Aspect related changes in biomass stocks and carbon sequestration rates of *Shorea robusta* (Sal) forest of Central Himalaya

Vishal Singh
Department of Forestry
Kumaun University
Nainital- 263001
India
Ph: +919412506263
vishal.the.1st@gmail.com

Ashish Tewari
Department of Forestry
Kumaun University
Nainital- 263001
India
Ph: +915942236607
atewari69@gmail.com

Jeet Ram
Department of Forestry
Kumaun University
Nainital- 263001
India
Ph: +91594225197
jeetram2001@yahoo.com

Chandan Singh
Department of Botany
Kumaun University
Nainital- 263001
India
Ph: +919451574013
ctenvirus@gmail.com

Abstract
Biomass and carbon sequestration are one of the most controversial debates among scientists dealing with the importance of terrestrial ecosystems in mitigating global warming. Extrapolation of average biomass values, outmoded inventories and lack of scientific understanding are the crux of the dispute. For a better understanding this paper demonstrates the impact aspect related changes on biomass stocks and carbon sequestration rates of a similar aged young sal forest on adjoining aspects in Indian Himalayan region. The North Eastern aspect in spite of having lesser biomass showed greater sequestration rate than the South Eastern aspect which has higher biomass and less sequestration rate. Percent soil carbon also varied on the two aspects. [Report and Opinion. 2009;1(2):56-60]. (ISSN: 1553-9873).

Introduction

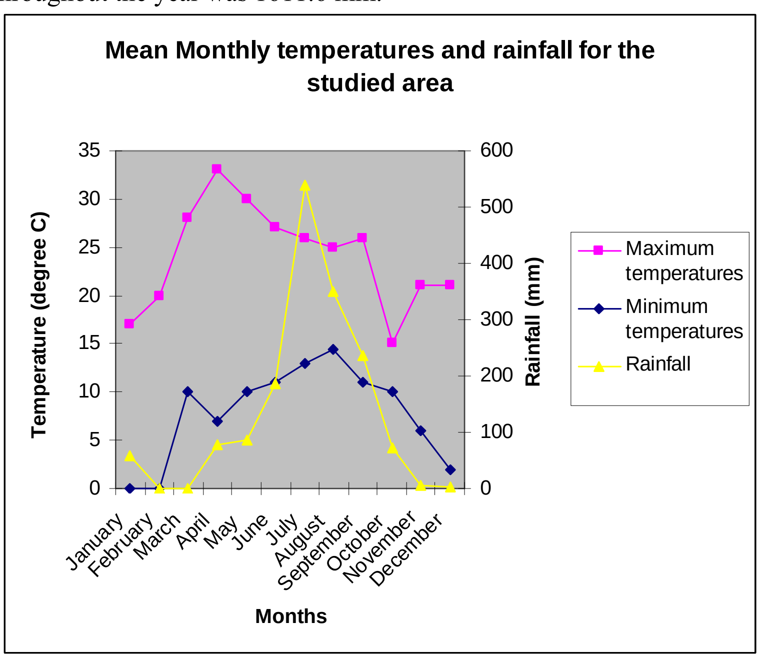
There is disturbing recent evidence about the unexplained carbon sinks and the uncertainty in the biomass stocks in the terrestrial ecosystem (Houghton 2002, Houghton 2005). These publications by Houghton have added extra urgency to work of terrestrial ecologists concerned with the carbon cycle. There is growing demand of accurate rates of biomass stocks and carbon sequestration rates in the warming world. Researcher know that is difficult to measure an annual carbon sequestration rate of even a small area, and impossible to quantify the change globally.

Biomass varies with environmental, anthropogenic and topographical factors. In spite of its importance in the present scenario, uncertainty in terrestrial biomass studies have persisted largely due to (i) the extrapolation of average biomass values used in most calculations for measuring biomass stocks till date, the possibility that anthropogenic disturbances, topographic features and environmental gradients occur in forests with biomass significantly different from average biomass, (ii) the inventories carried out for the measurement are out of date, incomplete or lacking. Extrapolation of results obtained from plots studied earlier can be problematic as most previous studies were concentrated to a fairly intact forest which will result to an overestimation of biomass.

Carbon sequestration rates and biomass stocks varies in time and space. A young forest would sequester more carbon than an old forest. Similarly, forests associated with better quality of soils would yield higher carbon sequestration rates. Evidently, different species will behave in a different manner; a faster growing species (Eucalyptus, Popular etc) would sequester more carbon than a slow glowing species (Oaks etc). However, the slow growing species might out perform the fast growing species with time. Nevertheless, generalizations are difficult to make. In a nutshell there are a number of factors that would influence the carbon sequestration rates of a forest i.e. temperature, rainfall, soil type and quality, biotic components like microbial growth, predation, pollination etc. Not to forget topographical features and human disturbance. Hence, without a greater understanding of all the above mentioned factors the biomass and carbon sequestration rates will be at best, reliant on some guesswork. The paper is focused on aspect related changes in biomass and carbon sequestration rates in the forest of *Shorea robusta* the dominant and most extensively distributed species on India

Site sites

The study sites lie between 29 ^{0} 21\`-29 $^0$ 24\`N latitude and 79^0 25\`- 79$^0$29\`E. A rise of 270 m in altitude corresponds to a fall of 1^{o}C in the mean temperature up to about 1500 m, above which the fall is more rapid (Singh and Singh 1987). Uttarakhand occupies an area of about 53,000km^2. This region is often called as Uttarakhand Himalaya, the eastern part of which is the Kumaun region where the forests of present study are present. *Shorea robusta,* has an absolute dominance below 800 m, begins to be replaced by *Pinus roxburghii* above 1200m in response perhaps to lower temperature and disturbances, both natural and man made. The altitudinal belt of 800-1000m is tension zone where a mixture of broad leaf species such as *Holoptelia integrifolia*, *Mallotus phillipinses* Mull. and *Terminalia tomentosa* Bedd., gain local preponderance due to weak tolerance of *Shorea robusta* but remain associated with it. The soil may vary from deep loamy sand to shallow residual mountain soil. The study was conducted between altitudes of 900m to 1100m. The maximum temperature was 33^o C in April and minimum 0^{o}C in January and February. The total rainfall throughout the year was 1611.6 mm.



Materials and Methods

The study was conducted during 2004 -2005. The data were collected from two aspects i.e. North eastern and South eastern aspects. The methods as given here pertain to data collection procedure and analysis for carbon accumulation in biomass and soil carbon of forests using acceptable allometric equations (Table. 1) for the encountered species in this study. The vegetation analysis was also made using 10 sample of 10x10m on each aspect. Density, frequency and basal area were also measured for the forest. For the estimation of tree biomass, tree and sapling occurring in permanent plots were categorized into different girth classes on the basis of their circumference taken in December 2003.These trees/saplings in each permanent plot were measured again in December 2004 i.e. after 12 months. Using the allometric equations the biomass of different components (bole, branch, twig, foliage, stump root. lateral root, and fine roots) in different girth classes was calculated separately from the circumference measured in 2003 (B1) and in 2004(B2). The net change in biomass (ΔB= B2- B1) yielded the annual biomass accumulation. For estimating soil carbon three pits were dug in both the aspects up to 90cm depth in different strata to best represent the forest in terms of slope, aspect, vegetation, density and cover. Form each pit soil samples were collected from 4 different soil layers (0-10; 10-30; 30-60; 60-90 cm). Soil carbon can be estimated by the following Walkey's and Black (1958). Phyto-sociological analysis was done following Mishra 1968.

Table1. Allometric relationship between the biomass of the tree components (y kg tree^{-1}) and girth to breast height (x,cm). The equation used was InY = a+b InX (Source Rawat & Singh 1988).

Biomass (Kg tree^{-1})	Intercept (a)	Slope (b)	r^2	s_yx
Bole	-2.83	1.98	0.98	0.12
Branch	-2.04	1.50	0.92	0.19
Twig	-2.69	1.46	0.98	0.09
Leaf	-1.74	1.18	0.96	0.15
Total	-1.79	1.89	0.98	0.11

Results

In the forest on the North eastern aspect the density of ***Shorea robusta*** was 590 trees/ha. The mean tree basal area was 3.47 m^2 ha^{-1} and the total basal area 20.473 m^2 ha^{-1}.In the South Eastern aspect the density of ***Shorea robusta*** was marginally lower (480 trees/ha) The mean basal area was 4.91 m^2 ha^{-1} and the total basal area was 28.983 m^2ha^{-1} .

The total biomass of the tree layer in the North Eastern aspect was 408.61t ha^{-1}which incremented to 411.28 t ha^{-1} in the next year of which approximately 53% is contributed by bole,13% by branch, 5% by twig and 4.2% by leaf .The total biomass production of this aspect is was 8.73 t ha^{-1}. The total biomass in the South Eastern aspect the total biomass was slightly higher as compared to the north eastern aspect. The total biomass was 413.88 tha^{-1} on the first year and then incremented to 415.76 t ha^{-1} in the next year, of which approximately 54% is contributed by bole, 12% by branch, 5.3%by twig and 3.77% is contributed by leaf. It is important to note that the total biomass was on the higher side but the total production is estimated to be lesser than the north eastern aspect. The NPP of north eastern aspect is 8.73 tha^{-1} and that of south eastern aspect was 3.21 t ha^{-1}, the carbon sequestration rates also varied in the two aspects. Thus, the total carbon also varied in both the aspects. The North Eastern aspect in spite of having lesser biomass showed greater sequestration rate than the South Eastern aspect which has higher biomass and less sequestration rate.

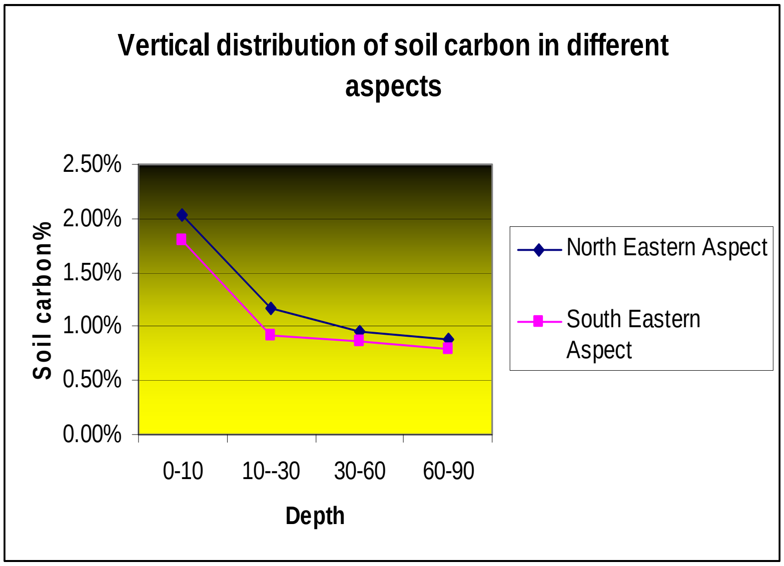
Table 2. Biomass and Carbon distribution in different tree components in North Eastern aspect

Component	B_1 (t ha^{-1})	B_2 (t ha^{-1})	ΔB (B_2-B_1)	Carbon (t ha^{-1})
BOLE	214.74 t ha^{-1}	219.81 t ha^{-1}	4.44 t ha^{-1}	2.22 t ha^{-1}
BRANCH	53.22 t ha^{-1}	54.20 t ha^{-1}	0.98 t ha^{-1}	0.49 t ha^{-1}
TWIG	23.25 t ha^{-1}	23.61 t ha^{-1}	0.36 t ha^{-1}	0.18 t ha^{-1}
LEAF	17.05 t ha^{-1}	17.32 t ha^{-1}	0.27 t ha^{-1}	0.135 t ha^{-1}
TOTAL	408.61 t ha^{-1}	411.28 t ha^{-1}	2.67 t ha^{-1}	1.33 t ha^{-1}

Table3. Biomass and Carbon distribution in different tree components in South Eastern aspect

Component	B_1 (t ha^{-1})	B_2 (t ha^{-1})	ΔB (B_2-B_1)	Carbon (t ha^{-1})
BOLE	224.40 t ha^{-1}	225.50 t ha^{-1}	1.1 t ha^{-1}	0.55 t ha^{-1}
BRANCH	51.25 t ha^{-1}	51.40 t ha^{-1}	0.15 t ha^{-1}	0.075 t ha^{-1}
TWIG	22.19 t ha^{-1}	22.24 t ha^{-1}	0.05 t ha^{-1}	0.025 t ha^{-1}
LEAF	15.65 t ha^{-1}	15.68 t ha^{-1}	0.03 t ha^{-1}	0.015 t ha^{-1}
TOTAL	413.88 t ha^{-1}	415.76 t ha^{-1}	1.88 t ha^{-1}	0.94 t ha^{-1}

The soil carbon concentrations in both the aspects were estimated up to 90cm depth. The soil carbon of the North Eastern aspect was found to be on the higher side than the soil carbon of South Eastern aspect. The top layers of the soil (0-10) in both aspect showed maximum carbon % 2.03% in South Eastern aspect and 1.79% North Eastern aspect and decreased up to 0.89 % in South Eastern aspect and 0.798% in North Eastern aspect in last (60-90) cm



Discussion

Site and vegetation mapping has shown that forest respond with great sensitivity to even minute differences in temperature and moisture regimes (Schoene, 1983). Modern technologies augment understanding of globe's carbon cycle and role of forests in it. However, forest inventories are indispensable to complement or substantiate estimates and models for quantifying vast carbon stocks and flows in forest ecosystem. Improved and more frequent inventories and forest assessments have become essential with the advent of obligatory carbon stock changes by countries (FAO, 2005). It is also not clear how much of the discrepancy is the result of omissions of management practices, natural and human induced disturbances, space and time and how much is the result of environmentally enhanced rates of tree growth on biomass and carbon sequestration rates.

References

FA0.. Afforestation and reforestation projects under the clean Development Mechnaium to Kyoto Protocol. Fact sheet role 2005 *WWW. Fao. Org/forestry/site/30/08/en.*

Houghton R. A. Terrestrial carbon sinks –uncertain explanations. *Biologist,* 2002 49 (4)

Houghton R. A., Aboveground Forest Biomass and the Global Carbon balance. *Global Change Biology*2005 *11, 945-948.*

Mishra, R., *Ecology Work Book.Oxford and IBH Publishing Company, Calcutta*1968 *,244pp*

Rawat Y. S., Singh J. S., Structure and function of oak forests in Central Himalaya. I. Dry Matter Dynamics. *Annals of Botany* 1988 *62: 413-427.*

Schoene,D.. The valuation and use of site information for Douglas-fir reforesteration in Western Oregon Ph.D. Thesis. *Oregon state university, Carvallis Oregon, USA.* 1983

Singh, S.P., Himalayan Forest Ecosystem Services. Incorporating in national accounting. Kyoto: *Think Global Act Local.* Central Himalayan Environment Association 2007 pp 12-13

1/4/2008