Journal of Asia-Pacific Biodiversity 9 (2016) 293–300

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Contents lists available at ScienceDirect

Journal of Asia-Pacific Biodiversity

journal homepage: http://www.elsevier.com/locate/japb

Original article

Tree species richness, diversity, and regeneration status in different oak (*Quercus* spp.) dominated forests of Garhwal Himalaya, India

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ARTICLE INFO

Article history:
Received 22 December 2015
Received in revised form
20 March 2016
Accepted 5 June 2016
Available online 11 June 2016

Keywords:
Dominance Index
Himalaya
oak forest
sapling
seedling

ABSTRACT

Himalayan forests are dominated by different species of oaks (*Quercus* spp.) at different altitudes. These oaks are intimately linked with hill agriculture as they protect soil fertility, watershed, and local biodiversity. They also play an important role in maintaining ecosystem stability. This work was carried out to study the diversity and regeneration status of some oak forests in Garhwal Himalaya, India. A total of 18 tree species belonging to 16 genera and 12 families were reported from the study area. Species richness varied for trees (4–7), saplings (3–10), and seedlings (2–6). Seedling and sapling densities (Ind/ha) varied between 1,376 Ind/ha and 9,600 Ind/ha and 167 Ind/ha and 1,296 Ind/ha, respectively. Species diversity varied from 1.27 to 1.86 (trees), from 0.93 to 3.18 (saplings), and from 0.68 to 2.26 (seedlings). Total basal area (m^2/ha) of trees and saplings was 2.2–87.07 m^2/ha and 0.20–2.24 m^2/ha, respectively, whereas that of seedlings varied from 299 cm^2/ha to 8,177 cm^2/ha. Maximum tree species (20–80%) had "good" regeneration. *Quercus floribunda*, the dominant tree species in the study area, showed "poor" regeneration, which is a matter of concern, and therefore, proper management and conservation strategies need to be developed for maintenance and sustainability of this oak species along with other tree species that show poor or no regeneration.

Introduction

Species is one of the major analytical characteristics of the plant community (Malik et al 2014). A plant community is an assemblage of plant species growing together in a particular location with a definite association with each other. Species richness is a simple and easily interpretable indicator of biological diversity (Peet 1974). Knowledge of species composition and diversity of tree species is of utmost importance not only to understand the structure of a forest community but also for planning and implementation of conservation strategy of the community (Malik et al 2014; Malik and Bhatt 2015). Understanding of forest structure is a prerequisite to describe various ecological processes and also to model the functioning and dynamics of forests (Elourard et al 1997). Assessment of forest community composition and structure is very helpful in understanding the status of tree population, regeneration, and diversity for conservation purposes (Mishra et al 2013). The nature of forest communities largely depends on the ecological characteristics of sites, species diversity, and regeneration status of tree species. Quantitative information on composition, distribution, and abundance of woody species is of key significance to understanding the form and structure of a forest community and also for planning and implementation of conservation strategy of the community. The species richness and diversity of trees are fundamental to total forest biodiversity, because trees provide resources and habitat for almost all other forest species (Malik 2014). In case of forest ecosystems, trees are responsible for the overall physical structure of habitats, and thus, they define fundamentally the templates for structural complexity and environmental heterogeneity (Malik et al 2016).

Regeneration potential is the ability of a species to complete the life cycle. Regeneration is a key process for the existence of species in a community under varied environmental conditions (Khumbongmayum et al 2005). In forest management, regeneration study not only depicts the current status but also hints about the possible changes in forest composition in the future (Malik and Bhatt 2016; Sharma et al 2014). Regeneration of any species is

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Peer review under responsibility of National Science Museum of Korea (NSMK) and Korea National Arboretum (KNA).

http://dx.doi.org/10.1016/j.japb.2016.06.002

confined to a specific range of habitat conditions that determine its geographic distribution (Grubb 1977). Survival and growth of seedlings/saplings determine the successful regeneration (Good and Good 1972), which is perhaps the single most important step toward achieving long-term sustainability of forests (Malik 2014; Malik and Bhatt 2016; Saikia and Khan 2013). Mountain forests, in general, have a major problem of poor regeneration (Krauchii et al 2000). The same is true for Himalayan Mountains and the main problem in this region is habitat loss. It includes various forms of land degradation, adverse human impacts on plant resources, deforestation, and lowering of the productive capacity of rangelands. Furthermore, other anthropogenic activities such as constructions of hill roads, forest fires, overgrazing, lopping of trees for fodder and fuelwood, and removal of leaf and wood litter from the forest floor are also affecting plant diversity in the Garhwal Himalayan region, India (Malik et al 2016). Reliable data on regeneration trends are required for successful management and conservation of natural forests (Eilu and Obua 2005). Keeping in view the aforesaid facts, an attempt was made to study the diversity and regeneration status of eight forests of three ridge tops in Garhwal Himalaya.

Materials and methods

Study area

Uttarakhand Himalaya, a part of Indian Himalayan Region, has two mega floristic zones, namely, Garhwal and Kumaon. This study was carried out in the natural forests of Garhwal Himalaya during 2013–2014. After the reconnaissance survey, three ridge tops were selected in three districts of Garhwal, namely, Uttarkashi, Tehri, and Pauri (Figure 1). Within these ridge tops, a total of eight forests covering an altitudinal range of 2000–2550 m asl were selected (Table 1). These forests include three from the Dhanaulti region of Tehri [Buranskhanda (BK), Batwaldhar (BD), and Dhanaulti (DN)]; one from the Nachiketa region of Uttarkashi [Nachiketa (NT)]; and four from Pauri [Sukuru top (ST), Jandidhar top (JT), Ullidhar top (UT), and Pokharidhar top (PT)]. The climate of the study area is a typical temperate type. The average annual rainfall in the study area is ~1,552–2,110 mm, which is highly variable, depending on the altitude. Approximately 75% of rain occurs in this area during the monsoon season (i.e. from June to September). Because the climate is of temperate type, the temperature varies during

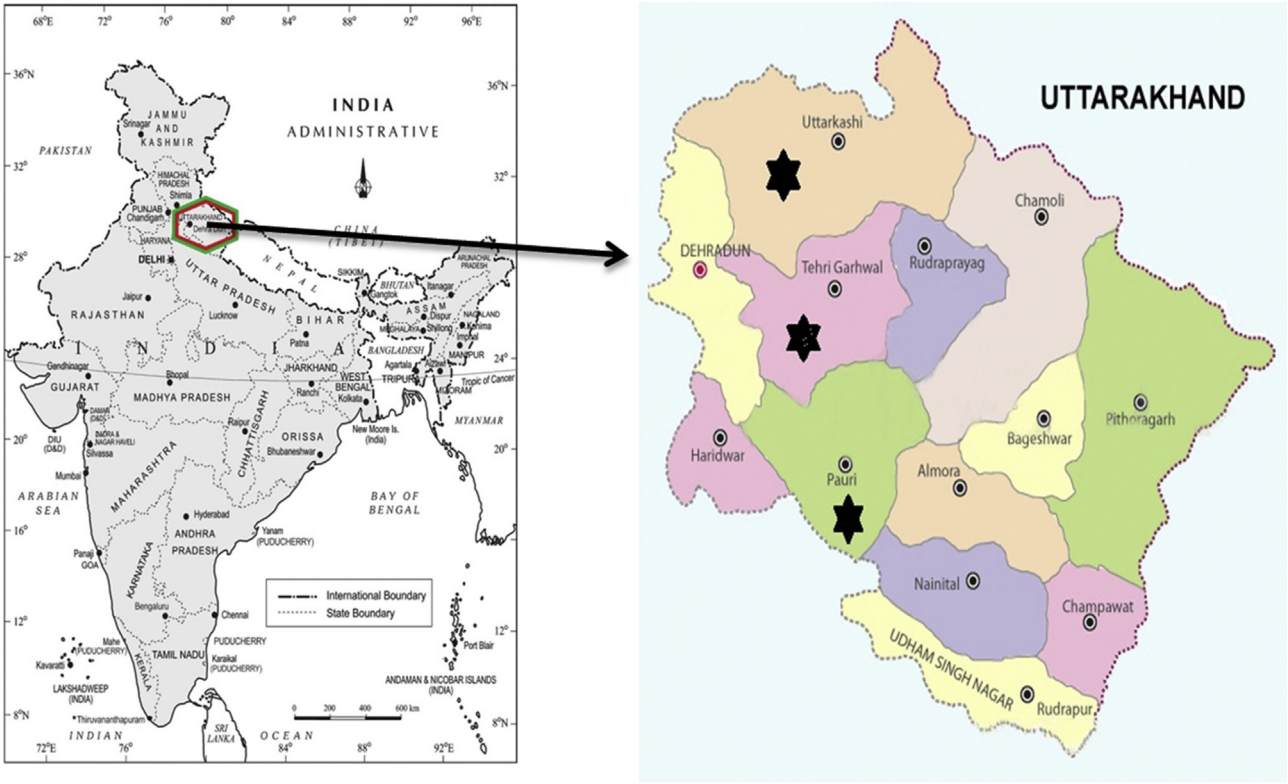

Figure 1. Location of the study sites in Uttarakhand.

Table 1. Characteristics of the study sites.

Ridge top	Forests	Altitude (m asl)	Latitude (N)	Longitude (E)	Dominant tree species
Dhanaulti	Buranskhanda	2459	30°26′ 83.3″	078°11′ 71.6″	*Quercus floribunda*
	Batwaldhar	2534	30°24′ 44.9″	078°15′ 34.8″	*Q. floribunda*
	Dhanaulti	2547	30°26′ 11.8″	078°13′ 08.1″	*Q. floribunda*
Nachiketa	Nachiketa	2565	30°38′ 33.9″	078°28′ 65.9″	*Q. floribunda*
Pauri	Sukuru top	2207	30°10′ 31.2″	078°53′ 10.1″	*Quercus leucotrichophora*
	Jandidhar top	2144	30°78′ 38.4″	078°46′ 39.6″	*Rhododendron arboreum*
	Ullidhar top	2060	30°07′ 31.8″	078°49′ 37.2″	*Q. leucotrichophora*
	Pokharidhar top	2010	30°08 23.6″	078°49′ 32.3″	*Q. leucotrichophora*