STUDY ON SELECTIVE TREE SPECIES FOR CARBON REDUCTION IN NORTH MAHARASHTRA UNIVERSITY, CAMPUS, JALGAON (M.S.), INDIA

S.R. Thorat*

K. P. Dandge*

Abstract:

In the present investigation, total carbon sequestered trees in the campus of North Maharashtra University, Jalgaon was studied. The biomass and total organic carbon of standing trees was estimated by non destructive method. A total 11 trees species having diameter > 10cm DBH was considered for study to know the sequestered standing carbon stock in tree species grown in university campus area. Theodolite is used for the measurement of angle between tree top and observer. It was observed that allometric model based on theoretical model can success used to determine the tree biomass by non-destructive method so, the total biomass and total organic carbon has been determined and compared with model. Understanding of standing carbon stock in North Maharashtra University campus trees is an important knowledge base for management decision making for forest generation programmes aimed at mitigating climate change, biodiversity loss, sociological and hydrological issues. In the present investigation, the study examines carbon storage in tree biomass of above 10cm DBH in a regenerating university campus forest stand.

Key words: *Reduction, trees species, Carbon storage, North Maharashtra University Campus area.*

* School of Environmental and Earth Sciences, North Maharashtra University, Jalgaon, MS, India

Introduction:

Jalgaon city is situated in north-west Maharashtra bounded by Satpuda mountain ranges in the north and Ajanta mountain ranges in the south. Jalgaon city lies between 75° 31' 36.39" to 75° 36' 5.30"E Longitude and 20° 58' 22.40" to 21°01'26.35"N Latitude. The average rainfall of the city is 700-750 mm which categories it as semi-arid region. Temperature extends from 10° to 46° C. the forest plays major role in the global carbon cycle; they encompass over a third of terrestrial carbon stock and contribute approximately 30% of terrestrial net primary productivity. Not only are many temperate forests under direct threat from land use changes and logging (Defries *et.al.*, 2002; Achard *et. al.*, 2002) but it has also been suggested that pristine, apparently undisturbed these forest may also be undergoing widespread shifts in carbon stocks and floristic composition as a result of large scale anthropogenic environmental changes (Hughes *et. al.*, 1999). Carbon dioxide (CO_2) capture and sequestration (CCS) is a set of technologies that can greatly reduce CO_2 emissions from new and existing coal and gas fired power plants and large industrial sources. CCS is a three-step process that includes: Capture of CO_2 from power plants or industrial processes, Transport of the captured and compressed CO_2 (usually in pipelines) and Underground injection and geologic sequestration (also referred to as storage) of the CO_2 into deep underground rock formations. These formations are often a mile or more beneath the surface and consist of porous rock that holds the CO_2. Overlying these formations are impermeable, non-porous layers of rock that trap the CO_2 and prevent it from migrating upward. Above-ground biomass, below-ground biomass, dead wood, litter and soil organic matter are the major carbon pools in any ecosystem (FAO, 2005; IPCC, 2003; IPCC, 2006). The increasing carbon emission is of major concerns for entire world as well addressed in Kyoto protocol (Chavan and Rasal, 2010; Ravindranath, *et. al.,* 1997). The Kyoto Protocol, prepared by the United Nations in the Framework of Convention on Climate Change stipulates Clean Development Mechanisms (CDM) and its Joint Implementation whereby storage of carbon in various terrestrial sinks may be acceptable for insertion in national greenhouse gas inventories of each nation.

The rehabilitation of degraded lands through the establishment of tree plantations and agro-forestry may play an important role in sequestering CO_2. These strategies have become popular in many places due to a combination of economic return and the environmental benefits they provide (Aggangan 2000); however, there is little information on the carbon budgets of tropical tree plantations and tree farms. This information is needed for a more accurate picture of their role in mitigating climate change.

In the present investigation, the aim of the study was to predict the carbon stocks and sequestration of small holder tree in North Maharashtra University Campus, Jalgaon with captures carbon from the atmosphere and act as sink, stores and same in the form of fixed biomass during the growth process, therefore growing trees in North Maharashtra University Campus areas can be potential contributor in reducing the concentration of CO_2 in atmosphere by its accumulation in the form of biomass. The field measurement was done in the NMU campus followed by volume, biomass and carbon storage and sequestration prediction. With approximately 50% of dry forest biomass comprised of carbon, biomass assessment also illustrates the amount of carbon that may be lost or sequestered under different forest management regimes.

Material and Methods:

Site description: The North Maharashtra University is located in Dharangaon taluka between 20^0 and 21^0 north latitude and 74^0 55' to 76^0 28' east longitudes, in the northern part of the Maharashtra state of Jalgaon district. The site is managed as a Teak cultivation 16 years ago and is currently being converted to a temperate forest ecosystem through assisted forest regeneration activity. The area receives an annual average rainfall of 690.2mm. Topographically, the site is located in a low mountainous area at an elevation of 209 m above sea level. This area is adjacent to a social forestry of Takarkheda and Paladhi village areas. The current land use type of the site is shown in figure A, B and C.

Field Methods: Considering the available time, resources and extent of forest, woody flora were enumerated in 10mx10m sampling plots (13 in total) laid in randomly selected locations in University campus area representing different vegetation types. These were permanent sampling plots earmarked not only for forest carbon studies but also for other ecological parameters, especially for long term observation of changing structure and composition of regenerating flora. In each plot, all trees > 10 cm in DBH (diameter at breast height) were tagged identified botanically and diameters measured to the nearest millimeter. The default point of measurement was at 130 cm above ground following standard forestry techniques.

Estimation of Tree Biomass from Field Inventories: The biomass and total organic carbon of standing trees was estimated by non destructive methods. Above-ground biomass was calculated using a regression model that converts stem diameter, wood density and tree height into an estimate of total oven-dry above-ground biomass. The evaluation looked for the contribution of above-ground carbon of woody plants ≥10 cm in DBH. The following allometric regression model was applied for individual plants to convert the inventory data into above ground biomass.

$$AGB = 0.0509 \times q\ D2\ H$$

Where,

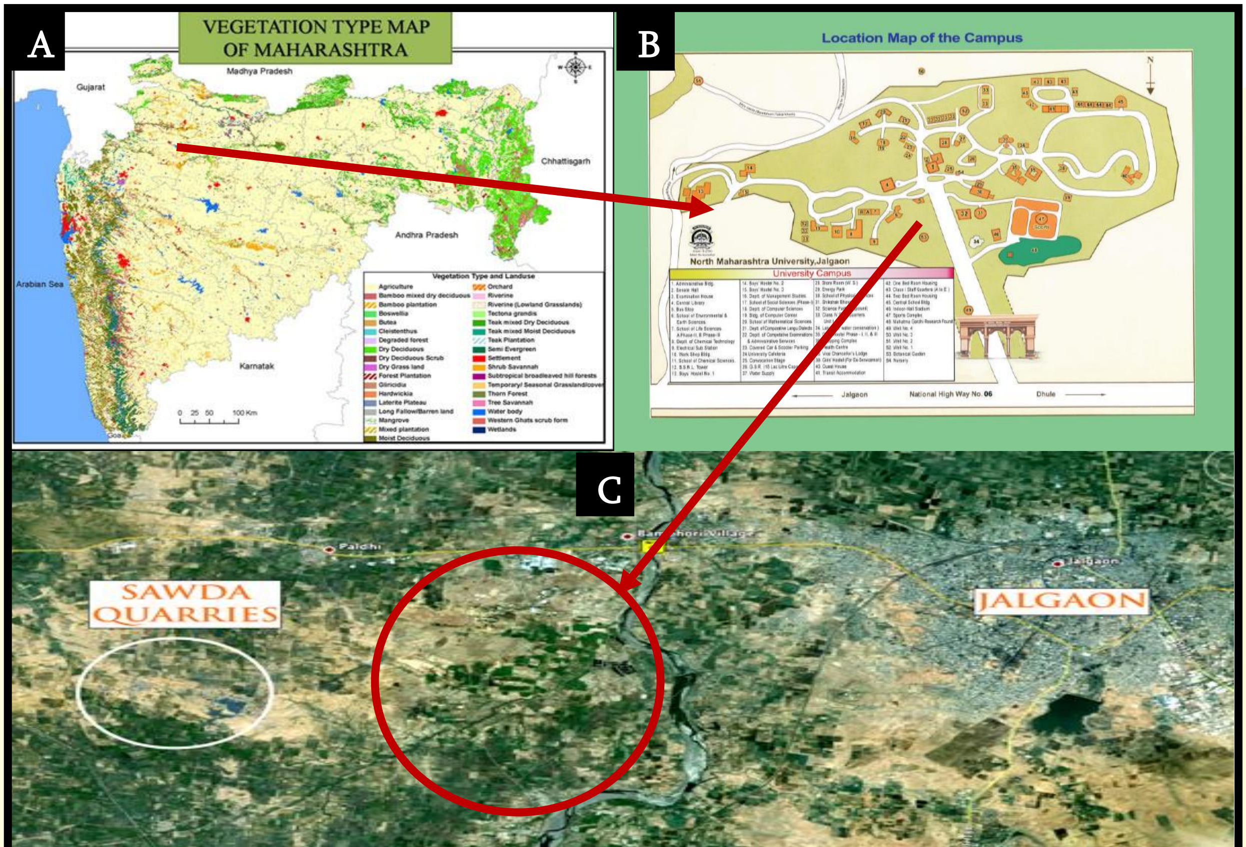
AGB = above-ground tree biomass [kg]; q = wood specific gravity [g cm^3]; D = tree diameter at breast height [cm]; and H = tree height [m].

The allometric regression model was selected on account of published literature which revealed that it is most suitable for use with tropical forests and biogeographic zone of the present investigation. Wood densities were taken from Zanne *et. al.*, 2009 and Forest Department. Wherever the wood density of tree species was unavailable, the mean value of the relevant plant genera was taken from Zanne *et. al.*, 2009 which is the best option as per Chave *et. al.*, 2006. In case the wood density is not available for at least the generic level, the standard average value of 0.6 g/cm^3 was taken. The below-ground biomass was calculated considering 15% of the above-ground biomass. The sum of the above-ground biomass and the below-ground biomass was the total tree biomass. The total biomass was divided by 2 in order to calculate the amount of carbon in biomass. In the case of multiple-stemmed trees, the allometric model was applied to each stem and summed, to provide a tree-level aboveground biomass estimate.

Constraints and Limitations: The estimation of carbon content during the present study may be influenced by the following constraints and limitations; Limitations associated with the use of allometric equation that was not developed for exactly the same forest species and forest sub type. Minor variations may arise when used in different locations. Element of subjectivity related to approximation of wood densities and possible errors of laser finder instrument. Limitations related to small size of the samples adopted considering time and resource constraints.

Measurement of tree height: To estimate biomass from selective tree species it is not advisable to cut them. The biomass can be measured by mathematical models by measuring Diameter at

Breast Height (DBH) directly and the girth at DBH. Girth considered is the DBH measured at breast height at approximately 1.3 meter and diameter of tree having diameter above >10 cm are treated as trees and are measured. The tree height was measured by Theodolite at DBH. The angle between the tree top and eye view at breast height angle (α) is taken into consideration for tree height measurement and height of the tree is calculated.



A: Showing vegetation type in Maharashtra, India; B: Showing Location of North Maharashtra University Campus where the study is carried our; C: GPS Location of North Maharashtra University and Jalgaon city

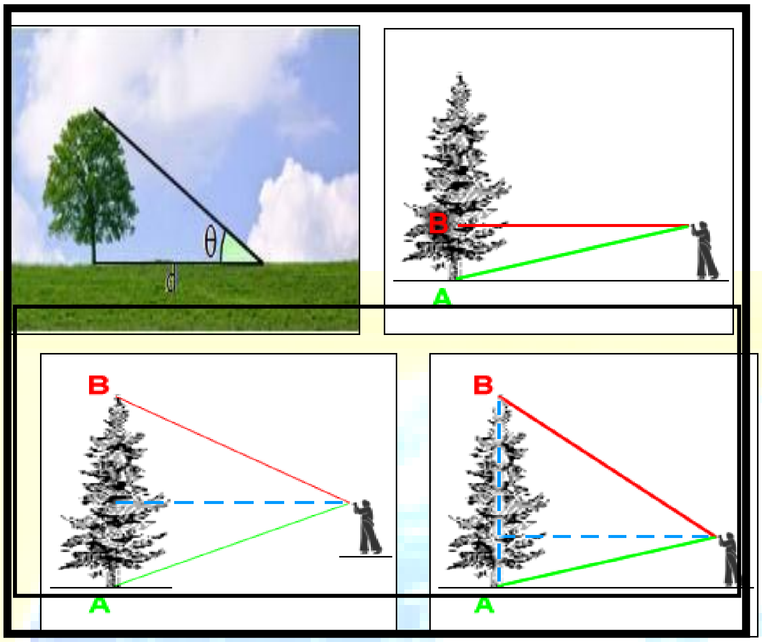


Fig 1: View of tree height measurement by Theodolite.

Considering the angle ACB between tree top and the distance (b) at the point of observer at DBH, the tree height was calculated If α is the angle between eye view and top of the tree, a is the height of the tree in feet, c is the slope between tree and eye view, b is the distance in feet between tree and observer and h is height of horizontal plane of Theodolite instrument, then the height of tree (H) is calculated by the following formulae: $H = h + b \tan \alpha$.

Biomass: The biomass estimation was carried out by harvest method (Flombaum and Sala, 2007). Five seedlings from each treatment were uprooted carefully by putting the pot upside down at the time of experiment termination. The fresh weights of the above and below ground components of the plants were recorded and the samples were kept in the oven at 80°C until the constant weight obtained. Then the dry weight was recorded. The comparative total biomass of the two experimental set ups, at various treatment levels as well in various plant components were determined for the species.

Carbon content analysis: The carbon content of different components of seedlings namely the root, shoot and leaf were estimated by multiplying oven dry biomass with a constant (0.475) as per the method of Magnussen and Reed (2004).

Results and Discussion:

Green plants consume carbon dioxide gas in the atmosphere in the process of photosynthesis and use it to produce sugars and other organic compounds for growth and metabolism. Long lived woody plants store carbon in their wood and other tissues until they die and decompose, at which time the carbon in their wood may be released to the atmosphere as carbon dioxide, carbon monoxide or methane, or it may be incorporated into the soil as organic matter. Plant tissues vary in their carbon content and many studies have shown that it is related to aspects such as climate, geographic region, physiographic features, soil fertility, plant species, age, stand density and stand vigour. Similarly, the content of carbon in soil also varies depending on climate, associated land use practices, plant species, physico-chemical properties, parent material and microbial activities. Therefore, the stock of soil carbon in a given forest is highly specific to the location.

There was a general pattern observed in our study, where the growth parameters, biomass allocation and the present carbon content showed a typical trend of gradual reduction. Total number of trees, average diameter at breast height (DBH) and average height has shown in table no 1. Our study reveals that the 2013 number of 11 species of trees is present in North Maharashtra University Campus, Jalgaon. Above Ground Carbon (AGC), Below Ground Carbon (BGC) and Mean Organic Carbon (MOC) values are summarized in Table 2 and also presented in Graph 1 and 2 for comparison, some of trees having a carbon content 1.5t/tree respectively. Many workers have investigated and got similar results Augus, 2003; Sileshi *et. al.*, 2007; Saraswathi and Paliwal, 2008; Gomez *et. al.*, 2008; Seape *et. al.*, 2008; Trumper, 2008; Chavan and Rasal, 2010; Saraswathi and Paliwal, 2011;Saraswathi and Ezhilarasi, 2012. The study is helpful to estimate the Organic Carbon Stock (OCS) present in North Maharashtra University Campus, Jalgaon and other cities or forest covers by using non-destructive method and is best suited for the plantation programmes in the semi arid ecosystems.

The allometric equation applied in the present study is not free of errors in calculating carbon levels in different trees. Such errors are caused by approximation of wood densities of trees, slight deviations of biological make up of species in different sites that are not equal to where the allometric equation was developed and site specific environmental conditions. As a solution, the allometric equations formulated for other countries should be calibrated to suit local situations through field research and then use them to determine the carbon levels in indigenous flora.

Table No.1: Field data of trees studied from the campus

Sr. No	Scientific name	Local Name	Number of Trees	Average DBH in cm	Average Height
	Azadirachta indica	Neem	333	28	22
	Eucalyptous camaduelensis Dehun	Nilgiri	113	24	34
	Leucaena leucocephala	Subabhul	280	26	26
	Bauhinia racemosa L.	Aapta	72	22	18
	Tectona grandis Teak	Saag	930	10	20
	Annona squamosa L. Ranunculaceae	Seetaphal	98	12	12
	Emblica officinalis Gaertn. Euphorbiaceae	Awala	12	20	11
	Hibiscus rosa sinensis L. Malvaceae	Jaswandi	53	09	10
	Murraya koenigii (L.) Spereng Rutaceae	Kadhipatta	67	12	10
.	Prunus Dulcis	Almond	48	22	15
.	Ficus religosa L.	Pipal	07	26	25
Total Number of Trees			**2013**		

Graph 1: Showing Field data of trees studied from the NMU campus, Jalgaon

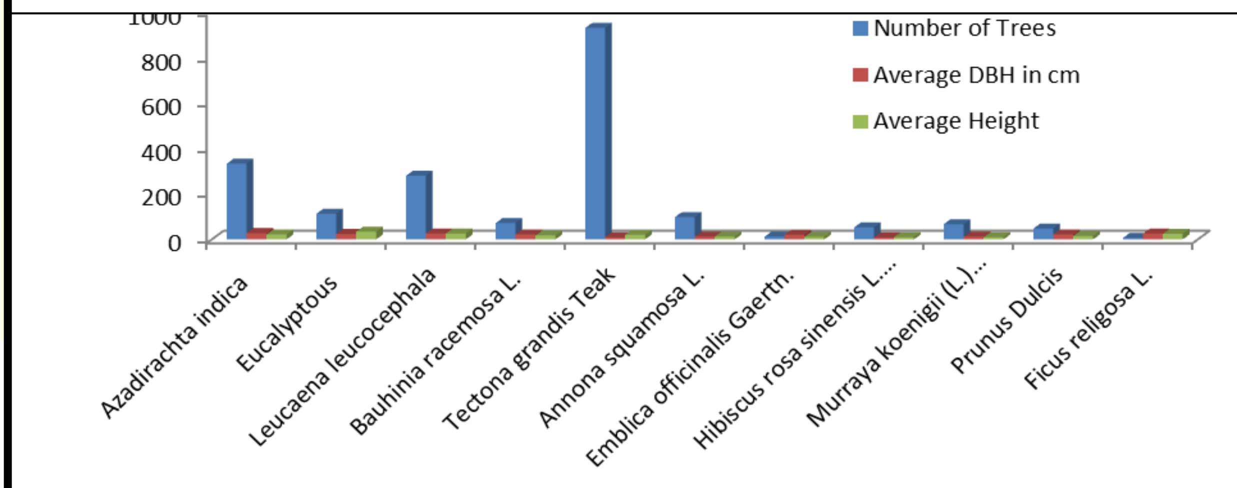
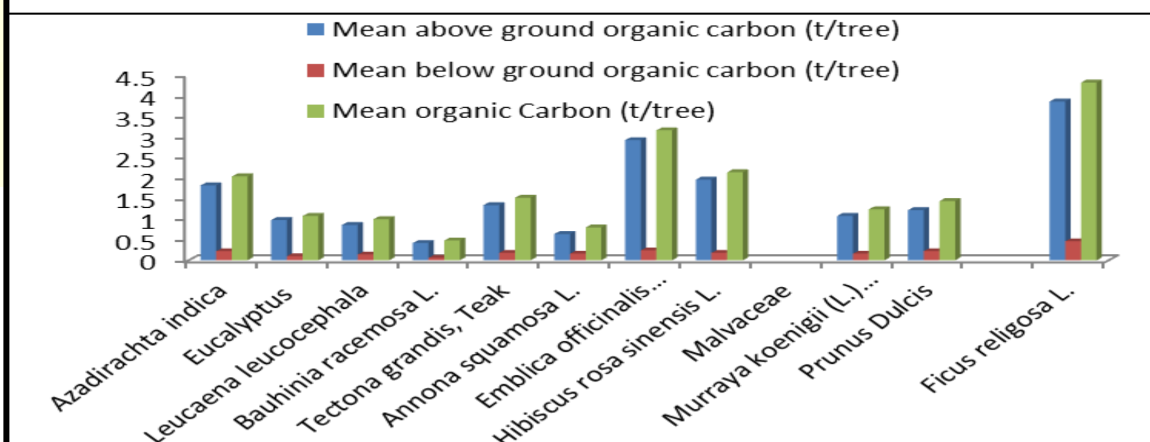


Table No.2: Mean Organic carbon stock in 11 different trees species.

Sr. No.	Scientific name	Mean above ground organic carbon (t/tree)	Mean below ground organic carbon (t/tree)	Mean organic Carbon (t/tree)
	Azadirachta indica	1.82	0.22	2.04
	Eucalyptous camaduelensis Dehun	0.98	0.10	1.08
	Leucaena leucocephala	0.86	0.14	1.00
	Bauhinia racemosa L.	0.42	0.06	0.48
	Tectona grandis, Teak	1.34	0.18	1.52
	Annona squamosa L. Ranunculaceae	0.64	0.16	0.80
	Emblica officinalis Gaertn. Euphorbiaceae	2.92	0.24	3.16
	Hibiscus rosa sinensis L. Malvaceae	1.96	0.18	2.14
	Murraya koenigii (L.) Spereng Rutaceae	1.08	0.16	1.24
.	Prunus Dulcis	1.22	0.22	1.44
.	Ficus religosa L.	3.86	0.46	4.32
Total organic carbon		**17.1**	**2.12**	**19.22**

Graph 2: Showing Mean Organic carbon stock in 11 different trees species in NMU Campus



Conclusion:

This baseline assessment has shown that North Maharashtra University campus area is harboring 19.22t from studied 11 tree species of carbon in its forest biomass and also has the potential to significantly increase its carbon stock through gradual progression into a mature temperate forest. The floristic composition 2.12t as well as the above ground carbon content 17.1t of this area is indicative of the fact that the forest cover is currently in an intermediate stage of succession, thus demanding active restoration interventions in future in order to accelerate natural succession and storage of carbon.

References:

- Achard F., Eva H.D., Stibig H.J., Mayaux P, Gallego J. (2002): Determination of deforestation rates in the world's humid tropical forests. *Science* 297: 999–1002.

- Aggangan, R.T. (2001): 'Tree farming in the Philippines: Some issues and recommendations', in S.R. Harrison and J.L. Herbohn (eds.), *Socio-Economic Evaluation of the Potential for Australian Tree Species in the Philippines*, *ACIAR* Monograph, 75, pp. 33-44.

- Agus, C. (2003): Carbon sequestration in fast growing plantation forest in Indonesia, a paper presented at the International Conference on Tropical Forests and Climate Change: Carbon Sequestration and CDM, Manila, the Philippines, 21-22 October, pp. 143-149.

- Chavan B. L. and Rasal G. B. (2010): Sequestered standing carbon stock in selective tree species grown in University campus at Aurangabad, Maharashtra, India. International Journal of Engineering Science and Technology Vol. 2(7), 2010, 3003-3007.

- Chave J., Muller-Landu H.C., Baker T.R., Easdale T.S.A., Steege H., Webb C.O. (2006): Regional and phylogenetic variations of wood density across 2456 neotropical tree species, *Ecological Applications*, 16(6): 2356–2367.

- DeFries R.S., Houghton R.A., Hansen M.C., Field C.B., Skole D. (2002): Carbon emissions from tropical deforestation and regrowth based on satellite observations for the 1980s and 1990s. *Proc Nat Acad Sci USA*, 99:14256–14261.

- FAO (2005): *Support to national forest assessments*. FAO Forestry Department Available URL: http://www.fao.org/forestry/site/24673/en.

- Flombaum, P. and O.E. Sala (2007): A non-destructive and rapid method to estimate biomass and aboveground net primary production in arid environments. *J. Arid Environ.*, 69, 352-358.

- Gnaana Saraswathi, S. and K. Paliwal (2008): Diurnal and seasonal trends in photosynthetic performance of Dalbergia sissoo Roxb. and Hardwickia binata Roxb. from a semi-arid ecosystem. Photosynthetica, 46, 248-254.

- Gnaana Saraswathi, S. and Kailash Paliwal (2011): Drought induced changes in growth, leaf gas exchange and biomass production in Albizia lebbeck Benth. and Cassia siamea Lam. seedlings. J. Environ Biol., 32, 173- 178.

- Gnaana Saraswathi, S. and S. Ezhilarasi (2012): Comparative study on growth, yield and carbon content in Pongamia pinnata under water stress and urea supplementation, J. Environ. Biol. 33, 579-584.

- Gomez, D.S., M.A. Zavala and F. Valladares (2008): Functional traits and plasticity linked to seedlings' performance under shade and drought in Mediterranean woody species. Ann. For. Sci., 65, 311-325.

- Hughes R., Flint J., Kauffman B., Jaramillo V.J. (1999): Biomass, carbon and nutrient dynamics of secondary forests in a humid tropical region of Mexico, *Ecology* 80:1892–1907.

- IPCC (2003): Good practice guidance or land use, land-use change and forestry. Institute for Global Environmental Strategies, Hayama.

- IPCC (2006): Guidelines for national greenhouse gas inventories. Agriculture, Forestry and other land use. Institute for Global Environmental strategies, Hayama, Japan. Vol.4.

- Magnussen, S. and D. Reed (2004): Modeling for estimation and monitoring. www.fao.org/forestry/8758/en.

- Ravindranath, N. H. and Ostwald M. (2008). Carbon Inventory Methods Handbook for Greenhouse Gas Inventory, Carbon Mitigation and Round wood Production Projects. *Springer*, Vol. 29.

- Ravindranath, N.H., Somashekhar B.S. and Gadgil M. (1997): Carbon flows in Indian forests. Climate change. 35: 297-320.

- Sheskin, D.J. (2004): Handbook of parametric and nonparametric statistical procedures. 3rd ed. Boca Raton: Chapman and Hall / CRC.

- Sileshi, G., F.K. Akinnifesi, A. Mkonda and O.C. Ajayi (2007): Effect of growth media and fertilizer application on biomass allocation and survival of Upaca kirkiana Müell Arg seedlings. Sci. Res. Essay., 2, 408-415.

- Stape, J.L., D. Binkey and M.G. Ryan (2008): Production and carbon allocation in a clonal Eucalyptus plantation with water and nutrient manipulations. For Ecol Manag., 255, 920-930.

- Trumper, K., C. Ravi lious and B. Dickson (2008): Carbon in drylands: Desertification, climate change and carbon finance. A UNEP-UNDPUNCCD Technical note for discussions at CRIC 7, Istanbul, Turkey, 1-12.

- Zanne, A.E., Lopez-Gonzalez, G., Coomes, D.A., Ilic, J., Jansen, S., Lewis, S.L., Miller, R.B., Swenson, N.G., Wiemann, M.C., Chave, J. (2009): Global wood density database. Dryad. Identifier: http://hdl.handle.net/10255/dryad.235.

****