Voices from the Commons
6th Annual Common Property Conf., IASCP
Berkeley, CA. 5-9 June, 1996

Sustainability Indicators in a Temperate Mountain Watershed:

Two Villages of the Upper Beas River, Himachal Pradesh, India

Colin E. Duffield

Natural Resources Institute
University of Manitoba
Winnipeg, Manitoba R3T 2N2, Canada

Abstract

Villages in the Himalayan front ranges of NW India are undergoing a rapid livelihood change from self-reliant agriculture and herding, to apple monocropping and tourism. Given that sustainability involves biophysical, social, and economic dimensions, the objective of the present project was to investigate relevant indicators. A conceptual ecosystem model of flows of material (e.g. fodder) and services (e.g. landslide protection) suggests that forests are the primary foundation of village sustainability. Agriculture, horticulture and pasture viability, the condition of soils, and tourism are also important components. Forest cover, tree age-class, and species inventory data for the forest use areas of the villages of Goshal and Chachoga were collected from government sources. A changing pattern of forest cover and density since 1918 suggests an overall loss in both cases. Three of Chachoga's six common tree species (spruce, chestnut and silver fir), and three of Goshal's seven (deodar, pine, and chestnut) have unsustainable age-class structures in that they lack younger trees. The age-class structures of two other of Goshal's common species (silver fir and spruce) may also be moving towards unsustainability. Observation of soil erosion characteristics showed that erosion occurs mostly in areas of high animal traffic which are concentrated in pathways close to the villages. Animal traffic, transport of timber down-slope, forest clearing, and the high energy monsoon rains all contribute to areas of massive erosion.

Thirty-six interviews conducted in the two villages suggest the concept of sustainability indicators makes sense. Thirty-one indicators ("signs or signals which should be monitored") were aggregated from the consultants' responses. In decreasing order, the top ten indicators were the extent and quality of forest cover; tree species diversity; adequate market access; forest density; orchard area; number of landslides and avalanches; stable hydrology; amount of reforestation and regeneration; family planning; and enforcement of tree-felling rules.

1. Introduction

> ...Lofty mountains are most worthy of deep study. For everywhere you turn, they present to every sense a multitude of objects and interactions to excite and delight the mind. They offer problems to our intellect; they amaze our souls. They remind us of the infinite variety of the world, and offer an unequalled field for the observation of the processes of humans and nature (quoted liberally from Josias Simler 1574, *De Alpibus Commentarius*).

A direct relationship with forests is the reality for people of the villages of the Himalayan front ranges, whose basic needs for fuelwood, animal fodder, bedding materials, minor forest products, and timber are still met from upslope forests. Sustainability indicators which include biophysical, social, economic, and equity dimensions, are necessary to monitor the effects of management policies. The linkages between policy, management, and indicators need to be understood to shape a sustainable future. Indicators themselves have the normative quality of comparing what is, to what is considered desirable. The identification of indicators is thus an exercise in compiling the views of a number of interests, depending on the scale at which monitoring is required. The present research compiles often diverse views from two villages. A comparison with the views of a selection of local resource management professionals is made. An assessment of several forest related measures is also undertaken

Context and Objectives. Dynamism inherent in mountain environments is often reflected in the changing ways in which residents make their livelihoods. Villages in the upper Beas watershed (Himachal Pradesh, NW India - Figure 1) are no exception; indeed, many people of this region are strongly reliant on the changing natural and agricultural resources of the area. Other residents, more reliant on the growing flow of tourism, are still indirectly dependent upon the attractiveness of the area, an attractiveness which is in flux as well. These peoples' livelihoods are based in an environment prone to unpredictable climate and catastrophic events, where human induced changes are only a part of the environmental change.

An agriculturalist and pastoralist society in what has long been a trade route, the people of Kullu Valley (Figure 1) have seen times dominated by export crops of tobacco and opium in the 1800's, periods of British settlement and the introduction of apple orchards, large-scale 1960's government clearing of some forests, land redistribution. Today, the conversion to a cash economy based on rapid expansion of apple orchards and tourism continues this historical evolution.

The use of forests has long played an important role in village livelihoods; an importance recognized by the pre-independence colonial government which, in the 1886 Settlement Report, gave usufructuary forest rights (often exclusive) to each village (for more detail see I. Davidson-Hunt 1995). The legacy of caste structure is seen in the majority landholdings of the Rajput caste, who usually meet their needs from horticulture, agriculture, and inputs from the forests, thus making greater use of the village forest use areas. Although landholdings of the Scheduled castes have increased as a result of the land reforms of the 1950's and 1970's, people with smaller landholdings generally do wage work, thus having less interaction with the forests as an input to horticulture and agriculture.

As part of a larger study on temperate mountain watershed sustainability in India and the Canadian Rockies, this research tackles the goal of:

> evaluating and developing criteria for assessing and monitoring sustainability in mountain environments and, in particular, to examine some of the relevant cross-cultural dimensions of sustainability in these watersheds (Berkes et al. 1995:4).

The present research assumes that sustainability includes biophysical, social, cultural, and economic elements, with an emphasis on natural resources - the prerequisite to human endeavour. The evaluation and development of locally relevant indicators is done by drawing from the literature, from a conceptual model of the human environment system of the area, and from interviews with people of the villages (consultants). The field research was carried out over six weeks.

Key Concepts and Definitions. The essential ideas underlying this research are those of sustainability, natural and human-made capital, sustainable livelihoods, and sustainability indicators. The term sustainability can be used interchangeably with the term sustainable development, so long as development is a qualitative term referring to improved equity, efficiency, and wellbeing, rather than ongoing growth in resource utilization ("sustainability" is used in the present project for simplicity and because it avoids definitional impasses and multiple connotations which can accompany the term "sustainable development").

Natural capital refers to "a stock [of natural assets] that yields a flow of valuable goods and services into the future" (Costanza and Daly 1992:38). The goods and services include yields, waste assimilation, erosion and flood control, and "life support services" such as consistent hydrological cycles and climate moderation. Human-made capital refers to the stock of manufactured capital. As William Rees suggests:

> There is general agreement that no development path is sustainable if it depends on the exhaustion of natural assets. From the perspective of capital theory, society can be said to be (economically) sustainable if it passes on undiminished

per capita stock of capital from one generation to the next (1995:350).

Weak sustainability implies that human-made capital is a substitute for natural capital. By contrast, *strong* sustainability posits that natural and human capital are complements. Further, natural capital is a prerequisite to human capital, thus Rees suggests natural and human capital be kept intact separately to be passed on to future generations.

Sustainability has often referred to the maintenance of ecosphere function and diversity (Opschoor and Reijnders 1991; Holmberg and Karlsson 1992); however, the definition is being expanded to include the idea of sustaining people's livelihoods. Livelihoods refer to the capabilities, assets (stores and access to resources), and activities required to make a living. A sustainable livelihood is one which can cope with and recover from stress and shocks, maintain and enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation. It also contributes net benefits to other livelihoods at the local and global levels in the short and long term (Chambers and Conway 1992).

2. Sustainability Indicators: Principles and Criteria

To ensure consistency and utility of sustainability indicators, most projects on indicators start with overriding principles, goals, or future visions. An indicator of sustainability is "a quantitative or qualitative variable which can be measured or described and which, when observed periodically, demonstrates trends" (Montreal Process 1995:5). Criteria, a description of desirable indicator characteristics, are used to select which indicators to monitor.

The principles behind sustainability indicators are rooted within the various definitions of sustainability; sustainable livelihoods as supported by maintenance of: ecological and economic integrity, resilience, productiveness and diversity, and social and cultural wellbeing. Principles also delineate the scope of indicators, which should include equity and efficiency, as well as sustainability (Opschoor and Reijnders 1991). The major goals underlying indicators is that they provide analytical, communication, warning and mobilization, and coordination functions (Hardi and Pinter 1995). The Montreal Process (1995), and the Alberta Round Table (1994) provide examples of principles. A selection of these sustainability principles have been selected for their applicability to the present study:

- Maintenance and enhancement of long-term multiple socio-economic benefits to meet social needs
- Maintenance of productive capacity of ecosystems
- Maintenance of ecosystem health and vitality

- Conservation and maintenance of soil and water resources
- Conservation of biological diversity
- Maintenance of air, water, and land quality
- Legal, institutional and economic framework for conservation and sustainable management
- Healthy living environment in communities
- Citizens are educated and informed about the economy and the environment
- Citizens are stewards of the environment and economy

Various criteria may be used to select indicators that best fit a given situation. The nature of such criteria can be surmised from the following list, adapted from Alberta Round Table (1994), Opschoor and Reijnders (1991), Hardi and Pinter (1995), and Holmberg and Karlsson (1992). Criteria used in selecting indicators should:

- Be measurable, relevant data should be available, and data gathering should be cost efficient gathering - in sum, indicators should be workable
- Be responsive to change, and shows results of action to effect change
- Reflect the concerns of people and institutions in the area through their input
- Cover biophysical, social and economic realms
- Be easy to understand and meaningful
- Focus on crucial factors in the human/environment system
- Relate to one or more principles by being integrative
- Have predictive ability
- Be sensitive to reversibility
- Be sensitive to changes in time, across space, and over social distribution

After indicators have been screened through the preceding list, they remain normative in the sense that they monitor a state of affairs which is compared with desirable conditions or goals laid out in the principles (Kimmins 1992). Indicators are categorized several ways in the literature. They can be drivers of change in the form of environmental pressure, or they can show the results of change, or environmental effects (Opschoor and Reijnders 1991; Alberta Round Table 1994), or they may have qualities of both within a linkage model of cause and effect. Measures of "potential for management toward sustainability" should be distinguished from factual measures of pressures and effects. Potential for sustainable management indicators include current and anticipated science and technology (relevant to products, processes, and inputs), and managerial tools such as appropriate institutions and policy (Opschoor and Reijnders 1991).

To be useful, the condition shown by various indicators must be compared with a past, or a desired future condition; indicators can thus provide an instantaneous measure comparing the two, or can show trends. It may also be possible to aggregate different types of indicators by standardizing them into ratios of actual versus desired condition (e.g. rate of flow vs. stock, or rate of flow vs. goal), and compiling the ratios into a single number - so long as the different ratios can be weighted in importance (Holmberg and Karlsson 1992; Opschoor and Reijnders 1991). Yet the utility of a single aggregate number may not be so high as it first appears: separate indicators facilitates the fine tuning of policy and management.

Additional suggestions on indicators include periodically revisiting the desired goals, and public input into choice and weighting of indicators so as to reflect driving social, economic, technological, and political trends (Hardi and Pinter 1995). In spite of regional differences, and the resulting differences in appropriate indicators, Carpenter (1994) suggests the need for several "standard measures" in the areas of: yield characteristics, hydraulic cycle, water quality, soil condition, atmosphere, and keystone and pest species.

Several international organizations have recently agreed upon the *Pressure - State - Response* framework to make indicators operationally useful by addressing causal linkages between actions, effects, and reactions (Hardi and Pinter 1995:13). In the PSR framework, indicators should signal:

1) the *pressure* that society puts on the environment (in the form of resource depletion and pollution);
2) the resulting *state* of the environment (especially the incurred changes) compared to desirable (sustainable) states;
3) the *response* by human activity, mainly in the form of political and societal decisions, measures and policies.

The development of sustainability indicators in the present study incorporates many of the principles and criteria described above, including input from two villages on choice of indicators, and their weighting. Actual data was not obtainable for several of the measures as a result of resource and time constraints.

3. Study Area: The Villages of Goshal and Chachoga

The study area lies at the northern reaches of the Kullu Valley, close to the headwaters of the Beas River, in the province of Himachal Pradesh, NW India (Figure 1). The river and its valley run southward, bisecting the Pir Panjal Range of the Western Himalaya, and flows out onto the Punjab plains. Manali is the commercial centre of the immediate vicinity. A burgeoning tourist town, Manali is situated near the valley floor at 2000 metres. Numerous smaller villages, most of which are very old, occur throughout the valley. As with most mountain environments, settlement and agriculture are found near the valley floor. The steep and forested slopes rise through to 4500 m alpine areas, with some 6500 m peaks. Glaciers and meltwater feed the energetic Beas River and its many side streams - nallas. The area has a temperate monsoonal climate, and the high altitude slopes lead to a variety of ecoclimatic zones. The people of the villages are of the Pahari culture, which although Hinduized, is distinct from North Indian plains culture and from the high Himalayan Bhotian culture (for more detail see K.Davidson-Hunt 1995).

Two villages near Manali were chosen as case studies: Chachoga and Goshal. As well as including private agricultural land, each village has a defined resource use area, stretching from the valley floor, through forests, up to alpine areas (see Figure 2). Figure 2 provides an idea of the scale of relief in the area, although it does not show the other villages. Exclusive resource use areas for each village provided an ideal template on which to examine the sustainability of each village. The resource use areas are under the management of the Forest Department. Areas higher than the demarcated resource use areas are shared by the villages.

The village of Chachoga was selected partly because of the role of the Mahila Mandal (a local women's group) in halting forest depletion (as identified by the Forest Department). The Mahila Mandal provided a contact for entry into the village for interviews. Goshal was selected for comparison, and was chosen because it was the home of the senior translator involved in the study, and it was thus an opportune place to arrange interviews.

Livelihood System. Figure 3 is a conceptual model of the flows of biophysical resources upon which people of the two villages rely directly, or rely for income. The model shows that the villages are supported by materials, services, and income from system components of: forests, pastures, horticulture and agriculture, livestock, and tourists. The first three of these components are founded on the inputs of sun, rain, and temperature, which are further shaped by factors of altitude, soil quality, slope and aspect. Indeed, these latter factors are profoundly important in a mountain environment.

In terms of importance to village livelihoods the forest component is paramount, as can be seen in Figure 3 from the large number of materials and services which originate from forests. Further, forests dominate the landscape, in particular the slopes. The indicators described in the present research thus focus mainly on forests, as do the indicators identified by villagers.

For simplicity, feedback loops illustrating the influence of village management upon the components, let alone the effects of policy on management, are not shown in Figure 3. Most management affects the rates of use of components, and component use is already shown in the figure. Indirect impacts on soil quality and erosion relate to management, and are essential considerations. In response, the research also focuses on soil erosion. Unfortunately, soil quality analysis was beyond the resources of the study. The figure does not illustrate the direct flows of timber which historically went to government contractors.

The origins and destinations of biophysical resource flows are best examined in Figure 3. In short, the flows include: fuelwood, timber, income, minor forest products, landslide and avalanche control, stable hydrology, bedding for animals, fodder, food, manure (mostly as fertilizer), and local climate moderation.

4. Biophysical Results

4.1 The Forests: Cover, Quality, and Age-Class of Trees.

Methods. Data for this section came from the July/August 1994 field season in Manali. Photocopies of original forest cover maps, and forest stand descriptions for Chachoga and Goshal forest use areas, were obtained from Manali's Forest Range Office. Tree age-class data from a 1979-1980 inventory were obtained from the same office. The age-class data was compiled for the forest use areas of each of the two villages, and the results graphed for the more common species (greater than 100 individual trees). Observations of reforestation (plantation) sites were also made, and added to the Chachoga map.

Forest Area Cover and Quality. Forest cover and quality (i.e. its extent, its density, and the mix of utilized species), are the best indicators of livelihood sustainability in the Himalayan context. The greater the forest (in particular forest close to the villages), the more fuelwood, fodder, timber, bedding material, and minor forest products (MFP's) can be sustainably taken from each village's forest use area. In the case of the two villages, much of the forest is too distant for daily access. Cover and quality of forests near the village relates to how easily needs can be met. In the longer term, dense forests and ground covering vegetation, like any dense cover, hold the soils on the steep slopes - particularly important in the monsoon climate. Forest maps dating back to 1918 show changing patterns of cover, and descriptions indicate changing quality. Unfortunately, the most recent map and inventory data are 15-18 years out of date; this is a serious shortcoming in a rapidly changing environment. See Table 1 for a list of tree species mentioned in the following text.

Chachoga's Forest Cover Pattern. (Figure 4) Chachoga's forest use area in 1918 had a healthy cover of mature spruce in its middle portions. Himalayan cedar (deodar) was either young (less than 40 years) in the northern reaches, or as described by the Forest Office records, "malformed" and sporadic. The existing pine was younger than the deodar. Broad leaf species were found in one valley, but were not described. A large area of cleared forest occurred upslope of the village on which no regeneration was described. Data for the upper portion was not recorded. The frequency of young trees suggests some clearing of forests had occurred prior to 1918. Harvest of the spruce from the southern mid-slope area was planned.

By 1949, the pattern of forest cover had changed dramatically. The middle portion of mature spruce had either been thinned to an open canopy of over-mature trees, or cleared. Previously cleared areas north and north-east of the village had become a "mass of woody undergrowth", while recently cleared areas directly east and south-east were not described. However, young (pole-age) deodar, often mixed with pine, was found regenerating over much of the lower areas, and older, 50 year old deodar was growing well north of the village. Some planting and thinning was undertaken. Broad leaf species were not noted. The upslope area to the far north-east of the village was described as rocky and precipitous, with a sporadic mix of spruce & silver fir (fir), interspersed with oak (korsh) higher up to the north-east, and with alpine grazing areas in between.

In 1977, the pattern becomes more similar to that found in 1918. The scattered over-mature spruce in the mid-slope areas remain, with more spruce growing up in open spaces. Areas of pine and broad leaf species to the east and north of the village are described as "doing well", some of these broad leaf species were planted. Deodar to the far north of the village is nearly 100 years old, and doing well, however to the north-east and east of the village, young deodar is either suppressed by over-mature trees, or absent underneath a patchy canopy (some deodar planting occurred in 1968-1969). The far up-slope area is described as unchanged since 1949.

Goshal's Forest Cover Pattern. Goshal has two forest use areas, the changing forest cover pattern of the larger area north-east of the village is described first, starting in 1949. In that year, most of the area indicated as spruce and silver fir in Figure 5 were undergoing "regeneration felling", that is, most of the mature spruce and fir trees were removed, leaving scattered mature trees as seed bearers and clusters of pole-age (15-30 yr) trees. Some unfelled areas of pole-age to middle-age spruce and fir were also described, but not delineated on the map. On some rocky areas, spruce, oak (korsh), deodar, and pine were found. Oak (korsh) and other broad leaf species were also left in the process. The mid-slope areas were characterized by oak (korsh), while the upper reaches were characterized by open mixed stand of oak (korsh) and birch, with sporadic silver fir and broad leaf species in nallas, and alpine grazing and massive rock at the uppermost areas to the east.

An inspection of forest condition was done in 1972 after the fires of 1970 and 1972. Most of the forest was affected, and killed trees were removed by the Timber Extraction Division. Conifer tree planting mostly failed. Planting of broad leaf species of beech, ash, walnut, maple, and bird cherry in nallas (valleys) and depressions was also done. The village of Shanag apparently has access to a portion of the area, and cattle grazing was found to be killing seedlings. Fencing of the planation area was undertaken, but not mentioned later on.

By 1977, as can be seen on Figure 5, much of the spruce and fir trees were clear felled under a "Mechanical Logging Scheme" during the first half of the 1960's. Natural regeneration was described as successful until a major fire in 1970 destroyed much of the forest, particularly seedlings. Subsequent planting of spruce and fir in the years from 1971-74 and 1976-77 (areas indicated by "P" in Figure 5) have had success ranging from less than 25% in the southern plantation to 70% in the north. The attempted plantings in the middle cleared area have been a complete failure. Heavy grazing and browsing is described as the cause of low planting success. Some mixed age-class areas of thin canopy spruce and fir with a few deodar and pine are found to the north and south - natural regeneration in those areas is reported as being suppressed by grazing in places. Oak (korsh) and other broad leaf species are found in depressions and nallas. A pattern of more spruce at lower altitudes, shifting to silver fir further upslope to the east, shifting again to oak even further up before reaching the upper areas of open oak (korsh) and birch, sporadic silver fir and broad leaf species in nallas, and alpine grazing and massive rock at the uppermost areas to the east.

Goshal's other forest-use area lies to the south-west of the village (Figure 6). In 1918, the south-east portion consisted of an open fir and spruce forest which was heavily lopped, and showed no regeneration. The area was described as "over-felled, over-grazed, and over-lopped". The portion to the north-west was the same type of forest although further away from the village and thus less heavily lopped. In 1949, no descriptive records were kept, however the site was mapped (Figure 6). An area to the south-east was clear felled, broad leaf species were noted in nallas (valleys), and oak (korsh) was found higher up to the west.

A fuller picture was provided in the 1977 description. In the south-east portion, there was mostly open (scattered) spruce and fir which had undergone "regeneration fellings", which means trees were thinned to provide more light for regeneration, and to meet saw mill demands. Some over-mature and damaged trees were left behind. Regeneration was poor due to grazing and browsing, and from dragging and rolling of logs to the saw mills. A report from 1963 said this portion once had excellent regeneration. Deodar and some spruce planted in 1931-32 to the south has become a good pole-age crop. The middle portion was described as a heavily lopped, thin to open, mixed-age spruce and fir forest. More fir was found higher up, with deodar on rock outcrops, pine on steep slopes and spurs, and broad leaf species (maple, chestnut, walnut, hazelnut, and bird cherry - jaraínth) in nallas and depressions. Oak and birch was found pure higher up. The north-west portion was a thin to open fir and spruce forest ranging in size from pole-age to mature with density improving with elevation. Again, there was no regeneration, and the lower area was heavily lopped and very open.

In summary, there has been an overall reduction in forest cover and density in the forest use areas of both villages. Cover and density loss has occurred at the forest margins near both villages as a result of fuelwood lopping, from taking over-lopped and partially dead trees, and from both sanctioned and unsanctioned felling. In Goshal's case, large areas of forest were removed as a result of fires in the early 1970's, and from government cutting of spruce and silver fir in the 1960's. Forestry Department records, and observation, suggest poor choice and poor handling, of planting stock, and overgrazing, are the causes of continued reforestation and regeneration failures. In Chachoga's case, government clear cutting of deodar at the turn of the century, and again after World War Two, has left their mark upslope from the village. Reforestation and regeneration difficulties in Chachoga's forest were also described in records and noted in observation.

Age-Class of Trees. The theoretical future yield of forests is based on the number, size, and species of the current stock of trees and vegetation, and on abiotic factors (Sheehy 1989; Clutter et al 1983; and Bickerstaff et al 1981). When multiple uses are made of the forest, it becomes important to know the number of trees of different age-classes (Clutter et al 1983). In order for the village forest to provide a sustainable supply of products and services, a mixture of all ages of the desired species are needed. Figure 7 contrasts theoretically sustainable tree age-class structures with unsustainable ones, the diameter values are "dbh" measures, or diameter at breast height.

The two top graphs in Figure 7 represent mixed-aged forests. They are theoretically sustainable because as the medium and larger trees are used, there are a greater number of young trees which will grow to take the place of the larger trees. The bottom two graphs show theoretically unsustainable tree age-class structures because there is a lack of young trees available to take the place of older ones.

To illustrate with an example, evergreen trees between 40-60cm dbh are lopped for fuelwood and bedding. The trees do not provide enough fuelwood when smaller, and cannot be climbed when larger. In the bottom left graph of Figure 7, current need for these products are hypothetically being met, however in 25 years, when the 10-30cm dbh trees have grown to size, there will be far fewer trees available for lopping given the current age-class structure. This sort of analysis can be used to assess sustainability of the age-class structure of Chachoga's and Goshal's more common trees, given their use.

The upward trend at the right side of some graphs indicate the existence of large trees which reach diameters greater than 90cm. The taper on the other two graphs suggest smaller trees with a maximum size of 100cm dbh (if the scale went to 200cm, the left hand graphs would also taper to zero). The downward turn in number of older and larger trees suggest the size at which trees are felled; for example, between 40-60cm dbh in the top left graph.

Age-class structure can indicate *potential* sustainability of a forest; data on overall wood volume change, and number of trees at each size-class over time, are required to assess whether the forest is being maintained. Total volume figures from the 1979-1980 inventory are also presented as baseline values for future comparison.

Chachoga's Forest Age-Class Structure. (Figure 8) Deodar is Chachoga's most common species, reflecting the suitability of deodar to Chachoga's lower altitude growing area, it is also the most valuable commercially. Plantations account for the high number of 10-30cm deodar trees. A historically heavy use of large trees (over 70cm) is reflected in the graph, such use is for timber. This species normally grows very large (150-200cm) and one would expect an upward tail on the right side of the graph, thus historical depletion of larger age-classes is shown.

The age-class structure of spruce, used for fuelwood, timber, and bedding, is mixed, but evidently 50-70cm size trees were, or are, heavily used. Availability of young trees (10-30cm) is lower than in earlier years, indicating a decline in regeneration, unfortunately the 0-10cm size class was never recorded. Thus, there is a 7-10 year lag in information before trees reach 10cm in diameter (which can be added to the 15-18 year age of the records). The upward tail on the graph indicates larger age-classes remain.

Pine (kail) presents an apparently sustainable age-class structure with some deficiency in the 20-30cm size. Pine is also a large tree, preferred for timber, as well as for bedding and fuel. The graph reflects heavy use of the larger age-classes by depletion of trees over 80cm.

Chestnut is the next most frequent species, its graph suggests a relative paucity of smaller age-classes in comparison with the number of large trees. This species is preferred for fuelwood and fodder, and the graph suggests smaller trees are overused for this purpose.

Oak (morr) is preferred for winter fodder and fuel, and would normally grow to 100cm+. The graph suggests heavy use and depletion of larger (>40cm) trees. More numerous smaller trees have the potential to eventually increase the larger age-classes.

The last species, silver fir, is generally uncommon and lacks smaller age-classes, it is used for fuel and timber.

The total wood volumes in cubic metres, provided in the forest range office inventory are: deodar 8814, spruce 8729, kail (pine) 1228, chestnut 545, morr (oak) 28, and silver fir 381.

Goshal's Forest Age-Class Structure. (Figure 9) Oak (korsh) is the most common species. This high altitude species reflects the large proportion of high altitude grazing area in Goshal's forest. The age-class graph shows korsh oak to be mixed age, as this is not normally a very large tree, there is good representation in the larger age-classes. Severe fires in 1970 and 1972 probably caused the current number of 20-50cm trees to be fewer than they might otherwise be (larger trees are more likely to survive fire). This species is desirable for fodder and fuel, however its high altitude makes access difficult.

Silver fir, the next most common tree, is also a high altitude species. Regeneration is lower in the last 30-40 years as evidenced by the slightly reduced numbers of trees in the 10-40cm class. Overgrazing, described in the forestry records, may be the cause of lowered regeneration, and thus potential unsustainability.

The age-class structure of spruce appears as if it may be moving towards potential unsustainability, as regeneration is reduced in the 10-20cm class, and regeneration of 0-10cm trees is not recorded.

The shape of Goshal's deodar graph indicate a deodar plantation was created about 30 years prior to the inventory. Deodar had either been depleted in the past, or was never present.

Pine (kail) has insufficient regeneration of young trees (10-20cm), and being a large tree, the graph shows larger age-classes have been used (this is a valuable commercial timber species, second to deodar).

Chestnut also has insufficient regeneration of young trees (10-30cm), while Hazelnut shows a pattern of sustainable use with heavier use of larger trees.

The total wood volumes in cubic metres, provided in the forest range office inventory are: korsh (oak) 18,287, silver fir 50,685, spruce 29,734, deodar 952, kail (pine) 366, and chestnut 1467.

In summary, three of Chachoga's six common tree species (spruce, chestnut and silver fir) have unsustainable age-class structures in that they lack younger trees. Whereas deodar (Chachoga's most common species), kail (pine), and morr (oak) have potentially sustainable age-class structures.

Three of Goshal's seven common tree species (deodar, pine, and chestnut) have unsustainable age-class structures, while two others (silver fir and spruce) show signs that their age-class structures are becoming unsustainable. Korsh oak (Goshal's most common species) and hazelnut have potentially sustainable age-class structures.

4.2 Soil Erosion in Orchards, Forests, Fields, and Agriculture-Forest Interface.

Not every soil can bear all things (Virgil 30 B.C., *Georgic II*).

Methods. Estimation of the percentage of soil exposed to direct rain was qualitatively recorded for orchards, forests near the villages, and the agriculture-forest interface to gain insight on the relative level of soil erosion. Observations along the interface were made approximately every 20m. Several random observations were made in forest and orchard.

Soil Erosion. Soil erosion risk in any one place is a function of the amount of soil directly exposed to rain, the steepness of the slope, and soil characteristics. Soil was mostly of one type (micaschist overlain by clay in Chachoga's forest, and micaschist overlain by shallow loam and clayey loam in Goshal's forest). As slope analysis was beyond the scope of this report, the focus is on percentage soil exposure. It should be noted however, that the predominantly clay and clayey loam soils have a low natural erodability (as opposed to sandy soils), thus reducing the negative impact of soil exposure to rain.

The percentage of exposed soil in older orchards (usually found on flat well maintained terraces formally used for agriculture), and orchards planted on steep haying areas, was zero because of thick grass cover. When orchards are planted in steep haying areas, a small (50-75cm diameter) terrace is typically created in which to plant the tree. However the exposed soil of this terrace is flat, covered with manure, and quickly grows over with grass, and thus poses little erosion threat. This new type of orchard is encroaching on steep grassed haying areas, and will eventually result in improved holding of the soil, improved slope stability, and improved snow avalanche protection and prevention, as opposed to grass alone. This assumes that apple trees have deeper roots than grasses, that apple tree-trunks can play a role in avalanche protection and prevention, and that a two-tier cover of both apple-tree crowns and grasses leads to improved slope hydrology (Tejwani 1994).

New orchards are also being planted into terraced agriculture found higher upslope. In this case, the new, and some mid-size trees are surrounded by mixed agriculture of legumes, greens, and vegetables. As the trees grow, the mixed crop around their bases will be replaced by grass, providing a nearly zero erosion risk. However, in the future, some of the orchards may be of the miniature tree variety, thus mixed agriculture around the trees could be maintained. Many people of the villages suggested this was a preferred option.

Such upslope terraced agriculture is less productive and profitable than those in lower and flatter ground, and often belong to the poorer members of the village, either via land redistribution or recent arrival. Thus, the switch from mixed subsistence agriculture to the more profitable apple is an attractive one. Some of these terraces presently being planted with apple trees are not new, but are reclaimed from previously abandoned terraces. The young apple trees are surrounded by thick grass, a low to zero erosion risk, plus the future benefits of improved slope stability.

Actual encroachment on the forests by new orchards was rarely described in the forest inventory report, except in a few areas near Chachoga where the forest boundary was close to the village site. However, according to S.S. Madan (pers.comm. 1995), "over 20 patches of forest have been clean-felled to make place for orchards right within reserved forest areas" in the Manali region. In the study area of the present project, most of the advance of apple orchards has been onto agricultural terraces and "nautor" land in Chachoga's case, and onto agricultural terraces, upslope abandoned terraces, and steep haying areas in Goshal's case.

The amount of exposed soil within the forests near the village depends on the amount of animal traffic. Fencing between the orchards and the forests of Chachoga keeps animal traffic outside privately held orchards, so grazers travel up well worn rocky paths to the forest. Concentration of cattle, as well as some sheep and goat traffic, along the fencing and just inside the forest, results in exposed soil paths. Aside from these limited traffic areas, little soil was exposed to rain-fall.

Above Goshal, there remains some grazing and haying areas, as well as utilized and abandoned agricultural terraces, between orchard and forest. Grazing traffic paths leading up to the forests consist of exposed soil, rather than rocks. Rain running down these paths has led to serious gully erosion in many places. Along these paths, and further upslope, the practice of "wood throwing" while transporting timber downhill has exposed soil, and led to gully erosion (timber is transported down-slope by human power alone, thus the "sleepers" of wood were often thrown downhill rather than carried).

In the monsoons of 1993, some mud-slides occurred above Goshal. The cause of the slides was the particularly heavy rains that year. The site of the slide's origin was a steep grazing area, thinly treed, which overlay rock. Such slides are bound to occur when the monsoons are heavy.

Erosion was also apparent on a broad, steep, and grazed slope above Goshal. The slope, thinly forested in the recent past, is criss-crossed with animal paths. Some gully erosion has begun, and the forest department has made efforts to block gullies to halt erosion. Pine saplings are planted, but are often trodden upon, or browsed. The village is concerned about the snow avalanche risk of this slope.

Apart from the limited areas described above, the bulk of the forest area's soil is well covered by undergrowth, grasses and shrubs. However, some problems in forest regeneration and plantation success are attributed to trampling and browsing by grazing animals according to the forest inventories.

5. Village Perspectives on Sustainability

5.1 Trees: Species Change and Preferred Use.

The idea behind researching "preferred use" is that there must be some criteria on what should be sustained. Determining what use is made of the forest, and the preferred species for that use, is key to deciding how to measure sustainability. Of course there are numerous objective criteria as well, but in the Himalayan context, people know well what aspects of their environments are important to their livelihoods, thus a subjective element needs to be considered. Changes in the relative species composition - trends in species change, or the availability and area of preferred species - can suggest whether levels of use of particular species are progressing at a sustainable level or not.

Methods. The information in this section was gathered using non-scheduled structured interviews with a translator. At their convenience, villagers (also referred to as consultants) were asked how they used the forest, what species were best for those uses and why, and what 30-year and 2-3 year trends have been perceived in the availability and area coverage of those species. A list of 28 utilized tree (and shrub) species was compiled over the course of interviews, and used to aid discussion of trends. During the initial part of the interviews, villagers typically spoke spontaneously of 5-20 preferred species (median range of 9-15). Some of the interviews took place with groups of 2-5 people who would put forth single responses (not necessarily agreed upon). Twenty interviews were conducted in Goshal, and sixteen in Chachoga. The number of spontaneous responses was used as a rough proxy for strength or importance of the response. These same interviews were also used to ask about village perspectives on sustainability indicators (see Section 5.2).

Use of the Forest. Figure 10 illustrates the relative importance of tree (and shrub) uses by graphically displaying the number of responses given by Goshal and Chachoga villagers. The results suggest that the two most significant forest uses (likely on the basis of frequency), are for fuelwood, and for fodder & grazing. These uses are roughly equal in significance, although potential alternative sources for heating and cooking, and reduction in the amount of grazing activity, may change the relative importance of these two uses. Trailing behind in terms of use-significance (or frequency) are timber, bedding material (ultimately used for fertilizer), and small-wood & MFP's (small-wood refers to wood for tools, handles, furniture, and carving, while "MFP" means minor forest products such as food, oil, and medicines).

Tree Species and Overall Trends in Change. Table 1 shows the English name, the local name (spelled phonetically), and the scientific name for the trees (including shrubs) used by village consultants. The species are grouped under what constitutes their most frequent use (see Table 3 on preferred use of tree species). Trends in availability and area covered by each species are shown on the right of Table 1. This is an aggregated perspective from both Chachoga and Goshal, and it shows 30-year, and 2-3 year trends. If both the 30-year and 2-3 year trends show decline, the species is clearly being used unsustainably. When the 30-year trend shows decline, yet the 2-3 year trend shows constant or increasing trends, past unsustainable use has been halted and a new lower stock is being maintained or increased. Downward trends in the past 2-3 years are the most critical, as they suggest currently unsustainable levels of use. Further, sharp declines over 30 years should be countered with definite increasing trends in recent years so as to rehabilitate the benefits derived from the stock of those species in the past, because in all cases, those species (spruce, alder, deodar, and pine) are preferred for various uses (see Table 3). In some cases, catastrophic events such as fires and floods are responsible for the declines.

A strong general decline in fuelwood species over 30 years has halted in the recent 2-3 years in all but two species (wild chestnut and spruce). Continued decline in these two species needs attention if stocks are not to decrease further. In general, these fuelwood species probably make up a lower proportion of the forest today than they did 30 years ago. The interview results suggests fuelwood species have been used at unsustainable rates until recently. There are some possible explanations for the general halt in fuelwood species decline. In Chachoga, rules against the selling of fuelwood outside the village were recently created and enforced by the Mahila Mandal, a women's group (for more detail see K.Davidson-Hunt 1995). There is no clear reason behind the halt in Goshal other than the greater distances people said they had to go for fuel.

Increasing distance can effectively lead to sustainable levels of fuelwood use as follows: the amount which can be gathered near to the village becomes depleted, thus greater distances are travelled. The total stock of fuel species within a half day's return distance is greater than the stock within a quarter day's return distance. The perceived depletion of fuelwood over the past 30 years refers to the area within a quarter day's return travel (villagers described how two or more loads could be fetched in the past in the same time it takes to fetch one load today). Now that people travel further upslope into the forest use area, the available stock and sustainable fuelwood harvest is larger, so that depletion has halted. However, this self-regulating process faces the limit of distances that can be travelled in a day. It would not be easily possible to reach the treeline in one day's travel.

The next cluster of tree species are under the heading of fodder (Table 1). The most critical time for fodder availability is during the winter months, either if stored fodder and grass run low, or as a supplement. The two species of winter fodder tree are important because they keep their leaves all year. According to the consultants, these two species, have declined over the last 30 years either by over-use of fodder, or use as fuel in the case of the oak species. In recent years the trends have stabilized at a lower level of availability.

The species used as general fodder have not shown nearly the decline as fuel and winter fodder trees over 30 years. The reason is that livestock feed mostly upon grasses, thus general fodder species form only a small proportion of the diet. Further, livestock populations have declined over the last 30 years. Two introduced tree species are increasing in recent years while the other species have remained constant all along, or in yet other species, decline has halted.

The tree species most preferred for timber and construction is the highly valuable deodar. Unlike most other species, deodar, together with several other timber species, provide opportunity for direct commercial use of the forest. The trends in construction species (which also includes spruce and silver fir) (see Table 3), have undergone strong declines over 30 years (Table 1). Over-harvesting by villagers, both legally and unsanctioned, and in Goshal's case, direct over-harvest by government clear cutting in the 1960's, and fires in 1970 and 1972, have been the evident causes of the decline. Such declines suggest highly unsustainable cutting of these species. The decline in pine and silver fir has halted in recent years, while the trends in deodar and spruce are perceived by the villagers to be continuing their decline.

Trends in high altitude species (silver fir, korsh oak, and birch) tend to be more stable. Trends in rare species (sweet chestnut, black mulberry, elm, ash, and wild walnut), where there may be only a handful of individual trees, are stable in the cases where the trees are considered holy by villagers (ash and walnut), but are declining in other cases (black mulberry and elm).

The trends of other utilized species can be read from Table 1. In recent years, most of these species are constant or increasing. Referring back to the frequency and importance of different uses shown in Figure 10, the "other species" shown in Table 1 constitute only a small proportion of the pie graph, being neither fuel, nor fodder, nor commercially valuable. This fact alone probably explains why these species have suffered the least depletion over 30 years, and show the most positive trends in recent years.

Trends in Tree Species Change by Village, by Forester. Table 2 shows trends in tree species change for each village, and contrasts these views with those of the forest range officer. In just over half of the cases, the consultants' and forester's views are the same. Agreement between forester and village tends to be lower concerning recent 2-3 year trends. In particular, the forester tends to be more optimistic regarding 2-3 year trends in commercially valuable species and trends in the more common species (deodar, spruce, and pine for Chachoga, and oak (korsh), silver fir, spruce, and deodar for Goshal - see Figures 8 & 9 for forest inventory). Whereas the forester is less optimistic on the 2-3 year trends of other less common species (many of which are preferred by villagers for various uses).

The perspective of consultants are opposite that of the forester in only one case: the 2-3 year trend for deodar in Chachoga. In this case, the villagers perceive deodar as continuing to decline, whereas the forester suggests it is increasing. In discussion, villagers emphasize the continuation of unsanctioned felling of deodar, whereas the forester suggests Chachoga villagers are unaware of all the healthy deodar seedlings and saplings in many clearings, which are not visible from a distance. To be fair, people of Chachoga might be referring to the area and availability of a mature stock of deodar from which they derive benefits of lopped wood, avalanche and slide control, stable hydrology, and the like - an overall stock which needs to be sustained to provide many benefits. Seedlings and saplings are not old enough to provide such products and services. Further, the difference in perspective may reflect a village view that saplings are not guaranteed to reach maturity.

As with Table 1, negative trends within the last 2-3 years should be given the greatest attention, and sharp declines over 30 years should be countered with increases in recent years in order to rehabilitate the benefits of a larger stock. In all cases, the species suffering sharp decline (spruce, deodar, and pine in Chachoga, and spruce and alder in Goshal) are also preferred species for various uses (see Table 3).

In Chachoga, as shown in Table 2, villagers note 2-3 year downward trends in the fuelwood species of kahti and shyen (shrubs), and spruce, whereas the forester notes alder as the only fuelwood species in recent decline. Area of familiarity might account for the different views, for example shrub species are lost as agricultural lands are converted to apple orchards, and the shrubs which once grew along fencelines and between fields are cut. Table 2 also notes where there was some opposing perspectives within the village; a few individuals held opposing views on the same species of kahti, shyen, spruce and alder discussed above (Table 2 shows the majority response). Such differences likely have to do with the type of interaction the person has with the forest. Notably, sharp historical declines in spruce are not being countered with recent increases.

Among Chachoga's winter fodder species (oak [morr] and black mulberry), the forester indicates that in recent years, both are continuing a downward trend seen over the past 30 years. Such recent declines in the important winter fodder species warrant concern, whether identified by villagers or forester. In contrast, the people perceive stable levels in recent years. Chachoga consultants, and the forester are in near perfect agreement over trends in general fodder tree species, although the forester states elm is in decline in recent years.

Declines in Chachoga's valuable timber species of deodar and pine were sharp over the past 30 years, and both continue downward in the last 2-3 years according to consultants - suggesting continued unsustainable use. The forester however states that the downward trend in pine has halted, and that deodar's trend has reversed. Only the forester's views on deodar suggest sharp declines in past years are being reversed today.

Other species in Chachoga show much more positive trends overall. Some differing perspectives are noted on Table 2. A species called jarainth may also be called bird cherry, and is used as a base tree on which to graft pears. In recent years, this species is increasing because of increasing use in orchards, however, in the forest, it is actually continuing a 30-year trend of decline. Positive trends are seen with Chachoga's poplar and black walnut.

In sum, recent years show a continuing decline in Chachoga's species of kahti, spruce, alder, shyen, oak (morr), black mulberry, elm, deodar, and pine. Unfortunately, deodar, spruce, and pine constitute Chachoga's most common forest cover, thus sustainability is in question.

In Goshal's forests, the situation is different. Referring to Table 2, sharp historical declines in the preferred fuelwood species of spruce and alder have at least halted according to consultants, or are increasing in recent years according to the forester. Only one fuel species (wild chestnut) continues a downward trend. Some opposing views within the village are shown in the table for kahti and alder. A striking example of the dynamic environment of the area, is the 30-year decline in Goshal's preferred fuelwood species: alder. Much of the alder in the past was located in the historical bed of the Beas River close to the village. This alder provided a ready supply of fuelwood, preferred because of its proximity. The historical bed of the Beas River is a broad area of rock with some "islands" of agricultural fields, trees, and shrubs. The actual river only occupies a narrow channel. Over time the Beas has changed course. In 1948, and further in 1970, Goshal's alder was washed away by the Beas River as it made radical course changes during particularly heavy monsoons. Only a small patch of this stand of alder remains.

The two important winter fodder species of oak (morr) and black mulberry are in decline over recent years in Goshal's forest as well as in Chachoga's. Goshal's general fodder tree species show stable or increasing trends. As was the case for Chachoga, there is near perfect agreement between consultants and the forester concerning general fodder species.

Goshal's valuable timber species of deodar and pine are generally not as common as in Chachoga's lower altitude forests, yet a sharp decline in the 30-year trend of deodar is perceived. Villagers have some opposing views on recent deodar trends, but the majority response is that deodar decline has halted. The forester suggests deodar declines are now reversed. The forester is also more optimistic about the 30-year trend for pine, and all agree that pine is showing an upward trend in recent years. Perspectives on Goshal's other tree species show generally positive trends, especially in poplar and black walnut. Some differing intra-village views are noted in the table.

In sum, severe past declines of spruce, alder, and deodar have at least been halted, and according to the forester, are increasing. Goshal's most common forest cover - korsh oak, a high altitude species - has remained stable over the years. However, wild chestnut, morr oak, and black mulberry are showing continued depletion in recent years. The overall importance of Tables 1 and 2 is the way they reflect the dynamism of the area. Depletion tends to have occurred mostly among commercially valuable trees, or preferred fuel and winter fodder species.

Preferred Tree Species. Table 3 shows the preferred use for various tree and shrub species. Under each heading (fuel, fodder, construction, and other), the tree species are shown in decreasing strength of preference. If trees were preferred for multiple uses, they were placed under the heading for which preference was strongest. The table also provides much detail in its numerous footnotes. Many species were preferred for multiple uses.

Preferred fuelwood species were described as wood which was clean burning, provided good heat, and was easy to fetch and carry, such as the shrub kahti. Spruce and deodar are also lopped for fuel as well as for the bedding material provided by the small branches and needles. Although these species are poorer fuel, they were preferred by virtue of their availability. According to the area's forester, the bottom quarter or third of evergreen branches can be lopped without harm to the tree. This can only be done once in the tree's life, as evergreens are poor coppicers. However, evergreen trees are often lopped so that only the top 15% of branches (the crown) remains. Such practice can lead to the thinning of forests as trees weaken and die and are then taken down for timber. Unfortunately, many of the preferred fuel species are uncommon (alder), or not counted in forest inventories (kahti and shyen). Most of the "multiple purpose trees", robinia, poplar, and ash, were not preferred fuel. Probably the best coppicer, willow, could provide repeated harvests of fuelwood, but was also not a preferred species. These latter species, often found along the roads, were used as fuel by non-villagers living alongside the roads.

Table 3 also shows the preferred fodder species, the top two are winter fodder trees, with green leaves available year round. These are an important form of backup insurance if stores of hay are lost or insufficient for the winter season. Other species are preferred for certain types of livestock at certain times of year. Most summer fodder is actually provided by grass from pasture and haying areas with the tree fodder providing supplement. Willow and robinia are preferred summer fodder for cattle, while maple is eaten by water buffalo. Several of the fodder species are also preferred fuel. Unfortunately, as was the case with several preferred fuel species, many of the preferred fodder trees (black mulberry, willow, robinia, bon oak, elm, and maple) are not common.

On Table 3, the species preferred primarily for construction are really multiple purpose trees. In fact, two of the construction species are listed under preferred fuel species. The species listed under the heading "other species" are not so frequently used. Poplar and ash, both multiple purpose trees according to the forester, were not seen in the same light by consultants.

Although the rarity of ash provides some explanation, poplar is increasing in availability. The lack of use of poplar for multiple uses suggests the tree is inferior, as it would be difficult to believe the consultants would be unaware of the qualities of poplar. Some of these trees are also considered sacred, for example ash and walnut. Birch-bark is sometimes used to fashion dishes for special occasions, although birch is a high altitude species, and is hard to access. Jarainth, perhaps more commonly known as bird cherry, is important as root and trunk stock upon which to graft different types of pear.

Considering Figure 10, which shows the importance of fuel and fodder species over other uses, trees which are preferred for both of these uses would likely be highly desirable. Such species include the shrub species kahti, as well as all the chestnut and oak species, and hazelnut. From these species, only Goshal's stock of oak (korsh) forms a major portion of their forest cover, however, this oak species is only found at high altitudes, and is thus difficult to reach.

Figure 11 shows the results when consultants were asked what species they would most like to see planted, and thus increased. The results did not match what might have been expected. Preferred fuel and fodder trees (the most frequently used products of the forest) were not at the top of the list, rather, Figure 11 shows deodar and pine at the top. These are of course the most commercially valuable trees, and in Chachoga's case, deodar provides its majority of forest cover (note Figure 8). Alder, a convenient fuelwood species was the next most desired for planting. Alder typically grows alongside the Beas River and other nallas (side valleys), and would provide a nearby supply of fuel. Robinia and willow were next, followed by spruce, chestnut, walnut, and poplar. Spruce forms a significant proportion of the forest cover for both villages, and is a multiple use tree, thus desirable. Chestnut is preferred for both fuel and fodder, and is also a fairly common species. Three people responded that all species need to be increased.

5.2 Villager Perspectives on Sustainability Indicators.

Methods. During the same non-scheduled structured interviews described above, the question was asked: "what signs and/or signals should be watched to predict a good or bad future for you, your children, and your grand children?" This question was asked in general, and more specifically concerning natural resources. The first few interviews posed the question as "what are the good or bad changes happening in this area", before the "signs and signals..." question was formed.

The resulting signs and signals are used as a proxy for locally identified sustainability indicators. As an open-ended question, no list of possible indicators (signs and signals) was provided to consultants, responses were thus spontaneous. The technique was informal, and as interviews progressed, responses which were interesting or unclear were followed up. The median range of suggested indicators was from four to seven. Prompting, using recent interview responses, did occur during many of the interviews.

The responses for each village, Goshal and Chachoga, were clustered in what seemed logical manners. Given their similarities, and for simplicity, the responses for the two villages were then combined. The combined indicator clusters are shown in Figure 12. These locally identified indicators, and the weighting of them by response rate, hold relevance to the social, cultural, economic, and ecologic interactions of the upper Kullu Valley in 1994. Such interactions differ from place to place, and may also change over time. The resulting list of indicators are what need to be monitored in future studies.

Forest Indicators. The first grouping of indicators in Figure 12 relates directly to the quantity and quality of the forest. These indicators include forest area cover, tree species diversity, forest density, and the availability of forest products (fuel, fodder, bedding, MFP's, and timber). The first three are considered positive indicators of a good future, while the forth is a positive result of high levels among the first three. The first three were the most frequently identified measures (excepting one) by the villagers of Goshal and Chachoga. The measures may seem obvious and simplistic, yet these indicators relate to a multitude of present and future human-environment interactions, and to the ability of people in the villages to cope with and adapt to events and changes in livelihood. Forest indicators would measure the stock of natural capital (cover, diversity, and density), and help us recognize whether the interest being drawn (in the form of forest products) is appropriate. Monitoring may also reveal aspects of the "pressure-state-response" dynamics of this system, and help determine the appropriateness of management, and whether system resiliency is being maintained.

Linkages to Forest Indicators. The forest measures described above affect various other components of the environment. The second cluster of indicators identified by the villagers in Figure 12 captures the secondary effects of the state of forest cover, diversity, and density. The number of snow avalanches and landslides (understood and distinguished by the people), and consistent hydrology (of streams, springs, and rivers) were the two most frequent response in this grouping. Clean water, and scenic beauty of the area were the next most identified as signs or signals to be monitored, followed by control of erosion, and consistency of climate - all of which relate to forest cover. The amount of shade (an indirect measure of crown closure), and the presence of bees (as pollinators for apple orchards and crops) were also identified as signs or signals to observe, which relate to forest quantity and quality.

Forest Management Indicators. The third cluster of village indicators in Figure 12 relate to forest management. Like the first set, these are forward-looking measures. The presence of reforestation efforts and natural forest regeneration, together constitute the most important sign or signal of a good future forest. This indicator supports the present project's analysis of tree age-class structure, and demonstrates the obvious importance of healthy new growth which will eventually be needed to replace the older forest.

Enforcement effectiveness over the annual timber harvest allowed by households (called "right holders") is the next most important thing to monitor according to villagers. The number of individual trees marked for harvest by right holders is set by the Range Forest Office. This process, called "timber distribution", is referred to as "TD" rights. In the recent past, each household was allowed five trees per year, this has been reduced incrementally to one tree every five years, and just in 1994, was changed to a system where the household has to justify its need for a tree. It remains to be seen how this system can be maintained in the face of the rapid growth in tourism - tourism which leads to increased wood demand for hotel construction and cooking in Manali. There is already some evidence of unsanctioned felling of green trees, which are sold on an illegal market for one quarter the legal price.

A recent enforcement challenge in Chachoga's forests was the selling of "headloads" of fuelwood in Manali. This sale of fuelwood made it more difficult to acquire fuelwood for local use, as nearby sources were used unsustainably. In response to this, and to the illegal fellings, a women's group called the Mahila Mandal took up the role of enforcement. They made selling of fuelwood outside the village illegal, and patrolled the forests in groups to prevent illegal harvest. A third positive indicator, suggested by a few people, would be increased village control of timber distribution, and increased village enforcement of rules.

Orchard, Crop, and Grazing Indicators. The fourth and fifth indicator groups, counting from the top of Figure 12, relate to agriculture. Increased area under apple orchard and increased area of any other cash crop are both considered signs of a good future. The term "cash crop" likely refers in the most part to apples, and less to other crops such as peas and red rice. The switch to more orchard and cash crop area would come at the loss of former mixed-crop agricultural area. The emphasis on apples reflects the growth of the agricultural cash economy over the last 30 years. As a result of the increase in orcharding, mixed-crop agriculture, and food self-reliance is in decline. Observation of young apple trees interplanted with mixed-crops suggests that 90 percent of the agricultural area will eventually be covered by thick orchard, with insufficient light for understorey crops. This assumes normal size apple trees; dwarf apple trees have not been introduced to the area at this time, although such introduction would allow the maintenance of mixed crops.

The village perception that increased orchard and cash crop area are signs of a good future is an indication of the importance of the economic dimensions of sustainability in the minds of those respondents. Many factors relate to the long-term success of such agriculture, yet such factors were rarely mentioned by consultants as important to future sustainability. Providing detail of factors which make apples and cash crops a sustainable livelihood is beyond the scope of this report. However, two assumptions were likely being reflected in the respondents choice of apple and cash crop area as indicators, first, villagers may be assuming that orchard management is sustainable with respect to soil, and with respect to apple species diversity (important for long-term crop resiliency); these are both dubious assumptions. Secondly, and less dubious, is that a market for the product is maintained. An area of further concern is the use of pesticides on orchards. Recent perceived declines in bird, insect, and bee populations and diversity may be a result of excessive pesticide use, and bodes poorly for ecosystem function.

Area of quality grazing, and area for hay growth are first in the next cluster. These two are together considered a good sign, and would be telling of good grazing management. Proximity of good grazing was also mentioned as a positive sign. Finally, the availability of manure for fertilizer is something which respondents thought should be monitored. Manure is mixed with bedding material and distributed on the fields and around apple trees, it is the fertilizer of choice in every case. It is also free, unlike costly manufactured fertilizers. Manure is sometimes used as cooking fuel, desirable for its slow consistent heat, but is used principally as fertilizer.

Economic and Social Indicators. The sixth group of signs or signals identified for future monitoring in Figure 12 starts with market access, in particular, the existence of good roads down to the plains. This single indicator is the third most frequent response after forest area cover and tree species diversity. Access, important for apple crop export, and for the import of tourists, is of obvious importance to emerging cash economy-based livelihoods.

Discussion of livelihoods based on apples, and those which rely more on tourism is needed at this point. Many of the people interviewed in the villages belonged to households which owned at least some orchards, and such people would obviously have an interest in market access. However, villagers usually base their livelihoods on several sources; orchard owning households are often involved with tourism via weaving (for sale Manali), or by having some members of the household involved in trekking, or running a business in Manali. The market for tourism is thus also important. There are however, village households which rely more heavily on a business located in Manali (or located along the roads below Chachoga, or in Bahang, which lies across the Beas River from Goshal). The market for tourism would obviously have greater bearing on the livelihoods of these people. Those with the greatest reliance on tourism are the people of Manali, although many of the larger tourist oriented businesses in Manali are owned by people from the plains, Kangra district, Lahaul to the north, by Tibetans, and increasingly by foreigners. Some antagonism towards this concentration of non-local ownership was felt by villagers.

The next sign or signal to be watched is the flow of tourism into the area. Consultants were aware that if violence in Jammu and Kashmir ceased, tourists would be drawn away to Jammu and Kashmir - historically a much more important tourist destination. The third indicator in this cluster is closely linked to markets and access to the plains: cultural health. Undesirable aspects of opening a culture up to a larger market include challenges to cultural identity, assimilation into mainstream plains culture, crime, and examples of undesired lifestyles. An example of undesired lifestyles, according to people of the villages, are Manali's and Old Manali's fluctuating "hippie" population, a heterogeneous non-Indian group, some there since the 1960's and presently raising children. Other "new" hippies, more recently from Israel, Britain, France, and other countries, stay for several years, or return for half of each year, attracted by the location, by the availability of *Cannabis sativa* (known as bhang, marijuana, or hashish - grown legally for hemp-rope fibre), by the availability of other illegal substances, and by the low cost of living.

Social and Science Indicators. As indicated on Figure 12, the seventh cluster of signs and signals to monitor (so that children and grandchildren will be able to sustain their livelihoods) includes education and literacy for children, and women's rights, particularly for the coming generations. Respondents suggested that the forest conservation interests of young men would be a good sign, although currently young men tend to favour the profitability of working in Manali. Their lack of interest in forest use and conservation, and perhaps even their active participation in unsanctioned harvesting of green timber, leaves the job of forest conservation to women.

Increased milk production per cow is considered a good sign. Introduction of Jersey cattle crossed with small Himalayan breeds has resulted in milk production rising from half a litre per day, to between five and ten litres per day (and possibly much more). One cow, rather than five, can now meet the needs of a household. Less grazing area is thus needed per litre of milk, although how much less is unclear. In addition, one cow means the availability of manure per household is reduced.

Mechanization of agricultural labour, and subsidization of pesticides, were also considered signs to monitor. Mechanization is nearly non-existent today, probably a result of very small terraced fields, as well as cost. Ploughing is done by bullock, and planting, weeding, harvesting, and fertilization (using manure and bedding material), is all done by hand, mostly by women, except for ploughing. Various pesticides are 50 percent subsidized, and manufactured fertilizers were also subsidized until recently.

Air and Water Quality as Indicators. The next to last indicator type on Figure 12 identified by villagers was air and water quality. Respondents expressed concern over air pollution in and near Manali, as well as along roads. Negative effects of air pollution on human health, crops, forests, and climate, were discussed. Concern over water pollution included sewage and garbage entering the Beas River, however the importance of village water potability was given greater emphasis by respondents. Steps to improve air and water quality would likely be considered a positive sign, although none were described.

Family Planning as an Indicator. The last sign or signal to monitor for a good future identified by some people of Chachoga and Goshal, was population control (Figure 12). The consultants placed emphasis on local family growth in villages, rather than on people arriving via immigration. It seemed immigration was mostly into Manali, not into the villages. Population statistics were inadequate, more research is thus needed in this area. The topic of population is controversial among many people of the villages, and the people who identified it as a sign or signal were often older men in positions of political or commercial significance (usually the two coincided). There are many theories relating social, economic, cultural, political, and environmental conditions to population growth. Yet in the village context, with its direct interaction with, and reliance on, a limited area of forest (Figure 3), increases in population, without reduction in per capita use of forest products, could deplete or change the forests undesirably, and reduce resilience in the human/environment system.

Village Perspectives on Sustainability: Summary. Figure 12 gives an initial idea of the signs or signals villagers think should be monitored in order to predict a good future. Used as a proxy for sustainability indicators, these signs and signals are most relevant to the people of Goshal and Chachoga. The spontaneous responses shown totalled in the figure make it possible to weight the different indicators once monitoring is undertaken. Some village indicators would probably show positive trends, other negative, thus weighting is required to obtain an overall picture of whether the livelihood system is becoming more or less sustainable.

The most frequently identified indicators (identified by 15 or more consultants), and which should be more heavily weighted once ascertained are:

- forest area cover
- tree species diversity
- market access

Those identified by ten or more consultants also include:

- forest density
- orchard area
- avalanche and landslide frequency
- waterflow consistency
- reforestation and regeneration area and success

Those identified by more than five consultants also include:

- family planning - population growth
- forest protection enforcement success
- clean water availability from the forest
- scenic beauty
- grazing and haying area
- availability of forest products - time to harvest
- amount of erosion
- cash crop area

Other Perspectives in Contrast. In addition to the 36 interviews with village consultants, nine other interviews were made with various local professionals in the field of natural resources as a comparison to the village perspectives. Agricultural, horticultural, and entomological researchers, foresters, an environmental non-government organization representative, and a representative from the Mountain Research Institute of Manali were interviewed with a non-scheduled structured questioning technique. The questions generally focused on environmental issues of sustainability. All interviewees spoke English.

In the same way that the village consultants' responses are clustered into nine themes, so too are the responses of the local natural resources professionals. The nine indicator themes are roughly parallel, and the weighting given to each are compared in two pie charts in Figure 13. The two pie charts should be read counter-clockwise from the top.

In the village perspective, two-thirds of the weighting is on forests, measures directly linked to forests, and forest management, whereas the local professionals give a one half weighting to these same measures. Among the factors related to forests, villagers emphasized avalanche and landslide frequency, and stable hydrology, while the local professionals emphasized the relation of Kullu Valley climate to forest cover, and again stable hydrology. Although both groups mentioned the presence of bees, professionals attributed the current absence of bees to excessive use of pesticides on orchards. This last point was emphasized strongly as an issue of concern. The natural resource professionals also gave relatively much greater weighting to good forest management than did the village consultants.

The weighting given to the measure of agricultural area was equal, although villagers focused on apples and cash crops more generally, while professionals emphasized vegetables as being the cash crop of the future (summer squash, cabbage, summer cauliflower, potato, baby corn, and onion were recommended), and agroforestry in general (which includes diversifying apple species, including more pears, apricots, cherries, and including more multi-purpose trees such as robinia, ash, poplar, beech, and willow). The professionals gave greater weighting to the importance of grazing area, which includes manure availability, but did not note the importance of haying area for fodder as an indicator.

Villagers gave greater bearing to market access, and existence of a tourism market, whereas the local professionals considered the existence of village business co-operatives and availability of credit to be of greater import for monitoring. If the two indicator themes of market access and credit and co-operatives in the lower pie chart are clumped together as "economic sustainability", and market access in the upper pie is also renamed, then both groups gave them similar relative weighting.

The local professionals did not mention education, literacy, and women's rights as signs or signals to monitor, although village "environmental awareness" was mentioned once. The exodus of young men and women as an indicator was described by both groups. Professionals gave greater weighting to air and water quality as indicators, citing unplanned tourism development as the primary problem. Professionals also considered family planning, or its opposite, population growth as a relatively more important indicator than did village consultants.

6. Conclusions

> If we cannot reliably measure whether a given current management practice is sustainable, or predict whether an alternative would be more or less sustainable, how can we move toward sustainability?

The question posed above by Carpenter (1994, cited in Rees 1995:351), captures the value of developing appropriate sustainability indicators. The cultural relevance of the resulting indicators is based on incorporating a local perspective into what should be monitored. Socially desirable goals or targets against which measures will be compared still need to be developed. In decreasing order, the top ten indicators identified for monitoring, out of 32 identified by people of Chachoga and Goshal, were the extent and quality of forest cover; tree species diversity; adequate market access; forest density; orchard area; number of landslides and avalanches; stable hydrology; amount of reforestation and regeneration; family planning; and enforcement of tree-felling rules. The village perspective supports a conceptual model showing the fundamental importance of forests to sustainable livelihoods, and also gives weighting to the relative importance of each indicator. Comparative results from the Canadian Rockies will help identify indicators which are cross-culturally applicable and robust.

Government map information of forest cover for the two villages' forest use areas show a general decline since 1918, and records describe low success rates in reforestation and regeneration in many instances. Fire and grazing are both described as playing major roles in forest changes in government records. From a village perspective, there has been a 30-year downward trend in the availability of preferred fuelwood, fodder, and timber tree species. The downward trend has apparently halted in recent years, stabilizing at reduced levels. In the case of some other tree species, the trend has turned upwards. Most of these observations were confirmed by the local government forester.

Encroachment of orchards into the forests did not seem to be occurring in the two village areas; rather, new orchards were usually located in agricultural terraces, abandoned terraces, steep haying areas, and nautor lands. Food self-reliance is declining as a result of orcharding. There is concern that emphasis on only a few apple varieties will increase the risk of crop failure, and that excessive use of pesticides is reducing the populations and diversity of bees, insects, and birds (the 80 percent crop reduction which resulted from late snows in the spring of 1994, and perhaps from a lack of pollinating insects, supports this concern). Erosion occurs where animal traffic is high, and where there has been a history of transporting timber down-slope. However, the predominance of clay and clay loam soils results in a naturally low erodability of exposed soils (as opposed to sandy soils). The allowance of timber per village household has been lowered in recent years, from five to three to one every five years; to one on the basis of demonstrated need. The results of this change in policy remain to be seen.

The literature on sustainability indicators suggests that several "standard measures" should be monitored together (Carpenter 1994). These measures include yield characteristics, hydraulic cycle, water quality, soil condition, atmosphere, and keystone and pest species. The indicators identified by village consultants, and by local resource management professionals, in fact, cover all these standard measures, and attest to an understanding of the dynamics of the mountain ecosystem in which they live.

References

Alberta Round Table. 1994. *Creating Alberta's Sustainable Development Indicators.* Environment Council of Alberta, Edmonton.

Berkes F, G.S.Chauhan, I.Davidson-Hunt, K.Davidson-Hunt, C.Duffield, J.S.Gardner, L.Ham, B.W.Pandey, J.Sinclair, R.B. Singh and M.Thakur. 1995. "Sustainability of a mountain watershed ecosystem in the Himachal Pradesh Himalayas: Background and Overview." Tech. Rep. No. 1 (Feb).

Bickerstaff A., W.L.Wallace, and F.Evert. 1981. *Growth of Forests in Canada, Part 2: A quantitative Description of the Land Base and the MAI.* Forestry Services Canada, Environment Canada, Ottawa/Hull.

Carpenter, Richard A. 1994. Can sustainability be measured? *Ecology International Bulletin* 21: 27-36.

Chambers R., and G. Conway. 1992. "Sustainable rural livelihoods: practical concepts for the 21st century." IDS Discussion Paper 296. Institute for Development Studies, University of Sussex, UK.

Clutter J.L., J.C.Fortson, L.V.Pienaar, G.H.Brister, and R.L.Bailey. 1983. *Timber Management, a Quantitative Approach.* John Wiley & Sons, Toronto.

Costanza, Robert, and Herman E. Daly. 1992. Natural capital and sustainable development. *Conservation Biology* 6: 37-45.

Davidson-Hunt, Iain J. 1995. "The state, village and the commoner: Interactions in the management of a western Himalayan commons." Tech. Rep. No. 4 (June).

Davidson-Hunt, Kerril. 1995. "Gender, class and the commons: A case study from the Indian Himalayas in Natural Resources Management." Tech. Rep. No. 3 (May).

Hardi, Peter, and Laszlo Pinter. 1995. "Models and methods of measuring sustainable development performance." A revised draft discussion paper prepared for the sustainable development coordination unit of Manitoba. International Institute for Sustainable Development, Winnipeg.

Holmberg, John, and Sten Karlsson. 1992. On designing socio-ecological indicators. In *Society and the environment,* U.Svedin and B.Aniansson. eds. Kluwer Academic Press, Dedrecht, Netherlands.

Kimmins, Hamish. 1992. *Balancing Act, Environmental Issues in Forestry.* University of British Columbia, Vancouver.

Montreal Process. 1995. "Criteria and indicators for the conservation and sustainable management of temperate and boreal forests." Proceeding of a working group ("Montreal Process"), Santiago, Chile. Canadian Forest Service, Natural Resources Canada, Ottawa/Hull.

Opschoor, Hans, and Lucas Reijnders. 1991. Toward sustainable development indicators. In *In Search of Indicators of Sustainable Development,* O.Kuik and H.Verbruggen, eds. Kluwer Academic Press, London.

Rees, William E. 1995. Achieving sustainability: reform or transformation? *Journal of Planning Literature* 9: 343-361.

Sheehy, Greg. 1989. "The use of forestry indicators to show the state and recent trends in sustainable development: A forestry pilot study." Paper prepared for State of the Environment Reporting Office, Ottawa/Hull.

Tejwani K.G. 1994. *Agroforestry in India.* Oxford & IBH, New Delhi.

Personal Communication

S.S. Madan. April 29, 1995, facsimile. Chairman, SHARE, Manali. (Society for Holistic Action in Rehabilitation & Ecology)

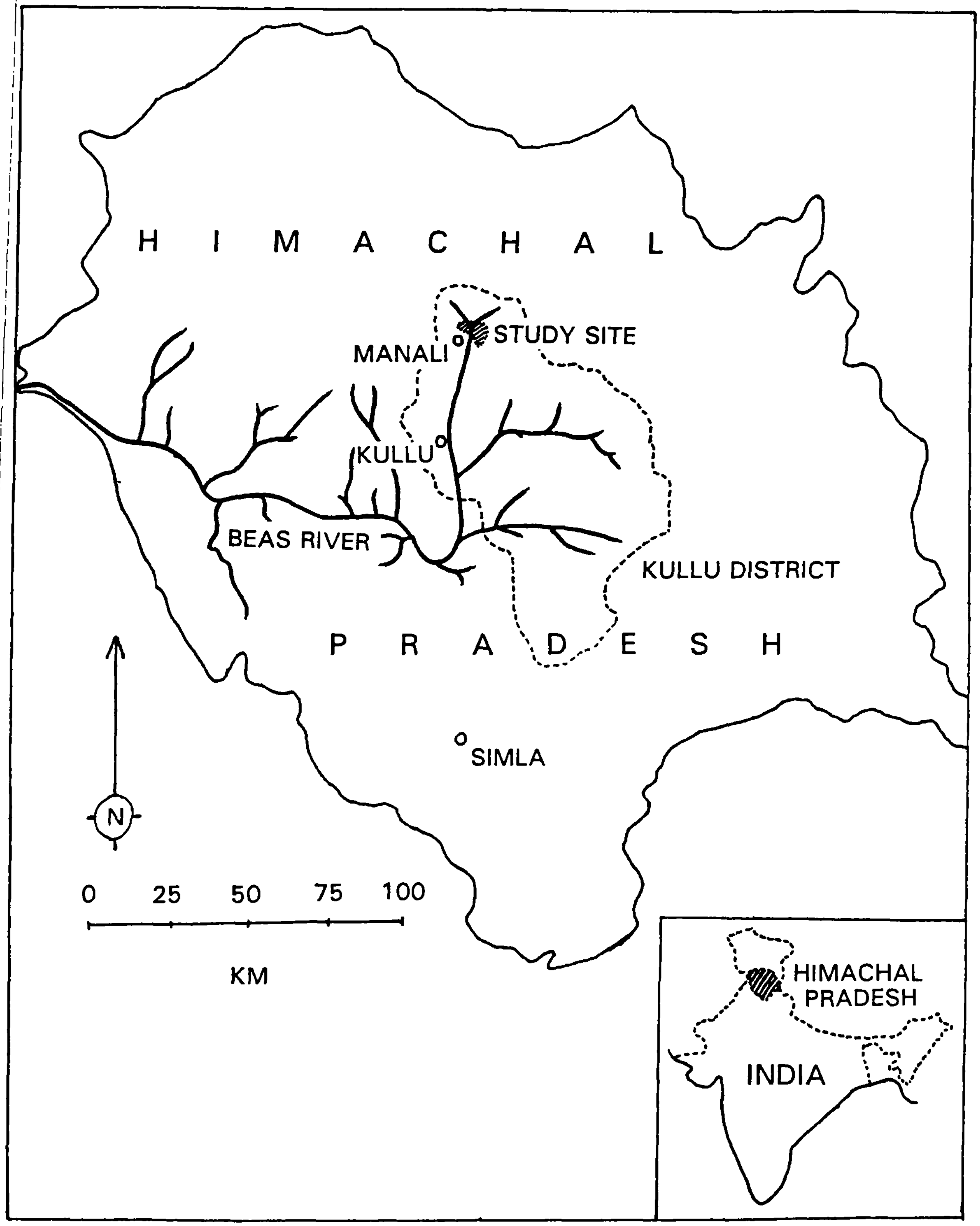


Figure 1. Location of the study site in Kullu District of temperate Himachal Pradesh state in the Himalayan foothills.

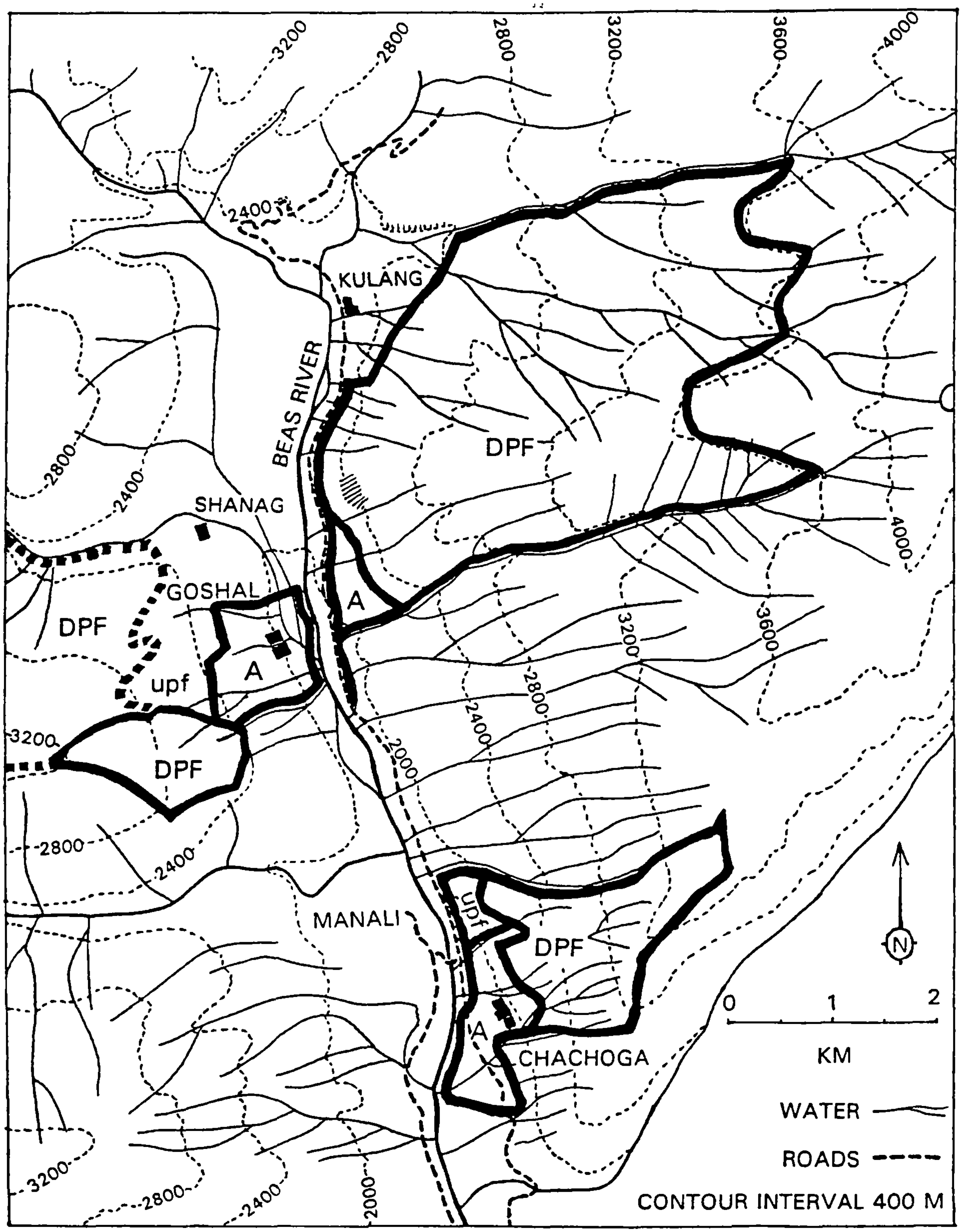


Figure 2. Village use areas of Goshal and Chachoga showing their respective demarcated protected forests ("DPF"), approximate undemarcated protected forests ("upf"), and approximate agricultural areas ("A"). Goshal shares its small south western DPF area with Shanag, and its large eastern DPF area with Kulang. Goshal also makes some *de facto* use of the dashed DPF area west of the village. The ("■■■") symbol denotes village sites.

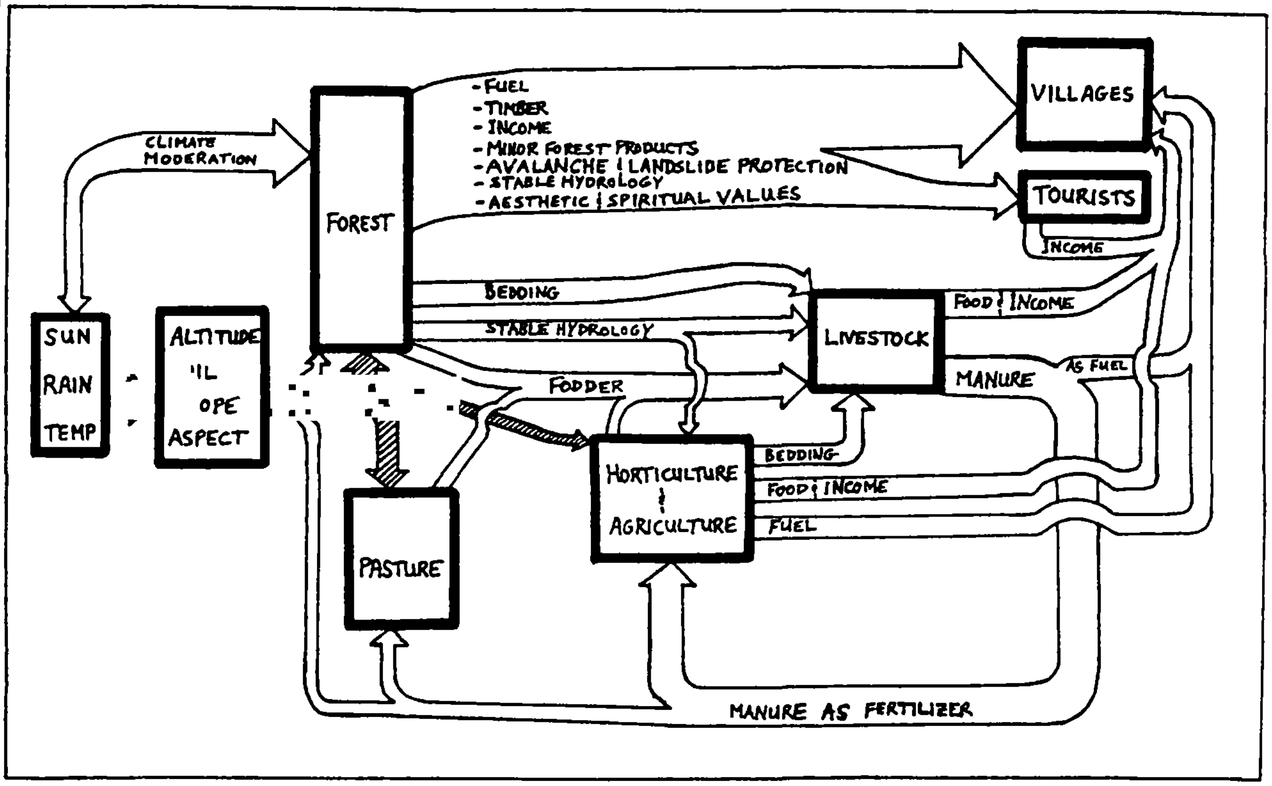


Figure 3. Village livelihood system: a conceptual illustration of the biophysical basis of sustainability and the importance of forests.

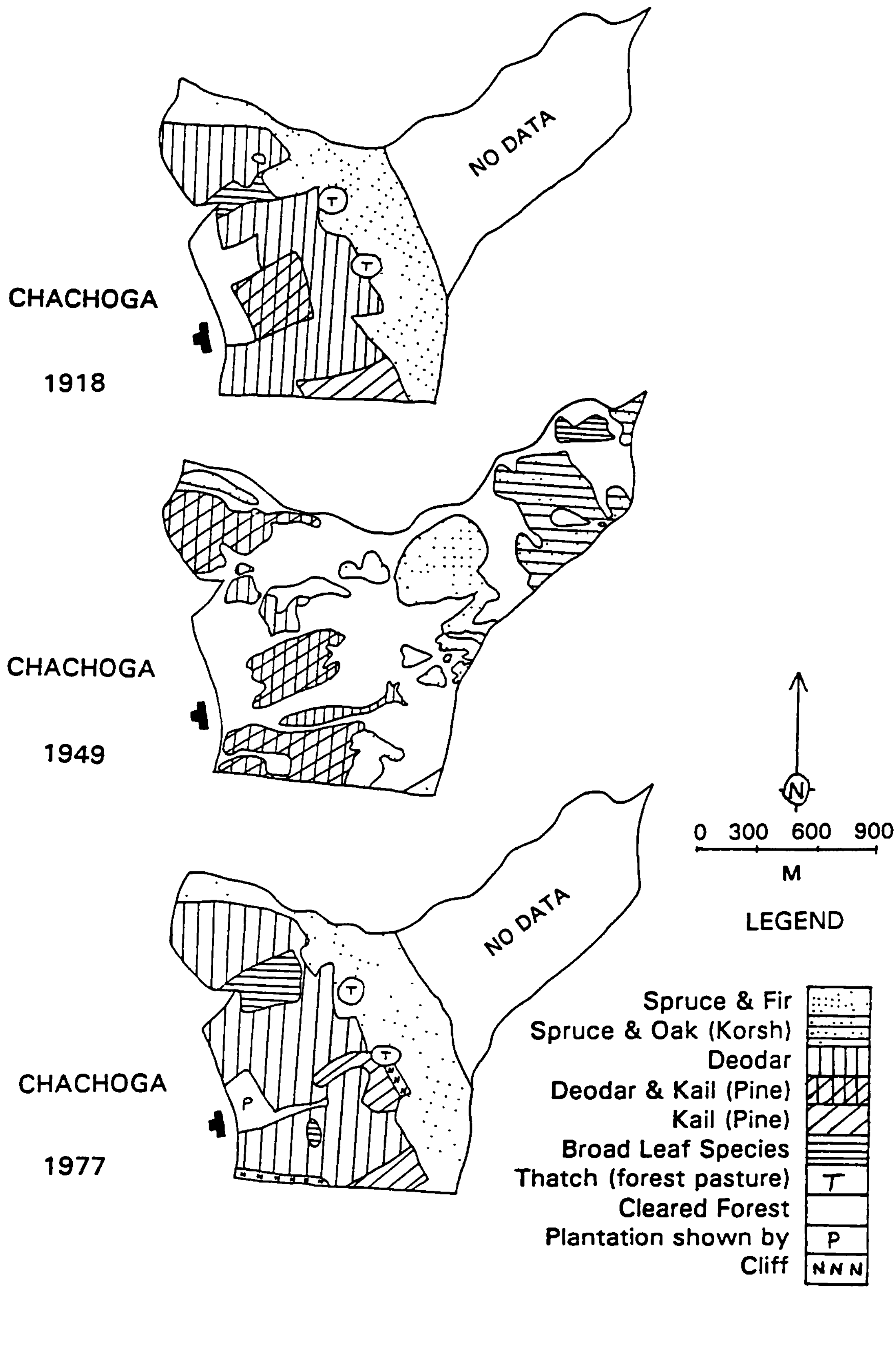


Figure 4. Chachoga's changing forest cover pattern: 1918, 1949, and 1977. Upslope is east (to the right).

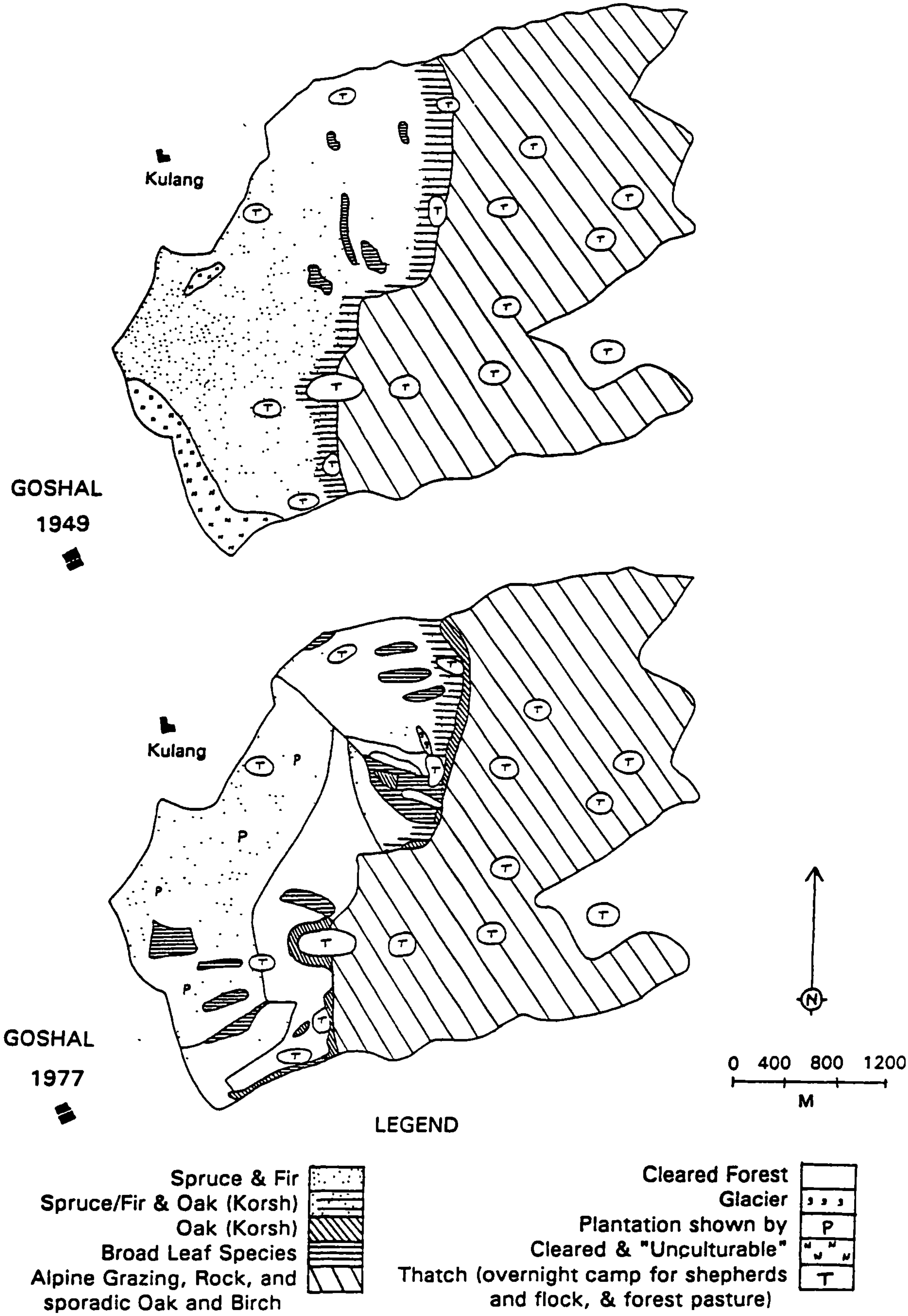


Figure 5. Goshal's (and Kulang's) changing forest cover pattern: 1949 and 1977. Upslope is east (to the right).

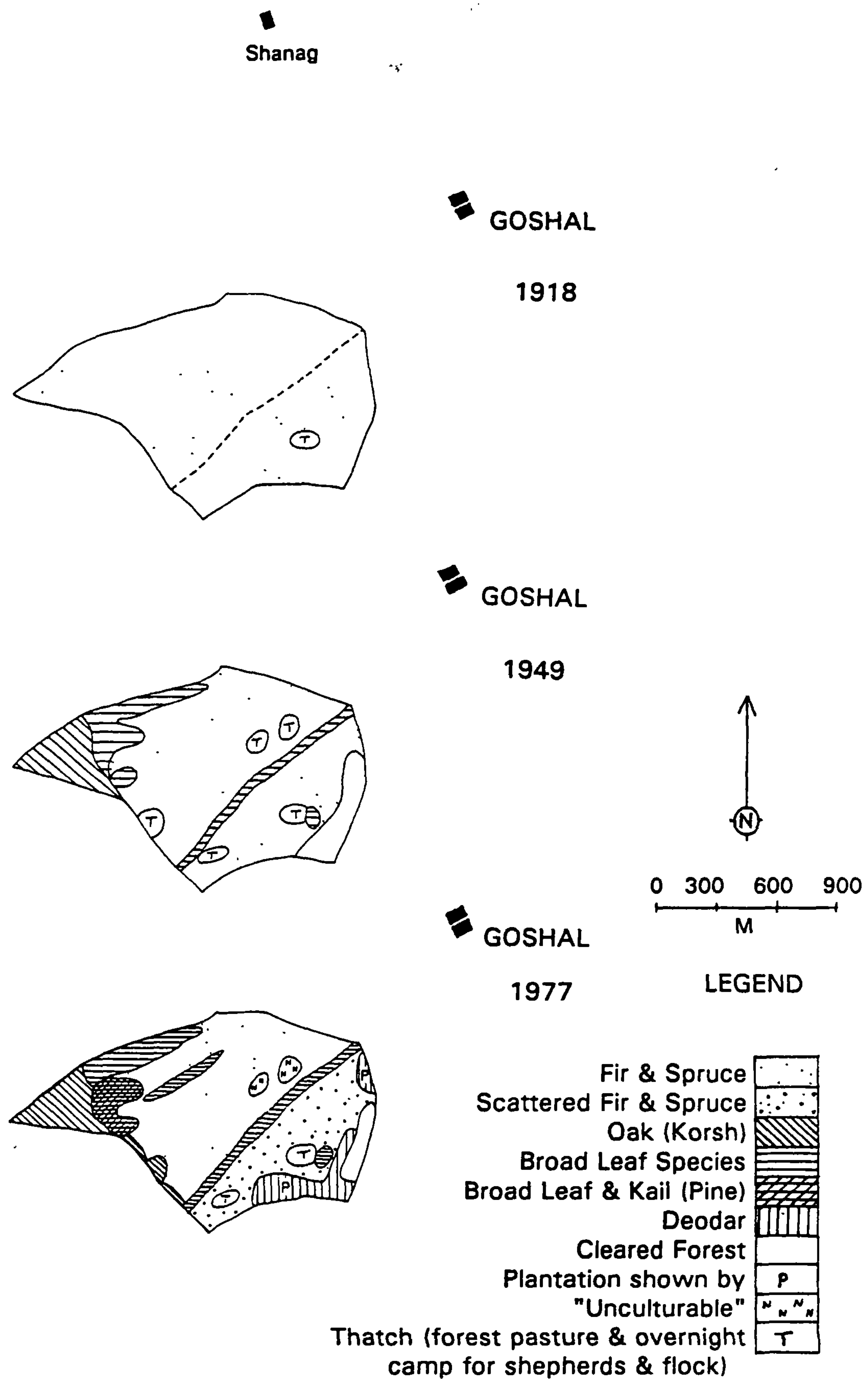
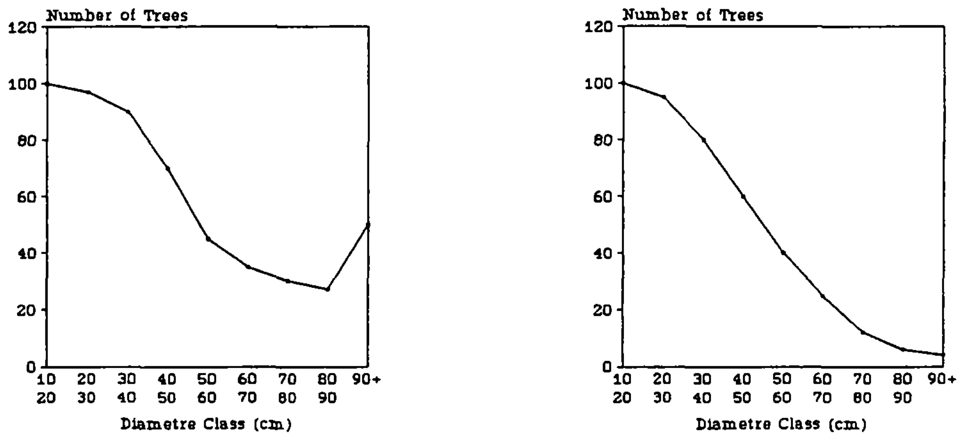
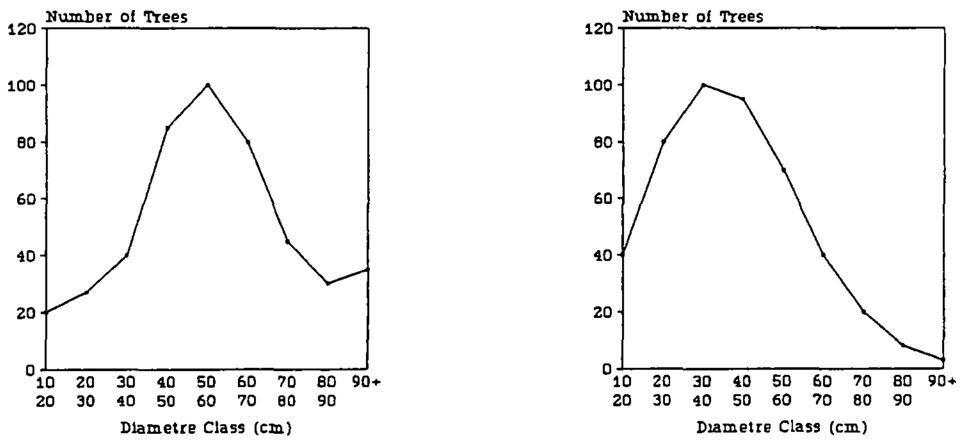


Figure 6. Goshal's (and Shanag's) changing forest cover pattern: 1918, 1949, and 1977. Upslope is west (to the left).



Theoretically sustainable tree age-class structures



Theoretically unsustainable tree age-class structures

Figure 7. Theoretically sustainable and unsustainable tree age-class structures.

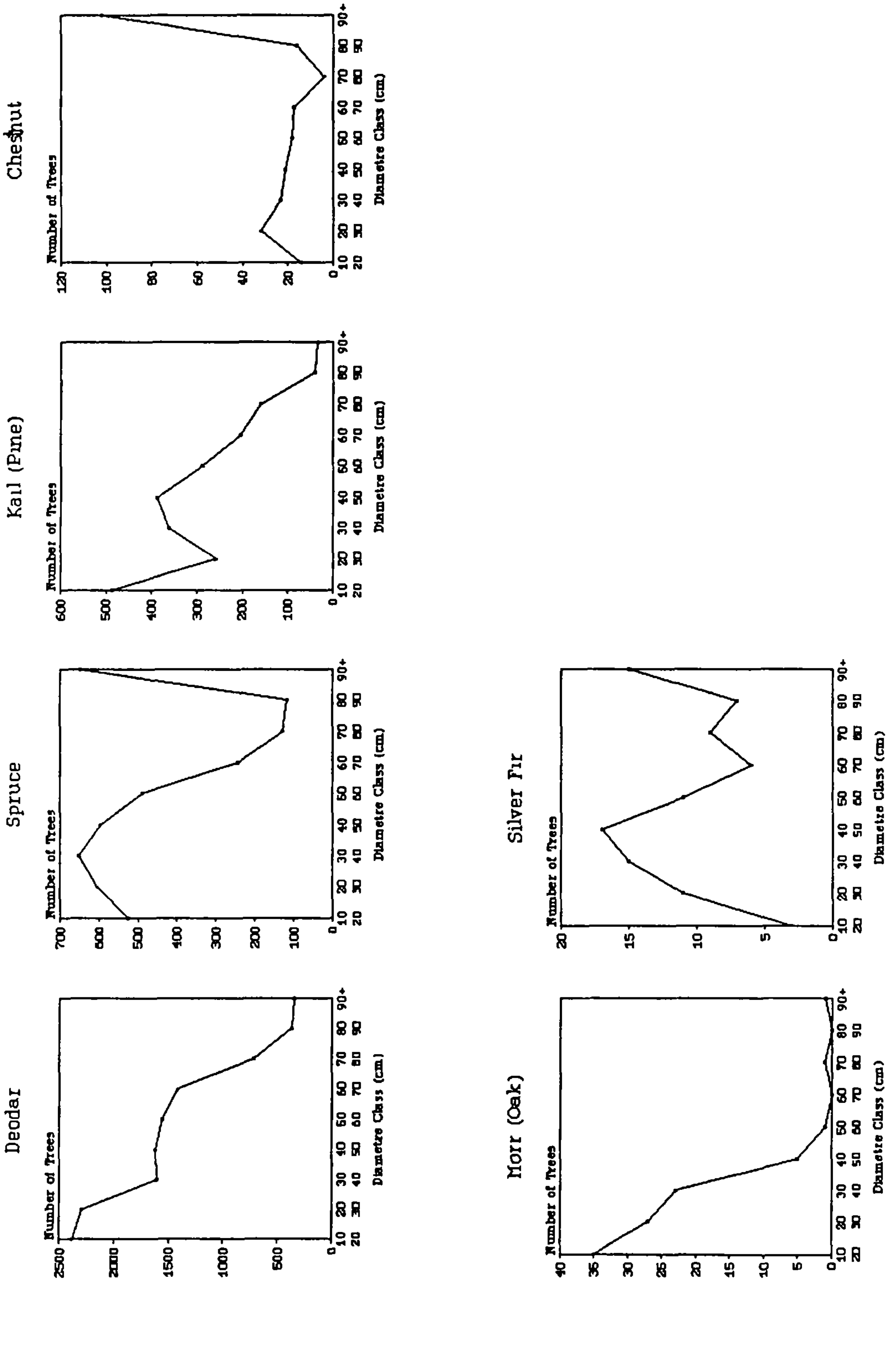


Figure 8. Tree age-class structure of Chachoga's more common species.

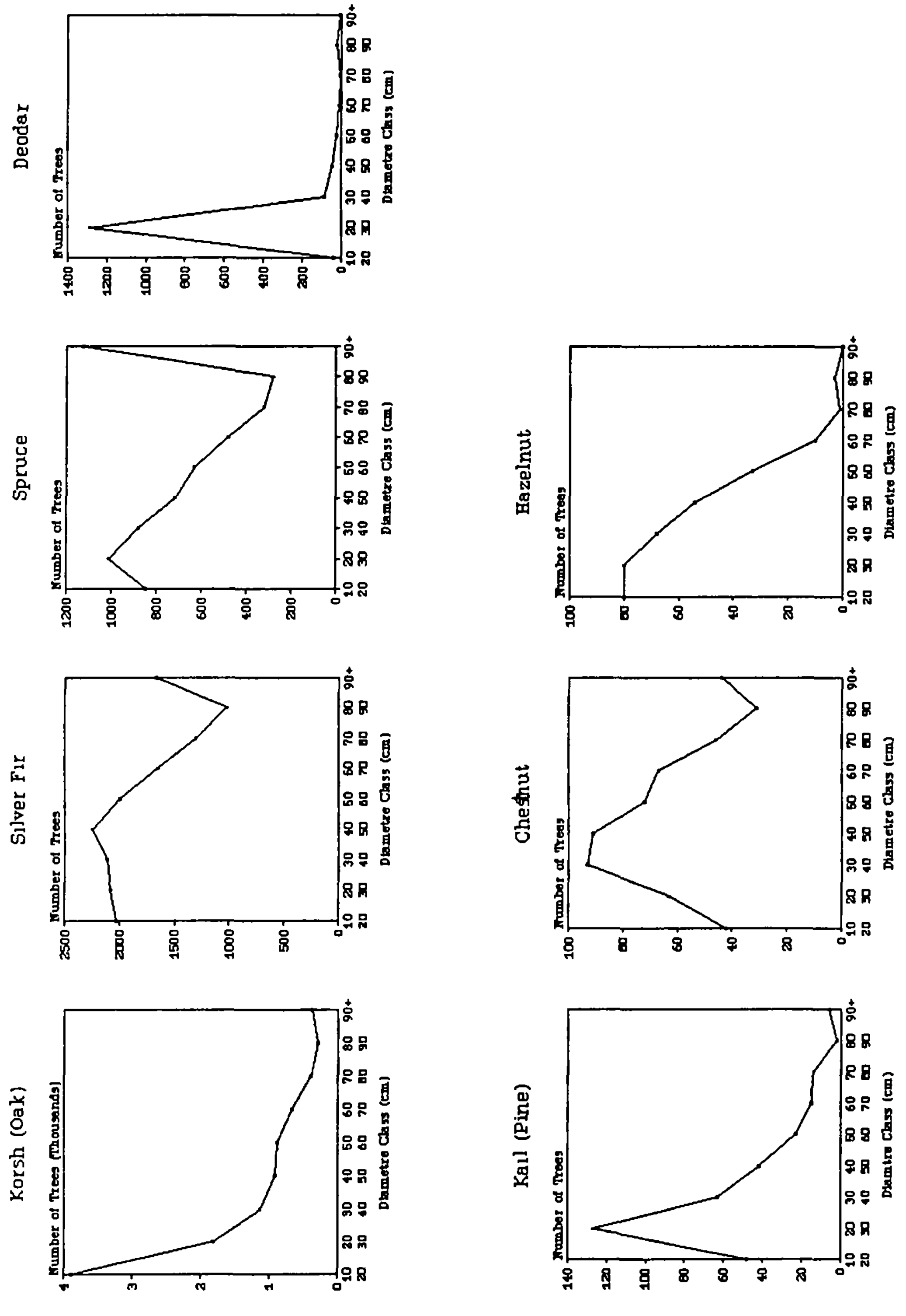


Figure 9. Tree age-class structure of Goshal's more common species.

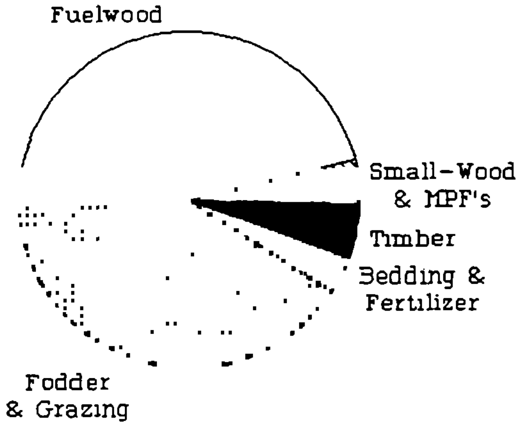


Figure 10. Relative importance of tree uses according to Goshal and Chachoga villagers (Based on response rate for tree use; MFP's are minor forest products, e.g. food, resin, seed-oil, medicine...).

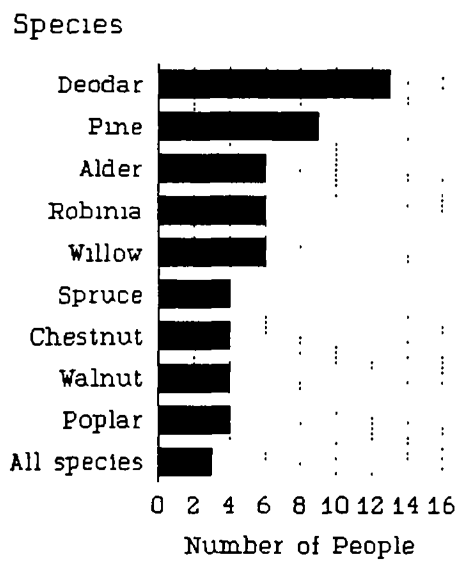
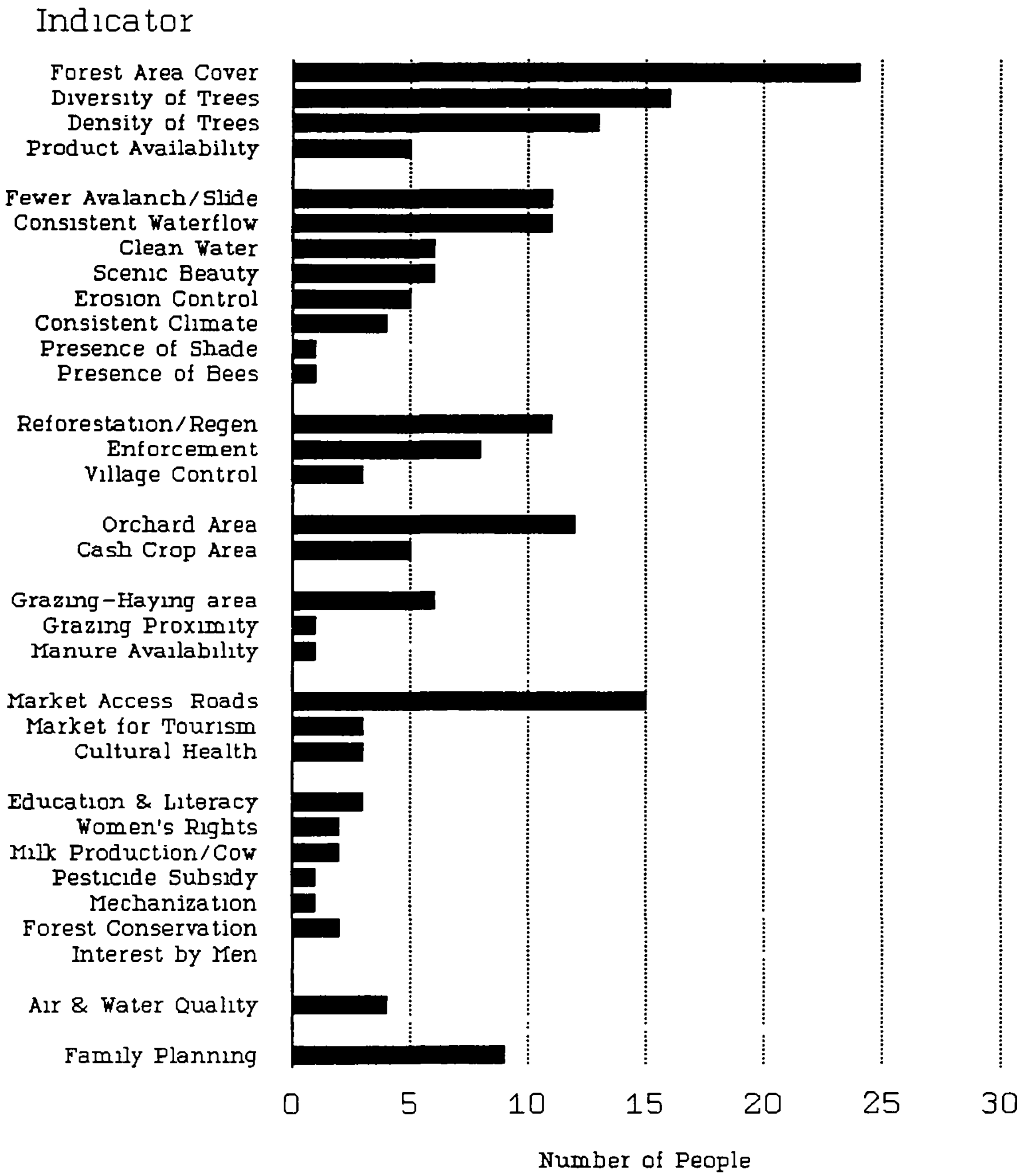
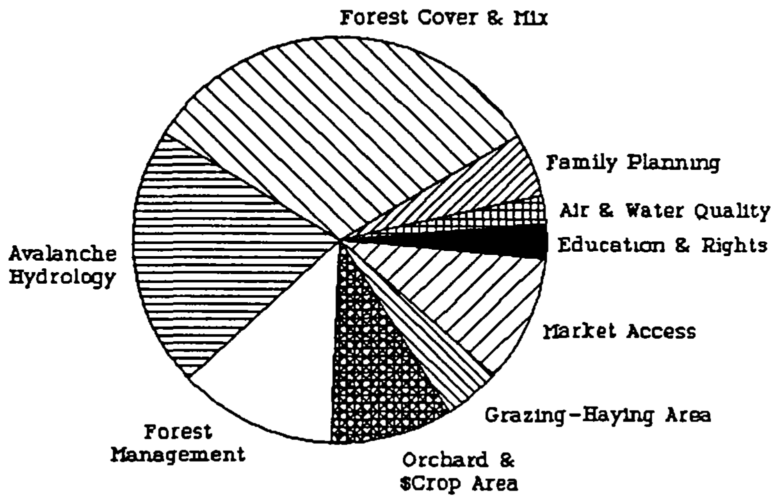


Figure 11. Tree species desired for planting according to Chachoga and Goshal villagers.

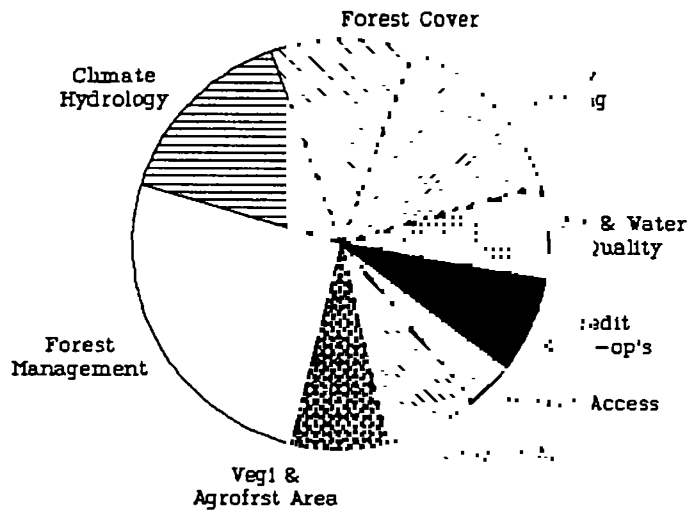


Sample of 36 (20 Goshal, 16 Chachoga)
Median # of suggested indicators 4 - 7

Figure 12. Signs and Signals which should be monitored in order to predict a good future, according to Goshal and Chachoga villagers - a proxy for locally identified sustainability indicators.



Chachoga and Goshal Villagers



Local Natural Resources Professionals

Figure 13. Comparing the relative importance of nine types of sustainabiltiy indicator - according to the two villages, and according to local natural resources management professionals.

Table 1. Tree species and trends in change[1] over 30 years and 2-3 years; aggregated perspective according to Chachoga and Goshal villagers.

ENGLISH NAME[2]	LOCAL NAME	SCIENTIFIC NAME	30 YEAR	2-3 YEAR
FUEL[3]:				
B.Kahti (shrub)	Kahti (black)	*Indigofera spp.*	↓	↔
W.Kahti (shrub)	Kahti (white)	*Desmodium spp.*	↓	↔
Sweet Chestnut	Kenorr	*Castanea sativa*	↔	↔
Wild Chestnut	Jangli Kenorr	*Aesculus indica*	↓	↓
Spruce	Roi/Rai	*Picea smithiana*	↓↓	↓
Alder[4]	Kosh	*Alnus nitida*	↓↓	↔
Silver Fir[5]	Tos	*Abies pindrow*	↓	↔
Shyen (shrub)	Shyen	*Spirea spp.*	↓	↔
WINTER FODDER:				
Oak[6]	Morr/Mohru	*Quercus himalayana*	↓	↔
Black Mulberry	Chehwn/Tut	*Morus spp.*	↓	↔
GENERAL FODDER:				
Willow	Behli/Manjanu	*Salix spp.*	N	↑
Robinia	Kicker	*Robinia pseudoacacia*	N	↑
Oak[6]	Ban/Bon	*Quercus leucotricophora*	↓	↔
Elm	Mahan	*Ulmus wallenchia*	↓	↔
Hazelnut[6]	Himli/Himri	*Corylus spp.*	↔	↔
Oak[5]	Korsh/Kharsu	*Quercus semecarpifolia*	↔	↔
Maple	Maundre	*Acer spp.*	↓	↔
CONSTRUCTION:				
Deodar[7]	Deyar/Kaol	*Cedrus deodara*	↓↓	↓
Pine[7]	Kail	*Pinus wallenchia*	↓↓	↔
OTHER UTILIZED SPECIES:				
Poplar	Paoous	*Populus spp.*	↔	↑
Ash	Ongu	*Fraxinus excelsia*	↔	↔
Black Walnut	Awkrot/Korr	*Juglans nigra*	↑	↑
Wild Walnut	Jangli Awkrot/Korr	*Juglans regia*	↓	↔
Wild Apricot	Jangli Koobahni	*Prunus armeniaca*	↔	↔
Beckeli (shrub)	Beckeli/Becki	*Principia utilis*	↓	↑
Shambel (shrub)	Shambel	*Berberis spp.*	↓	↔
Jarainth[8]	Shegaal	*Pyrus spp.*	↓	↑
Birch[5]	Bhojh pater	*Betula alnoides*	↔	↔

[1] Changes are denoted by: (↑↑) large increase, (↑) increase, (↔) constant, (↓) decrease, (↓↓) large decrease, (N) introduced in the last 30 years, and (blank) species not found in area.

[2] The species are clumped under primary use, as indicated by number of responses (see "preferred tree species", Table 3).

[3] Preferred for clean burning and good heat.

[4] Preferred because of availability (beside river), especially in Goshal's past.

[5] High altitude (above 2800 M) species.

[6] Also a preferred fuel.

[7] These species have sticky smoke, however they are desirable fuel because of availability.

[8] Pears are grafted onto this species (also called bird cherry), recent increases because of use in grafting; has declined in the wild.

Table 2. Goshal villagers', Chachoga villagers', and forester's perspectives on trends in tree species change[1].

SPECIES	CHACHOGA				GOSHAL			
	30 year		2-3 year		30 year		2-3 year	
	village	forester	village	forester	village	forester	village	forester
FUEL:								
B.Kahti (shrub)	↓	↓	↓[2]	↔	↔[2]	↓	↑	↔
W.Kahti (shrub)	↓	↓	↓[2]	↔	↔[2]	↓	↑	↔
Sweet Chestnut	↔	N	↔	↑	↔[2]	N	↑	↑
Wild Chestnut	↔	↓	↔	↔	↓	↓	↓	↔
Spruce	↓↓	↓	↓	↔	↓↓	↓	↔	↑
Alder	↓	↓	↔[2]	↓	↓↓	↓	↔[2]	↑
Silver Fir[3]	↔	↔	↔	↔	↓	↓	↔	↑
Shyen (shrub)	↓	↓	↓[2]	↔	↓	↓	↑	↔
WINTER FODDER:								
Oak (Morr)	↓	↓	↔	↓	↓	↓	↔	↓
Black Mulberry	↓	↓	↔	↓	↔	↓	↔	↓
GENERAL FODDER:								
Willow	N	N	↑	↑	N	N	↑	↑
Robinia	N	N	↑	↑	N	N	↑	↑
Oak (Bon)	↓	↓	↔	↔		↓		↔
Elm	↓	↔	↔	↓	↔	↔	↔	↔
Hazelnut	↔	↔	↔	↔	↔		↔	
Oak (Korsh)[3]	↔	↔	↔	↔	↔[2]	↔	↔	↔
Maple	↔	↔	↔	↔	↓	↔	↔	↔
CONSTRUCTION:								
Deodar	↓↓	↓	⇓[4]	⇑	↓↓	↓	↔[2]	↑
Pine	↓↓	↓	↓	↔	↓	↔	↑	↑
OTHER:								
Poplar	↑	↑	↑	↑	↔[2]	↑	↑[2]	↑
Ash	↔	↔	↔	↔	↔		↔	
Black Walnut	N	↑	↑	↑	↑	↑	↑	↑
Wild Walnut	↓	↔	↔[2]	↑	↓	↔	↔	↑
Wild Apricot	↔		↔		↔		↔	
Beckeli (shrub)	↔[2]	↓	↑	↔	↓	↓	↔[2]	↔
Shambel (shrub)	↔[2]	↓	↑[2]	↔	↓	↓	↔	↔
Jarainth[5]	↓	↓	↑	↑	↓[2]	↓	↑	↑
Birch[3]	↔	↔	↔	↔	↔	↔	↔	↔

[1] Changes are denoted by: (↑↑) large increase, (↑) increase, (↔) constant, (↓) decrease, (↓↓) large decrease, (N) introduced in the last 30 years.

[2] Intra-village disagreement, where perspectives included both increase and decrease. Constant vs increase, and constant vs decrease disagreement is not noted in the table, but was at least as frequent as the intra-village polar opposite perspectives.

[3] High altitude (above 2800 M) species.

[4] The hollow arrows (⇓ and ⇑) indicate where villager and forester perspectives were opposite.

[5] Recent increases because of use in grafting; all agree that it has declined in the wild.

Table 3. Preferred tree species[1] for different uses, according to Goshal and Chachoga villagers.

SPECIES	USE					
English Name[2]	Fuel[3]	Fodder	Timber	Bedding/ Fertilizer	Small wood[4]	Food/ Oil
FUEL:						
B.Kahti (shrub)[5,6]	●	○			○	
W.Kahti (shrub)[5,6]	●	○			○	
Sweet Chestnut[6]	●	○				○
Wild Chestnut[6]	●	○				○
Spruce	●		○	○		
Alder[7]	●			○		
Silver Fir[8]	○		○			
Shyen (shrub)	○					
FODDER:						
Oak (Morr)[6,9]	○	●				
Black Mulberry[9]		●				
Willow[10]		●				
Robinia[10,11,12]		●				
Oak (Bon)[6]	○	●				
Elm		●				
Hazelnut[6]	○	○				
Oak (Korsh)[6,8]	○	○				
Maple[13]		○			○	
CONSTRUCTION:						
Deodar[14]	●		●	○		
Pine[14]	○		○	○		
OTHER:						
Poplar[11]				○		
Ash[11,15]						
Black Walnut[15]					○	○
Wild Walnut[15]					○	
Wild Apricot						○
Beckeli (shrub)[12]						○
Shambel (shrub)						○
Jaraınth (pear graft)						
Birch[8]						

[1] Tree utilization denoted by: ("●") preferred by most (> half) of respondents, ("○") preferred by some (< half) of respondents. Villagers typically spoke about 5 - 20 preferred species.

[2] The species list is clumped according to greatest preferrence, based on the number of responses. Each clump begins with the strongest preferrence, and decends to the weakest.

[3] Two respondents indicated all species are used as fuel.

[4] Small wood refers to wood for tools, handles, furniture, and carving.

[5] Used in prayer and marriage ceremonies.

[6] Best fuel species because of clean burning and good heat (particularly Kahti - which is also easy to carry).

[7] Preferred as fuel because of availability by river, especially in Goshal's past.

[8] High altitude species, above 2800 M.

[9] Particularly important as winter fodder.

[10] Used by cattle in summer.

[11] A multi-purpose tree according to foresters.

[12] Thorny, thus not preferred for fuel, Beckeli in particular is recognized as good fuel excepting its thorns.

[13] Eaten by water buffalo.

[14] These species have sticky smoke, however they are desirable fuel because of availability.

[15] Some individual trees considered sacred