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Analysis of Forest Volume Based on Height and Girth of Trees

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Abstract: This research is about the Correlation and Regression analysis in forest productivity, how the volume of a forest depends upon height and girth of the tree species in a particular habitat. It is very important for forest manager to know the productivity analysis for better management ofbiodiversity and sustainability. The correlation and regression of the data helps to analyze the dependency and determination of the volume using height and girth of the trees.

In an area taking the sample plots and conducting a survey for kind of tree species, their height and girth measurement to find out the volume and applying statistical tools like correlation and regression helped to analyze that there is correlation between these three variables. The primary data was collected in the sample plot of 20*20 in the region of Sirsi, Karnataka. It is analyzed that the height and girth have the significant impact on the volume of the trees and hence influence the productivity of the forest.

Index Terms - Productivity, Volume, Multiple linear regression, Biodiversity, Management, Tree species

I.INTRODUCTION

Effective Forest management decisions are reliant on the evaluation of the quality, quantity, and distribution of forest resources. To acquire this information, it is essential to systematically collectdata that characterizes the forest stands. However, the extensive nature of forest resources makes it unfeasible and uneconomical to measure the entire resources.

In addition to this, Biodiversity (BD) plays a crucial role in forest management, encompassing thediversity of living organisms and the ecological systems they inhabit. BD comprises not only the species present in the ecosystem but also their relationships and roles within the ecosystem. As a result, forest managers must consider BD when making decisions on forest management practices, including understanding the distribution of species, their roles in the ecosystem, and the relationships between them, in order to maintain healthy and sustainable forests. Regular monitoring of changes in BD over time can also provide valuable insight into the overall health ofthe forest ecosystem.

The assessment of biodiversity (BD) can be approached in various ways, but a comprehensive approach that considers the human factor is essential for effective evaluation and conservation prioritization. Foresters often face the challenge of determining the appropriate level at which to assess BD for the implementation of coordinated management practices.

Biomass serves as a significant indicator of ecological and management processes in vegetation. The dominant plant species on a site, in terms of biomass, are a reflection of the species that controlthe resources available, such as nutrients, water, and sunlight. Therefore, the measurement of biomass is commonly used to assess the ecological status of a site. Additionally, the amount of energy stored in vegetation, as reflected by measures of standing crop, can indicate the potential productivity of the site. Consequently, the estimates of biomass are useful for assessing rangeland condition.

Biomass refers to the total mass of living and dead plant material, including both above and below-ground components, such as trees, shrubs, vines, and roots. However, research on biomass estimation has primarily focused on aboveground biomass due to the challenges involved in collecting belowground data. Forest biomass is affected by several factors specific to the site, including stand density and site productivity.

II.General description of study area:

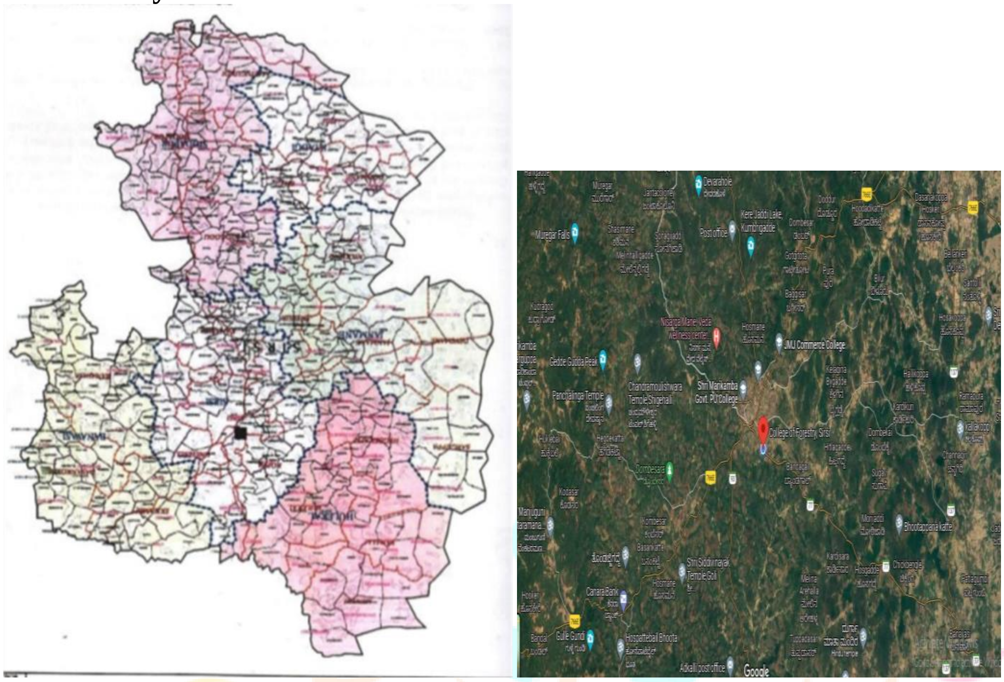

FIGURE 1: GEOGRAPHICAL LOCATION OF STUDY AREA

TABLE I: General description of study area.

Area studied: Sirsi range	**Altitude:** 611 m
Location :14.6ºN, 74.8ºE	The range **headquarters** is at Sirsi,
Type of forest: Moist deciduous, Evergreen.	The range covers 15026.74 **ha** of forest.
Rainfall: 2500-3500 mm	Semi-evergreen forest: **2336.36ha**
Avg annual Temperature: 23.9°C	Moist deciduous forestt: **12268.38ha**
	Scrub forest: **422ha**

So, from the total area of moist deciduous forest area a single 20*20 plot is taken as sample and used for analysis of productivity.

III.REVIEW OF LITERATURE

Inamati et al., 2005; conducted a study on the ecological analysis of vegetation across altitudinalgradients in the Devimane ghat of the UK district. Using species-area curves, a standard sample plot size of 30 x 30 meters was established. This study identified Knema attenuate, Alstonia scholaris, Vateria indica, and other species as dominant in different altitudinal zones. Interestingly,the study found that more than 57% of species were common across all the altitudinal zones (100,200, 300, 400, and 500 meters above MSL), as indicated by community similarity coefficients. Notably, the dominant species varied based on their adaptability and growth requirements.

In 2003, Raghu conducted ecological research on the vegetation characteristics of the Gersoppa forest range, which involved the analysis of the floristic composition and structure across variousaltitudinal zones. The study employed the quadrant sampling method with different ideal plot sizes,including 30x30m for trees, 10x10m for shrubs, and 2x2m for herbs. The dominant species withinthe area were identified as Knema attenuata, Syzygium gardneri, and Hopea ponga, among others.

Du et al., 2022; Responses of Forest Net Primary Productivity to Climatic Factors in Chinaduring 1982–2015 In his study he large-scale dynamics of net primary production (NPP) and its link with climatic conditions, which was crucial for national forest ecology and management, weremade clear in the study So, the purpose of this study was to investigate how significant climatic conditions affected the NPP estimated by the Carnegie-Ames-Stanford Approach (CASA) modelfor the entire forest and its associated vegetation types in China from 1982 to 2015.

Lal, 2019; Compositional and Structural Diversity of Forest Vegetation in Kais Wildlife Sanctuary, North Western Himalaya Conservation Implications This research was done in the KWLS to evaluate the structural and compositional diversity of the forest vegetation. 23 different types of forest communities, including broad-leaved evergreen, board-leaved deciduous,broad-leaved evergreen and coniferous mixed, broad-leaved evergreen and coniferous mixed, coniferous broad-leaved evergreen mixed, and coniferous board-leaved deciduous mixed communities, were identified, totaling 607 vascular plant species. The ecosystem of the forest hasbeen badly impacted by the haphazard harvesting of forest resources. The study comes to the conclusion that anthropogenic activities and shifting environmental circumstances pose serious dangers to natural resources.

Pant & Samant, 2012 Diversity and regeneration status of tree species in Khokhan Wildlife Sanctuary, north-western Himalaya In this study, they assessed the richness of tree species, identified forest tree communities, evaluated the pattern of tree species' regeneration, and recommended conservation actions. Eight of the 17 identified forest tree communities exhibited maximum regeneration of the dominant species, six exhibited maximum regeneration of the co- dominant species, indicating the potential for at least partial replacement of the dominant species by the co-dominant species in the future, and three communities exhibited poor or no regenerationof the dominant species, indicating a complete replacement of the dominants in the upcoming years.

Raja, 2015; The orchid Bulbophyllum tremulum Wight was first discovered in Tamil Nadu's Sirumalai highlands, in the Southern Eastern Ghats. The author described it in this taxonomic description. Before, it was thought that this species solely lived in the Western Ghats. As a result,this species' current collection is being recorded here as a new record for the Eastern Ghats.

Sathish et al., n.d.; Comparative assessment of floristic structure, diversity and regeneration statusof tropical rain forests of Western Ghats of Karnataka, India, one of the biodiversity hotspots, the Central Western Ghats, served as the site of this investigation. The study's objective was to examine the floristic diversity in tropical wet evergreen forests in Karnataka's northern and southern Western Ghats.
There was a total of 22 such samplings conducted across the southern and northern Western Ghats.All trees larger than 30 gbh in each of these transactions were counted, botanically classified down to the species level, and the same information was utilized to calculate diversity indexes. While the northern section of the Western Ghats had a higher concentration of vulnerable tree species, the southern part of the Western Ghats had a higher concentration of richness and diversity.

Sharma et al., 2014a, 2014b Floristic diversity and distribution pattern of plant communities along altitudinal gradient in sangla valley, Northwest Himalaya
In order to evaluate the vegetation's structure and trend along the valley's altitudinal gradient, this study was carried out in the Sangla Valley of the northwest Himalaya. This has made the quantitative and qualitative evaluation of the vegetation necessary. Several selected species that are sensitive to climate change were discovered to have their highest maximum altitudinal distributions in northeastern and northern parts.

IV. OBJECTIVE

To find the dependency of volume of trees based on their height and girth.

V. RESEARCH METHODOLOGY

Sampling technique

Quadrate method: As it is impossible to consider all the trees in the population, quadrates of 20m×20m are laid in each site and all the trees within the quadrates are botanically identified and vegetation is studied through sampling within the identified locations.

Parameters recorded were

1. Tree height measured using trigonometric instrument called Ravi altimeter
2. Tree girth at breast height (Measuring tape)
3. Tree species name

In quadrate method, 1 plot of 20m×20m was laid in moist deciduous forest of Sirsi range.
Estimation of Productivity: Volume per hectare in each transact is calculated for analyzingproductivity.
Volume = V= Form factor* basal area* Full height of the tree.
where Form factor is the reduction factor used for calculating volume taking tree cylinder to the actual size of the tree, as trees differ in shape due to aging and different forest management practices.
Basal area= (Girth of tree)/4π.

VI. DATA COLLECTION

Primary data was collected and the same is presented in Table II.

Table II: **D**ata collected in the field of a Forest Patch near Sirsi, UttarKannada, Volume calculated in 20*20 plot.

Plot 1	Quadrat method Vegetation: moist deciduous						Location: **Podembail14°35'28.1"N 74°50'36.3"E**		
Sl.no.	Tree species	Height (m)	Girth at tree base (m)	$(\text{Girth})^2$ at tree base (m^2)	Girth at BH (m)	$(\text{Girth})^2$ at BH (m^2)	Basal area (m^2)	Form factor	Volume (m^3)

1	*Acacia auriculiformis*	11	1	1.000	0.91	0.8281	0.065	0.83	0.60058
2	*Acacia auriculiformis*	10	0.79	0.624	0.66	0.4356	0.034	0.70	0.24206
3	*Acacia auriculiformis*	9	0.96	0.922	0.83	0.6889	0.054	0.75	0.36900
4	*Alseodaphne semecarpifolia*	12	1.64	2.690	1.2	1.44	0.114	0.54	0.73660
5	*Alseodaphne semecarpifolia*	11	1.5	2.250	1.31	1.7161	0.136	0.76	1.14632
6	*Aparosa lindleyna*	7	0.59	0.348	0.5	0.25	0.019	0.72	0.10007
7	*Aparosa lindleyna*	8	0.71	0.504	0.69	0.4761	0.037	0.94	0.28640
8	*Aporosa lindleyana*	7	0.87	0.757	0.7	0.49	0.039	0.65	0.17679
9	*Aporosa lindleyana*	7	0.91	0.828	0.8	0.64	0.050	0.77	0.27567
10	*Aporosa lindleyana*	8	0.71	0.504	0.64	0.4096	0.032	0.81	0.21198
11	*Aporosa lindleyana*	8	0.89	0.792	0.73	0.5329	0.042	0.67	0.22836
12	*Buchanania lanzan*	8	0.77	0.593	0.6	0.36	0.028	0.61	0.13923
13	*Buchanania lanzan*	8	0.89	0.792	0.75	0.5625	0.044	0.71	0.25443
14	*Careya arborea*	5	0.85	0.723	0.6	0.36	0.028	0.50	0.07141
15	*Careya arborea*	7	0.57	0.325	0.4	0.16	0.012	0.49	0.04391
16	*Careya arborea*	5	0.85	0.723	0.6	0.36	0.028	0.50	0.07141
17	*Diospyros melanoxylon*	8	0.67	0.449	0.49	0.2401	0.019	0.53	0.08180
18	*Diospyros melanoxylon*	8	0.73	0.533	0.56	0.3136	0.024	0.59	0.11755
19	*Gardenia gummifera*	4	0.33	0.109	0.11	0.0121	0.0009	0.11	0.00043
20	*Gardenia gummifera*	5	0.37	0.137	0.2	0.04	0.003	0.29	0.00465
21	*Olea dioica*	9	1.03	1.061	0.87	0.7569	0.060	0.71	0.38695
22	*Olea dioica*	8	0.7	0.490	0.51	0.2601	0.020	0.53	0.08794
23	*Olea dioica*	8	0.7	0.490	0.51	0.2601	0.020	0.53	0.08794
24	*Olea dioica*	8	0.7	0.490	0.51	0.2601	0.020	0.53	0.08794
25	*Olea dioica*	9	1	1.000	0.86	0.7396	0.058	0.74	0.39196
26	*Syzygium cumini*	13	1.3	1.690	1.03	1.0609	0.084	0.63	0.68931
27	*Syzygium cumini*	15	1.21	1.464	1.47	2.1609	0.172	1.48	3.80891
28	*Syzygium cumini*	11	1.4	1.960	0.87	0.7569	0.060	0.39	0.25599
29	*Terminalia chebula*	9	0.8	0.640	0.61	0.3721	0.029	0.58	0.15502
30	*Terminalia paniculata*	10	0.85	0.723	0.77	0.5929	0.047	0.82	0.38738
31	*Terminalia paniculata*	10	1	1.000	0.85	0.7225	0.057	0.72	0.41561
32	*Terminalia paniculata*	9	0.93	0.865	0.8	0.64	0.050	0.74	0.33935
33	*Terminalia paniculata*	8	0.69	0.476	0.5	0.25	0.019	0.53	0.08361
34	*Terminalia paniculata*	8	0.73	0.533	0.6	0.36	0.028	0.68	0.15490
35	*Terminalia paniculata*	9	0.95	0.903	0.82	0.6724	0.053	0.75	0.35897
36	*Terminalia paniculata*	9	0.97	0.941	0.8	0.64	0.050	0.68	0.31194
37	*Terminalia paniculata*	8	0.69	0.476	0.5	0.25	0.019	0.53	0.08361
38	*Terminalia paniculata*	8	0.73	0.533	0.69	0.4761	0.037	0.89	0.27093
39	*Terminalia paniculata*	7	0.69	0.476	0.58	0.3364	0.026	0.71	0.13247
40	*Terminalia tomentosa*	10	1.13	1.277	0.9	0.81	0.064	0.63	0.40909
41	*Terminalia tomentosa*	11	1.11	1.232	0.8	0.64	0.050	0.52	0.29115
42	*Terminalia tomentosa*	9	0.79	0.624	0.64	0.4096	0.032	0.66	0.19263
43	*Terminalia tomentosa*	10	0.83	0.689	0.7	0.49	0.039	0.71	0.27749
44	*Xylia xylocarpa*	7	0.88	0.774	0.73	0.5329	0.042	0.69	0.20438
45	*Xylia xylocarpa*	8	0.69	0.476	0.54	0.2916	0.023	0.61	0.11376
								Vol of plot	**15.13787**
	45							vol/ha	**378.446**

By taking Height and $(Girth)^2$ at BH as an independent variable and volume of the given tree species as the dependent variable the regression analysis run in excel gave the data below.

VII. RESULTS AND DISCUSSION

Table III. Correlation Output

Regression Statistics	
Multiple R	0.982
R Square	0.964
Adjusted R Square	0.962
Standard Error	0.33
Observations	49

Table IV. ANOVA Output

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	134.042	67.021	614.92	0
Residual	46	5.014	0.109		
Total	48	139.056			

Table V. Regression Output

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.18	0.177	-1.019	0.314	-0.536	0.176	-0.536	0.176
Height(m)	-0.019	0.023	-0.847	0.401	-0.065	0.026	-0.065	0.026
Girth at breast height	1.058	0.045	23.661	0	0.968	1.148	0.968	1.148

From the Table III, it is analyzed that the Coefficient of correlation between height, girth and volume is 0.982 which depicts that there is very strong positive correlation between the variables under consideration. The Coefficient of determination is 0.964, which means 96.4% of variation in volume is explained by the height and girth of the trees. The remaining is not explained by the model.

From Table IV, the F significance value is less than 0.05 which means the model is significant.

From Table V, the best fit line or the regression line connecting the considered variables is given below
Y=1.05*Girth-0.019*Height-0.18
This can be used for the prediction of Volume of further more trees in that population if we know the height of the particular tree.

The P value= 0 for girth factor which is less than 0.05 which indicates that the girth of a tree has significant impact on the volume. The P value= 0.401 for height factor which is greater than 0.05, hence height of the tree has a no significant impact on the volume of a particular tree. This is because of the consideration of multiple species trees in the same area.
Hence, the further scope of the study lies in analyzing the model for similar species of trees instead of a combination of them.

VIII. CONCLUSION

In conclusion, this analysis reveals that there is a strong correlation between the volume of the forest, the height and girth and of the trees. This suggests that taller and bigger trees typically contribute more to the growth of the forest. Additionally, species of trees have a strong positive correlation between their height and girth. For the purpose of forest management, the multiple regression analysis makes it possible to estimate the volume of the forest based on the height and girth values that are provided. In general, for efficient forest management and environmentally friendly practices, it is essential to comprehend the relationship between volume, girth, and height.

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