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Assessing forest dynamics of broadleaved forest ecosystems in the South-Central part of Bhutan

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Abstract

Mountain forests are rich repositories of biodiversity. They are important for providing various ecosystem services which sustain the rural livelihoods and fuels the national development. A key to maintain these precious resources is to carefully manage them by having management plans based on proper resource assessment and volume increments derived from growth models. We established 96 inventory points in a systematic grid of 800 m by 800 m covering an area of 6423 hectares of broadleaved forests. Parameters such as dbh, tree height, horizontal distance from the center, azimuth were collected for every tree and sapling for understanding the stand information. Increment cores to understand the growth rate of the trees for the last 10 years was collected from every plot. A total of 140 plant species was recorded indicating rich diversity of the watershed. The total mean basal area increment for the 2004-2008 and 2009-2014 were 3.13 ± 3.34 m^2 and 3.74 ± 4.06 m^2 respectively. The annual increment for the last 10 years was 0.69 m^2. The understanding of the forest dynamics and the available information of the forest increment rates is expected to further improve the sustainable forest management and avoid exploitation of the resources.

Keywords: Bhutan, forest dynamics, increments, growth model, watershed

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1. Introduction

Mountain forests which are rich repositories of biodiversity. They are important for providing various ecosystem services which sustain the rural livelihoods and fuels the national development. As observed in other parts of world, the mountain forests are now increasingly degraded due to unsustainable agricultural and forestry practices (Sundriyal and Sharma 1996; Wakeel et al. 2005). With forest cover of 70.46 % (excluding shrub land), the Bhutan Himalaya is an exception in the region for high forest cover (Ministry of Agriculture and Forests 2010). However, high forest cover doesn’t mean the forests are sustainable (Tenzin and Hasenauer 2016). A key to maintain these precious resources is to ensure sustainable forest management by having management plans based on proper resource assessment and volume increments derived from growth models (Monserud and Sterba 1996; Hasenauer 2006; da Cunha et al. 2015; Tenzin et al. 2016).

Bhutan is one of the countries located in the mountain Himalayas with very limited scientific information on forest management especially with regard to broadleaved forests. The harvesting of timber is based on the annual allowable cut (AAC), which is calculated for each harvesting unit using the growing stock (m^3 ha^{-1}), the area (ha) and the rotation period (years) (Forest Resources Development Division 2004). Currently, there is no information on the relative increment or species specific changes in volume growth over time, which might be limiting the sustainable management of forests. The purpose of the paper is to: (i) assess the forest dynamics of the broadleaved forest ecosystems through forest inventory and (ii) understand the forest increment rates through study of growth rates of individual trees.

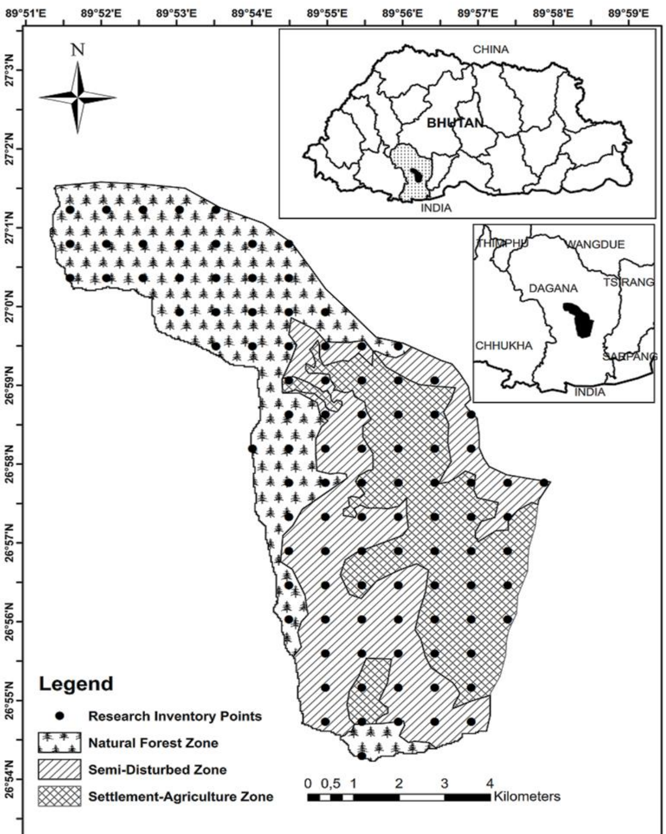

Figure 1: Map of the area with inventory points

2. Materials and methods

The detail description of site and study design are provided by Tenzin and Hasenauer (2016). The data for this study come from a watershed in Dagana, a district in the south central part of Bhutan. We established 96 inventory points in a systematic grid of 800 m by 800 m covering an area of 6423 hectares of broadleaved forests. Parameters such as dbh, tree height, horizontal distance from the center, azimuth were collected for every tree and sapling for understanding the stand information. In every plot, we selected the tree with the median Dbh for every species to extract the increment cores.

Two increment cores were extracted from each tree at 1.37 m height from ground level, with the first coring being on the side of the tree facing plot center and the second one on the opposite side. For each increment core samples extracted, we measured the annual radial increment for the last 10 years to 0.001 mm precision using a Velmex TA measuring system (Velmex Inc. Bloomfield, New York). The sum of the recorded annual radial increments provided the 5 year diameter increment (id). Next, we reconstructed the past Dbh_i by subtracting the diameter increment (id) from the current Dbh. We used the available information of current Dbh, diameter increment (i_d) and past Dbh_i to calculate the periodic mean basal area increments for the last five years (equation 1).

$$\mathrm{BAI_i} = \left[\frac{\frac{\pi}{4}\left(2.\ \mathrm{Dbh_i}\ .\ \mathrm{i_d} + \mathrm{i_d^2}\right)}{5}\right] \quad (1)$$

where BAI_i is the annual basal area increment (cm^2 /year), Dbh_i is the Dbh at beginning of the five year growing period in cm and i_d is the five year diameter increment in cm.

Figure 2: Glimpses of the field work

3. Results and Discussion

A total of 124 tree and 16 shrub species were recorded in the watershed. The record of 140 plant species in the area indicates the biodiversity of the area is rich and confirms with other studies carried out in similar ecosystems in the region (Singh and Singh 1987). However, the forests in the area are under high pressure due to increase in anthropogenic activities and improved accessibility. Tenzin and Hasenauer (2016) recommends such areas to be taken up as part of management regimes to control overexploitation of resources. This suggests for the need to have the annual increment rates by tree species, site as well as by stand conditions to guide sustainable forest management and conservation.

The total mean basal area increment for the 2004-2008 and 2009-2014 were 3.13 ± 3.34 m^2 and 3.74 ± 4.06 m^2 respectively. The annual increment for the last 10 years was 0.69 m^2. For sustainable management of the forests, correct assessment of growing stock along with forest increment rates from suitable forest growth models will be required. Therefore, we recommend forest growth models to be calibrated for predicting the forests increment. The model can be a mathematical representation of BAI or diameter increment as a function of tree size, comp and site variables (equation 2).

$$BAI = \exp\left(\mathrm{a} + \mathrm{b_i} \times (\mathrm{Treesize}) + \mathrm{c_i} \times (\mathrm{Comp}) + \mathrm{d_i} \times (\mathrm{Site})\right) \quad (2)$$

The rich species diversity will possess constraints in developing species specific growth models (Akindele and LeMay 2006). Consequently, grouping of the species and developing equations for the groups instead of individual species is the best way forward. Hence, we strongly recommend grouping of the species in to suitable groups for scientific management.

4. Conclusions and outlooks

The results and recommendations from this study will be incorporated in to the watershed management plan which is currently being developed for the watershed. The findings from this study will also be used in calibrating a forest increment growth models for the broadleaved forests of Bhutan. The growth models can be used for simulating forest increment under different forest stand and site conditions and hence will enhance sustainable forest management in Bhutan.

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