MANAGEMENT AND CUTTING BUDGET PROBLEMS IN THE HIMALAYAN CONIFER FORESTRY

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SELOSTUS:

HIMALAJAN HAVUMETSÄTALOUDEN JÄRJESTELYN JA METSIEN HAKKUUMÄÄRÄN LASKENNAN ONGELMIA

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Preface

Under the terms of the Agreement between the Government of Finland and the Government of India, on Technical Assistance to India, which came into force on 14th June 1957, an investigation was carried out in the area of the Beas River and on the conifer forests of the surrounding region as a possible supply of raw material for forest industries. The Finnish team assigned to India consisted of two men, of Mr. ILMARI KOSKINEN, a pulp and paper engineer, and of the author. This paper is a part of the final report to the Government of India.

The author spent seven months in India, from 15th October 1957 to 15th May 1958. His headquarters were in the Indian Forest Research Institute at Dehra Dun, from which several tours were made to the conifer areas. The Forest Research Institute was an ideal headquarters for the study. The staff of this unique Institute and its facilities offered an inspiring and co-operative atmosphere for concentrating the local problems.

The Indian Government and the Forest Research Institute aided the study with collaborative guiding and research, as well as secretarial aid. The author is greatly indebted for this indispensable co-operation.

Of the Indian authorities the author respectfully thanks Mr. G. G. TAKLE, Inspector General of Forests, and Mr. C. A. R. BHADRAN, Deputy Inspector General of Forests, in the Ministry of Food and Agriculture. In spite of their numerous responsibilities they always had time for discussions which were most valuable.

The author is greatly indepted to Mr. R. N. DATTA, President of the Forest Research Institute & Colleges, as well as to many branch officers and research workers whose vast scientific knowledge and experience were so many months at his disposal.

Field tours were carried out in the forests of the Punjab and Himachal Pradesh. It is the pleasant duty of the auther to express his thanks to Mr. G. S. DHILLON, Chief Conservator of Forests, Punjab, and Mr. G. S. KAITH, Chief Conservator of Forests, Himachal Pradesh, and to all Forest Departmental staff members of these States for the guiding and assistance which they always gave with equal readiness.

Respectful thanks are due to Mr. Eino Saari, professor at the University of Helsinki, who playd an important part in organizing the mission to India and aiding the author to carry out his task.

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Helsinki, November 9, 1958.

Kullervo Kuusela

Content

Introduction

Present Use of Conifer Wood in the Indian Economy

Forest resources of India are very limited and the situation is characterized by a serious unbalance between demand and supply. Constructional and fuel wood on markets and on major transportation routes is valuable and expensive. The mushrooming pulp and paper industry suffers an acute shortage of raw material. Even if the bulk of its requirements could be provided with bamboo, grasses and bagasse, wood will still be greatly in demand, especially for newsprint and rayon. Vigorously developing India will need all kinds of pulp and paper products in enormously increasing quantities which have to be either produced domestically or imported. E.g., all the rayon pulp and most of the newsprint are imported at present. One can say that every piece of wood on markets will meet an urgent need.

On the other hand, in a tract 1 500 miles long from East to West and consisting of Himalayan hills and mountain ranges there are still large areas under partly used or untapped conifer forests which are guarded by long transportation distances, steep slopes and numerous extraction difficulties. The unquestionable importance of these forests has been known long ago and emphasized many times but their value is still a potential one. They only supply railway sleepers and scantlings to the markets. Compared with the yield obtainable, the quantities extracted are very small and the largest part of every felled stem is left as waste in the forest. Small timber under the limiting diameter of 8 inches has so far had no use worthy to mention. Resin tapping is the main source of revenue in large long-leaf pine areas.

The main role of the Himalayan conifer forests has been to preserve the hill sides against erosion, to maintain an equable flow of water in streams and rivers and to supply timber, fuel, grasses and other minor forest products for the domestic and agricultural requirements of the local population.

The commercial use of the conifers is very one-sided. Only a single type of product, i.e., sleepers and scantlings, is converted from the best part of the largest trees by handsawing beside the stump. This usage is a deep rooted custom and the product has served requirements for a long time. From the point of view of an independent India and her vigorously developing national economy, this

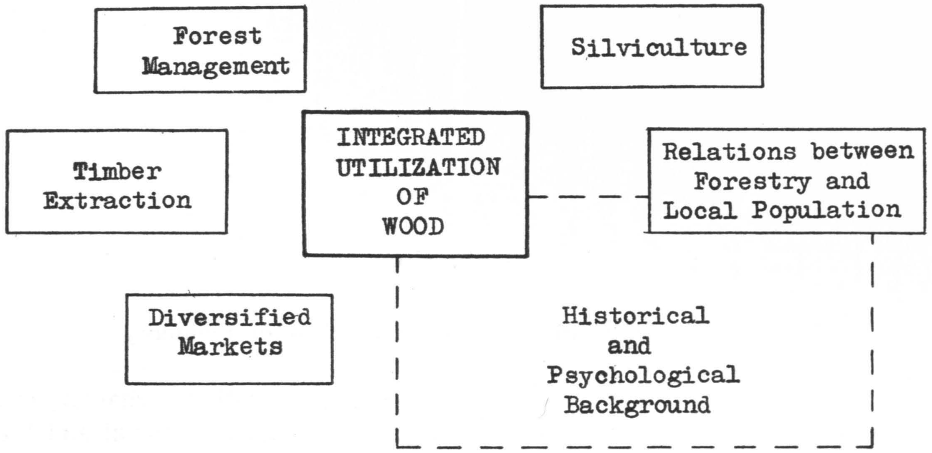


Fig. 1. Problem groups in creating integrated utilization of wood.

state of affairs is very unsatisfactory. Diversification of the wood markets is highly desirable. It is time to bring the conifer forests out of their stagnation, to stop the reckless waste in conversion and to supply diversified forest products for the multiple requirements of the national economy. This can only be attained by means of integrated utilization of wood.

Problems in Creating Integrated Utilization of the Himalayan Conifer Forests

The potential resources of the Himalayan conifer forests can only be in full use provided that the utilization of wood is properly integrated. There should be a suitable demand for every dimension and quality of wood and every acre of land growing trees or suitable to grow trees should provide the maximum integrated yield.

Utilization of these conifer forests is often called a logging or extraction problem. Logging in mountaneous terrain is certainly a serious bottle-neck for timber from the stump to the markets. But it would be erroneous and fatal to stare at logging as the only difficulty. Under the prevailing conditions the integrated utilization of wood sets up a jungle of compound problems.

The five problem groups considered essential and necessary in developing the Himalayan conifer forestry are illustrated in Fig. 1. If any of them remains unsolved the whole scheme will collapse.

Forest Management

Forest management deals with the means of growing trees for the most profitable yield. The objectives of forestry, suitable tree species, composition and structure of the desirable growing stock, proper silcivultural system, exploitable size and age of the trees, location of the age classes, etc. must be defined. In this case the main problem is how to grow trees for a variety of markets keeping in mind the existing silvicultural conditions, logging difficulties, soil preservation and the requirements of the local population.

E.g., if one certain size of timber is more loggable than another size, the former will be the objective of the management provided that this more loggable size does not jeopardize the highest amount of total yield. Management system must not be allowed to become a stiff skeleton of principles defined in the past but it should be a flexible body that can find a new way to meet every new situtation.

Silviculture

Silviculture and its problems can only be taken under consideration in an extent which is necessary for the forest management.

Pines (*Pinus longifolia*, Roxb. and *Pinus excelsa*, Wall.) and deodar (*Cedrus deodara*, London) have up to now been the main objects of the extraction, management and silviculture. The regeneration areas and young stands of these species are a convincing proof of the sound and scientific methods of their silviculture. In regard of these species only some suggestive notes can be mentioned.

Cutting cycle of ten years is a rule for the young stands even on best sites. For this reason many fast growing tree stands appear to be over-dense. On the other hand the over-dense young stands are a characteristic feature of extensive forestry because there is no demand for small timber. The rate of growth and the potential value even of the smallest timber are so high that they justify early commencement of thinnings carried out lightly and repeated at fairly frequent intervals.

Natural regeneration is the rule for pines and in most cases for deodar too. The regeneration period is 30 years' long. The high value of the timber and fast growth of these species justify their artificial regeneration on a much larger scale than is used now. Long regeneration period and irregular seedling stands result in considerable losses of time and of the growing capacity of the site. A 10 years' regeneration period for the pines and deodar should be the aim in developing the regeneration technique. Longer period is only justified in the case of long-leaf pine mother trees under resin tapping.

Spruce (*Picea morinda*, Link.) and fir (*Abies pindrow*, Spoch.) forests offer a quite another kind of silvicultural picture from pine and deodar forests. Because of their location on high hills and of the primitive logging methods they have been outside the interest of silviculture. A typical spruce and fir forest consists of large and over-mature trees with dry tops and rotten stems. Pole size trees are either single or in small groups and they are usually comparatively old, suppressed and with inside rot. Seedling and sapling stands are very rare. Small seedlings are very badly browsed and infected by fungus attacks. Wind falls and other calamities are common. Immadetiate research and experimental regeneration should begin in these forests. The inimical factors to regeneration are grazing, heavy weed growth and accumulation of deep raw humus.

Timber Extraction

Extraction problems are most outstanding (Huber, 1953 and Koroleff, 1956). The existing inefficient and wasteful methods of timber extraction must be changed into modern and partly mechanized logging and transportation operations. This requires new tools and other equipment, new logging methods and corresponding training for the operational staff and labour.

At present the trees are felled and cut into proper length by axes and hand saws and sawn by hand into sleepers (10 feet × 10 inches × 5 inches) and smaller scantlings beside the stump. Timber is carried on human back to the nearest floatable river or to the upper head of wire ropeway. In latter case timber is roped down to the river side. In small streams the floating commences during the monsoon, usually at the end of September. In the streams with little water elaborate systems of telescopic floating and wet slides are applied.

In large side streams and in main rivers the floating is free, uncontrolled and unequipped. Sleepers and scantlings are taken to the stream and the floating crew follows the timber breaking up jams and pushing stranded timber back to the water. The speed of floating is very low, sometimes only a mile in every 24 hours in a stream where the speed of water is several miles in an hour. In lower streams the timber is floated in rafts of about 300 sleepers with a crew of two men on each craft. Speed of rafting is 10—15 miles in every 24 hours.

The logging waste is very large. The percentage of conversion to which exploitation works is 45 per cent to deodar and pines and 25—30 to fir and spruce. More than half of every stem up to the limiting diameter of 8 inches is left as waste into the forest. The loss of timber in floating is usually under 5 per cent but in bad side streams and in the case of flood it can be much higher. According to the data from the Timber Depot at Dhilwan on the Beas river, the average damage percentage (proportion of the floated timber which cannot be used as sleepers) varies from 10 to 20 per cent and can be as high as 40—50 per cent. It is highest for spruce and fir.

»Labour is extremely cheap and their standard of living very low. The workers take shelter under a rock or clift, have their simple meals twice a day. Clothing is by no means adequate for the heavy work and tools are most primitive consisting of a crude village made axe, some primitive cross-cut saws, a wrapping saw and perhaps a stick for turning the logs, is required. Apparently not much, if any, attention has been paid to the labour conditions in the past.» (Huber, 1953)

Daily wages in the forest work vary from 1.5 to 3 rupees and a good sawer can make 5—6 rupees per day (1 rupee = 0.21 US dollars).

Timber is sold and cut in comparatively small lots of about 2 000 trees and the extraction has to be completed within 1—2 years. This practice prohibits any long term interest and investment on the part of the purchaser.

Extraction cost per cubic foot in the form of sleepers from the stump to the timber depot down in the Plains is 1.75—2.00 rupees. In 1957—58 the sale prices varied from 4.5 to 7.0 rupees for pine, from 6.0 to 11.0 rupees for deodar and from 2.5 to 4.5 rupees for spruce and fir per cubic foot in timber depots.

Relations between Forestry and the Local Population

In most cases the forests owned by the Government are burdened with numerous rights enjoyed by the local population. These rights, which are said to be unsurmountable obstacles in the way towards intensive forestry, are classified:

1. grazing or pasture, 2. grass cutting, 3. lopping and leaf gathering, 4. wood rights, 5. right to fallen leaves for litter and manure, 6. rights to other forest produce, 7. hunting and fishing and 8. temporary and shifting cultivation.

The present situation is a heritage from former days when the Government allowed the rights to grow up in order to keep the people content and only retained something less than full public ownership over the unoccupied waste and reserved limited forest areas for the future use and for soil conservation purposes.

Some data about population and cattle density may illustrate this problem. In the long-leaf pine areas of the Kangra District in the Punjab the population varies from 200 to 350 on a square mile. 95 per cent of the total population belong to the agricultural classes whose life is simple and primitive. Their economy is based on small scale farming, fruit growing, sheep and goat rearing and village crafts.

In the hills proper the population varies from 50 to 60 on a square mile. In 1945 there were in Kulu, Rupi and Inner-Seraj on an average 0.8 cows and bullocks and 1.4 sheeps and goats per person which makes 40—45 cows and bullock and 70—85 sheeps and goats on a square mile.

Obviously the relations between forestry and the local population call for much modification. At present the inhabitants have many rights but few responsibilities. Reckless grazing and cutting are forcing the scattered forests higher and higher up into the mountains and are destroying the national resources and the pre-requisites of human life in the hills. The problem has its administrative, legistlative and educational aspects.

Diversified Markets

Besides the local rural use of wood the timber is transported down to the Plains for railway sleepers, constructional purposes, packing cases, etc. Manufacture of wood is undertaken in small bench saws and workshops. The preservation plants of railway sleepers are the largest industrial units. The use of conifer wood in pulp and paper industry is in an experimental stage.

Diversification of the wood markets is mainly dependent on three items:

1. Timber should be extracted wherever possible in the form of logs and manufactured in industrial centres.
2. Small timber should have proper demand.
3. Existing pulp and paper industry should use more wood as raw material. New units of integrated forest industries should be built.

Extraction of logs is a logging problem and the centralized manufacture of wood requires modern sawmilling in connection with pulp and paper units. Pulp and paper industry is the most important mass consumer of small timber and sawing waste. Building up pulp and paper units is the key item in developing the Himalayan conifer forestry.

Historical and Psychological Background

The historical and psychological background is the human screen on which all economic and technical problems are projected. Uses of wood and methods of forestry are everywhere controlled and curbed by old and deep rooted customs. Certain tree species, sizes of logs and logging methods are used because historically they have served the needs. The usage continues in spite of the fact that the economic and technical level, at which these customs came into existence, has been changed long ago. Human factors are a characteristic part in every economic and technical project.

The present stage in the Himalayan conifer forestry is a heritage from the time of the British Administration in India. The main objectives seem to have been in that time:

1. To satisfy the primitive needs of the hill population.
2. To reserve limited forest areas for soil conservation purposes and for the needs of war or other emergencies.

3. To provide sleepers for railways which were the backbone of the administration.

Obviously there was no great interest in the requirements of intensive and integrated forestry because all pulp and paper products, for instance, could be imported from the United Kingdom to India. As long as there were enough sleepers for railways there was no need to develop logging methods, intensify forestry and educate the inhabitants to grow trees for their requirements.

The present administrators and the forest departmental staff members are well aware of the better and more efficient ways of utilizing the conifer forests but they are under the spell of the »sleeper heritage». It is always difficult for man to liberate himself from deep rooted customs and it will certainly not be easy in India where the national customs are honored and cherished more than in many other countries.

The attitude of the administrators, industrialists and forest officers in regard to the conifer forests is often influenced by their location at the frontiers of the Indian continent and in the mountains, which differ thoroughly from the Plains where the centres of the national culture and economy are located. Thus it is quite understandable that the conifer species have a minor role in the research work, compared with the tree species which grow in the Plains, and many research men and even some of the forest officers in the hills don't believe in conifers as a raw material for pulp and paper industry.

The industrialists and other enterprisers tend to prefer to work in the neighborhood of the cultural and economic centres. Even forest officers are not always over-enthusiastic about devoting themselves to the forestry in the hills where everything is strange compared with the conditions in the Plains, and where the difficulties are seemingly impossible to overcome. A prejudice is often more difficult to overcome than a material obstacle and sometimes rich resources are being left unused in remote areas because life is more familiar and comfortable in the neighborhood of the principal cities and traffic routes.

In order to guarantee the available benifits of the conifer forests to the Indian national economy, the historical and psychological background of economic and technical problems will be carefully studied and a proper attitude will be worked out to meet the challenge of the existing difficulties.

Forest Management

General Conditions in the Himalayan Conifer Area

Geographical Situation. The conifer forests lie in the Himalayan mountain ranges which belong to the Extra-Peninsular region adjoining the Plains of the Indian Peninsula at the North. They lie between the latitudes of 35° and 28° and between the longitudes of 75° and 95° East.

Conifer species grow mainly between the altitudes of 2 500 and 11 000 feet (760—3 350 m) above the sea level. In upper altitudes the terrain is mountaneous and the slopes and gorges are often very precipitious. In the lower hills and in the Siwalik Range, where there are scattered long-leaf pine stands too, the terrain is undulating and the differences of altitude are usually within 1 000 feet (305 m).

Climate and Rainfall. The climate varies from sub-tropical to alpine and to permanent snow at the highest altitudes. E.g., in the Kulu Valley of the Upper Beas River, rice can be grown at the bottom and one can pass all the intermediate vegetation zones up to the alpine pastures within a ten to fifteen miles' (sixteen to twenty four km') walk. The maximum temperature in Manali in the Upper Beas (at the altitude of 6 500 feet or 2 000 m) is about 87° F (31° C) and the minimum 29° F (— 2° C). In Kangra (at the altitude of 2 000 feet or 650 m) the corresponding temperature records are about 93 °F (34° C) and 35° F (2° C). In the lowest pine areas the maximum temperature frequently exceeds 100° F (38° C).

Annual rainfall ranges in the Beas Basin between 26.9 inches (680 mm) at Mukerian in the Plains to 134.5 inches (3 400 mm) at Lower Dharamsala at an altitude of 4 580 feet (1 400 m). On an average it varies in the conifer areas from 35 inches to 50 inches (900 mm to 1 300 mm). Bulk of the rainfall comes down during the monsoon months of July and August. The weather is bright and cloudless on most days during the remaining ten months of the year.

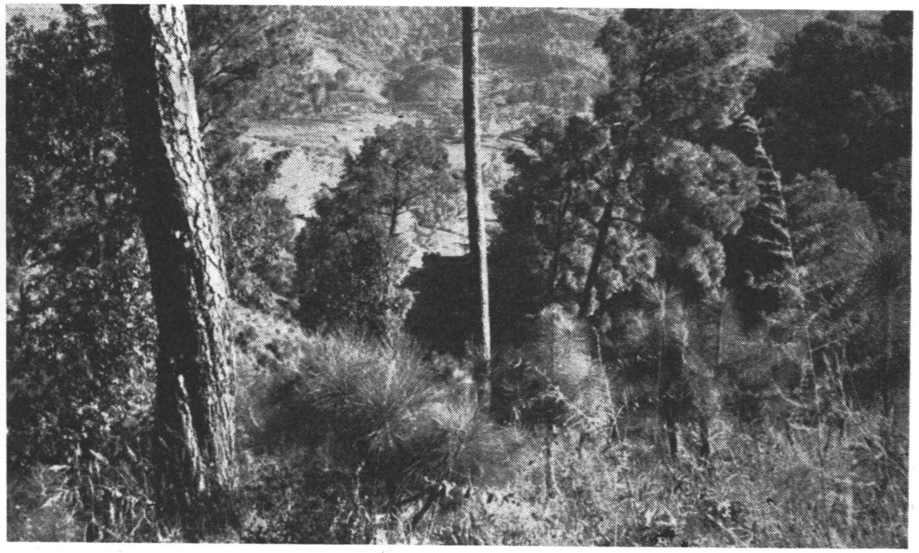
Heavy monsoon rainfall often causes serious floods and landslides damaging fields and roads. In the »dry» months the rain is usually light drizzling, but sometimes it can be very heavy too. Snowfall is common from an altitude of 6 000 feet (1 800 m) upwards during the winter months of December, January and February. A snow coverage lasting at least two months and thick enough for snow transportation occurs from 7 500 feet (2 100 m) upwards. In the lower hills the snowfall is sometimes heavy but the snow does not lie any length of time.

Ownership and Administrative Units. Practically all forests are owned by the states. Each state has its own Forest Department and the forests are divided into Forest Circles and Forest Divisions. The commercial forest land in a division varies from 25 000 acres to 500 000 acres (10 000 ha to 200 000 ha). Every division has its Divisional Forest Officer and is divided into ranges with Range Officers.

Traffic Routes and Transportation Ways. The Himalayan conifer area is outside the Indian railway net with two small exceptions. A narrow gauge rail link from Pathankot to Jogindarnagar passes through some scattered pine forests and another narrow gauge link from Kalka to Simla reaches the outskirts of the deodar zone.

The main hill stations are connected to the Plains by metalled roads. Most towns and many largest villages can be reached by motorable roads. Large interiors in the hills with important conifer forests are only provided with bridle paths and every large scale logging operation is dependent on road construction.

The rivers and they tributaries form up transportation routes for timber down to the Plains. Obviously the floating will be the most important method of major transportation in the future.



Picture 1. Regeneration area of the long-leaf pine. Mother trees have been under resin tapping.

Composition of the Conifer Forests

A natural way to divide the Himalayan conifer forests into sub-groups or zones is based upon the altitude and the tree species. The following three zones will serve the purpose in this paper:

Chir zone is situated between the altitudes of 1 500 and 5 000 feet (460 and 1 500 m), the best forests between 3 500 and 5 000 feet (1 100 and 1 500 m). In exceptional cases it can reach 6 000 feet (1 800 m) or even 7 000 feet (2 100 m).

The main conifer tree in this zone is the long-leaf pine (*Pinus longifolia*, Roxb.). It is called chir in Hindi and chil in Punjabi. Chir pine is a gregarious light demander but at its upper and lower limit it is often mixed respectively with deodar, blue pine and oaks and with lower level sub-tropical broadleaved species.

Chir is the most important timber tree in the lower hills. In addition to this, it produces resin which provides the bulk of revenue in many forest divisions.

Picture 2. Dense deodar stand in an age of 40 years.

The average quality of chir crops is comparatively low. Forests are often scattered and surrounded by over-grazed scrubby slopes and agricultural areas.

Deodar and kail zone lies between 5 000 and 8 000 feet (1 500 and 2 400 m), exceptionally up to 9 000 feet (2 700 m).

The main species in this zone is deodar (*Cedrus deodara*, London), Himalayan cedar. It is essentially gregarious, not as typical a light demander as pines, and it occurs frequently in pure stands. Besides spruce, the commonest companion of deodar is kail (vernacular name) or blue pine (*Pinus excelsa*, Wall.). Kail is a typically gregarious light demander and a pioneer species which occupies abandoned grasslands and fields. It often flourishes with oaks.

Deodar is the most valuable Himalayan timber tree. It has been the prey of the old time exploiter and the main conifer object of the later silviculturist. One of the working plan objectives is still »to increase the proportion of deodar trees» (AGGARWAL, 1949) by natural and artificial regeneration measures.

Compared to its companion, kail is greatly inferior as a timber tree. It is more susceptible to fire damage, often lopped heavily and thus liable to fungus damage. A marked tendency has prevailed to convert kail on better sites and cool aspects into deodar.

Spruce and fir zone lies between 8 000 and 12 000 feet (2 400 and 3 700 m), chiefly between 7 000 and 11 000 feet (2 100 and 3 300 m). Spruce grows occasionally on northern slopes as low as at 5 000 feet (1 500 m).

The main species in this zone are the West-Himalayan spruce (*Picea morinda*,

Picture 3. Conifer species, especially spruce and fir lie as a narrow belt on the highest shoulders of the Himalayan mountain ranges.

Link.) and the West-Himalayan low-level silver fir (*Abies pindrow*, Spoch.). Spruce is a moderate light demander (or a moderate shade bearer) and gregarious but not often found pure in large areas. At its lower level, in the so-called tension belt, it is mixed with deodar, kail and oaks.

Fir is the main companion of spruce. It is a true shade bearer, but sometimes mixed with deodar and kail in which cases it usually seeks cool and moist aspects.

Spruce and fir cover the shoulders of the Himalayan ranges. Because of the rough terrain with many logging difficulties they have not been exploited as heavily as the lower level conifers. However, they have been a valuable timber reserve for emergency demands. They provided much wood for requirements during the war and their value is increasing with the improving logging methods.

The commonest broadleaved species in the conifer area are oaks. *Quercus incana*, Roxb. grows in the chir zone, *Quercus dilatata*, Lindl. in the deodar and kail zone and *Quercus semicarpifolia*, Smith. in the spruce and fir zone. They form almost pure stands with low density and scrubby stems in large areas, especially *Q. semicarpifolia* in the altitudes above the spruce and fir zone. Many other broadleaved species, too numerous to be mentioned in this connection, are usually found in damp depressions, on limestone formations, around villages, etc.

Growing Stock and Yield Data

Growing stock data can be collected from the working plans prepared for each forest division. Working plan inventories are carried out after 10—15 years' periods. The inventory method is a partial enumeration. Saw timber trees down to the limiting D. B. H. of 8 inches are enumerated using 4 inch diameter classes. Height and age is measured for estimating the average site quality class. Volume tables are based upon the D.B.H. and the site quality class. All trees and parts of the stems under the limiting diameter of 8 inches are excluded from the working plan volumes. In many forest divisions there are large areas, especially in high altitudes, where no stock data are available. From the point of view of intensive forestry the stock data are by no means adequate.

For pines and deodar there are complete yield tables (Champion and Mahendru, 1929 and 1933; Howard, 1926). In the case of pines the saw timber and small timber yield within the stand age up to 140 years, for one thinning grade and on three site quality classes is shown in the yield tables. The site quality class is based upon the average height and age of the tree stands. In the deodar yield tables there are four site quality classes and four thinning grades.

The principal types of conifer forests are illustrated by the stock data from latest working plans in the Punjab (Aggarwal, 1949 and Chandra, 1952). Though the conditions vary in different states the following data are characteristic for the most of Himalayan conifer forests.

Growing Stock of the Regular Working Circle in Kulu & Seraj

The Regular Working Circle of Kulu & Seraj Forest Division could be called the Deodar Working Circle because in it the main object of the management has been and still is deodar. The Beas Felling Series of this Working Circle cover 36 974 acres (15 000 ha). The saw timber volume down to the diameter of 8 inches is 76 milj. cu.ft. from which deodar comprises 32 per cent, kail 36 per cent, chir 2 per cent and spruce and fir 30 per cent.

In the figures above the pine and deodar volumes are given in commercial units and spruce and fir in Standard volume units. Standard volume, or full basal area volume, is also used in the yield tables. In order to compare the growing stock with the yield table volumes the pine and deodar volumes will be converted into Standard units. On an average the commercial volumes are 125 per cent of the Standard volumes (Howard, 1927). This as a correction factor for pine and deodar gives the growing stock as 89 mill. cu.ft. This Standard timber comprises the volume based upon the full basal area, including the stump but excluding the bark, down to the limiting diameter of 8 inches over bark.

The growing stock on an acre is 2 400 cu.ft. or 56 per cent of the normal growing stock of deodar with 120 years' rotation and E grade thinning on the I/II site quality class. Bearing in mind that 81 per cent of the Working Circle is under conifer species, the average volume on an acre is 3 000 cu.ft. or 69 per cent of the normal growing stock.

In Kulu Division the volume ratios of the diameter classes are:

8″—	12″—	16″—	20″—	24″—	28″—	32″—	over 36″	Total
3.0	8.0	16.8	20.9	18.0	12.2	7.5	13.6	100.0

There are no estimates for small wood because it has been considered commercially valueless. In the yield tables the Standard small wood, volume between limiting diameters of 8 inches and 2 inches over bark, including bark, comprises 18 per cent of the normal Standard timber in the case of E grade thinning and 25 per cent in the case of C grade thinning.

It is assumed that the small wood percentage, comprehended as above, is 20 per cent. The bark percentage of small wood is 18 per cent (Howard, 1927). The total growing stock in cu.ft. on an acre, excluding bark, comes out as:

Standard timber	Small wood	Total
2 400	390	2 790

Growing Stock of the Fir Working Circle in Kulu & Seraj

The Beas Felling Series of the Fir Working Circle comprise spruce and fir forests and an area of 68 536 acres (27 500 ha). The growing stock is 205 mill. cu.ft. of Standard timber from which spruce and fir (considered to be one commercial species) comprise 97 per cent. The volume on an acre is 3 000 cu.ft.

In Kulu Division the volume ratios of the diameter classes are:

8″—	12″—	16″—	20″—	24″—	28″—	32″—	over 36″	Total
1.0	4.5	7.3	10.8	14.0	14.4	13.4	34.6	100.0

Because the young age classes are very scarce and the enumeration has only covered the sound trees (judged by their appearance) the Standard small wood and the unsound trees can be estimated as 15 per cent of the Standard timber. The bark percentage of the small wood is 17 per cent (Howard, 1927). This gives the total growing stock in cu.ft. on an acre, excluding bark, as:

Standard timber	Small wood	Total
3 000	400	3 400

Growing Stock of the selection Working Circle in Kulu & Seraj

The Beas Felling Series of the Selection Working Circle consist of forests on steep slopes where uniform management system is not feasable. Its total area is 24 873 acres (10 000 ha) and the growing stock 42 mill. cu.ft. from which deodar comprises 11 per cent, kail 24 per cent, chir 1 per cent and spruce and fir 64 per cent. The growing stock is 45 mill. cu.ft. of Standard timber or 1 800 cu.ft. on an acre.

In Kulu Division the volume ratios of the diameter classes are:

8″—	12″—	16″—	20″—	24″—	28″—	32″—	over 36″	Total
1.7	6.7	11.7	15.7	16.0	13.9	11.1	23.2	100.0

Growing Stock of the Chir Working Circle in Kangra

The Chir Shelterwood Working Circle of the Kangra Division covers 20 873 acres (8 500 ha). The growing stock is 25.5 mill. cu.ft. of Standard timber or 1 220 cu.ft. on an acre.

The average site quality of the chir forests is said to be low III but obviously this is an under-estimate because of the small height of the poor and irregular tree stands. Judged by their appearance, the even-aged young stands belong at least to the II site quality class. The actual growing stock is 97 per cent of the normal growing stock with 120 years' rotation on the III site quality class and 44 per cent of the normal growing stock on the II site quality class.

The volume ratios of the diameter classes are:

8″—	12″—	16″—	20″—	24″—36″	Total
4.1	18.1	28.2	25.5	24.1	100.0

In the yield tables the Standard small wood comprises 35 per cent of the Standard timber and the bark percentage of the small wood is 35 per cent (Howard, 1927). Thus the estimate of the total growing stock in cu.ft. on an acre, excluding bark, is:

Standard timber	Small wood	Total
1 220	280	1 500

Table 1. Normal yield in cubic feet on an acre (in parenthesis in cubic metres on a hectare) of solid measure, excluding bark, using 100 years' rotation for deodar and chir and 80 years' rotation for kail.

Site quality	Deodar		Chir		Kail	
	Standard timber	Small wood	Standard timber	Small wood	Standard timber	Small wood
I	157 (11.0)	32 (2.2)	131 (9.2)	41 (2.9)	190 (13.3)	29 (2.0)
I/II	132 (9.2)	32 (2.2)	—	—	—	—
II	107 (7.5)	32 (2.2)	85 (6.0)	29 (2.0)	132 (9.2)	26 (1.8)
III	62 (4.3)	33 (2.3)	52 (3.6)	22 (1.5)	88 (6.2)	22 (1.5)
IV	25 (1.7)	29 (2.0)	—	—	—	—

Normal, Obtainable and Prescribed Yield in Some Working Circles

In the working plans the yield is prescribed for every working circle. The prescribed yield can be compared with the normal and obtainable yield which comparison shows how intensive the forestry is at present. The normal yield of deodar, chir and kail from the yield tables is presented in Table 1. Small wood is calculated from the Standard small wood using bark percentages of 18 per cent for deodar and 35 per cent for pines.

The obtainable yield is usually considered to be 80 per cent of the normal yield on account of the unavoidable gaps and stand boundaries in the forests. The obtainable yield is compared with the prescribed yield in regard of Standard timber only because small wood is outside the scope of the present management. The comparison with the yields in some working circles is shown in Table 2. Because there are no yield tables for spruce and fir the yield of these species is assumed to equal the yield of deodar on the II site quality class (which is likely to be an underestimate). The prescribed yield is hardly one fifth of the obtainable yield. In addition, all small wood is considered as waste.

In Kulu & Seraj Forest Division the percentage of conversion has been 49 per cent for deodar, 39 per cent for kail, 30 per cent for chir and 25 per cent for spruce and fir. E.g., in the case of deodar 51 per cent of the commercial timber volume and in the case of spruce and fir 75 per cent of the Standard timber is left as logging waste in the forest. Using these conversion percentages, the prescribed yield turns out to be in scantling form as it is in Table 2. Thus the extract-

Table 2. Obtainable and prescribed saw timber yield in cubic feet on an acre (in parenthesis in cubic metres on a hectare) in some working circles.

Working Circle	Obtainable yield	Prescribed yield	Percentage of prescribed yield against obtainable one	Prescribed yield in scantling form
Regular Working Circle of Kulu & Seraj, site quality I/II	106 (7.4)	20 (1.4)	19	6.1 (0.43)
Fir Working Circle of Kulu & Seraj, site quality II	85 (6.0)	13 (0.9)	15	3.4 (0.24)
Chir Working Circle of Kangra .. site quality II	67 (4.7)	10 (0.7)	15	2.7 (0.19)
site quality III	42 (2.9)		24	

able prescribed yield on an acre is 6.1 cu.ft. in Regular Working Circle of Kulu & Seraj, 3.4 cu.ft. in the Fir Working Circle of Kulu & Seraj and 2.7 cu.ft. in the Chir Working Circle of Kangra. In the case of failure in logging, e.g., on account of the labour shortage, the actual yield may be still smaller. And 10—40 per cent of the floated sleepers and scantlings are lost or broken. In the light of these figures, the extensiveness and ineffectiveness of the Himalayan conifer forestry are fantastic.

Principles of the Present Forest Management

Management Objectives

In the revised Working of Plan the Kangra Forest Division (CHANDRA, 1952), the chapter dealing the with objectives of the forest management starts with a quotation of a speech delivered by Sir Michael O'Dwyer, the Lieutenant Governor, in Kangra in 1916. Part of it sounds:

»The general policy of Government is to maintain a reasonable proportion of forests for the use of future generations. The main objective is not to derive revenue from the forests, but to protect adequately such share of them as is necessary for future generations.»

The objectives of forest management derived from these principles and expressed in 1916 are still in force. Summarized from the latest working plans they are as followes:

1. To preserve the demarcated forests and other hill sides against denudation and to preserve an equable flow of water in streams and rivers, provided that reasonable use of the forests for grass and grazing is not interfered with.

2. To provide for the domestic and agricultural requirements of the local population.
3. To bring the growing stock to a condition nearer to that of normal forest.
4. To replace the inferior species by more valuable ones, e.g., to replace diseased kail by deodar.
5. To obtain the highest possible sustained yield of timber.
6. To produce the maximum permanent yield of resin in chir forests.

These principles and their order of importance may have been sound in the time of the British Administration in India. The local inhabitants, short-sighted in their primitive economy, have certainly been content with them. But they are highly deleterious to the present efforts to build up a self-supporting nation. The management objectives and their order of importance, as defined above, are pronouncedly conservative and anachronous. They have curbed the efforts to develop forestry and, as seen in the results of the past management, these principles turn out to be detrimental to the long-term requirements of the local inhabitants too:

»The destruction of forests by heavy incidence of grazing and browsing, repeated forest fires and intense logging has caused and continues to cause erosion and denudation to an extent which seriously threatens the welfare of an overwhelmingly agricultural district like Kangra. Grazing destroys large areas of invaluable protective forests with the result that whole hill sides are being rapidly eroded to the serious detriment of villages at foot-hills.»

»Old perennial streams are now dry except during monsoon when they become raging torrents. In the years 1944 and 1947 concentrated heavy rains during the monsoons on the heavily grazed Dhanta-dhar resulted in serious floods, dislocating traffic routes and destroying cultivation, bridges, roads and irrigation channels.»

»The unclassed and undemarcated forests have suffered the most and increasing demand for the forest produce has put such a strain on demarcated and reserved forests that in many cases they are unable to stand.» (CHANDRA, 1952)

In regard to the grazing: »Thoroughly useless weeds like Zanthium spp. and poisonous plants like Brojoplyth spp. are spreading on to the grazing grounds and it is only a question of time when grazing will be ousted from such areas.» (SINGH, 1958)

Only the reserved and demarcated protected forests make up a scattered cluster of bright spots against the general, highly unsatisfactory and depressing condition of the forest land. They have been exploited on a cautious sustained yield basis for several decades and treated with peveloped silvicultural and management technique for the fulfillment of specified management objectives. Results are best in favourable extraction conditions and in deodar and pine forests. On the other hand, almost all the spruce and fir forests on high altitudes are mature and over-mature and their silvicultural condition is very poor.

Management Systems, Exploitable Size and Rotation

Pine, deodar and some spruce and fir forests are under uniform management system and they are regenerated by seed tree or shelter wood cuttings. The modified uniform method used for spruce and fir is called the Punjab Shelterwood System. According to it all healthy advance growth (groups of trees younger and smaller than the mature trees) shall be retained to form a part of the future crop.

Forest divisions are divided into working circles according to the main tree species. Forests on rough terrain and on hill sides, which are liable to erode, form selection and protection working circles. Thus the working circle is a management unit where the objects and means of forestry are more or less homogeneous.

Working circle under uniform management system is divided into periodic blocks. In the case of pines and deodar the commonest rotation is 120 years and the forests are allotted into four periods of 30 years. The regeneration period is 30 years. All tree stands and forests which are proposed to be regenerated within the next 30 years are allotted into the Periodic Block I (P.B. I). Seedling and sapling stands up to small poles form P.B. IV and the intermediate age classes form the respective intermediate P.B. III and P.B. II. If the age class distribution is normal, which is hardly the case even in the working circles under most intensive management, the tree stands in each periodic block belong to the same age class. Every periodic block covers one fourth (or whatever is the number of periodic blocks) of the total area of the working circle.

Most of the spruce and fir forests as well as the forests on rough terrain and high altitude are managed by selection system. For commercial cuttings there is an exploitable size or diameter and only trees which have reached this diameter can be cut. Silvicultural thinnings are comparatively rare because the small wood has no demand. In large spruce and fir forests it is customary to pick up single trees of exploitable size and to leave thinnings and regeneration to nature.

Exploitable size is applied in the forests under uniform management system too. These forests are often near to the transportation routes and villages and therefore the small wood has demand and the thinnings can be carried out. However, the revenue is almost exclusively based upon the trees of exploitable size.

The exploitable size is a key concept in the Himalayan conifer forestry. It specifies the trees which are considered commercially exploitable, rotation and the number of the periodic blocks. The aim is to grow every single tree of the final crop up to the most profitable size for converting it by hand sawing into sleepers and scantlings. The most profitable sawing yield is achieved from the trees with D.B.H. of 24—28 inches. The corresponding rotation, defined by yield studies, is 120 years for pines and deodar and 150—180 years for spruce and fir.

Outline for Future Management

In order to improve the pre-requisites for intensive forestry the principle of sustained yield must be modified. Under present circumstances it means maintaining conditions that are not the best ones. The principle of progressive yield is a much more exacting basis for the management. The management objectives based upon it can be formulated for the Himalayan conifer forests as follows:

1. To bring the forest areas into a condition of being able to produce the highest integrated yield consisting of the most profitable ratios of large and small timber. Resin is evidently an important component of the integrated yield in chir pine forests.
2. Silvicultural systems must be modified in such a way that forests serve the purposes of soil conservation. In most cases forests under regular, silvicultural cuttings are also the best protection forests.
3. Every open acre which would be most profitable under the tree growth should be afforested.
4. The area defined as forest land should be allowed to satisfy the wants of the local inhabitants to an extent which does not jeopardize the highest integrated yield. It should be realized that forest land under vigorous tree growth is the most beneficial to the inhabitants too.

The existing conditions challenge the management to put into effect the following principles:

1. To exploit and regenerate the existing over-mature growing stock without jeopardizing the permanent annual cut.
2. To define rotations of maximum integrated yield on an acre for young and new crops.

Historically the management systems described in the previous chapter are sound and logically correct but at present they are out of date. Allotment of the forests into periodic blocks guarantees the sustained yield in a simple and rigid way. The system tends to sustain or retain unfavourable conditions which exist in the present forests.

Regeneration period of 30 years is definitely too long in the Himalayan extreme y favourable climate and it results in losses of time and growing capacity of the soil. In the intermediate periodic blocks there are tree stands which should be regenerated immediately. Retaining them increases inside rot, natural removal and loss of the increment. A scattered structure of the periodic blocks is an obstacle for centralized logging too.

Periodic blocks with permanent boundaries and equal areas make flexible silviculture and efficient utilization of the forests impossible. The harms of a rigid management system are most obvious in the case of spruce and fir forests. Postponing their regeneration increases natural calamities as insect and fungus attacks, windfalls, etc.

The general principles of the applied uniform system seem to be sound for pines and deodar. It can easily be developed to serve the needs of intensive forestry. The situation with spruce and fir, unfortunately is not equally good.

In Kulu & Seraj the spruce and fir forests are under the Punjab Shelterwood System. In the last working plan inventory the former rotation of 150 years was found to be too short to produce timber up to an exploitable diameter of 24—28 inches. In the present working plan the rotation is defined to be as 180 years. But it is hopeless to wait for the existing trees to reach this size within a reasonable time. Their capacity to grow is much lower than that of those trees which have been exploited in the past and which in their young age have obviously been dominant ones. Growing the present small trees up to a exploitable diameter of 24—28 inches will need longer and longer rotation leading finally to a dead end.

It was mentioned earlier that under the Punjab Shelterwood System all healthy advance growth is to be retained to form a part of the future crop. Accordingly, small and seemingly healthy but actually old trees have been left in regeneration areas. They are incapable of growing and merely form obstacles to regeneration.

The old spruce and fir crops are in increasing danger of being destroyed by climax calamities. The only sound rule is to liquidate and regenerate them as fast as possible.

Selection system has been a failure in most spruce forests (Troup, 1921). It seems to be unsuitable for these species wherever they can be grown in closed stands. Selection system is used succesfully on very steep slopes and at high altitudes. A modified uniform system with clear seeding fellings and more or less even-aged crops is suitable for spruce and fir. When the biological and silvicultural characteristics of spruce and fir are thoroughly studied it may turn out to be possible to use the highly developed and very intensive Middle-European selection system, or Control Method (Knuchel, 1953) for the new crops but at present and with the existing crops it will not work.

The present rotations are based upon the most profitable saw timber yield of a single tree. The correct basis for rotation is the maximum yield on an acre. The yield of a single tree as a basis of management is detrimental to maximum yield on an acre,even if the rotation is a technical one having as its objective to grow saw timber only. This is illustrated by the mean yield (or increment) from the deodar yield tables, site quality class I, E grade thinning, final crop over 12 inches at D.B.H., in the Table 3.

It is shown in Table 3 that even if the aim is to grow large timber trees with D.B.H. more than 12 inches and if the rotation is based upon the maximum volume yield of the final crop on an acre, the most profitable rotation is 70—80 years. After this age the yield of a tree naturally increases but the yield on an

Table 3. Mean yield of final deodar crop with different rotations

Age in years or rotation	Average D.B.H. in inches	Saw timber volume of a stem in cubic feet	Mean yield on an acre
120	27.8	147	88
110	23.5	133	90
100	22.2	114	94
90	20.9	96	95
80	19.4	79	99 } maximum
70	18.0	60	99 } maximum
60	16.4	50	93

acre decreases. Growing trees beyond a certain limiting diameter decreases the total yield on an acre.

Growing very large trees may be disadvantageous from the point of view of timber extraction too. The products of the past and present management have definitely been too large and heavy for extraction in the form of logs. The extraction of smaller trees should be easier and cheaper in mountainous terrain.

However, even the technical rotation producing saw timber only is one-sided and archaic. The aim should be the highest financial yield on an acre. At present it is not feasable to calculate financial rotations for the Himalayan conifer forests on account of the changing technical and economic conditions. Using the present prices, logging and transportation costs in rotation calculations would be a sheer play with numbers. Final rotations cannot be calculated until modern logging methods and the integrated utilization of wood are introduced and the price and cost level confirming with them is stabilized.

Based upon experience obtained in foreign forestry and keeping in mind that timber for sawn products is likely at least in the near future to fetch much better prices on the Indian markets than raw timber for pulp and paper, the following rotations may be suitable:

80—100 years for deodar
100 years for chir
60—80 years for kail
100 years for spruce and fir

Rotation of 120 years or even longer than that may be justified for deodar in limited areas on account of the enourmous value of large deodar trees. Remembering war time experience, it is always good to have a reserve of large size timber for cases of national emergency. A comparatively long rotation for chir

Table 4. Scheme of a Cutting Budget with a Budget Period of 10 years from 1958 to 1968.

Periodic block (Age class)	Initial growing stock in 1958	Initial volume of the exploitable stock	Periodic increment of 5 years	Final cut	Initial volume of the developable stock	Periodic increment of 10 years	Growing stock in 1968
IV (1—30)							
III (31—60)							
II (61—90)							
I (91—120)							
Total				→			

Allowable periodic cut

Initial growing stock in 1958 = Initial volume of the exploitable stock in 1958 + initial volume of the developable stock in 1958 Final cut = Initial volume of the exploitable stock in 1958 + periodic increment of 5 years

Allowable periodic cut = Summation of the final cuts from each periodic block

Growing stock in 1968 = Initial volume of the developable stock in 1958 + periodic increment of 10 years

pine is necessary for resin tapping because the integrated yield of chir forests comprises thinnings, resin and final cuttings.

The rotations given above are considered suitable for site quality classes I and II. Usually they are shortest on the best sites and are extended on poor sites.

Outline for cutting budget

General Principles

Cutting budget is a harvesting plan and a prescribed order of measures to develop the growing stock. It specifies the allowable annual and periodic cut and it can be broken down into specific parts. E.g., the allowable cut can be calculated separately for each tree species, periodic block and age class. It is usually prepared for a management period of 10 or 20 years. In the case of more or less normal distribution of age classes the procedure is simple and based upon the inventory data and existing yield tables.

The budget calculation may follow the scheme illustrated in Table 4 (Lihtonen, 1943 and Kuusela, 1958). The total growing stock is divided into sub-parts according to the periodic blocks (or age classes) and each sub-part into two components: exploitable stock and developable stock. Their summation can be called initial growing stock.

Exploitable stock consists of the trees which are proposed to be cut during the budget period. On an average, these trees will be growing half the number of the years in the whole period. The corresponding increment is added to the initial volume of the exploitable stock and the summation gives the final cut in the respective periodic block. The summation of the final cuts from each periodic block is the allowable periodic cut in the calculation unit. Divided by the number of the years in the budget period it gives the allowable annual cut.

The developable stock consists of the trees which will be growing through the budget period in the forest. Forecasted periodic increment added to it gives the growing stock in the end of the budget period. This is the initial growing stock for a new period.

The initial volume of the exploitable stock is estimated and fixed in accordance with the silvicultural condition of the forests, distribution of the age classes, rate of growth, degree of the stocking (if the area is under- or over-stocked), amounts of wood expected by the dependent industries and communities, etc. The aim is to develop the present growing stock towards a desirable growing stock and to guarantee a constant or, preferably, a gradually increasing annual cut.

Long Term Dutting Budget for the Fir Working Circle of Kulu & Seraj Forest Division

Besides for a period of 10—20 years the cutting budget can be prepared for a longer period too in order to study the possibilities of utilizing the existing resources. The following example is calculated for illustrating the principles of a long term cutting budget. As it turns out, bulk of the important data needed for it is either deficient or lacking. They are substituted by the best means at disposal. Incidentally, a proper resource inventory should be the first step in developing the Himalayan conifer forestry.

The over-mature spruce and fir forests are a crucial problem. Therefore the growing stock of the Fir Working Circle of Kulu & Seraj is chosen to be the object of a long term cutting budget.

Constitution of the Growing Stock The growing stock is in cu.ft. on an acre, solid wood, excluding bark (compare with p. 20)

Standard timber	Small wood	Total
3 000	400	3 400

»The forests are very much understocked and there is a large preponderance of mature and over-mature stock; more particularly of trees 36 in. and over in diameter. Many of the huge trees are unsound» . . . »sometimes fellings had borne on the I—A and I—B» (24—28 inches and 28—32 inches of D.B.H.) »trees leaving the over-mature stock merely because their fellings would give no timber» . . . »The general impression that younger age classes are absent is, however, not borne out by detailed examination of these forests. Although these classes are undoubtedly somewhat deficient, but frequently a fair amount of advance growth and poles is present wherever the canopy is lightly opened and the soil is sloping and well drained» . . . »Indeed, their proportion is fairly good, especially of silver fir, in several forests considering that no attention had been paid to these forests either to tend the natural regeneration that had come or to protect the tender seedlings from grazing and browsing or from being smothered by heavy weed growth.» (AGGARWAL, 1949)

In accordance with this description (compare with pp. 9 and 26 too) and the principle of the progressive yield these forests should be exploited and regenerated during the shortest period which guarantees a constant or increasing annual cut. Based upon preliminary calculations the exploitation period is fixed at 70 years and divided into 7 sub-periods of 10 years (Table 5.).

Necessary Additional Data The lacking stock data are substituted by the deodar yield tables which obviously are much more suitable for spruce and fir than the pine yield tables. The site is assumed to be quality class II, thinning grade E and rotation 100 years.

Annual Increment The normal mean annual increment on an acre is 139 cu.ft. (all volumes are given in solid measure, excluding bark). The obtainable increment is 80 per cent of this or 111 cu.ft.

According to North-European growth studies the increment of actual forests varies from 50 to 70 per cent of the normal yield. On account of the high age and the poor silvicultural condition of the spruce and fir forests the actual increment is assumed to be 50 per cent of the normal increment, or 70 cu.ft. on an acre.

Thinning Yield of the New Crops The new tree stands, which are to be regenerated during the exploitation period, should be in proper silvicultural condition. Their obtainable thinning yield in cu.ft. on an acre is:

Age	Yield
30	100
40	490
50	430
60	750
70	790
80	800

Development of Standing Timber of the New Crops The development of the new tree stands will be forecasted in order to carry the cutting budget over the transition period from the old stock to the new one. Based upon the same yield tables and the same considerations as above, the standing timber and its annual increment in cu.ft. on an acre are:

Age	Standing timber	Annual increment
30	600	
		90
40	1 500	
		120
50	2 700	
		90
60	3 600	
		80
70	4 400	
		70
80	5 100	
		50
90	5 600	

Course of the Cutting Budget The unit area is 700 acres and the area to be exploited and regenerated during each sub-period of 10 years is 100 acres. (These areas are only part of the calculation technique and they do not specify proper cutting areas for centralized logging and regeneration.)

The calculation is carried out in Table 5. In the first subperiod from left to right, 100 is the area in acres of the first block to be regenerated, 3 400 is the exploitable stock in cu.ft. at the beginning of the sub-period and 5 × 70 the sub-periodic increment of the exploitable stock. The second addendum in the numerator is that part of the sub-periodic cut which comes from the area outside of the block to be regenerated and it consists of the thinnings, preparation, salvation and improvement cuttings. This part of the periodic cut is assumed to be 60 per cent of the total periodic increment in the area of 600 acres under the developable stock. The remaining 50 per cent of this increment is left to accumulate on the trees that are silviculturally and technically the best in the developable stock. The total summation gives the sub-periodic cut and divided by 10 it gives the allowable annual cut during the I sub-period.

The contents of the formula for the II sub-period are the same as in the case of the I sub-period. 280 in the first addendum of the numerator is the increment on an acre left to accumulate in the developable stock of the I sub-period. This time 70 per cent of the increment in the area under the developable stock is included into the sub-periodic cut and the remaining 30 per cent is left in the forest.

In the end of the IV sub-period the regenerated tree stands in the first block of 100 acres are 30—40 years old. It is assumed that these spruce and fir stands give the same thinning yield as a 30 years' old deodar stand. This gives 1 000 cu.ft. of small wood to the annual cut. With such volume the young and vigorously growing tree stands will start to redeem the promises of good silviculture and management.

Table 5. Long Term Cutting Budget for the Exploitation Period of 70 years.

Sub-period of 10 years	Calculation	Annual cut
I	$\dfrac{100 \times (3\,400 + 5 \times 70) + \dfrac{60}{100} \times 600 \times 10 \times 70}{10}$	62 700
II	$\dfrac{100 \times (3\,400 + 280 + 5 \times 70) + \dfrac{70}{100} \times 500 \times 10 \times 70}{10}$	64 800
III	$\dfrac{100 \times (3\,680 + 210 + 5 \times 70) + \dfrac{80}{100} \times 400 \times 10 \times 70}{10}$	64 800
IV	$\dfrac{100 \times (3\,890 + 140 + 5 \times 70) + \dfrac{90}{100} \times 300 \times 10 \times 70}{10} + 1000$	63 700
V	$\dfrac{100 \times (4\,030 + 70 + 5 \times 70) + 200 \times 10 \times 70}{10} + 4900 + 1000$	64 400
VI	$\dfrac{100 \times (4\,100 + 5 \times 70) + 100 \times 10 \times 70}{10} + 4\,300 + 4900 + 1000$	61 700
VII	$\dfrac{100 \times (4\,100 + 5 \times 70)}{10} + 7\,500 + 4\,300 + 4\,900 + 1\,000$	62 200
	Average annual cut	63 400

In the end of the VII sub-period the old growing stock is exploited and the situation is quite a new and entirely different. The annual cut will be drawn from the new crops and it will be large enough for a permanent supply for dependent industries and other wood users.

The obtainable annual thinnings are 37 800 cu.ft. less than the annual cut in the past:

$$
\begin{array}{rr}
7\,900 + 7\,500 + 4\,300 + 4\,900 + 1\,000 = & 25\,600 \\
\text{deficit} & 37\,800 \\
\hline
 & 63\,400
\end{array}
$$

This deficit could easily be covered by adopting a 70 years' rotation. But if the value of large timber is still as high as it is now compared with the value of small wood, the 70 years' old crop will be at its highest rate of value increment

and its exploitation would be uneconomic. On the other hand the permanent supply for wood users must be guaranteed, which will justify the sacrificies on the part of future revenue. Therefore it is necessary and permissable to exploit a part of immature growing stock for the sake of the urgent need though the highest attainable yield will thereby be reduced in the future. This kind of sacrifices are often compulsory in the transition periods of progressive forestry.

The deficit can be covered by exploiting a part of the oldest growing stock or reducing its volume on an acre below desirable amount. E.g., the permanent annual cut is obtained by exploiting one half of the 75 years' old growing stock which gives 23 750 cu.ft.:

$$\frac{50 \times (4\,400 \times 5 + 70)}{10} = 23\,750$$

and by drawing the remaining 14 050 cu.ft. from the developable stock.

After this transition period, development will continue towards a desirable growing stock with 100 years' rotation (or whatever the most profitable rotation will be at that time) and the annual yield will gradually increase to the obtainable 111 cu.ft. on an acre or 77 700 cu.ft. in the calculation unit.

The exploitable trees will naturally be much smaller after the 70 years' exploitation period than they are during it. From the point of view of the saw milling this is by no means alarming. The concept of a saw timber tree will certainly change during these 70 years. The present sleeper and scantling production will gradually give place to modern methods by which the 70—100 years' old trees can be converted into sawn products much more profitably than the overmature and over-large trees are produced now by hand sawing.

The forecasted development of the growing stock, annual increment and annual cut is shown in Fig. 2. The course of the lines is typical for a case when an over-mature growing stock is exploited according to the principle of progressive yield. At first the annual cut is larger than the annual increment and the growing stock decreases. The exploited stock is replaced by new tree stands and after 3—4 decades the increment curve turns up. The growing stock curve follows later. Finally the annual increment reaches the desirable one. This forecast represents a drastic and determined effort to improve forests in poor condition. It is fundamentally dependent on the regeneration measures carried out promptly.

The annual cut given by this cutting budget is about 63 000 cu.ft. in the calculation unit and 6 200 000 cu.ft. in the Fir Working Circle. The annual cut is 80 per cent of the obtainable yield from the desirable forest and 72 per cent of the normal yield.

Compared with the yield prescribed in the present Working Plan (AGGARWAL, 1949) for the same area, which is 922 000 cu.ft. of Standard timber, the forecasted yield is many times higher. Though these two estimates are not quite compar-

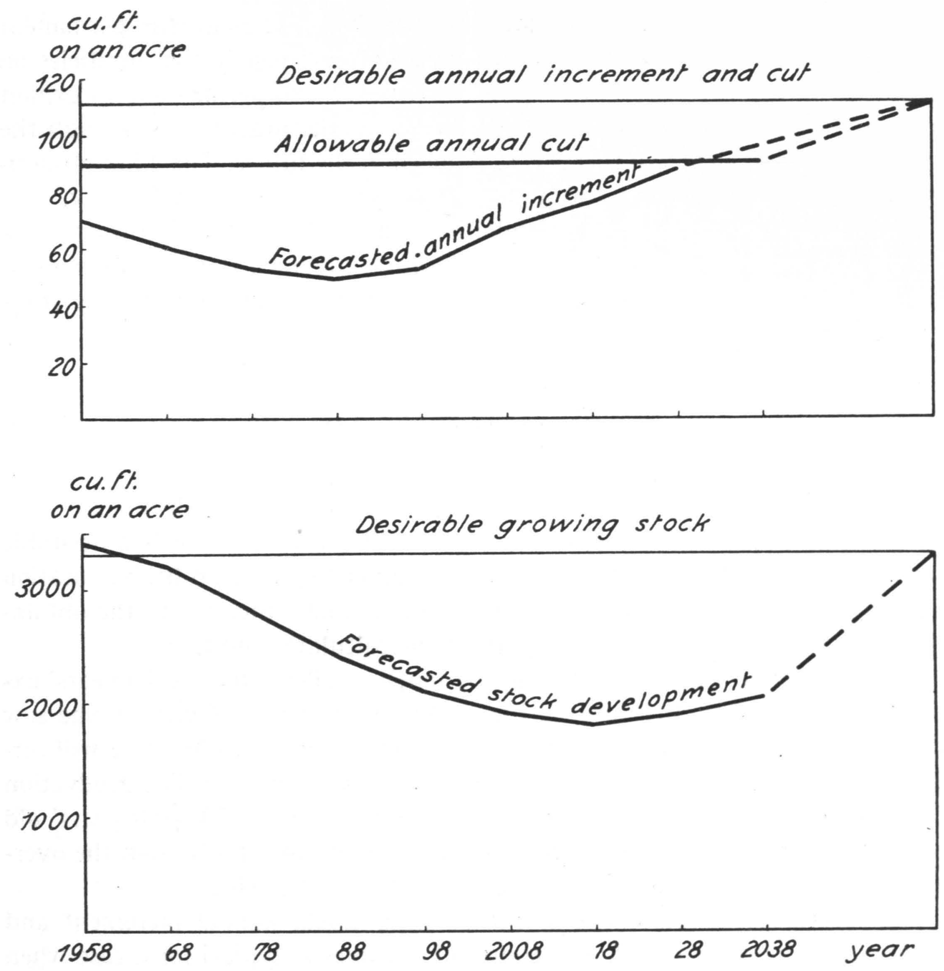


Fig. 2. Forecasted development of the growing stock, annual increment and annual cut.

able the result gives an idea what the yield of the Himalayan spruce and fir forests could be under progressive management.

The forecasted yield consists of Standard timber and small wood down to the limiting diameter of 2 inches. In Northern Europe the waste percentage in logging is usually less than 10 per cent. Keeping in mind the high value of wood in the Indian economy, the waste percentage as low as 20 per cent, caused by the stumps and felling losses, should be attainable. If the small wood percentage is 10 per cent and the conversion percentage for saw timber 40 per cent, the total yield of the near future is broken down into components:

Sawn products	1 800 000 cu.ft.
Small wood and sawing waste suitable for pulp	3 160 000 »
Unavoidable logging waste	1 240 000 »
Total	6 200 000 cu.ft.

The last but not the least striking conclusion in this reasoning is: If the logging waste is given to the local inhabitants they will receive more household wood from the forests under intensive management than in the forests in stagnation.

Summary

Though the Himalayan conifer forests are scattered and they lie on high altitudes and in difficult terrain their potential value is very important to the Indian national economy. Their extraction is obviously feasable in much larger scale than now. The present yield coming to the markets varies from 30 to 10 per cent, or even less, of the obtainable yied under intensive management and integrated utilization of wood. The obtainable yield could support comparatively large saw milling as well as pulp and paper industries.

The problems in developing the Himalayan conifer forestry are numerous. They cover the field of forest management, silviculture, re-forestation, logging, relations between forestry and the local population, forest administration, sale policy and industrial planning.

Estimating the actual possibilities requires complete and statistically reliable resource inventories. Growing trees for primitive sleeper production should be abondened, management systems modified in accordance with the principle of progressive yield, rotations, regeneration periods and cutting cycles should be shortened in order to increase the activity. The future management should be based upon the exploitation of the existing over-mature stock and upon the growth of the new tree stands.

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SELOSTUS:

HIMALAJAN HAVUMETSÄTALOUDEN JÄRJESTELYN JA METSIEN HAKKUUMÄÄRÄN LASKENNAN ONGELMIA

Havupuun käyttö Intiassa ja sitä kehitettäessä ratkaistaviksi tulevat ongelmat

Intian metsävarat ovat hyvin niukat, varsinkin jos niitä vertaa maan väestön määrään ja sen puun tarpeeseen tulevaisuudessa. Rakennus- ja polttopuu on jo nyt kallista. Laajeneva paperiteollisuus potee pysyvää raaka-ainepulaa. Ripeästi kehittyvä kansantalous tarvitsee tulevaisuudessa suunnattomat määrät paperituotteita, jotka on joko valmistettava omassa maassa tai tuotava ulkoa. Tällä hetkellä pääosa sanomalehtipaperista ja tekosilkkimassa ovat tuonnin varassa.

Toisaalta maassa on vielä laajahkoja vajaakäytössä olevia metsiä, joista ehkä arvokkaimmat ovat Himalajan vuoriston rinteillä kasvavat havumetsät. Ne ovat säilyneet vaikeakulkuisen maaston ja pitkien kuljetusteiden suojaamina. Niitten potentiaalinen merkitys on ilmeinen, mutta toistaiseksi niistä hakattavat puumäärät ovat olleet suhteellisen vähäiset. Hankintojen kohteena ovat olleet pääasiassa ratapölkyt ja paksut lankut. Lisäksi metsien tehtävänä on suojella vuorten rinteitä eroosiolta sekä tyydyttää paikallisen väestön puunkäytön ja laiduntamisen tarpeita.

Puun käyttö noudattaa syvälle juurtuneita perinnäistapoja eikä ole nykyaikaisessa mielessä läheskään paras mahdollinen. Uudenaikaistuvan Intian etujen mukaista on saada vähäisten metsävarojensa tuotteet mahdollisimman tarkoin järkevään käyttöön.

Himalajan havumetsien käytön tehostamista pidetään usein hankintatekniikan ongelmana. Puun hakkuu ja kuljetus onkin vuoristossa vaikeata, mutta asiaintilan kehittämisen tiellä on myös muita tekijöitä. Metsätalouden järjestelyn periaatteet ovat jäykät ja vanhoilliset. Pyrkimyksenä on kasvattaa erittäin järeitä yksittäisrunkoja ratapölkkyjen tuottamiseksi. Väestön tarpeiden tyydyttäminen sekä suojametsien kutakuinkin täydellinen rauhoittaminen hakkuilta ovat tärkeämpiä näkökohtia kuin puun kasvattaminen kansantaloutta varten. Eräitten puulajien metsänhoito on erittäin korkealla tasolla, mutta suurin osa kuusi- ja jalokuusimetsistä on yli-ikäisiä, luonnontilaisia tai harsimalla pilattuja. Hankintatekniikka on hyvin primitiivistä. Kaadetut rungot valmistetaan metsässä kirveellä ja käsisahalla ratapölkyiksi tai paksuiksi lankuiksi, jotka useimmissa tapauksissa kannetaan ihmisten selässä lähimmän uittoväylän varteen. Suurin osa arvokkaista rungoista jää hakkuutähteinä metsään. Uittoväylät ovat rakentamattomat ja uittovälineet mitä yksinkertaisimmat. Tasangolle kuljetettuina kuusesta ja jalokuusesta valmistetut pölkyt maksavat 200—250 mk kuutiojalalta, männystä tehdyt pölkyt noin 300 mk ja seetriset aina 700 mk. Paikallinen väestö pitää metsiä »ikimuistoisessa» nautinnassaan ja hävittää niitä jokaisessa sopivassa tilaisuudessa. Puun käyttö on yksipuolista ja tuhlaavaa.

Ennenkuin metsän käyttö tehostuu, niin metsätalouden järjestelyn, metsänhoidon, hankinnan, paikallisen puunkäytön ja markkinoinnin ongelmat on ratkaistava ja niitä ratkaistaessa on otettava huomioon Intian metsätalouden historiallinen tausta sekä kansalliset tavat ja tottumukset.

Metsätalouden järjestely

Yleiset olosuhteet

Pohjois-Intian havumetsävyöhyke sijaitsee Himalajan vuoriston etelärinteillä. Tasangon pohjois-laidalla ilmasto on kuuma ja kuiva tai vähäisillä korkean sademäärän alueilla troopillinen. Havumetsät alkavat sub-troopillisesta ilmastosta ja ulottuvat alpiiniselle metsänrajalle 3 000—3 700 m merenpinnan yläpuolella. Vuotuinen sademäärä vaihtelee havumetsien alueella 1 000 mm:n molemmin puolin ja on paikoitellen yli 3 000 mm. Suurin osa sataa monsuunin aikana heinä- ja elokuussa. Toinen vähäisempien sateiden aika on tammi- ja helmikuussa. Kahdesta kolmeen kuukauteen kestävä lumipeite alkaa 2 000—2 500 m:n korkeudella merenpinnasta.

Metsät ovat kaikki valtion omistuksessa. Jokaisella osavaltiolla on oma metsähallintonsa, alayksikköinä piirikunnat ja hoitoalueet. Talouden piirissä oleva metsäala on hoitoaluetta kohden 20 000—40 000 ha, vuoristossa aina 200 000 ha.

Teitten ja yhteyksien laatu vaihtelee suuresti riippuen siitä, kuinka syvällä vuoristossa metsät sijaitsevat. Muutamissa hoitoalueissa ovat ratsupolut ainoat yhteydet ulkomaailmaan ja puu kuljetetaan yksinomaan uittamalla. Lähellä tasankoa tyydyttää maantieverkko kutakuinkin metsätalouden tarpeet. Rautateillä ei sensijaan ole mitään merkitystä havumetsäalueella. Uitto on selvästi tärkein kuljetusmuoto.

Puulajit

Himalajan havumetsäalueen länsiosassa on viisi metsää muodostavaa puulajia. Alinna, 460—1 500 m merenpinnan yläpuolella kasvaa pitkäneulasmänty (*Pinus longifolia*, Roxb.). Sen yläpuolella 1 500—2 400 m:n korkeudella on seetrin (*Cedrus deodara*, London) ja sinimännyn (*Pinus excelsa*, Wall.) vyöhyke. Ylinnä, 2 400—3 700 m:n korkeudella kasvavat kuusi (*Picea morinda*, Link.) ja jalokuusi (*Abies pindrow*, Spoch.). Vyöhykkeiden rajakohdissa ovat sekametsät yleisiä. Alimmassa vyöhykkeessä tavataan lukuisia sub-troopillisia lehtipuita. Muualla on tammi yleisin lehtipuu. Se nousee myös jalokuusen kanssa korkeimmalle ja on metsänrajaa muodostava.

Metsävarat ja puuston kasvu

Sivuille 18—22 on metsätalousasiakirjoista koottu tietoja tärkeimpien havumetsätyyppien metsävaroista. Parhaissa hoitolohkoissa on havupuun kuoreton keskikuutio 190—240 k-m³ hehtaarilla. Varttuneissa ja täysitiheissä metsiköissä on 500—600 k-m³ tavallista. Huonoimmissa vielä talousmetsiin luettavissa hoitolohkoissa keskikuutio on noin 100 k-m³. Puusto on erittäin järeätä. Niinpä kuusimetsissä rinnantasalta yli 36 tuuman vahvuiset puut käsittävät noin 30 % kokonaiskuutiomäärästä. Mänty- ja seetrimetsissä vastaava osuus on noin 10 %.

Taulukossa 1 (s. 21) on esitetty kasvutaulukoiden mukaiset kuorettomat keskikasvut eri tuottoluokille, käyttäen seetrille sekä männylle 100 vuoden kiertoaikaa ja sinimännylle 80 vuoden kiertoaikaa. Järeä puu käsittää yli 8 tuuman vahvuisen puun sekä pienpuu vahvuudeltaan 2 ja 8 tuuman välissä olevan puun. Näin laskettu keskikasvu on parhailla mailla 13—15 k-m³.

Taulukossa 2 (s. 22) on hyvin hoidetuista metsistä saatavaksi arvioitu keskikasvu, jota on verrattu taloussuunnitelmien hakkuusuunnitteeseen sekä nykyisillä hankinnan menetelmillä hakkuusuunnitteesta saatavaan käyttöpuun määrään. Hakkuusuunnite on vajaat 20 %

hyvin hoidetun metsän keskikasvusta. Kun suurin osa kaadetuista puista jää hakkuutähteinä metsään, niin käyttöpuuta saadaan edullisimminkin sijaitsevissa hoitolohkoissa enintään 0.5 k-m³ hehtaaria kohden. — Pitkäneulasmännyn tuottoa arvosteltaessa on otettava huomioon, että siitä saatava pihka on arvoltaan paljon suurempi kuin sen tuottama käyttöpuu.

Metsätalouden järjestelyn periaatteet

Metsätalouden järjestelyn periaatteet ovat peräisin brittiläisen hallinnon ajalta. Päätavoitteina on säilyttää metsäkasvillisuus rajankäynnein erotetuilla alueilla maan suojelemiseksi eroosiolta, pitää väestö tyytyväisenä antamalla sille laajoja metsänkäyttöoikeuksia sekä harjoittaa kaupallista metsätaloutta sikäli kuin se on mahdollista. Joskin eräillä alueilla on hyvin hoidettuja metsiä, niin kokonaiskuvalle ovat ominaisia laajat metsänhävitykset, jotka pienentävät mahdollisuuksia tuottaa puuta sekä tuhoavat maatalousvaltaisen väestön edellytyksiä elää vuoristossa.

Metsät on ryhmitetty 30 vuoden pituisiin käsittelyperiodeihin. Iältään vanhimpien metsikköjen uudistusjakso on siis 30 vuotta. Kiertoaika on laskettu niin, että sen kuluessa puut saavuttavat keskimääräisen koon, josta saadaan mahdollisimman edullinen sahaustulos metsässä käsisahalla. Tämän mukainen hakkuukypsän puun läpimitta rinnantasalla on 24—28 tuumaa ja vastaava männyn sekä seetrin kiertoaika 120 vuotta ja kuusen sekä jalokuusen 150—180 vuotta. Järeitten yksittäisrunkojen kasvattamisesta on luonnollisesti seurauksena suhteellisen pieni kuutiotuotto pinta-alayksikköä kohden. — Edellä lyhyesti kuvattua järjestelyn menetelmää vastaa hyvin käytössä oleva inventointimenetelmä. Inventoinnissa luetaan kaikki rinnantasalta 8 tuumaa täyttäneet rungot.

Koska pienpuuta on vaikea markkinoida, niin nuorien metsiköiden kehitys on usein ylitiheyden vuoksi hidasta. Vanhat metsiköt, lähinnä kuusikot, ovat harsinnanluontoisten hakkuiden vuoksi repaleisia, yli-ikäisiä ja lahovikaisia.

Mänty ja seetri uudistetaan siemenpuu- ja suojuspuuhakkuilla. Kuusi- ja jalokuusimetsiä käsitellään yleisesti harsintahakkuilla tai harsinnan luontoisilla suojuspuuhakkuilla. Pyrkimys kasvattaa vanhoja pienikokoisia puita vahvistettuun käyttöpuun kokoon johtaa pitenevään kiertoaikaan ja suureneviin luonnontuhoihin.

Mikäli metsien hyväksikäyttöä aiotaan lisätä, on järjestelyn periaatteita kehitettävä niin, että runsaan ja arvokkaan puun tuottaminen on mahdollista niillä alueilla, jotka varataan metsän kasvulle. Näillä alueilla on puun kasvattaminen asetettava ensisijaiseksi tavoitteeksi. Metsien tilan parantamisen edellytyksenä on, että yli-ikäiset ja alitiheät puustot uudistetaan määrätietoisesti, ja että kiertoaikoja lyhennetään. Metsikön uudistamiseen käytettävä aika olisi saatava paljon lyhyemmäksi kuin nykyiset 30 vuotta. Erittäin edullisessa ilmastossa näkyisivät metsän uudistamisen ja sen viljelyn tulokset nopeasti.

Harsintahakkuiden jatkaminen yli-ikäisissä kuusikoissa johtaa väistämättömästi metsien tilan heikkenemiseen. Kuusi- ja jalokuusimetsien käsittelemiseksi olisi laadittava keskitetyn eksploatoinnin ja uudistamisen suunnitelma. Vanhojen puustojen nopeasta hakkaamisesta saataisiin varoja metsätalouden kehittämiseksi ja uudet puusukupolvet takaisivat metsätalouden jatkuvuuden sekä tulevaisuudessa suurenevan hakkuumäärän.

Nykyinen puun käyttö ja alkeellisesta hankintatekniikasta johtuvat korkeat hankintakustannukset eivät ole oikeat perusteet kiertoaikalaskelmien suorittamiseksi. Kasvutaulukoiden perusteella näyttävät seuraavat kiertoajat sopivilta: Seetri, 80—100 vuotta; pitkäneulasmänty, 100 vuotta; sinimänty, 60—80 vuotta; kuusi ja jalokuusi, 100 vuotta.

Hakkuulaskelman periaatteita

Metsien hakkuumahdollisuuksien selvittämiseksi sopii hyvin suomalainen tuottohakkuulaskelma. Kun puustotiedot tunnetaan periodeittain, niin laskelma voidaan suorittaa periodittaisena analyysinä, mikä vastaa ikäluokittaista analyysiä.

Hakkuulaskelma kuusi- ja jalokuusimetsien uudistamiseksi

Kulun ja Seraj'n hoitoalueen kuusi- ja jalokuusimetsien uudistamiseksi sekä yleisten hakkuumahdollisuuksien selvittämiseksi on kirjoittaja laatinut hakkuulaskelman 70 vuoden jaksolle. Joskin käytettävissä olevat puustotiedot ovat puutteelliset, on laskelma kuitenkin suoritettavissa niin, että määrätietoisen metsien käsittelyn tulokset tulevat esille.

Sivuilla 29—31 on esitetty ne puusto- ja kasvutiedot, joille laskelma perustuu, taulukossa 5 (s. 32) on itse laskelma ja piirros 2 (s. 34) kuvaa laskelman mukaista keskikuution, kasvun ja hakkuumäärän kehittymistä kohden tavoitemetsän arvoja. Laskennan yksikkö on 700 acrea, joista 100 acrea uudistetaan kunkin 10 vuoden alajakson aikana.

Voimakkaiden hakkuiden vuoksi pienenevät sekä keskikuutio että kasvu alussa, mutta kun uudet ikäluokat ohittavat varsinaisen taimistovaiheen, niin kasvun kehittymistä osoittava murtoviiva kääntyy nousevaksi ja vetää keskikuution kehityskäyrän mukaansa. Noin 100 vuoden kuluttua käyrät lähestyvät tavoitemetsän arvoja. Kestävä hakkuumäärä on järeän puun osalta viisinkertainen nykyisin voimassa olevaan hakkuusuunnitteeseen verrattuna.

Laskelma osoittaa selvästi, että yli-ikäisten metsien käsittelyn tulee olla rohkeata eksploatoimista ja voimaperäistä uudistamista. Vanhojen puustojen eksploatoiminen vapauttaa metsässä seisovia pääomia taloustoiminnan kehittämiseksi ja voimaperäinen uudistaminen on ainoa korkean hakkuumäärän tae. Edellä kuvatuissa olosuhteissa nykypuuston hoitaminen ja sen kasvu eivät paljoakaan vaikuta kestävän hakkuumäärän suuruuteen vaan se on yksinomaan riippuvainen onnistuneiden metsänuudistusten määrästä.

Päätelmät

Vaikka Himalajan havumetsät sijaitsevatkin korkealla vaikeakulkuisessa vuoristossa ja ovat hajallaan laajalla alueella, niin niiden käytön tehostamisesta olisi Intian metsätaloudelle erittäin paljon hyötyä. Metsän kasvukyvyn ja metsänhoitoteknillisten tekijöiden puolesta voitaisiin hakattavia puumääriä 3—5-kertaistaa. Tällä raakapuumäärällä voitaisiin ylläpitää huomattavaa sahaustoimintaa sekä myös selluloosa- ja paperiteollisuutta.

Metsätalouden kehittämiseksi on ratkaistava lukuisia ongelmia, jotka ulottuvat varsinaisen metsätalouden alueelta sivistyksellisen ja teknillisen tason kohottamiseen, metsäpoliittisiin uudelleen järjestelyihin ja teollisuuden perustamiseen. Metsänkäytön tehokkuus ei ole irrallinen alue vaan se on riippuvainen koko yhteiskunnan taloudellis-teknillisestä tasosta ja suorituskyvystä.

Varsinaisista metsätaloudellisista tehtävistä havumetsien käytön tehostaminen edellyttää ennenkaikkea luotettavaa metsävarojen inventointia, metsätalouden järjestelyn periaatteiden ja menetelmien uudelleen muotoilua, hankintatekniikan ja kuljetusten kehittämistä sekä yli-ikäisten puustojen uudistamista ja aukeiden alueiden metsittämistä.

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