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PEOPLE-FOREST INTERACTION: A NEGLECTED PARAMETER IN HIMALAYAN FOREST MANAGEMENT

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ABSTRACT The village of Munglori in the Aglar watershed north of Dehradun, Uttar Pradesh Himalaya, is used for a case study on rural forest management. The study points out that the subsistence needs of the villagers invariably have been omitted from forest management planning. This neglect began in the last century under the British Raj and has continued to the present day.

Munglori, with a population of 250, is overwhelmingly a subsistence village, but situated close enough to the expanding influence of Mussoorie and Dehradun to serve as a basis for comparison with other villages that are progressively adapting to a market economy. Research was directed at the biomass flow of the village, concentrating on the fuel cycle, the fodder cycle, and the yearly migration cycle. Relationships between village biomass consumption and forest productivity are demonstrated. In particular, it is shown that, under certain management situations, loss of forest cover can occur even though overall biomass productivity far exceeds village demand. Further quantitative studies are needed; in particular new developments in forest management must provide for full participation of the villagers without which success will remain uncertain.

RÉSUMÉ *L'interaction peuples-forêts: un paramètre négligé dans l'exploitation des forêts himalayennes.* Le village de Munglori dans le bassin hydrographique d'Aglar au nord de Dehradun, Etat d'Uttar Pradesh, est utilisé pour une étude de cas portant sur l'exploitation rurale des forêts. Cette étude fait ressortir qu'en règle générale le besoins de subsistance de la population n'ont pas été pris en compte pour la planification de l'exploitation des forêts. Cet état de choses a commencé au siècle dernier sous l'empire britannique et a continué jusqu'à présent.

L'économie de Munglori (250 habitants) repose presque entièrement sur l'autoconsommation, mais ce village est suffisamment touché par l'influence croissante de Mussoorie et Dehradun pour servir de base de comparaison avec d'autres villages qui s'adaptent progressivement à une économie de marché. La recherche a porté sur le flux de biomasse du village, en particulier le cycle de combustible, le cycle de fourrage, et le cycle annuel de migration. Les relations entre la consommation de biomasse du village et la productivité des forêts sont mises en évidence. Il ressort en particulier que dans certaines conditions d'exploitation, une perte de la couverture forestière peut se produire alors que la productivité totale de biomasse dépasse de beaucoup les besoins du village. Des études quantitatives complémentaires sont nécessaires. En particulier, les nouveaux modes d'exploitation des forêts doivent obtenir l'entière participation des habitants, autrement leur succès demeurera incertain.

ZUSAMMENFASSUNG *Die Wechselbeziehung Mensch-Wald: Eine vernachlässigte Größe beim Forstmanagement im Himalaya.* Das Dorf Munglori, im Gebiet der Aglar Wasserscheide, nördlich von Dehradun Uttar Pradesh Himalaya, wird für eine Fallstudie des ländlichen Forstmanagements benutzt. Die Untersuchung zeigt, daß bei der Planung des Forstmanagements Existenzbedürfnisse der Dorfbewohner immer übergangen worden sind. Diese Vernachlässigung begann unter der britischen Raj Herrschaft im vergangenen Jahrhundert und hält bis heute an. Munglori, mit einer Bevölkerung von 250, hat eine solide Selbstversorgungswirtschaft, liegt aber nah genug, daß es der Expansion von Mussoorie und Dehradun ausgesetzt ist. Das Dorf dient als Bezugspunkt bei Vergleichen mit anderen Dörfern, die sich mehr und mehr einer Marktwirtschaft anpassen. Der Kreislauf der Biomasse des Dorfes mit besonderer Betonung des Brennstoffzyklus', des Futterkreislaufs und des alljährlichen Migrationszyklus' wird detailliert. Das Verhältnis zwischen dem Verbrauch an Biomasse im Dorf und der Waldproduktivität wird aufgezeigt. Es wird außerdem veranschaulicht, wie unter besonderen Managementsituationen ein Waldverlust selbst dann eintreten kann, wenn die erzeugte Biomasse den Bedarf des Dorfes übersteigt. Weitere quantitative Untersuchungen sind notwendig. Besonders neue Entwicklungen auf dem Gebiet des Waldmanagements müssen die volle Teilnahme der Dorfbewohner gewährleisten, oder ihr Erfolg ist in Frage gestellt.

ECOLOGICAL DEGRADATION IN THE HIMALAYAN WATERSHEDS

The Himalaya is a delicate mountain ecosystem. This ecological fragility is rooted in its geological and morphological setting. From the foothills (about 750 m in the Dehradun area) the Himalaya reach a height of several thousand metres within a short horizontal distance across the Siwalik and lesser Himalaya which is characterized by very steep slopes. These mountain ranges act as a meteorological barrier to the summer monsoon and intercept a large proportion of the total available precipitation. This heavy seasonal downpour on the geologically young and

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unconsolidated ranges creates an extremely difficult challenge in land and water management.

This ecosystem evolved its own self-defence over millions of years in the evolution of the dense mixed natural forests that sheltered the slopes from the direct impact of the torrential rainfall and facilitated the absorption of water for delayed discharge via springs and streams. This central and very significant ecological process is given its due respect in the Hindu mythology through the story of the River Ganges (Ganga) being arrested in mid-descent by the long hair of Lord Shiva. Human settlements that have existed in the Himalaya for thousands of years have respected the sanctity of the forests, knowingly or unknowingly, and have thus avoided destabilizing its critical ecological function.

Though human civilization has existed and thrived in the Himalaya for thousands of years, large-scale human intervention, particularly by people from the plains, began only in the last one hundred years or so. Beginning with the introduction of tree felling for commercial and industrial purposes, the present exploitation is more diverse and has created equally diverse and accelerating social, economic, and ecological instabilities. The concepts of economic development, which have evolved within the context of a fragmented view of nature without consideration of the overall natural productivity and stability of natural processes, have been applied to the resource-rich but ecologically sensitive Himalaya, accelerating its destabilization.

The forest resources in the Himalayan watersheds play a central economic role in soil and water conservation and act as a nutrient bank for basic economic activities of agriculture and animal husbandry. In spite of the long history of commercial exploitation, due to lack of a road network forest resources in many interior areas remained relatively out of reach. Following the border conflict with China in 1962 there was a dramatic increase in road construction which has led to large-scale exploitation of forest resources. By the 1970s several disasters, such as the Alaknanda, Tawaghat, Bhagirathi floods and debris flows, indicated destabilization of Himalayan watersheds.

In 1973 the famous Chipko Movement, aiming at stopping the destruction of forests, was started by the people of the Garhwal Himalaya, climaxing a long-standing conflict over forests in the region (Bahuguna, 1984). This movement focused attention on the prime economic role of the Himalayan forests in the conservation of water resources for the country and the stabilization of Himalayan topsoil to ensure continuation of this role. The Chipko Movement cautioned that Himalayan forests should not be destroyed in the process of extracting commercial timber and that exploitation could lead to disaster.

LAND-WATER STABILIZATION THROUGH WATERSHED MANAGEMENT

The importance for the national economy of an ecologically stable Himalaya, and in particular for the agriculture and the human settlements on the Gangetic plains, has been recognized both at the national and international level. In order to provide instant relief to the battered Himalayan watersheds of the Ganges and Yamuna, the Government of India has accepted the demands of the Chipko Movement for a 15-year moratorium on commercial felling. At the same time long-term programmes for ecological rehabilitation are being undertaken, assisted by liberal international financing. Following the Bhagirathi disaster in 1978, the Government of India formed a Working Group for the development of an integrated action plan for flood control. A programme for integrated watershed management was launched in the Sixth National Five-Year Plan and several watershed development projects are presently being executed.

The World Bank is now financing a major Himalayan Watershed Management Project at Nayar and plans substantial expansion both in Uttar Pradesh and in other Himalayan states, such as Jammu and Kashmir, and Himachal Pradesh. The European Economic Community has also provided funds for a Bhagirathi Watershed project in the Tehri-Garhwal district. The Swiss Development Corporation is considering a request for funding of the Aglar Watershed Project.

The official recognition of the urgency of the existing situation and the encouragement of international funding agencies, however, do not ensure a comprehensive approach to the problem of ecological rehabilitation of the Himalayan watersheds. Thus, there is no guarantee for successful completion of these projects. A correct approach, enriched by the analysis of past mistakes and failures, is more important than funding in such critical cases since there are ample success stories of afforestation for ecological rehabilitation where no funding was needed (Saklani, 1985).

HIMALAYAN WATERSHED MANAGEMENT: GAPS IN KNOWLEDGE

The official approach to the stabilization of the Himalayan region through watershed management seems to have evolved more as a result of international trends and fashions than from a real epistemic breakthrough and objective understanding of processes affecting the region itself. As a result, while the activities on watershed management projects have started, the knowledge base required for development of a new strategy for land and water management has not evolved. Watershed management can be successful only when based on the foundations of both qualitative and quantitative knowledge of at least the major ecological processes that are occurring within the specific watershed as well as the dynamics of resource movement both within it and across its limits. Movements of water, biomass, soil, and soil nutrients are of the utmost importance. Without precise knowledge of these processes watershed management cannot succeed. Unfortunately, the major management projects have not been based on re-

The ecological stability in this remote Garhwal village is evident from the balanced use of land for agriculture, forestry, and human settlement.

search and development studies aimed at systematically bridging these gaps in knowledge. Such research has been undertaken in many parts of the world (Kunkle and Thames, 1977). However, Himalayan watersheds remain some of the least known, both in terms of the qualitative description of the processes and of quantitative measurement of them (CSWCRTI, 1982; Pandey *et al.*, 1983; Pathak *et al.*, 1984).

It is to fill in this gap in knowledge that the present study of "Ecosystems Evaluation and Planning in the Himalayan Watersheds of the Ganga and Yamuna", sponsored by the Department of Environment of the Government of India, has been undertaken. The main objective of this study is the generation of qualitative and quantitative knowledge on each ecological state in the movement of water, biomass, soil, and soil nutrients in selected sample watersheds of the Ganges and Yamuna. Further, this information will be utilized:

1. to evolve a watershed-based land-use plan to ensure hydrological stability, soil conservation, and satisfaction of the local biomass needs of the people;
2. to project sustainable development scenarios for Himalayan watersheds in accordance with the aspirations of the local people and the significance of the region to the national economy as a whole.

Undoubtedly, all four types of basic material movements in Himalayan watersheds are strongly modulated by the actual condition of the forests. The degradation of forest resources initiates the destabilization of these processes. Accordingly, the dynamics of forest resource degradation form a significant starting point for such quantitative studies. The two most important factors to be identified are:

1. commercial exploitation and illegal over-exploitation;
2. satisfaction of forest product requirements of the villagers in terms of fuelwood, fodder, and timber.

In the watershed areas of the Ganges and Yamuna, together with other Himalayan areas of the State of Uttar Pradesh, a temporary ban on commercial green felling has been imposed by the Government of India. As a result, official felling of trees has been halted for 15 years. The establishment of the major economic roles of the Himalayan forests, such as the stabilization of soil and water systems, will take time. Therefore, the comparatively less important economic role of the forests, the extraction of timber, must be suspended until this primary function is operating efficiently. However, utilization of forest resources at the village level to satisfy domestic needs must continue without interruption. Unfortunately, with the introduction of organized forest management during the British Rule the forest rights of the villagers had been ruthlessly denied and their requirements were not internalized in the forest working plans (Bandyopadhyay, 1984). Though the 1952 Forest Policy accepts as vital and appropriate the satisfaction of these basic needs, no systematic analysis has been undertaken to determine the silvicultural and ecological implications of forest resource utilization at the village level. It must be emphasized, at the same time, that the village people have been living in the Himalaya for centuries and the satisfaction of their needs must be central to any development planning. It is imperative to understand both qualitatively and quantitatively the biomass requirement of the villages (Bajracharya, 1983; Singh, 1984; Upreti *et al.*, 1985).

It must also be emphasized that the utilization of forest resources at the village level is not a static phenomenon. With changes in the nature of village economics and lifestyles resulting from the various development projects themselves and with the changing pattern of forest resources, the pattern of biomass utilization also changes. Thus, it is not enough to study patterns of forest resource use under present conditions alone. Estimates must be made to provide at least the general direction of likely future change under foreseeable development activities.

The case study, the preliminary results of which are presented here, has two objectives. First, to provide an initial sketch of the patterns of biomass utilization in an isolated, sub-Himalayan village; and second, to outline the probable effects village-generated demands have on forest condition. To meet these objectives, the study was carried out in a village which has easy access to good forest resources yet is isolated from the direct impacts of commercial felling and other non-village demands. The village was also selected because it was marginal to the area affected by official development programmes. The village thereby retains its historical pattern of resource utilization, while the surrounding region provides information on the directions of future change. Although this study is location specific, the interactions described and the current changes may have implications for a much greater region in the Indian Himalaya. Hence, it is a contribution to filling in part the knowledge gap in the management of Himalayan watersheds as a whole.

THE VILLAGE OF MUNGLORI IN THE AGLAR WATERSHED

Munglori, the village chosen for the study[1], is located eleven kilometres north of Mussoorie along a tributary of the Aglar River in the district of Tehri Garhwal, Uttar Pradesh. The Aglar watershed, which is about 20 km long and drains into the Yamuna, is characterized by topographic and climatic variability. The highest peak, Nag Tibba, reaches 3,022 m and lies on the northern boundary of the watershed. The valley of the Aglar, with a base altitude of 1,100 m, lies between the Nag Tibba and Mussoorie (2,200 m) ridges (Figure 1). Climatically, the northern portions of the watershed fall within the rain-shadow of the Mussoorie ridge and are much drier than the southern portions. Systematic meteorological data for the region do not exist. However, rainfall in Munglori during the summer monsoon season of 1984 (June–September) was measured to be less than 25 percent of that received in Mussoorie (average annual rainfall 2,000 mm). A difference of this order of magnitude is also widely reported by villagers in the area. In addition, precipitation at higher altitudes near Nag Tibba is apparently much greater than lower down, although no direct measurements are available. However, a portion of the annual cycle of migration – the movement of buffalo and other livestock from the high forests to lower areas for the summer monsoon – is undertaken specifically to avoid the heavy rains in the upper areas. There is undoubtedly a significant difference in precipitation with altitude.

In addition to the regional rain-shadow and effects of altitude, aspect plays a large role in the local climatic variability. South-facing slopes within the Aglar watershed tend to be grasslands, particularly those at low elevations, while north-facing slopes are generally forested. In the northern region, forest can give way to grassland within twenty metres due to changes in aspect. In a similar manner, the cropping patterns in villages separated by only a few kilometres can be completely different due to the constraints imposed by differing micro-climates.

Village economic structure also varies widely within the region. In a general manner, the Aglar River represents an economic divide. Villages to the south of the river, with greater access to roads and markets, tend to participate in the flourishing milk trade of the tourist and education centre in Mussoorie and to act as off-season vegetable producers for the plains (MGVS, 1985). Villages to the north of the river tend to be oriented less toward these markets and more toward subsistence production. Similarly, the amount of food produced for home consumption ranges from less than a three-month supply in villages south of the river to the full year's supply in Munglori north of the river.

[1]Detailed methods and results of this case study are described in Moench (1985).

AGRICULTURE IN MUNGLORI

Munglori itself is located high (1,740 m) in a valley at the base of Nag Tibba. It is one of the Aglar region's most isolated villages. Until seven years ago, when a road was opened to Thatyur in the main valley, the only road was the Mussoorie–Tehri link along the southern crest of the watershed. From Munglori, the four-hour trip to Mussoorie involved first descending to the Aglar and then a 1,100-m climb back to the southern ridge crest. Even today, the village is a two-hour walk from the road-head.

Munglori has a population of 250 divided among 45 households. Thirty-three of these are Rajputs, the others are scheduled castes. It is a wealthy village, owning a total of 70.6 ha of non-irrigated and 7.5 ha of irrigated agricultural land. The rain-fed agricultural lands stretch out on high alluvial terraces lining the valley both above and below Munglori, while irrigated lands are located 10 km away in the main Aglar valley near Thatyur. The village also owns 237 head of mature cattle and buffalo, 198 other stock animals, and 224 ha of grassland to support them. In contrast to other villages of the Aglar watershed there are extensive tracts of reserved forests accessible to Munglori. These forests are composed predominantly of oak (*Quercus leucotrichophora*), in places mixed with other species such as Rhododendron (*Rhododendron arboreum*) and chir pine (*Pinus roxburghii*). Near the village these forests are heavily lopped, but they grade rapidly upward into the uncut, full-canopy forests of Nag Tibba. Land-use patterns in the village area are shown in Figure 2.

The primary occupations in Munglori are agriculture and animal husbandry. Most of the agricultural land is devoted to grain production. The main crops grown in the Kharif (monsoon) season are irrigated and rain-fed rice and a variety of millets. The main rabi (winter) crop is wheat. Most families are self-sufficient in grain and it is a point of pride not to purchase staple foods from the market. In addition to the main grain crops, potatoes are grown during the Kharif season and the amount of land under vegetable production for the market, although small, has been increasing year by year. Animal husbandry is also mainly

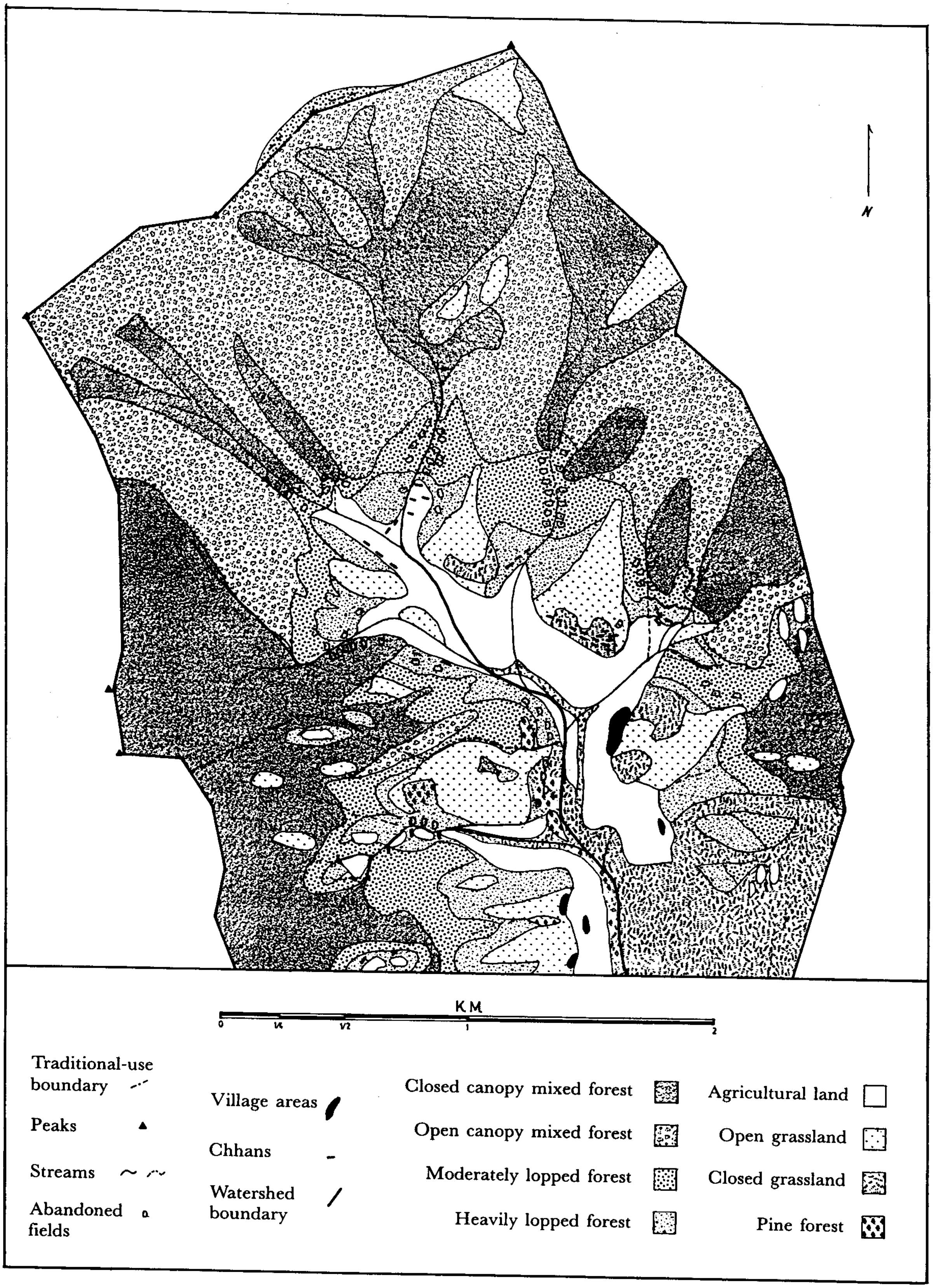


Figure 2. Land use around Munglori and the location of chhans.

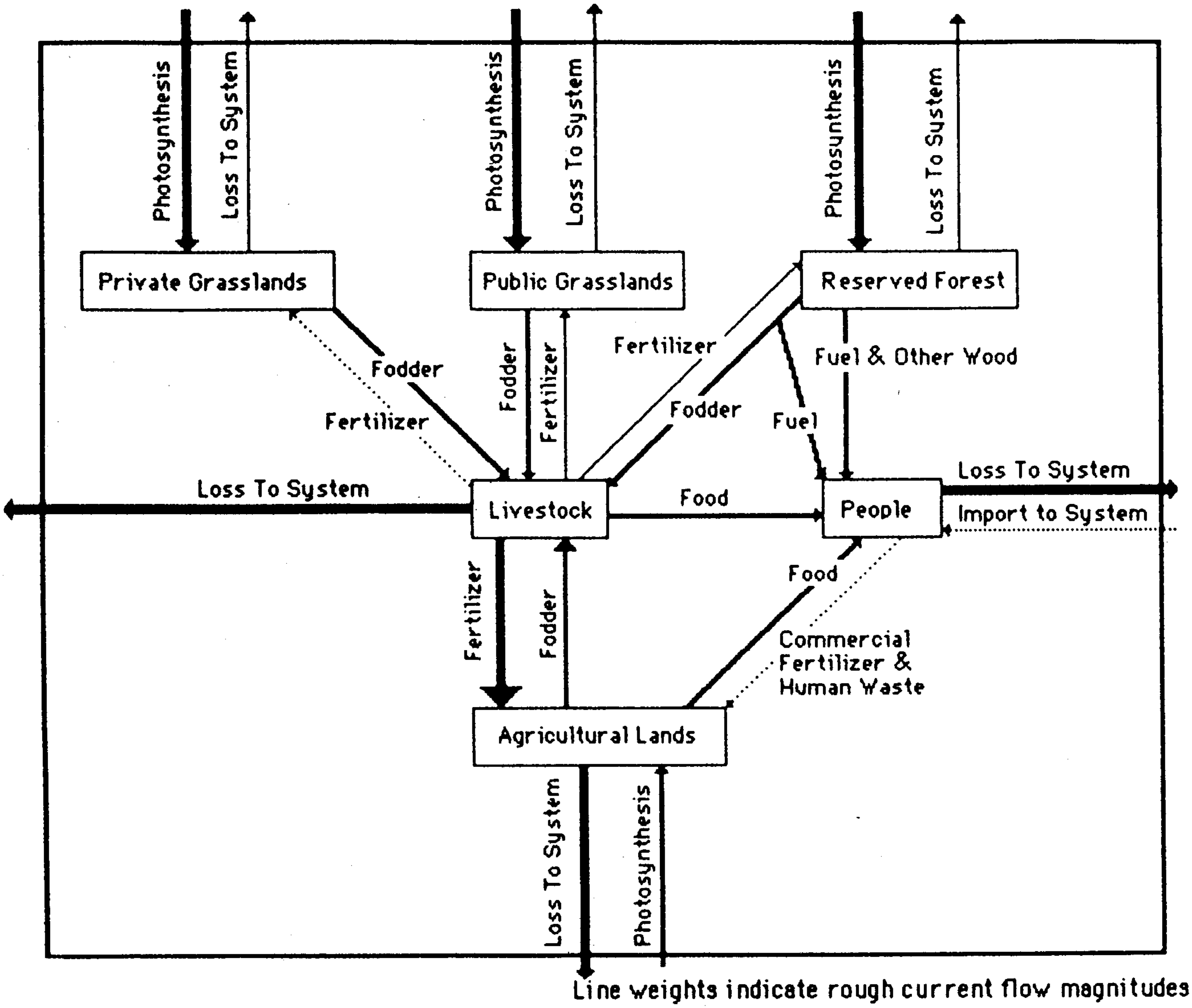


FIGURE 3. The biomass flow system in Munglori.

An important element in the composition of this demand is its seasonality. Munglori has a hot summer and a cold winter and the seasonal variations in fuel demand are important. Where fodder is concerned, the level of demand varies due to migration and the sources from which the demand is satisfied vary according to seasonal availability of feed types. Thus, a complete analysis requires an understanding of the annual cycle associated with fuel use, migration, and fodder use.

1. Fuel Cycle

Wood is the dominant fuel used in Munglori. The village has no electricity and the only commercial fuel used regularly is kerosene. This, however, is only used for lighting. Furthermore, other sources of fuel, such as crop residues and fried dung, are not used in the village.

The primary wood used for fuel in Munglori is oak; other tree species are also used but to a much lesser extent. This is due to the dominance of oak trees in the forests surrounding the village and to the poor quality of fuel from many of the secondary species present. Two major categories of fuelwood are used: wood cut directly from the forest for fuel, and wood gathered as a by-product of leaf fodder collection. Wood cut directly for fuel consists primarily of medium-sized branches lopped from full canopy trees and dead wood of any type. Regularly-lopped trees are not viewed as good sites for fuel cutting because the new growth on them is green and wet. Trunk wood is also not generally cut for fuel. Wood cut directly from the forests for fuel is usually collected as needed, although some is stored under the houses for use during the summer monsoon and winter wet periods. The second major type of fuelwood is that gathered as a by-product of lopping for leaf fodder and consists of small twigs and branches. These are generally twigs less than 3 cm in diameter at the base which remain after feeding the livestock. Large piles of this type of wood are collected and stacked for drying around the village throughout the season during which leaf fodder is cut.

An estimate of total village fuelwood demand was made by direct measurement and by two independent procedures. Direct measurement of fuelwood use within the village houses was difficult for a variety of reasons. The first estimate was based upon weighing piles of wood equivalent to the amounts used each day by a village chulla (family cooking hearth). This was done for a large sample of the total village chullas. It was repeated several times for each family in the sample and the average obtained was taken as representative. This type of measurement was repeated at different times of the year so that winter and summer fuel-use levels could be compared. The second estimate was developed by weighing a large number of head-loads as they were brought into the village and then asking how many days fuel they represented (Table 1).

From the estimates contained in Table 1 it appears that summer fuel use ranges from 11 to 14 kg/chulla/day and winter use is about 22 kg/chulla/day. Daily direct measurements in Chullas 1 and 2 are well within the range of weights derived from estimate one. Thus, the estimates appear to be reasonable in terms of daily fuelwood use.

Table 1
Chulla firewood-use estimates

Estimate (kg/day, air-dry)	Measurements[1]			
	Chulla 1	Chulla 2	Estimate 1[2]	Estimate[3]
Summer	12 ± 1	–	14	11
Winter	17 ± 2	31 ± 3	22	22

[1]Direct measurements within village houses; errors shown are based on the day-to-day variability in fuelwood use.

[2]Based on piles of wood shown by villagers as representative of use within their chulla.

[3]Based on head-load weights and group estimates of how long one head-load of fuel lasts.

2. Migration Cycle

The migration cycle in Munglori follows the seasons in a similar manner to the agricultural cycle. There are three major and one minor "internal" migrations. The three major migrations include the remnants of the one to Dehradun and Mussoorie, the migration to Nag Tibba, and a short migration to the lower valley *chhans* (temporary huts) near Thatyur. The internal migration involves seasonal shifts between village *chhans* and upper valley *chhans* (Table 2).

3. Fodder Cycle

The types of fodder used for stall feeding in Munglori are green and dried grasses, cut leaf from the forests and farm trees, and agricultural crop residues. In general, villagers prefer to feed a mixture of fodder types during the day. A steady diet dominated by one type of fodder is not viewed as healthy for the stock. Many types of fodder are viewed as having their own characteristics and as being appropriate for use at certain times and with certain stock. Munglori has significant stocks of paddy, mandua, and wheat straws. Jangoura and mandua straws (local varieties of millet) are viewed as being good "all-purpose" fodders. Rice is regarded as a good winter fodder but one which is most appropriate for oxen and which must be given in limited quantities to buffalo. Wheat straw is thought to be a poor fodder, suitable only for warm weather and then only in limited quantities. A similar breakdown is true for

Table 2
The migration cycle in Munglori

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
To Dehradun 16 buffalo, 20 cows in migration	x	x	x	x							x	x	
To Aglar *chhans* 20 buffalo, 30 cows in migration	x												x
To Nag Tibba *chhans* 20 buffalo, 30 cows in migration					x	x							
Village and Village *chhans* Total buffalo	53	73	73	73	69	69	89	89	89	89	73	73	53
% of total buffalo population	60	82	82	82	78	78	100	100	100	100	82	82	60
Total cows	104	134	134	134	108	108	148	148	148	148	134	134	104
% of total cow population	70	91	91	91	73	73	100	100	100	100	91	91	70

x = period of occurrence.

TABLE 3
The fodder cycle in Munglori

Fodder type	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
					Periods of Use							
Leaf												
Oak	+	+	+	+	+	+	+			+	+	
Bhimal	+											+
Kharik (*Cettis australis*)					+	+	+	–	–			
Grass												
Green grass							– –	+	+	+	+	–
Dried grass	+	+	+	+	+ –				– +	+	+	
Agricultural Waste												
Paddy straw	+	+	+	–	–	–			– –	+	+	+
Wheat/barley straw					+	+	+	+				
Mandua[1] straw	+	+	+	+	+				–	–	+	+
Jangora[1] straw	+	+										+

[1]Local varieties of millet.
+ = periods of greater use; – = periods of lesser use.

cut leaf. Oak is a good general feed, bhimal is a winter feed and useful only in limited amounts for buffalo, and kharik is a summer feed. Dried and green grasses are good all-round fodders but, even then, some mixture with other types is considered important. The mixture of fodder types used, therefore, is not dependent only on availability but also on the specific characteristics of the fodder. What is important is the availability of a mixture of types throughout the year. Table 3 presents the fodder cycle in Munglori.

It is important to note that farm trees have only a marginal role in the fodder composition in Munglori. In other villages in the Aglar watershed where the forests are 3–4 hours away on foot, farm trees play a very significant role in the production of lopped fodder.

Within the lopped oak forests, the quality of fodder varies according to the rotation of lopping. Branch analysis from head-loads collected in Munglori indicates that the proportion of wood to leaf increases with the age of the branch. There is also increased difficulty in collection when the branches are very small; the absolute amount of leaf on a branch increases with its age. Thus, there is an optimal age for branches collected where there is little difficulty of collection. This optimum is obtained where the proportion of wood to leaf supplies a maximum amount of usable firewood as a by-product of fodder collection. The stall-feeding biomass demand has been estimated from the actual weighing programme and the head-load survey (Table 4).

TABLE 4
Biomass demands

Metric tons/year	Estimate I Low	Estimate II Mid	Estimate III High
Oak	188	296	368
Dried agriculture residue and grass	437	560	736
Sub-total	625	856	1104
Green grass	300	416	368
Total	925	1280	1470

FORESTS AND BIOMASS COLLECTION

Two important factors must be considered in assessing the fodder production role of oak forests in the Munglori region. The first of these concerns the level of lopping on individual trees which best meets fodder and fuel demands while maintaining the health of the tree. The second is the "natural" reaction of the forest to the demands placed upon it.

The level of lopping on the basis of an individual tree which most suitably meets village demand is a function of the type of leaf required, the amount of wood desired as a by-product, and the productivity of the tree. In this context the first point is that oak trees must be lopped on a regular basis for them to be a source of fodder. Conversely, if they are lopped on a regular basis they are not an optimum source of fuelwood. Leaves from older branches tend to be hard and dry and the buffalo refuse them. The most desirable leaves are the soft new ones which grow on young, or regularly lopped, trees. The new growth on lopped trees, however, is too wet and small to provide an attractive source of fuel if this is the primary objective. As a result, forest biomass demand is dispersed. Regularly-lopped trees are used primarily for fodder collection (although fuel is a very important by-product even here) and cutting specifically for fuelwood is concentrated on dead wood and previously less-lopped parts of the forests.

The second point is that the amount of wood acquired as a by-product of fodder collection varies with branches of different size and age. An analysis of branches from

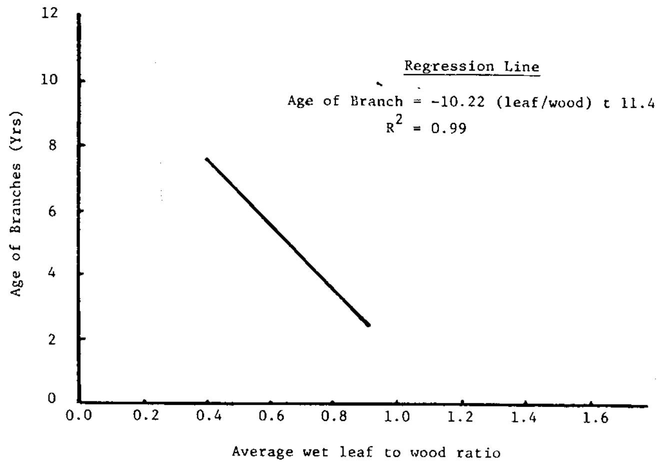


FIGURE 4. Correlation of age of oak branches with leaf/wood ratio.

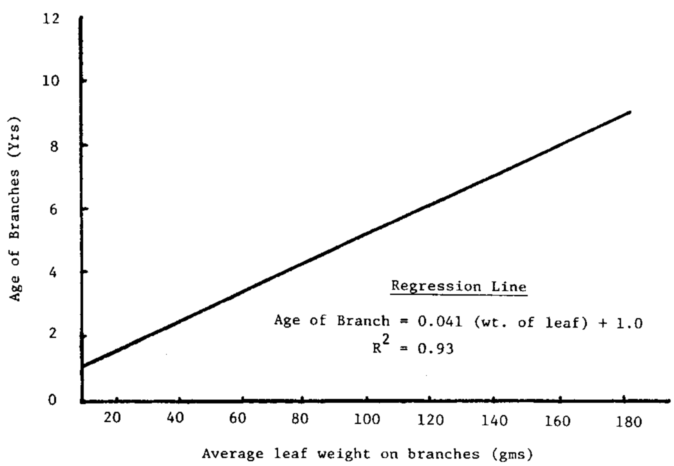


FIGURE 5. Correlation of age of oak branches with leaf weight.

lopped oak in the Munglori region shows a regular decline in the wood-to-leaf ratio as branches increase in age (Figure 4). As the age of the branches increases so does the absolute weight of the leaf on it (Figure 5). Thus, there is a theoretically optimum branch age for lopping at which the leaf content will meet fodder requirements and a maximum amount of wood will be collected as a by-product. Since forest resources are abundant in Munglori, it is a reasonable assumption that villagers cut branches of the size which best suits their needs. If this assumption is correct, then the average age of branches in the village head-loads should be indicative of the optimum lopping rotation. Preliminary analysis of branch ages from a number of head-loads in Munglori indicates that the desired average age is 4.5–5.0 years. The actual frequency of lopping is less than suggested by the average branch harvest age because many of the smaller branches are not cut. The harvest age, however, is significantly greater than the 2–3-year lopping rotation which early work suggests is sustainable (Gorrie, 1937). If lopping is infrequent, branches will grow beyond the optimum size and the tree will become less suitable for fodder collection. If, on the other hand, lopping is too frequent, the average branch size will decrease—increasing the number of branches required to complete a head-load, decreasing the amount of wood supplied as a by-product, and probably affecting the health of the trees.

Lopping levels in the forest decrease consistently with increase in altitude and in distance from Munglori and its *chhans*. At low altitude, forests tend to be very heavily lopped and oaks are dominantly present as cut and browsed bushes. As altitude increases, the percentage of trees of cut-bush morphology decreases and trees with a telephone pole or spreading lopped morphology become common. At this stage there is also an increase in the number of bush morphology shrubs which is indicative of recent regeneration. With increase in altitude the size of bush and cut-bush morphology shrubs decreases, the height of pole morphology trees increases, and occasional non-oaks begin to appear. In most locations this regular transition stops about midway up the slope and the character of the forest changes from lopped to full canopy over a relatively short distance. The eight different morphologies present in the various stages of degradation of the oak canopy are shown in Figure 6. This gradual change is not a recent phenomenon and has been reported even in the oldest available forest working plan of the area (Raturi, 1932).

EFFECTS OF ASPECT

The effects of aspect are as important as the effects of altitude. In lopped areas, south-facing slopes are dominated by grasslands and those oaks present tend to be of the spreading-lopped or cut-bush forms. Away from the south-facing aspect, either to the east or to the west, there is an increase in the number of trees present (mostly cut-bush morphology). This is followed by a gradual increase in the number of bushes and the initial appearance of trees with a pole morphology. Approaching the north-facing slope from northeast- or northwest-facing aspects, pole morphology tends to dominate and species other than oak become more common. At the change to the north-facing slope there is an abrupt transition to a full canopy forest. This full canopy forest may still contain lopped oak trees; other species, however, appear to have filled in the gaps as the oak canopy has been opened.

Aspect changes cause a similar transition in the un-lopped forests. On south-facing slopes the oaks have an open spreading morphology, are widely spaced, and are interspersed with grassland. On east- and west-facing slopes, un-lopped oak forests form relatively dense stands of high, narrow trees. On north slopes oak can be present either in the tall dense stands or, more frequently, as huge spreading trees forming a high canopy over a lower canopy created by other species.

The effects of exposure modify those of altitude, aspect, and accessibility. In protected positions, such as along river valleys or in the shade of large ridges, forests display characteristics closer to those of higher altitudes or more north-facing aspects. In a similar manner, forests which are near

1. Full canopy spreading — generally found growing in open scattered stands.
2. Full canopy longitudinal — generally found growing in close stands.
3. Sapling — young plant with no evidence of previous cutting.
4. Pole — single stem, tall and with short branches.
5. Spreading lopped — single main stem; number of major branches.
6. Stump — major stump; fresh growth from stump.
7. Cut bush — one or more stems often twisted due to long-term lopping; no evidence of major stem.
8. Bush with one or more small stems; no evidence of previous tree.

FIGURE 6. Tree morphologies observed in the various types of oak forests around Munglori.

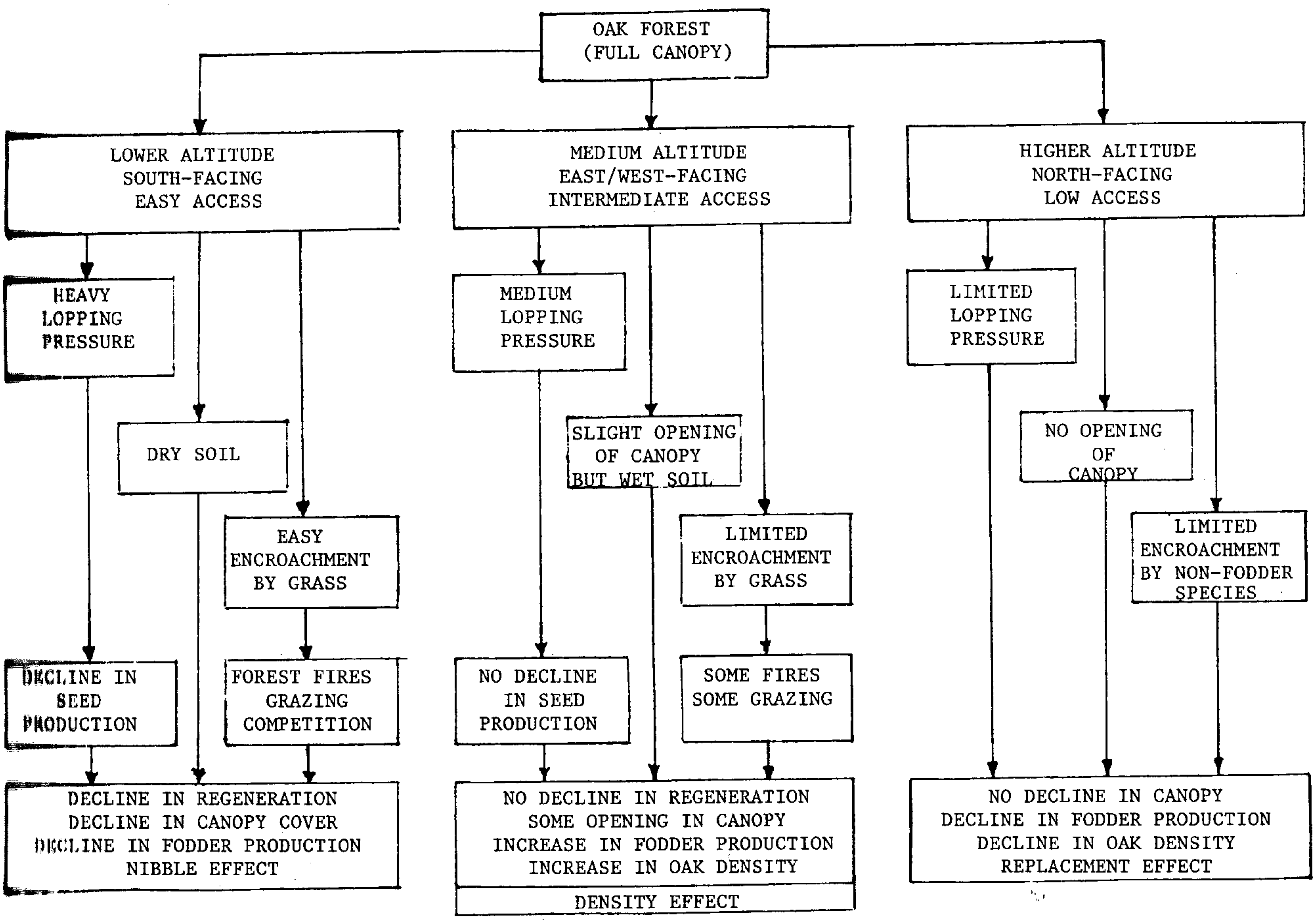


FIGURE 7. Schematic representation of the model showing nibble effect, density effect, and replacement effect in the oak forest around Munglori.

points of fodder demand, such as the village or its *chhans*, but are in climatically protected positions, will display characteristics typical of less accessible areas.

More research is required before these observations can be correlated with the impact of biomass utilization on forest productivity. However, a preliminary model of forest response to lopping is presented in Figure 7. This model describes what has been coined as the peripheral degradation ("nibble"), density, and replacement effects.

The Peripheral Degradation, or "Nibble" Effect

The peripheral degradation, or "nibble" effect, is, as the name implies, degradation on the margins of the forest. This occurs on south-facing slopes, at low elevations, and in areas where demand is high. A number of factors affecting regeneration are probably the fundamental cause. As lopping starts in an area and opening of the canopy occurs, grass enters in large quantities. This creates both increased competition for oak seedlings and encourages grazing and fires. The amount of shade present also decreases and the soil dries up; this affects both seed germination and the health of the lopped trees (Singh, 1982). Furthermore, lopping pressure may well be preferentially directed toward these marginal areas. People in Munglori readily state that they cut the closest areas first. The only exception to this are trees very close to the *chhans* which are kept for times when other work requirements are high. Also, the south-facing slopes are easy and attractive to cut; trees are low, obstructing bushes few, and the sun warm during the cold winter and spring period when oak is the primary fodder. Finally, if the pressure on an area is high, seeding could be affected. Flowering and pollination of the oaks takes place on new shoots (the most desirable fodder) between April and June. This is also the time when lopping pressure is the greatest. In heavily-lopped areas seed production, as a result, could be low and regeneration thereby inhibited.

The net result is that regeneration ceases on the forest margins and in ecologically sensitive (drier) areas. With the lack of regeneration, as trees die or are cut to meet the demand for tools and building materials, the forest margin rolls back. It is a gradual process which occurs despite the fact that total forest production is much greater than total demand on the resource.

The Density Effect

The density effect is the opposite of the peripheral degradation effect. In essence, it is an increase in the number of trees or oak bushes per unit area as lopping occurs. The essential difference between it and peripheral degradation is that, when the canopy is opened, the combined pressures are not enough to stop regeneration. In this case, seedlings survive but, as they are under continual pressure from lopping and browsing, remain as shrubs. This effect results in the forest conditions which are commonly found on east- or west-facing slopes and in climatically protected areas. In some locations near Munglori, where the density effect is strong, the number of oak stems is much higher per unit area in the lopped forest than in the unlopped forest.

The first result of the density effect is a presumed increase in the level of fodder productivity. With more trees per unit area, unless individual tree productivity is greatly reduced for some reason, more fodder will be produced. A second result is an increase in the cover provided by the lopped trees. In some places where the density effect is strong, the percentage cover provided by the lopped forest has been measured at values roughly equivalent to those in un-lopped forests with the same aspect. Furthermore, leaf litter present in un-lopped forests and some of the more dense lopped forests is also roughly equivalent. Since both cover and leaf-litter (which is also indicative of soil conditions) are important elements in the hydrologic characteristics of watersheds, these two factors indicate that if lopped forests were managed to enhance the density effect, watershed characteristics of the forests could be similar to those of un-lopped forests.

The Replacement Effect

The replacement effect occurs predominantly on north-facing slopes in the Munglori area. The essential feature controlling its occurrence is the presence of non-fodder species intermixed with the fodder species. In the mixed forests, typical of north-facing slopes in the Munglori region, opening of the oak canopy simply provides an avenue for the expansion of other tree species and bushes. The net result of the replacement effect on the north-facing slopes may well be to deflect fodder and fuel demands from these areas. Many north-facing slopes near Munglori, where the canopy has been opened, now contain dense shrubbery, making access difficult. Oak trees in these areas also show possible evidence of being lopped and browsed less frequently even than trees a few tens of metres away on slightly different aspects; oak saplings also may be present.

The replacement effect, however, is not confined to the north-facing slopes. In the region as a whole, it is also common where chir pine (*Pinus roxburghii*) or deodar (*Cedrus deodara*) is present. In this case, there is no evidence indicating reduced lopping pressure on the oaks. Rather, there is little oak regeneration and the oak is slowly giving way to the other species. This effect has been noted previously in the Himalayan region, particularly with mixed chir–oak forests (Singh, 1984; Upreti *et al.*, 1985). Major factors contributing to the decline of the oak and its replacement are the competitive disadvantage of the oak while under continuous browsing and cutting pressure and, in the mixed oak–chir forests, the effect of regular fires exacerbated by the heavy chir needle fall.

In summary, there are a number of factors in the lopping of oak forests that are important to the maintenance of the fuel–fodder cycle. On the level of individual trees, the frequency of lopping determines both the quality of the fodder and the amount of wood collected as a by-product. In the case of over-lopping, the branches collected will have a low wood content and fuel demand will be shifted to other parts of the forest. With under-lopping, the branches available will have too great a wood content and be less suitable as fodder. In terms of the entire forest there are three important reactions to lopping. The first is peripheral degradation, a gradual, long-term, roll-back of the forest edge due to the lack of regeneration in ecologically sensitive zones and the focusing of pressure on the margins of the forest. This effect can cause degradation even in areas where total forest production greatly exceeds total consumption. Second is the density effect which occurs where lopping, grazing, and other pressures are not great enough to stop regeneration. In this case the number of trees present increases, as does fodder productivity per unit area. Third is the replacement effect which, near Munglori, dominates wet areas and consists of secondary species growing into the opening caused by lopping of the fodder species. The combination of peripheral degradation and replacement effects suggests that fodder demand may well be focused on the dry slopes which, in the absence of careful management, are less able to support lopping over the long run. At the same time, however, the density effect suggests that, with careful management to enhance regeneration, village leaf fodder needs could be met without damage to the protective hydrologic role of the forest.

IMPLICATIONS FOR WATERSHED MANAGEMENT IN THE HIMALAYA

Domestic Needs in Forest Management

Domestic biomass needs have been ignored in the formulation of forest management strategies. They were ignored by the British who wanted to direct the maximum possible biomass harvest into the commercial channel. The Munglori case study clearly establishes that even when no commercial felling is practised or major urban demand has not crept in through organized smuggling, the biomass needs of the villagers may lead to degradation of the forest ecosystem.

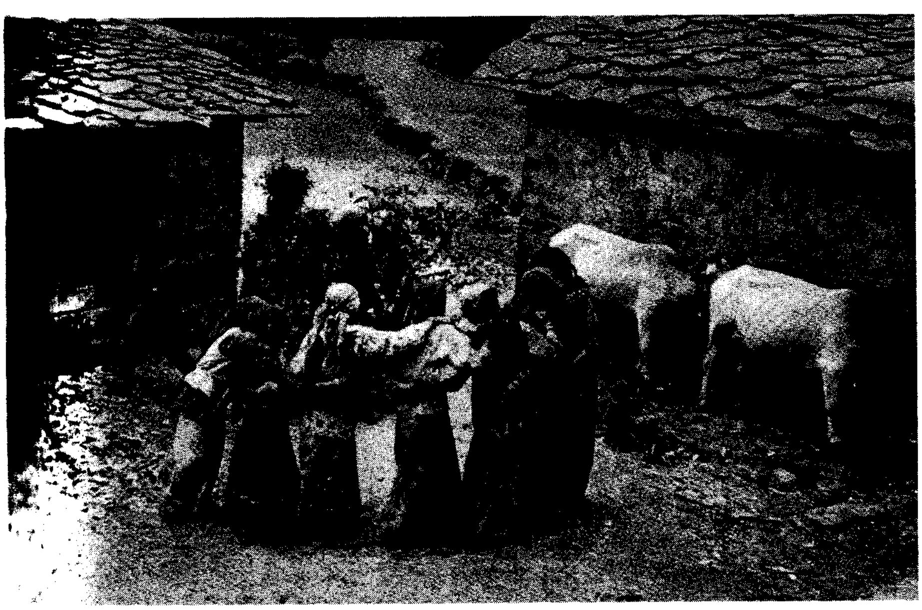
Accordingly, the internalization of domestic biomass needs in forest management is a necessity. As early as the beginning of the century, some enlightened revenue officials saw this flaw in forest management and argued in favour of quantification of domestic biomass needs and their systematic satisfaction (Bandyopadhyay, 1984). However, the needs of the people have never been given their due place in forest planning except that the term "biotic pressure" has often been used in forest management as a blanket reason behind the disappearing green cover.

In the absence of detailed qualitative and quantitative knowledge of the domestic biomass needs it is difficult to stipulate whether the existing requirements can or cannot be met from the existing sources through better load distribution techniques. As a result, even the lowest biomass requirement can lead to the "nibble" effect since the hill women are unwilling to venture deep into the forest to more widely distribute the load. The overall antagonism between local people and the forest guards keeps the pressure of biomass collection concentrated at the boundaries of the forests.

Non-forest Land Use and Forest Resources

Watershed management in the Himalaya has emphasized the role of forests in soil and water conservation. However, the impact of non-forest land use, particularly in grass production and agriculture, on the forest resources needs serious study. Since Himalayan watersheds are composed of a matrix of rainfall and rain-shadow areas, land use in the former should be geared toward soil and water conservation. Land use in rain-shadow areas should be aimed at providing the necessary biomass for village consumption. In this way pressure on the forests in the rainfall areas will be reduced to minimum and these vital forests can then be more readily conserved.

There are a few points of prime importance here. First, management of high rainfall areas for soil and water conservation does not necessarily exclude some village utili-



High physical quality of life is reflected in the development of a rich folk culture. Here children in the Aglar valley are dancing to a local tune.

zation. As the density effect indicates, with careful management of lopping levels and other land uses to enhance oak regeneration, it may be possible to both meet village needs for fodder and maintain the desired soil and water conservation properties of the forest. Second, in the dry rain-shadow areas tree planting may not necessarily be synonymous with ecological rehabilitation. This is more so, if grasslands are converted to plantations of species such as chir-pine. Though no quantitative information exists to evaluate the surface hydrology of grasslands in the region, visibly there are no major signs of soil erosion and heavy runoff in these areas. On the other hand, by enhancing sustainable productivity of grasslands through better management, existing lopping pressure on oak forests could be reduced further.

Similarly, the importance of agricultural products, such as straw, that provide about one-third of the total fodder requirements, gives indications for improved agriculture. Unfortunately, agricultural change (that is, "improvement") has been assumed to be synonymous with growing cash crops or shifting to varieties of crops that reduce straw biomass production while increasing grain biomass production. This means that with "improvement" in agriculture through increase in marketable products, the load of lopping on the oak trees for green fodder will also increase, creating heavy negative effects. In short, non-forest land use has very important implications for success or failure of watershed management in the Himalaya.

Participatory Management

Management of common grasslands around Munglori by 18 villages with the traditional management techniques for using the commons clearly indicates that civil forests, grasslands, or reserved forests, can be successfully managed with the participation of the people, particularly the women. Garhwal, after all, is the region where men and women have combined to protect forests through the Chipko Movement in opposition to the armed might of the police. Extensive afforestation has been achieved by the people of Saklana in the nearby catchment of Song River without external financial support (Saklani, 1985). Compared with the contract-based afforestation of civil forest lands in the same region this must be regarded as a spectacular success. Basic principles of management indicate that this wealth of experience and social knowledge of the Garhwal people must be integrated into any watershed management programme. Official programmes so far have not taken seriously into account either the creative or the consumptive roles of the local people. The case study of Munglori establishes the potential of the participatory approach in watershed management. The degradation of Himalayan watersheds can be arrested and the massive new programmes can be made successful only by associating the local people at all levels. Their continued isolation, especially of the women, from these projects will only make success more elusive.

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