Chemical soil properties under five age series of
*Alnus nepalensis* plantations in the Eastern Himalayas

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Summary  Five age series stands of *Alnus nepalensis* D. Don monocultures have been selected from the Pankhasari range of the Kalimpong forest division in the Eastern Himalayas. Chemical soil properties such as organic carbon, total nitrogen, C:N ratio, available phosphorus and exchangeable cations (Ca$^{2+}$, K$^+$ and Na$^+$) were analysed in all these different ages of plantation stands from the surface to 1 m deep profiles to find out the long term effect of *A. nepalensis* on the soil quality of these erosion vulnerable slopes.

Organic carbon, available phosphorus and total nitrogen content per-hectare increased with increasing plantation stand age. Analysis of variance for nutrients showed significant variation in depth (total nitrogen, $P < 0.001$; organic carbon, $P < 0.001$; available phosphorus, $P < 0.05$; exchangeable Ca$^{2+}$, $P < 0.01$; and exchangeable K$^+$, $P < 0.01$) and between plantation stands (organic carbon, $P < 0.05$; and available phosphorus $P < 0.05$). High value of total nitrogen content (34.97 t ha$^{-1}$) was obtained in 46 yr old stand. Soil pH is low. It increased down the depth and in older plantations. These stands with high soil total nitrogen and organic carbon content show increased fertility of the stands. The cover of *A. nepalensis* in rocky, landslide and erosion prone slopes of the Eastern Himalayas, serves to protect and improve soil quality.

Introduction

*Alnus nepalensis* D. Don is a common tree in both natural and managed ecosystems in the Central and the Eastern Himalayas. It is planted as an associate species with *Cryptomeria japonica* Don, *Cupressus cashmeriana* Royle, *Betula alnoides* Ham, *Michelia champaca* Linn etc. and in monocultures. It is good nurse tree in *Cinchona* spp. and *Amomum subulatum* plantations in the Himalayan region. *A. nepalensis* is found to be a successful pioneer in freshly exposed soils in landslide affected areas, rocky and eroded slopes. *A. nepalensis* with actinorhizal root nodules is an efficient biological nitrogen fixer in the Eastern Himalayas$^{15}$. Actinorhizal species have been shown to improve soil nitrogen status and act as pioneer species on denuded habitats$^{16}$. The soil-improving properties of other *Alnus* species are well known. Studies have shown that *Alnus rubra* Bong. makes a significant con-
tribution to fertility of forested sites in the Cascade Range, USA\textsuperscript{18, 19} and on some of the more fertile coastal soils\textsuperscript{4}.

On the erosion prone slopes of the Himalayas the conservation of soil nutrients against erosion is an important task. Forest plantation by suitable species is probably the best way of control against erosion of soil along with nutrients. \textit{A. nepalensis}, a fast growing tree with nitrogen fixing capability, is a good species for plantation. Nitrogen, being easily washed down by torrential rains and through leaching, can be introduced into the system by \textit{Alnus} through biological nitrogen fixation\textsuperscript{15}. Thus a series of five different ages of \textit{A. nepalensis} plantation stands were selected to study chemical soil properties and nature of the effect of stand age on a long range basis (7 yr to 56 yr old plantation stands).

Materials and methods

Five different stands in the Pankhasari range of the Kalimpong forest division in the hills of Darjeeling (Eastern Himalayas) were selected (27° 7' N, 88° 35' E). These stands represented monocultures of \textit{A. nepalensis} of 7, 17, 30, 46 and 56 years. The selection of these stands were done on the basis of available age series of \textit{A. nepalensis} monocultures in close proximity. Ages of these alder stands were recorded in stand history maintained by West Bengal Forest Development Corporation. Each of the stand was divided into sample, buffer, measurement and study areas\textsuperscript{13}. The studies on soils were done in the measurement area. All the stands were within 10 km distance. These stands fall between 1670 m to 2040 m altitude above m.s.l. with a temperate climate. Normal annual precipitation is 3000 mm to 4000 mm. Mean maximum of 22.4°C, mean minimum of 15.4°C temperatures for the growing season (April to November) and mean maximum of 14.2°C, mean minimum of 6°C temperatures for the winter season (December to March) were recorded in 1981 to 1982. The selected stands occupy sloping topography (25° to 35° slope). Soils in the study stands were sandy loam in texture and dark brown to yellowish brown in colour. Soils exhibited little differences among stands. The geological formation belonged to Darjeeling Gneiss consisting of different grades of metamorphic rocks.

In July 1981, soil pits were excavated up to a depth of 1 m at five different monoculture stands of \textit{A. nepalensis}. The pits were divided into five horizons viz., (a) 0–20 cm, (b) 20–40 cm, (c) 40–60 cm, (d) 60–80 cm and (e) 80–100 cm. A bulk sample of each horizon was taken from each pit, air-dried and used for chemical analysis. Bulk density samples of soil were obtained from all the pits using bulk density tube sampler, oven dried (80°C for 48 hrs) and weighed. The calculated bulk density values were used to convert analytical data on kilograms or tons-per-hectare basis.

All chemical analyses were carried out with the air-dried, sieved (< 2 mm size) samples. Soil-water paste was prepared in 1:1 proportion for measurement of pH by glass electrode pH meter\textsuperscript{2}. Some of the chemical analyses were carried out by the procedures outlined by Jackson\textsuperscript{6}: (i) available phosphorus-dilute acid extracted and estimated by chlorostannous-reduced molybdo phosphoric blue colour method, (ii) total nitrogen – by modified Kjeldahl method and (iii) exchangeable calcium, potassium and sodium extracted by ammonium acetate solution and determined by flame photometer. The organic carbon was determined by Walkley-Black titration method\textsuperscript{14}.

In calculation of kilograms or tons per hectare of the various nutrients, values were calculated separately for each horizon and then added to obtain data for each profile.