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GROWING STOCK OF VARIOUS PURE CONIFER FOREST TYPES OF CENTRAL (GARHWAL) HIMALAYA, INDIA

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ABSTRACT

Objective: The Conifers forests cover an extensive area in Uttarakhand and provide variety of ecosystem services. The Present study was intended with an aim to assess the growing stock potential of the pure coniferous forest of Garhwal Himalaya.

Methods: Five sample-plots of 0.1 ha were randomly laid out at five different sites in each forest type to estimate the Growing Stock Volume Density (GSVD) using appropriate volume tables and volume equations.

Results and Conclusion: Abies pindrow forest was observed to possess the highest growing stock (988.3 m3/ha) followed by Cupressus torulosa (922.3 m3/ha). It is observed that conifers forests possess high stand volume and long rotation period hence promising as carbon sink therefore should be recommended for plantation silviculture alongwith special conservation protection to mature forests.

Key Words: Growing stock, Rotation period, Conifers, Standing volume

INTRODUCTION

The terrestrial vegetation plays an important role within the global carbon cycle and hence the earth system, as it sequesters atmospheric carbon dioxide and is thus able to mitigate global warming (Bonan, 2008). Biomass dynamics reflect the potential of vegetation to act as a carbon sink over the long term, as they integrate photosynthesis, autotrophic respiration and litter fall fluxes. The tons of forest biomass per unit volume of growing stock (GS) energize the ecosystems and can fuel economies (Kauppi *et al.*, 2006). Forest biomass assessment for large areas across the globe are based on three main approaches: estimating using mean biomass densities (Ajtay, 1979); using field inventory of GS and biomass expansion factors (Lal and Singh, 2000) and spatial modelling approach in geographic information system using spatial databases of physiography, climatic, soil and forest distribution and models of biomass productivity (Iverson *et al.*, 1994). Many factors act to alter forest biomass, including selective wood harvest, forest fragmentation, ground fires, shifting cultivation, browsing, grazing and accumulations of biomass in growing and recovering (or secondary) forests (Houghton, 2005) .The estimation of increment and felling of Standing volume has therefore assumed crucial, significance in estimating climate change. The growing stock(GS) volume, a key parameter in the context of forest resource management and global change issues, also referred to as stem volume or bole volume of living trees, represents the volume of the tree stems (including bark but excluding branches and stumps) for all living species per unit area (Santoro *et al.*, 2011). The inter annual variability of carbon fluxes remains relatively unexplored (Wolf *et al.*,2011) mainly due to the absence of consistent spatial information on biomass (Bellassen *et al.*, 2011). The Growing Stock Volume Density (GSVD) is a major predictor for assessing the above-ground biomass (Shvidenko *et al.*, 2007) and is central for estimating compartment (Jenkins *et al.*, 2003) or total above-ground biomass (Somogyi *et al.*, 2008), which is a elementary variable for assessing the net carbon dioxide exchange between the land surface and the atmosphere.

In Garhwal Himalaya conifers are main forest forming species which constitute about 1/3rd of total forested area and provide variety of ecosystem services. Conifers form a distinct group, which has become very important in world economy, because they grow fast on poor soil even under harsh climate and yield timber that is suitable

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for industries. Growing stock inventory is being done by the forest department but not species wise for pure forest types. The present study was therefore aimed to know the growing stock variation in the pure coniferous forest types of Garhwal Himalaya of Uttarakhand, India.The information on forest volume from forest inventory can provide us valuable information about stand biomass and carbon flux.

MATERIAL AND METHODS

Growing stock Estimation: General survey of the study area was carried out to identify and earmark different pure coniferous forest type's viz., *Abies pindrow*, *Cedrus deodara, Cupressus torulosa, Picea smithiana, Pinus roxburghii,* in different forest types of Garhwal. For quantitative analysis of forest vegetation, five sample plots of 0.1ha each were randomly laid out in each forest type (05 sample plots×05 forest types =25 plots). The volume of individual tree species for various sample plots was calculated on the basis of existing standard volume table or equations (FSI, 1996) given in Table 1. The volumetric estimation of the tree species have been done on the basis of standard volume tables/equations based on the Indian forest records, F.R.I., & F.S.I. publications of the respective species.

Study Area: The state is located in North-West part of the country. Uttarakhand's geographical area is 53,483 square km which constitutes 1.63% of the country's total area (FSI, 2011). Garhwal Himalaya, which is situated in western part of the Central Himalaya encompasses biodiversity rich forests and is located between the latitudes $30^0$00.993' to $30^0$03.764' N and longitudes $79^0$9.724' to $79^0$12.040' E. The study area ranged from 1200-3100 m asl of altitude experiencing temperate type of climate with moderate to high snowfall from December to February. The precipitation effectiveness increases with elevation because of temperature and sunshine decline (Muller, 1982). The mean annual rainfall and snowfall in the study area ranged between 2731mm and 23 inches (at 1200 m asl) to 1745 mm and 170 inches (at 3100 m asl). The rainy season accounts for about three-quarters of the annual rainfall. Mean minimum monthly temperature ranged between 8°C (Jan) to 20.65°C (Jun) at 1200 asl and 2.68° C (Jan) to 9.30°C (Jun) at 3100 m asl. Whereas, maximum monthly temperature ranged between 20.0°C to 30.15°C at 1500 m asl and 7.45°C to 18.73°C at 3100 m asl. The soil type was basically brown- black forest soils and podozolic soils (Valdiya, 1980; Gairola, 2010).

RESULTS

The allocation of the standing volume in all five conifer forest types is shown in Table 2. Among all the conifer forest types studied *Abies pindrow* was observed to be possessing the maximum growing stock that is 988.3 m^3/ha followed by C*upressus torulosa* that is 922.3 m^3/ha (Figure1). The maximum growing stock for *Abies pindrow* forest type was 1174.4m^3/ha recorded in Site IV, followed by1099.9 m^3/ha for Site V. The growing stock in *Cedrus deodara* forest cover type oscillated between 501.1 m^3/ha to 913.3 m^3 /ha. For *Cupressus torulosa* forest cover type the highest GSVD 1834.6 m^3/ha was estimated in Site II. The growing stock in *Picea smithiana* and *Pinus roxburghii* forest cover type oscillated between 268.7 m^3 /ha to 804.3 m^3 /ha and 297.4 m^3/ha to 925.6 m^3/ha.

DISCUSSION

The estimation of stem volume and tree biomass is needed for both sustainable planning of forest resources and for studies on the energy and nutrients flows in ecosystems (Zianis *et al.*, 2005). Walle *et al.*, 2005 reviewed the potential role of biomass as an energy source and carbon stocks in the 21st century. The total growing stock of wood in India is estimated to be 6,098.23 million m^3 compromising 4,498.66 million m^3 inside forested area and 1599.57 million m^3 outside recorded forest area (FSI, 2009).The total growing stock of forests of Uttarakhand is 481.006 million m^3 (FSI, 2011). The growing stock values in the present study for various forest type was recorded as 998.30m^3/ha in *Abies pindrow*,922.2 m^3/ha in *Cupressus torulosa*, 755.8 m^3/ha in *Cedrus deodara*, 681.6 m^3/ha in *Pinus roxburgii*, 515.6 m^3/ha in *Picea smithiana*. Baduni (1996) has recorded values of growing for *Abies pindrow as* 239.66-389.95 m^3/ha in Pauri Garhwal whereas Gairola (2010) reported 272.87 m^3/ha for Mandal-Chopta forest. The higher volume in the present study is attributed to the more number of trees present in higher diameter classes and selection of less disturbed areas for study. Sharma *et al.* (2000) studied that there was the variation in growing stock of high Himalayan and Shiwalik Chir pine in different aspects and recorded maximum growing stock as 440 m^3/ha. The current need to assess changes in the forest carbon has arisen as a result of the Climate Convention and the Kyoto Protocol. Forest cover and forest structure provide additional important feedbacks on biophysical properties and processes like albedo and evapo-transpiration (Bonan, 2008). Thus, improving our knowledge about the state of the world's forests is also important for understanding their influence on energy and water fluxes. Certain qualitative and quantitative parameters of the forest inventory such a tree diameter merchantable height of trees which are important for volume calculations cannot be measured for satellite imagery (Mahto, 2001). It is noted that satellite imageries obtained by remote sensing can only complement or improve and reduce field work but cannot replace it (Chaturvedi and Khanna, 1982).

The growing stock of a managed forest is lower than the growing stock of pristine forests due to application of thinning and clear cut management. The old and mature growth forests have high stand volume. During the ages from100 to 400 years, spruce forests have a high growing stock which will lead to higher average values in unmanaged forests (Kindermann *et al.*, 2008). The significance of forest area is not sole indicator of forest development but growing stock and carbon storage can be considered equally important parameters (FAO, 2005). Stem volume does not determine the biomass of the foliage and roots, but it certainly has several build-in factors that affect the biomass of the tree components (e.g. water and nutrient supply, fertility, competition, moisture and length of growing season) (Makela *et al.*, 1995).

CONCLUSIONS

Forests are the largest carbon pool on earth. They act as a major source and sinks of carbon in nature. Hence they have huge potential to form a chief component in the mitigation of global warming and adaptation to climate change. Estimation of the forest growing stock will enable us to assess the extent of loss of forest cover due to deforestation. The present study can form a basis for management, planning and decision making as forests are source of timber and NTFPs (FSI, 2011). As our study reports that Himalayan conifers have high growing stock potential it can be recommended for plantation silviculture hence playing a major role in curbing Global carbon emission.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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Table 1: General composition of the different Conifer forest types studied along with the volume equations used:

Forests	Vernacular Name	Elevation (m asl)	Associated species	Understory	Volume equations used**
Abies pindrow	Raga	2700-3100	Quercus semecarpifolia , Acer sps., Aesculus sps., Rhododendron arboreum	Species of Rosa, Thamnocalamus, Viburnum, Rubus, Plectranthus	$0.175070+0.226058*D^2H$
Cedrus deodara	Deodar	2350-2450	Pinus roxburghii, Quercus leucotrichophora, Q. semecarpifolia, Rhododendron arboreum	Species of Berberis, Rosa, Rubus, Sarcococca, Agrostis, Carex, Heteropogon	$0.06168+0.27696*D^2H$
Cupressus torulosa	Surai	2400-2600	Pinus roxburghii, Quercus semecarpifolia, Rhododendron arboreum	Species of Rubus, Berberis, Cotoneaster, Indigofera, Smilax	$0.087+0.289*D^2H$
Picea smithiana	Rai	2650-2700	Abies sps, Quercus floribunda, Q. semecarpifolia, Cedrus deodara	Species of Viburnum, Indigofera, Lonicera, Strobilanthes	$0.033695+0.283177 D^2H$
Pinus roxburghii	Chir	1900-2000	Lyonia ovalifolia, Quercus leucotrichophora	Species of Berberis, Rosa, Prunus, Rhus parviflora, Carex, Heteropogon	$0.00249+0.27408*D^2H$

** Source: FSI (1996)

Table 2: Distribution of standing volume in the pure conifer forest types in all five sites.

Forest types	Forest	Rotation period* (Years)	Growing Stock (m³/ha)				
			Site I	Site II	Site III	Site IV	Site V
FT1	Abies pindrow	140-180	1008.4	914.8	794.1	1174.4	1099.9
FT2	Cedrus deodara	150-180	501.1	895.0	748.9	720.7	913.3
FT3	Cupressus torulosa	120	638.4	1834.6	524.8	741.5	872.2
FT4	Picea smithiana	120	268.7	484.6	414.5	804.3	605.8
FT5	Pinus roxburghii	70-80	579.9	925.6	297.4	812.4	792.7

*Source: Negi, 1985

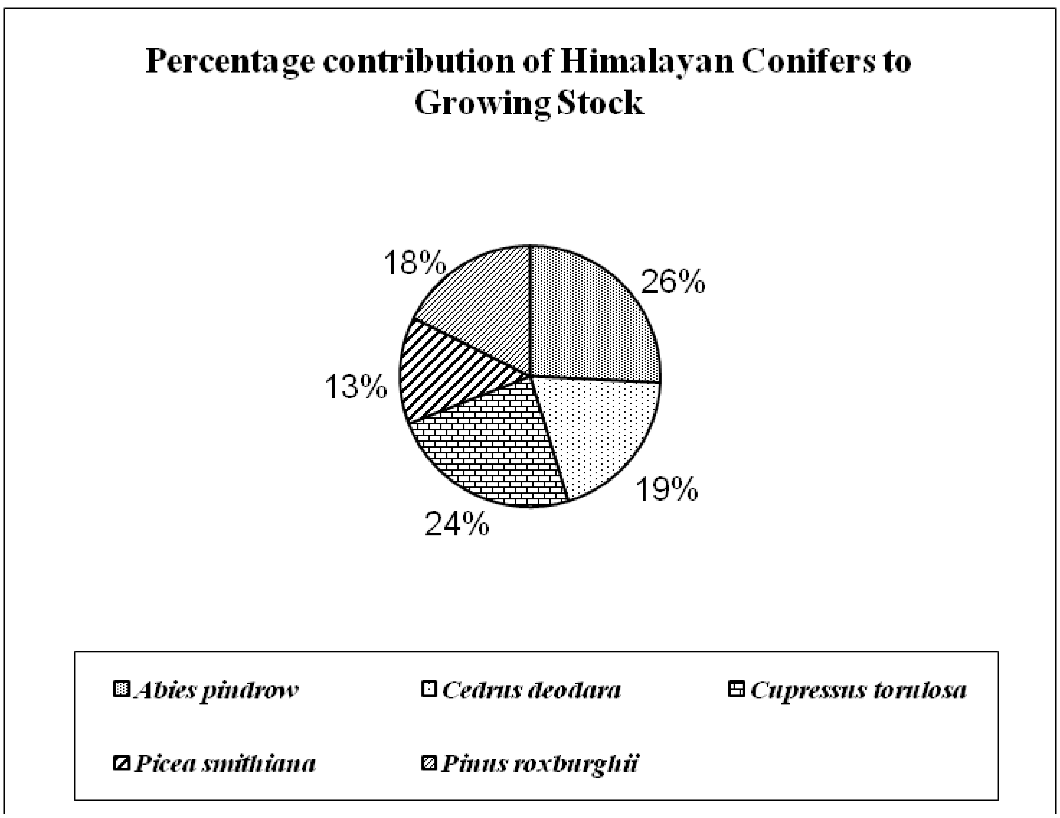

Figure 1: Percentage contribution of Himalayan Conifers to Growing Stock.