

## Short Communication

# Restoration of Degraded Forests: A Case Study of Kujapuri Hills of Garhwal Himalaya, Uttarakhand

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## ABSTRACT

Present study has been carried out in the degraded forests of Kujapuri Hills located in district Tehri of Garhwal Himalaya, Uttarakhand. Excessive grazing and lopping in this hill forest has experienced a heavy degradation resulting in the loss of biodiversity and depletion of natural resources on which a very sustenance of local people depend. Considering the importance of biodiversity and sustaining resources for the livelihood of rural people, species of diverse importance depending on the ecological adaptability and peoples needs, species such as *Quercus leucotrichophora* A. Camus, *Grewia optiva* Drum ex. Burret, *Celtis australis* L., *Acer oblongum* Wall. ex. DC. (fodder), *Arundinaria falcata* Nees, *Dendrocalamus strictus* (Roxb.) Nees (commercial), *Cedrus deodara* (Roxb. ex. D. Don) G. Don (sacred), *Fraxinus micrantha* Lingelsh, *Toona ciliata* Roemer, *Aesculus indica* (Colebr. ex. Camb.) Hook. (forestry) have successfully been introduced under restoration measures in the degraded forest. Species diversity which was 0.67 and 1.52 for shrubs and trees before restoration has increased significantly to 2.36 and 1.86 respectively, after restoration measures. The paper describes the change in the floristic composition and species diversity as a result of restoration in degraded forest of Kujapuri hills.

*Key Words:* Restoration, Degraded Forest, Natural Resources, Diversity

## INTRODUCTION

Forests are significant part of the land use in India being occupying 20.64 % of the total geographical area of the country. Forests continues to be very important for Indian society because more than 100 million people are actually forest dwellers and another 275 million are dependent on them for their livelihood and means of survival (Lynch 1992).

In the context of fragile Himalayan mountain ecosystem forests play the central role in the economy and ecology of the region through providing various tangible and intangible goods and services. They are considered sustainers of rural-livelihood. The over- and unspecific extraction of forest resources such as fuel, fodder, flowers, medicinal plants, timber, and over-grazing are causing heavy degradation of forest eco-

systems in the Himalayan region. The degradation in the mountain ecosystems is further compounding with the occurrence of natural calamities such as landslides, landslips, cloudburst, outbreak of beetals, pathogens etc. Therefore, Himalayan resources and environment are under severe ecological and economic stress. Manifold problems such as loss of gene pool, soil erosion, sedimentation, resource crisis are very much associated with the loss of plant resource. Losses of forest cover, biodiversity, agricultural productivity, and ecosystem services are interlinked problems in the region that threaten the sustainable livelihoods of not only 115 million mountain people but also the much larger population inhabiting the adjoining Indo-Gangetic plain (Hamilton 1987, Ives and Messerli 1989, Myers 1990, Hurni 1999).

Though degradation of natural forest is a global problem (Guppy 1984, Sayer and Whitmore 1991), however, the degradation in mountain forest ecosystem is experienced heavily firstly because the majority of the people lives in rural areas and practice forest dependent agriculture. Secondly dependency on forest for their day to day requirements particularly for fuel, fodder, medicine and other forest based resources, and thirdly most important is regulating ecological function including prevention of soil erosion and land degradation (Govt. of India 1999). Further the degeneration of forest resources are not only pronouncing the impact on the mountain ecosystems, but also liable to the long term catastrophic impacts on the plains/valleys regions and consequently in whole of the country. Conservation of plant resource or biodiversity is felt necessary to maintain the varied microclimate and ecological niche not only for plants and animals but also for human beings. Biodiversity conservation besides having important ecosystem functions and watershed protection also plays an important role in maintaining the tangible benefits on which very sustenance of human and cattle population in rural mountain areas are dependent. In view of growing threat to biological diversity, conservation and rational use of biodiversity in the Himalayan region could bring enormous economic benefits to the local populations and can indeed contribute to sustainable development (Khoshoo 1992, Dhar 1997).

Realization to involve the local communities in conservation of natural resources and developing awareness among mass about ecological value of conserving natural resources is being well appreciated at the present context when there is continuous degradation of natural resources. As an example to sustain and conserve the forest resources particularly plant resources, a study has been carried out in the degraded forests of Kujapuri hills in Garhwal Himalaya with active participation of villagers.

## CASE STUDY

The present study was undertaken in the hills of religious place named Kujapuri, which is situated at an altitude of about 1,676 m. The place lies at latitude 30° 11' N and longitude 78° 20' E, about 93 km from Devprayag and 7 km from Narendra Nagar on Rishikesh -Gangotri highway.

The hills are dominated by the forests of *Quercus leucotrichophora*. The villages adjacent to the Kujapuri

hills, derives their day to day requirements such as fuel, fodder, etc. from the adjoining forests. The villages are therefore, directly influenced by the present condition of the forest existed in the region. More than 150 households belonging to different caste groups i.e. Brahmins, Rajput and Schedule Castes inhabit these villages. The human population of these villages is about one thousand five hundred. Agriculture and cattle rearing are the main source of villagers' livelihood. Due to increasing biotic pressure on the forest on account of heavy dependency, the area is experiencing degradation resulting in loss of biodiversity and resource depletion. As the whole livelihood of the villagers depends on forests, there is a need to conserve the plant resource and resulting ecological functions of degraded forest ecosystem is felt deemed importance.

## Species Selection in Restoration

The selection of species used in restoration measures were based on (i) adaptability of the species in the prevailing environmental condition, and (ii) species with commercial, economic and various other values including that for soil conservation etc. (Table 1).

The study was conducted during the period 2004-2007. Plant species selected were planted through seedling planting and culms and as in the case of *Arundinaria falcata* Nees and *Dendrocalamus strictus* (Roxb.) Nees. Villagers' involvement was the prime objective through out the study period. Their involvement achieved through developing awareness campaign time to time and creating awareness about the functional role and importance of conserving biodiversity.

## Vegetation analysis

In order to ascertain the impact of restoration on plant resource particularly the composition, structure and diversity of woody species, vegetation analysis was done before and after implementation of restoration activities. Vegetation analysis was done using quadrat method (Mishra, 1968). Two quadrat sizes, i.e., 10x10m for tree vegetation and 5x5m for shrub vegetation were used. Saplings were considered under shrub layer. Quadrat was placed randomly in the study area. Community attributes such as frequency, density and finally Importance Value Index was calculated. Diversity index was also calculated using Shannon and Wiener (1963).

Table 1. Species of multiple importance used in restoration process in the Kujapuri hills

Species	Local names
<b>Forestry</b>	
<i>Acer oblongum</i> Wall. ex. DC.	Parang
<i>Aesculus indica</i> (Colebr. ex. Camb.) Hook.	Pangar
<i>Toona ciliata</i> Roemer	Tun
<i>Cupressus torulosa</i> D. Don	Surai
<i>Ficus rumphii</i> Bl.	Pilkhan
<i>Fraxinus micrantha</i> Lingelsh.	Angu
<i>Myrica nagi</i> Thunb.	Kaphal
<i>Platanus occidentalis</i> L.	Chinar
<i>Prunus cerasoides</i> D. Don	Padam
<i>Rhododendron arboreum</i> Smith	Burans
<i>Robinia pseudacacia</i> L.	Bini
<b>Fodder</b>	
<i>Bauhinia variegata</i> L.	Kachnar
<i>Celtis australis</i> L.	Kharik
<i>Desmodium tiliaefolium</i> D. Don	Chamlai
<i>Grewia optiva</i> Drum ex. Burret	Bhimal
<i>Quercus leucotrichophora</i> A. Camus	Banj
<b>Sacred</b>	
<i>Abies pindrow</i> Royle	Fir
<i>Aegle marmelos</i> (L.) Correa	Bel
<i>Ficus benghalensis</i> L.	Burgad
<i>Ficus religiosa</i> L.	Pipal
<i>Cedrus deodara</i> (Roxb. ex D. Don) G. Don	Deodar
<b>Commercial</b>	
<i>Arundinaria falcata</i> Nees	Ringhal
<i>Cinnamomum tamala</i> (Buch-Ham) Nees ex Eberm.	Tej pata
<i>Dendrocalamus strictus</i> (Roxb.) Nees	Bans
<b>Biofuel</b>	
<i>Jatropha curcas</i> L.	Ratanjot

## RESULTS AND DISCUSSION

Floristic attributes of woody vegetation i.e. trees and shrubs before and after restoration are presented in Tables 2-5. The tree species which were three in number before restoration has increased five in number after restoration (Tables 2 and 4). Increasing two more tree species particularly *Cedrus deodara* and *Debregeasia hypoleuca* after restoration may be due to protection of

the area. At the time of vegetation survey before restoration, the diameter of these species might not be qualifying the criteria of tree. As a result of protection of these species might get the chance to enhance their growth in the form of diameter. *Debregeasia hypoleuca* is generally grown in the form of shrub, but in moderate conditions the species get a change to qualify the criteria of tree restoration. Therefore in literature also the habit of *D. hypoleuca* is mentioned as shrub or medium sized tree. As regard to *Cedrus deodara* it is a planted species in the area. At the time of initiation of activities, there were few planted trees of *C. deodara* and they were in the form of saplings. After two year of restoration, the same *C. deodara* attained the growth up to the mark of a tree. Both before and after restoration, *Q. leucotrichophora* attained highest dominance and hence, highest IVI (134.8 and 156.1 before and after restoration respectively).

Table 2. Tree community structure in Kujapuri hills before restoration

Species	Frequency %	Density Number 100m <sup>-2</sup>	T.B.C cm <sup>2</sup> 100m <sup>2</sup>	I.V.I.
<i>Quercus leucotrichophora</i> A. Camus	100	2.0	185.0	134.8
<i>Pyrus pashia</i> Buch.-Ham. ex D. Don	100	2.3	106.2	116.1
<i>Cocculus laurifolius</i> DC.	33.3	1.3	37.3	148.7

As regard to the species under shrub layer there were nine shrubs species and three species in the form of saplings before restoration (Table 3), whereas after restoration the species number under shrubs layer were recorded twenty nine containing 17 shrubs and 12 saplings (Table 5). The increase in the number of shrubs species after restoration may be due to the protection of area from biotic disturbance, and the planting of seedlings of tree species which were in the form of saplings at the time of vegetation survey. These tree saplings in due course of time will attain the growth and qualify the characteristics of a tree. *Eupatorium glandulosum* a common weed has attained highest dominance in both conditions i.e., before and

after restoration, having recording highest value of IVI. *Q. leucotrichophora* and *Celtis australis* attained highest dominance among saplings, with the highest IVI value. Their pronounce growth is attributed to the better acclimatization of species in the existing environmental conditions. The better acclimatization of these species

Table 3. Shrub community structure in Kujapuri hills before restoration Values for 25m<sup>2</sup> plots

Species	Frequency %	Density (number)	IVI
<i>Eupatorium glandulosum</i> HBK. non Michx.	100	109.6	194.0
<i>Strobilanthes</i> sp. Nees	66.6	7.0	16.4
<i>Desmodium tiliacifolium</i> D. Don	66.6	1.0	13.6
<i>Rubus lasiocarpus</i> Smith	66.6	3.6	13.5
<i>Rubus ellipticus</i> Smith	66.6	2.3	12.8
<i>Hypericum patulum</i> non Thunb.	66.6	0.6	11.2
<i>Berberis asiatica</i> Roxb. ex. DC.	33.3	1.0	6.3
<i>Rhamnus virgatus</i> Roxb.	33.3	0.67	5.8
<i>Cocculus laurifolius</i> DC.	20.0	0.80	2.8
<i>Zanthoxylum alatum</i> Roxb.	33.3	0.15	5.5
<i>Prunus cerasoides</i> D. Don *	20.0	0.20	2.1
<b>Saplings</b>			
<i>Grewia optiva</i> Drum ex. Burret *	20.0	0.20	2.0
<i>Cocculus laurifolius</i> DC.	33.3	6.78	6.3
<i>Acer oblongum</i> Wall. ex. DC.*	20.0	0.20	2.0
<i>Grewia optiva</i> Drum ex. Burret	33.3	0.50	5.8
<i>Thuja orientalis</i> L.*	20.0	0.20	2.0
<i>Machilus</i> sp. Nees	33.3	1.13	5.6

Table 4. Tree community structure in Kujapuri hills after restoration

Species	Frequency %	Density Number 100m <sup>2</sup>	I.V.I.
<i>Quercus leucotrichophora</i>	100	4.2	156.1
<i>Pyrus pashia</i>	100	1.6	96.2
<i>Cocculus laurifolius</i> DC.	20.0	0.2	17.7
<i>Cedrus deodara</i>	20.0	0.6	17.9
<i>Debregeasia hypoleuca</i>	20.0	0.2	12.1

Table 5. Floristic composition of shrub vegetation in Kujapuri hills after restoration

Species	Frequency %	Density (number)	IVI
<i>Eupatorium glandulosum</i> .	100.0	53.8	160.0
<i>Arundinaria falcata</i> Nees *	100.0	2.6	22.4
<i>Boenninghausenia albiflora</i> (Hk.) Reichb..ex. Meisn.	60.0	9.8	16.9
<i>Desmodium tiliacifolium</i> D. Don *	100.0	3.0	12.3
<i>Cissus repanda</i> Vahl.	40.0	1.4	5.1
<i>Randia uliginosa</i> DC.	40.0	0.8	4.8
<i>Clematis grata</i> Wall.	40.0	1.0	4.6
<i>Rubus lasiocarpus</i> Smith	40.0	0.8	4.4
<i>Zanthoxylum alatum</i> Roxb.	40.0	0.6	4.4
<i>Smilax glaucophylla</i> Klotz.	20.0	0.8	2.7
<i>Clematis buehanianiana</i> DC.	20.0	0.6	2.4
<i>Dioscorea belophylla</i> Voigt.	20.0	0.4	2.2
<i>Reinwardtia trigyna</i> Planch	20.0	0.4	2.2
<i>Dendrocalamus strictus</i> (Roxb)Nees	20.0	0.2	2.0
<i>Hypericum patulum</i> non Thunb.	20.0	0.2	2.0
<i>Asparagus racemosus</i> Willd.	20.0	0.2	2.0
<i>Jasminum humile</i> L.	20.0	0.2	2.0
<b>Saplings</b>			
<i>Quercus leucotrichophora</i> *	60.00	1.0	6.5
<i>Toona cilata</i> Roemer*	60.0	0.8	6.3
<i>Celtis australis</i> L.*	60.0	0.8	6.2
<i>Rhamnus virgatus</i> Roxb.	40.0	1.2	4.9
<i>Pyrus pashia</i>	40.0	0.8	4.7
<i>Fraxinus micrantha</i> Lingelsh.*	40.0	0.6	4.3
<i>Cedrus deodara</i> *	40.0	0.4	3.9
<i>Cocculus laurifolius</i> DC.	20.0	0.8	2.8
<i>Prunus cerasoides</i> D. Don *	20.0	0.2	2.0
<i>Grewia optiva</i> Drum ex. Burret *	20.0	0.2	2.0
<i>Acer oblongum</i> Wall. ex. DC.*	20.0	0.2	2.0
<i>Thuja orientalis</i> L.*	20.0	0.2	2.0

\* Species planted

in the area is further supported by the fact that the existing climatic condition is already supporting *Q. leucotrichophora* and *C. australis* in this region. The IVI indicator of dominance has reduced from 194.0 before restoration to 159.98 after restoration in case of *E. glandulosum*. This behaviour indicates a positive sign of control of unwanted weeds and management of degraded forests. In due course of time when planted species will attain thick canopy cover the growth and spatial distribution of *E. glandulosum* will be restricted. *Arundinaria falcata* has registered its dominance next of

*E. glandulosum*. This indicating that this area would be able to cater the need of raw material for making household goods such as mats, baskets etc. in future and that may boost the rural economy .

Species diversity index of shrubs increased significantly from 0.67 before restoration to 2.40 after restoration. Similarly, the diversity of tree species increased from 1.52 to 1.86 after restoration measures (Table 6). The significant increase in the diversity of shrubs is attributed to introduction of various tree species. Since at the time of survey these planted tree species were in the form of saplings, therefore they were considered under shrub layer. As the diversity index is the function of number of species and distribution of individuals in the system, the increased number of saplings on account of planting has resulted the enhancement of diversity index of shrub layer.

Table 6. Species richness and diversity of woody vegetation before and after restoration in degraded forests of Kujapuri

	Before Restoration		After Restoration	
	Tree	Shrub	Tree	Shrub
Species richness	3	12	5	29
Species diversity	1.52	0.67	1.86	2.40

In Himalaya region as regard to restoration most of the studies are concentrated in mined and landslides areas. Very few studies are available in the context of enhancing diversity of degraded forests. Studies may be available of planting of one or two species in degraded forests but not in the context of enhancing diversity. Soni and Vasistha (1986) have attempted restoration of rock phosphate mined lands in Doon Valley, where they reported significant enhancement of diversity of all plant forms after restoration. Similar efforts have also been made by them in lime stone mined in Mussoori hills (Soni et al. 1994). Pandey and Singh (1984) studied the vegetation recovery mechanism in disturbed moist temperate oak forest ecosystems due to landslides in Kumaun Himalaya, where they observed sequential development in vegetation community from i.e. annual forbs in the initial stage to the perennials in later stages of development.

## CONCLUSIONS

Restoring diversity of degraded forests will not only be facilitating the natural process of speciation but will also become a source of germplasm of various species for the research. Enhancement of carbon sequestration will be another important function of biodiversity conservation in degraded hill forests. The project which has now been developed as a model can be replicated in other parts of mountain area.

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