Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 15	No. 4	pp. 1143-1152	2016

Original Research Paper

Status of Ground Species Richness, Diversity, Percent Cover and Biomass of Papgani River Basin, a Tributary River of Pennar, Andhra Pradesh, India

Rajendrakumar S.
Centre for Sustainable Future, Amrita Vishwa Vidyapeetham (Amrita University), Amritanagar P.O., Ettimadai, Coimbatore-641 112, T. N., India

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 10-12-2015
Accepted: 04-02-2016

Key Words:
Papgani
Biomass,
Ground cover
Grazing

ABSTRACT

In the present study, status of ground plant species of the Papgani river basin was studied. A total of 210 sampling points were selected and nested plots were developed to quantify the herbs and grasses of this region. 156 plant species were recorded with the diversity (H) of 2.33 and density 16 plants/sqm. Biomass of an ecosystem showed 0.90t/ha with a ground cover of 54.32%. The regression analysis was carried out to examine the relationship among density, ground cover and biomass. Relationships of the above said variable was weakened by grazing, frequent fire and human intervention, the hypothetic statement was proved using "t" test. The anthropogenic threads dominate the fast growing unpalatable species like, *Cymbopogon* and *Heteropogon* spp. It reduces the productivity and functions of a river ecosystem.

INTRODUCTION

River basin is a unique setting, exhibiting a wide range of physical and temporal variability due to the availability of a mixture of open and closed canopies. Plants that grow in the active channels of river basin are greatly influenced by hydrologic conditions (Naiman & Decamps 1997). Reversely, the plant species that grow on the river basin influence water quality, temperature, flow and sediment load (Naiman & Decamps 1997 and Hefting et al. 2005). This interaction in turn influences diversity, density (Kabzems & Lousier 1992, Legare et al. 2002) of species, survival rate, carrying capacity and health (Kern et al. 2006, Hart & Chen 2008) of an ecosystem. All above factors determine the productivity of the ecosystems.

Productivity of the ecosystem was quantified by measurement of biomass (Kiniry et al. 2008). Destructive method of biomass estimation is the most suitable method for rapid estimation of aboveground biomass (Rottgermann et al. 2000). Also, percent cover estimation, a relatively simple technique is used to estimate the abundance of ground vegetation (Mueller-Dombois & Ellenberg 1974, Chiarucci et al. 1999). Relating the species biomass and cover ratios is very important, as it would indicate the relationship of morphology and growth characteristics of species in an ecosystem (Muukkonen et al. 2006 and Porte et al. 2009). Further, estimation of the above parameters in relation to the palpability of species would provide knowledge of environmental factors that influence ecosystem process and species establishments in the river basin. The study was carried out in the Papgani river basin with the following objectives:

- Estimate the richness and diversity of ground flora in the river basin.
- Quantify the biomass and percent cover of ground flora in the river basin.
- Determine the biomass and ground cover of palatable and unpalatable species in the river basin.
- Understand the establishment process of an ecosystem by relating species density, ground cover and biomass.

MATERIALS AND METHODS

Study area: The study area falls in the southernmost part of undivided Andhra Pradesh, where the three semi-arid districts of Chittoor, Cuddapah and Anantapur meet and form the catchment of the river Papagni-a tributary of river Pennar (Fig. 1). It is spread between 26°03'36" and 13°14'61" N latitudes and 59°26'27" and 70°39'22" E longitudes (FES 2011). The elevation ranges from 300 m to 1300 m above MSL and temperature varies from 10°C in winter to 45°C in summer. The climate is characterized by hot, dry summer and mild winter. Total area of river basin is 34,28,100 ha (FES 2011) and land use pattern of study area is given in Fig. 2. Hydrogeomorphologically, the study area has an excellent groundwater potential (Krishnaiah 2013). The soil types were classified as red and black sandy, clay and red loamy. The forest is classified as: southern tropical dry mixed deciduous type (5A/C3) and southern tropical thorn type (6A/C1) (Champion & Seth 1966). However, it is difficult

to distinguish sharply, the above two types, from each other, as they often coalesces into each other. In these forests, trees shed their leaves by December and between February and May depending on the vegetation type. The forests look very open, but no area remains completely leafless at any given time of the year. Flowering and fruiting was generally before the onset of the southwest monsoon.

Field data collection: Based on the land use map developed by the FES (2011), a total of 210 sampling plots were used for this study. At each sampling point, five 1 m^2 quadrats (one in centre and rest four quadrates in four different directions), a totalling to 1050 (210×5) were laid. In addition, to estimate the ground cover, the point intercept method was used. A total of 28 points were made at two diagonals of the quadrat, based on the presence/absence data from 29,400 (1050×28) points, the percentage of the ground cover was calculated.

Biomass estimation was carried out in each 1 m^2 plots; two biomass plots were laid with the size of 30×30 cm. A destructive method was used, where plants were harvested, species wise separated and measured wet biomass in the field. For the estimation of biomass a total of 2100 (210×5×2) plots were laid. All the plants were identified based on their key vegetative and reproductive features using regional flora (Pullaiah & Chennaiah 1997, Pullaiah & Ali Mouali 1997 and Pullaiah 1997). When taxon identification appeared uncertain in the field, the specimens were collected for later validation of the species.

Data analysis: Shannon Wiener Index (Shannon & Wiener 1949) is the widely used index for calculating species diversity (Clark & Warwick 2001) and considered useful for describing the ecological trends of any habitats (Lewis et al. 1988, Magurran 1988).

Shannon Wiener Index $H = -\sum P_i \log_e P_i$

Where $P_i = n_i / N_i$ (n_i is the number of individuals of the species i, and N is the total number of individuals.

In addition, density and ground cover were also estimated.

Density was estimated by,

Density (no./sq. m) = number of individuals of the species i/Total number of plots

Ground cover was estimated by,

Ground Cover (%) = No. of point plants were intercepted /Total no. of points × 100

Biomass was estimated by,

Biomass (t/ha) = Biomass in g × 1000/Area in m^2 × No. of plots × 10000

The list of palatable/unpalatable species list was prepared based on field observation, people participatory survey and discussion with local resource person. The species which are palatable in juvenile but become unpalatable when mature, were grouped into unpalatable.

The relationship between density, percent cover and

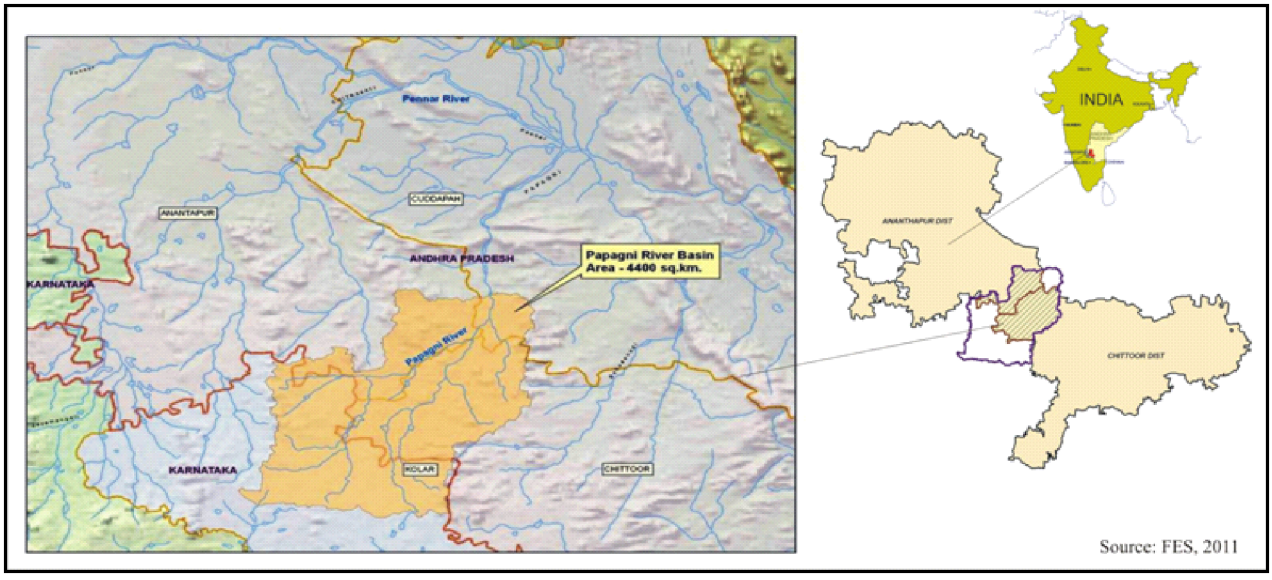


Fig. 1: Location of study area-Papagini river basin.

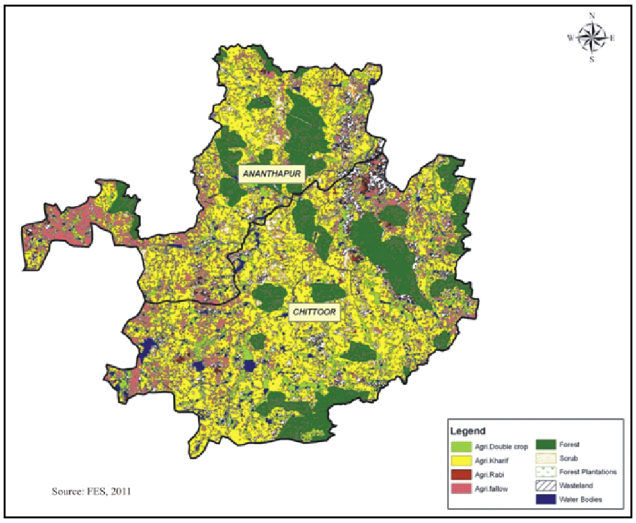


Fig. 2: Land use map-Papagini river basin.

Table 1: Status of ground plant communities in Papgani river basin.

	Herbs	Grasses	Total
Family	31	2	33
Genera	76	26	102
Species	111	45	156
Density (no./sq.m)	5	11	16
Diversity (H)	3.85	2.29	2.33
Percent Cover	9.49	44.83	54.32
Biomass (t/ha)	0.18	0.72	0.90

Table 2: Status of palatable and unpalatable of species present in Papgani river basin.

	Palatable Species	Unpalatable Species	Total
Percent Cover	27.21	27.11	54.32
Biomass (t/ha)	0.34	0.56	0.90

biomass was analysed using simple linear regression bivariate models with the help of SPSS 14.0 version software. Hypothesis was framed and tested with "*t*" statistic to examine the relationship between density percent cover and biomass.

RESULTS AND DISCUSSIONS

Abundance, density and diversity: A total of 156 species of herbs, including grasses were recorded from the Papagani river basin, which belonged to 33 families and 102 genera. Within, 111 were herbs and 45 were grasses with the diversity (H) of 3.85 and 2.29 respectively (Table 1). The abundance of herbs was 5568 individual with density of 5 individuals/sqm and dominant species showed *Sparmacoce pusilla* with 375 (<1) individuals, 372 *Bergia ammannioides* (<1/sqm), 300 *Lepidagathis cristata* (<1/sqm), 273 *Euphorbia hirta* (<1/sqm) and 238 of *Sparmacoce articularis* (<1/sqm) (Annexure 1). Grass density showed 11 individuals (clumps)/sq.mt, dominant grass was *Heteropogon contortus* with 4295 individuals (4/sqm), followed by 2226 of *Chrysopogon fulvus* (2/sqm), 791 of *Fimbristylis ferruginea*, 708 of *Cynodon dactylon* (1/sqm) and 560 of *Cymbopogon coloratus* (1/sqm) (Annexure 1). Species composition of an area was important because it seems that the multiple factors contribute to, or influence the diversity of an area. Species richness and species diversity, in particular region, was an obvious feature of the region.

Percent cover and biomass: Ground cover or percent cover of the river basin was measured, it was 54.32%, and among this herb contributed 9.49%, and grasses 44.83% (Table 1). The major portion of the ground area was occupied by grasses like *Cymbopogon coloratus* (12.93%), *Cynodon dactylon* (10.57%) *Heteropogon contortus* (7.41%), *Chrysopogon fulvus* (5.96%) and *Aristida adscensionis* var. *adscensionis* (1.80%) (Annexure 1). Biomass of river basin was measured as 0.90 t/ha, in that 0.72 tons/ha biomass was grasses and 0.18 tons/ha was recorded as an herbaceous species (Table 1). Three species contributed bulk of biomass that is *Cymbopogon coloratus* (0.24t/ha), *Heteropogon contortus* (0.21t/ha) and *Chrysopogon fulvus* (0.11t/ha) (Annexure 1). In the case of percent cover and biomass *Cymbopogon coloratus* was one of the dominant species in Papgani river basin and it occupied 12.93% of cover and contributed 0.24tons/ha of biomass. The dominance of *Cymbopogon* spp. in one habitat indicated frequent occurrence of fire (Dabadghao & Shankarnarayan 1973, Yadav & Singh 1977), grazing and human intervention (Rajendrakumar et al. 2011 and Rajendrakumar 2014). Grazing results patches of mosaics vegetation and it increases the soil erosion (Linera et al. 1997). So the intensity of erosion in the study area was high in both structured and non-structured hill. It exceeds more than 45m^3/hectare/year (Krishnaisah 2013). This process aggregated by unsustainable practices in agricultural and human intervention in river basin (FES 2011).

Palatability and unpalatability: In the recorded herbs and grasses, palpability of the species to cattle was examined. Out of 54.32% of the recorded ground cover, 27.21% area was covered by palatable species, which showed biomass of 0.34t/ha (Table 2). In the palatable category, the major contribution was by *Chrysopogon fulvus* (0.11t/ha), *Tonningia axillaris* (0.03t/ha), *Celosia argentea* var. *cristata Cynodon dactylon*, *Dichanthium filiculme* and *Digitaria longiflora* contribute around 0.02t/ha (Annexure 1). The unpalatable

Table 3: Outputs from simple linear regression between density, percent cover and biomass in Papgani river basin.

	A	SE a	b	SE b	r	r^2
Density Vs Percent Cover	2.45	0.259	0.096	0.101	0.605	0.366
Density Vs Biomass	0.054	0.004	-1.92E-05	0.002	0.746	0.556
Percent Cover Vs Biomass	0.015	0.001	0.001	0.002	0.825	0.681

Table 4: Outputs of "t" statistic to examine the relationship between density, percent cover and biomass in Papgani river basin.

	B	SE B	t	Upper Limit of B	Lower Limit of B	P
Density Vs Percent Cover	0.150	0.16	9.4342	0.118	0.181	<0.000
Density Vs Biomass	10.356	0.746	13.881	8.882	11.830	<0.000
Percent Cover Vs Biomass	46.251	2.952	15.666	40.403	52.099	<0.000

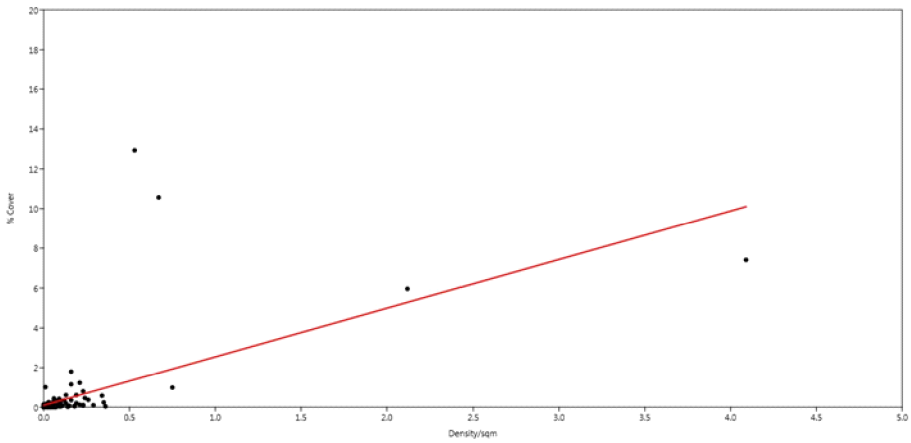
species formed 27.11% of ground cover with the biomass of 0.56t/ha and major contribution was by *Cymbopogon coloratus* (0.24t/ha), *Heteropogon contortus* (0.21t/ha) and *Cymbopogon nardus* var. *confertiflorus* (0.04t/ha).

The dominance of *Cymbopogon* spp. affects the palatable species present in the river basin. Ground cover of palatable and unpalatable species was almost equal, but biomass of unpalatable species (0.56t/ha) was more than that of palatable species (0.34t/ha) of the river basin. It means the unpalatable species (*Cymbopogon* spp. and *Heteropogon* spp.) grow faster than palatable species contribute to biomass. These tall grasses are dominant in resource abundant environments, because of their ability to compete for light and nutrients than other species (Grime 2001). Thus, intensive grazing on the river basin affects the growth of the palatable species. Frequent occurrence of fire result in the growth of secondary vegetation (Rajendrakumar 2014), which constitutes the exotic unpalatable species (Turner et al. 1994) and they prevent the growth of native species (Kruckeberg et al. 1985 and Gentry 1986). The dominance of unpalatable species influences the floristic richness and functions of the ecosystem and are often regarded as 'biological pollutants' owing to their often disruptive /destabilizing effects on natural ecosystems (West Brooks 1991).

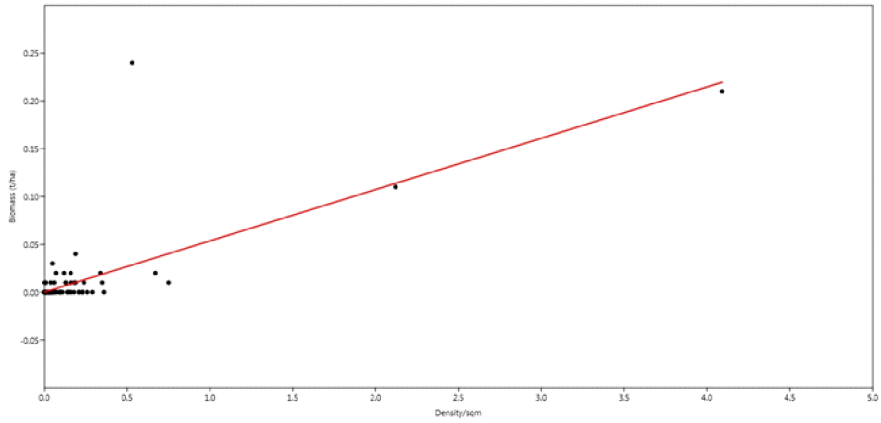
Relationship between density, biomass and ground cover: The regression analysis indicates that, the percent cover of the species increased with respect to density of species in the river basin (a=2.45; b=0.096). Percent cover and biomass showed a positive relationship, when the percent cover of the species increased the biomass of the river basin (a=0.015; b=0.001) also increased. In the case of density and biomass, density increased, the biomass decreased (a=0.054; b= -1.92E-05) (Table 3, Fig. 3). This indicates that some external factors influence the biomass of the river basin.

The *r* value of the regression analysis indicates that, positive relationship of density with percent cover and biomass of river basin (Table 3). The values range from 0.605-0.825, it indicated that the percent cover-biomass is strongly related (0.825) than the density-percent cover (0.605) and density-biomass (0.746). The regression coefficient determination between variable was indicated by r^2. It explained that, 36% (0.366) of total variation in the percent cover in explained by density, likewise 55% (0.556) in density-biomass and 68% (0.681) in percent cover-biomass (Table 3). The lowest value of r^2 stated that, there is a maximum possibility of many external factors that influence relationships of the above variables and species establishment of Papgani river basin. Further, early successional stage, density, percent cover and biomass are more related. But in the later stages, the relationship between each variable weakened by the external factors (Fig. 3). This was tested hypothetically with the help of "t" statistic (Table 4). The proposed statement was "strong relationship between density, percent cover and biomass" and the alternate hypothetic statement was "weakened relationship between variable". Recorded "t" values are beyond the control limits (Table 4) and p values are insignificant (p<0.000). So, the alternate hypothesis indicates that, many external factors weakened the relationships and affected the species establishment in the Papgani river basin (Table 4).

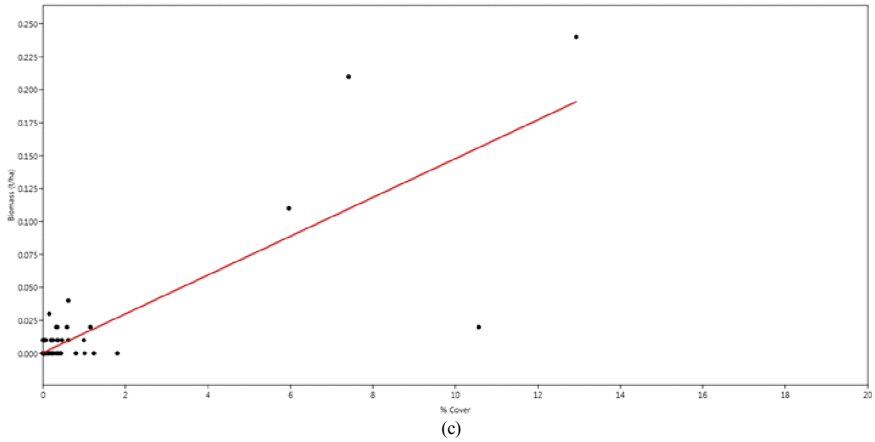
The river ecosystems losing its potentiality (productivity) by severe grazing pressure, frequent incidents of fire. The increasing population in and around the river basin, puts enormous pressure on this habitat (Krishnaiah 2013). A decrease of rainfall has also had its impact, causes severe drought except monsoon season. Many native species could not tolerate these conditions and decreasing its number very vastly. Loss of native species from river basin affects the



(a)



(b)



(c)

Fig. 3: Simple linear regression between density, percent cover and biomass of Papgani river basin.

ecosystem services and fluvial functions. As an outcome of these impacts, the river basin losing its water resources capacity and make the habitats more dry. Because of less water availability, many farmers left their cultivable lands as fallow land. Resulting local people have been forced to depend on the forest resources for meeting out the day to day needs of their life (Krishnaiah 2013) and added greater effect to the forest ecosystem of the river basin. The serial degradation in river basin affects the regular function of the fluvial plains and down streams. To safeguard the river ba-

sin from its degradation, the programs like watershed development, restoration of native species through afforestation, clearing of invaders, sustainable agricultural practices, reduce the human interventions and creating awareness among the people regarding natural resource usage and land management practice should be followed.

ACKNOWLEDGEMENT

The author wish to acknowledge Foundation for Ecological Security (FES), Anand, Gujarat, for funding, constant encouragement, supports and facilities provided during the study period. Many thanks are due to the Papgani Cell of FES, Andhra Pradesh, project staffs and field associates for facilitating during field visit and timely completion of this work. The author places heartfelt thanks to the Management of Amrita Vishwa Vidyapeetham (Amrita University), Tamil Nadu for support and facilities provided during the writing stage of this paper.

REFERENCES

Champion, H.G. and Seth, S.K. 1968. Revised Forest types of India. Government of India Publications, New Delhi.

Chiarucci, A., Wilson, J.B., Anderson, B.J. and De.Dominicis, V. 1999. Cover versus biomass as an estimate of species abundance: does it make a difference to the conclusions? Journal of Vegetation Science, 10: 35-42.

Clarke, K.R. and Warwick, R.M. 2001. Changes in Marine Communities: An Approach to Statistical Analysis and Interpretation. 2nd edition, PRIMER-E: Plymouth.

Dabadghao, P.M. and Shankarnarayan, K.A. 1973. The Grass Covers of India. Indian Council of Agricultural Research, New Delhi.

FES 2011. Eco-profiling of NABARD watersheds in Papagni river basin, Andhra Pradesh. A Report Prepared by Foundation for Ecological Security, Anand, Gujarat, India.

Gentry, A.H. 1986. Endemism in tropical versus temperate communities. In: Soule, M.E. (ed.) The Science of Scarcity and Diversity, Sinauer Assoicates, Sunderland, Masschusetts, pp. 153-181.

Grime, J.P. 2001. Plant Strategies, Vegetation Processes, and Ecosystem Properties, 2nd ed. John Wiley & Sons, Ltd., West Sussex, UK. 39-40.

Hart, S.A. and Chen, H.Y.H. 2008. Fire, logging, and overstory affect understory abundance, diversity, and composition in boreal forest. Ecological Monitoring, 78: 123-140.

Hefting, M.M., Clement, J.C., Bienkowski, P., Dowrick, D., Guenat, C., Butturini, A., Topa, S., Pinay, G. and Ver-hoeven, J.T.A. 2005. The role of vegetation and litter in the nitrogen dynamics of riparian buffer zones in Europe. Ecological Engineering, 24: 465-482.

Kabzems, R. and Lousier, J.D. 1992. Regeneration, growth and development of *Picea glauca* under *Populus* spp. canopy in the boreal white and black spruce zone. FRDA Research Program, Research Branch, BC Ministry of Forest. FRDA Report 176. Victoria, Canada.

Kern, C.C., Palik, B.J. and Strong, T.F. 2006. Ground-layer plant community responses to even-age and uneven-age silvicultural treatments in Wisconsin northern hardwood forests. Forest Ecology and Management, 230: 162-170.

Kiniry, J.R., Macdonald, J.D., Kemanian, A.R., Watson, B., Putz, G. and Prepas, E.E. 2008. Plant growth simulation for landscape-scale hydrological modelling. Hydrological Science Journal, 53: 1030-1042.

Krishnaiah, Y.V. 2013. Landuse pattern and landuse efficiency of the Papagni river basin, India. Indian Journal of Spatial Science, 4(1): 59-68.

Kruckeberg, A.R. and Rabinowitz, D. 1985. Biological aspects of endemism in higher plants. Annual Review of Ecology Systematics, 16: 55-87.

Legare, S., Bergeron, Y. and Pare, D. 2002. Influence of forest composition on understory cover in boreal mixedwood forests of Western Quebec. Silva Fennica, 36(1): 353-366.

Lewis, C.E., Swindel, B.E. and Tanner, G.W. 1988. Species diversity and diversity profiles: concept, measurement and application to timber and range management. Range Management, 41(6): 466-469.

Linera, G.W., Gastelu, V.D. and Zurita, E.G. 1997. Microenvironment and floristic of different edges in a fragmented tropical rainforest. Conservation Biology, 12(5): 1091-1102.

Magurran, A.E. 1988. Ecological Diversity and its Measurement. Princeton University Press, Princeton, N.J.

Mueller-Dombois, D. and Ellenberg, H. 1974. Aims and Methods of Vegetation Ecology. John Wiley & Sons, New York.

Muukkonen, P., Makipaa, R., Laiho, R., Minnkkinen, K., Vasander, H. and Finer, L. 2006. Relationship between biomass and percentage cover in understorey vegetation of boreal coniferous forests. Silva Fennica, 40: 231-245.

Naiman, R.J. and Decamps, H. 1997. The ecology of interfaces: Riparian zones. Annual Reviews of Ecology and Systematics, 28: 621-658.

Porte, A.J., Samalens, J.C., Dulhoste, R., Du Cros, R.T., Bosc, A. and Meredieu, C. 2009. Using cover measurements to estimate aboveground understorey biomass in Maritime pine stands. Annals of Forest Science, 66(3): 307.

Pullaiah, T. 1997. Flora of Andhra Pradesh (India) Vol III. Scientific Publishers Jodhpur, India, 922-1349.

Pullaiah, T. and Ali Mouali, D. 1997. Flora of Andhra Pradesh (India) Vol II. Scientific Publishers Jodhpur, India, 464-921.

Pullaiah, T. and Chennaiah, E. 1997. Flora of Andhra Pradesh (India) Vol I. Scientific Publishers Jodhpur, India, 1-463.

Rajendrakumar, S. 2014. Floristic Richness in catchment areas of Papgani River-A tributary of river Pennar, Andhra Pradesh, India. International Journal of Environment, 3(1): 177-204.

Rajendrakumar, S., Joshi, P.N., Joshua, J., Sunderraj, S.F.W., Kalavathy, S. and Ragunathan, P. 2011. Importance and conservation values of disturbed lands of the North Gujarat Region (NGR), Gujarat, India. Plant Sciences Feed, 1(8): 121-141.

Rottgermann, M., Steinlein, T., Beyschilag, W. and Dietz, H. 2000. Linear relationships between aboveground biomass and plant cover in low open herbaceous vegetation. Journal of Vegetation Science, 11: 145-148.

Shannon, C.E. and Wiener, W. 1949. The Mathematical Theory of Communication. University of Illinois Press, Urbana.

Turner, I.M., Tan, H.T.W., Wee, Y.C., Ibrahim, A.B., Chew, P.T. and Corlett, R.T. 1994. A study of plant species extinction in Singapore: Lessons for the conservation of Tropical Biodiversity. Conservation Biology, 8(3): 705-712.

West Brooks, R. 1991. Plant protection issues-I. a commentary on new weeds in the United State. Weed Technology, 5: 232-237.

Yadav, P.S. and Singh, J.S. 1977. Progress in Ecology Vol II, Grassland Vegetation. Its Structure, Function, Utilisation and Management. Today and Tomorrow Printers and Publishers, New Delhi.

Annexure 1: List of ground plant species recorded from Papgani River Basin.

Sl.	Scientific Name	Abundance	Density/sqm	Percent Cover	Biomass (t/ha)
1	**Acanthaceae**				
1	*Blepharis repans* (Vahl) Roth,*	187	0.18	0.05	
2	*Indoneesiella echioids* (L.) Sreemadh.*	9	0.01	0.03	0.00
3	*Indoneesiella longepedunculata* (Sreemadh.) Sreemadh*	3	0.00		
4	*Lepidagathis cristata* Willd.	300	0.29	0.10	
5	*Peristrophe paniculata* (Forssk.) Brummitt	6	0.01		
6	*Rostellularia procumbens* (L.) Nees*	28	0.03	0.02	
7	*Rostellularia simplex* Wight,*	2	0.00	0.14	
8	*Rungia repens* (L.) Nees*	29	0.03	0.09	
2	**Agavaceae**				
9	*Agave americana* L.	3	0.00	0.01	
3	**Amaranthaceae**				
10	*Achyranthes aspera* L. var. *Aspera*	10	0.01	0.13	
11	*Allmania nodiflora* (L.) R. Br. Ex Wight var. *aspera* (Heyne ex Roth) Hook. f.*	1	0.00		
12	*Amaranthus viridis* L.	3	0.00		
13	*Celosia argentea* L. var. *argentea**	74	0.07	0.32	0.02
14	*Celosia argentea* L. var. *cristata**	5	0.00	0.04	
15	*Digera muricata* (L.) Mart.*	9	0.01		0.01
16	*Pupalia lappacea* (L.) Juss. var. *lappacea*	7	0.01	0.04	
17	*Trichurus monsoniae* (L. f.) C. Towns.*	39	0.04	0.01	0.00
4	**Aristolochiaceae**				
18	*Aristolochia bracteolata* Lam.	13	0.01		
5	**Asteraceae**				
19	*Acanthosperum hispidum* DC.	56	0.05	0.09	0.00
20	*Blainvillea acmella* (L.) Philipson*	12	0.01	0.04	
21	*Dicoma tomentosa* Cass.*	11	0.01		
22	*Eclipta prostrata* (L.) L.	16	0.02	0.01	0.00
23	*Glossocardia bosvallea* (L. f.) DC.*	55	0.05		
24	*Gnaphalium polycaulon* Pers.	22	0.02	0.01	0.00
25	*Oligochaeta ramosa* (Roxb.) Wagenitz*	4	0.00		
26	*Parthenium hysterophorus* L.	140	0.13	0.61	0.01
27	*Pulicaria wightiana* L.f.*	27	0.03	0.13	0.00
28	*Tridax procumbens* L.*	202	0.19	0.20	0.01
29	*Vigna radiata* (L.) Wilczek *radiata**	1	0.00		
30	*Xanthium strumarium* L.	2	0.00	0.03	
6	**Boraginaceae**				
31	*Trichodesma indicum* (L.) R.Br.	5	0.00	0.01	0.01
7	**Caesalpiniaceae**				
32	*Cassia pumila* Lam.*	24	0.02	0.09	
33	*Cassia tora* L.	32	0.03	0.04	0.00
8	**Caryophyllaceae**				
34	*Polycarpaea corymbosa* (L.) Lam.*	2	0.00		
9	**Cleomaceae**				
35	*Cleome monophylla* L.*	1	0.00		
36	*Cleome simplicifolia* (Camb.) Hook. f. & Thoms.*	1	0.00		0.00
37	*Cleome visocsa* L.*	11	0.01	0.14	0.00
10	**Commelinaceae**				
38	*Commelina attenuata* J. Koenig ex Vahl*	4	0.00		0.00
39	*Commelina benghalensis* L.*	171	0.16	0.35	0.01
40	*Commelina clavata* C. B. Clarke*	1	0.00		
41	*Commelina diffusa* Burm. f.*	101	0.10	0.14	0.00
42	*Cyanotis tuberosa* (Roxb.) Schult. & Schult. f.*	30	0.03	0.01	0.00
43	*Tonningia axillaris* (L.) O. Kuntze*	48	0.05	0.15	0.03
11	**Convolvulaceae**				
44	*Convolvulus arvensis* L.*	40	0.04	0.01	0.00
45	*Evolvulus alsinoides* (L.) L.*	217	0.21	1.23	0.00
46	*Ipomoea eriocarpa* R. Br.*	3	0.00		

cont...

...cont.

47	*Ipomoea pes-tigridis* L.*	28	0.03	0.04	0.00
12	**Cucurbitaceae**				
48	*Coccinia grandis* (L.) J. O. Voigt*	1	0.00		
13	**Cyperaceae**				
49	*Cyperus articulatus* L.*	52	0.05	0.04	
50	*Cyperus difformis* L.*	65	0.06	0.01	
51	*Cyperus rotundus* L.*	111	0.11	0.08	
52	*Fimbristylis falcata* (Vahl) Kunth*	35	0.03		0.00
53	*Fimbristylis ferruginea* (L.) Vahl*	791	0.75	0.99	0.01
14	**Elatinaceae**				
54	*Bergia ammannioides* Roxb. ex Roth*	372	0.35	0.24	0.01
55	*Bergia capensis* L.*	186	0.18	0.06	0.01
15	**Euphorbiaceae**				
56	*Acalypha indica* L.*	24	0.02	0.03	
57	*Euphorbia heterophylla* L.	1	0.00		
58	*Euphorbia heyneana* Spreng.*	3	0.00		
59	*Euphorbia hirta* L.*	273	0.26	0.37	0.00
60	*Euphorbia parviflora* L.*	24	0.02	0.05	
61	*Euphorbia rosea* Retz.*	7	0.01		
62	*Euphorbia thymifolia* L.*	1	0.00		
63	*Phyllanthus amarus* Schum. & Thonn.*	31	0.03	0.06	
64	*Phyllanthus maderaspatensis* L.*	3	0.00		
65	*Phyllanthus virgatus* Forst. f.*	76	0.07	0.01	0.00
16	**Fabaceae**				
66	*Alysicarpus hamosus* Edgew.*	1	0.00	0.01	0.00
67	*Alysicarpus longifolius* (Rottl. ex Spreng.) Wight & Arn.*	2	0.00	0.03	
68	*Alysicarpus monilifer* (L.) DC.*	33	0.03	0.01	
69	*Alysicarpus vaginalis* (L.) DC.*	142	0.14	0.02	
70	*Arachis hypogaea* L.*	46	0.04	0.07	0.00
71	*Crotalaria medicaginea* Lam. var *medicaginea* Munk	12	0.01	0.02	
72	*Desmodium triflorum* (L.) DC.*	18	0.02	0.01	
73	*Goniogyna hirta* (Willd.) Ali*	76	0.07		
74	*Indigofera cordifolia* Heyne ex Roth*	34	0.03		
75	*Indigofera linifolia* (L. F.) Retz. var. *linifolia**	37	0.04	0.02	0.00
76	*Indigofera linnaei* Ali*	96	0.09	0.42	0.00
77	*Rhynchosia minima* (L.) DC.*	19	0.02	0.01	0.00
78	*Tephrosia purpurea* (L.) Pers.	173	0.16	1.15	0.02
79	*Tephrosia strigosa* (Dalz.) Sant. & Mahesh.	4	0.00		
80	*Vernonia cinerea* (L.) Less.*	50	0.05	0.04	
81	*Vigna trilobata* (L.) Verd.*	28	0.03		0.00
82	*Zornia gibbosa* Span.*	64	0.06		0.00
17	**Gentianaceae**				
83	*Enicostema axillare* (Lam.) Raynal*	62	0.06	0.44	
18	**Lamiaceae**				
84	*Leonotis nepetiifolia* (L.) R. Br.	144	0.14	0.03	0.00
85	*Leucas aspera* (Willd.) Link*	66	0.06	0.35	0.01
86	*Leucas biflora* (Vahl) R. Br.*	5	0.00		
87	*Leucas martinicensis* (Jacq.) R.*	12	0.01		
88	*Leucas stricta* Benth.*	154	0.15	0.07	
89	*Leucas urticaefolia* (Vahl) R. Br.*	3	0.00		
90	*Ocimum americanum* L.	38	0.04	0.08	0.00
91	*Orthosiphon rubicudus* (D. Don) Benth. *rubicundus*	19	0.02		
19	**Liliaceae**				
92	*Dipcadi erythraeum* Webbl. & Berth.*	50	0.05	0.03	
93	*Dipcadi montanum* (Dalz.) Baker.*	26	0.02		
94	*Scilla hyacinthina* (Roth) Macbr.*	5	0.00		
20	**Malvaceae**				
95	*Hibiscus lobatus* (Murr.) O. Kuntze,	1	0.00		
96	*Pavonia zeylanica* (L.) Cav.	8	0.01		
21	**Molluginaceae**				
97	*Molluga pentaphylla* L.*	8	0.01		
22	**Nyctaginaceae**				

cont...

...cont.

98	*Boerhavia diffusa* L.*	14	0.01	0.03	
99	*Commicarpus verticillatus* (Poir.) Standl.*	5	0.00	0.02	
23	**Onagraceae**				
100	*Ludwigia perennis* L.	3	0.00		
24	**Pedaliaceae**				
101	*Pedalium murex* L.	4	0.00		
25	**Poaceae**				
102	*Alloteropsis cimicina* (L.) Stspf*	47	0.04	0.01	
103	*Apluda mutica* L.	241	0.23	0.11	0.00
104	*Aristida adscensionis* L. var. *adscensionis*	163	0.16	1.80	0.00
105	*Aristida funiculata* Trin.& Rupr. var. *funiculata*	53	0.05	0.21	0.00
106	*Aristida hystrix* L.f.	4	0.00	0.01	0.00
107	*Brachiaria ramosa* (L.) Stapf*	40	0.04	0.03	0.01
108	*Brachiaria reptans* (L.) C. Gardner & C. E. Hubbard*	109	0.10	0.32	
109	*Cenchrus ciliaris* L.*	4	0.00	0.03	
110	*Cenchrus setigerus* Vahl*	2	0.00		
111	*Chloris barbata* Sw.*	91	0.09	0.21	
112	*Chrysopogon fulvus* (Spreng.) Chiov.*	2226	2.12	5.96	0.11
113	*Cymbopogon coloratus* (Hook. f.) Stapf	560	0.53	12.93	0.24
114	*Cymbopogon jwarancusa* (Jones) Schult.	6	0.01	0.05	
115	*Cymbopogon martinii* (Roxb.) Watson	13	0.01	0.10	
116	*Cymbopogon nardus* (L.) Rendle var. *confertiflorus* (Steud.) Stapf	195	0.19	0.61	0.04
117	*Cynodon barberi* Rang. & Tad.*	30	0.03	0.02	
118	*Cynodon dactylon* (L.) Pers.*	708	0.67	10.57	0.02
119	*Dactyloctenium aegyptium* (L.) Willd.*	133	0.13	0.20	0.01
120	*Dichanthium annulatum* (Forsk.) Stapf*	17	0.02	0.19	
121	*Dichanthium filiculme* (Hook. f.) Jain et Deshp.*	358	0.34	0.58	0.02
122	*Dichanthium pertusum* (L.) Clayton*	15	0.01	0.02	
123	*Digitaria ciliaris* (Retz.) Koel.*	239	0.23	0.80	0.00
124	*Digitaria longiflora* (Retz.) Pers.*	131	0.12	0.34	0.02
125	*Diplachne fusa* (L.) Beauv.*	23	0.02	0.07	
126	*Echinochloa colona* (L.) Link*	104	0.10	0.04	
127	*Echinochloa crusgalli* (L.) P. Baeuv.*	6	0.01	0.01	
128	*Eleusine indica* (L.) Gaertn.	247	0.24	0.46	0.01
129	*Eragrostis ciliaris* (L.) R. Br. var. *ciliaris**	6	0.01	0.04	
130	*Eragrostis japonica* (Thunb.) Trin.*	17	0.02	0.04	
131	*Eragrostis minor* Host.*	15	0.01	0.02	
132	*Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult.	4295	4.09	7.41	0.21
133	*Melanocenchris jacquemontii* Jaub. & Spach.*	7	0.01	0.02	0.01
134	*Oplismenus burmannii* (Retz.) P. Beauv.	48	0.05	0.03	
135	*Panicum paludosm* Roxb.*	57	0.05	0.04	0.00
136	*Panicum psilopodium* Trin.*	2	0.00		
137	*Setaria intermedia* Roem. & Schult.*	36	0.03	0.25	
138	*Setaria verticillata* (L.) P. Beauv.*	7	0.01	0.13	
139	*Sporobolus coromandelianus* (Retz.) Kunth*	34	0.03	0.01	
140	*Tetrapogon tenellus* (Koen. ex Roxb.) Chiov.*	34	0.03	0.01	
141	*Themeda triandra* Forssk.*	1	0.00	0.01	
26	**Polygalaceae**				
142	*Polygala erioptera* DC.*	2	0.00	0.05	
27	**Polygonaceae**				
143	*Polygonum plebeium* R. Br.*	93	0.09	0.04	
28	**Rubiaceae**				
144	*Hedyotis corymbosa* (L.) Lam.*	222	0.21	0.12	0.00
145	*Hedyotis puberula* (G. Don) Arn.*	4	0.00		0.00
146	*Sparmacoce articularis* L.f.*	238	0.23	0.08	
147	*Sparmacoce pusilla* Wall.*	375	0.36	0.04	
29	**Sapindaceae**				
148	*Cardiospermum halicacabum* L.*	1	0.00		
30	**Scrophulariaceae**				
149	*Lindernia ciliata* (Colsm.) Pennell*	2	0.00		
150	*Striga densiflora* (Benth.) Benth.*	41	0.04	0.01	
151	*Striga sulphurea* Dalz.*	73	0.07	0.09	

cont...

...cont.					
31	**Solanaceae**				
152	*Physalis minima* L.*	2	0.00	0.01	
32	**Tiliaceae**				
153	*Corchorus aestuans* L.*	37	0.04	0.03	
154	*Corchorus fascicularis* Lam.	2	0.00		
155	*Corchorus tridens* L.	3	0.00		
33	**Zygophyllaceae**				
156	*Tribulus terrestris* L.	14	0.01	1.01	0.00
		16946.00	**16.14**	**54.32**	**0.90**

*palatable species