Final Project Report of UGC Major Research Project for the period 01.04.2013 to 31.03.2017

An ecological study of paradoxical re-establishment of white oak in chir-pine invaded habitats and change in certain ecosystem processes and services in white oak-chir-pine ecotone areas in central Himalaya

F.NO 42-436/2013 (SR)

Dated: 12-3-2013

By

Prof (Dr.) Satish Chandra Garkoti

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Annexure-IX

UNIVERSITYGRANTS COMMISSION
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PROFORMA FOR SUBMISSION OF INFROMATION AT THE TIME OF SENDING THE FINAL REPORT OF THE WORK DONE ON THE PROJECT

1. Title of the Project: "**An ecological study of paradoxical reestablishment of white oak in pine invaded habitats and change in certain ecosystem processes and services in oak – pine ecotone areas in central Himalaya"**

2. Name and Address of the Principal Investigator: **Prof. S, C.Garkoti**
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3. Name and Address of the Institute: Jawaharlal Nehru University
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4. UGC Approval Letter No. and Date: **F. No. 42-436/2013 (SR), 12-03-2013**

5. Date of Implementation: 01.04.2013

6. Tenure of the Project: 01.04.2013 to 31.03.2017

7. Total Grant Allocated: Rs. ***12, 29,800/-***

8. Total Grant Received: ***Rs. 9, 59,471/-***

9. Final Expenditure: ***Rs. 9, 38,053/-***

1. 10. Objectives of the Project: To study regeneration of oak in oak-pine transition areas previously encroached by pine and to study changes in status of plant diversity with stand age.
2. To study the litter production, nutrient return and litter quality in regenerating oak forests

3. To estimate rate and amount of carbon sequestration and characteristic changes in habitats under oaks and,
4. To suggest management implications of oak re-establishment in the central Himalaya

11. Whether Objectives were Achieved: YES

12. Achievements from the Project:

- Garkoti, S. C. (2014). Litter production and nutrient return in two regenerating white oak *(Quercusleucotrichophora A. Camas*) forests in central Himalaya. International Journal of Ecology and Environmental Sciences 40: 139-148.
- Garkoti S.C. (2014). Regeneration of white oak (*Quercusleucotrichophora*) in two pine invaded forests in Indian Central Himalaya. In: Management of Natural Resources in a Changing Environment, N. J. Raju, W. Gossel and M. Sudhakar, eds., Capital Publishing Company, New Delhi (ISBN 978-93-81891-25-4), 200-205.
- Verma, A. andGarkoti S.C. (201x).Tree diversity, population structure and carbon stock of the regenerating oak forests in Almora, Central Himalaya. Current Science. (Submitted).
- Verma, A. and Garkoti S.C. (201x). Fine root biomass, productivity and turnover of four regenerating oak forests in Almora, Central Himalaya. Journal of Forest Research (Submitted).

13. *Summary of the Findings (in 500 words):*

Introduction and study area

Among the various oak species that occur in central Himalaya, white oak (*Quercusleucotrichophora*) contributes to a greater proportion of ecosystem services than most

of other species in the region (Singh 2002, Joshi *et al.* 2011). Present study reports regeneration of white oak in chir-pine encroached forests in oak-pine transition zones in the central Himalaya. After completion of phytosociological study in seven representative sites (Asota, Thath, Toli west, Toli east, Takoli band, Hathikhan east and Hathikhan west) located in Lamgara block of Almora district in Indian central Himalaya, four stands were selected for detailed study on carbon stock, C sequestration, soil characteristics and litter dynamics.

Phytosociology and species population structure

A total of five tree species were found in white oak regeneration forests, of which *Q. leucotrichophora*, *P. roxburghii*, *M. nagi* and *R. arboreum* were common and *Pyruspashia*, was found only in one site (Toli East). Total tree density varied from 330 trees ha^{-1} (Toli East) to 1550 trees ha^{-1} (Hathikhan East). Although, total basal area (TBA) for chir pine was higher than white oak, IVI values of oak (126.96 – 165.50) and pine (72.82 – 128.14) suggested that oak was the dominant species across the sites. Total basal area of trees varied from 17.0 m^2 ha^{-1} (Toli East) to 46.1 m^2 ha^{-1} (Hathikhan West). The presence of white oak in lower size classes showed young expanding population of the species whereas in case of chir-pine, presence of individuals mostly in higher size classes indicated declining population. Existence of mostly old chir-pine trees and younger stage white oak trees indicate the dominance of chir-pine in the past. It seems the shade being created by regenerating white oak does not allow establishment of light demanding chir-pine seedlings.

Biomass and carbon stock

Total tree biomass of forests varied from 137.03- 503.27 Mg ha^{-1} and total carbon density was found to be between 64.40- 236.54 Mg ha^{-1}. White oak has a more developed root system (~30% of the total biomass) than chir-pine, (~20%). Carbon density of white oak varied between 48.81-

166.1 Mg ha^{-1} while for chir-pine it varied from 11.44- 63.50 Mg ha^{-1}. The carbon density was found to be significantly correlated (R^2=0.9) with the basal area of trees. Across the sites white oak accumulated the highest biomass and C followed by chir-pine. Contribution of white oak to total biomass ranged from 58 % to 73.8 % whereas contribution of chir-pine remained less than 30% (range 17.8 %- 30.0 %). Carbon density for white oak was 55-75% followed by chir-pine 21-30%.

Litter dynamics

In each site, litter fall varied with change in total basal area (TBA) of the forests. Maximum litter fall was reported in the summer season (March to June) with a peak in the month of April. Among the forest stands, the highest total litter fall was found in Hathikhan west (3.9 Mg ha^{-1}) and the lowest in Toli west (1.7 Mg ha^{-1}) forest.

The rate of decomposition was faster during the rainy season (June to September) which declined during winters. In one year, percentage decrease in the litter biomass was found 66% and 54% in white oak and chir-pine, respectively. Decay rate constant was analyzed by using single exponential model given by Olsen (1963). Decay constant was found 1.08 and 0.812 for white oak and chir-pine, respectively. Half-life time for white oak and chir pine leaf litter was 0.64 year and 0.85 year, respectively indicating higher rate of litter decomposition in white oak leaves compared to chir-pine.

In both the species, concentration of total nitrogen increased initially and then started decreasing. Percentage of total nitrogen declined from 0.86-0.43% for white oak and from 0.76-0.49% for chir-pine. Total initial phosphorus in decomposing litter was found 0.26% in white oak and 0.07% in chir-pine which reduced to 0.08% in white oak and 0.025% in chir-pine at the end of

one year. Significant decrease ($p<0.05$) in the N and P concentration in both the species were recorded.

Soil characteristics

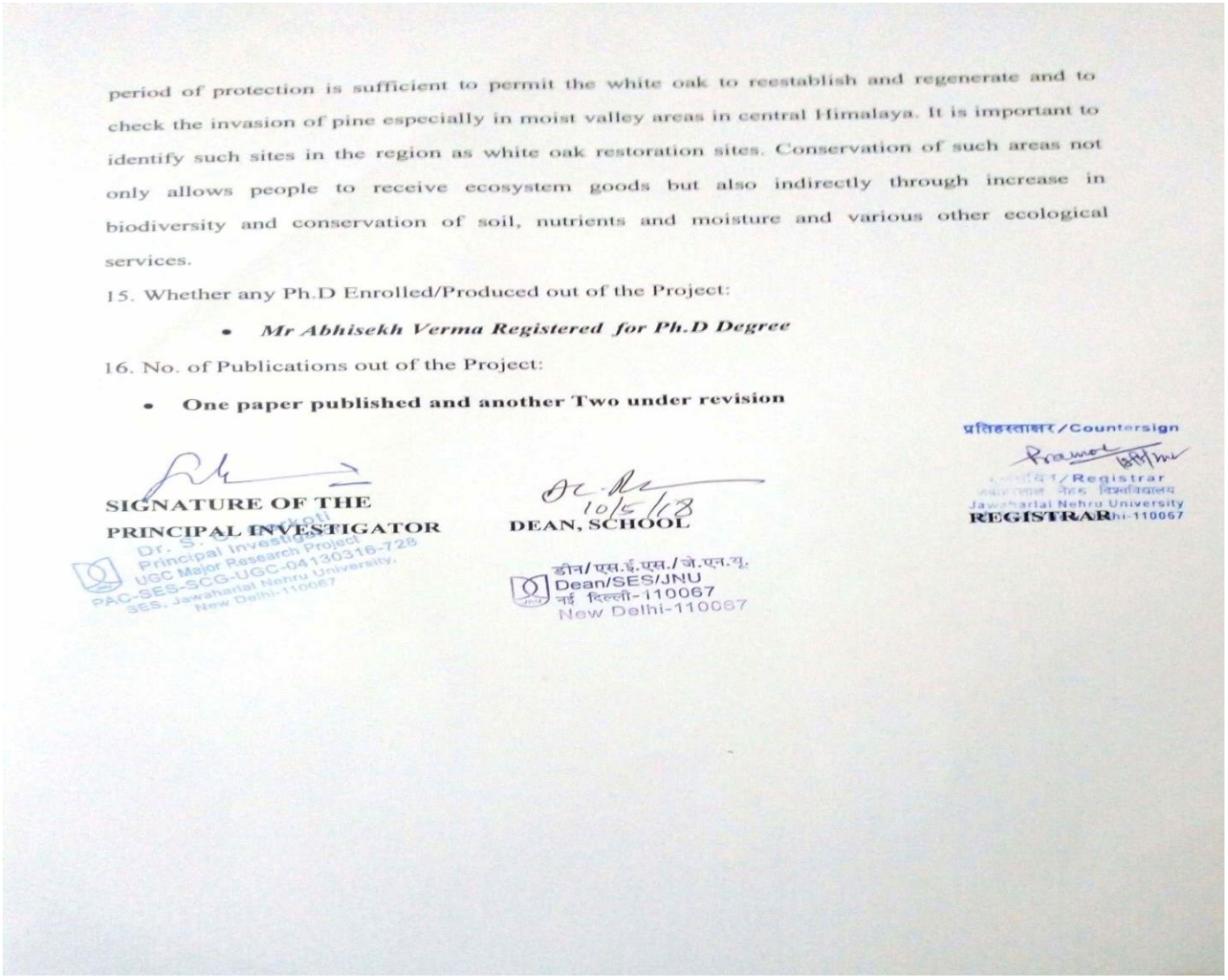
Clay percentage increased from Toli east (4.17 %) to Hathikahan west (7.95 %) (Table 11). Soil was sandy loam in Toli west, Thath, and Hathikhan east and loamy in Hathikhan west, Fig 27). Across the sites, soil was slightly acidic (4.7- 5.8) (Table 12). Soil pH values did not vary significantly ($p>0.05$) across the forests. Total soil organic carbon (TOC) was found higher in older forests compared to younger regenerating forest stands. In all the forest stands, total nitrogen and available phosphorus were highest in top soil layer (0-10 cm). ANOVA indicated that values varied significantly ($P<0.05$) across sites and soil depths.

Conclusions

Across the sites, regeneration of *Q. leucotrichophora* (white oak) was significantly higher as than co-occurring species. IVI values for white oak were higher than chir-pine indicating its clear dominance. As the disturbance in the form of forest fire and lopping has been excluded for some time in the past the white oak was able to reestablish and expand. Population structure analysis of present study sites indicates that contribution of light demanding chir pine in terms of TBA, biomass, C stock and litter would gradually decline in future. It seems that reoccupation of the sites by white oak ameliorates the habitat conditions (e.g., N and moisture) which results into faster growth and higher biomass and C sequestration in the forest stands. Once established, white oak is able to maintain high soil fertility, through return of nutrient rich litter and rapid mineralization of nutrients (Singh and Singh 1992). The contribution of light demanding chir pine gradually declines in those stands.

14. Contribution to the Society:

Disturbances are now considered integral part and also the driving force in ecosystem dynamics in most of the regions in the Himalaya and elsewhere. Present study indicates that even a short



period of protection is sufficient to permit the white oak to reestablish and regenerate and to check the invasion of pine especially in moist valley areas in central Himalaya. It is important to identify such sites in the region as white oak restoration sites. Conservation of such areas not only allows people to receive ecosystem goods but also indirectly through increase in biodiversity and conservation of soil, nutrients and moisture and various other ecological services.

15. Whether any Ph.D Enrolled/Produced out of the Project:

- ***Mr Abhisekh Verma Registered for Ph.D Degree***

16. No. of Publications out of the Project:

- **One paper published and another Two under revision**

SIGNATURE OF THE PRINCIPAL INVESTIGATOR

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