# STUDIES IN THE VEGETATION OF THE PHILIPPINES.
# I. THE COMPOSITION AND VOLUME OF THE DIPTEROCARP FORESTS OF THE PHILIPPINES.

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SUMMARY OF CONCLUSIONS.

I. The virgin forest area of the Philippines comprises approximately 40,000 square miles or about one-third the total area.

II. Seventy-five per cent of the virgin forest area (30,000 square miles) is covered with forests in which the members of the dipterocarp family predominate.

III. The members of the dipterocarp family, comprising an average of 75 per cent of the volume, can, from a forester's and lumberman's standpoint, be divided into three tree groups, viz, the hard and durable yacals, the apitongs, and the lauans.

IV. The apitongs and lauans can furnish by far the greatest amount of timber. The apitongs can be favorably compared to the hard pines in general mechanical properties, the lauans, to the soft pines.

V. From many standpoints the dipterocarp family is to the Philippines what the pine and oak families are to the United States and other temperate countries.

VI. Success in virgin forest growth should be measured in terms of bulk or bulk and annual increment combined.

VII. The nearer the climatic, edaphic, and biotic conditions reach the optimum, the heavier the bulk of the forest and the simpler the systematic arboreal composition.

VIII. If measured in bulk alone, some temperate regions as compared with the Philippines show greater success in forest growth. If annual increment is used in combination with bulk, the forests of the Philippines will compare favorably with forest growth in temperate regions.

IX. If the tropics in general are like the Philippines in the above respects, they can be depended on to produce woods to compete with general construction timbers grown in temperate regions.

X. An inventory of the forest resources of other tropical regions will give scientific and economic results of great importance.

## INTRODUCTION.

An estimate of the capacity of any region to produce and maintain a virgin forest presupposes a standard of comparison by which to judge success in forest growth.

What is meant by success depends on the investigator's standpoint. Those who critically examine forest growth can, I think, be roughly divided into four classes. These are systematic botanists, ecological botanists, lumbermen, and foresters. The systematic botanist would usually consider the most successful forest to be that which contains on a unit of surface the greatest number of species of all kinds from the ground to the tops of the highest trees. On the above idea, variety in species and form are the main points considered. Thus the forest is composed of a great many species assuming in outline a great many forms, such as lichens, mosses, liverworts, herbs, epiphytes, parasites, climbing bamboos and palms and dicotyledonous trees. He usually brings his material together in the form of a "flora," associating plants in groups or families. Thus a qualitative analysis is made of the forest. The idea of bulk is expressed in vague terms, associated with different species, like "common" or "abundant," "a large tree," "a liana," etc. A brief description of the region usually precedes the lists of plants. This is the conventional idea of the tropical forests and those people, who disregard value as an element of success would place such a forest as the most successful in the world.

The ecological botanist will consider habitat as well as vegetation. He will divide the forest into formations or societies, or types, corresponding to the different habitats, and then describe each forest type in greater or less detail, calling attention qualitatively, and more or less quantitatively, to the composition of the forest. He may or may not make an attempt to measure, or express in some way, the factors of the habitat. To him the best physical and biotic conditions produce the best or most successful forest which he calls a mesophytic forest. The idea of "succession" may or may not be considered. In the above ideas there is little or no attempt to measure the amount of vegetation per unit of surface, hence they may be designated as qualitative standards in distinction from the quantitative standards, viz, the standard of the lumberman and the forester.

The lumberman takes into consideration "value" as an element of success in forest growth. Any given forest would be judged by the trees suitable for his needs and the rest would be considered as "weed trees." As the cost of handling a large amount and a few kinds of lumber is less than in handling a small amount and many kinds on any given area, he desires to obtain a great bulk of one or of very few kinds of timber per unit of area. To him the most successful forest in the world would be the greatest amount of the most valuable timbers of the most con-

venient size best situated, so as to yield the highest profits to immediate utilization.

The forester would inject into the lumberman's view the idea of increment for the sake of future yields and the possibility that the woods which he now considers as valueless, may, in a readjustment of market conditions, become valuable. In other words, the forester's standard of success is the earning capacity of the forest as a permanent investment.

These four views, the systematic botanist's, containing the idea of variety associated (consciously or not) with bulk; the ecologist's, associating the idea of bulk and variety with habitat; the lumberman's, considering the variety and bulk of wood necessary for his present needs; and the forester's, considering the variety and bulk for present and future use, are, I believe, fairly representative of the different standpoints of observing men who judge forest and forest conditions. An ideal study of the vegetation of a forest would be a combination of all of these in which the vegetation would be arranged by habitats with the idea of succession recognized and the physical and other factors measured. A complete list of plants in each habitat could be obtained, the number (stand) of each species could be enumerated, the volume by cubic contents or weight of each plant ascertained, and the market value of each merchantable kind could be estimated.

Because of the impracticability of such a study, I propose to use bulk as measured in cubic contents as the standard of comparison by which success is judged in forest vegetation. By "bulk" I mean the amount of vegetable tissue (mainly wood) that is formed and maintained for a greater or less length of time. From this standpoint the unit of area (of a size large enough to be considered a "region") that produces and is able to maintain for some time the greatest amount of vegetable tissue per unit of surface is the most successful. I am purposely leaving out of account the idea of annual increment, principally because it is impracticable at present to give any figures showing this. In a general way the influence of this element of success will be used in certain conclusions at the close of this paper. The measuring of the forest by weight per unit of surface would perhaps be a better standard of comparison. This could easily be obtained with the volume and specific gravity of each kind of wood mentioned. The idea of judging by value is disregarded because it would not be a stable standard of comparison.

It is proposed to confine the discussions of the dipterocarp forests in this paper to the dicotyledonous trees and after a preliminary discussion on the composition of the forest with a mention of trees of all sizes, to limit the studies to those trees above a certain diameter. That the forest is composed of plants other than dicotyledonous trees goes without saying. Most descriptions of tropical forests give, I think, undue importance to these other elements. Thus one gains the impression that

tree palms, epiphytic orchids and ferns, insectivorous plants, large lianas and the like are the main features of tropical forests, principally because these forms are not as a rule present in temperate regions and consequently are more apt to force themselves upon investigators from temperate regions. After all, these peculiar forms are only ornaments that a tropical climate permits. Stripped of their showy forms the tropical forests of the Philippines are more nearly like temperate forests than they are different from them.

To measure the entire bulk of any forest is impracticable. It is therefore proposed to apply the methods used by lumbermen and foresters, viz. rough cruising and valuation surveys.

While the measurement of the merchantable "bulk" of the forest is not by any means the entire bulk, yet for the purposes of this paper it can be used comparatively and will give a far better indication of what comprises the main bulk than merely indicating the number of trees and other plants. It may be objected that the measurement of trees of merchantable size gives undue importance to those reaching that size, and that if those species that do not reach merchantable size were measured, the proportion of the entire bulk would be greatly changed in favor of the smaller species. It must be remembered, however, that the large-sized species have small-sized unmeasured representatives and that the quantity of the latter in most instances would be as great as the entire bulk of the other species that do not reach merchantable sizes. Then the great amount of bulk in the branches of the large trees would add greatly to the bulk of the principal species. All things considered, it is believed that if the entire woody bulk of the forest could be measured the relative proportion of the principal family would be even greater than that shown in the tables given below.

In most of the discussions on the composition and volume given below no attempt is made to arrange the forests under discussion in "types." That "types" do exist is without question, but a discussion of such types and their composition and volume is reserved for another paper.

## FORESTS IN BATAAN PROVINCE.

In a previous paper [1] by the author the results of a quantitative analysis of the arboreal composition of a number of measured plots was given. In these no consideration of volume was taken other than that all trees under 4 meters in height were excluded.

In order to give a more comprehensive idea of the volume, one [2] of these tables taken at random has been copied and then rearranged.

Table I illustrates the complexity qualitatively and quantitatively.

[1] Whitford, H. N. The Vegetation of the Lamao Forest Reserve. *This Journal* 1 (1906) 373–431; 637–682.

[2] Loc. cit. 637, 638.

It shows that, on an area of 8,325 square meters (a little over 2 acres) there are 1,160 trees (representing 85 species) over 4 meters in height. Column A gives the number of trees and B the percentage of each.

TABLE I.

| Name of plant. | A. | B. |
|---|---|---|
| 1. *Dipterocarpus grandiflorus* Blanco | 182 | 15.7 |
| 2. *Shorea polysperma* Merr. | 134 | 11.5 |
| 3. *Memecylon edule* Roxb. | 94 | 8.1 |
| 4. *Aporosa sphaeridophora* Merr. | 81 | 7.0 |
| 5. *Ternstroemia toquian* F.-Vill. | 66 | 5.7 |
| 6. *Diospyros pilosanthera* Blanco | 59 | 5.1 |
| 7. *Santiria nitida* Merr. | 52 | 4.5 |
| 8. *Calophyllum blancoi* Pl. & Tr. | 46 | 4.1 |
| 9. *Pentacme contorta* Merr. & Rolfe | 41 | 3.5 |
| 10. *Cyclostemon microphyllum* Merr. | 30 | 2.6 |
| 11. *Evodia glaucicalyx* Merr. | 26 | 2.2 |
| 12. *Cinnamomum mercadoi* Vid. | 23 | 2.0 |
| 13. *Aporosa symplocosifolia* Merr. | 22 | 1.9 |
| 14. *Semecarpus perrottetii* March. | 22 | 1.9 |
| 15. *Hopea acuminata* Merr. | 20 | 1.7 |
| 16. *Quercus* sp. | 17 | 1.6 |
| 17. *Kayea paniculata* Merr. | 15 | 1.3 |
| 18. *Litchi philippinensis* Radlk. | 15 | 1.3 |
| 19. *Plectronia viridis* Merr. | 12 | 1.0 |
| 20. *Euphoria cinerea* Radlk. | 12 | 1.0 |
| 21. *Shorea guiso* Blume | 12 | 1.0 |
| 22. *Ellipanthus luzoniensis* Vid. | 10 | [a] |
| 23. *Symplocos oblongifolia* Rolfe | 10 | |
| 24. *Vatica mangachapoi* Blume | 10 | |
| 25. *Baccaurea tetrandra* Baill. | 10 | |
| 26. *Eugenia* sp. | 8 | |
| 27. *Pandanus luzoniensis* Merr. | 8 | |
| 28. *Anisoptera thurifera* Blanco | 6 | |
| 29. *Calophyllum whitfordii* Merr. | 6 | |
| 30. *Gonocaryum calleryanum* Beec. | 6 | |
| 31. *Ormosia calavensis* Blanco | 6 | |
| 32. *Knema heterophylla* Warb. | 6 | |
| 33. *Eccocaria philippinensis* Merr. | 5 | |
| 34. *Dimorphocalyx longipes* Merr. | 4 | |
| 35. *Kopsia longiflora* Merr. | 4 | |
| 36. *Litsea luzonica* F.-Vill. | 4 | |
| 37. *Litsea fulva* F.-Vill. | 4 | |
| 38. *Myristica philippensis* Lam. | 4 | |
| 39. *Siderozylon duclitan* Blanco | 4 | |
| 40. *Talauma villariana* Rolfe | 4 | |
| 41. *Antidesma edule* Merr. | 3 | |
| 42. *Ficus* sp. | 3 | |
| 43. *Aglaia harmsiana* Perk. | 2 | |
| 44. *Champereia cumingiana* Merr. | 2 | |
| 45. *Eugenia* sp. | 2 | |
| 46. *Eugenia* sp. | 2 | |
| 47. *Grewia stylocarpa* Warb. | 2 | |
| 48. *Mangifera altissima* Blanco | 2 | |
| 49. *Pygeum glandulosum* Merr. | 2 | |
| 50. *Shorea* sp. | 2 | |
| 51. *Sterculia brevipetiolata* Merr. | 2 | |
| 52. *Linociera* sp. | 2 | |
| 53. *Unona clusiflora* Merr. | 2 | |
| 54. *Aglaia bordenii* Merr. | 1 | |
| 55. *Albizzia procera* Benth. | 1 | |
| 56. *Ardisia philippinensis* A. DC. | 1 | |
| 57. *Artocarpus communis* Forst. | 1 | |
| 58. *Buchanania arborescens* Bl. | 1 | |
| 59. *Citrus hystrix* DC. | 1 | |
| 60. *Cyathocalyx globosus* Merr. | 1 | |
| 61. *Dipterocarpus vernicifluus* Blanco | 1 | |
| 62. *Ficus* sp. | 1 | |
| 63. *Guioa* sp. | 1 | |
| 64. *Ixora* sp. | 1 | |
| 65. *Ixora* sp. | 1 | |
| 66. *Memecylon* sp. | 1 | |
| 67. *Michelia cumingii* Merr. & Rolfe | 1 | |
| 68. *Mitrephora merrillii* C. B. Rob. | 1 | |
| 69. *Paludia rhomboidea* Prain | 1 | |
| 70. *Palaquium tenuipetiolatum* Merr. | 1 | |
| 71. *Randia* sp. | 1 | |
| 72. *Shorea* sp. | 1 | |
| 73. *Voacanga* sp. | 1 | |
| 74 to 85. (unknown species) | 12 | |
| Total (85) | 1,160 | |

[a] The following have less than 1 per cent.

But when judged from the standpoint of size a quite different impression is obtained. By that standard, we should note that of the 1,160 trees only 826 (about 71 per cent) reach merchantable size (30 centimeters in diameter), that 409 of these (35 per cent of the whole number or 50 per cent of those that may reach merchantable size) are of one botanical family (the *Dipterocarpaceae*).

Table II shows the species and number of the dipterocarps found in the above mentioned plot.

TABLE II.

| Name of plant. | Number. | Name of plant. | Number. |
|---|---|---|---|
| *Dipterocarpus grandiflorus* Blanco | 182 | *Vatica mangachapoi* Blume | 10 |
| *Shorea polysperma* Merr. | 134 | *Anisoptera thurifera* Blanco | 6 |
| *Pentacme contorta* Merr. & Rolfe | 41 | *Shorea* spp. | 3 |
| *Hopea acuminata* Merr. | 20 | *Dipterocarpus vernicifluus* Blanco | 1 |
| *Shorea guiso* Blume | 12 | Total | 409 |

It will be seen that of the *Dipterocarpaceae,* two species, *Dipterocarpus grandiflorus* and *Shorea polysperma,* have 316 representatives or about 38 per cent of the total number of trees that may reach a merchantable diameter of 30 centimeters.

The following table shows the proportion of the other trees mentioned in Table I by families that may reach merchantable size when mature.

TABLE III.

| Name of plant. | Number. | | Name of plant. | Number. | |
|---|---|---|---|---|---|
| THEACEAE: | | | ANACARDIACEAE: | | |
| 1. *Ternstroemia toquian* F.-Vill. | 66 | | 15. *Semecarpus perrottetii* March. | 22 | |
| EBENACEAE: | | | 16. *Mangifera altissima* Blanco | 2 | |
| 2. *Diospyros pilosanthera* Blanco | 59 | | 17. *Buchanania arborescens* Blume | 1 | |
| BURSERACEAE: | | | | | 25 |
| 3. *Santiria nitida* Merr. | 52 | | FAGACEAE: | | |
| GUTTIFERAE: | | | 18. *Quercus* sp. | | 17 |
| 4. *Calophyllum blancoi* Pl. & Tr. | 46 | | CONNARACEAE: | | |
| 5. *Calophyllum whitfordii* Merr. | 6 | | 19. *Ellipanthus luzoniensis* Vid. | | 10 |
| | | 52 | MYRISTICACEAE: | | |
| MYRTACEAE: | | | 20. *Knema heterophylla* Warb. | 6 | |
| 6. *Eugenia glaucicalyx* Merr. | 26 | | 21. *Myristica philippensis* Lam. | 4 | |
| 7. *Eugenia* sp. | 8 | | | | 10 |
| 8. *Eugenia* sp. | 2 | | LEGUMINOSAE: | | |
| 9. *Eugenia* sp. | 2 | | 22. *Ormosia calavensis* Blanco | 6 | |
| | | 38 | 23. *Albizzia procera* Benth. | 1 | |
| LAURACEAE: | | | 24. *Pahudia rhomboidea* Prain | 1 | |
| 10. *Cinnamomum mercadoi* Vid. | 23 | | | | 8 |
| 11. *Litsea luzonica* F.-Vill. | 4 | | ICACINACEAE: | | |
| 12. *Litsea falva* F.-Vill. | 4 | | 25. *Gonocaryum calleryanum* Becc. | | 6 |
| | | 31 | SAPOTACEAE: | | |
| SAPINDACEAE: | | | 26. *Sideroxylon ducitan* Blanco | 4 | |
| 13. *Litchi philippinensis* Radlk. | 15 | | 27. *Palaquium tenuipetiolatum* Merr. | 1 | |
| 14. *Euphoria cinerea* Radlk. | 12 | | | | 5 |
| | | 27 | | | |

TABLE III—Continued.

| Name of plant. | Number. | | Name of plant. | Number. |
|---|---|---|---|---|
| MELIACEAE: | | | ROSACEAE: | |
| 28. *Aglaia harmsiana* Perk. | 2 | | 32. *Pygeum glandulosum* Merr. | 2 |
| 29. *Aglaia bordenii* Merr. | 1 | | MORACEAE: | |
| | 3 | | 33. *Artocarpus communis* Forst. | 1 |
| OPILIACEAE: | | | ANONACEAE: | |
| 30. *Champereia cumingiana* Merr. | 2 | | 34. *Cyathocalyx globosus* Merr. | 1 |
| TILIACEAE: | | | Total | 417 |
| 31. *Grewia stylocarpa* Warb. | 2 | | | |

While all the trees mentioned above may in exceptional cases reach a diameter limit of 30 centimeters, as a matter of fact most of them will reach when mature not over 40 centimeters in diameter and very few of them have the power to reach the diameter and height of some of the dipterocarps.

If bulk were taken into consideration the proportion of the dipterocarps would be much greater. This will be shown in another connection.

The 334 remaining trees that can not reach, when mature, 30 centimeters in diameter will not average over 15 centimeters in diameter. Strange to say, while 40 species are represented in these, the vast majority of them are distributed among species of the *Euphorbiaceae* and *Melastomataceae*. Thus *Memecylon edule* Roxb. (*Melastomataceae*) is represented by 94 trees, and *Aporosa sphaeridophora* Merr. by 81, *Cyclostemon microphyllum* Merr. by 30, *Aporosa symplocosifolia* Merr. by 22, and *Baccaurea tetrandra* Baill. by 10. The last four named belong to the *Euphorbiaceae*.

It might be argued that plots adjoining the one given above might greatly increase the number of species. While this is true to a certain extent, yet the possibilities are not great when it is known that on the Lamao Forest Reserve comprising 4,426 hectares and ranging in altitude from sea level to 1,406 meters there have been listed so far 548 tree species. This covers the trees of all habitats from those where introduced tree species are found to the mossy forests on top of the highest peaks. It is to be expected that the variety of habitats thus represented would bring about a variety in tree species peculiar to those habitats. Thus beach and mangrove habitats show distinct sets, river bottoms others, the mossy forest and various types of dipterocarp forest still others. It should be noted here that all eight of the dipterocarps found on the Lamao Forest Reserve of 4,426 hectares are also found on the plot given above comprising less than one hectare. At the time I wrote the "Vegetation of the Lamao Forest Reserve" the significance of the above did not

appeal to me as my studies had not been extensive enough to reach certain conclusions that have since become apparent.

The figures given above, showing that about 50 per cent of the actual number of trees over 1 meters in height on one hectare are members of one family, are significant not only from an ecological standpoint but from a lumberman's standpoint.

Since they were compiled, various parts of the Islands have been studied in detail and still larger areas have been visited so that the conclusions reached herein have solid foundations. The work of other men coöperating with me shows similar results.

Previous to my work on the Lamao Forest Reserve, Bryant[3] made valuation surveys on the Lamao River basin, in Bataan Province. In general, his figures show the predominance of the dipterocarps both in stand and bulk. His statement concerning this family is as follows:

"In the region south of a line drawn from Bagac on the west coast to Lamao to the east coast, an area of approximately 65,900 acres, * * * a detailed examination was made of the forest. In this part of the province the family of the *Dipterocarpaceae* reaches a fine development and constitutes the bulk of the merchantable timber."[4]

Unfortunately for the purposes of this paper all trees of a merchantable size were not considered by Bryant so the exact proportion of dipterocarps to all others can not be given.

A recent estimate of the stand and volume of all timber over 40 centimeters in diameter was made on a tract of land covering approximately 50 hectares near Limay, Bataan Province. This tract is immediately adjacent to that covered by Bryant. All trees on this tract above 40 centimeters were counted and the volume was obtained by the sample tree method. The altitudinal range is from 170 to 425 meters. The following shows the stand in this forest:

[3] Preliminary report on working plan of Bataan Province. Report of the Bureau of Forestry of the Philippine Islands, from July 1, 1901 to September 2, 1902, from the Report of the Philippine Commission, pp. 483–500.

[4] Loc. cit. p. 484.

TABLE IV.—*Stand on 50 (49.49) hectares on Limay (Bataan) tract—all trees 40 centimeters and over counted.*

| Scientific name. | Common name. | Number of trees per hectare. | Per cent. |
|---|---|---|---|
| DIPTEROCARPACEAE: | | | |
| *Dipterocarpus grandiflorus* Blanco | Apitong | 12 | 17.3 |
| *Dipterocarpus vernicifluus* Blanco | Panao | | |
| *Pentacme contorta* Merr. & Rolfe | White lauan | 19.6 | 28.6 |
| *Anisoptera thurifera* Blanco | Palosapis | 4.6 | 6.6 |
| *Shorea polysperma* Merr. | Tanguile | 5.1 | 7.3 |
| *Shorea guiso* Blume | Guijo | .8 | 1.1 |
| Total *Dipterocarpaceae* | | 42.1 | 60.9 |
| All others | | 27 | 39.1 |
| Total | | 69.1 | 100.0 |

Among the others the following were noted:

FAGACEAE-*Quercus* spp.; ULMACEAE-*Celtis* sp.; MORACEAE-*Artocarpus communis* Forst., *Ficus variegata* Blume and other *Ficus* spp.; OLACACEAE-*Strombosia philippinensis* Rolfe; ANONACEAE-*Xylopia dehiscens* Merr., *Cyathocalyx globosus* Merr.; MYRISTICACEAE-*Myristica philippensis* Lam., *Knema heterophylla* Warb.; LAURACEAE-*Cinnamomum mercadoi* Vidal, *Litsea* spp., *Endiandra coriacea* Merr.; ROSACEAE-*Pygeum glandulosum* Merr., *Parinarium griffithianum* Benth.; LEGUMINOSAE-*Pithecolobium acle* Vid., *Adenanthera intermedia* Merr., *Parkia roxburghii* G. Don, *Pahudia rhomboidea* Prain; BURSERACEAE-*Canarium* spp., *Santiria nitida* Merr.; MELIACEAE-*Dysoxylum* spp., *Reinwardtiodendron merrillii*, *Amoora* spp., *Aglaia* spp.; POLYGALACEAE-*Xanthophyllum* sp.; EUPHORBIACEAE-*Bischofia trifoliata* Hook., *Macaranga bicolor* Muell.-Arg., *Macaranga tanarius* Muell.-Arg., *Endospermum peltatum* Merr.; ANACARDIACEAE-*Mangifera altissima* Blanco, *Dracontomelum cumingianum* Baill., *Dracontomelum dao* Merr. & Rolfe, *Koordersiodendron pinnatum* Merr., *Semecarpus perrottetii* March.; SAPINDACEAE-*Euphoria cinerea* Radlk., *Pometia pinnata* Forst.; RHAMNACEAE-*Zizyphus zonulatus* Blanco; STERCULIACEAE-*Pterospernum* spp., *Pterocymbium tinctorium* Merr.; DILLENIACEAE-*Dillenia philippinensis* Rolfe; GUTTIFERAE-*Calophyllum blancoi* Pl. & Tr., *Calophyllum whitfordii* Merr.; DIPTEROCARPACEAE-*Hopea acuminata* Merr., *Vatica mangachapoi* Blanco; DATISCACEAE-*Octomeles sumatrana* Miq.; LYTHRACEAE-*Lagerstroemia speciosa* Pers.; COMBRETACEAE-*Terminalia* spp.; MYRTACEAE-*Eugenia* spp.; SAPOTACEAE-*Illipe ramiflora* Merr., *Palaquium luzoniense* Vid., *Palaquium tenuipctiolatum* Merr.; EBENACEAE-*Diospyros pilosanthera* Blanco; APOCYNACEAE-*Alstonia scholaris* R. Br.; VERBENACEAE-*Vitex littoralis* Decne.; BIGNONIACEAE-*Radermachera pinnata* Seem.

On the above mentioned plot there were counted in all 3,458 trees; of these 2,110 belong to the enumerated dipterocarps (*Hopea acuminata* and *Vatica mangachapoi* not being included) and the remainder 1,348 distributed among the remaining of which the list given above is fairly representative. An examination of this list shows that there are included 29 families and over 60 species.

The following table gives the volume on the Limay tract:

TABLE V.—*Volume on 50 (49.49) hectares on the Limay (Bataan) tract—all trees 40 centimeters and over included.*

| Scientific name | Common name. | Cubic meters per hectare. | Per cent. |
|---|---|---|---|
| DIPTEROCARPACEAE: | | | |
| *Dipterocarpus grandiflorus* Blanco | Apitong | 81.6 | 28.6 |
| *Dipterocarpus vernicifluus* Blanco | Panao | | |
| *Pentacme contorta* Merr. & Rolfe | White lauan | 66.5 | 23.3 |
| *Anisoptera thurifera* Blanco | Palosapis | 28 | 9.8 |
| *Shorea polysperma* Merr. | Tanguile | 16 | 5.6 |
| *Shorea guiso* Blume | Guijo | 4.1 | 1.5 |
| Total *Dipterocarpaceae* | | 196.2 | 68.8 |
| All others | | 89.0 | 31.2 |
| Total | | 285.2 | 100.0 |

Tables IV and V show that 60.9 per cent of the stand and 68.8 per cent of the volume respectively on the above tract are composed of six species of *Dipterocarpaceae,* and that three species, viz, *Dipterocarpus grandiflorus, Dipterocarpus vernicifluus* and *Pentacme contorta* form 45.9 per cent of the stand and 51.9 per cent of the volume.

### FORESTS ON A DELTA PLAIN IN MINDORO.

In coöperation with M. L. Merritt, a tract of land on the east coast of Mindoro comprising some 55 square miles was examined. This is a delta formation, slightly raised, forming a number of different physiographic units. Corresponding to these are distinct vegetative types. In this connection it is not important to distinguish between these. After some intensive study to learn to distinguish the numerous kinds of trees found on the tract, valuation surveys were run by what is known

as the strip method. All through the work botanical collections were made, by felling trees if necessary, in order to check up the identifications. Thus such identifications as were made were checked up in Manila and those that could not be made were determined by systematic botanists. Thus a fair idea was obtained of the composition of the forest.[5]

Tables VI and VII show the stand of timber on two types on the Mindoro delta plain. (All trees over 40 centimeters were measured.)

TABLE VI.—*Narra type (average of 28.4 hectares.)*

| Scientific name. | Common name. | Number of trees per hectare. | Per cent. |
|---|---|---|---|
| DIPTEROCARPACEAE: | | | |
| *Pentacme contorta* Merr. & Rolfe | White lauan | 14.811 | 22.23 |
| *Shorea guiso* Blume | Guijo | 4.243 | 6.37 |
| *Dipterocarpus* sp. | Apitong | 2.555 | 3.83 |
| *Dipterocarpus affinis* Brandis | Hagachac | .450 | .68 |
| Total *Dipterocarpaceae* | | 22.059 | 33.11 |
| LEGUMINOSAE: | | | |
| *Pterocarpus indicus* Willd. | Narra | 4.769 | 7.16 |
| ANACARDIACEAE: | | | |
| *Koordersiodendron pinnatum* Merr. | Amuguis | 4.702 | 7.06 |
| *Dracontomelum dao* Merr. & Rolfe | Dao | 3.395 | 5.10 |
| MELIACEAE? | Agupanga? | 4.709 | 7.07 |
| COMBRETACEAE: | | | |
| *Terminalia pellucida* Presl | Malagabi | 1.322 | 1.98 |
| *Terminalia nitens* Presl | Sacat | | |
| *Terminalia edulis* Blanco | Calumpit | | |
| BURSERACEAE: | | | |
| *Canarium luzonicum* A. Gray | Pili | 1.048 | 1.57 |
| *Canarium villosum* F.-Vill. | Pagsahinguin | | |
| ULMACEAE: | | | |
| *Celtis* sp. | Malaguilbuyo | 3.126 | 4.69 |
| All others[6] | | 21.498 | 32.26 |
| Total | | 66.628 | 100 |

[5] For a more detailed statement of the composition and character of this forest see Merritt, M. L. and Whitford, H. N. A Preliminary Working Plan for the Public Forest Tract of the Mindoro Lumber and Logging Company, Bongabon, Mindoro, P. I. Bureau of Forestry (Philip.) Bulletin 6 (1906) 1–55.

[6] See Merritt & Whitford *l. c.*, 53–55, for list.

TABLE VII.—*Hagachac type (average of 14 hectares.)*

| Scientific name. | Common name. | Number of trees per hectare. | Per cent. |
|---|---|---|---|
| DIPTEROCARPACEAE: | | | |
| *Pentacme contorta* Merr. & Rolfe | White lauan | 11.016 | 18.28 |
| *Dipterocarpus affinis* Brandis | Hagachac | 10.519 | 17.45 |
| *Shorea guiso* Blume | Guijo | 3.338 | 5.54 |
| *Dipterocarpus* sp. | Apitong | .141 | .23 |
| Total *Dipterocarpaceae* | | 25.014 | 41.50 |
| LEGUMINOSAE: | | | |
| *Pterocarpus indicus* Willd. | Narra | .568 | .95 |
| ANACARDIACEAE: | | | |
| *Koordersiodendron pinnatum* Merr. | Amuguis | 3.625 | 6.01 |
| *Dracontomelum dao* Merr. & Rolfe | Dao | 3.907 | 6.48 |
| MELIACEAE? | Agupanga? | 6.326 | 10.50 |
| ULMACEAE: | | | |
| *Oltis* sp. | Malaguibnyo | 3.128 | 5.19 |
| BURSERACEAE: | | | |
| *Canarium luzonicum* A. Gray | Pili | 1.354 | 2.25 |
| *Canarium villosum* F.-Vill. | Pagsahinguin | | |
| COMBRETACEAE: | | | |
| *Terminalia pellucida* Presl | Malagabi | .994 | 1.65 |
| *Terminalia nitens* Presl | Sacat | | |
| *Terminalia edulis* Blanco | Calumpit | | |
| All others | | 15.352 | 25.47 |
| Total | | 60.268 | 100 |

It will be seen by the above that in the *narra* type approximately 22 trees out of every 66 and in the *hagachac* type 25 out of every 60 trees per hectare are dipterocarps or respectively 33.11 per cent and 41.50 per cent of all trees over 40 centimeters.

Unfortunately for the purposes of this paper the volume tables published in Bulletin 6, showing the cubic contents of timber per unit of area do not include all of the species. But the results given below showing the proportion of dipterocarps are not far from the actual proportion, for a large per cent of the species not mentioned show a maximum diameter of not over 45–50 centimeters and short boles usually one-fifth to one-third the length of the boles of the dipterocarps. Four species, *Dracontomelum, agupanga* and two species of *Canarium* mentioned in the stand tables are not included in the tables below. *Agupanga* has a short bole usually about one-fifth the length of any of the dipterocarps of the same diameter. While the bole of the Canarium is somewhat longer yet the number of trees per hectare is small. Neither *agupanga* nor the Canariums attain the maximum diameter of the dipterocarps. *Dracontomelum dao* on the other hand, reaches a maximum of 140 centi-

meters, the maximum of *Pentacme contorta,* but the bole is invariably shorter in trees of the same diameter.

Tables VIII and IX show the volume in the two types mentioned in Table VI and VII.

TABLE VIII.—*Narra type.*

| Scientific name. | Common name. | Average per hectare. | Per cent. |
|---|---|---|---|
| | | *Cubic meters.* | |
| DIPTEROCARPACEAE: | | | |
| *Pentacme contorta* Merr. & Rolfe | White lauan | 62.55 | 37 |
| *Shorea guiso* Blume | Guijo | 14.90 | 8.8 |
| *Dipterocarpus* sp. | Apitong | 11.03 | 6.5 |
| *Dipterocarpus affinis* Brandis | Hagachac | 2.39 | 1.4 |
| Total *Dipterocarpaceae* | | 90.87 | 53.7 |
| LEGUMINOSAE: | | | |
| *Pterocarpus indicus* Willd. | Narra | 12.50 | 7.4 |
| ANACARDIACEAE: | | | |
| *Koordersiodendron pinnatum* Merr. | Amuguis | 12.08 | 7.2 |
| COMBRETACEAE: | | | |
| *Terminalia pellucida* Presl | Malagabi | 3.75 | 2.2 |
| *Terminalia nitens* Presl | Sacat | | |
| *Terminalia edulis* Blanco | Calumpit | | |
| All others (estimated) | | 50.00 | 29.5 |
| Total | | 169.20 | 100 |

TABLE IX.—*Hagachac type.*

| Scientific name. | Common name. | Average per hectare. | Per cent. |
|---|---|---|---|
| | | *Cubic meters.* | |
| DIPTEROCARPACEAE: | | | |
| *Pentacme contorta* Merr. & Rolfe | White lauan | 42.4 | 28.1 |
| *Dipterocarpus affinis* Brandis | Hagachac | 43.3 | 28.7 |
| *Shorea guiso* Blume | Guijo | 13.7 | 9.1 |
| *Dipterocarpus* sp. | Apitong | .2 | .1 |
| Total *Dipterocarpaceae* | | 99.6 | 66.0 |
| LEGUMINOSAE: | | | |
| *Pterocarpus indicus* Willd. | Narra | 1.3 | .9 |
| ANACARDIACEAE: | | | |
| *Koordersiodendron pinnatum* Merr. | Amuguis | 7.9 | 5.2 |
| COMBRETACEAE: | | | |
| *Terminalia pellucida* Presl | Malagabi | 1.9 | 1.3 |
| *Terminalia nitens* Presl | Sacat | | |
| *Terminalia edulis* Blanco | Calumpit | | |
| All others (estimated) | | 40.0 | 26.6 |
| Total | | 150.7 | 100 |

The figures show the percentage of bulk of the dipterocarps in the two types to be respectively 53.7 per cent and 66 per cent, a percentage that is much higher than that of the stand, indicating that the volume of these trees averages higher than that of the other species.

FORESTS IN NORTHERN NEGROS.

On the lower slopes of Mount Silay, Negros, is a large body of timber. In coöperation with H. D. Everett, this region was investigated.

The work was done on a lumber concession containing about 16,000 hectares of solid dipterocarp forest. The tract lies on the lower slopes of Mount Silay just back of the coastal strip of cultivated sugar lands, here about 10 kilometers wide. It is situated on both sides of the Himugaan River. The land is characterized by gentle slopes, with alternating ridges; the elevation ranges from 30 to 370 meters. Small streams and arroyos are scattered profusely over the tract.[7]

The methods used in estimating the stand and determining the composition of the forest were identical with those in Mindoro.

Tables X and XI show the stand and volume of the forest.

TABLE X.—*Stand of trees 40 centimeters and over in diameter in northern Negros (average of 54.65 hectares).*

| Scientific name. | Common name. | Number of trees per hectare. | Per cent. |
|---|---|---|---|
| DIPTEROCARPACEAE: | | | |
| *Dipterocarpus grandiflorus* Blanco | Apitong | 19.158 | 23.6 |
| *Shorea furfuracea* Miq.? | Almon lauan | 16.178 | 19.9 |
| *Shorea polysperma* Merr. | Tanguile | 11.32 | 13.9 |
| *Shorea* sp. | Red lauan | 20.854 | 25.7 |
| *Pentacme contorta* Merr. & Rolfe | White lauan | 5.114 | 6.3 |
| *Parashorea plicata* Brandis | Bagtican lauan | | |
| Total *Dipterocarpaceae* | | 72.624 | 89.4 |
| All others | | 8.626 | 10.6 |
| Total | | 81.250 | 100 |

The significance of these figures, showing a dipterocarp stand of 72,624 trees per hectare out of a total of 81,250 and a percentage of 89.4 needs no comment.

*Diospyros mindanaensis* Merr. (*Ebenaceae*) and *Vitex aherniana*

[7] Everett, H. D. and Whitford, H. N. A Preliminary Working Plan for the Public Forest Tract of the Insular Lumber Company, Negros Occidental. P. I. Bureau of Forestry (Philip.) Bull. 5 (1906) 1–54.

Merr. (*Verbenaceae*) with a stand of 1.4 and 0.95 trees respectively per hectare are the only two other species of any numerical importance in this forest, though the following species occur very scattered: *Hopea philippinensis* Dyer and *Hopea acuminata* Merr., (*Dipterocarpaceae*), *Calophyllum* sp., (*Guttiferae*), *Eugenia* spp., (*Myrtaceae*), *Canarium* sp., and *Santiria nitida* Merr., (*Burseraceae*), *Palaquium* spp., (*Sapotaceae*), *Terminalia* spp., (*Combretaceae*), *Koordersiodendron pinnatum* Merr., *Dracontomelum dao* Merr. & Rolfe, *Mangifera altissima* Blanco, (*Anacardiaceae*), *Macaranga tanarius* Muell.-Arg., (*Euphorbiaceae*), *Dillenia* sp., (*Dilleniaceae*), *Neolitsea* sp., (*Lauraceae*), and *Artocarpus communis* Forst., (*Moraceae*).

The volume of the dipterocarps is given in the following table. The minor species are not included in this estimate because of their small numbers and comparative unimportance.

TABLE XI.—*Volume per hectare of the six principal species 40 centimeters and over in diameter on a tract in northern Negros (average of 54.65 hectares).*

| Species. | Common name. | Average per hectare. |
|---|---|---|
| | | *Cubic meters.* |
| *Dipterocarpus grandiflorus* Blanco | Apitong | 66.63 |
| *Shorea furfuracea* Miq. ? | Almon | 92.02 |
| *Shorea polysperma* Merr. | Tanguile | 59.93 |
| *Shorea* sp. | Red lauan | 185.18 |
| *Pentacme contorta* Merr. & Rolfe | White lauan | 25.23 |
| *Parashorea plicata* Brandis | Bagtican lauan | |
| Total | | 428.99 |

While the figures of the stand show 89.4 per cent of dipterocarps it is estimated that the six species given above comprise more than 95 per cent of the total bulk of the forest.

### FORESTS IN ARAROY REGION, MASBATE.

On a detail to investigate the forest resources of the Araroy mining region in Masbate rough estimates of stand were made. This study, comprising 200 square kilometers, is more than half in forest. The topography is rough and consists of sharp ranges of hills and higher and more resistant peaks. The hills are about 125 to 150 meters in altitude and the highest peak is 362 meters. Approximately 80 per cent of the forested area, distinguished as the lower slope type, is distinctly dipterocarpous in nature.

The following shows its character:

TABLE XII.—*Stand of trees 30 centimeters and over in diameter on the lower slope type of the Aroroy region, Masbate (average of 16 acres).*

| Scientific name. | Common name. | Average number of trees per hectare. | Per cent. |
|---|---|---|---|
| DIPTEROCARPACEAE: | | | |
| *Parashorea plicata* Brandis | Bagtican lauan | 47.5 | 56.88 |
| *Shorea guiso* Blume | Guijo | .7 | .82 |
| COMBRETACEAE: | | | |
| *Terminalia quadrialata* Merr. | Toog | 12 | 14.36 |
| STERCULIACEAE: | | | |
| *Sterculia blancoi* Rolfe | Mugalipac | 4.2 | 5.02 |
| ANACARDIACEAE: | | | |
| *Dracontomelum dao* Merr. & Rolfe | Dao | 1.7 | 2.02 |
| *Koordersiodendron pinnatum* Merr. | Amugnis | .5 | .6 |
| LEGUMINOSAE: | | | |
| *Pterocarpus indicus* Willd. | Narra | 1.5 | 1.8 |
| OLACACEAE: | | | |
| *Strombosia philippinensis* Rolfe | Tamayuan | .9 | 1.1 |
| All others | | 14.5 | 17.4 |
| Total | | 83.5 | 100 |

It is thus to be noted that 47 trees out of 83, or approximately 57 per cent of the stand, belong to two species of the dipterocarps. A discussion of the other types of forest in this region is reserved for another paper.

## FORESTS OF THE ZAMBOANGA PENINSULA IN MINDANAO.

In coöperation with W. I. Hutchinson, the forests of a lumber concession located at Port Banga at the head of Zamboanga Peninsula on the Island of Mindanao were investigated. The work here was similar to that accomplished in Mindoro and Negros. This tract, comprising 355 square kilometers, has about 52 per cent (or 186 square kilometers) in virgin forest. Of this, 16,144 hectares or 86.37 per cent is forest in which the dipterocarps predominate.

The topography of the region is rough and broken. It is composed mostly of low irregular ridges 15 to 100 meters in height extending into headlands bordering on the sea. These lead inward to the base of the mountains. The rivers are small and beyond tidal limits are hill streams with cañon-like valleys whose beds are full of bowlders and rock outcrops. Tables XIII and XIV show the stand and volume on two types.

TABLE XIII.—*Stand in yacal type—trees 40 centimeters and over in diameter—Port Banga, Zamboanga, Mindanao: (average of 51.17 hectares).*

| Scientific name. | Common name. | Average number of trees per hectare. | Per cent of total stand. |
|---|---|---|---|
| DIPTEROCARPACEAE: | | | |
| *Hopea plagata* Vid. | Yacal | 12.41 | 15.59 |
| *Pentacme contorta* Merr. & Rolfe | White lauan | 7.24 | 9.10 |
| *Parashorea plicata* Brandis | Bagtican lauan | | |
| *Dipterocarpus* sp. | Apitong | 3.875 | 4.87 |
| *Shorea guiso* Blume | Guijo | 3.335 | 4.19 |
| *Vatica* sp. | Narig | 2.535 | 3.19 |
| (?) | Calunti lauan | 2.38 | 2.99 |
| *Shorea squamata* Turcz. ? | Danlig lauan | 2.175 | 2.72 |
| *Shorea furfuracea* Miq. ? | Almon lauan | | |
| *Hopea* ? sp. | Malayacal | 1.025 | 1.29 |
| Total *Dipterocarpaceae* | | 34.975 | 43.94 |
| STERCULIACEAE: | | | |
| *Tarrietia javanica* Blume | Lumbayao | 7.23 | 9.08 |
| LEGUMINOSAE: | | | |
| *Kingiodendron alternifolium* Merr. & Rolfe | Batete | 3.59 | 4.51 |
| All others | | 33.785 | 42.47 |
| Total | | 79.580 | 100 |

TABLE XIV.—*Stand in lauan type—trees 40 centimeters and over in diameter—Port Banga, Zamboanga, Mindanao: (average of 15 hectares).*

| Scientific name. | Common name. | Average number of trees per hectare. | Per cent of total stand. |
|---|---|---|---|
| DIPTEROCARPACEAE: | | | |
| *Pentacme contorta* Merr. & Rolfe | Bagtican lauan | 13.38 | 16.59 |
| *Parashorea plicata* Brandis | White lauan | | |
| *Shorea squamata* Turcz. ? | Danlig lauan | 6.27 | 7.77 |
| *Shorea furfuracea* Miq. ? | Almon lauan | | |
| *Dipterocarpus* sp. | Apitong | 4.47 | 5.54 |
| (?) | Calunti lauan | 3.46 | 4.29 |
| *Hopea* ? sp. | Malayacal | 3.28 | 4.07 |
| *Shorea guiso* Blume | Guijo | 2.73 | 3.38 |
| *Hopea plagata* Vid. | Yacal | 2.40 | 2.98 |
| *Vatica* sp. | Narig | 1.00 | 1.24 |
| Total *Dipterocarpaceae* | | 36.99 | 45.86 |
| STERCULIACEAE: | | | |
| *Tarrietia javanica* Blume | Lumbayao | 3.74 | 4.64 |
| LEGUMINOSAE: | | | |
| *Kingiodendron alternifolium* Merr. & Rolfe | Batete | 3.07 | 3.81 |
| All others | | 37.41 | 45.69 |
| Total | | 81.21 | 100 |

TABLE XV.—*Yield in yacal type—trees 40 centimeters and over in diameter (average of 51.17 hectares).*

| Scientific name. | Common name. | Average per hectare. | Per cent of total stand. |
|---|---|---|---|
| | | *Cubic meters.* | |
| DIPTEROCARPACEAE: | | | |
| *Hopea plagata* Vid. | Yacal | 50.37 | 17.4 |
| *Pentacme contorta* Merr. & Rolfe | White lauan | 26.02 | 9.0 |
| *Parashorea plicata* Brandis | Bagtican lauan | | |
| *Dipterocarpus* sp. | Apitong | 12.05 | 4.2 |
| *Shorea guiso* Blume | Guijo | 16.80 | 5.7 |
| ?? | Calunti lauan | 12.34 | 4.3 |
| *Shorea squamata* Turcz.? | Danlig lauan | 9.46 | 3.3 |
| *Shorea furfuracea* Miq.? | Almon lauan | | |
| *Vatica* sp. | Narig | 6.14 | 2.1 |
| *Hopea?* sp. | Malayacal | 2.83 | 1. |
| Total *Dipterocarpaceae* | | 136.01 | 47. |
| STERCULIACEAE: | | | |
| *Tarrietia javanica* Blume | Lumbayno | 21.35 | 7.4 |
| LEGUMINOSAE: | | | |
| *Kingiodendron alternifolium* Merr. & Rolfe | Batete | 7.29 | 2.6 |
| All others | | 124.35 | 43 |
| Total | | 289.00 | 100 |

TABLE XVI.—*Volume in lauan type—trees 40 centimeters and over in diameter (average of 15 hectares).*

| Scientific name. | Common name. | Average per hectare. | Per cent of total stand. |
|---|---|---|---|
| | | *Cubic meters.* | |
| DIPTEROCARPACEAE: | | | |
| *Pentacme contorta* Merr. & Rolfe | White lauan | 51.14 | 17.5 |
| *Parashorea plicata* Brandis | Bagtican lauan | | |
| *Shorea squamata* Turcz.? | Danlig lauan | 21.91 | 7.5 |
| *Shorea furfuracea* Miq.? | Almon lauan | | |
| ?? | Calunti lauan | 17.00 | 5.8 |
| *Shorea guiso* Blume | Guijo | 13.68 | 4.6 |
| *Dipterocarpus* sp. | Apitong | 12.76 | 4.4 |
| *Hopea plagata* Vid. | Yacal | 9.09 | 3.1 |
| *Hopea?* sp. | Malayacal | 8.57 | 2.9 |
| *Vatica* sp. | Narig | 1.55 | .5 |
| Total *Dipterocarpaceae* | | 135.70 | 46.3 |
| STERCULIACEAE: | | | |
| *Tarrietia javanica* Blume | Lumbayno | 12.34 | 4.2 |
| LEGUMINOSAE: | | | |
| *Kingiodendron alternifolium* Merr. & Rolfe | Batete | 6.27 | 2.1 |
| All others | | 138.42 | 47.4 |
| Total | | 292.73 | 100 |

These figures show the bulk of dipterocarps to be not so high here as in some other forests, yet the preponderance of that family is still too apparent to be overlooked.

The following, giving some idea of the composition of the forest, is a list of the principal trees other than those mentioned in the yield and stand tables:

FAGACEAE-*Quercus* sp.; ULMACEAE-*Celtis* sp.; MORACEAE-*Artocarpus communis* Forst.; ANONACEAE-*Canangium odoratum* Baill.; MYRISTICACEAE-*Myristica* spp.; ROSACEAE-*Parinarium griffithianum* Benth.; BURSERACEAE-*Canarium* spp.; LEGUMINOSAE-*Erythrophlocum densiflorum* (Elmer) Merr., *Albizzia saponaria* Blume; EUPHORBIACEAE-*Cyclostemon* spp.; ANACARDIACEAE-*Koordersiodendron pinnatum* Merr.; SAPINDACEAE-*Euphoria cinerea* Radlk., *Pometia pinnata* Forst.; RHAMNACEAE-*Zizyphus zonulatus* Blanco; TILIACEAE-*Grewia stylocarpa* Warb.; STERCULIACEAE-*Pterospermum* spp., *Pterocymbium tinctorium* Merr.; GUTTIFERAE-*Calophyllum* spp., *Garcinia* spp.; DIPTEROCARPACEAE-*Hopea* spp., *Anisoptera* sp.; LYTHRACEAE-*Lagerstroemia piriformis* Koehne; COMBRETACEAE-*Terminalia nitens* Presl; MYRTACEAE-*Eugenia* spp.; SAPOTACEAE-*Palaquium* spp.; EBENACEAE-*Diospyros* spp.; APOCYNACEAE-*Wrightia laniti* Merr.; VERBENACEAE-*Vitex littoralis* Decne., *Vitex akerniana* Merr.; RUBIACEAE-*Sarcocephalus cordatus* Miq.

### FORESTS OF LEYTE, MINDORO, AND VARIOUS PARTS OF LUZON, AND MINDANAO.

Rough estimates of timber made in the Davao District of Mindanao show also the predominance of dipterocarps. On the Island of Samal near Davao, at least 80 per cent of the volume of the forest is composed of dipterocarps, mainly *Pentacme contorta* Merr. & Rolfe, *Parashorea plicata* Brandis, and *Shorea guiso* Blume. Untouched forests on the mainland at the head of Davao Gulf showed the dipterocarp forests reaching to the tide-water in many places and even occupying all but the frontal zones of the beaches.

The above represent regions in which more or less detailed studies have been made by the author. More hurried trips made in the Provinces of Tayabas and Camarines on the Island of Luzon, in the District of Zamboanga on the Island of Mindanao, and on the Island of Leyte, show that the large bodies of forest are composed of dipterocarps in greater or less proportion usually running over on an average 70 to 80 per cent of the bulk. The published work of Merritt[8] for Mindoro and the unpublished results of Curran, Hagger, Klemme, and other foresters in the Bureau of Forestry for various parts of the Island of Luzon, of Hutchinson for parts of Mindanao, and of Rosenbluth for northern Leyte, give results in entire confirmation of those mentioned above.

[8] M. L. Merritt. The Forests of Mindoro, Bureau of Forestry (Philip.) Bull. 8 (1908) 1–51.

SUMMARY OF STAND AND VOLUME.

The following is a summary of the stand and volume tables given in this paper.

| Locality. | Per cent of *Dipterocarpaceae* by— | |
|---|---|---|
| | Stand. | Volume. |
| Bataan Province, Luzon. | | |
| Limay | 60.9 | 68.80 |
| Mindoro: | | |
| Narra type | 33.11 | 53.70 |
| Hagnachae type | 41.50 | 66.00 |
| Negros | 89.4 | 95.00 |
| Zamboanga, Mindanao: | | |
| Yacal type | 43.7 | 47.00 |
| Lauan type | 15.86 | 46.3 |
| Samal Island, Mindanao | | [a]80 |
| Leyte | | [a]80 |
| Masbate | 47.5 | |

[a] Estimated.

It will be seen from the above that from 33 per cent to 89 per cent of the stand and 46 per cent to 95 per cent of the volume of these forests are composed of species of the *Dipterocarpaceae*. It is estimated that at least 75 per cent of the present virgin forest area comprising some 40,000 square miles is of like nature. Such a forest has been found in practically all classes of habitats from sea level to an altitude of approximately 900 meters on the largest mountain masses. Within these forests, to be sure, there are local conditions such as character of soil, steepness of slope, exposure to severe atmospheric conditions, and those due to artificial interference, that do not favor dipterocarps at the present time. However, the vegetation in many of these situations is only transitory in nature and may be considered as stages in succession toward some form of the most successful forest, viz, the dipterocarp forests. As mentioned heretofore it is not the intention to discuss in this paper the different types, nor the different stages of succession. Briefly it can be stated that a representative of a climax forest is found in Negros where the bulk reaches about 429 cubic meters per hectare of wood. Here it is believed that a combination of edaphic, climatic, and biotic factors have reached the optimum necessary to the establishment of most successful growth in the Philippines. The climate is uniform as regards temperature, and with the exception of a short dry season interspersed with showers it is fairly uniform as regards humidity and rainfall. The topography is composed of gentle slopes so that the soil wash is not great nor in the rainy season is there an accumulation of excessive moisture in the soil. It is probable that originally a greater part of the area of the Philippines

which is now under cultivation or in grass, and that has physiographic features similar to that of the Negros forest mentioned above had a forest that contained a similar composition and volume.

The forests of the Bataan and Port Banga regions on the other hand, are handicapped by less favorable climatic and edaphic conditions. The dry season is more pronounced and the topography is rough, in consequence of which the bulk of the forest is much less and the composition is more complex.

Again, the delta plain of Mindoro, which has a climate similar to that of northern Negros, during the wet season is periodically flooded by rain, which makes the soil excessively moist during a part of the year. The volume of the forest is consequently much less and the forest more complex in composition.

In temperate regions, generally speaking, the nearer success that mature forest growth attains, the simpler the arboreal composition. From the above the conclusion can be drawn that in this respect tropical virgin forests are like those found in temperate zones.

## ECONOMIC CONSIDERATIONS.

The economic aspect of the predominance of dipterocarp forests in the Philippines is significant. The high percentage of the members of one family, in many places approaching pure stands, and the comparatively high bulk per unit of surface make lumbering on a large scale with modern methods possible. In the previous tables the bulk per hectare is given in cubic meters, regardless of whether the trees are sound or decayed. Making liberal allowances for unsound timber the regions investigated are conservatively estimated to run from 8,000 to 30,000 or more, board feet per acre. Individual acres will yield 100,000 or more board feet. Including all species, the volume of the dipterocarp forests in the Philippines is estimated to be about 200 billion feet of lumber board measure.

The impression is general that tropical forests yield woods that can not compete with the coniferous woods of temperate regions. Fernow[9] speaking of the lumber supplies of Australia, Brazil and other South American countries states the following:

"The valuable hardwoods of those countries, possessing excellent quality besides their beauty, for which we use them at present, will never be able to compete or supplant our own materials, for they occur in single individuals scattered among hundreds of other species; so that to supply any considerable quantity of any one kind requires culling over many acres, which renders them too expensive for general use."

What are the facts of the case as regards the Philippine forests? It is true that with the exception of very limited stands of pine, the forests

[9] Fernow, B. E. Economics of Forestry (1904) 34.

here are composed of broad-leaved trees, and would, in the United States at least, be classed as hardwoods. In texture, however, a large per cent of the trees produce woods with the general mechanical properties of pines and other conifers.

The dipterocarp woods may be divided into three groups. Of these the lauans (*Pentacme contorta*, *Parashorea plicata* and a number of species of *Shorea*), though slightly harder, are not dissimilar to the white pines in mechanical structure. They are being used in the Philippines for lighter classes of general construction and bid fair to replace all imported woods of like qualities.[10]

The apitongs (species of *Dipterocarpus* and *Shorea guiso*) will compare favorably with the hard pines and are being used for heavier classes of general construction. The yacals (certain species of *Hopea*, *Vatica*, and *Shorea*) are hard and durable and are used for general construction work, especially where contact with the ground is necessary. However, the great bulk of the Philippine forests is composed of trees that yield timber of the grades of lauan and apitong. Of the trees other than dipterocarps found in the dipterocarp forest probably one-half of the bulk is composed of woods that would grade with the lauans or apitong. Of these the family *Anacardiaceae* produces *Koordersiodendron pinnatum* (amuguis), *Dracontomelum dao* (dao), *Mangifera altissima* (pahutan); in the *Sapotaceae* are *Illipe ramiflora* and several species of *Palaquium*; in the *Sterculiaceae* are *Tarrietia javanica* (lumbayao) and other species of several genera; in the *Sapindaceae* is *Pometia pinnata* (malugay); in the *Rhamnaceae* are species of *Zizyphus* (balacat); in the *Combretaceae* are several species of *Terminalia*, and in the *Rubiaceae* is *Sarcocephalus cordatus* (bancal).[11]

The prevalent idea that the tropics produce nothing but hardwoods suitable for special uses like the teak for shipbuilding, and the mahoganies and their substitutes, for fine interior finish, furniture and cabinet making, is due, in the Philippines at least, to a number of causes.

1. The wood-destroying forces in the tropics are much greater than in temperate regions. The continual heat and moisture favor the rapid development of fungi, and with the presence of anay (white ants) tend to shorten the duration of untreated timbers in almost every class of construction, consequently hard durable timbers are sought for permanent structures.

2. The cost of extracting such timbers by crude methods (animal and

[10] On account of color and fine figure, when quarter sawn, the best grades of the lauans are valuable for furniture, cabinet making, and fine classes of interior finish, and are used extensively as such.

[11] See Foxworthy, F. W. Philippine Woods, *This Journal* 2 (1907) *Botany* 351–404, and Gardner, R. Mechanical Properties and Uses of Thirty-four Philippine Woods, Bureau of Forestry (Philip.) Bull. 4 (1906) 1–66, for description of the uses and mechanical properties of these woods.

manual labor) is great, but the ruling high prices justify the expense. The cost of extracting the softer woods by the same methods is as great or nearly as great because the logs are usually much larger in size. The price paid for such logs is comparatively low so that the profits, if any, are much lower. The introduction of modern logging machinery will reduce and is reducing the cost of logging greatly.

3. The demand for great amounts of cheap construction timbers is supplied by bamboo stems or palms, and small or young dicotyledonous trees.

4. No widespread attempt has ever been made to place the general construction woods of the tropics on the markets of temperate zones.

It is shown from the above that the volume per acre of the dipterocarp forests of the Philippines is great enough to allow lumbering operations on a large scale, and the supply is sufficient to allow a large per cent for export of the cheaper classes of timber. It is believed that in time such timbers will be exported to temperate regions and sold at a price that will allow them to compete successfully with timber of a like grade. That it is not done at the present time is due to certain unfavorable economic conditions, which will in time be overcome.

The amount of timber in the Philippines is limited, principally because the land area of the Philippines (about 120,000 square miles) is small, with a virgin forest area of approximately 40,000 square miles. What proportion of this will ultimately be absolute forest land, to yield continuous crops of timber is not yet known. Large deforested areas are on non-agricultural land. It is shown that so far as the Philippines are concerned the forests yield mostly general construction timbers, which are as a rule practically unknown to the temperate zone markets of the world. Borneo with an area approximately two and one-half times that of the Philippines is rich in dipterocarps and because of its smaller population probably has a much larger percentage of virgin forest area than the Philippines. There as well as in other parts of the thinly settled Malayan regions, so far as is known, no attempt has been made to take an inventory of the forest resources. In thickly settled Java nearly all of the accessible virgin forest area has been removed. With the exception of *eng* (*Dipterocarpus tuberculatus* Roxb.) and *sál* (*Shorea robusta* Gaertn.), the dipterocarps of Burma and tropical India are little known outside local markets. Concerning the forests of Burma I quote the following from a letter of M. L. Merritt who recently visited a small portion of this region. "Naturally I saw more of the plains and low hill forests than any other. Here teak (*Tectona grandis*) and *pyingado* (*Xylia dolabriformis*) are the two species which they regard as being most valuable. The former is very scattered and I doubt if there will be one-half to one-third trees to the acre. *Pyingado* is more numerous and will run approximately one to three trees per acre. The dipterocarps, *Dipterocarpus alatus* and *Dipterocarpus laevis,* both of which resemble

*Dipterocarpus grandiflorus* and *Dipterocarpus vernicifluus* in shape of bole, habits of growth and wood as well as fruit, and *Dipterocarpus tuberculatus* occur scattered all through the forest and probably have as large a yield as there is of all other species combined. They are not logged, however, except in the more accessible places. I also noted a *Parashorea* and a *Shorea* in the forest." Foxworthy[12] states that if all woods other than the dipterocarps were excluded from the markets of the tropical East, the markets would hardly feel the difference.

So much for the Asiatic tropics. Will the tropical regions of Africa and South America show similar quantities of general construction timbers in their virgin forest? So far as I know, economic and scientific explorations have been mainly attempts, from the viewpoint of the lumberman, to find valuable hardwoods of the mahogany grade or hard durable timbers. The forests as a whole have not been sized up from the standpoint of the forester with a view to the utilization of all the species. From the results of the investigations given above, made in the Philippines, it is probable that the virgin forests of South America and Africa will show that a greater part of their bulk will consist of woods suitable for general construction purposes of certain classes, which can, with the introduction of modern methods of logging and milling and with improved economic conditions that are sure to come with the development of the tropics, be placed in the markets of the temperate regions at a cost that will enable them to compete with woods of similar qualities found in virgin forests in temperate regions or grown there as successive crops.

In the United States an inventory of the natural resources is being made with a view to conserving them. An attempt is being made to extend this conservation inventory to other parts of the world. So far as the forest resources of the world are concerned I believe that there is no problem that will ultimately yield greater scientific and economic results than an inventory of the forest resources of the tropical world. This will include a mapping of the forested areas, a rough estimate of the standing timber, and a brief description of the areas as regards their lumbering possibilities and the classes of timber found.

Mention was made above (page 701) that increment should be considered as a factor in an estimation of success in forest vegetation. In some forest trees of the Philippines rings of growth occur. In others these are lacking or obscure. It is not known whether these rings are annual or only seasonal. On this account no estimate can be made of the annual increment from rings of growth. Actual measurement of rate of tree growth in the tropics is not extensive enough to be of general application. It is believed, however, that the rate of growth in the tropics is much greater than in temperate zones, that generally speaking the soft wood forest trees will reach maturity in one-half to two-thirds

[12] Foxworthy, F. W. Indo-Malayan Woods. *This Journal* 4 (1909) *Botany* 506.

of the time they require in regions where the climatic conditions inhibit growth entirely for a considerable part of the year. If bulk alone is considered as a measure of success in forest growth, the virgin forests of some parts of the temperate regions are surely more successful than those of the tropics. This is especially true of the northwestern part of the United States where exceedingly heavy stands of coniferous forests occur. But if the annual increment is also used as an element of success it is believed that some tropical regions are capable of producing more bulk per year than temperate regions. Again, this is of economic importance. While the land area of the north temperate zone is much greater than that of the tropics and the absolute forest land (that is land that is better fitted for forest growth than agriculture) is also much greater, this inequality is in a measure offset by the possibility that each acre of land in the tropics can probably produce from one and a half to two crops of timber for one crop in temperate regions. A theoretical discussion of the causes of the shorter lives of tropical trees is reserved for another paper.

I wish to express my thanks to E. D. Merrill, Botanist of the Bureau of Science, for assistance in referring tree species to their scientific names, and especially to H. M. Curran, Forester in the Bureau of Forestry, for valuable suggestions in the preparation of this paper.

# ILLUSTRATIONS.

EXPLANATION OF THE PLATES.

PLATE XXXII. A tree of *Dipterocarpus vernicifluus*, (*panao*), showing the form of the bole and crown. Bataan Province, Luzon.

XXXIII. Interior view of a dipterocarp forest on a delta plain in Mindoro showing scattered large trees.

XXXIV. Interior view of a dipterocarp forest in Masbate. The trees are all one species, *Parashorea plicata*, (*bagtican lauan*).

XXXV. Outside view of a dipterocarp forest in Negros, on the lower slopes of Mount Silay. This forest will yield over 30,000 feet per acre, board measure, clear lumber, and consists of an almost pure stand of *apitong* and *lauan*.

XXXVI. Interior view of a dipterocarp forest on the lower slopes of Mount Silay, Negros. The trees are *red lauan* and *almon*, species of *Shorea*.

XXXVII. Interior view of a dipterocarp forest on the slopes of Mount Silay, Negros. The trees are *tanguile*, *almon*, and *red lauan*, all closely related species of *Shorea*.

XXXVIII. Interior view of a dipterocarp forest on the lower slopes of Mount Silay, Negros. The trees are *red lauan* and *almon*, species of *Shorea*.

PLATE XXXII.

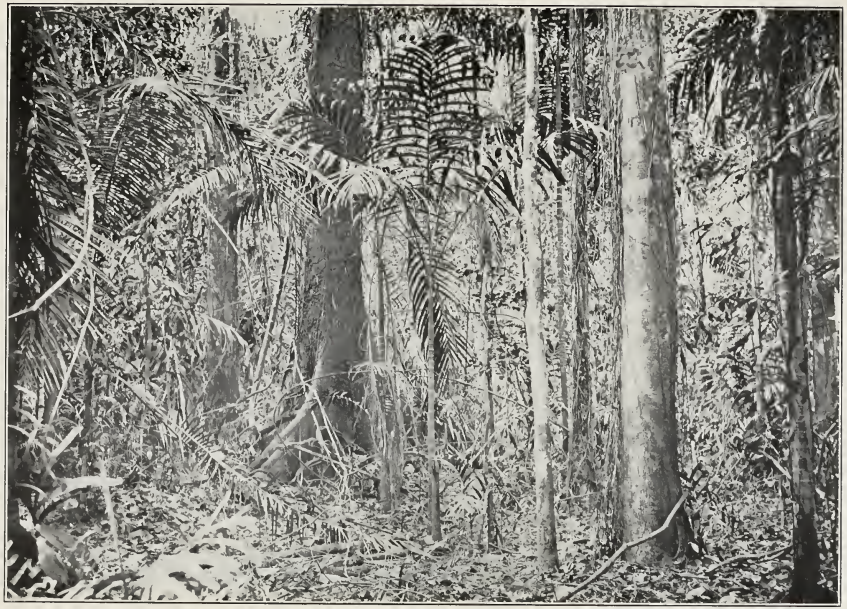

PLATE XXXIII.

PLATE XXXIV.

PLATE XXXV.

PLATE XXXVI.

PLATE XXXVII.

PLATE XXXVIII.