INTERNATIONAL JOURNAL
OF
CONSERVATION SCIENCE

ISSN: 2067-533X Volume 1, Issue 3, July-September 2010: 143-148 www.ijcs.uaic.ro

CARBON SEQUESTRATION POTENTIAL OF TREES ON TWO ASPECTS IN SUB-TROPICAL FOREST

Mehraj A. SHEIKH, Munesh KUMAR*

Department of Forestry, HNB Garhwal University, Srinagar Garhwal, Uttarakhand, India

Abstract

Forests are the largest terrestrial reservoir for atmospheric carbon. The present study investigated the species composition and tree carbon stocks in two different aspects (northern and southern) of sub-tropical region in Garhwal Himalaya. The results show that on northern aspect three species were observed, of which Pinus roxburghii was dominant. Similarly on southern aspect Anogeissus latifolia was dominant tree. Between the aspects and among the trees on each aspect, the maximum biomass was in Pinus roxburghii (132.96 t ha^{-1}*) on northern aspect while on southern aspect the maximum biomass was in Anogeissus latifolia (6.0 t ha*$^{-1}$*). The value of biomass was converted to carbon stock and amount of carbon stock was stored higher on northern aspect where the highest proportion among the species was in Pinus roxburghii. The study concluded that northern aspect favour the dominant growth of Pinus roxburghii and southern aspect of Anogeissus latifolia mixed forest in sub-tropical belt of Garhwal Himalaya, therefore, northern aspect have more carbon sequestration potential especially conifers than that of broadleaved forests on southern aspect.*

Keywords: *Carbon sequestration; north and south aspect; sub-tropical; Pinus roxburghii; Anogeissus latifolia*

Introduction

Since the beginning of industrial revolution, carbon dioxide concentration in the atmosphere has been rising alarmingly. Prior to the industrial revolution carbon concentration in the atmosphere was around 372 ppm [1]. If the pace of increase in carbon concentration remains constant, carbon concentration in the atmosphere would go up to 800-1000 ppm by the turn of this century [2].

Climate is probably the most important determinant of vegetation patterns globally and has significant influence on the distribution, structure and ecology of forests [3]. Several climate-vegetation studies have shown that certain climatic regimes are associated with particular plant communities or functional types [4, 5]. It is therefore logical to assume that changes climate would alter the configuration of forest in ecosystems [6].

Plants can contribute to mitigate green house effect and global warming. Terrestrial vegetation and soil currently absorb 40% of global carbon dioxide (CO_2) emission from human activities [7]. Forests are the largest terrestrial reservoir for atmospheric carbon. They remove CO_2 from the atmosphere and store it in the organic matter of soil and trees. The current carbon stock in tree biomass comprises half of the atmospheric storage and is continuing to grow despite deforestation, the rate of which is decreasing but still high [8]. The amount of carbon

---

* Corresponding author: muneshmzu@yahoo.com

stored in a forest stand depends on its age and productivity. The terrestrial carbon sink, inferred from changes in the concentrations of atmospheric gases and their isotopic composition, is normally attributed to the global increase in productivity [9, 10].

The reduction in concentration of CO_2 in atmosphere can be achieved either by reducing the demand for energy or by altering the way the energy is used and by increasing the rates of removal of CO_2 from atmosphere through growth of terrestrial biomass e.g. forests [11]. The most promising management practices for CO_2 mitigation are reforestation in temperate latitudes, and agroforestry and natural reforestation in the tropics. The 1997 Kyoto protocol to the climate convention recognizes that drawing CO_2 from air into the biomass is the only practical way for mitigation of the gas from the atmosphere [12, 11]. The direct solution to the problem is reducing CO_2 emission. However, the costs of the approach may be prohibitive for industrialized countries due to its adverse effects on their production [13]. The Himalaya zones cover nearly 19% area and contribute 33% of soil organic carbon reserves of the country, largely due to thick forest vegetation [14].

Therefore, the present study is undertaken to understand forest community composition and estimate above ground tree biomass and carbon stock stored in sub-tropical mixed forest of Garhwal Himalaya.

Materials and Methods

Two mixed forest stands on different aspects i.e., northern aspect and southern aspect were selected for the study. The study site was located between 30^0 29’ N and 78^0 24’ E in the District Tehri Garhwal at an elevation range from 800-1000 m asl.

The vegetation analysis on the aspect was done in rainy season (August to September) and tree more than 30 cm girth at breast height was only considered for analysis. Ten quadrats (each of 10 m x 10 m size) were laid out in transect in each aspect. The vegetation data were quantitatively analyzed for abundance, density and frequency [15]. The importance value index (IVI) was determined as the sum of the relative frequency, relative density and relative dominance [16].

Estimating above ground biomass sampling was done by the nested plot design method for each hectare as described by Hairiah *et al.* [17]. The diameter at breast height (dbh) was measured with caliper and height with Ravi’s multimeter, form factor was calculated with Spiegel relaskope to find out tree volume using the formula given by Pressler [18] and Bitterlich [19]

$$F = 2\, h_1 / 3h \qquad (1)$$

where, F is the form factor, h_1 is the height at which diameter is half dbh and h is the total height. Volume (V) was calculated by using the Pressler formula [18] as used by Koul and Panwar [13]

$$V = F \times h \times g \qquad (2)$$

where F is the form factor, h is the total height and g is the basal area and calculated as:

$$G = \pi r^2 \quad \text{or} \quad (dbh/2)^2 \qquad (3)$$

where r is the radius, thus biomass of wood was estimated using following equation:

$$\text{Biomass} = \text{Specific gravity} \times \text{Volume} \qquad (4)$$

The values of specific gravity for these species were collected from Timber Mechanics Division, Forest Research Institute, Dehradun.

The total number of branches irrespective of size was counted on each of the sample trees. These branches were categorized on the basis of basal diameter into three groups, viz < 6 cm, 6-10 cm and >10 cm. Fresh weight of two branches from each size group was recorded separately. Dry weight of branches was estimated by using following equation given by Chidumaya [20] as

$$B_{dwi} = B_{fwi} / 1 + M_{edbi} \quad (5)$$

where B_{dwi} is the oven dry weight of branches, B_{fwi} the fresh / green weight of branches and M_{edbi} the moisture content of branches on dry weight basis. Total branch biomass (fresh / dry) per sample tree was determined as follows

$$B_{bt} = n_1\, bw_1 + n_2\, bw_2 + n_3\, bw_3 = \sum_{i=1}^{n} n_1\, bw_i \quad (6)$$

where B_{bt} is the branch biomass (fresh / green) per tree, n_i the no of branches in the ith branch group and i = 1, 2, 3 …….. the branch groups [13].

Leaves from five branches of individual trees were removed. Five trees per quadrant were taken randomly for observation. The leaves were weighed and oven dried separately to a constant weight at 80 ± 5 °C. The average leaf biomass was then arrived at by multiplying the average biomass of the leaves per branch with the number of branches in a single tree and then the number of trees in a quadrant [20, 13].

To arrive at the amount of sequestered carbon content, biomass was converted into carbon by multiplying with a factor of 0.45 [21, 13].

Results and Discussion

Vegetation analysis

On northern aspect three species i.e., *Pinus roxburghii, Terminalia bellirica, Terminalia tomentosa* were observed. The dominant species on this aspect was *P. roxburghii* having highest (860 trees ha^{-1}) value of density (Fig.1) followed by *T. tomentosa* (80 trees ha^{-1}) and *T. bellirica* (40 trees ha^{-1}). The total basal cover values of *P. roxburghii, T. tomentosa* and *T. bellirica* were 18.14 $m^2\ ha^{-1}$, 1.36 $m^2\ ha^{-1}$ and 1.45 $m^2\ ha^{-1}$ respectively. The values clearly indicate the dominance of *Pinus roxburghii* forest on this aspect (Fig.2).

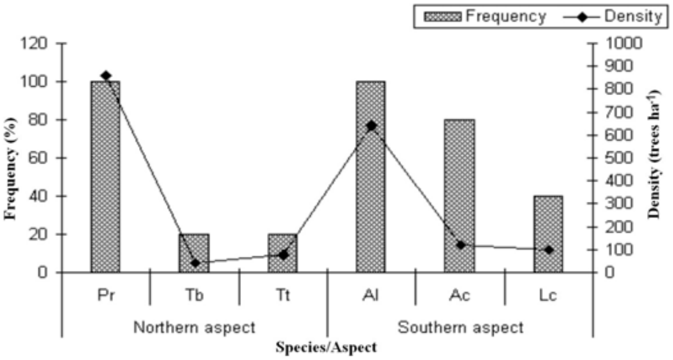

Fig.1 Frequency and density of species on northern and southern aspects
Pr-*Pinus roxburghii* Tb-*Terminalia bellirica* Tt-*T. tomentosa*
Al-*Anogeissus latifolia* Ac-*Acacia catechu* Lc-*Lannea coromendelica*

On southern aspect, three species were also observed i.e., *Anogeissus latifolia, Acacia catechu* and *Lannea coromandelica*. Among the species *A. latifolia* was dominant. The tree density of *A. latifolia* was highest (640 trees ha^{-1}) compared to *A. catechu* and *L. coromandelica* whose densities were 120 trees ha^{-1} and 100 trees ha^{-1} respectively (Fig. 1). Total basal cover of *A. latifolia, A. catechu* and *L. coromandelica* was 1.71 $m^2\ ha^{-1}$, 1.28 $m^2\ ha^{-1}$ and 0.25 $m^2\ ha^{-1}$ respectively (Fig.2).

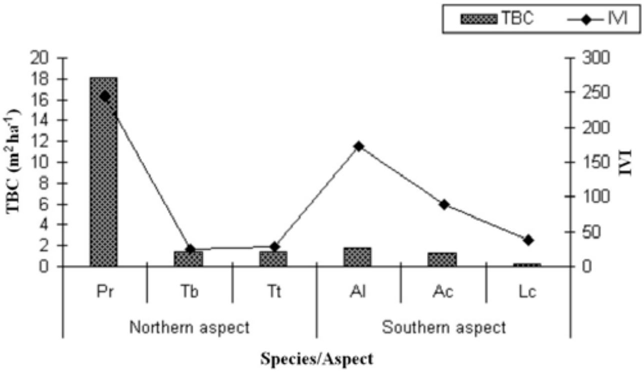

Fig.2 Total basal cover and importance value index of species on northern and southern aspects
Pr-*Pinus roxburghii* Tb-*Terminalia bellirica* Tt-*T. tomentosa*
Al-*Anogeissus latifolia* Ac-*Acacia catechu* Lc-*Lannea coromendelica*

Biomass and carbon stock

Aboveground biomass and carbon stock on northern and southern aspects is shown in Table 1. On northern aspect the biomass was maximum in *P. roxburghii* (132.96 t ha^{-1}) followed by *T. bellirica* (18.58 t ha^{-1}) and *T. tomentosa* (2.40 t ha^{-1}). While on southern aspect the maximum biomass was in *A. latifolia* (6.00 t ha^{-1}) and minimum in *L. coromandelica* (0.17 t ha^{-1}). The values of biomass was converted into carbon stock and the maximum carbon was stored in northern aspect in order of *P. roxburghii*>*T. bellirica*>*T. tomentosa*. In southern aspect the maximum carbon stock was in *A. latifolia* followed by *A. catechu* and *L. coromandelica.*

Table 1. Volume (m^3 ha^{-1}), specific gravity (g cm^{-3}), biomass (tones ha^{-1}) and carbon (tones ha^{-1}) of species in two different aspects

Site	**Species**	**Volume (m^3 ha^{-1})**	**Specific gravity (g cm^{-3})**	**Biomass (tones ha^{-1})**	**Carbon (tones ha^{-1})**
Northern aspect	*Pinus roxburghii*	270.8	0.491	132.96	59.83
	Terminalia bellirica	29.6	0.628	18.58	8.36
	T. tomentosa	3.4	0.707	2.40	1.08
Southern aspect	*Anogeissus latifolia*	8.12	0.739	6.00	2.70
	Acacia catechu	6.62	0.875	5.79	2.60
	Lannea coromendelica	0.36	0.497	0.17	0.07

Between the aspects, the maximum carbon stock was in northern aspect as compared to southern aspects, which might be due to higher density and total basal cover of the trees. Agnihotri *et al.*, [22] also indicated that aspect and physiographic positions, particularly on hills are expected to influence vegetation cover, because the southern and eastern facing slopes have early sun shine of the day, while northern and western aspects receive sun during the later parts of the day. Therefore, the southern aspect was hotter than the northern aspect which results in less moisture on southern aspects and higher evaporation. The higher moisture content on northern aspect favours maximum biomass production compared to southern aspect, because its natural regeneration is better on the northern aspect than on the southern aspect [23]. Among the species on aspects, the maximum amount of carbon was stored in *Pinus roxburghii* which was due to its higher biomass (Table 1). The results shown that, the wood which constitute maximum portion of biomass also stored maximum amount of carbon. Among the forests, conifer forests sequester maximum carbon than of deciduous forests. Similar finding also reported by Negi *et al.* [24], when compared with other life forms and observed that the maximum carbon was stored by conifers trees followed by deciduous trees, evergreen trees and bamboos. Thus conifers are more efficient in carbon sequestration especially *Pinus roxburghii* on northern aspect.

The forest of the study area is under highly anthropogenic threat, because the rural people are fully depend on these forests for their daily needs i.e., fuel, fodder, minor timber etc. The villager demand and its consequences, the forests have been depleting much faster rate. Atmospheric CO_2 concentrations have been increasing in response to the disruption of the global carbon cycle by anthropogenic activities such as deforestation, construction of dam, agricultural practices and burning of fossil fuels on these areas, which results in large shifts among carbon pools. Similar findings have been given by Rustand *et al.* [25]. Therefore some management practices need to be implemented to save these forests against various threats, so the carbon pools of these forests can be saved.

Conclusion

The study concluded that the northern aspect favors the carbon sequestration potential in the sub-tropical belt of Garhwal Himalaya due to dominance of *Pinus roxburghii* than that of southern aspect. Although each species on both the aspects played important role in carbon sequestration, the existing forest of *Pinus roxburghii* and its regeneration should be managed against anthropogenic treat for future environmental security.

References

[1] R.F. Sage, *Was low atmospheric CO_2 during the Pleistocene a limiting factor for the origin of agriculture*, **Global Change Biology, 1,** 1995, pp. 93-106.

[2] J. M. Whipps, *Carbon economy*, **The Rhizosphere** (ed. Lynch.J.M.), Wiley, New York, 1990, pp. 59-97.

[3] M. U. F. Kirschbaum, M. G. R. Cannell, R. V. O. Cruz, , W. Galinski and, W. P. Cramer, *Climate change impacts on forests*, **Climate Change 1995, Impacts, Adaptation and Mitigation of Climate Change: Scientific–Technical Analyses**, Cambridge University Press, Cambridge, 1996.

[4] L. R. Holdridge. *Determination of world plant formations from simple climatic data*, **Science, 105,** 1947, pp. 367–368.

[5] C. W. Thornthwaite, *An approach toward a rational classification of climate*, **Geographical Review, 38,** 1948, pp. 55–94.

[6] A. M. Solomon, *Transient responses of forests to CO_2-induced climate change: simulating modelling experiments in eastern North America*, **Oecologia, 68,** 1986, pp. 567–579.

[7] D. Adam, *Royal society disputes value of carbon sink*, **Nature, 412,** 2001, p. 108.

[8] R.T. Watson, I.R. Noble, B. Bolin, , N.H. Ravindranath, , D.J. Verardo, D.J. Dokken**, Land Use, Land-Use Change and Forestry**, Cambridge University Press, 2000, p. 377.

[9] J.Q. Chambers, N. Higuchi, E.S., Tribuzy, S. E. Trumbore, *Carbon sink for a century*. **Nature, 410**, 2001, p. 429.

[10] C, Boisvenue, S.W. Running, *Impacts of climate change on natural forest productivity - evidence since the middle of the 20th century*, **Global Change Biology, 12**, 2006, pp. 862-882.

[11] S. Bhadwal, R. Singh, *Carbon sequestration estimates for forestry option under different land-use scenarios in India,* **Current Science, 83,** 2002, pp. 1380-1386.

[12] J.K. Winjum, R.K. Dixon, P.E. Schroeder, **Water, Air and Soil Pollution, 64** 1992, pp. 213-228.

[13] D.N. Koul, P. Panwar, *Prioritizing land: management options for carbon sequestration potential,* **Current Science, 95,** 2008, pp. 658-663.

[14]T. Bhattacharyya, D. K. Pal, P. Chandran, S.K. Ray, C. Mandal, , B. Telpande,. *Soil carbon storage capacity as a tool to prioritize areas for carbon sequestration*, **Current Science, 95**, 2008, pp. 482-494.

[15] J. T. Curtis, R.P. McIntosh, *The Interrelation of certain analytic and synthetic phytosociological characters*, **Ecology, 31,** 1950, pp. 434-455.

[16]J. T. Curtis, **The Vegetation of Wisconsin. An Ordination of Plant Communities**, University Wisconsin Press, Madison Wisconsin, 1959, p. 657.

[17] K. Hairiah, S.M. Sitompul, M. Noordwijk, C. Palm, **Methodology for Sampling Carbon Stocks Above and Below Ground. ASB Lecture Notes 4B,** International Centre for Research in Agro forestry, Indonesia, 2001, http://www.icraf.cgiar.org/sea.

[18] M. Pressler. **Das Gesetz der Stambildung Leipzig**, 1895, p.153.

[19] W. Bitlerlich, **The Relaskop Idea Slough: Commonwealth Agricultural Bureause**, Farnham Royal, England, 1984.

[20] E.N. Chidumaya, *Aboveground woody biomass structure and productivity in a Zambezian woodland*, **Forest Ecology and Management, 36**, 1990, pp. 33-46.

[21] P.L. Woomere, *Impact of cultivation of carbon fluxes in woody savannas of southern Africa.* **Water, Air and Soil Pollution, 70**, 1999, pp. 403-412.

[22] R. Agnihotri, P. Prasad, R. Prasad, R. D. Aggarwal. *Effect of aspect and physiographic position of vegetation cover in a Shivalik watershed at Relmajra, Panjab,* **Indian Journal of Forestry, 29**(1), 2006**,** pp. 9-13.

[23] R. K. Luna, **Plantation Trees,** International Book Distributor, Dehradun 2005.

[24] J.D.S. Negi, R.K Manhas, P.S. Chauhan, *Carbon allocation of different components of some tree species of India: A new approach for carbon estimation,* **Current Science**, **85**, 2003, pp. 1528-1531.

[25] L. E. Rustand, T. G. Huntington, R. D. Boone, *Controls on soil respirations: Implications on climate change*, **Biogeochemistry**, **48**, 2000, pp. 1–6.

Received: July 8, 2010
Accepted: July 30, 2010