NEPAL AUSTRALIA COMMUNITY RESOURCE MANAGEMENT AND LIVELIHOODS PROJECT

Management of the High Elevation Oak Forests of Nepal: Case Studies in Sindhu Palchok and Kabhre Palanchok Districts with Management Recommendations

Prepared for

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Acronyms

AusAID	Australian Agency for International Development
DFO	District Forest Office/r
DPR	Department of Plant Resources (Ministry of Forests and Soil Conservation)
FUG	Forest User Group
HMGN	His Majesty's Government of Nepal
NACFP	Nepal – Australia Community Forestry Project
NACRMLP	Nepal – Australia Community Resource Management and Livelihoods Project
NACRMP	Nepal – Australia Community Resource Management Project
NAFP	Nepal – Australia Forestry Project
NAFP1	Nepal – Australia Forestry Project Phase 1: Pre-1978
NAFP2	Nepal – Australia Forestry Project Phase 2: Oct 1978 – Jun 1986
NAFP3	Nepal – Australia Forestry Project Phase 3: Jul 1986 – Jun 1991
NAFP4	Nepal – Australia Forestry Project Phase 4: NACFP Jul 1991 – Apr 1997
NAFP5	Nepal – Australia Forestry Project Phase 5: NACRMP May 1997 – Jun 2003
NAFP6	Nepal – Australia Forestry Project Phase 6: NACRLMP Feb 2003 - current
NGO	Non Governmental Organization
NTFP	Non Timber Forest Products
OP	Operational Plan (of a FUG)
SDC	Swiss Agency for Development and Cooperation
TOR	Terms of Reference
VDC	Village Development Committee

Summary

At higher elevations (2,000 – 4,000 m) in Nepal, where there are extensive and important forests and grazing lands, natural resources continue to be degraded and community forestry has yet to make a significant impact. The canopy density is declining and key species such as the oaks are not regenerating. The main issues are: scant knowledge about the ecology of the forests and grazing lands; large size of the forests in relation to the numbers of people living in them; improper, non-sustainable utilization of the natural resources such as overgrazing, excessive lopping of trees and shrubs for fodder, uncontrolled wild and deliberately lit fires, over harvesting of NTFPs; non-local, transient people, often from some distance away, frequent the forest and use/overuse forest resources; *chauri* herders put additional pressures on the resources, and limit the supply of forest products to local, settled people; conflicts between communities over forest boundaries; difficult, harsh life styles of the upper slopes communities; too strong a reliance of livelihoods on forest and grazing land resources; too few employment opportunities for upper slopes communities; lack of government structures and infrastructure.

The high elevation oak forests of Nepal are particularly affected by lopping for fodder and through livestock grazing palatable seedling regeneration. These oaks, principally *Quercus semecarpifolia*, are naturally long-lived (>300 yrs) and require small gaps for survival and regeneration of seedlings, as well as protection from grazing.

Four types of management interventions are recommended according to whether an area is open to grazing or not and whether the oak is now low stature scrub or tall old growth trees. The main intervention recommended is group selection in old growth stands to artificially create gaps large enough to release any seedling regeneration that is present, while at the same time providing protection from grazing.

Key Words: Nepal, Oaks, *Quercus semecarpifolia*, grazing, lopping, tree fodder, community forestry, forest degradation

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1 Introduction

Australia has been providing assistance to the forestry sub-sector for over 30 years. From early efforts on establishment of forest plantations, the emphasis quickly moved to community forestry. Successive phases of the Nepal – Australia project provided a leadership role in enabling communities to assume management responsibilities for their own forestry resources, which have been handed over by the government after the preparation of an Operational Plan (OP). The result has been the re-greening and improved management and utilization of the mid-hill forests under 2,000 m elevation, where most of the population lives and where nearly all of the project activities have been undertaken to date.

At higher elevations (2,000 – 4,000 m), where there are extensive and important forests and grazing lands, natural resources continue to be degraded and community forestry has yet to make a significant impact.

The requirement to start better management of the upper slope forests was first raised with the senior author when he was on an AusAID appraisal mission for NAFP4 in October – November 1990. By 1993, Australian foresters working on NAFP4 (NACFP) were actively expressing the need for improved management of the upper slope forests (e.g., Jackson *et al.* 1993). An environmental review of NAFP4 (NACFP) also highlighted concern over the degradation occurring in the upper slope forests (EDAW 1994). In 1996 NAFP4 (NACFP) engaged a team of consultants to carry out a detailed study of the upper slope forest areas in the two project districts, Sindhu Palchok and Kabhre Palanchok. This team recommended the need for specific activities to address the problem of the degradation of these high elevation natural resources (Messerschmidt and Rayamajhi 1996). Over the period 1993 to 1996, Jackson *et al.* (see Jackson *et al.* 1998, Jackson 1999) carried out four comparative land use studies in the two project Districts and found the forest cover in the upper slopes was being progressively and rapidly reduced and that shrubland and grassland areas were expanding at the expense of forest cover. NAFP5 (NACRMP) included a major initiative to develop a methodology for upper slope resource management to be achieved through (i) identification of sites and stakeholders, (ii) development of a participatory strategy for establishing upper slope forest management, (iii) implementation of pilot demonstration activities, (iv) evaluation of the effectiveness of the strategy, and, (v) dissemination of the results. NAFP5 (NACRMP) included a rangelands management consultancy (Miller 1999). Also a study was made of changes in land use between 1978 and 1992 in the Bhotekosi Bhairabkunde Area of Sindhu Palchok District (Hunt *et al.* 2002). Acharya (2003) has completed one of the latest reviews and syntheses of information relating to natural resource management in the high altitude areas of Nepal.

This body of evidence suggests that over the past 20 years or so upper slope ecosystems have been marked by significant degradation. (Degradation was ongoing for decades before, but had not been formally assessed and documented.) In Kabhre's Mahabharat Lekh, forest area decreased by 10 percent over 20 years and shrublands/grassland expanded. In the upper slopes of Sindhu, Himalayan Lekh forests decreased by 20 percent, also accompanied by an increase in grasslands and shrublands. The canopy density is declining and key species such as the oaks are not regenerating. The main issues are:

- Scant knowledge about the ecology of the forests and grazing lands (traditional management does not employ rotational use to encourage regeneration, hampers more effective management interventions)
- Large size of the forests in relation to the numbers of people living in them (complicates the development of an operational plan based on conventional models from community forestry in the middle hills)
- Improper, non-sustainable utilization of the natural resources such as overgrazing, excessive lopping of trees and shrubs for fodder, uncontrolled wild and deliberately lit fires, over harvesting of NTFPs (all lead to continuing degradation of the resource base)
- Non-local, transient people, often from some distance away, frequent the forest and use/overuse forest resources (lack of effective control on forest resource use)
- *Chauri* herders put additional pressures on the resources, and limit the supply of forest products to local, settled people (too few resources to go around for everybody, 2,500 – 3,000 m elevation belt critical)
- Conflicts between communities over forest boundaries (users not well defined, areas not demarcated, access and yields not controlled)
- Difficult, harsh life styles of the upper slopes communities (now drives out-migration to elsewhere in Nepal or abroad)
- Too strong a reliance of livelihoods on forest and grazing land resources (seasonal shortages and deprivation; must encourage people to produce more, need less in future)
- Too few employment opportunities for upper slopes communities (also drives out-migration to elsewhere in Nepal or abroad)
- Lack of government structures and infrastructure (difficult to provide government services because of remoteness and steep terrain).

2 Approach and Methodology

The senior author spent nearly three years (1997 – 2000) conducting research on the regeneration of the broadleaved forests of eastern Bhutan, including oak forests (e.g., see Davidson *et al.* 1999, Davidson 2000). The approach adopted here was to determine how much of this knowledge and experience was relevant to the current situation in Nepal and to build on it using a number of methods.

Existing published and unpublished literature, and reports on project files were examined. Over 2,500 pages of documents were reviewed, covering a range of topics on high altitude forests through pastoral/livestock systems, human/forest interactions, community forestry and livelihood systems, non-timber forest products (NTFPs), land tenure and land use change, social and cultural norms.

Discussions were held with project staff and consultants knowledgeable about the upper slopes situation. These gave insights into how existing project activities could complement work in the upper slope forests. Discussions were held with the two DFOs and other officials of the line agency, also with other projects, such as the Nepal – Swiss Community Forestry Project.

Field trips were conducted by the three co-authors to the Dhungkharka and Jethal areas (the former in Kabhre Palanchok District) of the Mahabharat Lekh, and to Yarmasing, Tashitang, Ghising Kharka, Dhakidanda and Bagam of the Himalayan Lekh (see Jackson 1999 for Lekh definitions). The field team attended FUG monthly meetings at Kalapani (Dhungkharka) and Tashitang and entered into discussions in these fora. Interviews were held with other FUG leaders, office bearers and members to determine what they thought were the issues of the upper slopes.

Several oak forest areas were visited on foot in order to understand the processes at work as part of the ecology of these areas. Orientation was through use of the Nepal topographic map sheet BĀRHABISE No. 278504 based on 1992 aerial photos and 1996 field verification.

2.1 Ecology of the Oak Forests of Nepal

2.1.1 Background

> *"Biology is the ultimate determinant of sustainability – species and ecosystems die, survive or flourish depending on whether their ecological requirements are met".* Peters 1994.

Nature provides the opportunities to meet these requirements, but, in people-impacted ecosystems, it is social organizations, individual decision makers and market opportunities – not nature – that determines whether the biological and ecological requirements of species and ecosystems will be met. Thus sustainability of any natural resource greatly depends on political, socio-economic and institutional factors.

"Sustainability" is defined here in a restricted ecological sense. From an operational or management point of view a sustainable system for harvesting forest resources is one in which products can be harvested indefinitely from a limited area of forest with negligible impact on the structure and dynamics of the plant populations being exploited. It is extremely difficult to eliminate potential impacts of harvesting on all components of a forest ecosystem, such as soils, hydrology, or associated plant and animal species.

Oak (*Quercus*) is a genus in the Family FAGACEAE, a large group of hardwood trees comprising about 600 species. Himalayan oaks are evergreen, mostly gregarious, medium to large sized trees occurring at elevations from 800 – 3,800 m elevation. They number more than 35 species, most of which are abundant in temperate forests throughout the Himalayan region. Eight species have been reported from Nepal (DPR 1997) (in alphabetical order): *Q. floribunda* Lindl., *Q. glauca* Thunb., *Q. lamellosa* Sm., *Q. lanata* Sm., *Q. leuchotrichophora* A. Camus, *Q. mespilifolioides* A. Camus, *Q. oxyodon* Miq. and *Q. semecarpifolia* Sm.

The most frequent species encountered by the co-authors in the study areas was *Q. semecarpifolia* (local name: khasru). This is a dominant species in the Himalayas, in moist temperate and subalpine forest types from southwest China, through Bhutan and Nepal to Afghanistan at elevations of about 2100 – 3800 m. Khasru is the most gregarious of all the species and usually forms near-pure stands. This oak is one of the oldest vegetation types in the Himalayas, invading the area millions of years ago, just after the final major uplift event of the Himalayan massif. *Q. semecarpifolia* has a very long life cycle. Upper canopy trees seen today are climax, old growth communities in the order of 300±50 years of age (data from Bhutan, estimated by ring counts in isolated associated trees of other genera that have distinct annual growth rings (Davidson, unpublished information)). (The term "overmature" should not be used for these stands, the old growth trees are still fully functional organisms, they put on tiny amounts of wood increment each year and set large quantities of seed if not disturbed by humans.) They are often referred to as a "keystone" species without which the complex web of the local ecosystem would soon unravel (Shrestha 2003).

Although these oak forests are oligoarchic (Greek: oligo = few; archic = dominated or ruled by), i.e., dominated by a single tree species in the upper canopy, the bark of the long-lived, old growth cohort supports on trunks and branches a luxurious growth of vascular and non-vascular epiphytic plants, including many ferns and orchids. There is a myriad of animal, bird and insect life associated with this complex, which means these forests have a very high biodiversity, especially when compared to say a native pine forest. *Q. semecarpifolia* occurs especially on the southern aspect of the upper slopes. Over thousands of years they have modified the site through above-average litter (organic matter) production to increase soil fertility. Southern aspects under oak have a greater number of permanent springs than northern aspects under mixed forest. It is not surprising therefore to find that humans have settled on these southern aspects in preference to others. It is also not surprising that humans living in these forests have developed a strong attachment to them and use them for a wide range of purposes such as for fodder, leaf litter, firewood and to a lesser extent timber. In addition, it is not surprising that, as human and domestic livestock numbers increased, more and more pressure would be placed on this traditional, familiar, nearby and immediately available resource. Taking too much resource capital from the forest is not sustainable in the ecological sense, so much so that now the very existence of the oak forest is being threatened.

The second most common species encountered by the team in the study areas was *Q. lamellosa* (local name: thulo phalaant). This species was found in both gregarious and mixed species stands. Other species (*Q. floribunda, Q. leucotrichophora, Q. lanata*) are less common and found in mixed oak and broadleaved forests and in mixed oak and conifer forests. Mixed conifer-oak forests often represent a seral stage of secondary succession driven by disturbances such as lopping, felling, grazing and fire.

2.2 Oak Survival Strategy

The life strategy of a plant species refers to all the physiological, morphological and behavioural adaptations that have evolved to increase the chance of survival of that species. Among the most important are the regeneration characteristics of the tree. If one understands those then one can understand the basic ecological requirements of the species. There are three groups or guilds of species that are separated on regeneration characteristics:

- Primary, mature or "climax" (or "old growth")
- Late secondary
- Early pioneer, late pioneer or early secondary

All three guilds can occur in one patch of forest. Primary forest guilds are characterised by having most of the following characteristics: restricted distribution (on world scale), mainly endemic (on regional scale), abundant seeding, no seed dormancy, relatively large seeds/fruits with good food reserves, seeds dispersed by mammals and birds, seedlings very shade tolerant at first, later intolerant or shade suppressed, small forest gaps required for seedling survival, slow to very slow growth rate, wood density very hard, life span very long (100s of years). *Q. semecarpifolia* in Nepal has most of the attributes of a primary guild.

2.3 Oak Life Cycle

Phenology is the term used to refer to the timing or seasonality of specific biological events (e.g., leaf fall, growth, production of flowers and fruits). Phenology of oaks varies somewhat with elevation, aspect and microclimate. The following is a typical account for *Q. semecarpifolia*. New shoots appear in the canopy April through June. Most of these leaves have reached full size before the previous season's leaves have all fallen. Rarely are the trees leafless. Male and female flowering spikes appear on two-year-old twigs at the same time as new shoots, and pollination takes place around June. The period between pollination and ripening of the acorn is more than a year, so the ripe acorn is carried on the previous year's growth (i.e., on the three-year-old twigs) and falls during the early monsoon (July – August). While the near ripe seed is held on the tree it is subjected to the first wave of predation. Seed predation refers to the destruction of seeds by animals that attack, eat, lay eggs on or in or otherwise fatally damage them. Examples of predators in Nepal include squirrels, rodents, beetles, ants and weevils. The size of the seed crop is somewhat unpredictable. While some seed are set every year, there is a tendency of mast fruiting, i.e., a very large crop produced at intervals of three to four years. The evolutionary advantage of this strategy is probably to overwhelm and defeat predatory populations (predators die out to low numbers in the lean years and cannot breed up fast enough to react to the periodically abundant mast years, thus there will be a greater chance of a surplus of unharmed seed in those years).

Ripe acorns fall during the rainy season and must germinate immediately. Oak seeds are recalcitrant, meaning they cannot be stored artificially more than a few days. Some seeds may even start germinating before they fall from the tree to the ground (partial vivipary). There is nothing wrong with the seed viability of these old growth stands. More than 95 percent of the fresh seeds can germinate. Germinating seeds were seen on the forest floor during fieldwork. However, every seed that reaches the floor is again subject to waves of animal predators (frugivores = rabbits, squirrels, rats, beetles, ants, etc.) and now also decay fungi, as the seed lies in the litter in an organic and moist environment. Both physically damaged and rotting seeds were seen on the forest floor in the field. There is a high probability that the germinating seeds will be found and eaten by domestic livestock also if they are roaming in the forest. In terms of total numbers, seed predation is one of the most significant sources of mortality during the life cycle. Only a small fraction, perhaps less than one in a million propagules will make it into the canopy in 100- 200 years time.

The seedling's first year is also fraught with difficulties. Light levels may be too low, making it difficult for the seedling to grow. Each seedling has a high probability that it will be browsed by wild and domestic animals, be out-competed by neighbours, smashed by falling debris, branches and rocks, attacked by fungi, become wilted and dry out, and its roots dug up and eaten (e.g., by squirrels and rats, as seen at Tashitang).

The excessive seedling mortality that characterises the regeneration of many long-lived forest species raises an important management question. Where are the few seedlings located that actually survive? What type of site provides the necessary conditions for seed germination and also for the new seedling to express an optimal rate of growth relative to its neighbours? The specific combination of environmental conditions that describe such a site make up what is termed the regeneration niche. The regeneration niche is related in some way to the sporadic occurrence of tree falls. They blow down, they are struck by lightning, or they just die of old age and fall down. Each of these events produces an opening or "gap" in the canopy that allows extra sunlight to reach the forest floor. Canopy gaps also exhibit lower humidity, higher ambient and soil temperatures and higher soil moisture levels (as a result of less interception of rain, since the canopy has gone). Within oak forests, in small gaps, many of the more shade tolerant, though shade suppressed, seedlings which have managed to survive under a closed canopy will display a significant increase in growth in response to higher light levels. Shade tolerant species possess certain physiological adaptations or traits (e.g., an enhanced photosynthetic system, an ability to become dormant) that better equips them to survive at very low light intensities. Most canopy species, even in the mixed oak forests, exhibit this behaviour. Their seeds germinate in the shade and young seedlings grow until they have produced 2-4 leaf pairs. The seedlings then enter a state of suppression in which they exhibit little or no height growth. There are only two possible outcomes to this physiological condition. The seedlings slowly die out over a long period of time, maybe 20 years or more, while undergoing waves of additional predation, or, they are "released" by the occurrence of a canopy gap overhead. Once released they become light demanding and are affected by competition from other light demanding saplings of the pioneer and secondary guilds.

In the study areas, individual falling trees seem incapable of creating a large enough gap to release the shade-suppressed regeneration (even when grazing animals are excluded). This is because the heavily lopped trees no longer have a significant volume of crown left to make sufficient impact. Also, in areas that have been grazed for a long time, the shrubby vegetation near the ground comprised of unpalatable pioneer species (e.g., *Symplocus* sp and *Viburnum* sp) and many, often spiny, weeds promoted by grazing, out-competes the desirable seedlings of broadleaved tree species, including the oaks.

Evidence from seedlings of *Q. semecarpifolia* grown in the open in a nursery in good soil near the school at Yarmasing indicates a maximum expected growth rate in gaps of about only 10 cm of height/year (half the rate of the three-year old seedlings observed which had reached about 60 cm in height in the nursery in good soil and completely open to the sun). In areas prone to grazing by cattle, at this estimated rate of height growth (10 cm/yr), it would require closure for at least 20 years to enable the young saplings to grow above browsing height (>2m tall).

Saplings probably would not reach the upper canopy for a hundred years and spend at least twice that long in the upper canopy and perhaps half of the latter time (100 – 150 years) as “old growth”.

Significantly, this means that most of the history of human/livestock impacts in the oak forests of Nepal has affected only one generation or the most recent “old growth” cycle of the trees.

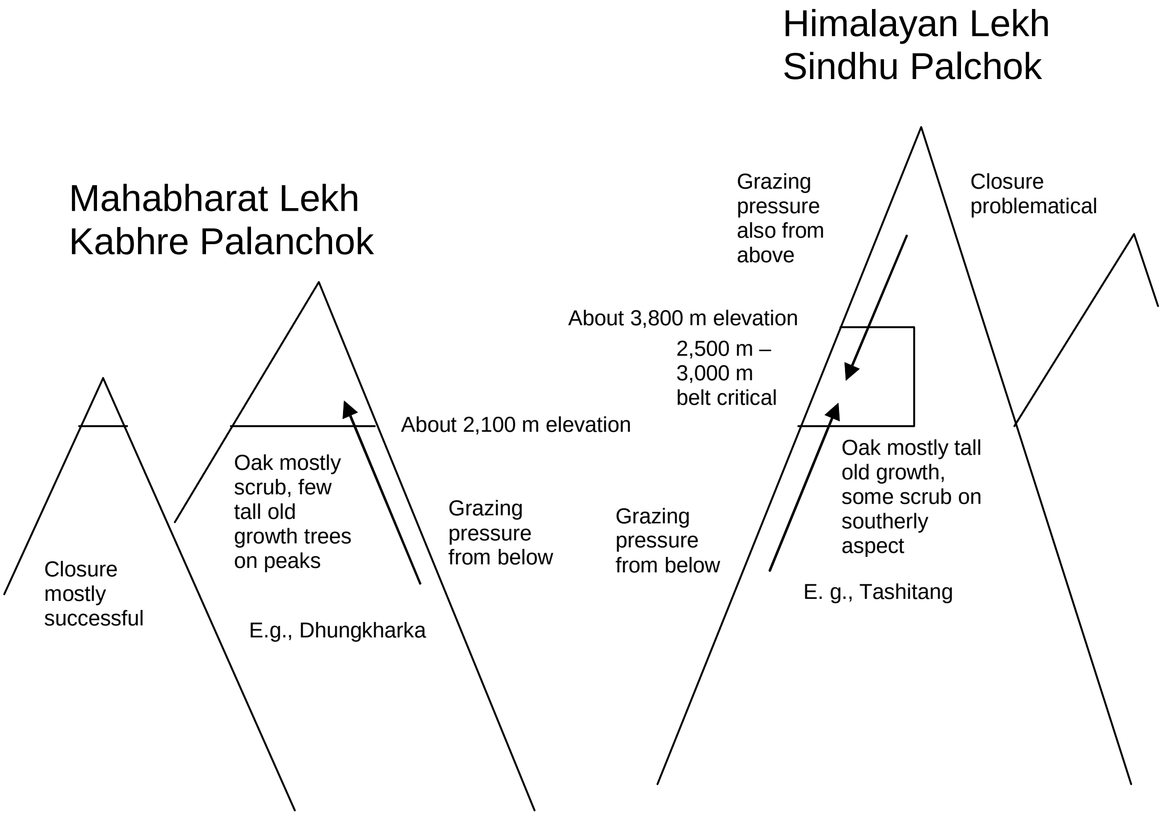
2.4 Management Plan for Oak Forests

The two working assumptions for management planning in oak are:

- Regenerating seedlings are very palatable to livestock, and,
- In human-impacted forests, where crown architecture has been altered by heavy lopping, individual tree falls do not provide a sufficiently large gap for seedlings to be “released”, even when protected from grazing.

The situation to be addressed differs between the Mahabharat Lekh and Himalayan Lekh localities (Figure 1).

Figure 1: Different oak forest situations

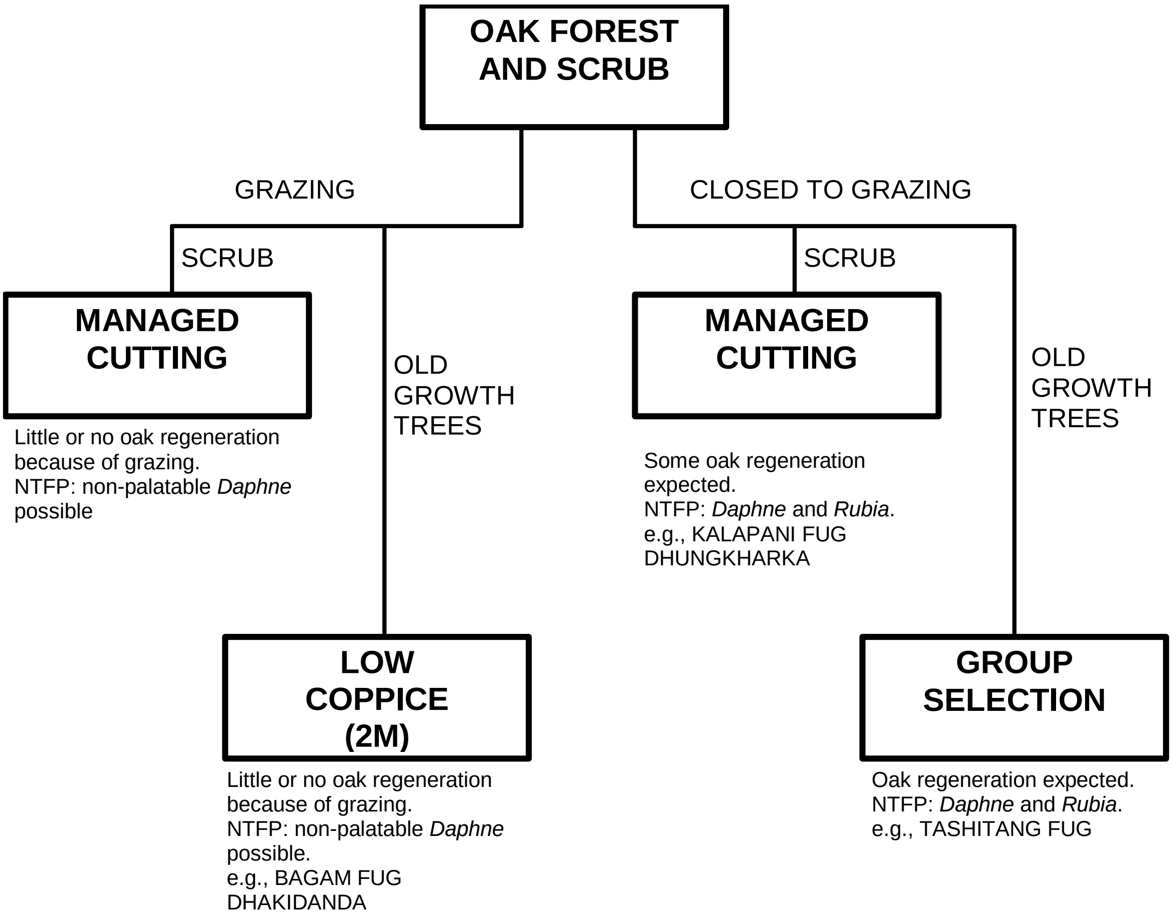


In the Mahabharat Lekh of Kabhre Palanchok, the oak has been reduced to a scrub-like form. Only a few examples of tall old growth trees occur on the peaks and ridges. The grazing pressure is mainly from below (Figure 1). Closure has been successful in many FUGs (e.g., Kalapani for past 3 years, animals are stall fed). In closed areas some oak seedlings numbering a few hundred per hectare were observed.

In the Himalayan Lekh of Sindhu Palchok, oak is found mainly on southerly aspects of the upper slopes to about 3,800 m elevation. There is much more tall old growth here, and both the tall forest and scrub is heavily lopped for fodder. Grazing pressure is seasonal and occurs from both above and below, with the 2,500 – 3,000 m belt critical. Closure of these areas is difficult. In an area that was closed for three years (e.g., above Tashitang), several thousand oak seedlings per hectare were observed but all were still shade suppressed.

Different kinds of interventions are required for the different situations (Figure 2).

Figure 2: Decision paths for interventions in different kinds of oak forests



The main dividing characteristics are whether the area is open to grazing by livestock or not, then whether the oak is low stature scrub or tall old growth trees (Figure 2). This leads to four kinds of interventions.

The first, in areas of oak scrub and subject to grazing, only the existing trees can be managed according to techniques already developed in NAFP5 (NACRMP) (Dangal and Eijnatten 2001). Without protection from grazing, there is little chance of regenerating these areas with new stems. Eventually the existing stems will die and not be replaced.

The second intervention, in tall old growth oak subjected to lopping over a grazed understorey, is to coppice the trees low down. The trees would be felled at a height of 2 m above ground or just above the first lower green whorl of branches whichever is the greater. One reason for choosing this approximate height is that any coppice would be above the height that livestock could easily reach. Only 10 percent of the trees in any FUG's area would be felled each year. One reason for this annual limit on numbers is to cause minimal disruption to current supply of fodder. Another reason is for risk management, in that environmental conditions in a particular year may not always be favourable to achieve a high success rate for coppicing. (Normally, coppicing and pollarding of *Q. semecarpifolia* is highly successful, but years of heavy lopping for fodder may have debilitated the trees somewhat.) Successful examples of this kind of coppicing were seen occasionally in the field, such as above Dhakidanda.

The coppice would be managed to promote a bushy growth according the prescription already mentioned (Dangal and Eijnatten 2001). This would lead to improved livelihoods because more foliage would be produced after a few years than with the current pole-like trees, and this foliage would be produced much closer to the ground and therefore easier to cut and collect, reducing the risk of climbing, which leads to hundreds, perhaps thousands of injuries, and some deaths, each year. The immediate benefit would be the wood of the felled tree, which could be used for firewood and for charcoal making.

The third intervention is for scrub type oak stands closed to grazing. Oak trees would remain in a scrub like condition but be managed according to the prescription given by Dangal and Eijnatten (2001). Closure to grazing would allow oak to regenerate in conjunction with selected seed trees. An example is Kalapani FUG, where the forest has been closed to grazing for three years. Several hundred oak seedlings can be found under the existing trees. Great care is now required to ensure the forest floor is managed to favour this regeneration. That is not to sweep the ground completely clear of all litter and not to slash the oak seedlings while periodically clearing the undergrowth. The regenerating seedlings will require a long time to reach a couple of meters height, probably in the order of >20years.

The fourth intervention is the main contribution the authors are making to future oak management. This is group selection in old growth stands. The reader will recall that the hypothesis concerning the lack of regeneration observed in these stands is that individual trees reduced in crown volume by lopping, or limb loss through old age, do not cause a sufficiently large gap in the canopy to release any seedling regeneration present. Thus the need is to create larger gaps artificially by felling small groups of trees on a pattern through the forest (Figure 3).

Figure 3 shows a systematic layout for such a system. Openings are about $400m^2$. They are shown square, but they need not be. They may be more round or have irregular shaped edges. The distance between groups in the line direction should be about 40 m. In any one locality the idea is to have one pass at year 0, and not return for the adjacent pass until year 10, and again have space for a third pass in year 20. This means that in year 0, the lines would be about 60 m apart (Figure 3).

(Note: The $400m^2$ opening refers to the opening up at crown level, not the distance between tree bases at ground level. Project the edges of crowns down to the ground using a homemade plum bob (heavy weight on the end of a piece of string).)

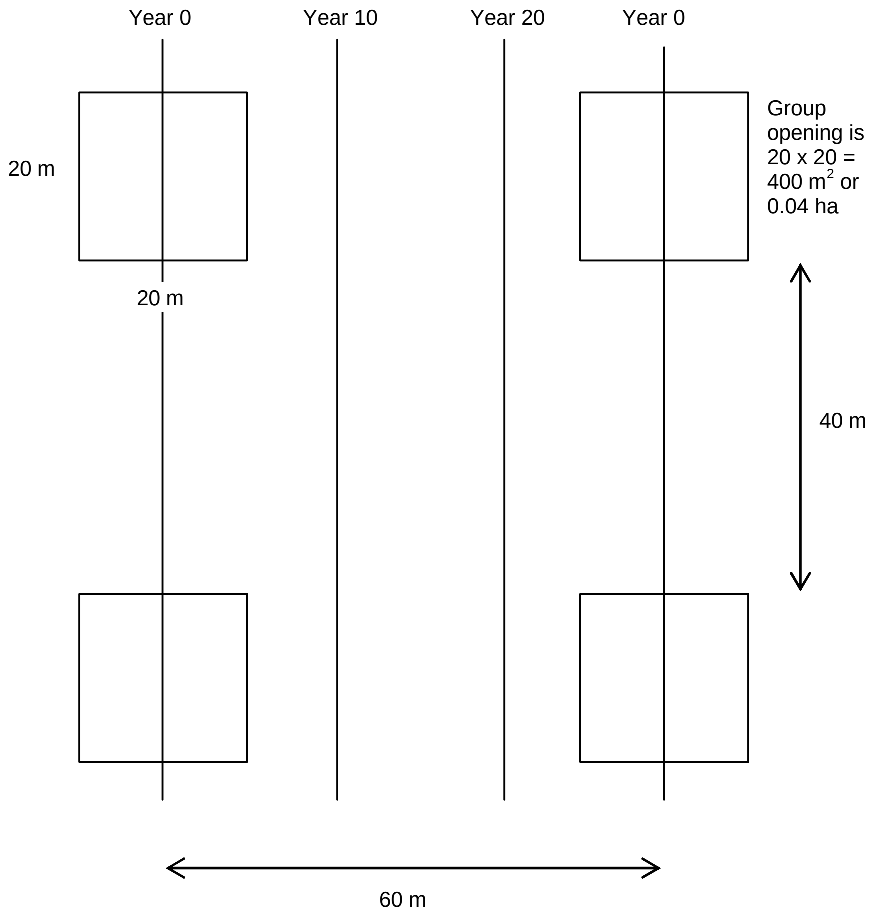
Each of the groups would be closed to grazing. A suitable pilot area would be in Tashitang FUG, where such an idea has already been raised during a monthly FUG meeting in the presence of the co-authors, and several thousand shade suppressed seedlings were noted in a previously closed area. Flexibility should be retained to slightly increase the size of the groups in the medium term if the desired regeneration is not forthcoming.

The immediate benefit to FUG members would be firewood and charcoal from the felled trees.

The group openings would have to be managed to remove weedy understorey vegetation, which could compete with regenerating oak seedlings.

There are opportunities for co-management of NTFPs in some of these schemes. This topic is discussed in the next Section.

Figure 3: Spatial layout of clear cut groups in oak forest



It is recommended a number of interventions should be undertaken in the upper slopes oak forests - chief among them is a group selection system to promote regeneration of oak.

Some variations are possible on the basic scheme. These could be followed up through conducting an action research program with FUGs.

- Transplant wildling oak seedlings (two – four leaves) from the inter-group spaces into the group opening during the beginning of the monsoon season.
- Transplant wildling oak seedlings (two – four leaves) during the beginning of the monsoon season from the forest into a nursery bed in full sunlight near a house where they can be protected for two to three years, then transplant them into the group openings, again during the beginning of the monsoon season.
- Collect oak seeds and immediately direct sow them into cultivated pits (30x30x30 cm) in the group openings.

In the medium term planning should be undertaken for establishment of species and provenance trials of alternative species that might be suitable for the *Q. semecarpifolia* niche. This niche has the following approximate characteristics:

Altitude 2,300 – 4,000 m

Mean Annual Rainfall 1,000 – 2,500 mm

Rainfall Regime Summer, Winter, Bimodal

Dry Season 4-6 months

Mean Annual Temperature 5-17 ^{0}C

Mean Temperature of the Hottest Month 16 – 23 ^{0}C

Mean Temperature of the Coldest Month 4 – 9 ^{0}C

Absolute Minimum Temperature -20 to -15^{0}C

A preliminary examination of species' databases, calls up the following 9 species in the first instance as having a good match to the above criteria. None is a perfect match, however, and properly designed trials would be required. This list is not exhaustive, and a search should be made for additional species.

Populus ciliata

Quercus leucotrichophora

Populus deltoides

Fagus sylvatica

Quercus petrea

Quercus pubescens

Betula alnoides

Aesculus indica

Quercus floribunda

Whatever management strategy is adopted, the growth of fodder trees in these upper slope areas will always be slow and the amount of tree fodder produced would be below the actual requirements for the foreseeable future. There is no magic solution.

Fodder tree initiatives should always be seen as just one component in a basket of solutions to the issues of natural resources management in the upper slope areas. Among other initiatives are the introduction of improved pasture grasses and legumes and more productive livestock. There is evidence of reducing numbers of humans and livestock in these areas, but some of it is contradictory. These numbers are important to the future sustainability of the upper slopes natural resources and new data should be collected periodically.

The environment under oak is conducive to the growth of several NTFPs. Two of the more common ones in the study area are *Daphne bholua* (local name: Lokta) and *Rubia cordifolia* (local name: Majitho). The environment under *Q. semecarpifolia* is highly suitable for Lokta growth.

2.5 Co-management of Oak and Non-timber Forest Products

Daphne bholua (Lokta) is a dicotyledonous, deciduous, unpalatable, shade loving, perennial shrub. *Daphne* is found growing well between 2,400 m and 3,200 m elevation (full range 1,800 – 3,600 m) and is a major understorey associate in oak forests. Highest densities are on north-facing slopes at 2,100 – 2,800 m elevation. Lokta is being severely over-harvested and sustainability threatened. Bark is harvested from too thin stems, young shrubs are uprooted, and stems and branches harvested while they are flowering and fruiting.

Rubia cordifolia (Majitho) is found up to 2,900 m. It is a dicotyledonous, climbing annual herb. It has a liana-like habit and requires support for good growth and development. *Rubia* is very competitive against non-climbing herbaceous weeds. It requires exposure to direct sunlight for best growth.

Lokta would be concentrated in the shady parts of the forest left between the group openings, while the Majitho would be grown in the group openings. In both cases, weedy understorey vegetation would need to be removed to favour oak seedlings and the NTFPs.

It is recommended Lokta (*Daphne bholua*) and Majitho (*Rubia cordifolia*) be co-managed in oak forests regenerated by the group selection system.

Both these NTFPs would improve livelihoods by providing an income while the groups are closed to grazing in the early years of oak regeneration.

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Limitations