CHAPTER VII

GENERAL SYNTHESIS,
SUMMARY AND CONCLUSION
7.1 DISTRIBUTION, COMPOSITION AND GROWTH RATE:

The present investigation was conducted in one of the most valuable teak forests of Gourjhamar Range. Of the total geographical area of 55,708 hectares, the area under teak forests is 10,140 hectares and under mixed forests 9,165 hectares. The teak forests of Gourjhamar constitute about 16.4 per cent of the total teak forests and 8.7 per cent of the total mixed forests of Sagar district. The studies on various aspects as described in preceding chapters were spread over the period 1972-75.

The previous chapters embodied mainly the studies concerned with the evaluation of structure, composition and growth rate of important constituent species of the forest. Natural and biotic factors operating in the forest stand and their impact on the establishment of natural regeneration has been studied. Root systems of important trees and ground flora species were investigated to determine the period of dying back which appears to determine the degree of success of
natural regeneration in dry deciduous forests. The contribution by subterranean (roots) and aboveground plant parts at various stages of growth, to the total biomass production was also studied. These studies although covering various interrelated aspects, were chiefly aimed at studying the growth patterns, processes and productive relations of various important constituent species living in these forest stands.

Instances exist in this country where disturbances of forest have often led to the formations of grasslands (Puri, 1961). Other possibility also exists in which excessive biotic interferences have led to the formation of deserts (Anonymous, 1960). The balance is often disturbed by such extraneous factors as lopping, cutting, grazing and trampling, fire etc. to the benefit of one or other (forests and grasslands).

In a broad sense, each tree is a potential forest. Tree canopies because of their organic influences act to keep the direction of development towards woodland side. Given sufficient time for the development and hospitability of the environment, a tree not only adds to its population but creates the conditions, congenial to the maintenance of other perennial life forms, the phanerophytes, geophytes, hemicryptophytes, chaemophytes etc. (Bhatnagar, 1968; Mishra and Kandya, 1971-72).

Structure, composition and growth rate have been correlated with the climatic factors such as mean annual temperature and
mean annual rainfall (Champion and Seth, 1964). In spite of identical climatic conditions prevailing all over the forests of Gourjhamar, the forests are very heterogeneous in their composition, quality, density and distribution (Chapter III - A & B). The impact of biotic factors appeared to affect the survival and establishment of natural regeneration (Chapters III-C, IV and V).

From the results of enumerations carried out in teak areas of Gourjhamar forests, it was seen that there was a general paucity of mature trees of all species in the crop stand. About 83.5 per cent of the total growing stock consisted of pole crop and 6.1 per cent of middle-aged trees. Mature trees in the forest stand accounted for about a per cent of the total plant density per hectare (Table 11B). Species like A. latifolia and D. melanoxylon germinate rather profusely but do not become mature trees due to various micro-climatic, edaphic and biotic factors (Table 9; Chapter IV). Formation of mature trees from seedlings and saplings was meagre. Other species also showed the similar regeneration patterns. However, the distribution and quality of T. grandis trees in the forest appears to be favoured by habitat conditions. The distribution pattern of this species was found to be normal because there were substantial number of seedlings and saplings which ultimately reached the stage of maturity (Tables 10, 11). Their contribution to the total basal area production and ultimate productivity of the forest stand was also found to be
substantial (Table 31).

In the present investigation, the growth patterns in teak was studied in detail. A comparison of the present growth rate, when the biotic interferences are at its peak was made with the growth rate of past years when such interferences might have been relatively less. The forest stands of Ramna, which are standing on deep fertile alluvial deposits showed better girth increment than the forest stand of Gourjhamar which is situated on shallow soil with more xeric conditions (Table 15). Comparison of height growth of teak trees in 1935 (Datta, 1935) and present study (1974) in the forest stand of Gourjhamar showed that rate of height growth was more faster in 1935 than in 1974 indicating the present deteriorated site conditions (Table 16).

As can be seen in Table 16, the growth pattern in T. grandis indicated that the height growth was maximum between 10-50 years of age beyond which it declined. After 50 years of age, when the height growth culminates, if the silvicultural operations like thinning of optimum grade are carried out the radial increment in main trunk takes place rather rapidly (Rutter, 1955).

Current annual increment (CAI) and mean annual increment (MAI) curves of volume production meet at 120 years of age, indicating the age of physical maturity (Fig. 11). However,
the current annual increment beyond 80 years of age was observed to be quite insignificant (Table 16). This indicated the possibility of reducing the age of rotation

7.2 NATURAL REGENERATION IN RELATION TO DYING BACK:

Under conditions sufficiently far removed from the optimum, one of Nature's method of assisting the survival of seedlings is to provide them with dying back. As soon as moisture conditions deteriorate at the end of monsoon, a large percentage of the seedlings die owing to their failure to get properly rooted to an adequate depth in the soil. Among the seedlings which survive, the growth is renewed in the second season, but usually new adventitious shoots are produced from the ground level which replace the previous year's shoot. This process is repeated annually, the root stock growing steadily in extent and vigour and the shoot struggling for many years in succession till a stage is reached when a permanent leading shoot is produced and the regeneration is established.

Dying back phenomenon appears to lengthen the regeneration period considerably. The period of dying back varies from species to species depending upon their ability to develop extensive root system in shortest time. While in *T. grandis* the dying back was observed to last up to 5-10 years of age, in *A. latifolia, D. melanoxylon* and *F. marsupium* it was found
up to 10-20 years of age. On the other hand, in case of *I. tomentosa* the dying back appeared to continue even beyond 20 years of age.

Dying back was observed not only in tree species but in ground flora also. These plants were found to develop various underground mechanisms to store water and food material for utilization during dry periods. Some plants were found to develop bulbs while other possessed rhizomes or other such subterranean growth (Table 20C).

7.3 PRODUCTION STUDIES:

Storage of organic matter in plant tissues in excess of respiratory utilization is the basis of primary productivity of an ecosystem (Odum, 1971). In the present investigation, the organic matter productivity of important tree species, viz. *I. grandis*, *I. tomentosa*, *A. latifolia*, *D. melanoxylon* were studied in relation to their density, average basal area and leaf fall (Chapter VI).

While comparing different species for their productivity it was found that *A. latifolia* was more efficient in dry matter production followed by *I. tomentosa*, *I. grandis* and *D. melanoxylon*. At 50-55 cm g.b.h. the total production per tree was 443.50 kg in *A. latifolia*; 184.13 kg in *I. tomentosa*, 157.89 kg in *I. grandis* and 78.35 kg dry matter in *D. melanoxylon* (Tables 25-28).
Maximum organic matter production was observed in trees of g.b.h. 100-145 cm in different species. The g.b.h. range for minimum production was found to be between 7.5 to 10 cm (Tables 25-28).

Mean annual productivity can be assessed accurately in T. grandis due to the presence of prominent annual growth rings whereas in T. tomentosa, A. latifolia, D. melanoxylon and other species of dry deciduous forest, due to diffused growth rings the assessment of age is neither simple nor accurate. Accordingly, any attempt to correlate their growth rate with age on the basis of available stand and volume tables prepared from planted crops of moist localities are bound to produce very erroneous results. In such cases, girth rather than age was found to be useful in comparing the productivity of different species.

7.4 GROWTH PHASES IN PLANTS:

In the light of foregoing observations and discussion, the growth phases in plants formulated by Kandy (1974) have been modified to correlate growth peaks in the life of a tree. The growth phases are given as under:

1. Seedling phase -- Plant height up to 1 m; up to 7.5 cm g.b.h.
2. Sapling phase -- 7.5 - 15.0 cm g.b.h.
3. Seedling coppice phase 16.0 - 30.0 cm
4. (A) Juvenile phase I
(Maximum height growth) -- 31.0 - 60.0 cm g.b.h.

(B) Juvenile phase II
(Maximum radial growth) -- 61.0 - 105.0 cm "

5. Adult phase
-- 106.0 - 120.0 cm "

6. Senile phase
-- over 120.0 cm "

7.5 AVERAGE DENSITY, BASAL AREA AND TOTAL STANDING BIOMASS:

Basal area was found to be directly related to the dry matter production per hectare as exhibited by very high and positive correlation coefficient (r) between plant density and standing biomass; and between basal area and aboveground and underground biomass (Table 29).

Owing to normal distribution of growing stock (Table 9) teak alone accounted for more than two-thirds of the total organic production of the stand. Its contribution to the total aboveground and root biomass was about 65 and 56 per cent, respectively. The other species in terms of their contribution to total standing productivity were T. tomentosa, A. latifolia and D. melanoxylon.

In these dry deciduous teak forests, the total production of organic matter was found to be 70.60 tons/ha of which 20.41 tons/ha was contributed by crown, 29.36 tons/ha by trunk and 20.83 tons/ha by roots. On percentage basis 70 per cent
of the total organic matter was contributed by aboveground plant parts and 30 per cent by roots (Table 29).

7.6 **LITTER PRODUCTION:**

Teak alone produced one-third of the total production of stand. The other species which dominated the litter output in stand were: *I. tomentosa*, *D. melanoxylon*, *B. monosperma* and *M. tomentosa*. Small broken pieces of minor species accounted for another one-third of the total production (Table 30). Other important tree species such as *A. latifolia* and *L. parviflora* in spite of high plant density contributed only a fraction to the total litter production indicating the immaturity of plants of these species (Table 9). The total leaf litter production in these forests was found to be 4.959 tons/ha.

In the light of present investigations, it can be concluded that while relatively younger crop is more efficient in litter production, their distribution pattern is most important. Abundance of plants in Juvenile phase instead of seedling and coppice phase appears to produce maximum foliage. Once the trees enter in Juvenile phase II the canopy is closed and thus the size of crown remains constant. In mature trees though, the crown biomass was maximum, it was not due to bigger crown and more leaves but due to thicker branchwood. Besides age, the tree density and basal area play equally
significant role in leaf litter output. This hypothesis can be explained by the basal area and litter output of *I. grandis* and *I. tomentosa* (Fig. 25).

7.7 **ORGANIC MATTER DYNAMICS AT THE TIME OF BIOTIC EXPLOITATION:**

A major portion of aboveground plant biomass, approximately 63 per cent is removed during human exploitation and the remaining biomass subsequently becomes part of the forest floor. In addition to remaining dead parts of the aboveground vegetation, leaf litter considerably add to the forest floor. Herbaceous ground flora also enrich the forest floor with organic matter both directly and indirectly. It traps around its litters and stumps a large quantity of leaf litter which would have otherwise gone outside the stand.

7.8 **ROOT SYSTEM OF IMPORTANT TREE SPECIES:**

In the present investigation, the root system of important tree species, viz. *I. grandis*, *I. tomentosa*, *D. melanoxyilon* and *A. latifolia* of various girth classes were studied (Table 32-33; Figs. 20-24).

While strout and deep taproots were observed in *I. grandis* and *I. tomentosa*, it was not very prominent in *A. latifolia* and *D. melanoxyilon* especially in bigger trees. In the latter species it was sometimes very difficult to differentiate the
taproot from lateral roots. While in other species, the secondary and tertiary roots were prominent and came out rather sparsely, in _A. latifolia_, cluster of small rootlets in a brush-like fashion were observed coming out mostly from the base of main trunk. It was found more pronounced in middle-aged and mature plants than in younger plants.

In _T. grandis_, the root spread ranged from 1.60 m in young plants to 13.20 m in mature trees. In _T. tomentosa_, root spread ranged from 0.56 m in young plants to 15.60 m in mature trees. In young _D. melanoxylon_ and _A. latifolia_ the lateral spread of 1.06 m and in mature trees lateral spread of 11.70 and 15.40 m respectively, was observed. Plants of comparable girth of these species when compared for their lateral spread, _A. latifolia_ showed superior lateral spread followed by _T. tomentosa_, _T. grandis_ and _D. melanoxylon_.

Comparative study of total estimated root length shows that _A. latifolia_ possessed the maximum root length because of the clusters of small fibrous roots at the base of its trunk. While _T. grandis_ and _T. tomentosa_ showed almost similar root length, it was minimum in _D. melanoxylon_ because of poor branching of primary lateral roots (Table 32-33; Fig. 24). The taproot penetration down in the soil ranged between 0.55 m to 3.60 m.

It appears that for some trees, the roots are generally
confined to the area covered by the crown, but for others such as pines and spruce (Champion and Griffith, 1948) they extend much further and so extensively overlap the roots of the adjacent trees. In the present investigation, however, it was observed that the root system extended far beyond the crown spread. Plant species in dry areas in particular, appear to have this growth behaviour to enable them to tide over the soil moisture stresses during prolonged dry periods.

On an average, root spread was found to be 1.16 times of crown spread in *I. grandis* and about 2 times in *I. tomentosa*. From these observations it can be concluded that similar crown and root spread in *I. grandis* may be responsible for frequent uprooting of this species. Compared to this in *I. tomentosa*, the superior root spread and relatively smaller crown enables this species to resist the impact of high wind velocity. During rainy season, while uprooted teak trees are of common sight it is rare to see an uprooted tree of *I. tomentosa*. In *D. melanoxyylon* and *A. latifolia* besides, extensive horizontal root spread, the favourable root/crown ratio appeared to help these species to stand the impact of high winds.
7.9 SUMMARY AND CONCLUSIONS

In brief, the results of this investigation revealed that in terms of plant density, the position of growing stock is fairly satisfactory, however, there was a general paucity of mature trees of all species in this forest stand. The analysis of structure, composition and growth data showed that *T. grandis* was the dominant tree species in top canopy with main associates such as *T. tomentosa, A. latifolia, D. melanoxylon, E. marsupium, O. dalbergioides* etc. Besides, the climatic extremes such as drought, frost and high wind velocity, and biotic factors appear to determine the extent of success of establishment of natural regeneration. Under unfavourable site conditions dying back plays an important role in survival of seedlings. Phenomenon of dying back was observed in almost all plant species. The plants have developed various mechanisms to survive year after year. Extensive root spread in four tree species and various modifications of roots in ground flora species enable them to survive in spite of adverse growing conditions.

Dying back was found to last for varying periods in different species depending upon their capability to develop effective root system in shortest possible time. In *T. grandis* dying back was observed up to 5-10 years of age. In *A. latifolia, E. marsupium* and *D. melanoxylon*, it was found
to be active in plants 10-20 years old. In *I. tomentosa* this phenomenon appeared to be active even beyond 20 years of age.

Basal area and plant density (trees/ha) were found to be important parameters in determining the site productivity. Among plants of comparable girth of selected four tree species, *A. latifolia* produced maximum organic matter followed by *I. tomentosa*, *I. grandis* and *D. melanoxylon*. However, in terms of total stand productivity (tons/ha), owing to its normal distribution of age classes and superior basal area, *I. grandis* accounted for about two-thirds of the total biomass production. Trunk biomass accounted for 40 per cent of the total biomass. Balance sixty per cent was contributed equally by root and crown biomass.

Almost all important tree species are exploited for human needs. Out of the total biomass of 70.60 tons/ha, 63 per cent is removed during silvicultural operations. The balance 37 per cent of biomass is ultimately left over to become the part of forest floor.

*Anogeissus latifolia* showed superior development of root system. In *D. melanoxylon*, the branching of primary lateral roots was lacking. Better root/crown ratio in *I. tomentosa* appeared to provide this species maximum anchorage than in *I. grandis* which were seen frequently uprooted by wind during rains when soil was wet and wind velocity relatively high.
PLATE - I

Photo showing the attack of Hyplia on Teak sp. and the new leaves coming up on the leaves shaded trees.

PLATE - II

Photo showing the leaf litter in October 1974