Conservation of Native brown oak forests through reduction in grazing pressures and facilitative means of regeneration in a temperate broadleaf forest of Bhutan Himalayas

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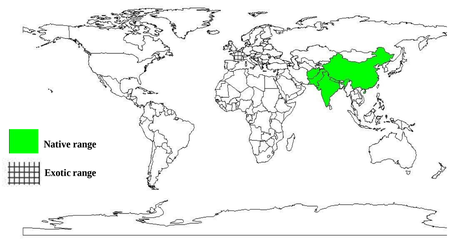
1. Introduction

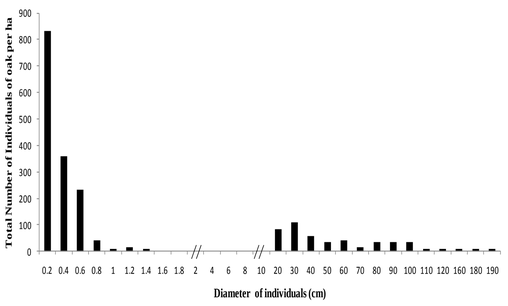
Temperate broadleaf forests dominated by old growth brown oak (*Quercus semecarpifolia* Sm.) is a precious gift to the Himalayan forests as it is strongly associated with subsistence farming, rich biodiversity and production of good quality and quantity springs.

The evergreen leaves serve as an important fodder resource during the dry winters when all the grasses dry up while the forests forms the grazing ground for livestock rearing which is one of the predominant activities in this forests.



Distribution of brown oak (source: Orwa et al.2009)

Throughout the Himalayan range old-growth oak trees dominate the canopy of these forests and they support the vast range of plant and animal species to survive under the canopy and are known as the "keystone species" without which the whole ecological balance would collapse (Shrestha, 2003).



Current status of brown oak recruitment in the study area according to the diameter distribution classes.

Brown oak forest is poorly regenerating and recruitment is lacking thoughout the Himalayan range. It was assumed as a consequence of overgrazing.

Regeneration and seedlings are hampered "Oak forest under threat: an urgent concern for mountain environment" (Shrestha & Paudel, 1996).

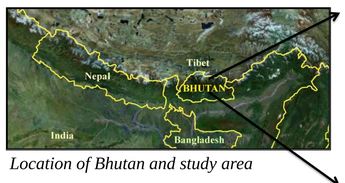
Oak recruitment into upper canopy classes is not occurring currently.

However, no adequate studies have been undertaken to understand the impact of grazing on oak seedlings and recruitment.

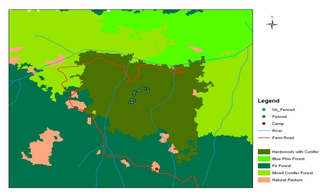
2. Research Objective

1. Assess the impact of Cattle grazing on the regeneration and survival of seedlings in oak forests
2. Understand the changes in plant composition after exclusion of cattle through fencing
3. Recommend some techniques whereby both grazing and oak regeneration can be sustainably incorporated

3. Study Area

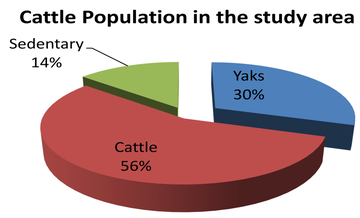


Location of Bhutan and study area



- Chimithangkha, western Bhutan
- alt. 2800m to 3100m above sea level
- Forest type -Evergreen broadleaved forests
- dominant Species –Oak and Hemlock

- Migratory Cattle graze through out the year
- Winter- Yaks
- Summer-Cow



Migratory Yaks and cows graze in the forests during winter and summer respectively

4. Methods

Twelve square plots of 10 m x 10 m fenced (Ungrazed) to exclude grazing and unfenced comparable plots were set in the forests. Three types of Seedling shelters (Protex tube, Iron mesh and wooden) are established in July 2014 to protect planted oak seedlings from grazing

Vegetation Survey

Tree layer survey was done in circular plots of 15 m radius from the centre of each square plot to understand the abundance and distribution of mother trees which act as seed sources.

Shrub layer survey was done in 10 m x 10 m plots . The height of tallest shrub individual was recorded which is then multiplied with its percent coverage in each plot to determine the relative volume which is used for dominance analysis.

Regeneration of seedlings were assessed in the 10 m x 10 m plots which are divided into 1 m x 1 m subplots. Height and collar diameter of seedlings were recorded.

Leaf Mass Area

$$LMA = \frac{\text{Oven dry weight}}{\text{Leaf area}} \ (gcm^{-2})$$

Social survey

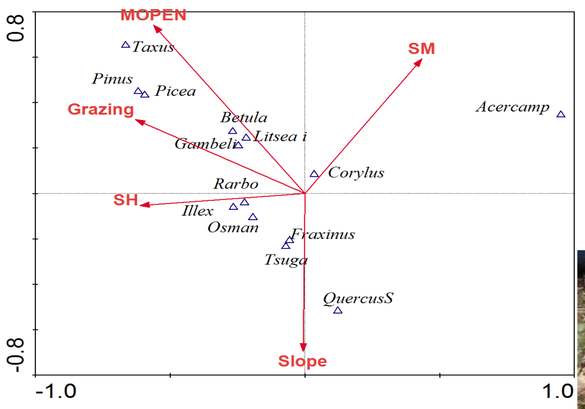
- House Hold interviews
- Herders interview

Vegetation survey in unfenced forest

Social survey with herders in winter

5. Results *Cont.*

5.4 Species environmental relationships (CCA)



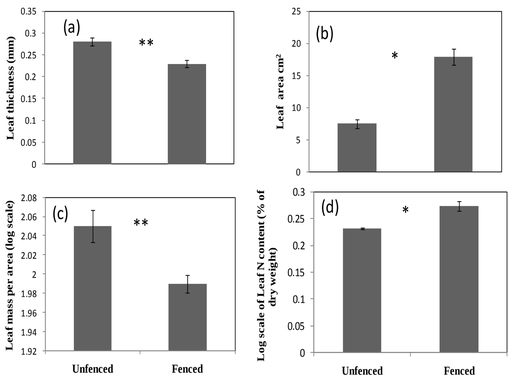
Grazing has significant effect on species distribution ($p<0.05$, Canonical Correspondence Analysis). Grazing in plots with more canopy opening resulted in recruitment of conifer species. Oak preferred sites with out much grazing intensities such as slopes.

5.5. Seedling morphology

Grazed leaves are thicker smaller and had more surface spines compared to ungrazed leaves.

Leaf mass per area (LMA) is a very important which can explain the growth characteristics of plants and determine whether they grow in stressful environments. Higher values of LMA is associated with more stressful conditions.

The LMA (g cm^{-2}) was significantly higher for the unfenced and grazed seedling leaves than the fenced seedling leaves .



Labels indicate results of one-way ANOVA tests, **P < 0.001, *P < 0.05, NS not significant. Bar represents standard error of the mean

5. Results

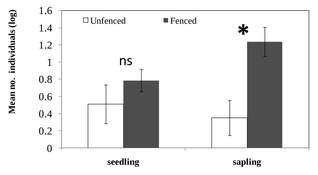


Figure 1 Effect of grazing and fencing on numbers of oak seedlings and saplings.

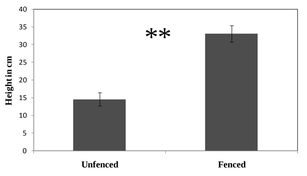


Figure 2 Effect of grazing and fencing on height growth of oak recruits.

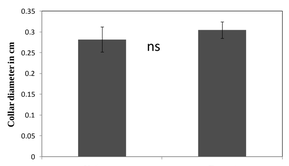


Figure 3 Effect of grazing and fencing on collar diameter of oak seedlings and saplings.

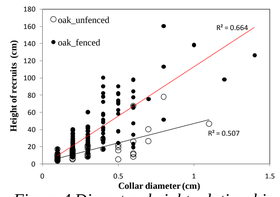


Figure 4 Diameter- height relationship of grazed and ungrazed oak recruits

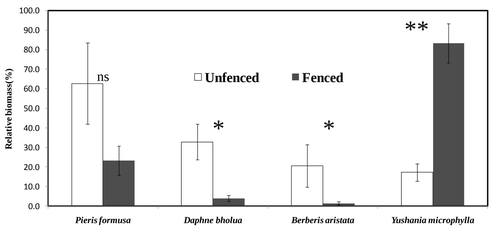


Figure 5 Effect of grazing on shrub composition .

**Labels indicate results of one-way ANOVA tests, *P < 0.05, ns= not significant. Bar represents standard error of the mean.*

5.1. Seedling and sapling densities

Seedling numbers did not differ considerably between grazed and ungrazed plots how ever saplings in the ungrazed plots were 3.5 times higher than the grazed plots.

5.2 . Height & diameter growth of seedlings

The height of oak recruits in the ungrazed plots were significantly larger than the mean height of oak recruits in the grazed unfenced plots (Fig 2).

Diameter- height relationship showed a depression in the height growth of grazed oak recruits (Fig. 4).

5.3. Shrub cover

Bamboo Yushania microphylla increased significantly in the ungrazed fenced plots compared to the grazed plots (one-way ANOVA, $F_{1,10}=32.49$, $p<0.001$, Fig.5).

Unpalatable shrubs increased in the grazed plots

No differences were observed in the composition of annual herbs in the grazed and ungrazed plots.

6. Discussions and conclusion

Regeneration of brown oak, was poorly represented at the sapling and small tree stage in the grazed plots. As reported in other Himalayan oak forests, heavy mortality of seedlings and saplings might be responsible for lower recruitment of oaks into upper classes (Thadani & Ashton, 1995; Vetaas, 2000).

Overgrazing by livestock appeared to hamper recruitment of brown oak. Due to taller height and easier visibility, saplings were more browsed and damaged than the seedlings by grazing animals (Nomiya et al., 2002). As a result the number of saplings in the un-grazed plots was more than three times higher than the grazed plots. Un-grazed oak seedlings were more than two times taller than the grazed oak seedlings. Grazing also led to significantly high LMA which is an indicative of grazing stress on the seedlings, their survival and lower recruitment into canopy layers.

Fencing has shown to improve the regeneration and reduce damage to brown oak seedlings. However, the build up of bamboo *Yushania microphylla* overgrowth following exclusion of grazing animals can result in strong competition and damages to seedlings from rodents and insects (Darabant et al., 2007, Douglas et al., 2005, Nomiya et al., 2002). Our findings indicate that complete exclusion of cattle in these forests is not advisable and is also against the sentiments of rural communities.

Use of rigid tubes as "seedling/tree shelters" placed over individual seedlings to protect the particular seedling/sapling until they attain a height safe from browsing (Approximately 2 m) could be an option to simultaneously regenerate oak and rear livestock in the broadleaf forests.

Many of the broadleaf forests of Bhutan are least studied and there are no adequate information on grazing and forest regeneration. Replication of similar studies by deploying fenced and adjacent comparable unfenced plots and seedling shelters will give a better idea of grazing and regeneration interactions on a wider scale.

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