KFRI Research Report 40

FOREST MANAGEMENT SYSTEM IN THE TROPICAL MIXED FORESTS OF INDIA

C.T.S.Nair
Mammen Chundamannil

KERALA FOREST RESEARCH INSTITUTE
PEECHI, THRISSUR

July 1985 Pages: 91

CONTENTS

		Page	File
	Abstract	ii	r.40.2
1	Introduction	iii	r.40.3
2	Forests and forest management	1	r.40.4
3	Selection system	21	r.40.5
4	Shelterwood systems	39	r.40.6
5	Coppice systems	55	r.40.7
6	Clearfelling system	65	r.40.8
7	Society, forests and forest management	76	r.40.9
8	References	88	r.40.10

SUMMARY

The tropical mixed forests of India form an important natural resource providing a variety of goods and services. Depending upon the vegetation characteristics and the prevailing socio-economic conditions these forests are managed under different silvicultural systems. An analysis of various systems in vogue indicate considerable divergences between theory and practice. What is actually followed seldom. resemble what is described in silvicultural text books.

Selection, shelterwood and coppice systems rely entirely on natural regeneration. Although overtime clearfelling followed by artificial regeneration is increasing in importance, as such natural forests supply most of the wood requirements. A detailed study of the management practices indicates the limitations of present approaches. In most cases regeneration has been neglected, seriously undermining sustainable production of goods and services. Fire, grazing and other biotic factors have further complicated the situation accelerating the degradation process. The low growing stock and poor increment in Indian forests are attributable to this.

Developments in biological and technical sciences have not significantly influenced the management of natural forests. Institutional changes in forest administration have been marginal and policing of forest property continues to be the main function. Establishment of forest development corporations have not improved natural management as they have mostly concentrated on clearfelling and artificial regeneration with profitability as the main objective.

Given the low growing stock, uncertainty of natural regeneration and severe biotic pressures, natural management has serious limitations in fulfilling the various social needs. Inteneively managed plantations raised on the extensive barren and degraded land alone can reduce the pressure on natural forests, and thus facilitating their sustainable management.

INTRODUCTION

The growing demand for goods and services in the context of declining resource base has made forest management extremely complex. This is particularly so in the case of developing countries,. in the tropics where land use conflicts are very severe. On. the. one hand there is an urgent need to utilise forest resources to promote economic development. At the same time it is also necessary that social and protective values of forests are not undermined. An understanding of how existing forest management systems are geared to fulfil the different objectives will give valuable information on their merits and demerits and may give an indication of the future course of evolution. The Food and Agriculture Organisation has initiated a study to collect and analyse relevant information on the most successful or most widely adopted forest management systems in the tropical mixed forests in Asia. This study on management systems in India was undertaken as part of the study on Asian forests.

Objectives of the Study: The objectives of the study are,

1. to review the current state and status of management in the mixed tropical hardwood forests,

2. to assess the extent to which advances in knowledge pertaining to biological, technological, socia1,management and orgaaisational sciences have influenced, been incorporated in or been neglected in recent developments in improving the design, operation and performance of forest management systems and

3. to indicate the possibilities for the future of natural management in the mixed tropical hardwood forests and the likely direction.

The study is restricted to the evergreen (including semi-evergreen), moist deciduous and dry deciduous forests which form the major forest types accounting for about 78 percent of the total forest area in India. For the purpose of this study, forest management system is defined as the silvicultural and yield regulatory procedures and operations prescribed together with the interactive ecological, social, industrial, . conservational, political, institutional and financial objectives and constraints underlying those prescriptions.

Plan of Study: The study is presented in six chapters. Chapter 1 gives an overview of forests and forestry in India. In addition to giving a brief account of the important cteistics of the forests, Chapter 1 traces the evolution of different silvicultural systems, and the area of forests worked under each in some of the important states. Chapter 2 to 5 discusses the salient features of important systems like selection (Chapter 2), shelterwood (Chapter 3), coppice (Chapter

4) and clearfelling (Chapter 5). Societal and forest characteristics that have favoured the adoption of each system and their positive and negative contributions are also described. Chapter 6 discusses how developments in biological, technical and organisational changes have influenced or have been incorporated into forest management systems. The future of natural management in India is also discussed in Chapter 6

CHAPTER 1

FORESTS AND FOREST MANAGEMENT: AN OVERVIEW

On account of variation in climatic, edaphic and physiographic factors, Indian forests present a wide spectrum of variability in terms of structure, physiognomy, floristics, etc. Man forest interaction also differs considerably and consequently the type of benefits and their quantum also vary, both in space and tine. This chapter gives a brief account of the most important mixes tropical forests in India and certain salient features of the evolution of management systems in vogue now.

1.1 FORESTS: A forest type is a natural unit with more or less well defined characteristics, especially as regards physiognomy, floristics, etc. Despite the drawbacks of the type classification by Champion (1936) and Champion and Seth (1968) (Puri, et al, 1983), it continues to be the basis for all forest management purposes. Area under important type groups under the broad category of tropical forests is given in table 1.1.

Table 1.1

Area under Tropical Forests

Major group	Type group	Area (in million ha)
Tropical Forest		
(1) Moist Tropical Forests	i. Wet Evergreen	*4.503*
	ii. Semit Evergreen	*1.854*
	iii. Moist Deciduous	23.303
	iv. Littoral and Swamp	0.671
(2) Dry Tropical Forests	v. Dry Deciduous	29.154
	vi. Thorn Forests	5.236
	vii. Dry Evergreen	0.075
Total		64.796

Source: Puri, et a1 (1983)

Tropical forests thus account for 86 percent of the total forest area in the country[1]. Of these the wet evergreen, semi-evergreen, moist deciduous and dry deciduous are the most important as regards wood production and management of these have a long history. Important characteristics of these forests which have a direct bearing on forest management are discussed below.

1.1.1 Tropical evergreen forests: Evergreen forests are found in the high rainfall zone (exceeding 2500 mm per annum) and are distributed in three widely separated regions namely, (1) Western Ghats, (2) Andaman and Nicobar Islands and (3) North Eastern Region (See Fig.1.1). Distribution of these forests in these regions is given in table 1.2.

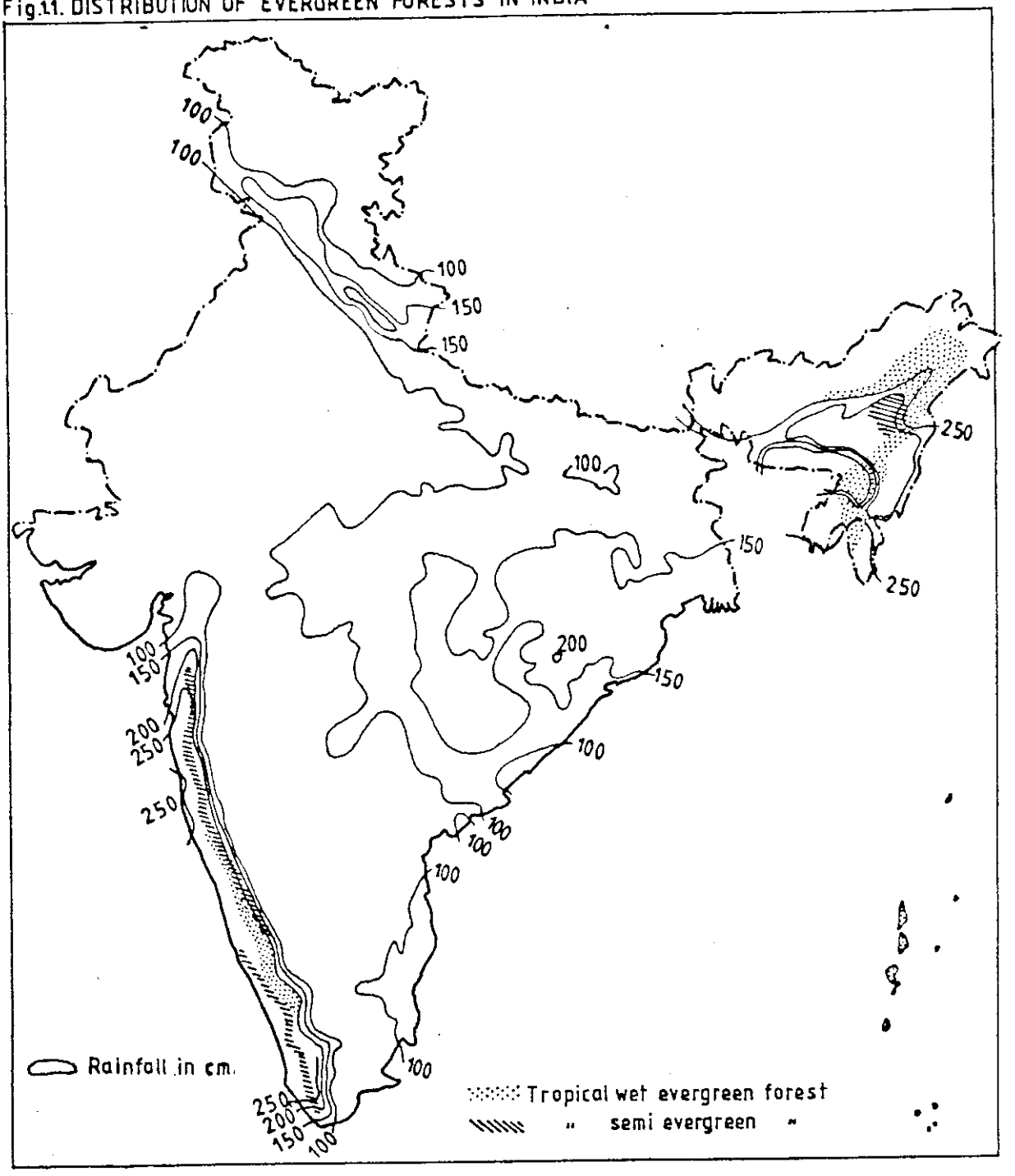
Table 1.2

Distribution of Evergreen Forests

Region	States	Area (in mill. ha)
1. Western Ghats	Karnataka, Kerala, Tamil Nadu, Goa, Maharashtra	1.19
2. Andaman and Nicobar Islands	Andaman and Nicobar Islands	0.63
3. North Eastern Region	Assam, Arunachal Pradesh, Nagaland, Manipur	2.68
Total		4.50

In structure and physiognomy there is very little difference between forests in the different regions. Trees are generally

Fig.11. DISTRIBUTION OF EVERGREEN FORESTS IN INDIA



arranged in tiers with dominants in the top canopy attaining a height of over 40 meters. Tropical evergreen forests are characterised by the presence of a large number of species and gregariousness is an exception than the rule. Smooth bark, large buttresses, cauliflory, etc. are some of the notable features of the trees. On account of the multitiered arrangement, light availability near the ground level is poor permitting little or sparse undergrowth.

The tropical wet evergreen forests in India are categorised into two sub groups, southern and northern,. the former consisting of forests in the Western Ghats and Andaman and Nicobar Islands and the latter found in the North Eastern Region (Champion and Seth 1968). Important climatic climax types under the southern sub group are as follows:

Southern Tropical Wet Evergreen Forests: Champion and Seth (1968) distinguish the following climatic climax types.

1. Giant Evergreen Forests	Andaman and Nicobar Islands
2. Andamans Tropical Evergreen Forests	
3. Southern Hill Top Evergreen Forests	Western Ghats
4. West Coast Tropical Evergreen Forests	

The Giant Evergreen Forest is the most luxuriant of the sub-types and occurs on deep alluvial soil with good moisture availability. Important species found in these forests are Dipterocarpus alatus, D. grandiflorus, D. gracilis, Calophyllum soulattri, Artocarpus chaplasha, Sideroxylon longepetiolatum, Amoora wallichii, Planchonia andamanica, Endospermum chinensis, etc. The composition of the Andaman tropical evergreen forest is very similar to that of the giant ever-greens except that the former is less luxuriant than the latter. In addition to Dipterocarpus spp., Artocarpus chaplasha, Calophyllum soulattri, Sideroxylon longepetiolatum, Myristica andamanica, Planchonia andamanica are the important species. On account of

inaccessibility and absence of habitation, forests in the Islands remained in a pristine condition till the latter half of the 19th century. Even now, the biotic pressure is negligible in comparison with the main lane. There are about 200 species of trees of which only 30 are commercially valuable (Bathew, 1983).

The West Coast Tropical Wet Evergreen Forests occur over the entire length of the Western Ghats from North Canara in Karnataka to Kerala and extends to portions of Tamil Nadu in the south and east. Dominant species in the top canopy are Dipterocarpus indicus, Vateria indica, Acrocarpus fraxinifolius, Calophyllum spp. Cullenia exarillata, Hopea parviflora, Mesua nagassarium and Dichopsis elliptica. Although gregariousness is an exception, associations are reco nised on the basis of dominant trees in the top canopy.

Several edaphic subtypes of the evergreen forests have been described (Champion and Seth, 1968) and their occurrence is primarily guided by soil characteristics which influence moisture availability. Reed and cane brakes occurring in wet pockets are important edaphic forms. Although their contributon towards wood production is very low, they supply valuable raw material to both traditional and modern industries (Nair, 1965). An interesting edaphic subtype is the Andaman Moist Deciduous forests occurring on freely draining slopes in the Islands. Species composition of this is given later.

Northern Tropical Evergreen Forests: This occurs in the North Eastern Region and three sub-types, namely, (1) Upper Assam Evergreen Forest, (2) Cachar Tropical Evergreen Forest and (3) Assam Valley Evergreen Forest, are identified (Champion and Seth, 1968). On account of shifting cultivation and other biotic factors the latter two types are in a highly degraded condition. Upper Assam forests occur in ArunachaI Pradesh (Tirap and Lohit divisions), Assam (Dibrugarh, Doomdooma and Digboi divisions) and Nagaland (Mon division). Important species in these forests are Dipterocarpus macrocarpus, Shorea assamica, Mesua nagassarium, Terminalia

Phoebe goalparensis, Hopea spp. etc. One of the distinguishing characteristics of the Upper Assam forests is the gregarious occurrence of Dipterocarpus macrocarpus (Hollong) and Shorea assamica (Makai) which together often account for about 80 percent of trees in the top canopy.

1.1.2 Semi-evergreen Forests: Semi-evergreen forests occur in the transitional zone between evergreen and moist deciduous forests where the annual precipitation varies from 2000 to 2500 mm. Like the evergreen forests, these also have a multistoreyed structure. The top canopy comprises of a mixture of deciduous and evergreen species while the understorey is almost entirely constituted by evergreens. Here also, two subgroups, southern and northern, are distinguished. Some of the climax formations under the southern subgroup are (1) Andaman semi-evergreen forest and (2) West Coast semi-evergreen forest. West coast secondary semi-evergreen dipterocarp forest is an important sera1 sub-type occurring in the Western Ghats.

In Andamans the semi-evergreen forest occurs in the valleys on well drained alluvial soil. Commercially important species are Dipterocarpus alatus, D. pilosus, Pterygota alata, Pterocymbium tinctorium, Terminalia bialata, Terminalia procera, Albizia chinensis, Albizia lebbek, Pterocarpus dalbergioides, Lagerstroemia hypoleuca, etc. In the Western Ghats semi-evergreen forests are found in Kerala, Karnataka, Goa and Maharashtra. Important species are Haldina cordifolia, Calophyllum tomentosum, Hopea parviflora, Spondias mangifera, Tetramales nudiflora, Terminalia paniculata and Vitex altissimma. Bambusa arundinacea is the most important bamboo species. Reed brakes (Ochlandra spp.) are also found in moist areas, especially along water courses.

The Northern tropical semi-evergreen forests occur in the North Eastern Region and extends to the moist regions in Bengal and Orissa. In comparison with the Southern form, the flora is poor and less diverse. Important climax types are (1) Assam Valley semi-evergreen

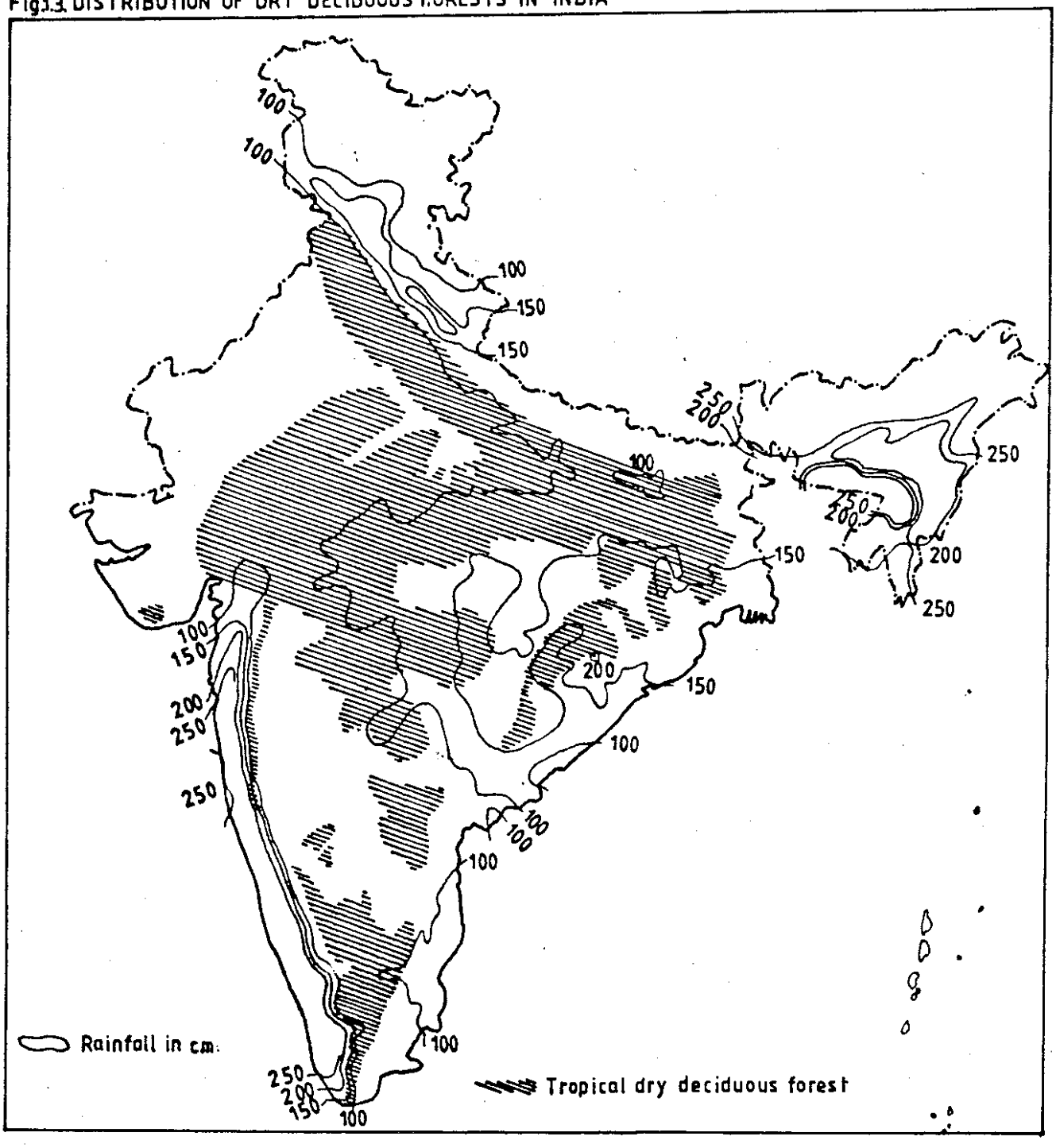
tomentosa, Grewia tiliaefolia, Lagerstroemia microcarpa, Xylia xylocarpa. Dalbereia latifolia, Haldina cordifolia and Pterocarpus marsupium. Most common bamboo in the moist localities in the South (Kerala and Karnataka) is Barnbusa arundinacea while Dendrocalamus strictus occurs in drier regions.

On the basis of presence or absence of Sal, the northern moist deciduous forests are divided into sal forests and mixed forests[3]. The former is characterised by the gregarious occurrence of Shorea robusta (Sal) which sometimes accounts for about 80 percent of the trees. Sal forests occur all along the sub Himalayan belt, from Himachal Pradesh to Assam, in the Gangetic plains, Chotanagpur plateau. Orissa coast, Andhrn Pradesh and parts of Madhva Pradesh. Characteristic species are Shorea robusta. Terminalia tomentosa. T. bellirica. Haldina cordifolia. Madhuca indica, Schleichera trijuga, Ougenia oojenensis, and Mangifera indica. Dendrocalamus strictus is thc most common bamboo. Composition of the mixed type is very similar to tne sal forests except that sal is scarce or totally absent.

Although floristically the moist deciduous forests are less diverse than and inferior to evergreen forests, they are extremely valuable comercially. Alnost all the species are utilised either as timber or firewood. These forests form the most important source of saw logs.

1.1.4 Dry deciduous forests: Dry deciduous forests occur in the rainfall zone of 1000 to 1500 mm with a long dry season extending over 6 months. These forests are found in the Deccan plateau, the Narmada and Tapti valleys and extends to the Gangetic plains (See Fig.l.3). Typically this contains fewer species than the moist deciduous type and almost all species are deciduous. Two subgroups, southern and northern are distinguished under this type. Three important climax types under the southern subgroup are (1) teak forests (2) red sander forests and (3) mixed forests. The most

Fig.1.3. DISTRIBUTION OF DRY DECIDUOUS FORESTS IN INDIA



common species in the southern types are Tectona grandis, Anogeissus latifolia, Diospyros melanoxylon, Boswellia serrata. Emblica officinales, Acacia leucophloea, Bridelia retusa, Wrightia tinctoria, Pterocarpus marsupium, etc. Apart from teak, some of the valuable species like Santalum album and Pterocarpus santalinus are found in these forests. The most common bamboo is Dendrocalamus strictus.

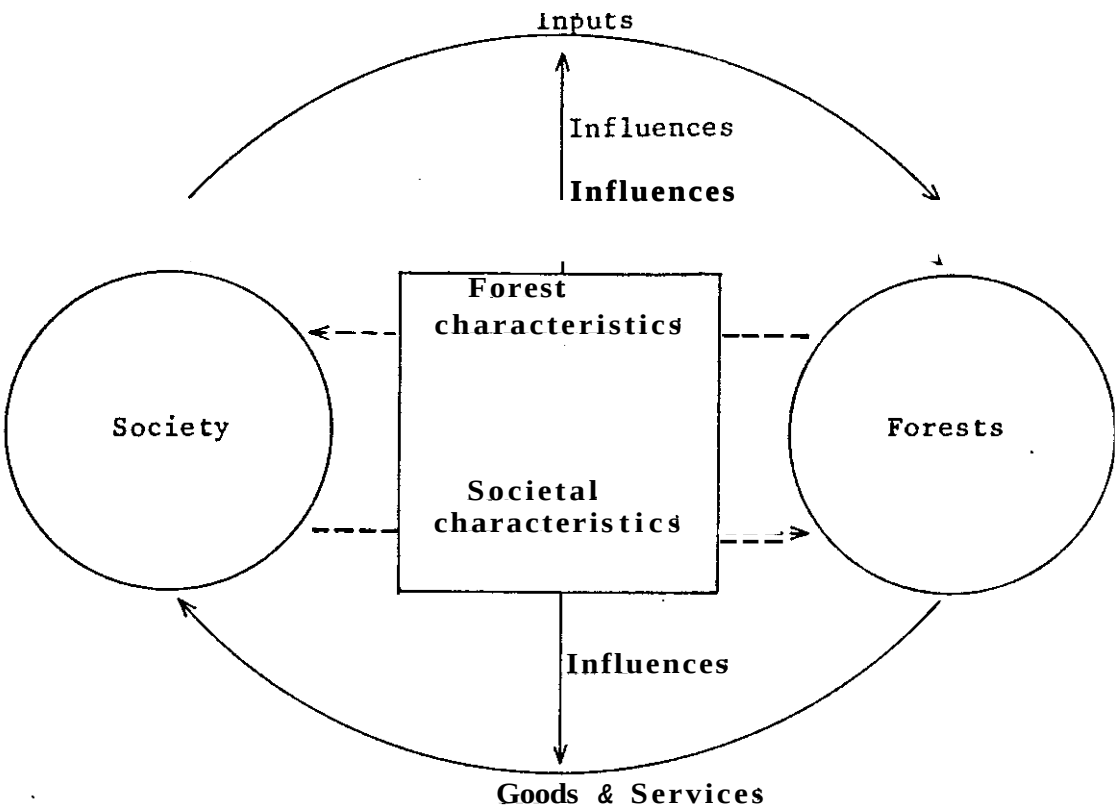
The northern subgroup is divided into sal bearing forests and mixed forests depending upon the presence or absence of sal (Shorea robusta). Sal is of inferior quality and the chief associates are Anogeissus latifolia, Buchnania lanzan, Terminalia tomentosa, Emblica officinales and Lannea coromandalica. In the mixed type species composition is essentially the same, except that sal is absent. As in the case of other forest types several subtypes and sera1 forms have been distinguished, based on floristics and locality factors.

Most of these forests are subjected to severe biotic interferences, particularly fire and grazing. Productivity of these forests is low, but removal far exceeds this, causing degradation. Firewood is probably the most important product from these forests. In addition, a large quantity of bamboo is also obtained. Other valuable products include tendu leaves (Diospyros melanoxylon), sandal wood, red sanders, etc.

1.2 MANAGEMENT SYSTEMS: Forests can produce a variety of goods and services, singly or in combination, depending upon the type and intensity of management to which they are subjected to. Forest management invo1ves the organised application of any particular silvicultural procedure to regulate and control yield and to ensure restocking of harvested areas to achieve pre-determined objectives. Management is thus an interaction between societal and forest characteristics as depicted in Fig.l.4.

The forest characteristics include species composition, accessibility, and synecology and autecology of species, while societal factors that influence management are pattern of ownership, objectives of the owner and the socio-economic environment in which the

Fig. 1.4. Forest - Society interaction



owner has to manage the property. The pattern of ownership of forests in India is given in table 1.3.

Table 1.3

Ownership of Forests

Type	Percentage of total area
Government	95.8
Corporate	2.6
Private	1.6

About 52.2 percent of the total forest area is constituted as reserved forests under the Indian Forest Act and here most of the rights have been settled/abolished[4]. Protected forests account for about 31 percent and these are burdened with rights. Often dual control exists in these forests in which land is under the control of the revenue department while protection of tree growth is the responsibility of the forest department. The balance 16.8 percent is unclassed forests. Management is effective only in the case of reserved forests which are worked systematically on the basis of regular working plans. About 66 percent of the forest area is now covered by working plans or working schemes (Central Forestry Commission, 1980). In the initial stages regulating the otherwise uncontrolled felling was the main objective of the working plans/ schemes and apart from isolated efforts, very little attention was paid to regeneration. Working plans are usually prepared for a division and areas identified for a specific set of treatments under a given silvicultural system are included in a working circle. Important silvicultural systems applied to different forest types are indicated below.

1.2.1 Silvicultura1 systems: A silvicultural system is a method by which crops consisting of forests are tended, harvested and replaced by new crops of distinctive forms in accordance with the accepted silvicultural principles'. The main components of a silvicultural system applied to natural stands are **(i)** harvesting the tree growth that already exists, (2) regeneration of felled areas and (3) tending the regeneration ti11 maturity to fulfill pre-determined objectives. A system is distinguished on the basis of the nature of operations carried out during harvesting, regeneration and tending as given be low.

1. Harvesting	1.1 Selective felling	Selective felling in a specified area adopting a felling cycle.
	1.2 Clearfelling	i. Clearfelling of an area spread of over a number of years
		ii. Clearfelling of an area in one operation
2. Regeneration	2.1 Natural	Seedling or Coppice
	2.2 Artificial	
3. Tending	3.1 Low intensity	
	3.2 High intensity	

Adoption of a silvicultural system involves the application of certain inputs to the forests at the stages of harvesting, regeneration and tending leading to the generation of specific goods and services. Over time, however, changes are brought to systems response to the changes in societal and forest characteristics.

Development of agriculture, industry and the changing priorities of government have considerably influenced forest management and for a large country like India, it is extremely difficult to compress the complex history into a general pattern. Table 1.4 gives the broad trend in the development of forestry in India.

Table 1.4

Development of Forestry

Period	Factors influencing forestry	Consequences
Prior to 1900	I. Demand limited to high quality timber for railway sleepers, construction etc. Poorly developed accessibility	Adoption of selective felling. Limited extent regenerated artificially. This is mostly limited to teak.
	2. Demand for fuel	Coppice system
	3. Need to increase land revenue	Transfer of forest land for agriculture, especially where it cannot produce good quality timber
1900-1910	Increasing demand for sawn wood	Accessibility was improved to tap more areas under selective felling
1910-1920	High demand for wood for defence and railways due to war. Setting up of industries. Improved accessibi1ity	In many areas under selective felling, systems of concentrated regeneration were attempted. Adoption of uniform system for Sal. But prescriptions were often set aside to meet war demand
1920-1940	Initially high demand continued, but later slumped due to recession	Adoption of intensive working methods. But slump in demand Zed to non-observance of working plan prescriptions
1940-1950	High demand due to war. Expansion of wood-based industries. Improved accessibility shortage of food; land reform acts	Non-compliance of working plan prescriptions and large scale exploitation of easily accessible areas. Deforestation for expansion of agriculture. Vesting of extensive jamindari forests burdened with rights with government
1950-1960	Growth of wood based industries. Development of agriculture	Exploitation of forests to meet industrial requirements. Improvement of accessibility. Consolidation of vested forests. Deforestation for expansion of agriculture
1960-1970	Growth of the pulp and paper industry and other wood based industries. Degradation of forests	Expansion of the plantation programme, especially by clearfelling natural forests. Large scale introduction of exotics. Afforestation and rehabilitation programmes. Farm forestry
1970 onwards	Rapid growth of wood-based industries – Emphasis on industrial orientation of forestry. Increasing rural energy crisis	setting up of forest development corporations to undertake large scale man-made forestry programme by clearfelling the mixed forests. Social forestry programme including farm forestry

In response to the changes, especially increasing demand, improved accessibility, etc. silvicultural systems have undergone changes as indicated in Fig. 1.5.

Table 1.5 gives the major silvicultural systems applied to Indian forests and their important characteristics (See, Ram Prakash and Khanna, 1979).

Table 1.5

Silvicultural Systems Applied to Indian Forests

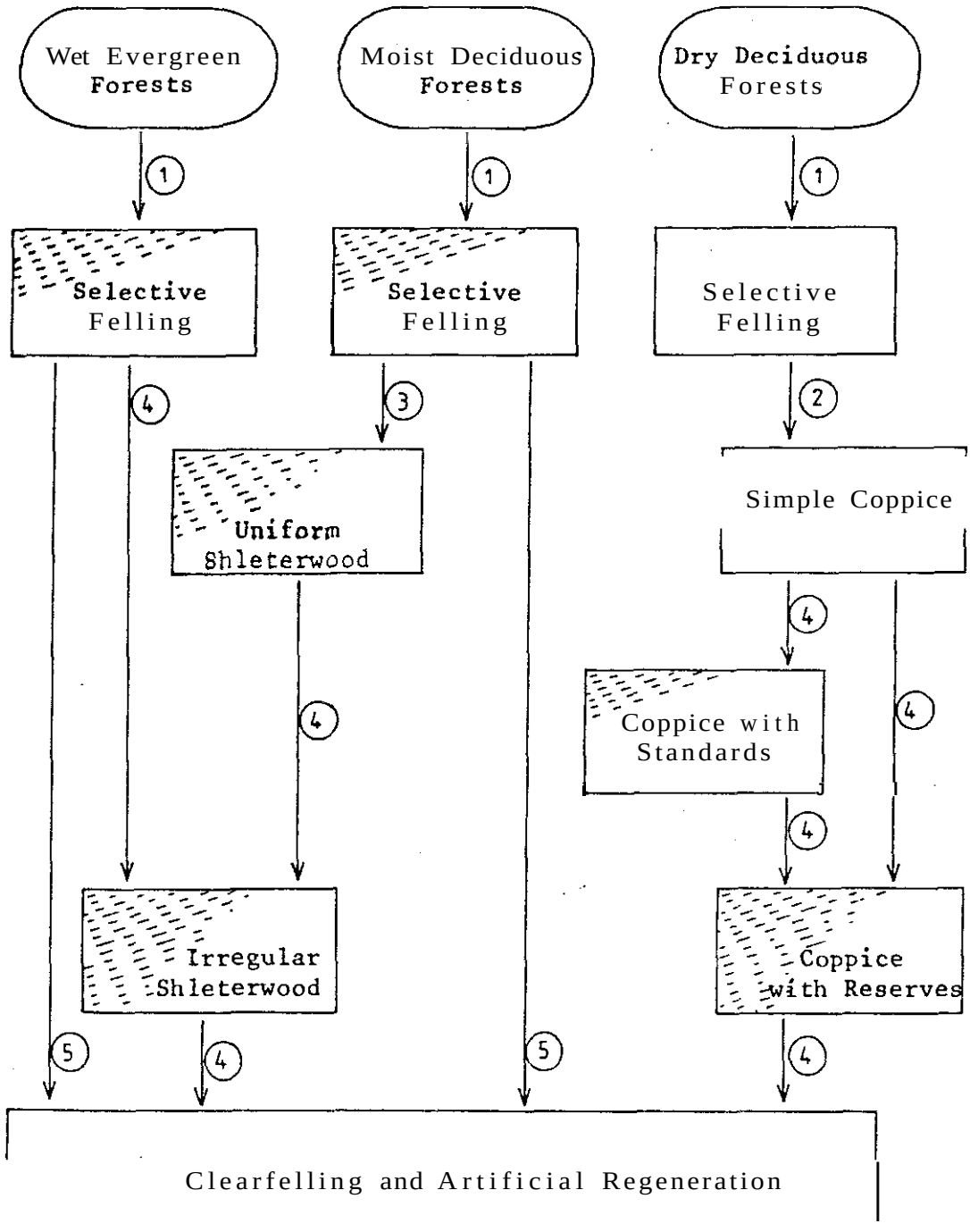
lvicultural system	System characteristics			Type of forest to which applied
	Harvesting	Regeneration	Tending	
1	2	3	4	5
·lection ystem and election-cum- mprovement elling	Selective removal of valuable species	Natural-mainly seedling origin	Limited to the establishment stage, neglected	Evergreen and semi-evergreen, moist deciduous and dry deciduous forests
ıelterwood ystems				
. Uniform system	Complete felling spread over the regeneration period	Natural-mainly seedling origin	Intensive tending	Moist deciduous forests where regeneration of valuable species is adequate
Irregular shelter-wood system	Complete fe11ing of trees above a specified girth spread over the regeneration period	Natural-seedling origin. Trees below exploitable girth retained as advance growth	Tending and other cultural operations	Evergreen and moist deciduous forests where regeneration can be established with considerable effort

(Contd....

1	2	3	4	5
3. Clearfelling system	Complete removal of standing Growth in one operation	Natural (seedling)	Intensive tending and thinning	kist deciduous forests where natural regeneration is very profuse.
		Artificial	"	Moist and dry deciduous forests where natura1 regeneration is unsatisfactory or where a change in crop composition is desired
4. Coppice systems				
i. Simple coppice	Complete felling	Gstural-coppice	Tending immediately after felling and thinning	Fry deciduous forests to produce fuelwood and small timber
ii. Coppice with standards	Comp1ete felling retaining specified number of standards	Natural-mainly coppice		
iii. Coppice with reserve	Reservation by arca, species and diameter limits. Felling the rest	Natura1-mainly coppice	"	Dry deciduous forests to produce fuelwood and small timber and to improve site conditions

No reliable data is available on the area under different silvicultural systemsin different forest types and for the country as a whole. Area under different systems in selected states is given in table 1.6, and this gives an indication of the relative importance of the systems.

Fig. 1.5. Evolution of Management Systems in Tropical Mixed Forests



Indicates - Part of the area remain in the same system

1. Intensive exploitation not feasible due to accessibility, demand or labour constraints
2. High demand for fuelwood and small timber, existance of traditional rights to forest produce
3. Natural regeneration of valuable species feasible
4. Failure or inadequate natural regeneration and forest deterioration
5. Need to change crop composition in favour of species in high demand.

Table 1.6

Area Under Different Silvicultural Systems

(Area in Sq. Km.)

State	Selection and selection cum improvement	Shelterwood		Clear-felling and others[1]	Coppice		
		Uniform	Indian irregular shelterwood		Simple coppice	Coppice with stds	Coppice with reserve
Bihar	2620	560	..	4320	..	21720	..
U.P.[2]	5800	5760	..	9040	4160[3]	1910	..
Orisea	20000	NA	..	NA	NA	5000	..
Tamil Nadu	190	..	..	NA	1560[3]	..	..
Maharaahtra	18290	3990	..	1480	..	..	13610
Kerala	920	NIL	..	1470	380[3]	..	..
Assam	NA[4]	..	650	350	NA	..	..

[1]Includes area under rehabilitation and afforestation programmes also. Details of area taken up under clearfelling and planting are not available separately.

[2]Includes details pertaining to the coniferous forests also.

[3]In all states eucalypt plantations are managed under simple coppice system. This is also included here.

[4]NA = Information not available.

In most states it can be seen that, selection or selection cum-improvement felling and coppice with standards continue to be the most important management systems. Details of the procedure for yield regulation, felling, regeneration are discussed in subsequent chapters.

1.3 CONCLUSION: Diversity of the vegetation coupled with the complexity of socio-economic conditions have led to the evolution of a wide spectrum of management systems. However, what actually

practised seldom fits into the description usually found in silviculture text books and often represents a compromise between conflicting factors. Growing demand for timber and firewood have brought changes in systems over time. Important features of different systems in vogue now are described in the ensuing chapters.

NOTES

1 Total forest area as per official records is 75.351 million hectares. This represents the area that is legally categorised as forests and includes totally barren areas also. Effective forest cover is estimated as only 12 percent of the geographical area.

2 Based on rainfall teak bearing forests are further subdivided as (i) very moist teak forest, (ii) moist teak forest and (iii) slightly moist teak forests, the last one merging with the dry deciduous formation.

3 Important climax formations distinguished are (i) very moist sal (ii) moist sal and (iii) moist mixed forests. Under each category several sub types are recognised.

4 This does not imply that biotic disturbances are absent in these forests. In the North Eastern Hill region, even reserved forests are subjected to shifting cultivation.

CHAPTER 2

SELECTION SYSTEM

The selection system practised in India involves the selective felling of exploitable trees from a given forest area at periodic intervals. It is one of the earliest systems to be applied to the forests and regulating the felling was the main objective. Areas worked under the system are included in the selection (or selection-cum-improvement felling) working circle or the hill working circle. In the case of economically important species distributed widely, working circles which overlap with areas worked under other systems are constituted. Details of the system applied to different forests in India are discussed in this chapter.

2.1 CHOICE OF SYSTEM: Selective felling is adopted in the tropical mixed forests under the following conditions.

(i) Low proportion of valuable species: Despitethe large number of trees per unit area, the high species diversity necessitates the tapping of a large area *to* ensure availability of wood to meet specific end uses. This becomes uneconomical except in the case of highly valuable species.

(ii) Lack of information on end uses: Properties of Large number of species in the mixed forests are yet unknown and thus even if extraction is feasible, they cannot be marketed easily. For example, there are more than 100 known tree species in the evergreen forests of Western Ghats, but only about 40 are commercially exploited.

(iii) Poor accessibility: This restricts the utilisation of forest, favouring less concentrated working. A large quantity of timber and firewood available cannot be transported economically and as a consequence extraction is limited to logs or sawnwood whose value/bulk ratio is high

(iv) Lack of information on silviculture and management: When no data are available on growth rate, rotation, response of the species to treatments, etc. selective removal is resorted to. This is particularly so during the early years of management when experience and information are lacking.

(v) Environmental protection: The system is also adopted where concentrated felling is inappropriate due to their adverse environmental impacts. To ensure protection of soil and conservation of water, permanent tree cover is essential. In hilly areas, low intensity selective felling ensures an acceptable trade off between protective and productive functions of forests.

2.2 APPLICATION: Exploitation of timber from most of the mixed forests in India commenced with selective felling. While in some areas this has been replaced by systems involving more concentrated fellings, in large areas selective felling is in vogue even now. This is the most widely adopted silvicultural system in India. Table 2.1 gives the type of forests and states where selective felling is practised (FRI6 Colleges,

Details of application of the system, especially yield regulation and prescriptions related to felling and regeneration, are given below.

Table 2.1

Selective Felling in India

Forest type	Species selectively removed	State
Evergreen forests	Mostly plywood and matchwood species. Hardwood species are sometimes converted to sleepers depending upon demand.	Kerala Karnataka Tamil Nadu
Moist deciduous forests	Shorea robusta, Terminalia tomentosa, Adina cordifolia, Lagerstroemia microcarpa, Tectona grandis, Bamboo	Uttar Pradesh Madhya Pradesh Bihar, Orissa Maharashtra Andhra Pradesh Assam
Dry deciduous forests	Santalum album	Tamil Nadu and Karnataka
	Bamboo	All states
	Boswellia serrata	Bihar Uttar Pradesh Madhya Pradesh
	Acacia catechu	Bihar Uttar Pradesh Madhya Pradesh

2.2.1 Selective felling in evergreen forests: Areas where selective felling is undertaken are included in the selection working circle or selection-cum-improvement working circle Selective felling was in vogue in the evergreen forests of Western Ghats right from the beginning of this century. Extraction was limited to species suitable for railway sleepers (e.g.) Hopea parviflora, Mesua nagassarium) and ship masts (notably Calophyllum spp.). During the first world war boom, accessibility was improved and in some areas attempts were made to introduce systems of concentrated felling (Champion and Osmaston, 1962). Failure of regeneratio

and more particularly the slump in demand during the inter war recession led to abandonment of such trials. Growth of the plywood industry during the second world war period and the increasing demand for railway sleepers led to the large scale adoption of selective felling in the evergreen forests of Western Ghats. At present evergreen forests of Western Ghats are primarily managed to supply veneer logs and railway sleepers. Intensity of management is closely linked to the growth of the plywood industry [1].

2.2.1.1 Objectives of management: The bhree most commonly stated objectives of management of evergreen forests under selective felling are,

(a) maintenance of tree cover to protect the soil and to regulate water yield in catchments

(b) increasing the supply of wood and other products and

(c) consistent with the above objectives realising the maximum revenue.

Selective removal is considered the most appropriate alternative to fulfill the above objectives under the constraints of poor accessibility and low density of utilisable species. Adoption of low intensity selective felling is primarily determined by economic constraints and is not always an outcome of integrating environmental considerations.[2]

2.2.1.2 Yield regulation: Under the polycyclic selection system the same area is visited at periodic intervals and trees reaching specified exploitable girth are removed. Factors like the time taken for trees in the pre-exploitable class *to* reach the exploitable class, condition of the crop, especially proportion of mature and over mature trees and infrastructure facilities are considered in determining the felling cycle. Where there is a preponderance of harvestable trees, a shorter cycle is preferred to enable their

speedy removal. A shorter cycle will, however, enhance the annual area requiring considerable investment on infrastructure and this have an overwhelming influence on the cutting cycle. Felling cycle adopted in different forest divisions in the Western Ghat region varies from 15 to 45 years (see Table 2.2).

Removal from the annual coupe is further subjected to a girth limit check. Exploitable girth is influenced by the nature of demand, the species and the size class distribution of trees. In unworked stands where there is a preponderance of large trees, girth limit is fixed high. Industries do respond to scarcity of large sized logs through technological changes and this often leads to a reduction in the girth limit, especially when an area has to be worked repeatedly. Girth limits for working the evergreen forests in Western Ghats vary between species, felling cycle and locality and ranges from 120 cm to 210 cm.

A further check is exercised on harvesting by prescribing an upper limit for the number of trees that can be removed from the exploitable class. Smythies safeguarding formula is sometimes used for this[3]. Table 2.2 gives the felling cycle, exploitable girth and number of trees that can be harvested for some divisions in the states of Kerala and Karnataka.

Some of the important felling rules followed in Kerala and Karnataka are given below:

i. to ensure that felling is not concentrated in pockets it is prescribed that a minimum distance of 20 metres should be kept between two marked trees;

ii. climber cutting is prescribed at the timc of marking to minimise damage during felling;

iii. n.o felling is to be carried out for a width of 20 metres on either side of water courses to prevent soil erosion;

iv. marking is to be carried out in such a way as not to cause any lasting gaps in the canopy and

v. only dead and dying trees are to be marked on steep slopes

Table 2.2

Prescription Pertaining to Selective Felling

Forest Division	Felling cycle (in years)	Exploitable girth (in cm gbh.)	Number removable/ ha
Coorg (Karnataka)*	45	210	17
Sirsi "	40	183	20
Honnawar "	30	183	NA
Hassan "	30	180	7 to 11
Wynad (Kerala)	15	120-180	20
Nilambur "	20	150-200	10
Ranni "	15	180	20

*Recently in Karnataka, the number of exploitable trees has been reduced to 2 per hectare in response to the growing pressure from environmental groups.

Timber extraction is carried out either by industries (especially plywood and match units) to whom an annual quota of timber is allotted or by the forest department who usually get the work done through the agency of contractors. The system of giving long term lease is not in vogue.

2.2.1.3 Regeneration: There is complete reliance on natural regeneration. It is assumed that selective removal improves light conditions

and thereby facilitates the establishment of regeneration and the growth of trees in the pre-exploitable class to the exploitable class. Important prescriptions aimed to promote natural regeneratior are as follows:

i. All broken and completely damaged trees should be cut back.

ii. A regeneration map is to be prepared for each annual coupe and treatments appropriate to the status of regeneration are to be carried out. Most working plans prescribe gap planting in areas deficient in natural regeneration. Nursery raised seedlings of Vateria indica, Dipterocarpus indicus, Dichopsis ellipticum, Artocarpus hirsutus, Dysoxylon malabaricum etc. are to be planted and are to be tended during the first three years.

iii. If required thinning has to be carried out to relieve congestion in patches of pole crop.

These prescriptions are seldom adhered to. Gap planting, strip planting, etc. undertaken under different schemes cover only a very small proportion of the area felled annually. Although only a few trees are felled, damage to other standing trees is very high[4]. Drastic change in light and moisture conditions encourage the growth of weeds, especially primary colonisers, impeding the establishment and growth of regeneration (Rai, 1979). Prescriptions are neglected due to technical, institutional and financial constraints (FAO, 1984).

Selective felling with sufficiently long felling cycles on moderate slopes seldom causes any soil erosion if felling rules are strictly adhered to and sufficient care is taken in laying out roads, extraction paths, etc. However, in practice such prescriptions are not always implemented. Logging contractors (employed both by industries and forest department) are primarily interested in profit maximisation, resulting in the neglect of silvicultural

prescriptions[5]. Surface run off and soil erosion tends to be very high during and immediately after harvesting. Very often, logging operations extend for two to three years due to sequential working by different agencies/industries and this aggravates the problem.

Selective felling does help to enhance wood supply in the short run. Feasibility of long run sustained supply of wood and other products depends on the intensity of exploitation and success of regeneration. Very few forests have been worked continuously over a number of cycles adhering to the same prescription. Between successive cycles, yield is maintained by (1) reducing the felling cycle, (2) reducing the girth limit and (3) removing the species not extracted during the previous cycle. In the absence of regeneration, selective felling at short intervals leads to degradation, seriously affecting wood production in the long run.

The relevance of selective felling has been examined on the implicit assumption that the objectives of management plans truly represent the societal objectives. This assumption may not be valid always. Most often, selective felling is a passing phase and is soon replaced by alternative systems or alternative land uses.

2.2.2 Moist deciduous forests: Although the system of clearfelling and artificial regeneration in the moist deciduous forests commenced from the 1850s, this was on a small scale and selective removal continued to be the main system applied to both teak and sal forests. Systems of concentrated felling were introduced in some of these forests during the first quarter of this century, primarily in response to the increasing demand for construction timber, railway sleepers, etc. This was, however, restricted to easily accessible areas and where natural regeneration could be relied upon for restocking. In due course of time improved accessibility enabled the extension of those systems and selective felling was mostly adopted in less accessible areas. Need to ensure the protection of steep slopes coupled with techno-economic constraints in undertaking intensive working have led to the continuation of the system in many areas Table 2.3 gives examplesof divisions where selective felling is still in vogue.

Table 2.3

Selective Felling in Moist Deciduous Forests

State	Division	Species
Uttar Pradesh	Dehra Dun Haldwani Ramnagar	Mainly Sal
Bihar	Saranda Chambaran	Sal
	Palmau	Sal and other species
Orissa	Kalahandi Angul Rairakhol etc.	Sal and other associates
Madhya Pradesh	Bastar	Teak and Sal
Maharashtra	South Chanda	Teak
Andhra Pradesh	Adilabad Ballampalli	Teak

2.2.21 Objectives of management: Since the conditions under which selective felling is undertaken in moist deciduous forests are identical to that of evergreen forests, the objectives of management are also more or less the same. Some of the most commonly stated objectives are:-

i. to protect the hill slopes from erosion and conserve moisture to regulate water supply;

ii. to improve the condition of the crop by encouraging regeneration of valuable species (eg. sal, teak, etc.) and

iii. consistent with the above to obtain the maximum sustained yield of timber (see, Singh, 1979; Maleta,

Priority given to wood production and revenue maximisation objectives in selection felling is dependent on the overall contribution of selection felling areas to the total wood production and revenue from the sector. When these objectives can be fulfilled from nreas managed under more intensive systems, protective function of forests gets priority.

2.2.2.2 Yield regulation and felling: Here also, yield is regulated by area followed by a girth limit check. Sometimes a further check is exercised by fixing the number of trees that can be removed from the exploitable class either arbitrarily or by using Smythie's safeguarding formula. Felling cycle, exploitable girth and the number of trees harvested per hectare for a few divisions in different states are given in table 2.4.

To ensure protection of slopes 'from erosion, working plans prescribe certain criteria for silvicultural availability of trees such as:-

i. no tree will be marked near the edge of steep slopes, precipitous areas and on erodible and unstable hill sides;

ii. marking should not be carried out for a width of 20 metres on either side of water courses; and

iii. felling of trees should not create permanent gaps in the canopy.

A set of subsidiary silvicultural operations are prescribed and this includes the cutting back of damaged stems, selective weeding to free supression of seedlings and climber cutting. In poorly stocked areas, particularly blanks, artificial regeneration is also

Table 2.4

Moist deciduous forests - Selective Felling Parameters

Divison	Felling cycle (yrs)	Exploitable girth (in cms at bh.) for different species		Selection number
Dehra Dun (Uttar Pradesh)	10	Shorea robusta	120	1 tree out of 6 exploitable trees
		Dalbergia sissoo	150	
		Terminalia tomentosa	120	
		Acacia catechu	120	
Haldwani (Uttar Pradesh)	10	Shorea robusta	150	Not fixed
		Bombax ceiba	180	
		Acacia catechu	129	
Adilabad (Andhra Pradesh)	20	Tectona grandis	120	
		Terminalia tomentosa	120	
		Pterocarpus marsupium	105	
South Chanda (Maharashtra)	20	Tectona grandis	120	
		Others	135	
Bhrndara (Maharashtra)	20	Tectona grandis	120-135	
Kalahandi (Orissa)	20	Shorea robusta	105-150	
Saranda (Bihar)	20	Shorea robusta	135-150	1 in 3 to be felled

2.2.2.3 Critical evaluation: Implementation of various prescriptio; however, tends to be rather tardy. Whether felling will be actualy undertaken or not depends on the importance of the area in relation to the overall sectoral objectives, particularly, wcod production and revenue realisation. Cost of selection working is very high and is a major factor that influence the intensity of felling and other operations. The following extreme situations are met with.

i. Yield from selective felling does not significantly enhance income and wood output. This is particularly the case when the same product can be obtained more economically from other forests worked under more intensive systems. Often it may not be possible to get contractors to work such areas. In such situations selective felling may not be taken up at all or carried out only in comparatively easily accessible areas (eg. selection coupes in Saranda Division in Bihar).

ii. The other extreme situation involves intensive working of easily accessible areas ignoring selection principles. Ultimately the area may be completely transferred to other working circles for intensive working[6].

There are no instances where selective felling has been employed to realise a sustained yield from moist deciduous forests. Regeneration of valuable species is poor and gaps created during felling seldom gets regenerated. Fire is a major factor impeding regeneration. Gap planting is technically feasible, but institutional and financial constraints prevent its widespread adoption. Probably it is cheaper to undertake intensive regeneration operations under systems of concentrated working. On the whole the system as applied to moist deciduous forests is a passing phase before more intensive systems are adopted.

2.2.3 Extraction of bamboos: Traditionally bamboo is used for a variety of household and agricultural purposes and is regarded as a poor man's timber. Also it finds extensive use in cottage industries like mat and basket weaving. Bamboo is one of the most important cellulosic material and accounts for about 65 percent of fibrous raw material used by the paper industry. Annual output of bamboo is estimated as about 3.23 million tonnes of which about 2 million tonnes are used by the pulp and paper industry (Varmah and Bahadur, 1980). Primarily it occurs in the moist and dry

deciduous forests. Bambusa arundinacea and Dendrocalamus strictus are the most important species. Cephalostachyium pergracile, Dendrocalamus hamiltonii and Ochlandra spp. are also important locally.

Until the pulp and paper industry began to use bamboo as a raw material, it was considered as a minor forest product and worked under the minor forest product working circle. The objective of management was limited to regulating the felling. In regeneration areas bamboo was treated as aweed and was being removed regularly to facilitate the growth of favoured species like teak and sal. This being the case, some of the pulp and paper units could get long term concessions for collection of bamboos at nominal prices. The system of management adopted for bamboo working is known as culm selection-cum-clump improvement (Krishnaswamy, 1957).

2.2.3.1 Objectives of management: Regulating felling is the foremost objective of bamboo management. Working plans do prescribe other objectives also, like improvement and augmentation of growing stock through appropriate silvicultural treatments.

2.2.3.2 Yield regulation and felling: All bamboo areas intended for working are included in a working circle, which most often overlaps with other working circles. The felling cycle adopted varies from 3 to 4 years and based on this yield is regulated by area. Important rules prescribed to prevent overfelling are given below:

i. No working is permitted from April to October[7].

ii. In each clump all new culms (less than one year old) and 6 to 8 mature culms (over 1 year old) should be retained.

iii. Clumps containing less than 8 culms should not be worked

iv. Cutting should be carried out between **15** to 45 cm above ground, leaving one internode.

v. In the case of flowered clumps, complete felling is permitted only after seeding is completed.

In some states bamboo forests have been leased out to pulp and paper units and extraction is undertaken by the lessees through contractors. Scattered nature of the work renders effective supervision difficult and felling rules ere often violated. Bamboo clumps located in easily accessible areas are often clear felled, while those in inaccessible locations are not worked at all. This coupled with fire, grazing and such other biotic factors, have led to the decline of bamboo resources in most states. Yield from successive felling have shown a declining trend[8]. A felling cycle of 3 or 4 years is too short to enable the clump to recoupe from felling damage (Prasad and Gadgil, **1981).** Bamboo plantations have been raised in some states in response to the growing industrial and other demand.

2.2.4 Extraction of sandal: Sandal (Santalum album) is primarily found in the dry deciduous forests of Karnataka and Tamil Nadu. It is one of the oldest known source of perfume material and was declare a royal tree long before the concept of reservation of forests came into practice. Oil extracted from the heartwood is an important ingredient in the manufacture of perfumes, medicines and toilet soaps Sandalwood forms an important source of revenue to the Karnataka and Tamil Nadu forest departments.

2.2.4.1 Yield regulation and felling: Yield is regulated by area. A felling cycle of 6 years was being followed earlier in most divisions. On account of the high mortality due to spike diseases, this has been reduced to 3 years (Joseph, **1970).** Within the annual coupe removal is limited to dead trees only.

Extraction is carried out departmentally. Trees are uprooted, billeted and after rough cleaning, transported to forest department depots. After removal of sapwood, heratwood is classified on the basis of the size and portion of the tree from where it is obtained[9]. Disposal is through open auctions held at periodic intervals.

2.2.4.2 Regeneration: Natural regeneration is very profuse. However establishment is poor on account of fire and grazing. The spike disease caused by a micoplasma-like-organism is a major threat and no remedial measures have yet been identified. The disease is spreading rapidly even to areas which were thought to be free from it. Un-scientific extraction and illicit removal have also contributed to its depletion, specially in states like Karnataka[10]. The technique of artificial regeneration has been more or less perfected and the total area under sandal wood plantations in Tamil Nadu, Karnataka and Kerala is about 3460 hectares. Unless spike disease is controlled, soon the sandal resource will be more or less completely depleted.

2.2.5 Extraction of other species: Khair (Acacia catechu) and Salai (Boswellia serrata) are two important species selectively extracted from the dry deciduous forests. Khair occurs as a sera1 formation on the river banks (Champion and Seth, 1968) in Uttar Pradesh, Bihar, Madhya Pradesh, Orissa and Gujarat. The heartwood of Khair is used for the extraction of Catechin (Katha) and Catechu tannic acid (Cutch). Catechu is an important comercial product used in dyeing and as a preservative agent and its chief industrial use is for dyeing cotton and silk and for calico printing. Katha is an indispensable ingredient in the preparation of chewing pan. It has a number of medicinal properties and is used as an astringent and digestive (FRI6 Colleges, 1972).

All Khair areas are included under the Khair overlapping working circle. Yield is regulated in the first instance by area. A felling cycle of 20 to 30 years is adopted. A further check is exercised by prescribing a girth limit, which varies from 35 to 45 cms. No silvicultural operations are carried out to encourage natural regeneration.

Salai (Boswellia serrata) is used primarily for the production of packing cases. It is also used as cellulosic raw material in the pulp and paper industry. Forests with salai are included under the salai overlapping working circle. As in the case of other species, yield is regulated by area following a felling cycle of 20 to 30 years. Selection girth is fixed at 90 to 105 cms. Regeneration is entirely left to nature.

2.3 CONCLUSION: Selective felling as a method of working mixed forests has mainly evolved in response to the urban/industrial demand for selected species'. Extraction of commercially utilisable/ valuable species is the primary objective. Two broad types of selective felling can be identified namely, (1) that undertaken in the initial stages and which will be replaced in a planned manner by more intensive systems.in response to techno-economic changes and (2) that attempted as a regular method of working. Improved accessibility and better utilisation of species lead to a more or less planned shift in the management system in the first case. The second type of selective felling also tends to change, largely due to unanticipated dysgenic effects. When natural regeneration is insufficient and removal exceeds increment, degradation sets in. Data on growing stock, increment, removal, regeneration, etc., which are essential to regulate yield are not readily available and the process of degradation is often imperceptible. Two alternatives available are (1) to exclude the area from the purview of production forestry or (2) to introduce intensive management systems like clear-felling and planting. With the growing pressure on land, the second alternative has been adopted in many areas.

Selective felling is generally species-oriented and thus completely neglects the complex ecological status of the forests. This has been one of the main factors contributing to the failure of regeneration. The future of natural management of the mixed forests in the context of failure of natural regeneration is discussed in the concluding chapter.

NOTES

[1]The Kerala-Karnataka region accounts for 19.5 percent of the installed capacity of the plywood industry in the country and most of their requirements of veneer logs are met from the evergreen forests (Sivananda and Nagaraju, 1983).

[2]This is evident from the fact that improved accessibility leads to a change in the system of working in favour of more intensive systems (see FAO, 1984) especially when there is no immediate and apparent adverse effects.

[3]Exploitable number is determined as a percentage of trees in the harvestable class as

$$Y = \frac{X}{I + \frac{X}{2}} \times 100.$$ where I = number of trees in the exploitable class

X = f/t (II - Z of II)

f = felling cycle

t = time taken for class II trees to reach class I

Z = mortality percent

Reliable data are not available on t and Z and consequently approximations are resorted to.

[4]Even if only 10 trees/hectare are felled, sometimes this results in opening the canopy to the extent of 50 percent.

[5]A change in the agency for logging seldom improves the situation. Workers employed for different operations lack sufficient training. Payment to them is made on piece rate basis and out turn becomes the primary concern then adherence to silvicultural prescriptions.

[6]In many divisions forests originally worked under selective felling have been included under Shelterwood Working Circle or Plantation Working Circle *(eg.* Chanda in Maharashtra and Wynad in Kerala)

[7]Culms grow during June to August and this prescription is aimed to prevent damage to the growing culms.

[8]Yield per hectare on a three year working cycle varies from 2 to 5 tonncs.

[9]About 18 classes have been recognised in trade. Oil content in the roots is very high and consequently they fetch a very high price.

[10]In some divisions the growing stock has come down by 50 percent during the last three decades (Adkoli, 1977)

CHAPTER 3

SHELTERWOOD SYSTEMS

Failure of regeneration coupled with the need to intensively exploit the valuable forests led to the search for alternative management systems. Success of shelterwood system in the European continent led to its introduction to India during the first quarter of this century[1]. Under shelterwood system felling of overwood regulated to provide favourable conditions for recruitment and establishment or regeneration. A number of variants under the broad category of shelterwood system exists. The two most commonly adopted in India are (1) the Indian irregular shelterwood system and the uniform system. Salient features of these are described below.

3.1 INDIAN IRREGULAR SHELTERWOOD SYSTEM: Due to difficulties in getting regeneration, fellings are carried out irregularly under the floating periodic block system. Uncertainty of regeneration has necessitated the retention of trees below a specified girth as part of future crop. The crop so produced is irregular and in many respects the system is very similar to the selective felling system. Table 3.1 gives the regions/localities where the Indian Irregular Shelterwood System is practised now.

Table 3.1

Application of Indian Irregular Shelterwood System

Forest type	Region/Locality
Tropical evergreen forest	Andaman Islands, Assam and Arunachal Pradesh
Moist deciduous forest	Uttar Pradesh (Dehra Dun, Ramnagar, Haldwani) Andamans

Details of yield regulation, method of felling, natural regeneration, etc. are discussed below.

3.1.1 Andaman Islands: Timber extraction commenced in the Andaman group of islands in 1857 when the first settlement was established. Initially meeting the wood requirements of the settlement was the primary concern of forest exploitation. For a very long time the demand was limited to three species, namely padauk (Pterocarpus dalbergioides) gurjan (Dipterocarpus spp.) and white chuglam (Terminalia manii) Selective felling was in vogue till the 1950s. Although the technique of regeneration under the Andaman canopy lifting shelterwood system was perfected about two decades back, for a variety of reasons, it could not be put into practice. Growth of the plywood industry, enhanced utilisation of species not in favour for a long time and improved accessibility facilitated the adoption of the Andaman canopy lifting system, a variant of the Indian irregular shelterwood system. This system is applied to both the evergreen and moist deciduous forests. Plywood and match industry form the most important wood based industries in the islands[2]. Although there is large scale migration, settlements are primarily confined to the South Andamans and on the whole the forests are not subjected to severe biotic pressures as in the mainland. Demand from the plywood industry seems to be the most important factor influencing forest management in the islands.

3.1.1.1 Yield regulation and felling: Important objectives of managemeut are (i) conversion of the irregular forest into a normal forest and (ii) realisation of the maximum yield of timber (Sharma, 1979). A rotation of 100 years is prescribed, but the area of annual coupe is worked out using a conversion period of 75 years to ensure that mature and overmature trees are removed quickly. The system of floating periodic blocks is adopted. Area identified for harvesting and regeneration during the tenure

of a working plan is allotted to PB I. PB I usually comprises of areas which contain advance growth and mature and overmature trees. Here the working plan period is taken as the regeneration period[3]. All the other areas are grouped as PB unallotted.

Yield is regulated by a combination of area, volume and number. Working in a year is confined to the annual coupe. Total volume of trees in the exploitable class is estimated by carrying out a 10 percent partial enumeration. Taking into account market demand exploitable girth is fixed as follows.

1.	Commercia1 Hardwoods	-	150 cm
	Softwood	-	120 cm
2.	Non-commercial	-	180 cm

From the total volume estimated, annual availability is worked out. A further check is exercised by limiting extraction to 15 trees per hectare. To ensure that removal does not exceed the prescribed volume, cumulative volume is worked out as the marking progresses and as soon as the prescribed yield or area is reached marking is stopped. Important marking rules prescribed for working PB I areas are as follows:

i. trees marked for felling should as far as possible be evenly spaced;

ii. no felling should be carried out on steep slopes if sufficient advance growth is not available;

iii. no tree occurring in blanks with deficient regeneration should be felled;

iv. where regeneration insufficient at least 10 sound healthy trees of commercial species will be retained per hectare as seed trees; and

v. no felling will be carried out for a width of 40 metres on either side of large streams.

Rules for felling are, however, not always adhered to, both in the coupes worked departmentally and by lessees directly[4]. Felling damage is high and the whole canopy gets opened. Soil in the Islands is extremely fragile and consequently erosion is a serious problem.

3.1.1.2 Regeneration: Natural regeneration is generally satisfactory and a series of operatisons spread over the first three years immediately following harvesting are carried out to facilitate establishment. All sound trees of commercial species below the prescribed exploitable girth are retained as advance growth and will form part of future crop. The main operations carried out are given in table 3.2.

Table 3.2

Andaman Canopy Lifting System - Regeneration Operations

Year	Month	Operations
1	March - April	(1) Completion of timber extraction
	October	(2) Brushwood cutting (3) Felling of undergrowth and poles upto a height of 10 metres (4) Girdling of trees between 10 to 20 metres
2	April - May	(1) Broad cast sowing of seeds of commercial species if natural seeding is considered inadequate (2) Weeding
	September	(3) Climber cutting and weeding (4) Girdling of understorey trees to permit more light
3	March - April	(1) Weeding
	September	(2) Final felling and girdling of unwanted trees (3) Weeding

Natural regeneration of Dipterocarpus spp. is found to be satisfactory. Although timber extraction leaves the canopy more or less completely open, weed growth is not very dense as in other evergreen forest regions in the country[5]. If weed growth is kept under check during the first one or two years, the light demanding species especially Dipterocarpus spp. are able to grow sufficiently tall and establish.

Light crown thinnings have been prescribed at the 6th, 15th, 30th and 50th years. In an uneven aged crop comprising advance growth of young saplings and poles, thinning becomes an extremely complicated operation and generally tends to be neglected.

3.1.1.3 Evaluation: Growing industrial demand is the main factor influencing the management of the forests in the Andaman Islands. Nothing can be said about the sustainability of wood production under the present system of management as no area has yet been worked for the second cycle. However, it is pointed out the yield is expected to decline during the second cycle and may be far less than that obtained during the initial phase of conversion.

No attempt has yet been made to assess the environmental effects of heavy fellings in the evergreen forests. The soil is extremely fragile and highly erodable. The change in composition and its long term impacts are also to be studied.

In essence, Andaman canopy lifting system is an intensive selective felling and the canopy gets opened up completely. The intensity and scale of fellings have increased during the last few decades, but regeneration operations have not changed since they were perfected the 1930s. The question whether the present management system will be able to fulfill the multifarious objectives is difficult to answer.

3.1.2 Assam and Arunachal Pradesh: In the North Eastern region (Assam, Arunachal Pradesh, Nagaland, Meghalaya, Manipur, Tripura and Mizoram) reserved forests account for a very small proportion of the total forest' area Most of the forests is under tribal control and are subjected to shifting cultivation.

The Upper Assam forests were initially utilised for production of railway sleepers and are under systematic management since the 1930s. With the growth of the plywood industry in the region[6], management is primarily directed at meeting the raw material requirements of the industry (KFRI, 1978). For management purpores the Upper Assam divisions[7] have been constituted into two working circles, namely (1) Hollong - Nakai regeneration Working Circle m d (2) Hollong plantation working circle. The former consists of good unworked evergreen forests and are managed partly under the irregular shelterwood bystem and partly under selective felling. The most important objective of management of forests included under the Hollong - Makai regeneration working circle is to supply veneer logs to the plywood industry.

3.1.2.1 Yield regulation and fellings: In the current working plan (Das, 1974)the rotation has bees reduced from 120 years to 84 years while the regeneration period has been reduced from 20 to 12 years. Each felling series is divided into PB allotted, comprising the area taken up for felling and regeneration during the plan period and PB unallotted. PB allotted consists of areas with advance growth and mature and overmature trees.

Yield i4 prescribed for the whole felling series and is obtained from (1) PB I areas by way of regeneration fellings and (2) PB unallotted areas through selective fellings on a cycle of 12 years. In both cases yield is regulated firstly by area and secondly by a girth limit check. In PB I areas the girth limit adopted is 150 cms and all trees below this are retained as advance growth and form part of the future crop. In the PB

unallotted a girth limit of 300 cm is followed. However, it is stipulated that if trees above 300 cm are not available, the girth limit can be lowered to 270 cm. Thus the shelterwood regeneration felling is limited to PB I areas and about 65 percent of the prescribed yield is obtained by selective felling in unallotted areas[8].

To facilitate regeneration in PB I areas felling is carried out in three stages as follows.

1.	Initial stage	(i) Removal of all trees above the exploitable diameter. If advance growth is absent stems above 180 cm girth are retained per hectare as mother trees.
		(ii) Removal of underwood leaving sufficient number of trees to keep down weed growth.
2.	Intermediate stage	Periodic removal of underwood and overwood as regeneration becomes established.
3.	Final stage	Removal of underwood and overwood except those retained as part of the future crop.

For the purpose of felling, PB I coupes are categorised as well stocked, medium stocked and poorly stocked[9] and felling is prescribed to be carried out in such a way as not to create a permanent gap.in the canopy. Profuse weed growth, especially of Michania sp. is a serious problem in the Upper Assam region. Drastic openings are soon covered by weed growth, totally smothering regeneration.

3.1.2.2 Regeneration: In PB I areas there is complete reliance on natural regeneration. Further, all Hollong and Makai trees below 150 cm girth are retained as advance growth, Prescriptions aimed to promote regeneration are given below:-

i. All marked trees not felled during main fellings are felled or girdled;

ii. Damaged seedlings are coppiced;

iii. Advance growth will be freed and thinning will be carried out in congested groups of poles;

iv. Weeding and climber cutting are to be carried out for three consecutive years after main fellings. After the third year weeding will be done every alternate year and climber cutting once in three years till the 9th year.

v. Where regeneration is deficient artificial planting should be done in strips by transplanting seedlings of 60 cm and up at a spacing of 50 x 50 cm.

Failure of regeneration in areas worked previously has necessitated artificial regeneration. Degraded forests and blanks have been constituted into Hollong Plantation Working Circle with the objective of converting these into plantations of Hollong and Makai on a rotation of 45 years [10]. PB I areas are clearfelled and planted. During clearfelling all hollong and makai trees below 100 cm girth and all miscellaneous species below 40 cm girth are retained as advance growth. Sowing is done in lines at 5 metresapart in worked soil. As in the case of PB unallotted in the regeneration working circle, PB unallotted in the plantation working circle is also subjected to a selective felling on a 15 year cycle,

3.1.2.3 Evaluation: Management of the Upper Assam evergreen forests is primarily dictated by the growing demand from the plywood industry Rotation, regeneration period, exploitable girth, etc. have been revised periodically to enhance immediate wood supply. Implementatio of regeneration prescriptions has been far from satisfactory. Consequently, most of the forests in the region are in a depleted condition and increasingly the plywood industry has to rely upon resources available from states like Arunachal Pradesh and Nagaland.

Drastic openings in the canopy under the irregular shelterwood system has not facilitated the establishment of regeneration. Although the predominance of hollong and makai in the top canopy is highly conducive for profuse seeding, establishment is hampered by weed growth. Failure of natural regeneration has necessitated the adoption of artificial regeneration. The purpose of introducing shelterwood system seems to have been not fulfilled.

Forest management in other North Eastern states, especially Arunachal Pradesh, Nagaland and Meghalaya is more complicated. Most of the forests are under tribal ownership and the extent of reserved forest is very low[11]. Shifting cultivation is rampant and consequently forests are in a highly degraded condition. Rapid growth of the plywood industry coupled with depletion of forests in Assam have necessitated the tapping of forests in these states. No scientific management exists in areas outside the reserved forests. There is considerable unauthorised felling, under the pretext of shifting cultivation, and most of the veneer logs are purchased by plywood units in Assam.

3.1.3 Sol forests of Uttar Pradesh: Irregular shelterwood system is followed in the case of Sal forests in Ramnagar and Haldwani divisions and to some extent in Dehra Dun division also[12]. Due to difficulties in getting regeneration, uniform openings cannot be made and often large trees are retained as part of future crop. In Dehra Dun the rotation followed is 120 years with a regeneration

period of 20 years, while in Raninagar and Haldwani divisions it is 150 years and 30 years respectively. In the latter divisions floating periodic blocks is adopted in view of the uncertainty regarding establishment of regeneration. In Dehrn Dun periodic blocks were fixed; but with failure of regeneration, it has become necessary to follow floating periodic block system.

3.1.3.1 Yield regulation: For the purpose of yield regulation, PB I area is divided into (i) areas with woody but unestablished regeneration and (ii) areas with deficient regeneration. Yield is prescribed only with respect to areas belonging to the first category and is regulated by a combination of area and volume checks. Annual volume yield is estimated as

$$Y = \frac{V + (I \times 0.5)}{P}$$

where Y = annual yield
V = Volume of growing stock above 120 cm girth
P = Regeneration period
I = Increment put on during P

As in the case of Upper Assam forests, a selective felling is carried out in the PB unallotted in Haldwani and Ramnagar divisions

3.1.3.2 Regeneration: A set of rules for felling and regeneration is prescribed depending upon the status of regeneration. Where regeneration is deficient, only dead, dry and diseased trees in the canopy are to be removed. Where regeneration is present, but not established, more light will be permitted by removing the understorey trees. Complete overwood will be removed in areas where regeneration is well established. In Ramnagar and Haldwani divisions all healthy and well grown sal trees upto 120 cm girth are retained as part of the future crop.

In category (ii) areas the main objective is to induce natural regeneration through intensive cultural operations. Canopy manipulation involves the removal of all dead, dry and diseased trees and felling of mature and overmature trees is carried out where canopy is very dense. Shrub cutting, burning, soil working, fencing, etc. are some of the important operations for getting de novo regeneration. Since the introduction of shelterwood system, forest managers have been making earnest efforts to regenerate the felled areas, and the techniques for de novo regeneration have almost reached a stage short of planting. However, in most of the areas regeneration continues to be an intractable problem (Sen, 1965; Anon, 1967; Srivastava, 1969). Consequently, planting of nursery grown seedlings or sowing are being resorted to.

3.1.3.3 Evaluation: No doubt irregular shelterwood system has played an important role in enhancing wood production in the short run. However, its long term sustainability is undermined due to failure of natural regeneration. Regeneration of species like sal was one of the major focus of research in Indian Forestry, but so far no reliable techniques have been developed. Thus, like the selective felling system, the irregular shelterwood system also seems to be destined to be replaced by other alternatives. In the case of the former, regeneration was almost neglected, while in the case of latter, efforts were made, but did not succeed.

3.2 UNIFORM SYSTEM: Uniform system is adopted in the moist deciduous forests with a preponderance of high value species like teak and sal. Management of these forests are geared to meet the national and regional demand, especially that of defence, railways, general construction, etc. Application of the system involves the creation of uniform openings in successive fellings and is usually followed where regeneration is satisfactory. Often all overwood removed in one clearfelling operation and the area gets restocked by natural regeneration. The true uniform system in which successive fellings are carried over a number of years and regeneration is gradually nurtured to the established stage is not in vogue in any of the mixed tropical forests in

India. What working plans state as uniform systems are in fact close to the clearfelling system in most respects. Table 3.3 gives examples of the so called uniform system.

Table 3.3

Practice of Uniform System in India

State	Division	Species
Uttar Pradesh	Dehra Dun	Sal
Bihar	Saranda	Sal
Madhya Pradesh	Raipur	Sal
	Hoshangabad	Teak
Maharashtra	Allappalli	Teak

3.2.1 Yield regulation: Yield is regulated by area with a volume check. Rotation, regeneration period, etc. adopted for the two principal species in different divisions are given in table 3.4.

Table 3.4

Uniform System- Rotation and Regeneration period

Division	Species	Rotation (in years)	Regeneration period (in years)
Saranda	Sal	120	20
Dehara Dun	Sal	120	20
Raipur	Sal	180	20
Hoshangabad	Teak	120	20
	Teak	100	20
Allappalli	Teak	100	20

The system of fixed periodic blocks is followed and areas earmarked for felling and regeneration are included in PB I. In addition to area check a volume check is also exercised for yield regulation. In Saranda yield is prescribed in volume units and marking for felling is stopped as soon as the prescribed area or volume is reached.

3.2.2 Regeneration: In sal forests worked under uniform system, there is complete reliance on natural regeneration. Intensity of felling the overwood depends on the status of regeneration. Where regeneration is abundant, existing growth is completely removed (eg. Saranda). However, groups of poles are often retained as future crop[13]. In South Raipur (Madhya Pradesh) annual coupe is thoroughly perambulated and a regeneration map is prepared. Where established regeneration is present, clearfelling is carried out, while in areas where regeneration has not established, some of the suppressed and dominated trees are retained to control weed growth. Steep slopes and eroded areas are not clearfelled. To promote regeneration a number of subsidiary silvicultural operations are prescribed. This includes cleaning, climber cutting and thinning.

Silvicultural treatments are prescribed for other periodic blocks also. Treatments in unconverted areas aim at encouraging regeneration and often a light crown thinning is prescribed. In regenerated blocks weeding, thinning and tending are prescribed. In Saranda climber cutting is done for the first five years after the main felling. At the 5th year a preliminary thinning is carried out during which all injured, unhealthy and malformed stems are cut back. At the 10th year a systematic thinning is carried out to a spacing of 2.4 x 2.4 m. The second thinning is carried out at the 20th year and subsequent thinnings are carried out at 20 year cycles.

In teak areas there is much less dependence on natural regeneration (Dubey, 1967). Where it occurs, the advance growth is retained. In other areas artificial regeneration through stump planting is the standard technique and the overwood is clearfelled in one operation.

3.2.3 Evaluation: The so called uniform system has been consistently applied to some of the good teak and sal forests in the country managed to produce large sized timber. Since the process of conversion to a normal forest has not been completed yet, no indication can be given on the outcome of past management. The system may continue to be adopted where natural regeneration is abundant, and pressure from alternative uses is negligible. Where these conditions are not satisfied, changes are to be expected. Where natural regeneration is difficult, artificial regeneration becomes essential. High investment necessary for artificial regeneration compels a reduction of rotation. This seems to be the case in most of the teak areas. In sal areas the more profitable teak is being planted.

3.3 CONCLUSION: Shelterwood systems have been introduced primarily in the valuable evergreen and moist deciduous forests and the main objective of management continues to be the production of large sized timber. Both irregular shelterwood and uniform systems are oriented towards one or a few species. Where the system had been in vogue for a long time and regeneration is not a problem, there is unlikely to be any changes. In the case of evergreen forests in the North Eastern Region and Andamans, management is primarily aimed to supply veneer logs and developments in the plywood industry have a direct bearing on management. Rapid development of the industry in the Assam region has led to instability in management due to frequent changes in rotation, regeneration period, etc. and it is evident that the system is not capable of fulfilling the protection and production objectives.

In the case of sal, the end product is not specifically aimed at a particular industry, and substitutes are available, and consequently increase in demand has not led to an appreciable change in the management. These forests are also not subjected to any serious biotic pressures and as long as natural regeneration is satisiactory, there will not be any serious compulsion to switch over to other systems.

Teak forests managed under uniform system face slighly different conditions. Here natural regeneration is patchy and uncertain. Rather than manipulating felling to promote natural regeneration, it is much easier to resort to artificial regeneration. Thus in most teak areas natural regeneration is not being relied upon. With the increasing possibility of getting good prices for small sized logs and the need to take into account economic feasibility into consideration, rotation for teak has been reduced considerably.

NOTES

[1] The period commencing from 1910 is one in which remarkable changes occurred in silviculture and management. Knowledge of the silvicultural practices in Europe has been primarily responsible for this (Troup, 1916). Stebbing summarises the changes *as* follows ·· Having passed the whole of his service in managing forest areas under the so called Selection Svstem by the equally so called Improvement fellings, which, as is now very thoroughly realised, did little more than remove the marketable individuals of a few species from the mixed crop - to such a man. The mere mention of the fact that areas are managed under concentrated regeneration fellings, by taungya or otherwise; under the uniform or shelterwood compatment system either by natural regeneration or by artificial work; or by combinations of this method with strips or groups; under coppice or coppice with standard would convey little. With the fixed ideas engendered during a life's work carried out on the one basis it would prove difficult to visualise the present great advance, to appreciate that at the present day work on as high a plane as anything on the continent of Europe is to be seen in India" (Stebbing, 1926, Stebbing however hastens to qualify that these methods have been applied to a very small proportion of the forest area.

2 Total quantity of timber extracted in the Islands during 1982–63 was about 143000 of which about 78000 m was utilised by the plywood and match industries (Forest Dept., 1983).

3 Area to be allotted to PB I is directly proportional to the plan period and is derived as $\frac{A \times P}{C}$ where A = total area allotted to the working circle, P = plan period and C = conversion period (75 years).

4 All the four major industrial units in the Islands have obtained long term harvesting leases extending over 10 years.

5 The dense forest cover does not permit the growth of weeds. Absence of biotic pressures and the ecological conditions peculiar to islands are important factors responsible for poor weed growth.

6 Assam accounts for about 55 percent of the installed capacity of plywood industry in the country.

7 Important forest divisions are Digboi, Doom dooma and Dibrugarh.

8 The area of annual coupe in PB I areas is Digboi division is 340 hectares, while that worked annually under selective felling is about 2120 hectares.

9 This grouping is based on the stocking of large trees above 150 cm gbh. If there are 15 or more large trees the area is considered as well stocked. If it is less than 8 it is understocked. Medium stocked includes areas with 8–15 large trees per acre.

10 In Das'plan for Digboi division the area allocated to Hollong Plantation Working Circle is 20074 hectares. While that allotted to Hollong Makai regeneration circle is 32765 hectares

11 For example in Arunachal Pradesh the total forest area is estimated as 51500 Km^2. But the area under reserved forest is only 8070 Km^2. In Nagaland reserved forests account for only 12 percent of the total forest area.

12 The system followed in the case of Dehra Dun is described as conversion to uniform system in the working plan. But strictly speaking, what is followed is Irregular Shelterwood System (Singh, 1979).

13 1n Dehra Dun all trees up to 90 cm girth are retained as advance growth.

CHAPTER 4

COPPICE SYSTEMS

Management under coppice systems also relies upon natural regeneration. However, unlike other systems where regeneration is primarily of seed origin, coppice systems, as the name indicates, depend on shoots emerging from the cut stumps. Variants of the system are widely applied, especially to the dry deciduous forests and plantations of species like eucalypt. Details of the silvicultural practices and yield regulatory procedures adopted under each system are described below.

4.1 APPLICATION OF COPPICE SYSTEMS: Conditions under which coppice systems are adopted are as follows:

i. When the objective of management is production of firewood and small timber coppice systems are more appropriate.

ii. Coppicing ability is another important consideration in adopting the system and it cannot be followed in the case of species, which are poor coppicers. With increasing age, coppicing ability declines and this necessitates the adoption of a shorter rotation.

iii. One of the main advantages of coppice systems is the low investment requirements. Returns are generally quicker than high forest systems and this seems to be an important reason for their widespread application.

iv. The system is highly flexible and a number of objectives can be incorporated. Thus, production of large sized timber can be achieved by retaining standards and soil and water conservation objectives can be fulfilled by reservation of areas and reservation of trees.

Important variants and their application are given in table 4.1

Table 4.1
Application of Coppice Systems

System	Forest type	States
1. Simple Coppice	Dry deciduous forests	Tamil Nadu
	Eucalypt plantations	All States
2. Coppice with standard	Dry deciduous forests and moist deciduous forests	Bihar, Orissa, Andhra Pradesh, Madhya Pradesh, Uttar Pradesh
3. Coppice with reserves	Dry deciduous forests	Madhya Pradesh, Maharashtra, Uttar Pradesh, Orissa

4.2 SIMPLE COPPICE SYSTEM: The system is being followed in the dry deciduous forests of Tamil Nadu which are worked primarily for production of firewood. Also simple coppice system is adopted in the case of eucalypt plantations throughout the country for the first three rotations after artificial regeneration.

4.2.1 Yield regulation: Yield is regulated by area. Usually the rotation followed varies from 30 to 40 years for fuel working. After demarkating the annual coupes, the entire tree growth is felled either departmentally or by purchasers. Felling operation should be completed before the commencement of the growing season. After felling the area is closed to grazing and protected from fire. Cleaning involving removal of excess coppice shoots, climber cutting, etc. are prescribed.

4.2.2 Regeneration: As indicated, regeneration is mainly from the coppice shoots. Since they grow fast, usually no weeding is required. Overtime,however, coppicing vigour declines and mortality of stumps tends to increase. If protected from fire, grazing and other factors, the seedling regeneration that comes up does help to compensate the stump mortality. Most of the coppice forests are subjected to severe biotic pressures and consequently seedling regeneration is absent. With increasing stump mortality, degradation sets in over time. On account of this Tamil Nadu has temporarily suspended the felling of fuel coupes.

Simple coppice system is followed in the case of eucalypt plantations also. Rotation for eucalypt varies from 8 to 15 years. Usually the second and third cycle crops are of coppice origin. After the third cycle, the entire area is replanted. In Nilgiris, Eucalyptus globulus plantations are replanted after four rotations[1]. During the second (coppice) rotation yield is higher by 6 to 10 percent while during the third and fourth, yield is less by 9 percent and 20 percent respectively (Jayaraman, 1974).

4.3 COPPICE WITH STANDARDS (CWS) SYSTEM: The coppice with standard (CWS) system involves the retention of a fixed number of overwood trees, mostly of seedling origin, and extracted on a rotation which is usually a multiple of the coppice rotation. A forest worked under the CWS system thus has two tiers, an upper

one consisting of the standards, usually producing timber, and a lower tier primarily aimed at the production of firewood and small timber. The standards also protect the coppice crop from adverse climatic factors and form a source of seeds for restocking the area and thus help to overcome the decline in productivity due to stump mortality.

The main objective of management is production of firewood and small timber. CWS is one of the most widely adopted systems in the country. Most of the coppice forests are located close to habitations and are burdened with rights[2]

4.3.1 Yield regulation and felling: Yield is regulated by area. The rotation varies from 30 to 60 years and is fixed taking into account the condition of the crop and the extent of local demand. Where stocking is good and demand is low, usually a longer rotation of 60 years is adopted[3]. The rotation of the standards is usually a multiple of the coppice rotation and usually they are retained for two coppice cycles[4]. The number of standards retained and the preferred diameter class also varies between different categories of areas (eg. Dhalbhum Division - Bihar) as given in table 4.2.

Table 4.2

Coppice with Standard System in Bihar

Category	Characteristics	Rotation	No. of stds. per hectare.	Preferred diameter class (cm)
A	Good soil- Low biotic pressure	60	20–30	20-25
B	Deteriorated soil High biotic pressure	40	30-40	15-20
C	Highly deteriorated and eroded soil. Very high biotic pressure	30	40-50	10-15

Marking rules indicate details regarding the retention of standards. Apart from the standards all fruit bearing trees like Mahua (Madhuca indica) Mango (Mangifera indica), Amla (Emblica officinales) and Bahera (Terminalia bellirica) are also retained. The total number of trees retained in a coupe as standards and reserved trees should not exceed 50 in the case of category A and B areas and 62 in the case of category c areas.

After demarkating the annual coupe, a portion is set aside to meet the traditional rights or nistar. In Bihar the coupe is divided into four sections. To begin with, one section is opened to right holders to collect the material required by them on the basis of the recorded rights. If all the requirements of right holders could not be met from the first section wood collection is permitted from the second section also. The residual material available from the right holders sections plus the unworked section, leaving the standards and reserved trees, are sold in open auction and is removed by contractors[5]. With the introduction of state trading, felling and transport is undertaken either by the department or by the forest development corporations who finally sell the material from the depots. Yield per hectare varies from 10 m^3 to 25 m^3, depending upon the condition of the crop which is primarily dependent on biotic pressures. In most cases, there is a declining trend in yield between successive rotations.

4.3.2 Regeneration: After felling a number of subsidiary silvicultural operations are undertaken to promote coppice regeneration. These include:

i. dressing down stumps higher than 15 cm from ground level,

ii. coppicing of damaged trees,

iii. tending of seedlings by climber cutting, weeding, etc.,

iv. cutting back of malformed seedlings and reducing coppice shoots to 2 to 3 per stump,

v. soil Working in unproductive blanks and sowing of seeds of sal and other valuable species and

vi. strict fire protection.

In Bihar thinning is carried out as per the cycle given in table 4.3.

Table 4.3

Thinning Cycle under CWS System

Rotation (years)	Thinning cycle (years)
60	15, 30, 45
40	15, 30
30	15

4.3.3 Evaluation: In theory the system is quite suitable for meeting the demand for firewood and small timber. Retention of standards incidentally helps seedling regeneration, and this helps to compensate the stump mortality.

The system is however unable to meet the growing demand for timber and firewood. Areas close to habitations particularly suffer from illicit removal, and this in turn undermines the productivity of the system. In response to the growing demand, an attempt has been made to enhance supply by reducing the rotation. This is particularly the case of forests adjoining villages. Reducing the rotation has, however, failed to be a realistic solution, because already the biotic pressure on these forests are very high and a reduction in rotation enhances the

frequency of removal and thereby the process of degradation is accelerated. Degradation has gone to such an extent that it has become necessary to take up large scale planting in these areas. Areas originally under CWS working circle have been reallocated to rehabilitation or plantation working circle (Anon, 1974). In states like Orissa some effort is being made to introduce coppice with reserve system.

There is nothing inherently wrong with the system. Where biotic pressures - fire, grazing, firewood collection - are not high, the system is able to thrive well and regeneration is quite satisfactory[6]. In fact some of the areas worked under coppice system in Dehra Dun has been later put under conversion to uniform system.

4.4. COPPICE WITH RESERVE (CWR) SYSTEM: The coppice with reserve system has evolved in the former Central Provinces, now consisting of portions of Maharashtra and Madhya Pradesh. As in the case of other coppice systems, the main objective is to produce firewood and small timber, partly to meet the traditional rights (nistar) and regeneration is primarily of coppice origin.One of the main objectives of the system is prevention of site deterioration. This is aimed to be achieved by a combination of trestments appropriate to the condition of the crop. Also it attempts to see that species with high coppicing power does not form a pure crop and cause site deterioration. Reservation thus involves the exclusion of specified areas, species and trees above a prescribed diameter from felling. In effect it is a combination of different elements in different systems applied to the same coupe. The system was first introduced in 1927 by Trevor as 'modified simple coppice'. It was later developed and improved by Datta and Sagreiya (Tiwari, 196.8).

The system is now applied to the dry deciduous forests of Madhya Pradesh and Maharashtra. In States like Orissa CWR system

is being introduced in areas worked under CWS system to improve the condition of the crop and to prevent degradation (Mahapatra, 1980). The main objectives of management under the CWR system are,

i. meeting the increasing demand for small timber, poles and firewood, and

ii. to improve the stocking and quality of the crop by scientific management.

4.4.1 Yield regulation: Yield is regulated by area. On account of the varying intensity in felling, equal annual yield is difficult to realise. Often equiproductive areas are demarkated to ensure equal annual yields. Rotation under CWR system varies from 30 to 60 years and as in the case of CWS system a shorter rotation is followed in areas where the demand for firewood is very high.

After demarkating the annual coupe, a treatment map is prepared identifying the following types of areas.

i. Protection areas: No felling is carried out in this area which usually includes understocked portions with a density of 0.4 or below, eroded areas or areas subject to erosion and strips on either side of water courses where retention of vegetation is essential.

ii. Areas requiring enrichment

iii. Areas fit for felling, and

iv. That fit for raising plantations.

Even in areas earmarked for felling certain species as well as certain trees above specified girth limits are reserved. All species yielding fruits and other minor forest products - eg.

Madhuca indica, Emblica officinales, Mangifera indica, Buchnania lanzan, Diospyros melanoxylon, Syzygium cuminii, Acacia catechu, Boswellia serrata, Terminalia chebula and Terminalia bellirica, - are retained. All advance growth upto 24 cm girth is reserved. In addition healthy trees of valuable species like Tectona grandis, Terminalia tomentosa, Dalbergia latifolia, Gmelina arborea, Chloroxylon swietenia are reserved to act as seed trees. Reservation of species and trees ensures that the mixed character is not lost during successive coppicing.

4.4.2 Regeneration: Regeneration is primarily from coppice. The large number of trees reserved ensures adequate seeding and natural restocking. To encourage seedling and coppice regeneration subsidiary silvicultural operations are carried out in the year following felling. These include cleaning, cutting back damaged stems, and climber cutting. The number of coppice shoots is reduced to 2 or 3 per stool. Artificial regeneration is carried out in blanks by sowing or planting. Thinning is prescribed in the case of pole crop.

4.4.3 Evaluation: Coppice with reserves system represents a unique attempt to adapt silvicultural treatments to suit the varying conditions obtainable in a mixed forest. The system is highly flexible and takes into account varying site conditions.

Two factors, however, seem to affect the effectiveness of the system. Firstly, CWR is a highly skill intensive system requiring a good understanding of the interaction between different species. The type of intensive silviculture necessary is not being practised. Secondly, as in the case of CWS system, excessive demand has led to unauthorised removal causing serious deterioration in areas close to habitation.

4.5 CONCLUSION: Coppice systems are primarily adopted in the case of the dry deciduous forests and the main objective is production of firewood and small timber. Performance of the system largely depends on the socio-economic conditions of the immediate environment. Where demand is low and biotic pressures minimal, coppice systems do contribute significantly to the production objective. Where biotic pressure is high, the system has been found to be unsuitable. Excess removal, often unrecorded, coupled with fire and grazing have led to degradation, and it has become necessary to tackle these wastelands with artificial regeneration under rehabilitation schemes.

NOTES

[1]Considerable work has been done on different aspects pertaining to the growth and performance of coppice shoots in eucalypts. The season for getting the best growth, size of stump, method of cutting, etc., have been standardised. However, very little is known on these aspects in respect of the mixed forests,

[2]This is particularly the case of the former zamindari forests which vested with the government with the enactment of land reforms act. They have been constituted as protected forests and the local people contine to enjoy certain rights.

[3]The condition of the crop is directly related to the demand, where demand is high a large quantity of wood is removed, often unauthorisely, and this is an important factor for the deterioration of the condition of the crop.

[4]Where demand is very high, the standards seldom reach the prescribed rotation.

[5]A major portion of the firewood so sold goes to meet the urban demand. Sometimes firewood is transported for a distance of over 1000 Km.

[6]For example stocking and regeneration in some of protected forests worked under CWS system in Gua range in Saranda division is as good as the adjoining areas worked under conversion to uniform system. Absence of biotic pressures seems to be the main factor.

CHAPTER 5

CLEARFELLING SYSTEM

Clearfelling system has a long history in India and the system, is adopted with the objective of changing the crop composition in favour of commercially and industrially more valuable species. Restocking of felled areas is accomplished either naturally or artificially. Artificial regeneration is necessary when new species are to be introduced or the composition of the crop is to be significantly improved. Both methods of regeneration are followed in India and the choice is determined by a number of factors. Evolution, growth and present status of clearfelling system and methods of regeneration are discussed below.

5.1 EVOLUTION: One of the earliest efforts at clearfelling and artificial regeneration was made at Nilambur in Kerala in 1842 in the case of teak[1]. Depletion of large sized teak trees required for ship building was the main factor that led to this effort. A number of plantations were raised at Nilambur following the initial trials and their success led to raising teak plantations in other provinces also. Two distinct periods can be identified in respect of the development of clearfelling and artificial regeneration in India and the characteristics of these are described below.

5.1.1 Pre-independence period: This period is characterised by (i) the small scale of clearfelling and planting (ii) the limited number of species raised artificially and (iii) the general preference for long rotation species. Extent of clearfelling and planting was limited due to the following factors.

(a) Both clearfelling and artificial regeneration required high input of labour. In most areas, availability of labour was a limiting factor, especially due to the fact that planting coincided with the agricultura1 season, when farm labour demand was at its peak. Establishment of forest villages and introduction of taungya system to some extent helped to solve the problem, but where these alternatives were not available, the scale of clearfelling and planting had to be kept to the extent permissible by available labour supply.

(b) Limited availability of funds was another important constraint. Although the long term justification for raising plantations was well understood by the forest service, often the government was not convinced about the rationale. Especially when most of the short-term demand for timber and other products could be met, there was very little compulsion to think about long term demand.

(c) Clearfelling of mixed forests releases a large quantity of assorted timber and firewood. Due to lack of demand disposal of this was often a major constraint which limited the area treated under clearfelling system[2].

Although artificial regeneration was attempted with a large number of species, indigenous species like teak, sal, sissoo and khair, continued to be the most favoured ones. Of these, teak was raised extensively in a number of states even outside its natural distribution[3]. On account of the early attempt to raise teak plantations, silvicultural and management aspects of the species were well understood. Further, the wood is extremely versatile and fetches a high price is comparison with other species. Exotic species like Cryptomeria japonica, Eucalyptus spp., Casuarina equisetifalia, and Acacia mearnsii were raised, but were limited to specific localities[4].

5.1.2 Post-independence period: The post independence period is characterised by the rapid growth of plantation forestry. Non-availability of labour, lack of demand for wood from clearfelling, etc. ceased to be constraints in expanding the area under clear-felling and artificial regeneration. A rapid increasein the price of timber and firewood, made clearfelling mixed forests a profitable proposition. Cost of reforestation, however, remained stable, especially if taungya system could be adopted. Clear-felling thus became an important source of revenue to governments. Establishment of plantations of quick growing species integrated with wood based industries became one of the major prescriptions for forestry development. Demand supply studies indicated a growing shortage of industrial wood supply, particularly pulp-wood. In one of the reports of the FA0 to Government of India (Von Mon Roy, 1960), the main prescriptions to enhance wood production were (i) planting 1.5 million acres in 10 years with fast growing species and (2) improvement of accessibility of hill forests to permit better exploitation. All these led to giving a high priority to plantation establishment and a number of schemes – plantation of quick growing species, economically important species, matchwood species, pulpwood species, etc. – were initiated under the five year plans, often with complete or partial financial support from the central government.

A further expansion of plantation activity took place in the 1980s as a result of the implementation of reconmendations of the National Commission on Agriculture (Govt. of India, 1972, 1976). The Commission reiterated the need for large scale man-made forestry programme linked to wood-based industries. Institutional inflexibility of existing departmental organisation and shortage of funds were identified as the major constraints in pursuing such a programme. Establishment of forest development corporations was recommended to overcome these problem. In pursuance of the NCA

recommendations, forest development corporations have been set up in most states[5]. Some of these corporations have initiated large scale plantation projects involving initial clearance of natural forests[6] (eg. The Godavari catchment covering Bastar, Chanda and Adilabad, and the Western Ghats in Kerala). Teak and eucalypts are the most important species raised by forest development corporations.

Table 5.1 gives the area of man-made forests raised during the different five year plans.

Table 5.1

Man-made forests raised during five year plans

Period	Area (in 000 hectares)
1951–1956 (First Plan)	52
1956–1961 (Second Plan)	311
1961–1966 (Third Plan)	583
1966–1969 (Annual Plans)	452
1969–1974 (Fourth Plan)	713
1974-1979 (Fifth Plan)	1220

The total area of man-made forests in 1980 is estimated as 3.5 million hectares. Part of this is raised under afforestation schemes in degraded and barren areas. Reliable data are not available on the area under each category.

5.2 Current Status: Clearfelling system is adopted in almost all states in India with the following objectives:

i. To enhance the proportion of valuable species, especially in the mixed moist and dry deciduous forests and to improve the condition of degraded areas (eg. planting of teak in Kerala, Karnataka, Tamil Nadu, Madhya Pradesh, Maharashtra, and Andhra Pradesh. Planting of padauk in the moist deciduous forests of Andamans, etc.).

ii. To drastically change the crop composition by introducing species outside its natural habitat (eg. introduction of teak to the sal zone in Uttar Pradesh, Bihar and West Bengal, and eucalypt and tropical pines in different states).

Plantations can be broadly grouped into two categories, namely (i) those of species like teak, sal, sissoo, khair, etc. raised with the objective of producing timber for conventional uses and to enhance income to the government and (ii) fast growing species like eucalypt, tropical pines, poplars, etc, grown to meet industrial requirements or to meet fuelwood demand. In the latter case, volume production is the main objective and hence shorter rotations are adopted.

5.2.1 Yield regulation and felling: When managed on the basis of working plans, yield is regulated by area and the extent of annual coupe is derived on the basis of rotation and area under the felling series. For the schemes implemented under the five year plans and by the forest development corporations, no attempt is made to regulate yield on a long term basis. The aim of such schemes is limited to converting the mixed forests to plantations within a short period depending upon availability of funds, labour, etc. Therefore, yield tends to fluctuate considerably.

Rotation varies between species and between regions for the same species. Where plantation programmes have started long ago, the rotation continues to be very long while in the case of plantation projects initiated by the Corporations it is much lower than what is adopted usually. Table 5.2 gives some of the typical rotations adopted in the case of some of the commonly raised plantation species.

Table 5.2

Rotation for Plantations/Natural regeneration

State	Division	Species	Rotation (in yrs)
Kerala	Nilambur	Teak	55
	Konni	Teak	70
Maharashtra	Allappalli - Plain FS	Teak	120
	Allappalli FDC Plantation	Teak*	50
Madhya Pradesh	Hoshangabad	Teak	80
Uttar Pradesh	Haldwani	Teak	50
	"	Sal	90
	"	Sissoo and Semul	60
West Bengal	Jalpaiguri	Sal	80
		Teak	70
All states	..	Eucalypts	7 to 15

* The objective of management of FDC plantations is to produce poles and small timber and hence a low rotation of 50 years.

Although the rotation remains still very high for most of the hardwood species, a trend towards reducing it exists (Ghosh and Singh 1981). Partly this depends on saleability of the produce, and a declining trend is particularly evident in the case of high value species like teak.

Different agencies are involved in clearfelling the natural stand. Where state trading has been introduced (eg. Madhya Pradesh and Bihar) logging and transport are undertaken directly by the department. Timber and firewood, are brought to government depots from where they are dispased off in public auction. In Kerala

timber extraction is carried out in two stages. During the first stage trees of valuable species above 120 cm g.b.h. are extracted departmentally, engaging logging contractors. The right to collect residual growth is then sold in public auction. In states like Gujarat and Maharashtra logging is often carried out by Forest Labourers' Cooperative Societies.

5.2.2 Regeneration: Dependence on natural regeneration to restock cleared areas is on the decline and is restricted to those areas where regeneration comes up profusely. Examples of natural restocking are Saranda in Bihar and Raipur in Madhya Pradesh for sal and Hoshangabad in Madhya Pradesh and Chanda in Maharashtra for teak. In the case of sal forests of Saranda, regeneration comes up profusely immediately after clearfelling[7]. Such a situation, however, seems to be an exception. In Saranda itself the mixed forests are regenerated artificially with teak. In the teak areas of Madhya Pradesh and Maharashtra dependence on natural regeneration is very partial. Compact blocks of not less than 0.8 hectares containing more than 750 saplings per hectare over 1.5 metres are retained and damaged and malformed saplings are cut back. Also poles upto 76 cm gbh are retained as advance growth. In other areas artificial regeneration is the usual practice.

Natural regeneration is taken advantage of restocking final felled Wattle plantations (Acacia mearnsii) during the second and subsequent rotations in Nilgiri and Palni hills in Tamil Nadu. Wattle is worked on a 10 year rotation for pulpwood and bark. After final felling the area is control burnt and this helps to end the dormancy of seeds. Natural regeneration comes up profusely and after 2 or 3 years thinning is done to remove excess number of saplings. Artificial regeneration is resorted to in failed areas and new areas only.

The technique of artificial regeneration varies between species and localities. Teak is usually raised by planting stumps in crowbar holes. Direct sowing in thalis is also

vogue. In the case of sal, seeds are dibbled in prepared lines, while eucalypt is raised by planting poly bag seedlings. Taungya system is widely adopted for raising plantations in Kerala, Tamil Nadu, Karnataka, Uttar Pradesh and West Bengal (FAO, 1981). Under this system, forest land is leased out to cultivators for a period of 2 to 3 years. Planting is carried out by the forest department and cultivation is permitted for a period of 2 to 3 years. In West Bengal and Uttar Pradesh, even the initial planting/sowing is carried out by taungya cultivators. During the tenure of taungya, all maintenance operations - weeding, cleaning, fire protection, etc. - are undertaken by the cultivators. In states like Kerala where land hunger is severe, the forest department realises a substantial lease rent due to competition between lessees. This sometimes completely offsets the cost of plantation establishment. Taungya has played a very useful role and it continues to be a cheap method of regeneration. However, there is uncertainty regarding its future, especially in the context changing land tenure, cropping pattern, etc. (FAO, 1984).

5.2.3 Evaluation: No systematic evaluation has yet been carried out on the multifarious effects of clearfelling system. The major objectives are (1) conversion of the less valuable mixed forests into plantations of valuable species and (2) creation of a normal forest for realisation of sustained yield of timber. Value of the growing stock can be increased either by (i) enhancing the productivity and (ii) changing the crop composition by planting more valuable species. However, the objective of enhancing productivity has not always been achieved. When plantations are taken up on a large scale, microclimatic and soil variations tend to be ignored affecting the overall productivity. Damage from pests and diseases is another important factor contributing to low productivity. Attack from defoliators, Hyblaea purea and Eutectona machaeralis is frequent in teak plantations throughout

the country and the effect of this on volume increment is substantial (Nair, et al, in preparation). Eucalypts grown in moist areas suffers from pink disease and often whole plantations have been affected (Sharma, 1984) drastically reducing productivity (Krishnankutty, et al, 1984)

Enhancing the value of forests has been achieved primarily by planting commercially valuable species like teak. Value in the market is determined by the pattern of demand which is primarily dependent on income distribution. The very high price of teak timber is primarily due to its decorative characteristics which is mostly demanded by consumers in the higher income groups. No doubt, this facilitates the realisation of a high revenue by government. But it leads to the neglect of less remunerative species required for common use, especially by the low income groups.

The other objective, namely creation of a normal forest has been achieved mainly because of the uneven pace of plantation development. Consequently, sustained yield is far from reality. Harvesting of natural forests releases a large quantity of timber and firewood. But this supply dries up as soon as the limit to clearfelling is reached. Often this affects both the production and revenue objectives.

Social and environmental consequences of clearfelling have not received adequate consideration yet. Changing the crop composition does affect the availability of non-wood products. Forest-dwelling communities are particularly affected by this. Consequent to local opposition, reforestation with teak, eucalypts, etc. had to be discontinued in certain states. Also there is an increasing awareness of the regulatory role played by natural vegetation in hilly catchments. In response to this, some states like Kerala and Karnataka have suspended clearfelling.

5.3 CONCLUSION: Clearfelling followed by artificial regeneration has gained considerable importance during the 1970s and 1980s. There is, however, a growing awareness of its possible adverse social and environmental effects. The future of the system will depend on a number of factors. One of the justification for clear-felling is to make available the land for plantation programmes geared to meet industrial and domestic wood requirements. However, this could be undertaken on the extensive degraded land already available (Bentley, 1984). Probably, the contribution of clear-felling towards revenue will be an important consideration in the continuance of the system. Financial profitability of the Forest Corporations is greatly dependent upon timber obtained during the initial felling. Hence, there are strong compulsions, for both governments and Corporations to continue clearfelling Another factor that will necessitate clearfelling will be the need to supply wood to industries like sawmilling. Most of the plantations belong to the younger age classes and output from them will not be available to replace timber obtained from natural forests. Further, most of the plantation programmes have focused on a few species, while no attempt has been made to raise those required for ordinary purposes. Considering all these, it is difficult to visualise the future direction. The system may continue to be adopted, but at a much reduced scale.

NOTES

[1]Although initial trials were made from 1842, regular planting commenced from 1844 only (Vasudevan, 1971).

[2]Transport facilities were not well developed to take advantage of the demand in distant markets. Truck transport began to be widely used only during the post second world war period.

[3]Teak has been introduced to West Bengal, Uttar Pradesh, Bihar and Andaman Islands. Primarily it is raised in mixed deciduous forest areas. However, in Uttar Pradesh, it is being raised in the sal belt also, where natural regeneration is not satisfactory.

[4]Cryptomeria japonica was introduced to the Darjeeling hills, while Eucalyptus globulus and Acacia mearnsii were raised extensively in the Nilgiris.

[5]There are 16 forest development corporations in India now.

[6]Although extensive tracts of degraded forests are available for raising plantations, often forest corporations have taken up well stocked natural forests. Income from initial clearing is accounted as a project benefit to enhance the financial viability of the programme.

[7]Details have been given in Chapter 3. Strictly the system adopted in Saranda is clearfelling with natural regeneration. But management plans refer to this as conversion to uniform system (Rajhans, 1976).

CHAPTER 6

SOCIETY, FORESTS AND FOREST MANAGEMENT

Society forest interaction as reflected in the management system undergoes changes in response to changing characteristics of society and forests. Management systems, therefore, seldom remain static and what is appropriate at a given time may not remain so later, The future of natural management of mixed tropical forests in India depends on a number of factors. To get a picture of emerging trends, it is imperative to analyse how developments in biological, technical, organisational and managerial sciences have influenced current management systems.

6.1 Technical changes: Developments in biological and technical sciences related to forestry can be grouped as **(1)** that which improved management and utilisation of natural forests and (2) those that contributed to better management of man-made forests. Identification, and cataloguing of species and research on forest utilisation were largely aimed to enhance the use of natural forests. Forest botany and forest products research were the major areas that got attention during the early stages of forestry research. Extensive exploration was undertaken with the objective of identifying commercially valuable species. Research on forest products, particularly wood anatomy, timber mechanics, wood seasoning and preservation, etc. was also taken up simultaneously.

Cataloguing and classification led to forest type classification, an important field in forest ecology. Autecological studies were initiated in response to the need for regenerating

some of the commercially valuable species like teak and sal. Initially there was complete reliance on natural regeneration and most of the techniques were standardised by way of trial and error. Sal was one species whose regeneration received considerable attention. Sal forests can be broadly grouped into those where regeneration is satisfactory and those which are difficult to regenerate. A lot of attention was given to promote regeneration in the latter, involving operations like canopy manipulation, shrub cutting, controlled burning, fencing and soil working. To identify the factors that inhibit regeneration, investigations were undertaken covering geology, soil, climate, biotic factors, ecological status of the forests, competition for light and moisture and so on. No doubt, these studies improved the understanding of sal ecology; but natural regeneration continued to remain an intractable problem. Artificial regeneration, often with species other than sal, had to be resorted to in many areas.

Growth and yield studies of important commercial species also received considerable attention. This led to preparation of volume and yield tables and a better understanding of the growth response to various treatments.

Synecological studies on tropical mixed forests are at best partial and most oftep limited to a small segment of the complex processes such as nutrient partitioning, biomass distribution, etc. (Nair, 1984). No research has been carried out to understand the intra and intersystem flows, fractioning of energy and matter, process of succession and the impact of different intensities of harvesting in representative forest ecosystems over a sufficiently long period to generate reliable data required for developing appropriate management practices.

Neither have researchers attempted to incorporate management objectives, nor have managers tried to adopt research findings. Consequently, management of natural forests continues to be unscientific and managers often act arbitrarily in response to immediate compulsions. Thus, when there is an increasing pressure from wood based industries, large areas are exploited heavily, disregarding long term sustainability of wood supply. Response in the opposite direction is also seen, often leading to the total stoppage of felling due to pressures from environmental groups.

An outcome of the emphasis on exploitation of natural forests is the high priority given to forest resource inventory and the attempt to improve logging techniques. Resource surveys focussing entirely on wood availability have been undertaken in most of the forest areas. This information has been utilised for management plans and particularly for taking up forestry projects by the forest development corporations. Considerable attempt has been made to improve logging techniques, but on a national scale the impact has been marginal. This is partly attributed to the prevalence of contract system (Govt. of India, 1976). However, even in states where the contract system of timber extraction has been abolished, no significant change is noticed.

Most of the recent developments in forestry are directed at creation and management of man-made forests. Here again, the emphasis is on expansion of area and much less attention has been paid to enhancing productivity. Success of the 'green revolution package' in increasing food production did have some impact on forestry. Green revolution is an outcome of the use of high yielding varieties coupled with application of fertilisers, pesticides and irrigation. Adoption of such techniques in forestry has been very slow. Although work on genetic improvement commenced in the 1960s, use of improved seeds in plantation forestry is still an exception. Fertiliser application based on

detailed soil studies is still not in vogue, and at best is limited to the planting stage in nutrient deficient soils. Pest and disease problems that have existed for a very long time continue to defy solutions.

No doubt, inherent complexity of forest ecosystems limits the adoption of techniquee appropriate to simple ecosystems like agriculture. Several other factors also have contributed to such a situation. Firstly, a large proportion of timber continues to be obtained from natural forests with practically very little investment. The assumption that forests are inexhaustible continues to influence the thinking of both people and decision-makers. Secondly, low prices for wood and other products provides little incentive for high investment. Industrial wood supply is highly subsidised and most consumers of wood regard it as a free good. Finally, the long gestation period of forestry investments acts as a discincentive, especially to the private sector. With the introduction of short rotation crops, this is, however, changing.

Development in the field of wood utilisation has been quite impressive, partly due to the compulsion to use lesser known species arising from the non-availability of conventional species. However, developments in silviculture and management is limited to a few well known indigenous species like teak, sal, sissoo and semul or exotics like eucalypt and tropical pines. Easy availability of information on management practices of exotics has been primarily responsibie for their large scale introduction[1]. Despite the long history of trials, information on many of the indigenous species continues to be inadequate, especially for those which are of local importance only.

6.2 Institutional changes: Like the slow adoption of developments in biological and technical sciences, introduction of organisational and managerial developments has also been extremely slow. In fact

the latter seems to have considerably hampered the development of forestry. Structure and organisational pattern of forest departments have undergone little change since their establishment. Policing the forests continues to be the main function and the function as land manager has been neglected considerably.

Attempts have been made to separate the different functions of forest service. Such organisational changes are mostly internal, like creation of separate wings or divisions for logging, afforestation, sale of timber, collection of minor forest products, social forestry, etc. Establishment of autonomous forest development corporations is a further step in the direction of giving more emphasis to the land management function. As pointed out earlier, forest development corporations were formed to ensure better operational flexibility necessary in land management and to utilise institutional finance for forest development. Activities undertaken by forest development corporations can be categorised as follows:

i. Harvesting natural forests and collection of comercially valuable minor forest products like tendu leaves, sal seeds, etc,

ii. Raising plantations of species like teak, eucalypt, and tropical pines and

iii. Cultivation of cash crops like oil palm, tea, rubber, coffee and cardamom.

Since commercial profitability is the main consideration, none of the corporations have taken up management of natural forests. Further the activities of most of the corporations have centred on well stocked natural forests from where a substantial quantity of timber can be obtained by way of clearfelling. In many instances treating the yield from clearfelling as a project benefit has enhanced the financial profitability of the projects.

Organisation and management of forest research and education have undergone little change during the last few decades and this has been an important factor that impeded the development of forestry. Training forestry personnel has been one of the most important functions of existing institutions, and institutions geared to the development of forestry science are poorly developed.

6.3 Natural Management: Future trend: True natural management involves practically little human intervention at the stages of regeneration and growth. When removal is limited to increment and sufficient time is given for natural recovery, a 100 percent natural management may be possible. With the increasing intensity of removal, substantial input of labour and other resources becomes necessary to maintain productivity. At what stage management ceases to be natural is, however, difficult to determine. For the present study, management is considered natural as long as there is complete reliance on natural regeneration, both seedling and coppice, for restocking felled areas.

Necessary conditions for natural management to be successful are (1) adequacy of natural regeneration, (2) negligible biotic factors which could affect recruitment and establishment of regeneration and (3) low and stable demand for wood and other products. Fulfilment of the above conditions in important forest regions are examined below.

6.3.1 Tropical evergreen and semievergreen forests: (1) Andaman and Nicobar Islands: Natural regeneration is satisfactory. Due to the low population density, biotic factors like fire, grazing etc. are not serious. Currently timber is obtained from harvesting unworked near virgin stands. Even if regeneration is good, a decline in yield during the second rotation is anticipated. Scarcity of veneer logs in the mainland will lead to overexploitation. Another important factor that could affect forest

management is the diversion of forest land for non-forestry purposes, particularly for cultivation of cash crops like rubber and oil palm. Already the forest development corporation in Andamans has taken up an oil palm project in Little Andamans. To reduce the growing foreign exchange drain through import of edible oil, there could be an expansion of oil palm cultivation. This could drastically change the land use pattern affecting natural management.

(2) North Eastern Region: The north eastern region presents another extreme situation. Industrial capacity and wood resources are unevenly distributed between different states. Rapid growth of plywood industry has led to over exploitation of all easily accessible forests. Natural regeneration is unsatisfactory and areas degraded due to past working are being restocked artificially. A large proportion of the forests is under tribal control and subjected to shifting cultivation ruling out the possibility of any long term sustainable management for wood production.

(3) Western Ghats: Natural regeneration is unsatisfactory. Adverse biotic factors like fire and encroachment are serious. Further, the demand for timber, especially veneer and saw logs, is increasing. Most often demand is met by reducing exploitable girth and felling cycle and enhancing the number of trees harvested per hectare[2]. Felling cycle is often unrealistically low inhibiting natural recoupment. Also there is growing pressure to divert forest land for non-forestry purposes. One cannot, therefore, be optimistic about the feasibility of natural management in the Western Ghat evergreen forests.

As can be seen, evergreen and semievergreen forests in all the three regions are exploited primarily to supply veneer logs. Future management of those forests is essentially linked to the growth of plywood industry and the availability of raw material from alternative sources. Import could be helpful to relieve the pressure for the time being. But in the long run, there has

to be reliance on man-made forests. Adoption of coppice with standard system in eucalypt plantations under which the standards harvested after 3 or 4 coppice rotations supply veneer logs, is an appropriate alternative. Failure to find alternative sources of veneer logs will lead to intensive, and often uncontrolled, exploitation causing total degradation.

Even if the problem of wood raw material to plywood industry is resolved, future management of evergreen forests will depend on the changes in overall land use. Climatic and soil conditions are apparently favourable for alternative land uses, especially for cash crop cultivation and the process of diversion for **non-** forestry purposes is continuing. How far this will continue depends on a large number of factors, particularly population growth, the pace of economic development, the dependence on land as a source of income and government policy on land use[3]. Although there is growing awareness Of the productive, protective and social functions of evergreen forests, diversion for **non** forestry purposes may continue for some more time, consequently increasing the pressure on the remaining forests. Natural management has very limited scope under such conditions.

6.3.2 Moist deciduous forests: (1) Sal forests: Natural management can be considered as successful only in a few areas like Saranda in Bihar and Raipur in Madhya Pradesh. Adequacy of natural regeneration seems to be the most critical factor. In most of the valley, plain and hill sal tracts (parts of UP, West Bengal, Bihar, Assam, Orissa and Madhya Pradesh) despite earnest efforts, regeneration continues to be problematic and artificial planting is being resorted to, often involving replacement of sal with teak, eucalypt,etc. In theory, selective felling, in which intensity of removal is low, relies upon natural regeneration. However, no study has been carried out on the long term impact of selective removal in sal forests. Also selective felling as practised now, cannot be strictly regarded as a management system.

(2) Teak forests: Dependence on natural regeneration to restock teak forests is limited to some areas like Chanda, Hoshangabad, etc. Even here, uncertainty of natural regeneration has led to its replacement by artificial regeneration, although this is known to cause site deterioration by way of soil loss (Seth and Kaul, 1978). The latter is particularly, cheap and simple when stump planting is resorted to. Status of natural regeneration is unsatisfactory in selection felling areas.

(3) Mixed forests: Natural regeneration of valuable species is unsatisfactory. Further most of these forests are subjected to fire, grazing and such other biotic pressures. Traditionally the objective of management has been to enhance the proportion of valuable species and inevitably artificial regeneration is resorted to.

6.3.3 Dry deciduous forests: Most of the dry deciduous forests are managed under coppice systems. Production of fuelwood and small timber is the main objective of management and these forests primarily cater to the local demand. Coppice regeneration is satisfactory, but most of these forests are subjected to severe biotic pressures, especially fire and grazing leading to degradation. Illicit removal of wood is also a serious problem and is an indication of the growing demand. Natural management is almost impossible under such circumstances. Consequently most of the degraded areas are being restocked artificially.

A similar situation exists in the case of forests predominantly used for production of bamboo, salai, sandalwood, etc. Especially when the same forests are utilised for producing more than one product, incompatibilities arise and operations intended to benefit one becomes deterimental to the other[4]. Biotic pressures like fire, grazing illicit removal and non-compliance of silvicultural prescriptions have adversely affected both growing stock and increment. Realisation of longrun sustainable supply under existing systems of management is impossible.

6.4 Forest management: Future options: Although India has about 75 million hectares of land legally classified as forests, the growing stock and increment is very low. The average growing stock is estimated as 26 m^3/hectare. This is unevenly distributed with easily accessible areas containing poor growth. Total demand for wood by 2000 AD is projected as 289 million m^3 (Govt. of India, 1976). With a low mean annual increment of 0.5 m^3/hectare this demand cannot be met. A radical change in the direction of forestry development is essential to ensure that forestry fulfills the multifarious requirements of society. The present phase of forestry is characterised by

(1) high dependence on natural forests to meet industrial and domestic demand,

(2) deforestation to meet the demand for land for alternative uses and

(3) low investment in forestry.

An alternative and more desirable scenario will be one in which

(1) the dependence on natural forests is minimal,

(2) very little diversion of forest land for non-forestry purposes and

(3) high investment on forestry, especially on plantation development.

Under this alternative, most of the wood requirements may be met from plantations raised in the degraded and waste lands. Natural forests, especially those in hilly areas, can be utilised to fulfill the protective and social functions, to supply a small quantity of high quality timber and to balance the cyclic fluctuations in wood demand. There are some indications of a change such as (1) a general opposition to felling natural forests for conversion to monoculture plantations,

(2) growing environmental awareness and resultant closer scrutiny of developmental projects, especially those implemented in forest areas and (3) assigning a high priority for social forestry and development of wastelands through afforestation. The Government has initiated an ambitious wasteland development programme and proposes to afforest 5 million hectares annually. To undertake this, a waste land development board has been constituted. Successful implementation of this programme will result in a radical change in forestry and the dependence on natural forests for meeting wood requirements will be reduced significantly. A balanced multiple use of mixed tropical forests requires the creation of intensively managed plantations on land which contains no tree growth now. Failure to pursue such a policy would result in heavy exploitation of natural forests seriously jeopardising the realisation of different values in the long run.

Constraints in the pursuit of a rational forestry programme have been indicated elsewhere (FAO, 1984). The new approach would require formulation of a forest policy as a component of an integrated land use policy, creation of appropriate institutions for implementation of such a policy, and provision of a suitable legal framework (Nair, 1984). Institutions involved in education, research and extension need to be remodelled and strengthened to overcome the information gap, communication gap and adoption gap. With the involvement of Universities in forestry education and research,development of forestry science is expected to gain considerable momentum.

6.5 CONCLUSION: Although plantation forestry has a long history in India, the high dependence on natural forests continues. Society has treated forests as a 'God given asset' and hence a freely available resource and this has led to uncontrolled exploitation. Application of developments in biological and technical sciences are primarily directed at the accelerated exploitation of natural forests. Organisational changes in forest administration have been marginal and have not brought about any significant change from the traditional policing role.

As long as such a situation persists, sustainable natural management of the tropical mixed forests will not be possible. Analysis of existing management systems indicate the limitations of present approaches. Creation of intensively managed plantations on barren land and thus meeting most of the wood requirements seems to be the only alternative. Indications are that Indian forestry is entering a transition phase during which current practices will be critically examined and a more rational approach to land use, in particular forestry, will be pursued.

NOTES

[1]A number of international institutions, including aid agencies, and research institutions, has played an important role in the introduction of exotics like eucalypts and tropical pines.

[2]Recently a change in the opposite direction is seen. For example in Karnataka the number of trees allowed to be harvested has been reduced to 2 largely due to the pressure from the environmental groups.

[3]Changes in agricultural land tenure is likely to have a significant effect. Although land reform legislation has been enacted in most states, their implementation is tardy and consequently feudal relationship persist in many areas. Implementation of land reforms could reduce the pressure on forest land, especially that due to migration of landless to forest areas. Better income could also reduce the need for collecting firewood.

[4]For example to induce production of connice shoots in Diospyros melanoxvlon (Tendu) burning is resorted to. No doubt this increases the availability of tendu leaves (which is an important source of revenue to forest departments in many states) but adversely affects natural seedling regeneration of a large number of species. Similarly collection of sal seeds could have serious implications on natural regeneration, especially during poor seed years (Verma and Sharma, 1978).

REFERENCES

Adkoli, N.S. (1977) Sandalwood in Karnatnka - Retrospect and Prospect. Proceedings of the All India Sandal Seminar, February, 1977, Karnataka Forest Department, Bangalore.

Anon (1967) Recent trends in the technique of natural and artificial regeneration of Sal. Proceedings of the Eleventh Silvicultural Conference, FRI & Colleges, Dehra Dun:62-73.

Bathew, W.B. (1983) Forward: In Hundred Years of Forestry in Andamans. Andaman & Nicobar Islands Forest Department.

Bentley, W.R. (1984) The Uncultivated Half of India: Problems and Possible Solutions. Discussion Paper No.12,Ford Foundation, New Delhi.

Central Forestry Commission (1980) India's Forests. Ministry of Agriculture, New Delhi.

Champion, H.G. (1936) A Preliminary Survey of Forest Types of India and Burma. Indian For. Rec. (ns) 1. FRI., Dehra Dun.

Champion, H.G. and F.C. Osmaston (1962) The Forests of India, Vol.IV. Oxford University Press.

Champion, H.G. and S.K. Seth (1968) A Revised Survey of the Forest Types in India. Manager of Publications, Delhi.

Das, A.C. (1974) Working Plan for the Digboi Forest Division 1974-75 to 1985-86. Forest Department, Assam.

Dubey, R.K. (1967) Natural and artificial regeneration of teak forest in Madhya Pradesh. In Proceedings of the Eleventh Silvicultural Conference, May 1967, Vol.11. FRI & Colleges, Dehra Dun:444-451.

Food and Agriculture Organisation (1981) India and Sri Lanka - Agroforestry. FAO., Rome.

Food and Agriculture Organisation (1984) Intensive Multiple Use Forest Management in Kerala. Forestry Paper No.53. FAO., Rome.

Forest Department, Andaman & Nicobar Islands (1983) Hundred Years of Forestry in Andamans. Forest Department, Andaman & Nicobar Islands, Port Blair.

FRI & colleges (1961) Hundred Years of Indian Forestry, v01.11. Forest Research Institute and Colleges, Dehra Dun.

FRI & Colleges (1972) Indian Forest Utilisation, V01.II. Manager of Publications, Delhi.

Ghosh, R.C. and S.P. Singh (1981) Trends in rotation. Indian Forester, 107(6): 336–347.

Government of India (1972) Interim Report on Production Forestry - Man-made Forests. National Commission on Agriculture, New Delhi.

Government of India (1976) Report of the National Commission on Agriculture, Part IX, Forestry. Ministry of Agriculture, New Delhi.

Jayaraman, V. (1974) Working Plan for Nilgiris South Forest Division 1974–75 to 1983–84. Tamil Nadu Forest Department.

Joseph, S .(1970) Working Plan for Coimbatore North Forest Division 1970–71 to 1979–80. Tamil Nadu Forest Department.

KFRI (1978) Availability of Wood Raw Material for the Plywood Industry (North-Eastern Region). Unpublished Report. Kerala Forest Research Institute, Peechi.

Krishnankutty, C.N. and M. Chundamannil (1984) Eucalypt plantations in the forests of Kerala: Are the goals being fulfilled. Paper presented at the National Seminar on Eucalypts, Kerala Forest Research Institute, Peechi.

Krishnaswamy, s. (1957) The culm selection system. Indian Forester, 88(12): 711-712.

Mahapatra, B.C. (1980) Working Plan for the Reserved Forests of Talcher Range of Angul Forest Division 1981–82 to 1990-91. Orissa Forest Department.

Maleta, B.P. (1976) Working Plan for Haldwani Forest Division 1976–77 to 1985–86. Uttar Pradesh Forest Department, Nainital.

Nair, C.T.S. (1984) Crisis in forest resource management. Paper presented at the seminar on Ecological Crises and Legislative Safeguards. India International Centre, New Delhi.

Nair, C.T.S. (1985) Bamboo-reed Based Industry in Kerala State, India (Unpublished Document). Kerala Forest Research Institute, Peechi.

Nair, K.S.S.; V.V. Sudheendrakumar and K.C. Chacko. Studies on the Seasonal Incidence of Teak Defoliators and the Effect of Defoliation on Volume Increment of Teak: Final Report of Research Project Entom.02/77 (In preparation). Kerala Forest Research Institute, Peechi.

Prasad, N. and M. Gadgil (1981) Conservation of Bamboo Resources. Karnataka State Council for Science and Technology, Bangalore.

Puri, G.S.; V.M. Meher-Homji; R.K. Gupta and S. Puri (1983) Forest Ecology, Vol.1. Phytogeography and Forest Conservation. Oxford & IBH Publishing Co., New Delhi.

Rai, S.N. (1979) Gap Regeneration in Wet Evergreen Forest of Karnataka: Research Paper KFD.2. Karnataka Forest Department.

Rajhans, K.S. (1976) Revised Working Plan for the Saranda Division, 1976-77 to 1995-96. Forest Department, Bihar.

Ram Prakash and L.S. Khanna (1979) Theory and Practice of Silvicultural Systems. Periodical Expert Book Agency, Delhi.

Sen, N.N. (1965) Trend of development of forestry in Haldwani, Ramnagar and T & B Divisions of Uttar Pradesh during the last 50 years. Indian Forester, 91(3): 158-169.

Seth, S.K. and O.N. Kaul (1978) Tropical forest ecosystems of India: The teak forests. In Tropical Forest Ecosystems: A state-of-knowledge Report. UNESCO:628-640.

Sharma, J.K. (1984) Potential threat to exotic Eucalyptus in Kerala by native pathogens. How to meet the challenge. Paper presented at the National Seminar on Eucalypts. Kerala Forest Research Institute, Peechi.

Sharma, S.K. (1979) Working Plan for the North Andamans Forest Divisisn 1979-80 to 1988-89. Forest Department, Andaman & Nicobar Islands, Port Blair.

Singh, K.N. (1979) Working Plan for the West Dehra Dun Forest Division 1979-80 to 1988-89. Uttar Pradesh Forest Department, Nainital.

Sivanada, V. and S. Nagaraju (1983) Wood-based panel industry in India – An overview. Background Paper. Proceedings of the FAO/UNDP Technical Consultation on Wood Based Panels, New Delhi, January 1983. FAO., Rome:227-250.

Srivastava, P.B.L. (1969) Some thoughts on the natural regeneration of sal (Shorea robusta). Indian Forester, 95(5): 293-298.

Stebbing, E.P. (1926) The Forests of India, Vol.II. John Lane The Bodley Head Limited, London.

Tiwari, S.D.N. (1968) The concept of coppice with reserve system. Indian Forester, 94(4): 303-314.

Troup, R.S. (1916) A Note on Some European Silvicultural Systems with Suggestions for Improvements in Indian Forest Management. Superintendent, Government Printing, Calcutta.

Varmah, J.C. and K.N. Bahadur (1980) Country report – India. In Bamboo Research in Asia. Proceedings of Workshop held in Singapore 28-30 May 1980. International Development' Research Centre:19-46.

Vasudevan, K.G. (1971) Working Plan for the Nilambur Forest Division 1967-68 to 1976-77. Kerala Forest Department, Trivandrum.

Verma, V.P.S. and Sharma, B.K. (1978) Studies on production and collection of sal seeds. Indian Forester, 104(6): 414-420.

Von mon Roy (1960) Integration of Forests and Forest Industries. Report to Government of India. FAO., Rome.