the average shrub biomass in reserve forests was 0.57 t/ha, in minor forests it was found to be 0.68 t/ha. However, the difference was not statistically significant ($t = 0.20$ $d = 6$, $p > 0.05$). These results show that while the relatively undisturbed forests such as Santgal tend to have low shrub biomass, the distrubed forest loclalities - irrespective of reserve or minor forest category - have higher shrub biomass. This tendency is also evident in highly disturbed localities such as Bhairumbe. The explanation for such a tendency, perhaps lies in the degree of anthropogenic pressures exerted on the forests rather than the differences in vegetation types perse.

PRODUCTIVITY OF HERB LAYER

Net above ground primary productivity of herb layer in different land uses

Table V gives the above ground NPP estimates for reserve, and minor forest localities as well as for the degraded open lateritic outcrops. The estimates for reserve forest vary from a minimum of 0.574 to a maximum of 8.623 t/ha/yr with an average of 3.150 t/ha/yr. For the minor forests, the minimum was 4.563 t/ha/yr and the maximum 11.176 t/ha/yr, with an average of 8.014 t/ha/yr. In the degraded open lateritic outcrops, an average of 3.056 t/ha/yr was obtained. The average productivity for three categories is 5.078 t/ha/yr. Thus the above ground productivity of herb layer in minor forests is about twice that of reserve forests. This difference was, however, not statistically significant (t = 1.9, df = 6, P>0.05). The higher productivity in minor forest could be ascribed to availability of sunlight due to open nature of canopy and also perhaps due to low densities of tree and shrubs.

The differences in productivity within the four reserve forest sites could be due to (a) closure of canopy to a high degree (as in the case of Nagur, Santgal and in Sonda), (b) high density of trees and shrubs and (c) thin soil cover or a combination of these three factors.

Geographical differences in NPP

The variation in NPP in minor forest localities, could be similarly explained. A close scrutiny of the results indicate that differences in NPP may be better explained if we group them into two geographical categories of Sirsi and Kumta taluks. Infact, the mean NPP of four plots of Bidrahalli, Sonda, Bengle and Bhairumbe in Sirsi taluk, was found to be more than twice the NPP of six plots namely Santgal, Sonda, Chandavar, Mirzan, Divgi ghat and Nagur cross in Kumta taluk. This difference was found to be significant ($t = 2.6$, $df = 8$, $p < 0.05$). It may be recalled from Table I, that the soil in the plots of Kumta taluk is exposed laterite in nature and therefore it holds little moisture and nutrients so essential for greater productivity of herbs.

Effect of elevation on NPP

In order to verify that the low productivity results are not due to differences in elevation of study sites, a linear regression of NPP (y) on altitude (x) was computed. The result shows that the slope of regression is not significantly different from zero ($b = 0.009$, $t = 1.85$, $df = 9$, $p > 0.05$) indicating that elevation in the observed range of 20 to 575 m, does not have a crucial role in determining the levels of above ground NPP of herb layer.

Seasonality of production

The attainment of peak biomass by different species ranged from July to March; although, in most localities, most species had obtained peak biomass by December itself. It is evident from Fig.5 that majority of species in reserve forest sites had attained peak biomass during September to December period. In the minor forest sites, the peak biomass was attained much more uniformly among the sites during this period; suggesting that the species make up in these sites is similar.

Biomass distribution among different species

The single most dominant group of herbs contributing to overall biomass in reserve and minor forests was found to be members of gramineae. While these contributed about half of the total biomass in reserve forests, in the minor forests on the contrary, these constituted more than 60% (Figs. 6-10) of biomass. In the case of degraded open areas too, gramineae constituted more than 60% of total biomass.

Biomass distribution and net annual above ground productivity (t/ha.) of tree shrub and herb layers of the Eight localities

In the reserve forest localities of Bidrahalli, Nagur, Santgal and Sonda, on an average, the tree biomass including their seedlings accounted for nearly 98% of total biomass. The shrub and herb layers contributed to 0.37 and 1.63% respectively. This result is in close correspondence with the estimate obtained for closed tropical forests elsewhere (Brown and Lugo 1984). Among these four localities itself, the contribution of tree biomass varied from a maximum of 99.63% in Nagur, to a minimum of 93.15% in Bidrahalli (Fig.11). In the latter locality, the percent biomass contribution by shrub and herb layers was thus, obviously more than those at Nagur, Santgal and Sonda. The tree canopy at Bidrahalli is relatively open and the underwood tree species are predominantly deciduous as compared to other localities. These three localities are characterized by a higher density of individuals of tree species, a closed canopy and by presence of underwood evergreen tree species which could result in minimal penetration of sun light. Therefore, this factor alone is involved in the observed low biomass values of shrub and herb layers.

t/ha/yr and 10.97 t/ha/yr for reserve and minor forests respectively. The low productivity could be due to a prolonged dry season.

DISCUSSION

The estimates of total standing biomass of tree layer along with tree seedlings, by the two indirect methods appear to be in close proximity with those obtained by the forest department of Karnataka. In a 20 hectare plot at Siddapur of Uttara Kannada district, the total volume of timber and fuelwood obtained by clearfelling amounted to 55.76 m^3/ha or 39 tons/ha (by considering an average wood weight volume ratio of 0.7) for a population density of 146 trees/ha. Applying the correction factor of 1.6 (Brown and Lugo, 1984) to obtain the total above and below ground biomass, we have an estimate of 62.45 t/ha. Thus, our estimates of total tree biomass are a close approximation of the data obtained from clearfelling. These results are also well within the range of estimates of 196 t/ha for closed forests and 79 t/ha for disturbed open forests of tropical Asia (Brown and Lugo, 1984). However, for localities at Nagur and Santgal, the estimates are considerably higher than these average values. This is mainly because of very high population densities.

Nevertheless these estimates are lower than those obtained by Rai (1981), for the evergreen forests of Karnataka and for some of the tropical moist forests (Kira 974). A much more precise estimate would be possible with accurate regression relationships based on tree felling. Obviously, this procedure is extremely elaborate, time consuming and laborious, since the State permission to fell trees is difficult to obtain. The above indirect procedure appears to be justified. Infact, standing biomass of tropical forests of Guatemala have been estimated by using regression obtained for New Guinea forests (Kunkel-Westphal and Kunkel, 1979). The estimates of annual above ground net productivity of tree layer are about half of those obtained by Rai for the evergreen forests of Karnataka (Rai 1981). However, the overall NPP estimates are well within the range of NPP for tropical forests (Cannell, 1982).

If these results on standing tree biomass and NPP are any indication of the situation in the entire district, it emerges out that more than 50000 ha of minor or protected forests, have at present only half of the tree biomass that could potentially exist in this district blessed with copious amount of rainfall. The situation thus, warrants an immediate programme of revegetation of these potentially productive areas. In the present context of worsening situation of wood and other forest poroduct shortages in India, reboissement of these vast area would needless to say, is an urgent priority not only to meet the growing demands but also to help conserve the precious soil and water resources.

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TABLE - I

Location and some physical characteristics of the study sites

Forest Category	Locality	Altitude (m)	Soil	Biotic disturbances
Reserve	Bidrahalli	525	Clayey-loam	Moderate
	Nagur	105	Exposed laterite	Moderate
	Santgal	350	-	Little or no disturbance
	Sonda	475	Clayey-loam	Moderate
Minor	Bengle	565	-	High
	Bhairumbe	475	Loam	High
	Chandavar	20	Exposed laterite	High
	Mirzan	25	-	High
	Divigighat	75	Exposed hard pan laterite	High
	Nagur cross	20	-	High

TABLE - II

biomass (t/ha) including that of seedlings (in parenthesis)
the eight localities of reserve and minor forests of Uttar
a district

se	Locality	N	Total standing biomass(including that of root (t/ha.) as estimated by		
			Regression		Average
e	Bidralli	300	223.79	146.58	185.18 (1.29)
	Nagur	1589	361.70	267.00	314.35 (1.11)
	Santgal	960	306.34	213.00	259.67 (0.64)
	Sonda	690	294.31	125.90	210.10 (0.67)
	Bengle	405	197.20	123.86	160.53 (0.67)
	Bhairumbe	414	180.21	104.00	142.10 (0.09)
	Chandavar	580	202.00	92.56	147.28 (0.36)
	Mirzan	261	66.15	-	66.15 (0.49)

TABLE - III

Estimates of net annual above ground productivity (t/ha.) in the reserve and minor forest localities in Uttara Kannada district of Karnataka, South India

Forest/Landuse Category	Locality	Net annual above ground productivity (t/ha/yr)
Reserve	Bidrahalli	3.946
	Nagur	7.250
	Santgal	5.296
	Sondi	5.088
Average		5.395
Minor	Bengle	3.533
	Bhairumbe	3.314
	Chandavar	3.476
	Mirzan	1.501
Average		2.956

TABLE - IV

inear regression of total above ground biomass on square of diameter. and H, height of the shrub in eight localities of reserve and inor forests of Uttar Kannada district.
N = Sample size, a = intercept, b = regression/coefficient, r = correlation coefficient and F = variance ratio.

anduse	Locality	N	a	b	r	F	Significance leve
eserve orest	Bidrahalli	108	12.449	0.115	0.92	612.89	P<0.01
	Nagur	82	1.736	0.468	0.82	156.52	P<0.01
	Santgal	43	7.117	0.252	0.82	83.41	P<0.01
	Sonda	101	42.996	-0.232	-0.23	5.62	P<0.05
inor orest	Bengle	140	6.263	0.157	0.74	167.87	P<0.01
	Bhairumbe	30	4.678	0.124	0.76	39.02	P<0.01
	Chandavar	58	35.736	0.220	0.51	20.13	P<0.01
	Mirjan	70	38.894	0.014	0.19	2.57	P>0.01

TABLE - V

Above ground biomass (kg/ha) of shrub species among the eight localities in Uttar Kannada district.

Landuse	Locality	No.of individuals (in 1000 m^2)	I(for mean dia. and height	II(for height classes)	Average Biomass (kg/ha)
eserve orest	Bidrahalli	3399	856.02	1081.48	968.75
	Nagur	953	162.93	285.35	224.14
	Santgal	90	40.25	36.18	38.21
	Sonda	2439	1047.8	1045.96	1046.88
inor orest	Bengle	2093	245.41	240.86	243.15
	Bhairumbe	654	63.386	68.032	65.70
	Chandavar	2418	2144	2116.3	2130.00
	Mirjan	582	244.6	320.02	282.31

TABLE - VI

Above ground net primary productivity (t/ha/yr) of herb layer in reserve and minor forests in Uttara Kannada district

Landuse Category	Locality	Herb layer productivity (t/ha/yr)	Average productivity for the [illegible] use (t/ha/yr)
Reserve Forest	Bidrahalli	8.623	
	Nagur	0.574	
	Santgal	1.396	
	Sonda	2.008	3.150 ±3.69
Minor Forest	Bengle	10.896	
	Bhairumbe	11.176	
	Chandavar	5.432	
	Mirzan	4.563	8.016 ±3.50
Degraded, open lateritic outcrops	Divgighat	1.608	
	Nagur cross	4.504	3.056
Combined landuse		50.78 ✓ [illegible]	5.078

LIST OF FIGURES

Fig.9 : Distribution of herb biomass among major species at Chandavar and Mirzan minor forests

Fig.10 : Distribution of herb biomass among major species at Divgi and Nagur cross of degraded open lateritic outcrops in Kumta taluk

Fig.11 : An overall picture of biomass among tree, shrub and herb layers of Reserve and minor forests.