Background

The concept of community involvement in forestry to supply products on a managed and sustainable basis is not new. Three hundred years ago in Germany and other parts of Europe, communities assigned user groups to certain parts of the forests. These user groups were responsible for managing and regulating the amount of produce which would come from certain components of the forest (Henschel 1976; Linnard 1980). Likewise, communal ownership and management of forests is common in many parts of Asia. However, this form of ownership was often sublimated by changing national and local power structures, particularly where colonial influence was involved. The concept of community forestry was reintroduced to the forestry profession in the late 1950s when many recognized that this was one of the few options available to successfully manage forest resources in areas where traditional ownership and use of forests had prevailed.

Forest management involves the integration of plans for both the utilization and protection of forests. It must not only ensure the viability of forests and the health of the trees, but must also ensure utilization of the tangible and non-tangible products of the forest according to sound ecological principles (Young 1978). The management of forests for multiple use requires that a thorough understanding of the functioning of the ecosystem is acquired so the management formulated for the forest ensures that it remains a productive entity. This necessitates a knowledge of the amount of organic material in the forest, the forest's productivity, and the impact of management practices on biological and edaphic processes, to enable the determination of the possible level of utilization of the forest.

Wyatt-Smith (1982) and Mahat et al (1987a) made estimates of the amount of forest area and the products required to sustain the mixed farming system. It seems clear that virtually all of the forest resource, both actual and potential, irrespective of tenure, will be needed to maintain the existing subsistence lifestyle.

In the initial stages of forest establishment and protection, the local people have seen that produce in the form of grasses, dead stems, and branches have been available to them from both panchayat and government owned land. Consequently they have applied the same degree of protection to both land tenures. This has been well demonstrated in Sindhupalchok where, from the very start of afforestation activities, the people were assured access to forest products from HMG land (Mahat pers. comm.).

Although it can be said with some confidence that all the forest products will be used by local people, there need to be different options and strategies applied to each forest type and land tenure; management input levels will vary accordingly. The level of management, as reflected in the degree of training of the decision makers, may well be greater on HMG land than on communal land. Nevertheless, some form of HMG participation will be necessary in the management of community forests. This will be particularly necessary when forest boundaries cut across political panchayat boundaries. The management plan, which is the legal agreement between the government and the panchayat, needs to be easily understood by the layman. This means that utilization schedules need to be translated into a language which the hill farmer can understand. An example of such a schedule is given in Table 9.

Forest Categories

Legislation has been passed to establish and manage forests under different tenures (Manandhar 1982): HMG Natural Forests, HMG Plantations, Panchayat Forests, Panchayat Protected Forests, Private Forests and Lease Forests. To contemplate a separate management plan for each of these forest categories in all panchayats in the Middle Hills is an impossible exercise, as the number of forests belonging to each tenure category in each of the 53 districts in the Middle Hills is enormous. Hence, an alternative system of classification for the purpose of forest management is required.

The ecological characteristics of forest structure and floristics are the factors which determine the components and fractions available as produce from the forest and hence, they should form the basis of the management of these forests. Reference has been made in this paper to the floristic diversity of the forests in the hills and the dramatic man-induced changes to forest structure. Nevertheless, it is still possible to group forests which have similar floristic composition and structure.

The purpose of grouping is to simplify the management process. Instead of developing separate plans for each patch of forest of different tenure, it would be more practical to develop plans for ecologically similar forest categories and to compile a small number of management options for each of them. An example using the forests in Sindhupalchok below about 2000 m elevation is given as an indication of grouping of forest categories:

- **Mixed broadleaf forest** comprises all degraded forest lands which are often remnants of original forests. They are usually heavily utilized, often coppiced, have low-density canopy cover and are low in height. The tenure of these forests is usually HMG Natural Forests, PF, Private, or Lease Forests.

- *Pinus sp.* **broadleaf forest** has been planted, usually with pines, and the subsequent protection has allowed the growth of a broadleaf fraction. The resulting stand often comprises roughly equal numbers of broadleaf trees and pine. The tenure of this land is usually HMG Forests, PF, or Private Forests.

- *Pinus sp.* **dominated forest** was established using *Pinus sp.* and this species has continued to dominate the site both spatially and temporally. These forests are often located on sites which contained only grass or were degraded or eroded, and often in zones which originally supported natural forests of the native pine. The pine-dominated forests are usually HMG Forests, PF, Private, or Lease Forests. Also included in this category are natural stands of *Pinus* where there is little or no broadleaf regeneration.

- **Sal forest** is dominated by naturally occurring sal (*Shorea robusta*). These forests are found in the lower altitudes of the Middle Hills along the lower slopes of the major drainage systems. They are heavily utilized and generally have very few large trees remaining. Coppicing or pollarding is commonly practised and the forest floor is often swept clean during litter collection. These forests are generally HMG Natural Forests or PPF.

In other areas of the Middle Hills, different groupings of forests or tree species may be necessary.

Mensurational Requirements

Forest inventory is the information-gathering stage of forest management and in conventional forestry is usually concerned with obtaining data on the volume of the merchantable bole of commercial species (Young 1978). This has ensured that the quantifying of stem volume involves simple measurements which can be carried out with a relatively high degree of accuracy. Inventory data involving diameters and tree heights have been traditionally used for estimating the volume of sawn timber and veneer, both of which come from the merchantable bole. It was probably for this reason that initially foresters and forest ecologists looked only at the volume of the stems as the unit of measurement. Until recently this has prevented the development of methods designed to assess total biomass production.

Traditional forest volume tables do not incorporate all the forest components and fractions such as branches, foliage, roots, understorey species and forest floor litter. Nor do they take account of the habit of the "unconventional" forest species such as fodder trees or bamboo.

The management of community forests requires the development of mensurational techniques which are applicable to such multi-faceted forest components and unconventional fractions. Biomass estimations in the form of tables can be used to measure productivity or the changes in the forest over time and are well suited to provide the information required for management. Although biomass estimations are generally expressed as an oven dry weight basis per unit area of land, a correction factor can be applied to allow for the moisture content of the components when fresh produce is harvested.

Estimates of forest productivity, in combination with the area of forest, can be used to schedule forest utilization. Many young forests contain a range of fractions and species whose components have different growth rates. Hence, their production must be estimated to enable utilization to be carefully scheduled to provide a sustainable yield while adhering to sound silvicultural principles to maintain forest productivity.

Management Aims and Options

The primary decision to be made before forest management is taken up is the determination of its aims. This is a vital step and must be carried out in consultation with all interested parties. In all but a few situations in the Middle Hills, the aims of management will be to provide the tangible benefits of fodder, fuelwood, construction timber, and minor forest products, while ensuring the intangible benefits which the forests afford to watersheds.

Because of the variable ecological conditions of the forests, it may be possible to manipulate the stand structure to better achieve the primary aims of management. Thus, a pine plantation with a developing understorey of *chilaune* could be subjected to three possible management options:

- o Maintain the stand as a predominantly pine forest;
- o Convert the stand to a mixed pine/broadleaf forest;
- o Convert the stand to a predominantly broadleaf forest.

At this early stage in the development of workable management plans for the hills it is suggested that the number of options be limited to reduce implementation problems, making the task of the forest manager much easier, irrespective of whether the manager is a panchayat forest committee or government forest officer. The options would not necessarily be static. As more information relating to forest productivity, floristic and structural composition, and user group preference becomes available, modifications could be made to refine, improve, and make management more acceptable to the local user communities. Once a number of options are developed for forest categories, it would then be up to the forest manager to choose which option would be suitable for the particular user group. However, it is important that the options reflect social attitudes and are compatible with the social framework in which they must operate. Examples are given in Tables 5a and b.

Management Objectives and Strategies

The management objectives are divided into two categories: the silvicultural objectives and the utilization objectives. The silvicultural objectives must be fulfilled to enable the productivity of the stand to be maintained. These objectives require information on regeneration, on which forest fractions and components of the biomass should be maximized, and on timing treatments to ensure that there is no deleterious effect (e.g. coppicing stems should be done in the late winter to maximize the number of new coppice shoots on the stump).

The utilization objectives will reflect the people's aspirations, taking full account of the implications that tenure of the forest will have on utilization. This is important when looking at the type of product and its end use. It is impractical, for example, to state that good quality fodder must come from a forest if it is to remain a pure pine stand. The stand will need to be manipulated by silvicultural treatments over a number of years to provide the required product. Similarly, it is unsound to provide the villagers with a 'shopping list' of the species they require. The possible products are dependent on the floristic and structural composition of the stand, altitude, climate, and soil conditions.

Once the objectives are determined for a small number of options, the details of the strategies can be formulated. Details of the techniques required to meet the objectives must be developed and recorded in the plan. The plan will also contain the level of utilization to be undertaken to facilitate and control the harvesting and provide some guidelines to maintain the productivity of the forests. At this early stage in the development of management schemes for community forests, it is desirable to plan for a utilization pattern that yields a relatively constant amount of produce annually. Examples are given in Tables 5a and 5b of management schemes for two forest categories: mixed broadleaf and *Pinus sp.* dominated forest.

A Case Study from Sindhupalchok District

Demonstration of management options. The natural forests and plantations which were planted and protected in the early 1970s in Sindhupalchok have reached a stage where some form of active management is possible. To date, these forests have been protected from grazing and lopping while providing grass and dead material to the local villagers who collect the produce by hand. A more active form of management is required where

Table 5a. Forest Management Aims and Objectives

Forest Type: Mixed Broadleaf Forest

Management Aims: To maximize foliage for livestock production, fuel wood and construction timber for the local village people

Option 1 (Coppice with standards)			Option 2 (To maintain mixed broadleaf stand)		
Silvicultural Objectives	Utilization objectives	Management strategies	Silvicultural objectives	Utilization objectives	Management strategies
Maintain biomass on the stand irrespective of species.	Remove only grass and litter for livestock and dead material for fuelwood.	Ensure maximum protection of the trees until they reach 4 m in height.	Maintain biomass on the stand irrespective of species.	Remove only grass and litter for livestock and dead material for fuelwood.	Ensure maximum protection of the trees until they reach 4 m in height.
Maximize foliage biomass on coppice shoots while maintaining biomass on standards.	Provide a yield of fodder, small size construction material and some fuelwood.	Coppice most stems retaining 300 per hectare as standards in year 1.	Maintain biomass on all species.	Provide a yield of fodder, bedding material and some fuelwood.	Prune to 20% of stem height when trees have reached 4m (all species).
Maximize foliage biomass on coppice shoots while maintaining biomass on standards which provide seedling regeneration.	Provide a yield of fodder, small size construction material and some fuelwood.	Coppice in year 4 while retaining new set of standards. Remove small & large standards depending on requirements to maintain 300 per hectare.	Maintain biomass on all species.	Provide a yield of fodder, bedding material and some fuelwood.	Prune to 40% of stem height when trees have reached 7m (all species).
			Maintain biomass on well formed stems while promoting foliage growth on coppice shoots.	Provide a yield of fodder, construction timber and some fuelwood.	Reduce multistems to single stems.
			Maintain biomass on broadleaf species while promoting foliage growth on coppice shoots.	Provide a yield of bedding material, fodder and construction timber.	Thin broadleaf species to a stocking of 1500 stem per hectare.
			Maintain biomass on broadleaf species while promoting foliage growth on coppice broadleaf shoots.	Provide yields of fodder, bedding material, construction timber and some fuelwood.	Thin broadleaf species to a stocking of 700 stems per hectare.
			Maintain biomass on broadleaf species while promoting foliage growth.	Provide yields of fodder, bedding material and construction timber.	Thin broadleaf species to a stocking of 300 stems per hectare. Remove coppice shoots every 4 years, while retaining standards.

Table 5b. Forest Management Aims and Objectives

Forest Type: Pinus sp. Dominated Forest

Management Aims: To maximize foliage for livestock production, fuel wood and construction timber for the local village people

Option 1 (To maintain pine forest)			Option 2 (To manipulate pine forest towards a broadleaf stand)		
Silvicultural Objectives	Utilization objectives	Management strategies	Silvicultural objectives	Utilization objectives	Management strategies
Maintain biomass on the stand irrespective of species.	Remove only grass and litter for livestock and dead material for fuelwood.	Ensure maximum protection of the trees until age 6 years.	Maintain biomass on the stand irrespective of species.	Remove only grass and litter for livestock and dead material for fuelwood.	Ensure maximum protection of the trees until age 6 years.
Maintain biomass on the stand irrespective of species.	Provide bedding material for livestock and some fuelwood.	Prune to 10% of the stem height (age 6 years).	Maintain basic stand structure and biomass.	Provide foliage, fuelwood and some construction timber.	Coppice broadleaf fraction retaining 500 standards per hectare. Thin pine to favour dominant broadleaf fraction.
Maintain biomass on the stand irrespective of species.	Provide bedding material for livestock and some fuelwood.	Prune to 20% of the stem height (age 7 years).	Maintain biomass but concentrate it on the broadleaf fraction.	Provide foliage for bedding material, some construction timber and fuelwood.	Thin pine to a stocking of 1000 stems per hectare.
Maintain biomass of the stand irrespective of species.	Provide bedding material for livestock and some fuelwood.	Prune to 40% of the stem height (age 8 years).	Maintain biomass but concentrate it on the broad-leaf fraction.	Provide foliage for bedding material and some construction timber.	Thin pine to 700 stems per hectare.
Maintain biomass on the pine fraction of the stand.	Provide bedding material for livestock, fuelwood and construction timber.	Reduce multistems to single stems on all species, then remove broad-leaf fraction. Thin pine to a stocking of 1300 stems per hectare (age 9 years).	Maintain biomass but concentrate it on the broad-leaf fraction.	Provide foliage for bedding material, fodder, some construction timber and fuelwood.	Thin pine to 400 stems per hectare and recut coppice shoots and standards leaving a total number of 500 standards.
Maintain biomass on the pine fraction of the stand.	Provide bedding material for livestock, some fuelwood and construction timber.	Thin to 1190 stems per hectare (age 10 years).	Maintain biomass on the broadleaf (standards) as well as the foliage component of the coppiced shoots.	Provide foliage for bedding material, some construction timber and fuelwood.	Remove pine and thin standards to 300 per hectare.

some major utilization can take place. In order to facilitate and control the utilization of produce a management scheme is needed. However, there is little information available on the silvicultural and utilization objectives, productivity, and societal requirements relating to the new forests. In addition, there was little perception among the local villagers, or the Forest Department staff, of the various possibilities that exist for managing forests in different ways. In order to develop suitable guidelines and to gain practical experience, a demonstration trial was established in one of the older plantations near Chautara. The purpose of the trial was:

- To provide demonstration areas to show different forest management options;
- To provide basic data which would assist in the development of management plans and facilitate yield prediction for various forest products;
- To gain practical experience in the implementation of a range of management options, including the distribution of forest products.

A series of five 20 m x 20 m plots was established in a forest which had been planted with chir pine nine years previously. The pine was planted on land that was degraded grassland with scattered remnants of the original broadleaf forest. The resultant forest consists primarily of pine with a strong secondary development of broadleaf species dominated by *Schima wallichii*. In some areas dense coppice regeneration of broadleaf species occurred and this has effectively dominated the pine component. One such area was included in the trial.

In deciding upon relevant and practical treatments for the demonstration plots, two overriding considerations applied:

- The trial needed to reflect societal aspirations as much as possible, one of which was the need to ensure an early return of produce to local people;
- The treatments needed to ensure that the forest was left in a sound silvicultural condition so that a variety of management options could be considered in the future.

Table 6. Stand Characteristics Prior to Treatment

	Treatments 1	2	3	4	5
Stems/ha					
pine	1500	1600	1400	1600	225
broadleaf	1450	1375	1725	700	17050
Total	2950	2975	3125	2300	17275
Estimated standing biomass (t/ha)					
pine	41.6	36.0	27.0	36.1	3.2
broadleaf	8.6	12.6	15.6	6.6	46.3
Total	50.2	48.6	42.6	42.7	49.5
Basalarea (m/ha)	14.5	13.2	11.9	12.1	10.9
Predominant height (m)*	8.1	8.0	8.4	8.6	n/a

* Predominant height is the average height of the tallest 50 trees per hectare.

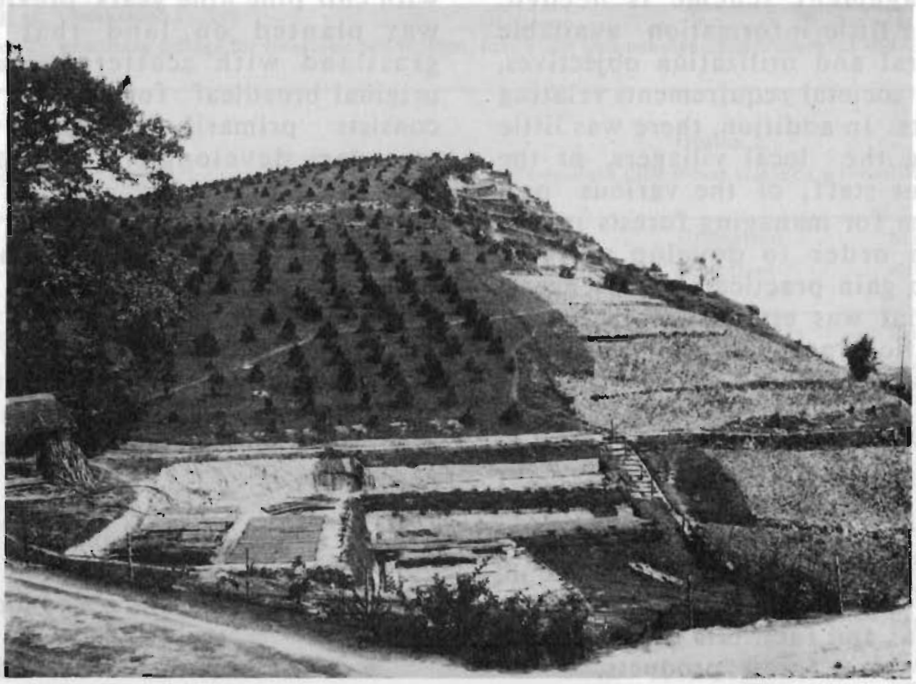

Plate 9 Former grazing land planted with chir pine adjacent to a panchayat nursery and agricultural terraces.

Plate 10 Utilization from the demonstration plots at Chautara.

The societal information was obtained by holding discussions with the Pradhan Pancha and members of the village who had traditional access to the land on which the demonstrations were to be carried out.

The first step in providing inventory data was to carry out biomass studies on the species comprising the forest. Biomass regression equations were established and biomass tables developed for the major species on the site. Secondly, diameter at breast height (dbh) by species of all stems greater than 2 m in height was recorded.

After careful consideration of the potential of the forest and the needs of the people, it was concluded that the product which can be derived earliest from silvicultural treatment is branch material from low pruning. Low pruning can be considered a universal treatment which will assist in the supply of fuelwood and give improved access to the forest. This treatment can be followed by a second pruning to a higher part of the stem and later by a treatment which will reduce all multi- stemmed individuals to the best single stem. These treatments, whether carried out simultaneously or sequentially, will not jeopardize th stand structure or composition and yet will provide a substantial amount of fuelwood (Plate 3) and fodder (Plate 10). Various types of thinnings (Plate 11) can then follow depending on the management objectives applied to the stand.

Treatments applied

Treatment 1 -- Pruning and reduction of multistems to single stems. This was the first utilization operation carried out. All stems above 3 m in height, regardless of species, were pruned up to 1 m or one-third of the height of the green crown, whichever was the lower. Large curved knives and sickles were used to cut the branches flush with the stem ensuring that no damage was done to the cambium. The use of such tools, once a suitable technique was devised, proved to be satisfactory and is more appropriate than using imported pruning saws. Conventional pruning saws are not necessary in the community forestry context, due to problems of cost and maintenance, and locally available tools can be readily used for this operation. The amount of pruned material removed was determined from previously established regression equations. Following pruning all low value stems greater than 2 m in height were removed and their biomass determined.

The reduction of multistemmed clumps to the best single stem was then carried out. Only clumps greater than 2 m in height were cut, leaving a stump height of 10 cm. The species and dbh were recorded. This information enabled the biomass of the various fractions removed (foliage, branchwood, and stem) to be determined by regression analysis.

Treatment 1 was applied as a base treatment to treatments 2, 3, and 4.

Treatment 2 -- Thinning to favour chir pine. Thinning was designed to favour the pine fraction and to encourage biomass production of this fraction. If a broadleaf species was greater than three- quarters of the height and within the crown of an adjacent chir pine tree, the broadleaf was removed in favour of the pine, unless the pine was a suppressed stem and would not respond to release. The dbh and species of the stems removed were recorded for subsequent biomass determination.

Treatment 3 -- Thinning to favour high-value broadleaf species. Thinning was designed to favour the broadleaf fraction and to encourage biomass production of this fraction. If a pine tree was greater than three-quarters of the height and within the crown of an adjacent broadleaf species, the pine was removed, unless the broadleaf was suppressed and would not respond once released. No further thinning of the remaining pines was carried out. The dbh and species of the stems removed were recorded for subsequent biomass determination. At this early stage of stand development, the broadleaf species appeared to be shade-tolerant so that thinning was not carried out on the broadleaf component in an endeavour to maintain high stocking levels and biomass production.

Treatment 4 -- Thinning to favour dominant high value stems, irrespective of species. Thinning was designed to favour the dominant stems in the stand and to concentrate the biomass production on these stems. If any stem was greater than three-quarters of the height and within the crown of an adjacent dominant stem, then the competing stem was removed. The dbh and species of the stems removed were recorded for subsequent biomass determination.

Treatment 5 - Coppice with standards Coppicing with standards is a viable method of management in densely stocked broadleaf stands which have the ability to coppice after being cut. If a stand is to be managed as a coppice system it is important to maintain a

Table 7. Standing Biomass and Biomass Yield

	Treatment 1: Prune, reduce multi-stems to single stems		Treatment 2: Treatment 1 plus thin to favour the conifer fraction		Treatment 3: Treatment1 plus thin to favour the broadleaf fraction		Treatment 4: Treatment 1 plus thin to favour the dominant stems		Treatment 5: Coppice with standards	
Biomass (t ha^{-1})	coni-fer	broad-leaf	coni-fer	broad-leaf	coni-fer	broad-leaf	coni-fer	broad-leaf	coni-fer	broad-leaf
Standing Biomass Before Treatment										
wood (stem & branch)	33.88	7.35	29.18	10.87	21.97	13.65	29.95	5.85	2.58	39.44
foliage	7.75	1.25	6.82	1.78	5.08	1.93	6.51	0.80	0.66	6.92
Total	41.63	8.60	36.00	12.65	27.05	15.58	36.10	6.65	3.24	46.36
	50.23		48.65		42.63		42.75		49.60	
Biomass Removed										
Pruned Material										
branches	5.46	0.21	4.09	0.04	2.58	0.63	3.12	0.24	-	-
foliage	1.26	0.10	1.02	0.02	0.64	0.28	0.84	0.11	-	-
Total	6.72	0.31	5.11	0.06	3.22	0.91	3.96	0.35	-	-
	7.03		5.17		4.13		4.31		-	
Thinned Material										
wood (stem & branch)	0.98	4.00	0.48	9.35	4.20	5.00	2.90	1.30	1.54	34.62
foliage	0.25	0.70	0.12	1.42	1.02	0.70	0.75	0.20	0.44	6.28
Total	1.23	4.70	0.60	10.79	5.22	5.70	3.65	1.50	1.98	40.90
	5.93		11.37		10.90		5.15		42.88	
Total Yield										
wood (stem & branch)	6.44	4.21	4.57	9.39	6.78	5.63	6.02	1.54	1.54	34.62
foliage	1.51	0.80	1.14	1.44	1.66	0.98	1.59	0.31	0.44	6.28
Total	7.95	5.01	5.71	10.83	8.44	6.61	7.61	1.85	1.98	40.90
	12.96		16.54		15.05		9.46		42.88	
Coppice Standards Remaining										
wood (stem & branch)									1.04	4.82
foliage									0.22	0.64
Total									1.26	5.46
									6.72	
Percentage of Standing Biomass Removed	26 %		34 %		35 %		22 %		86 %	

very high stocking rate to maximize productivity. Stocking rates of 8000-10,000 stems per hectare are not excessive for this type of forest management. All desirable species (broadleaf) which were greater than 2 m were coppiced. The stems were cut cleanly, about 3 cm above ground level. Standards were left at a stocking rate of 250 good vigorous stems per hectare. Standards remain to provide for seed production, protection, and for producing large stems of good form to be used for construction timber and poles. The dbh and species of the stems were recorded prior to coppicing to enable the biomass of the various fractions to be calculated by regression analysis.

Results of trials. The standing biomass and biomass yield from the five plots are shown in Table 7. Although the plots are unreplicated, they nevertheless serve as a valuable demonstration, as the results provide an indication of the relative effects of treatment. The plots on which the treatments were carried out had a similar standing biomass before treatment, varying from 43 to 50 t/ha. Treatment 1 involved removing a quarter of the standing biomass which was less than that removed from either Treatment 2 or Treatment 3 where about one-third was removed. Treatment 5, the most drastic of all the treatments, resulted in 86 percent of the standing biomass being removed. From this treatment a large amount of foliage for bedding material and fodder (0.4 and 6.2 t/ha respectively) was removed while 6.7 t/ha (14 percent) remained on the standards in the plot. Treatment 4 produced the lowest total yield, primarily due to the relatively low number of broadleaf stems prior to treatment (700 /ha). Consequently, there was only limited opportunity for thinning among competing stems.

It is apparent from a consideration of the treatment selected that many other possibilities could have been tried. In determining these prescriptions, care was taken to ensure that they were as simple as possible. This allows them to be easily understood and will hopefully promote a greater degree of acceptance by panchayat people and forestry staff who will generally be responsible for their implementation.

Distribution of forest products.The total yield of forest products harvested from the five demonstration plots amounted to 19.78 tonnes (calculated from the data in Table 7) made up of 16.15 tonnes of wood and 3.23 tonnes of foliage. Assuming that the pine foliage was not required for animal bedding purposes, the amount of usable foliage would be reduced to 1.96 tonnes and the total usable products to 18.11 tonnes. As these figures are expressed on an oven dry weight basis, the green weight equivalent would approximate 36 tonnes. Thus, even though the plots were small in area, there was still a substantial amount of material harvested and decisions had to be made on the way in which this material would be distributed.

Discussions were held with the local leaders who indicated that 18 families surrounding the forest traditionally had access to the forest. It was these families who had effectively protected the forest during the preceding nine years so they were the families who should receive the benefits from the forest. As a result, a representative of each of the families was called to the forest at a predetermined time and the products (wood and leaves) were distributed equally. Because the forest involved is HMG forest, the wood was sold at the government royalty rate of half a rupee per headload for fuelwood. No charge was levied for the leaf material.

Possible future yields. The trends and results from the demonstration plots provided valuable information on suitable treatment options which could be implemented in community forests. To illustrate the use of such information, productivity and biomass estimations were used to determine treatment schedules and product yields in a chir pine plantation of high site quality (corresponding to Site Quality I in the Indian Yield Tables) at an altitude of 1550 m, near Chautara. The land prior to planting was heavily grazed grassland and contained few broadleaf individuals. After nine years the stand had a predominant height of 8.7 m, a mean dbh of 11.4 cm and a stocking of 1400 stems per ha.

Past diameters (dbh) of the stand were required in order to determine productivity. Stem analysis techniques using increment corings and discs removed from standardised positions on the stem provided this information. These measurements enabled the mean annual increments (MAI) to be determined and used to predict future growth (Mawson 1982). These data were then used in conjunction with biomass regression equations and predicted stocking rates to provide estimations of stand biomass for a range of ages. Table 8 shows predicted above-ground biomass for this chir pine stand aged from six to fourteen years.

Table 9 shows one possible utilization schedule from the sixth to the tenth year for this same chir pine plantation near Chautara.

Table 8. Biomass of Chir Pine stands aged 6 - 14 years.

Approx. age (years)	Mean dbh[1] (cm)	Pre. Ht[2] (m)	Probable Stocking[3] (stems Ha^{-1})	Standing Biomass ($t\ ha^{-1}$)[4] — Foliage and branchwood by stem: 0 - 10 % Foliage	0 - 10 % Branch wood	10 - 20 % Foliage	10 - 20 % Branch wood	20 - 40 % Foliage	20 - 40 % Branch wood
6	6.6	4.0	1400	0.30	0.92	0.17	0.38	0.94	1.15
7	8.2	5.5	1400	0.42	1.59	0.32	0.91	1.42	2.07
8	9.8	7.0	1400	0.48	1.99	0.41	1.31	1.69	2.64
9	11.4	8.7	1300	0.57	2.72	0.58	2.26	2.11	3.74
10	12.8	9.5	1190	0.58	2.95	0.64	2.72	2.40	4.10
11	13.2	10.3	1100	0.59	3.19	0.70	3.22	2.29	4.48
12	14.6	11.1	1000	0.58	3.35	0.75	3.70	2.32	4.76
13	16.0	11.9	900	0.62	3.91	0.90	5.09	2.55	5.69
14	17.4	12.7	800	0.59	3.92	1.15	5.47	2.48	5.75

Approx. age (years)	Foliage and branchwood by stem: 40 - 60 % Foliage	40 - 60 % Branch wood	60 - 80 % Foliage	60 - 80 % Branch wood	80 - 100 % Foliage	80 - 100 % Branch wood	Complete tree: Foliage	Branch wood	Stem	Total
6	0.68	0.68	0.45	0.31	0.17	0.11	2.58	3.54	4.9	10.96
7	1.21	1.46	0.74	0.65	0.26	0.17	4.15	6.68	8.51	19.43
8	1.53	2.01	0.91	0.88	0.32	0.20	5.05	8.69	10.80	24.64
9	2.15	3.23	1.20	1.39	0.40	0.26	6.58	11.67	15.10	34.39
10	2.35	3.76	1.29	1.61	0.41	0.27	6.99	14.12	16.52	37.61
11	2.56	4.34	1.37	1.84	0.43	0.28	7.41	15.66	18.01	40.99
12	2.72	4.84	1.43	2.04	0.44	0.29	7.64	16.85	19.08	43.38
13	3.22	6.31	1.64	2.62	0.48	0.32	8.65	20.58	22.64	51.44
14	3.26	6.64	1.62	2.74	0.74	0.31	8.54	21.03	22.83	51.84

1 dbh for ages greater than 9 years conservatively estimated using a MAI of 1.4 cm yr^{-1} (based on the estimated MAI from years 6 to 10 of 1.6 cm yr^{-1}).

2 Predominant height for ages greater than 9 years conservatively estimated using a MAI of 0.8 m yr^{-1}.

3 Stocking based on a planting rate of 1750 ha^{-1}, a survival of 80 %, and a probable thinning schedule.

4 Component biomass determined from tables calculated from regression equations.

5 The biomass shown below the dotted line would normally be removed during pruning operations.

Table 9. Possible Utilization Schedule for Chir Pine Stand aged 6 - 10 years.

Predominant Height (m)	Approx. Age[4] (Years)	Mean dbh (cm)	Silvicultural objectives	Utilization objectives	Management strategies	Biomass harvested (t ha^{1})[3] Foliage	Branchwood	Stem	Total
4	6	6.6	Maintain biomass on the stand irrespective of species.	Provide bedding material, fodder for livestock and some fuelwood	Prune to 10 % of stem height (to approx. 0.4).	0.30	0.92	-	1.22
5.5	7	8.2	Maintain biomass on the stand irrespective of species	Provide bedding material and fodder for livestock and some fuelwood.	Prune to 20 % of stem height (to approx. 1.1 m).	0.32	0.91	-	1.23
7.0	8	9.8	Maintain biomass on the stand irrespective of species	Provide bedding material, fodder for livestock and some fuelwood.	Prune to 40 % of stem height (to approx. 2.8 m).	1.69	2.64	-	4.33
8.7	9	11.4	Maintain biomass on the pine fraction of the stand.	Provide bedding and fodder for livestock, fuelwood, and construction timber.	Reduce multistems to single stems on all species and coppice broadleaf fraction. Thin pine to a stocking of 1300 stems per ha. (remove 1 in 15 trees).	.30[1]	.56[1]	1.16	2.10
9.5	10	12.8	Maintain biomass on the pine fraction of the stand.	Provide bedding for livestock, fuelwood, and construction timber.	Thin to 1190 stems per ha. (remove 1 in 12 trees).	0.52[2]	.79[2]	1.53	2.84
					Total yield up to age 10 years:	3.21	5.72	2.69	11.72

1 Calculated on a proportional basis assuming 68 % of the height of the trees thinned is unpruned.

2 Calculated on a proportional basis assuming 70 % of the height of the trees thinned is unpruned.

3 Expressed as oven dry weight.

4 Refilling of seedlings was carried out for up to 4 years following initial establishment because of poor survival.

Additional information on the silvicultural and utilization objectives and options which are required to compile the schedule are included from Tables 5a and 5b. Table 9 indicates that utilization of the forest can commence as early as six years by removing the lower branches (up to 10 per cent of the height of the stem). Such an operation would yield 1.2 t/ha of which 300 kg is foliage and 900 kg is small branch material for fuelwood. A series of consecutive management strategies can then be applied which are designed to meet the overall management aims and satisfy the silvicultural and utilization objectives. By ten years, a total of 3.2 t/ha of foliage for bedding material, 5.7 t/ha of fuelwood, and 2.7 t/ha of poles suitable for construction timber or fuelwood would be harvested.

The schedule outlined in Table 9 could be readily extended up to rotation age as depicted in Table 5 b. In many cases, particularly in the community-owned forests, rotation age will probably be determined by the structure of the stand and on the size of the material required by the user group. In other words, the rotation length may not be determined by age alone or by the MAI/PAI curves. A more important criterion may be the time required to grow a product to the maximum size required by local communities. For example, it makes little sense to grow a stand for 40 years to a mean dbh of 45 cm when the villagers only require trees of 20 cm dbh which can be produced in 15 years.

Applying Forest Management. To date, few if any formal management schemes are operating in community forests in the Middle Hills. This is partly because most of the plantation forests are quite young (less than five years old). However, it is also partly because most of the management plans that have been compiled depend on a reasonably sound technical background for both their development and application.

The existing district staff of the Forest Department can barely cope with the modest forest development programmes operating at present. However, if the community forestry concept is to be successful and result in an adequate supply of forest products for village people, it must ultimately undergo enormous expansion. The staff will find it very difficult to deal with a greatly expanded programme, even if a substantial increase in staff numbers occurs.

In addition to the new plantation forests, the existing natural forests (40 per cent of the land area) must also be brought under better management. Consequently, forest management decisions must ultimately rest with the local community. This is quite a radical departure from conventional forest management and one that will take a good deal of patience and perseverance to implement. However, there are a number of leads which can be taken from the way in which villagers currently utilize produce from their existing forest resources.

In many areas, the traditional systems for the collection of various forest products reflect a combination of need, availability of produce, and season of the year (and hence time available to carry out the collection). There are also a number of models of traditional methods of management of natural forest (Arnold and Campbell 1985) which can provide guidance on the sort of system which may be socially acceptable.

Practical forest management must be a blend of **sound silvicultural practice, and social need and acceptability**. The development of a small range of options (examples of which were outlined in Tables 5 a,b), which can be readily understood by village people, simplifies the whole process. These options can be used to develop a series of utilization schedules which can be implemented under the control of the panchayat leadership (either at panchayat or ward level) and probably through the operation of the forest committee. This committee usually comprises villagers and a representative from the Forest Department. The administration of the utilization itself could be under the direct control of the panchayat secretary as one of his normal administrative functions.

One of the major problems to be solved in developing a self-sustaining system is that of payment for forest watchers. At present in the NAFP area forest watchers are employed at the rate of one per 15 ha of plantation forest. They ensure that straying animals are kept out of the forest and that people confine their harvesting activities to the removal of grass and dead material. In the two NAFP districts, most watchers are paid from project funds. This cost a total of 559,000 rupees (approximately US$ 32,500) in 1985/86 for the 415 watchers involved. This recurrent cost is a heavy burden to carry and one which ultimately must be passd, if only in part, to the panchayats. The rationale for the project continuing to pay for the recurrent cost of the watchers is that it is part of the capital cost of establishing the forests and getting them to the stage where utilization is feasible.

Once utilization commences, the return received by the panchayats from the sale of forest products will go, in part, towards the cost of operating the forestry enterprise, including paying the costs associated with employing forest watchers. C.D. Hamilton (pers. comm.), in a cost-benefit analysis of community forestry in Sindhupalchok estimated that a price of 5 rupees per headload (approximately 22 kg) of forest produce will be needed to cover the full recurrent cost of employing forest watchers, (at the rate of one watcher per 10 ha). This is a substantial sum in the local economy and the cost of the forest watcher is only one of the costs involved in running the community forestry enterprise. As the forests mature and begin yielding produce, methods of rationalizing forest protection and the associated costs need to be investigated.

A great number of practical issues need to be addressed as utilization commences and as more forest areas are brought under effective management, including:

- o the area to be utilized each year;
- o an identification of the user group for each forest area (i.e. the group of people who should share in the benefits coming from the forest, and who should also share in the management responsibilities);
- o the price to be paid for various forest products;
- o the time of year for the utilization of various forest components;
- o a method for the distribution of forest products;
- o any penalties to apply to wrongdoers.

Many of these issues can be resolved by discussion with the panchayats themselves with advice from Forest Department staff. The actual application of management schemes will be a new experience for most communities (as well as for the Forest Department). Consequently, it is bound to be accompanied by a great deal of discussion. Like most new ventures there will also be many uncertainties and doubtless many mistakes will be made as systems are implemented, tested, refined, and reimplemented. However, it is only in this way that a final solution will be achieved.