Proc. Indian natn. Sci. Acad. **B52** No. 6 pp 761–765 (1986)

Population Dynamics of Two Mixed Oak Forests in Central Himalaya

P B RAO* and S P SINGH
Department of Botany, Kumaun University, Naini Tal 263 002

(Received 30 September 1985)

The present paper deals with aspects of population dynamics, viz. natality, mortality, height growth and transfers of individuals from one size class to another of two oak species (*Quercus lanuginosa* D. Don. and *Quercus floribunda* Lindl.) in two mixed oak forests (mixed oak–rianj dominated and mixed oak–tilonj dominated), of Central Himalaya. Mortality and die-back, particularly in seedling population was common in both the forests. Absence of large saplings, transfer of large saplings from small saplings and declining tree population structure of *Q. floribunda* indicate poor regeneration in mixed oak–tilonj dominated forest. Comparatively better regeneration was observed for *Q. lanuginosa* in mixed oak–rianj dominated forest.

Key Words: Population dynamics, Natality, Mortality, Die-back, Regeneration

Introduction

Quercus lanuginosa D. Don. (rianj oak) and *Quercus floribunda* Lindl. (tilonj oak) form climax forests between 1700–2300 m elevations in the Central Himalaya (Champion & Seth 1968, Puri et al. 1982). In recent years, regeneration of these species has been described on the basis of population structure (Tewari & Singh 1981, Ralhan et al. 1982, Saxena & Singh 1982, 1984, Saxena et al. 1984, Upreti et al. 1985). The objective of this study was to interpret the regeneration of these oak species using data on population dynamics at the seedling stage, and to population structure.

Methods of Study

The study sites lie at 29°25′N lat. and 79°27′E long. in mid-montane zone. The rocks are exposed with purple, fawn to brown, fine-grained and cross-bedded muddy quartzite interbedded with slates. The soil is sandy loam, residual and shallow. The rianj and tilonj forests had a *p*H of 6.0 and 6.3, organic carbon content of 4.2 and 4.0% respectively (Khanna & Singh 1984). Of the annual rainfall of 2488 mm, nearly 86% occurs between mid-June to mid-September. The mean daily temperature ranges from 6.0°C in January to 20.5°C in June. The year is divisible into three distinct seasons: (i) dry and warm summer (March–mid-June); (ii) wet and warm rainy (mid-June–September); and (iii) dry and cold winter season with frequent frosts (October–February) (Singh & Singh 1984).

Circumference at breast height (at 1.37 m) of all the individuals with cbh 10 cm or more, within a permanent plot of 1 ha in the two sites was measured to indicate population structure. A plot of 0.2 ha was demarcated in the centre of the two forest types, and the fate of all seedlings and saplings was followed at four-monthly intervals from August 1981 for one year. The seedlings (height 30 cm or less) and saplings (>30 cm height and cbh <30 cm) were measured for height. The seedlings were divided into three height categories; (i) short (<10.0 cm), medium (10.0–20.0 cm), and tall (20.0–30.0); and the saplings into two categories: (i) small (10–30 cm height and up to 10 cm cbh), and

**Present address:* Department of Biological Sciences, College of Basic Sciences & Humanities, G B Pant University of Agriculture & Technology, Pantnagar 263145

(ii) large (>30 cm cbh saplings). Both natality and mortality were recorded. Natality included both root-sprouts and the seedlings emerged from seeds. The estimation of mortality was mostly the estimate of die-back of shoots to the ground level. We used the term die-back for the individuals losing a part of shoot, unless indicated otherwise.

Results and Discussion

Population Structure

Mixed oak-rianj dominated forest (hereafter referred to as oak-r forest) had a greater proportion of individuals in sapling classes (10–20 and 20–30 cm cbh), compared to larger girth classes (figure 1a), indicating expanding population or frequent reproduction (Knight 1975). In mixed oak-tilonj dominated forest (hereafter referred as oak-t forest), a majority of individuals was of intermediate girth classes with fewer ones both of higher and lower girth classes, and no saplings (figure 1b). Evidently, this is a declining population and is on the way to extinction (Benton & Werner 1976).

Population Dynamics

Though oak-t forest had greater number of seedlings initially than the oak-r forest, this difference narrowed at the end of the study period in the two types (figure 2). Greater mortality in oak-t forest (34.6%) than in oak-r forest (13.6%) was the reason. Compared to oak-r forest, many seedlings failed to register net or negligible growth in the oak-t forest (36.36% in oak-t forest vs 20.64% in oak-r forest). Such an event was reported also by others (e.g. Good & Good 1972, Rao & Singh 1985a, b). Further, most of the suppressed seedlings of oak-t forest died out by the end of the study period. In both the forests the mortality was greatest during the winter season when the effect of frost was most severe (Rao 1984, Singh & Singh 1984).

The small and large saplings in oak-r forest were about 6 and 14 times greater than in oak-t forest (figure 3). Some of the seedlings attained small sapling size in both the forests (50 in oak-r forest and 20 in oak-t forest). Eight out of 320 small saplings attained large sapling size in oak-r forest but none in oak-t forest.

In both the forests, the gain to saplings due to the transfer from seedlings was higher than the loss due to die-back and mortality, consequently the sapling population increased by about 9% and 27% respectively in oak-r and oak-t forests at the end of the study period (figure 3). None of the large saplings attained the tree size (>30 cm cbh) in oak-t forest, while a few (8 out of 70) attained the tree size in oak-r forest (figure 3a). In this forest, the gain to large saplings due to transfer

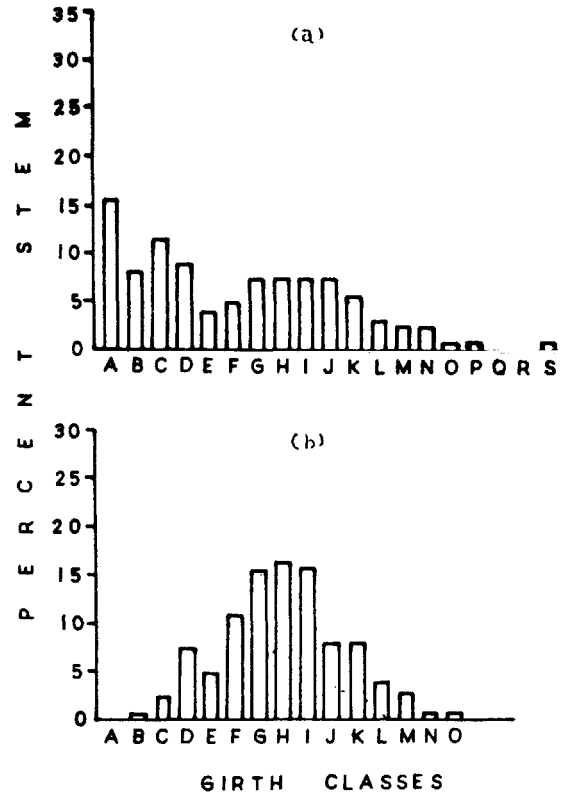
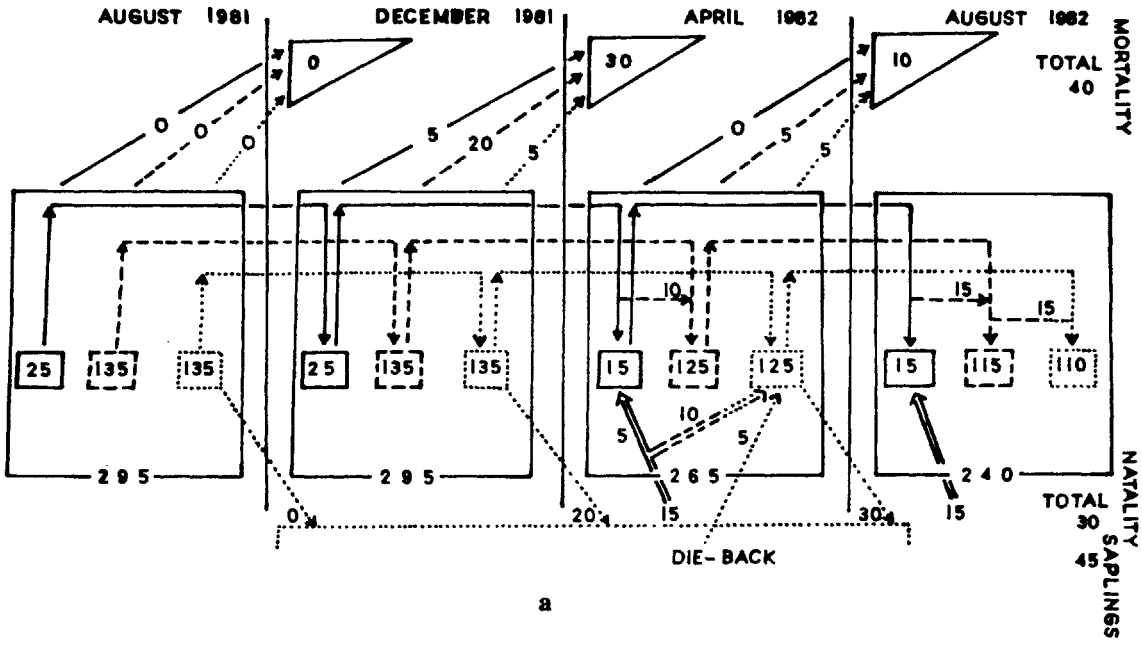


Figure 1 Population structure of (a) *Quercus lanuginosa* in mixed oak-r forest and (b) *Quercus floribunda* in mixed oak-t forest. A = 10–20; B = 20–30; C = 30–40; D = 40–50; E = 50–60; F = 60–70; G = 70–80; H = 80–90; I = 90–100; J = 100–110; K = 110–120; L = 120–130; M = 130–140; N = 140–150; O = 150–160; P = 160–170; Q = 170–180; R = 180–190; and S = 190–200 cm cbh

from small saplings was equal to the loss due to the transfer of large saplings to trees. Consequently, the large sapling population was in a steady state in oak-r forest.

Probabilities

Probabilities of death were high up to small sapling (0.703×10^{-1} for short, 0.189×10^{-1} for medium, and 0.095×10^{-1} for tall seedlings and 0.091×10^{-1} for small saplings in oak-r forest; 0.200×10^{-1}, 0.185×10^{-1}, 0.074×10^{-1} and 0.047×10^{-1} respectively for short, medium, tall seedlings and small saplings in oak-t forest). None of the large saplings showed either die-back or mortality in the two forests. When the small saplings attained large sapling size, the fleshy tap root system became large enough to produce sufficiently vigorous shoots which are not vulnerable to the combined effect of hydric-deficiency and frosts.



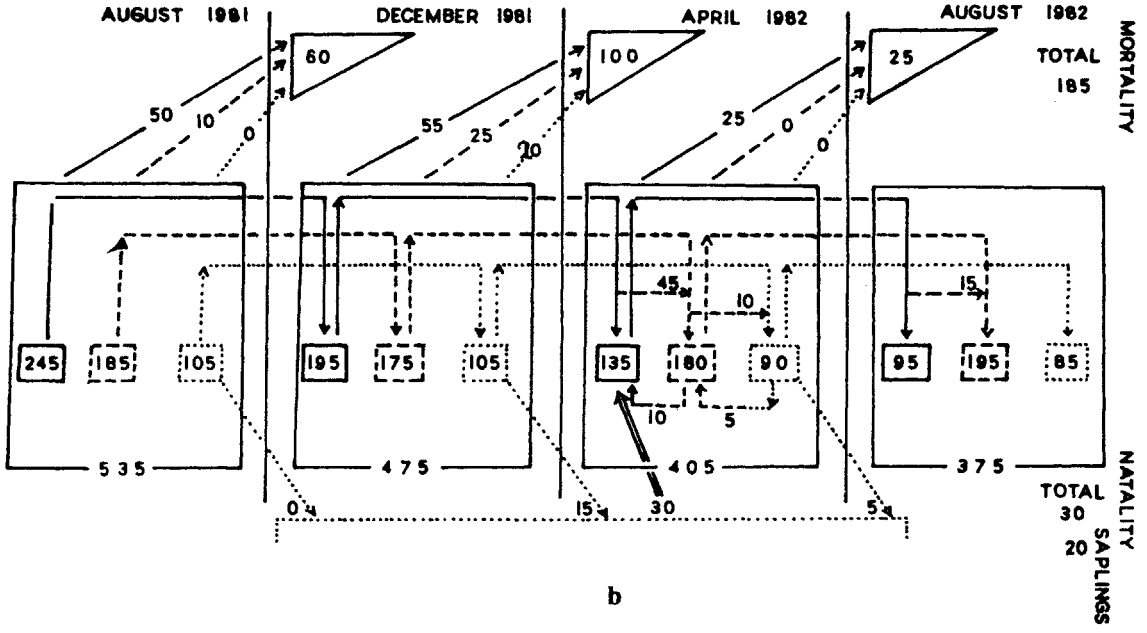


Figure 2 Population dynamics of oak seedlings in a plot of 0.2 ha during August 1981–August 1982, in Central Himalaya. (**a**) *Q. lanuginosa* in oak-r forest, (**b**) *Q. floribunda* in oak-t forest. Solid line boxes represent short size class (< 10 cm); broken line boxes represent medium size class (10–20 cm); dotted line boxes represent tall size class (20–30 cm) seedlings. Population of each size class at the beginning of the study are given in smaller boxes and that of total seedlings outside these boxes. Open triangles indicate mortality, arrows indicate transfer from one size class to the another size class. Sapling population is represented at bottom to indicate transfer to or from seedling population

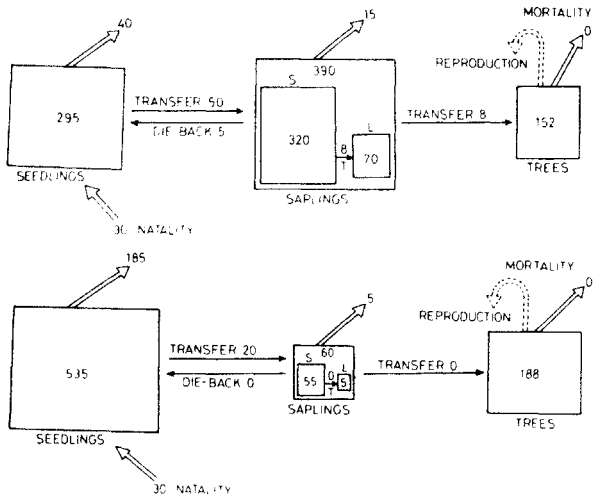


Figure 3 Population dynamics of number of individuals of seedlings, saplings and trees of two oak species each in a plot of 0.2 ha during August 1981–August 1982. (**a**) *Q. lanuginosa* in oak-r forest, and (**b**) *Q. floribunda* in oak-t forest. Within the sapling box, the small boxes represent small saplings (S = > 30 cm height and upto 10 cm cbh) and large saplings (L = > 10–30 cm cbh). The population of each one at the beginning of the study is given inside these small boxes, and arrow indicates transfer from S to L; and population size of the total saplings at the biginning is given inside sapling box, above the smaller boxes

It appears that the die-back and mortality of seedlings and small saplings of *Q. floribunda* enable them to withstand stressful conditions. The root-stock accumulates food translocated from the sprouted shoot, which die-back year-after-year until the root-stock becomes large enough to derive sufficient amount of water and nutrients from deeper soils to support sufficiently vigorous shoots, which are not susceptible to environmental hazards. A mild and relatively less dry winter may lead to the formation of a crop of such individuals. This phenomenon may also contribute to the formation of a population structure, indicative of a declining type of regeneration, as found for oak-t forest (figure 1b).

The time period of population dynamics data in the present study is very short than generally required for perennial species (Barkham 1980). However, the present trend of population dynamics in the two populations agree with the existing populations structure. Saxena and Singh (1984) have suggested that cutting and lopping of trees, trampling of seedlings and saplings owing to cattle and goat grazing, infection of acorns by a beetle (*Calandra glandium* Marshall.), decrease in total and winter rainfall, all contribute to failure of regeneration of *Q. leucotrichophora* A. Camus. (banj oak)—the most extensively distributed oak of the Central Himalaya. Intensity of the above biotic factors has been lesser in tilonj oak forest; hence better regeneration. It seems that with increasing biotic pressure, more and more oak forest stands are being adversely affected. For example, since the same beetle infests acorn of banj oak and tilonj oak (Troup 1921), it is likely that infestation of the acorn of one species will increase as the availability of the acorn of the other declines.

Further, marked decline in winter rainfall during recent years might partly account for the failure of tilonj oak regeneration. The tender tilonj oak seedlings produced later in the rainy season are likely to be more vulnerable to frost. In rianj oak, though seeds mature and fall during the winter season (Ralhan et al. 1985), they germinate at the beginning of the rainy season (Troup 1921) and, receive ample moisture during the early growth of seedlings.

Acknowledgements

The authors are thankful to the unknown reviewers of the manuscript. This work was funded by the Department of Science and Technology, New Delhi, and Ecodevelopment Project, Kumaun University, Naini Tal.

References

Barkham J P 1980 Population dynamics of the wild deffodil *(Narcissus pseudonarcissus)*. I. Clonal growth, seed production, mortality and the effect of density; *J. Ecol.* **68** 607–634

Benton A H and Werner Jr W E 1976 *Field Biology and Ecology* (New York: Mc Grew-Hill Inc.) 564 pp

Champion H G and Seth S K 1968 *General Silviculture for India* (New Delhi: Goverment of India)

Good N F and Good R E 1972 Population dynamics of tree seedlings and saplings in a mature eastern hardwood forest; *Bull. Torrey Bot. Club.* **39** 172–178

Khanna R K and Singh S P 1984 Standing state of nutrients; in *An Integrated Ecological Study of Eastern Kumaun Himalaya with Emphasis on Natural Resources* eds J S Singh and S P Singh; Final Report (HCS/DST/187/76), Vol. II pp 154–193 (Naini Tal: Kumaun University)

Knight D H 1975 A Phytosociological analysis of species-rich tropical forest on Borro Colorado Island, Panama; *Ecol. Monogr.* **45** 259–289

Puri G S, Meher-Homji V M, Gupta R K and Puri S 1982 *Forest Ecology* Vol. I, 2nd edition *Phytogeography and Forest Conservation* (New Delhi: Oxford and IBH Publ. Co.) 549 pp

Ralhan P K, Khanna R K, Singh S P and Singh J S 1985 Phenological characteristics of the tree layer of Kumaun Himalayan forests; *Vegetatio* **60** 91–101

——, Saxena A K and Singh J S 1982 Analysis of forest vegetation at and around Naini Tal in Kumaun Himalaya; *Proc. Indian natn. Sci. Acad.* **B48** 121–137

Rao P B 1984 *Regeneration of Some Trees of Western Kumaun Himalaya;* Ph.D. Thesis, Kumaun University, Naini Tal, 403 pp

—— and Singh S P 1985a Foothill sal regeneration in Himalaya; in *Proc. Seminar Environ. Regen. Himalaya: Concepts and Strategies,* ed. J S Singh, pp 294–308 (Nainital: Central Himalaya on Environmental Association, Gyanodaya Prakashan)

—— and —— 1985b Population dynamics of foothill sal *(Shorea robusta* Gaertn. f.) forest in Kumaun Himalaya; *Acta Oecologica/Oecol. Plant.* **6** 147–152

Saxena A K and Singh J S 1982 Quantitative profile structure of certain forests in the Kumaun Himalaya; *Proc. Indian Acad. Sci.* **91** 529–549

—— Singh S P and Singh J S 1984 Tree population structure of certain Himalayan forest associations and implications concerning their future composition; *Vegetatio* **58** 61–69

——, —— and —— 1984 Population structure of forests of Kumaun Himalaya: Implication for management; *J. Environ. Manage.* **19** 307–324

Singh J S and Singh S P 1984 *An Integrated Ecologicol Study of Eastern Kumaun Himalaya, with emphasis on Natural Resources* Final Report (HCS/DST/187/76) (Naini Tal: Kumaun University) Vols I–III

Tewari J C and Singh S P 1981 Vegetational analysis of forest lying in transitional zone between lower and upper Himalayan moist temperate forest; in *Proc. natn Seminar on the Vegetational Wealth of Himalaya;* pp 104–119 (Srinagar: Garhwal University)

Troup R S 1921 *The Silviculture of Indian Trees* Vols I–III (Oxford: Clarendon Press) 1195 pp

Upreti N, Tewari J C and Singh S P 1985 The oak forests of the Kumaun Himalaya (India): Composition, diversity, and regeneration; *Mount. Res. and Develop.* **5** 163–174