CHAPTER 9

Notes on Tropical Dendrology

ELBERT L. LITTLE, JR.
USDA Forest Service (Retired)
Washington, DC

What is dendrology? The term dendrology (dendrología in Spanish) is a scientific and artificial word. It is derived from two Greek words meaning trees and discourse or study, or the study of trees. A review of the history of usage of the term has been made by William A. Dayton (Dayton 1945). Perhaps the first use of the word was in the year 1668 as the title of a book or encyclopedia on trees by Ulisse Aldrovandi, Italian physician and naturalist. The limits of the science of dendrology are controversial. Originally, dendrology included all aspects of trees, and in that time there was no science of forestry. Now, and especially in Europe, dendrology includes also the shrubs, but in the United States of America it is restricted frequently to trees.

In actual use, dendrology is limited to the *botany of trees* or precisely to the *taxonomy of trees*. It can be considered as a division of forestry or botany that treats of the taxonomy of trees. In some universities of the United States the subject matter of dendrology is taught by a professor of forestry, and in others by a professor of botany who is a specialist in taxonomy or systematic botany.

Dendrology, then, is a division of forestry or botany that treats of the taxonomy of trees and other woody plants, including *nomenclature, classification, identification*, and *distribution*. The subject matter in tropical countries should be called *tropical dendrology*, or the taxonomy of tropical trees, in order to distinguish it from a course in dendrology as taught in a university of the United States or Europe. Those countries and continents of the Temperate Zone have trees very different from those of tropical regions. A forester who has studied dendrology only in a forestry school in the United States knows very little about tropical trees, for example.

WHY STUDY DENDROLOGY?

The study of tropical dendrology has five principal objectives:

Nomenclature of trees—To learn how trees are named, including scientific names, common names, and the code of botanical nomenclature.

Classification of trees—To learn how trees are classified into families, genera, and other groups according to their arrangements. To learn the names and characteristics of the common and important botanical families of trees.

Identification of trees—To be able to place an unknown tree in its family. To learn how to find the name of unknown trees or to identify trees by means of keys, manuals, and floras. To know the reference books for identification of the trees of your country. To learn how to collect botanical specimens. To learn how to maintain and use a herbarium.

Distribution of trees—To learn how trees are distributed into climatic zones and forest types. To know the geographic distribution of important forest trees.

Important forest trees—To know the important forest trees of your country, including scientific names, common names, family, distribution and abundance, and uses.

REFERENCE BOOKS ON DENDROLOGY

There are very few textbooks on dendrology. In the United States of America there are a few, such as the Textbook of Dendrology by William M. Harlow and Ellwood S. Harrar (Harlow and Harrar 1950). Various manuals and floras of regions and States are used also. However, the books do not include tropical trees and are not useful in the tropical countries.

As *there are no texts on tropical dendrology* for the tropical American countries, these notes may serve as an introduction to the subject. References and texts on plant taxonomy have much material that relates to dendrology. Many of these are published in English and other languages, rather than in Spanish. Various books, pamphlets, and articles on the trees, woods, and plants of a country or locality are useful to foresters in that country.

WHAT IS A TREE?

Everybody knows what a tree is, but it is not easy to prepare a precise definition. It is possible to classify seed plants, or flowering plants, into four artificial groups on the *basis of size and habit of the stems*: *trees, shrubs, herbs*, and *vines*. The ancient Greek Theophrastus (372 to 287 B.C.), disciple of Aristotle and called the Father of Botany, distinguished trees, shrubs, and herbs. These artificial groups are not related to the natural classification of botany into the botanical families.

The definitions in *Forest Terminology* (Society of American Foresters 1944), translated into Spanish by M. A. González Vale as *Terminología Forestal* (González Vale 1950), are modified slightly here.

• *Tree* (árbol): A woody plant that has a well-defined, erect, perennial trunk and a more or less definitely formed crown and that generally attains a height of at least 12 to 15 feet (or 4 to 5 m) and a trunk d.b.h. of 7 to 10 cm (1.3 m).

• *Shrub* (arbusto): A perennial woody plant smaller than a tree, usually with several perennial stems branched from the base.

• *Herb* (hierba): A plant with an herbaceous or soft stem, annual or perennial, but not woody. (An herb can be annual or perennial or, in cold climates, have a stem that dies to the ground each year.)

• *Vine* (bejuco): A woody or herbaceous plant with the stems not erect but depending on other plants or objects for support.

PRACTICAL APPLICATIONS OF DENDROLOGY

Dendrology is like a tool or an instrument for becoming acquainted with and studying the trees. The names serve as a guide for referring to the trees. *Before making a survey of the forest resources of a tropical country, it is necessary to know the names of the species*. Always, foresters need to know the names of the important trees with which they work.

THE NOMENCLATURE OF TREES

Nomenclature is a division of taxonomy that treats of the names of plants, including the correct names, synonyms, and rules of nomenclature.

Trees, like other plants, have two kinds of names, common names and scientific names. Both are important and necessary, and both have their advantages and disadvantages.

Common names are in the *language of the country*. Their origin is an interesting subject. Some Spanish names of trees in tropical America are words used before by the American Indians. Others are the same as those of different trees in Spain. Perhaps the Spanish colonists gave these names to unknown trees of the New World that resembled trees of the Old World. Some common names are of other kinds, such as descriptive—from the use, from the environment, or from the region or place where the species is found. In the United States, other English common names are translations of the scientific name or given in honor of the discoverer or another person.

ADVANTAGES OF COMMON NAMES

(1) They are in the language known by the people.
(2) They are used by the country persons, woodsmen, people in general, and in commerce.

DISADVANTAGES OF COMMON NAMES

(1) They change in different places, countries, and languages.
(2) The same common names can be used for different species in different places, countries, etc.
(3) Many species do not have their own distinct common names. There are still unknown species without names.
(4) Many common names are not exact. Some species have

indefinite common names that correspond only to a genus or to a botanical family.

(5) There is no definite authority or code of rules governing common names and for making them uniform.

As they are in modern languages, common names are useful only in one language and change from one country to another. A useful tree species of extensive distribution can have 5 to 10 or more names in various localities and in commerce. For example, a tree of the West Indies can have an English name in Jamaica, a Spanish name in Cuba, and a French name in Haiti. And perhaps in the other islands, such as Puerto Rico and the Lesser Antilles, it has other names. If it extends to South America or Central America, the names can change more. Also, there is confusion because the same common name can be used for different species in various parts of its natural range.

Therefore, for exactness and clarity and to avoid confusion, the botanists and also the foresters are obliged to use the scientific names of trees.

ADVANTAGES OF SCIENTIFIC NAMES

(1) They are uniform in a universal system in use throughout the world.

(2) They are in the Latin language, which is the language of no country and, being a dead language, does not change through the years.

(3) They show the classification and relationships of the species.

(4) There is an International Code of Botanical Nomenclature with rules for scientific names and for naming new species.

DISADVANTAGES OF SCIENTIFIC NAMES

(1) They are strange and long.

(2) They are not used by the people.

The Latin language that was used by the scholars of past centuries was continued by the biologists for the scientific names of plants and animals. A few centuries ago the botanists were studying medicinal plants or herbs and wrote books with the descriptions and text in Latin. The Latin description of a phrase served as the name.

Carolus Linnaeus (1707-1778), the distinguished Swedish naturalist, established the binomial system of nomenclature in the year 1753. In that year he published in Latin his book *Species Plantarum* (Species of Plants), which is the beginning of modern botanical nomenclature (Linnaeus 1753).

The binomial system of nomenclature, or system of two names, means that the name of each species of plants consists of two Latin words, the genus and the specific epithet. (The same system is used for animals.)

For example, the scientific name of the species of mahogany of Central America and South America is *Swietania macrophylla*. To these two words the systematic botanists add the name of the author, the botanist who first gave this name to the species and published a botanical description of it. Thus, *Swietenia macrophylla* King. Botanical works should include the author's name. However, generally it is unnecessary to write or remember the author, and foresters seldom need to mention the author.

Scientific names are subject to definite rules. These rules are adopted and revised by the systematic botanists in international botanical congresses. The last congresses were at Stockholm, Sweden, in 1950, and at Paris, France, in 1954. The most recent edition of the rules is called *International Code of Botanical Nomenclature* (Lanjouw and others 1952). Minor changes or amendments were made in 1954 and will be incorporated in a revised edition.

Under the Code, the scientific names are in Latin or, if from other languages or of artificial origin, they have Latin endings. The generic name is a noun and begins with a capital letter. The specific epithet commences with a small letter and can be: (1) an adjective that agrees with the generic name in gender (masculine, feminine, or neuter), (2) a noun in the Latin genitive case such as the name of a person, or (3) the name of another genus or another plant in apposition. The two words are underlined in manuscripts or on the typewriter and are in italics in publications. In origin and derivation the scientific names are descriptive or otherwise, like the common names.

There are three very important rules in the Code. The *rule of types* states that a scientific name is based upon a specimen called the type. The identity is fixed with this specimen, which is kept in a large herbarium. According to the *rule of priority*, the correct name of a group is the oldest that is in accord with the Code. For example, in the past many species have been given more than one scientific name by different botanists working independently. Thus, there is only one valid name, the oldest, and the others are called synonyms. The *rule of homonyms* treats of homonyms or identical names. The same name cannot be used for two different groups, and if a name was used earlier for one group, it never can be employed for another.

From these rules it may be seen that scientific names are not perfect. Among the botanists there is no complete agreement in the names, their application, or their limits. Some species still have two scientific names in use in different books. However, the scientific names are much more distinct and clear than the common names.

PRONUNCIATION OF SCIENTIFIC NAMES

Being in Latin, the scientific names are pronounced like Latin words. The Latin language is pronounced almost like Spanish, and the vowels are similar in both languages. Then, it is simple and easy in Spanish-speaking countries to treat the scientific names as if they were written in Spanish. However, there are some names derived from foreign words, such as modern languages. These names are pronounced as in the original language, often with accent different from Spanish. The British and other Europeans pronounce scientific names correctly according to Latin, but in the United States these words generally are spoken as if English.

ABBREVIATION OF NAMES OF AUTHORS

The names of some authors are written in abbreviated form after the scientific names. Generally these are botanists who have named many species or who have long names.

Complete names of these persons can be found in glossaries of some botanical references. Usually the abbreviation stops just before the second vowel. An exception is that of Carolus Linnaeus, which is only "L." For example, *Rhizophora mangle* L., mangrove or mangle. Also, there is seen H. B. K., for Humboldt, Boupland, and Kunth, as in *Byrsonima crassifolia* H. B. K., chaperro.

DOUBLE CITATION OF NAMES OF AUTHORS

Some scientific names of plants are followed by names of two authors, the first in parenthesis. For example, *Delonix regia* (Bojer) Raf., flamboyant-tree or flamboyán. This means that the first author gave the name of the specific epithet but in another genus or as a variety. Afterwards, the second author changed the name and put the specific epithet in this arrangement. In this case the earlier name, which also is now in use, is *Poinciana regia* Bojer. Some botanists regard *Delonix* as a genus distinct from *Poinciana* and others do not.

THE CLASSIFICATION OF TREES

Classification is a division of taxonomy that treats of the botanical arrangement of plants into groups, such as families and genera, in accord with the relationships.

This is the problem. There are approximately 350,000 known species of living plants. It is not possible to study and know them all one by one. How can they be arranged into groups for study, for compilation of data on the characteristics, and for organization of all this information? There are two kinds of classifications: artificial and natural.

ARTIFICIAL CLASSIFICATIONS

An *artificial classification* is a simple and convenient arrangement but is not done according to the relationships. It is like compartments or pigeonholes in a box or cabinet, one compartment for each species. The ancient Greek Theophrastus proposed the artificial classification previously mentioned. This arrangement of plants on the basis of stem habit as trees, shrubs, or herbs is useful and convenient. Foresters study mainly the trees, which form an artificial group.

Another artificial classification was the sexual system of Carolus Linnaeus, published in 1732. All plants were placed in 24 classes based upon the stamens: their number, union, and length. The classes were divided into orders, based upon the number of styles in each flower. This system served to identify specimens and was very useful in its time.

NATURAL CLASSIFICATIONS

A *natural classification* attempts to group together similar plants according to their relationships. After Linnaeus, other botanists proposed natural systems of classification of plants. In these works the species were arranged in natural groups such as families. The French botanist Antoine de Jussieu devised one of the first natural systems in the year 1789.

The modern classification of plants and animals is based upon the principle or theory of organic evolution. In 1859 the British naturalist Charles Darwin published his famous work, The Origin of Species (Darwin 1955). The principle of organic evolution means simply that the higher forms of plants and animals have developed from the simple or lower forms over millions and millions of years. Specialized plants have originated from primitive species. In other words, plant life has changed slowly during long periods of time.

Natural classification is based upon relationships through descent. Evolution can be compared with a tree. In theory, plant life began as a seed. Through millions of years it grew into a tree with many branches representing the plant kingdom. The buds correspond to the species that exist now, and the branches to the extinct or fossil species. Then, all the twigs on one branch belong to the same family and are related. But as the branches do not exist now, the relationships are not well known and are subject to differences of opinion among botanists.

There are many evidences and proofs to support the principle of organic evolution. Morphology, or the study and comparison of the form and parts of plants, is important. For example, those species with similar form or structure are thought to be related. Other evidences can be found in other subdivisions of biology such as anatomy, embryology, genetics, cytology, paleontology, and geographical distribution.

The methods of organic evolution are not so well understood. Among the theories is the theory of mutation (or of sudden changes in the hereditary variations) and the theory of natural selection (or survival of the fittest) by Darwin.

Probably the natural system of classification of plants most generally adopted by botanists at present is that of Engler and Prantl (1887), two German botanists, in their important work of 20 volumes entitled Die Naturlichen Pflanzenfamilien (The Natural Plant Families), which covers the entire plant kingdom. The most recent evidence indicates that perhaps this system could be improved. Nevertheless, it is the most detailed and convenient and is used in many large herbaria of the world.

Another important natural system also in use is that of Bentham and Hooker (1862-63), two British botanists, in their Latin work of three volumes, Genera Plantarum (The Genera of Plants).

THE CATEGORIES OF THE PLANT KINGDOM

In the natural classification, the species of trees and other plants are arranged into groups of small and large rank in a hierarchy. These groups of the plant kingdom are placed in categories. The categories are in Latin and also in modern languages. They are listed below in Latin, English, and Spanish, with examples.

Latin	**English**	**Spanish**
Regnum Vegetable	Plant Kingdom	Reino Vegetal
Divisio	Division	División
Classis	Class	Clase
Ordo	Order	Orden
Familia	Family	Familia
Genus	Genus	Génera
Species	Species	Especia
(Varietas)	(Variety)	(Variedad)

Latin Example	**English Example**	**Spanish Example**
Spermatophyta (Divisio)	Spermatophytes (Division)	Espermatofitas
(Subdivisio Angiospermae)	(Subdivision Angiosperms)	(Angiospermas)
Dicotyledoneae	Dicotyledons	Dicotiledóneas
Geraniales	Gereniales	Geraniales
Meliaceae	Mahogany family	Meliáceas
Swietenia	Mahogany	Caoba
Macrophylla	Central American	de Honduras

At the end, but not a category, is the individual (individuum in Latin and individuo in Spanish). Also, subgroups for other categories can be added in large groups as needed, such as the subdivision in the example above: subfamily, subgenus, etc.

The plant kingdom now consists of approximately 350,000 known species of living plants grouped into 19,000 genera. The division of Spermatophytes (phanerogams or seed plants) now contains 2 subdivisions, 7 classes, 45 or more orders, more than 300 families, more than 10,000 genera, and more than 250,000 species.

Then, the most important unit in the botanical classification is the species. Each individual, tree or other plant, belongs to a species and only to one particular species. It is difficult to define a species and also the other categories. It can be said that the *species* is composed of individual plants (or animals) that are similar in appearance and that can reproduce or breed among themselves and produce other individuals resembling the parents.

A *genus* is a *group of related species*. A *family* also is composed of a group of *related genera.* An *order* consists of a group of *related families*, etc.

The *variety* is a division or minor variation of a species or a group of individuals that differ slightly from the others. The majority of species have no varieties or are not divided into varieties. *Varieties are named, particularly in cultivated species*.

Scientific names of families and higher categories are plural, while names of genera, species, and varieties are singular.

The name of an *order ends in ales* and is derived from its type family. For example, geraniales is from the family geraniaceae, which is derived from the genus *Geranium*.

The termination of names of the botanical *families is -aceae*. However, the Code permits the use of eight exceptions with endings in *-ae*. For example, Palmae, Fabaceae, and Guttiferae. The name of a family is derived *from its type genus* or from a synonym. For example, Melisceae comes from *Melia*.

The subject matter of tropical dendrology includes the study of families of the important forest trees with distinguishing characteristics and examples.

THE IDENTIFICATION OF TREES

The identification of a tree consists of determining the correct scientific name, generally by means of manuals, floras, keys, etc.; or of determining that the plant or specimen is the same as a previously known plant with a scientific name. In these references a special botanical terminology is used for describing the differences in morphology or in the parts of the trees. For this reason, in the laboratory we study the terminology of the leaf, flower, fruit, etc.

METHODS OF IDENTIFICATION OF TREES

The question is: How to learn the name of a tree? There are several methods; in each case we should use the easiest, simplest, and most rapid method that also arrives at the correct name.

The Question

The simplest method of learning the name of a tree is to ask someone who knows the name. This method can be used anywhere. Whenever there is the opportunity, we should go to the forests with other foresters or botanists who know the species well. This method is very useful, particularly in a new region where many trees are strange. In the university and in the herbarium, as in the field, the question aids identification.

This method is especially important for learning common names, because many common names are not found in the books. The rural people who know well the trees of their locality have learned the names from other persons and not from botanical books. When in doubt, one should ask two persons, to see if both give the same name. Also, when the common name is known, it is frequently easy to obtain the scientific name of the genus or species in references on plants or woods.

However, there are limitations and disadvantages to the question method. (1) Other persons, including specialists, can be mistaken in the names and in the identifications. (2) In some localities there are no persons who know all the trees, especially the scientific names. (3) Many times foresters have to work alone and where there is no help in making the identifications. Therefore, foresters need to know how to identify trees and botanical specimens as well.

Books, Manuals, Floras, Catalogs, Keys, Monographs

Wherever there is a good illustrated manual of the region, as there is in various parts of the United States, one can look through the illustrations. This method, useful though not scientific, can waste time and cannot be employed where there are many tree species; an illustrated manual could not illustrate many species of minor importance.

These books generally are written by botanists for botanists and with the technical terminology of systematic botany. Thus, foresters in the study of dendrology should learn to read and understand these botanical books, which have numerous—perhaps too many—technical terms. There is a need for more popular illustrated manuals containing a minimum of technical terms and written for foresters and the public.

Therefore, we shall study in the laboratory the botanical terminology of the *leaf*, the *flower*, the *fruit*, and other parts of the trees, such as the *stem* and the *bark*.

A *flora* of a region generally contains botanical descriptions and keys. However, some tropical countries lack descriptive floras.

A *catalog* has a list of the species of a region, often with other notes. The Catalogo de la Flora Venezuela also has keys to genera.

A *monograph* is a study of a genus or family in a country or larger region. For example, Rubiaceae of Venezuela by Standley, and *Podocarpus* in the New World by Buchholz and Gray.

A *key*, like a key to a door, is a simple device for opening the way to the name, or an artificial device for finding rapidly the scientific name of a plant. This is much easier than reading many descriptions. The old botanical references of one or two centuries ago had no keys. In order to identify an unknown plant with a botanical book without a key, it is necessary to read the descriptions until reaching one that agrees with the plant. Thus, it is necessary to read half the book on average in the identification of a specimen.

The key is dichotomous, or with forks or branches two by two. It divides the plants of a book into groups of two or by halves until it arrives at the name that corresponds to the specimen. In a key there are pairs of contrasting short phrases, generally of a single line each. It is necessary to determine which of the two phrases agrees with the specimen. If the phrase contains two or more parts, all characters should agree with the specimen. Below the correct phrase is found another pair of contradictory phrases. The selection of a correct phrase is repeated until one arrives at the name. If there is a description, one should read it in order to check whether it fits the specimen. If it does not agree, probably there is an error and use of the key should be repeated by hunting another fork which leads to the correct identification.

There are keys to families and to genera within a family and to species within a genus. But unfortunately, in some tropical regions there are few keys to species. When there are two or more keys for use, it is simplest to use the shortest or that of the smallest region or with the smallest number of parts.

The *two kinds of keys are the indented key and the parallel key*. The indented key begins with the contrasting phrases of the pair at the left of the page, usually not together but separated by other pairs following a little more to the right. Generally there are number or letters to facilitate the comparison, but not in some short keys. Below each line the next pair is indented.

The parallel key always has the two contrasting phrases of the pair together, one directly below the other, and the position of the pairs that follow is indicated by numbers.

We should know how to use both kinds of keys, because both are found in reference books. Each has its advantages and disadvantages. The long keys of many pages usually are parallel and do not lose space as in an indented key with many short lines. The indented key generally is preferred because it is easier to follow, and if an error is made the correct branch can be found more rapidly.

The Herbarium

An herbarium is a collection of plant specimens, dried, pressed, mounted on cardboards, identified, and arranged according to a botanical classification. The specimens are placed in large cases or cabinets of steel or wood. Special ones are preserved by other methods such as large fruits in boxes and succulent plants or small plants in liquid.

The herbarium serves for the identification of botanical specimens and also for reference and teaching. Type specimens are the base of botanical nomenclature, and all the specimens together show the geographic distribution. The herbarium is the basis of many investigations and publications on taxonomy.

How is the herbarium used in the identification of trees? There are two principal methods:

(1) To verify the identification made by a key or a description in a botanical reference. It is much easier to compare a specimen with a named specimen than with a description.

(2) For comparison with specimens of various species. When there are no botanical references adequate for identification, the herbarium is very useful. For example, in a country that lacks a descriptive flora or keys to species, it is necessary to take the botanical specimens to an herbarium that has collections from the country or the region in order to find identified specimens of the same species.

Whenever the herbarium is used in identification, first the botanical references should be consulted. It saves time to identify the specimen as completely as possible with keys and floras beforehand. Time is lost in using the herbarium before eliminating many similar species with the books. The genus of most plants can be determined with the books of other regions.

If the specimen is poor or is not complete with flowers and fruits, it is difficult to follow a key. Then the herbarium can be examined by trial and error in search for identical specimens, but this method is slow.

In the identification of a dried specimen in the herbarium, frequently it is necessary to dissect the flower in order to study the parts. The dried flower can be soaked in hot or boiling water before examination. Then it will become soft and can be examined without breaking and nearly as well as when fresh.

Shipment of Specimens to a Large Herbarium

Instead of making his own determinations, the forester can send botanical specimens to a large herbarium for identification.

In order to facilitate the determinations and also to prepare specimens that will be preserved permanently in a large herbarium, foresters should know how to collect and prepare good specimens.

The principal advantage of sending specimens to a large herbarium is that the identifications by the specialists will be correct and in accord with the most recent studies.

The disadvantages are that it is necessary to collect and prepare botanical specimens, and that frequently there is a delay of some months or more than a year until the determinations are received. (Generally small collections are named faster than large ones.)

Before shipping the specimens for identification, one should always write and mention the number of specimens and the region or State where they were collected. Some herbaria do not have specialists in plants of certain parts of the world and are not interested in specimens from those countries. The service of identification is free, but in place of payment the herbarium keeps the specimens.

When there is a specialist working on a particular group, such as a family, and writing monographs on its genera, this botanist is the best authority on that group and can make the best identifications.

Many countries have national herbaria which vary greatly in size. The largest herbaria in the world are principally in Europe and North America. Extensive collections from tropical America are deposited in three herbaria in the United States: Chicago Natural History Museum, Chicago, IL; New York Botanical Garden, Bronx Park, New York City, NY; and United States National Museum, Washington 25, DC. Specialists from these and other herbaria in the United States have made extensive botanical explorations and collected many thousands of specimens in tropical America

THE COLLECTION OF BOTANICAL SPECIMENS

THE NECESSITY OF COLLECTING BOTANICAL SPECIMENS

In the identification of an unknown tree, a specimen is worth more than many words or notes. It is difficult to identify a tree solely from the notes written in the forest.

From time to time foresters need to collect some botanical specimens of the trees with which they work. If they do not know the trees in the forest, then they should preserve specimens for identification later or for shipment to a large herbarium or to a specialist for determination.

For example, on making an inventory of the forest resources of a region, numbers or common names can be used for the unknown trees. Then, specimens should be collected for later identification.

Systematic botanists have various methods of collecting specimens. However, foresters generally collect only a few specimens and can employ the simple methods. In an emergency a twig can be broken from a tree and pressed in a notebook, in the pocket, or in a book. But it is worth the trouble to collect good specimens and in the end the identifications will be better.

INSTRUCTIONS FOR MAKING COLLECTIONS

Collect Sufficient Material of Good Specimens with Flowers or Fruits

This is the first rule. Frequently, botanists are interested in collecting incomplete specimens of rare plants, but foresters are not. *A rare tree generally is unimportant in forestry*.

It is very difficult to identify correctly and completely a sterile specimen of a tree from only the leaves and twigs. Trees in various families have very similar leaves. Nevertheless, often unknown trees are found with neither flowers nor fruits, and it is necessary to collect sterile specimens. Possibly there can be found a tree flowering outside the regular season. If not, it is very useful to collect a wood sample from the same tree. Perhaps specialists in wood anatomy can identify the genus or family of the wood, and then botanists can continue the identification.

Collect at Least Two Sets

Two specimens should be collected from the same tree, one to keep and the other to send to the herbarium or specialist for identification. Also, a few additional flowers for dissection will be helpful. Whenever convenient, it would be useful to collect more sets. However, more time is spent and more equipment is needed in preparing the additional sets. In order to avoid a mixture of two species, all sets should be from the same tree.

Write Useful Notes in the Forest for the Label

A specimen without notes is not worth much either to the forester or to the herbarium. In the herbarium the notes on the label probably are worth more than the specimen. These notes include:

(1) **Name of the collector.**
(2) **Number of the specimen.** Each collector should use a series of numbers for convenience in his notes, in identification, and in the herbarium when later reference is made to the specimens.
(3) **Date.**
(4) **Locality.** The country, State, municipality, exact locality, or distance and direction from a city or from a point on the map.
(5) **Elevation above sea level.**
(6) **Forest type.** Associated species. Soil. Whether planted or wild.
(7) **Common name.**
(8) **Size and habit.** Height and diameter of the tree, or whether the plant is a shrub, vine, or herb.
(9) **Uses.**
(10) **Other notes.** Abundance. Color of the flower. Fruit. Bark and latex. Wood. Roots.

Naturally all these notes cannot be obtained for all specimens.

COLLECTING EQUIPMENT

It is difficult to collect botanical specimens of trees because the branches usually are high. In a search there may be located a small tree of the same species or a tree with low limbs on the edge of the forest. Sometimes the tree can be climbed or felled. Or leaves, flowers, and fruits fallen on the ground beneath can be found.

In obtaining specimens, tools such as knives, machetes, and axes are indispensable. Also, pruning shears and a pruning hook or pole may be used.

A notebook with pencil or pen, a hand lens, and a ruler or measuring tape are useful. So are field glasses and a camera.

It is important to carry the specimens from the forest to the office or base without losing parts, without damage, and without drying. Probably the best method is to carry a light press with old newspapers directly to the forest. Or the specimens can be placed in a canvas bag or wrapped in newspapers. Also, there are the large cans that are used with moist newspapers inside. For large fruits and seeds, paper sacks are useful.

PRESSING EQUIPMENT

Botanical specimens in the herbarium are dried and pressed, in order to preserve them better and save space. The challenge in drying the specimens is to remove the moisture with pressure, and rapidly. If it is not pressed, the specimen does not stay flat but wrinkles and folds. Then it is fragile and breaks or becomes damaged easily. If it is not dried rapidly and completely, mold damages it. Also, when dried rapidly the specimens retain their natural color better and do not lose leaves or other parts.

In an emergency, specimens can be pressed with only some newspapers and a weight, such as books, boards, bricks, or stones.

The Press

Generally a wood press, size 12 by 17 or 18 inches, with two straps of leather or canvas is used.

The old newspapers or newsprint that are folded for the specimens should be the same size as the press. Also, 50 to 100 or more sheets of blotting paper or driers such as felt are needed.

The sample is arranged within the newspaper. It should not be larger than the cardboard mounting sheets, which measure 16-1/2 by 11-1/2 inches. A large specimen can be folded in the form of V, N, or M. Since the mounting sheet and pressed specimen have only two dimensions instead of three, some leaves and twigs should be removed, leaving the base of the petioles to indicate the leaf arrangement. Generally one should not arrange a leaf directly on top of another. If too many leaves are left, the specimen does not dry well and the leaves underneath cannot be seen.

Outside, on the corner of the newspaper sheet, can be placed the number of the specimen that corresponds to the number of the collector in his notebook. Between each two folded papers containing specimens is inserted a drier. When all the specimens are arranged in papers, the press is tightened and fastened.

The press should be put in a warm dry place. Daily, or twice daily, the driers are changed until the specimens within the papers become completely dry and break when they are bent. The first time that the driers are changed the specimens should be examined and rearranged as needed; those that have become folded should be straightened. The moist driers are dried in the sun, near a stove, or placed one by one against the walls and on the floor of a room. If driers are lacking, newspapers can be utilized. The time for drying varies from a few days up to a week, depending upon the size of the specimens, thickness of the leaves, etc. This method is rather slow, consumes much time, and does not prepare good specimens of trees with thick leaves. However, it serves well enough for foresters who do not collect many specimens and do not wish to carry much equipment.

Heat

Botanists who collect botanical specimens in quantities in tropical regions always use heat to dry the specimens rapidly. In the laboratory, electric ovens with ventilators or fans, or an apparatus of electric heaters or electric lightbulbs, can be used under the press.

In the field, a portable stove of gasoline or kerosene or kerosene lanterns can be employed.

Corrugated Driers

With heat, corrugated sheets or ventilators of cardboard or metal are needed in order that the hot air can pass within the press and remove the water from the specimens. The corrugated sheets have the same size as the press. Those of cardboard can be flat on one or both sides. The metal sheets are made of aluminum or iron and last longer. They fit together in less space and dry the specimens in half the time required with cardboard. After 12 hours or more in an ordinary press with driers, the corrugated sheets are inserted in place of every second drier, and the press is mounted above the stove. A cloth is placed around the stove and fastened tightly around the bottom of the press, but opened near the bottom or on one side to permit entrance of air. With metal sheets the majority of the specimens will dry within 12 to 24 hours. At about the middle of this time the straps should be tightened and the press turned over. As there is danger of fire, *the stove never should be left unattended.*

After being dried the specimens should be arranged in order by number and kept in cardboard boxes or packages in a dry place. If they are stored for much time, insecticides should be applied.

THE HERBARIUM

From time to time, foresters collect botanical specimens for large herbaria and also use the herbaria in identification. Perhaps with the duplicate specimens they may make small herbaria of the regions where they work. Therefore, they should know something of the arrangement and care of the herbarium. How to identify specimens in the herbarium was discussed earlier.

THE MOUNTING OF SPECIMENS

After being identified and before being placed in the steel or wood cabinets, the specimens are mounted on mounting sheets of white cardboard. These cardboards, which measure 16-1/2 by 11-1/2 inches, should be of good, durable quality. In some herbaria the specimens are mounted with glue or paste. In others, narrow pieces of gummed cloth tape are used. With both methods the thick parts, such as stout twigs and large fruits, can be sewed with needle and thread. Loose parts, such as additional flowers and fruits, are placed in pockets or envelopes glued to the mounting sheet.

The Label

The label is glued or pasted on the lower right corner of the mounting sheet. Generally labels are printed in part. The notes by the collector should be added with a typewriter. In addition there are added the scientific name with author, the name of the person who made the identification, and preferably also the year of the identification.

Genus Folders

The mounted specimens of a genus, or of a species if there are many, are placed in a folded cardboard sheet 12 by 17-1/4 inches after folding. The generic name is placed on the lower left corner outside.

ARRANGEMENT OF THE HERBARIUM

Large herbaria generally follow a natural system of classification in their arrangement. The most popular is that of Dalla Torre and Harms, based upon that of Engler and Prantl (1887), with numbers for the families and genera. Each genus of seed plants has a number, and the specimens are arranged and may be found in this numerical order.

In a small herbarium of a region, or in a personal herbarium, it is simpler to follow the order of the botanical flora of the country. Generally the order of the families in botanical references is that of Engler and Prantl (1887). Within a family, it is simplest to arrange the genera and species alphabetically.

PROTECTION AGAINST INSECTS AND MOLD

It is always necessary to protect the herbarium against insects and, in humid climates, also from mold. No method is perfect. Perhaps the simplest is to place repellents, such as paradichlorobenzene or naphthaline, in small cloth sacks or pockets within each cabinet, at the top. From time to time, every few months during the year, it is necessary to add more chemicals.

Mercuric chloride (bichloride of mercury) in solution is employed for killing insects on botanical specimens. Before mounting, the specimen is dipped into this solution and then dried. Fumigation with carbon disulfide or a poisonous gas is another method. Or the specimens can be placed in a special cabinet or in an oven, where insects may be killed with heat.

BOTANICAL TERMS

In order to use botanical references in the identification of trees, it is necessary to understand the botanical terminology. The botanical descriptions for identification and also the natural classifications are based principally upon morphology and anatomy. In distinguishing the species of trees, differences in parts are used, such as presence or absence, number, arrangement, shape, size, etc. Thus, foresters should know the names of the important parts of a tree.

Flowering plants (Angiosperms), those with both flowers and seeds, and particularly the trees, are composed of parts or organs. The principal organs are the *root*, *stem*, *leaf*, *flower*, and *fruit*. The first three—root, stem and leaf—are vegetative in function and serve in the development and growth of the plant from the seed:

The *root*, composed usually of a vertical axis and branches, grows downward, anchors the plant in the soil, and absorbs the nutritive substances, but never bears leaves.

The *stem*, composed generally of a vertical axis and branches, grows upward (or opposite to the root), and supports the leaves and flowers.

The *leaf*, or foliar organ, generally is flat and green and functions to manufacture the food for the plant.

The other two organs, the flower and the fruit, are reproductive in function and serve in the production of seeds to propagate the species:

The *flower*, usually colored, is the organ of reproduction and consists of an axis or stem with modified leaves of four kinds: the calyx, corolla, the stamens with pollen, and the pistil with the feminine elements or ovules.

The *fruit* is the mature ovary developed from the pistil and containing the mature seeds.

In the botanical classification of trees and also in their identification, the most important and most useful organs are the reproductive organs. The flower and fruit show the natural relations and botanical families much better than the other organs. The vegetative organs respond more easily and more rapidly to differences in the environment, such as climate and soil, and consequently are less constant and more variable. However, when a tree has neither flowers nor fruits, it is necessary to make use of these organs, such as leaves, bark, and wood, in the identification.

Systematic botanists have a special terminology of many words for describing the differences among the many thousands of species of plants. These words are derived from the ancient languages Latin and Greek. Many are similar to Spanish words and not difficult to remember. In the past centuries, botanists wrote their books and descriptions in Latin, and for this reason there now remains for us a very rich botanical terminology. Actually there are more terms in plant taxonomy than are needed, and some are rarely used.

Foresters do not need as many terms as do botanists. In the study of dendrology we shall learn the common terms that are used in descriptions of tropical trees. Other new or unfamiliar terms that are found in publications can be sought in botanical glossaries or other botanical references.

THE ROOT

The root generally is not important in classification of trees. As they are within the ground, roots are not seen or easily examined. Also, they probably have very few characteristics useful in identification. However, a few species of trees have *aerial roots* that are useful in the forest for recognition.

Characters of the bark utilized in identification include external and internal color; the surface, the texture—whether smooth, rough, or furrowed; whether thin or thick; and if there is latex (colored juice or sap) or odor.

The trunks of some species have the base enlarged into buttresses, especially in the wet tropical forests.

It is difficult to describe the characteristics of bark and its differences. However, with experience in the forest one can recognize and distinguish various tree species by the bark.

THE STEM

The stem bears the branches and leaves. The *node* is the point on the stem where one or more leaves are inserted. Sometimes it is enlarged or marked with a ring. The *internode* is the space on the stem extending between two consecutive nodes.

The *bud* is a short growing point of a stem, composed of young leaves or flowers and frequently also of some scales. In tropical regions generally there are no scales. However, in temperate regions with cold winters there are dormant buds covered with scales. There are two principal types of buds. The *terminal bud* is in the apex of the stem or a branch. The *lateral bud* (or axillary bud) is located at the base of a leaf and can grow into a branch. (Branches, or lateral stems, are formed only at the nodes and from lateral buds.)

THE LEAF

A tree that has leaves in all seasons of the year is *evergreen*. If it remains without leaves during part of the year, such as in the dry or cold season, a tree is *deciduous*.

The *parts of the leaf* are the *blade* and the *petiole*. In some species there are also two (or one) *stipules*, or scales, usually deciduous, at the base. Also, in some species the petiole is lacking, and the leaf is said to be sessile. Upon falling, the leaf leaves a scar at the node.

In *number of blades* the leaves are simple or compound. The *simple* leaf consists of a single blade. The compound leaf is composed of usually several blades (two or more), which are called *leaflets*. Leaflets may have petioles or not, but never have buds at the base. This character, the absence of the bud at the base, distinguishes a leaflet from a simple leaf. Compound leaves are divided into *pinnate* and *digitate* leaves. Leaves are *pinnate* when the leaflets are inserted along a common axis. If the axis is divided, the leaf can be twice pinnate (*bipinnate* or three times pinnate (*tripinnate*). Leaflets are alternate in some species and opposite in others. If a pinnate leaf ends in a single leaflet it is *odd pinnate* (*imparipinnate*). If it has paired leaflets and ends in two leaflets it is *even pinnate* (*paripinnate*). Leaves are *digitate* (or palmate) when the leaflets are inserted together at the apex of the petiole.

Shapes of Leaf Blades

The shape or form of leaf blades generally is characteristic of a species and is used in identification. Many terms are employed for describing the shape, but it is sufficient here to mention only the commonest types. A *linear* leaf has the blade long and narrow with margins parallel, for example in grasses or the grass family. A *lanceolate* leaf has the blade in the shape of a lance, several times longer than broad, broadest near the base, and pointed at the apex. (The reverse shape is called oblanceolate.) An *ovate* leaf has the blade oval but broadest toward the base, more or less as in the longitudinal shape of an egg. (The reverse shape is called obovate.) An *elliptic* leaf has the blade oval but broadest at the middle. An *oblong* leaf has the blade several times longer than broad and with margins parallel. A *circular* leaf (or orbicular) has the blade more or less in a circle.

Margins of Leaf Blades

The margin or border of the leaf blade can be: *entire*, when the margin is smooth, or straight or curved, but without teeth or lobes; *toothed*, when it has pointed teeth, such as on a saw; or *lobed*, when it has deep indentations or lobes, which are larger than teeth but not deep enough to divide the blade into separate blades.

Apexes of Leaf Blades

The apex of the leaf blade can be: *acuminate*, gradually narrowed to the point in the shape of a wedge; *acute*, with short point; *obtuse*, with blunt point; or *rounded*, circular and without a point.

Bases of Leaf Blades

The base of a leaf can be: *acute*, with short point; *rounded*, or circular and without a point; or *heart-shaped*, with a deep indentation as in the heart.

Venation of Leaf Blades

According to the venation or network of veins, the leaf blade can be: *parallel-veined* when the veins are parallel; *pinnate-veined* or *not-veined*, when there is a single principal vein or midrib with other, lateral veins on the sides; or *palmately-veined*, when there are several principal veins which arise at the base and spread like fingers of the hand.

THE FLOWER

A complete flower consists of four concentric parts, spirals or circles (whorls), called: the *calyx*, the *corolla*, the *stamens* (the androecium), and the *pistil*. However, some flowers lack one or more of these parts. The *calyx* is composed of modified small leaves, generally green, and called *sepals*. The *corolla* is composed of modified small leaves, generally colored, and called *petals*.

The *stamens* are the masculine organs of the flower and provide the pollen, which is the male element. A *stamen* consists of two parts: the *filament* or stalk, generally thin, and the *anther* or enlarged part at the apex, composed of pollen sacs with the pollen grains.

The *pistil* is the feminine organ of the flower and is composed of one or more modified small leaves called *carpels*. The *carpels* form the ovary which is the feminine element and which is transformed into the fruit. The ovary contains one or more ovules which develop into the seeds. Other parts of the pistil are: the *style*, a small column above the ovary which supports the stigma; and the *stigma*, the uppermost enlarged part of the pistil, which receives the pollen grains. The stigma can have different shapes, such as rounded, lobed, or feathery.

The *receptacle* is the enlarged base of the flower where the floral parts are inserted. The *peduncle* is the stalk of the flower. If there are several flowers together, the stalk or secondary peduncle of each one is called a *pedicel*.

In the different families there are many differences in the shape of the flower and in the number, size, and arrangement of the parts. The parts of a circle or whorl can be separate (free) or united into a tube, or united with other parts. The *gamopetalous* corolla has the petals united. The *regular corolla* has petals of equal size and symmetrically arranged. The *irregular* corolla has the petals unequal.

The carpel can be compared with a leaf on whose borders have developed the ovules. Also, the leaf has become incurved until the ovules are within a cavity of the ovary. The ovary encloses one or several small cavities called *cells* or *locules*, which contain the *ovules*. An ovary formed from one carpel has necessarily a single cell. An ovary formed by two or more carpels has a single cell if the carpels are joined by their borders. If the carpels are folded toward the interior, they form as many cavities or cells as there are carpels. According to the number of cells the ovary can be: unilocular, bilocular, trilocular, or multilocular.

In position with respect to the other floral whorls, the ovary can be *superior* (free), or *inferior* (adhering). The *superior ovary* is free or separate in the middle of the flower and is inserted above the other whorls. The *inferior ovary* is united with other parts of whorls which appear to be inserted above.

Pollination is the transport of the pollen from the anther to the stigma. The pollen grain germinates and forms the pollen tube, which carries the male element to the ovule. Fertilization is the union of the nucleus of the male element with the nucleus of the female element in the ovule to form the fertilized egg. The fertilized egg divides to form the embryo, and the ovule is transformed into the seed. The *seed* is the mature ovule and consists of the embryo with stored food and one or two seedcoats.

The *inflorescence* is the arrangement or disposition of the flowers on the stem. It is *terminal* when it is at the apex of the stem, or *lateral* (or axillary) when it is at the base of a leaf, on the side of the stem.

There are many types of inflorescences, but it is sufficient here to mention only some of the commonest. The *soli-*

tary inflorescence (or simple) has the flowers isolated or one by one, separated by the leaves.

The *spike* has an elongated axis and flowers without pedicels. The *racine* has an elongated axis and flowers with pedicals. The *panicle* is a compound racine with the axis branched.

The *umbel* has the flowers together at the apex of the peduncle, terminating in spreading pedicels of equal length. (Also, there is the compound umbel.) The *head* has the apex of the axis broadened as a disk and the flowers without pedicels. The *cyme* is a definite or determinate inflorescence with the principal axis ending in the first flower, and below it arising other secondary axes with flowers.

THE FRUIT

The *fruit* develops from the mature ovary, contains the seeds, and sometimes bears other flower parts which persist. A *simple fruit* comes from a single pistil. An *aggregate fruit* develops from several pistils of a single flower (annona, strawberry, etc.). A *multiple fruit* comes from several flowers united (fig, pineapple, etc.).

Simple fruits are classified as *dry* and *fleshy* (juicy); the dry fruits are *indehiscent*, if they do not open to discharge the seeds, or *dehiscent*, if they open.

There are several types of simple fruits. The *achene* is a dry indehiscent fruit with a single seed that does not adhere to the wall of the fruit. The *nut* is a dry indehiscent fruit with a single seed and with the wall of the fruit thick, hard, and woody. The *pod* (or legume) is a dry dehiscent fruit of one carpel which opens on two lines, while a *follicle* opens on one line. The *capsule* is a dry dehiscent fruit of two or more cells that opens on as many lines as there are cells.

The berry is a fleshy indehiscent fruit with several seeds. The *drupe* is a fleshy indehiscent fruit generally of one carpel (or more) and with a single seed (or more) enclosed in a stone or hard wall.

THE DISTRIBUTION OF TREES

Distribution of trees includes the geographic area where they occur, the climatic zone, the forest type, and the altitude or elevation above sea level.

In the study of plant geography there are two kinds of geographic distribution, that of the flora and that of the vegetation. The *flora* of a region is a list of the species of plants. The units of the flora are the species, genera, etc. The *vegetation* of a region is the appearance or the physiognomy of the plants or the growth form or habit of the commonest species. The units of vegetation are the plant communities, such as formations, associations, and forest types.

For example, let us suppose that two areas have only two species of plants: a tree species and a grass species. In one there is a single example of a tree and many individuals of the grass—it is a grassland. In the other there are many trees and few plants of the grass—it is a forest. Both areas have the *same flora* or list of species but have *different vegetation*. One is a grassland and the other a forest.

Thus, the distribution of the trees of a region can be studied from the viewpoint either of the flora, or of the geographic range of each species. Distribution maps of each tree species can be made. Or, from the viewpoint of vegetation, vegetation types can be studied in relation to climate. *Maps of vegetation types*, such as forests, grasslands, etc., can be made. In dendrology both types of geographic distribution of plants are studied. Maps of the distribution of individual tree species and likewise of forest types are prepared.

Many tree species of tropical America are not sufficiently known for compiling maps of geographic distribution or for analyzing the origin, the migrations, and the distribution. Some species have a broad range, while others are rare and local.

For example, some tree species have a very large distribution in tropical America, from Central America or Mexico to Brazil. Those of ocean shores, such as the mangroves, have a wide range up to Florida in the southeastern United States. Other trees are confined to high mountains, still others to grassy plains, or to deserts, etc. Few are local or endemic. A job for the future is to prepare more detailed distribution maps.

The study of vegetation and distribution of vegetation types is often included in a subdivision of biology known as ecology. Much of the following material treated under ecology might equally well be considered as forestry or dendrology.

ECOLOGY

The name ecology (originally spelled oecology) was first used in 1869 by the German zoologist E. Haeckel. It is derived from two Greek roots meaning home and discourse or study, or, literally, the study of homes. *Ecology* is defined as the study of organisms in relation to their environment. Opinions differ as to whether ecology really is a subject-matter branch of biology or whether it is merely a point of view for studying biology. Thus, ecology might be biology with emphasis on the surroundings of animals and plants.

Ecology is often subdivided into autecology and synecology. The former prefix is a Greek root meaning self, while the latter means together. *Autecology* is the ecology of the individual, or study of an individual organism or species in relation to its environment. By some authors, autecology is considered as physiology—for example, an investigation of a single tree species in relation to its surroundings. In contrast, *synecology* is the ecology of the group, or study of groups of organisms, or communities, in relation to their environment.

Since the subject matter or viewpoint of ecology is so large that it embraces biology, ecology is usually divided into *animal ecology*, which treats of animals in relation to their environment, and *plant ecology*, which deals with plants in relation to their environment. By some authors, plant ecology is restricted to synecology, the study of plant communities or vegetation.

Plant ecology was established by the Danish botanist E. Warming (1895) in his classic book, Oecology of Plants, first published in Danish. Another important early reference was Plant Geography upon a Physiological Basis, by the German botanist A. F. W. Schimper (1898).

The *environment*, or surroundings, includes everything that may affect an organism or group of organisms in any way. In plant ecology, one classification divides the environment into factors, or environmental factors, as follows: (1) *climate factors*, or climate, which include temperature, rainfall, and other widely distributed elements chiefly from the atmosphere; (2) *physiographic or edaphic factors*, such as topography and soil; (3) *biotic factors*, or other organisms. Because modern man has had such a profound influence, mostly destructive, on other organisms, man has often been separated from the third group as a fourth group of factors called *anthropeic factors*. As fire has become widespread and has had serious effects upon vegetation, it is often listed as a fifth group, known as *pyric factors*.

One of the principles of ecology is often called *balance of life*, or *web of life*. This means that organisms living together in a group or community are more or less balanced, or at equilibrium, interrelated by their mutual requirements for food for energy, the original source of which is the sun. The activities within the group, and particularly the number of individuals, are in balance with the available supply of energy. A simple relationship of several kinds of organisms, each dependent upon a surplus of another for food, is called a *food chain*. For example, in a pond the green algae or pond scums make food with energy received from the sun and are eaten by microscopic animals. These in turn are consumed by less-minute aquatic animals later eaten by small fish. The latter are devoured by larger fish, which are prey of birds, mammals, and man. The relationship of foods generally is more complex, with branches, and is a network or web rather than a chain.

Adaptation, or the adjustment of organisms to their environment, is another principle of ecology. Each species fits a set of external conditions, sometimes within very narrow limits, where it is in equilibrium or in balance.

An important principle of ecology is that of *change*, also known as the *dynamic viewpoint*. The whole universe, or rather the universes about us, from the giant galaxies of stars to the minute particles within the atom, are changing or in motion all the time. Specifically, the climate of a region is slowly changing and the soil is changing. Therefore, the vegetation, which is dependent upon climatic and soil factors, is slowly changing at a particular place too.

CLASSIFICATION BASED ON WATER RELATIONS

Tree species as well as other plants, and also vegetation, can be classified on the basis of water relations or distribution based upon rainfall or water. There are three or more principal groups: a *hydrophyte* is a plant of wet places with adequate water, such as one growing along river banks; a *xerophyte* is a plant of dry places with very little water, as in deserts; a *mesophyte* is a plant of places with average amounts of water, such as forests neither very humid nor very dry—most trees and most other plants belong here.

A *tropophyte*, literally change plant, is a plant that grows under conditions that change markedly during the year, such as plants of places where the quantity of water changes during the year from much to little in seasons from humid to dry; for example, a deciduous tree in a tropical savanna. The term *tropophyte* also is applied in the temperate zones, where the temperature changes during the year, to a tree that is deciduous in the cold or winter season.

A *halophyte* is a plant of places with concentrations of salt, such as sea shores and alkali deserts; for example, the mangroves.

Also for vegetation the adjective terms hydrophilous, xerophilous, mesophilous, tropophilous, and halophilous are used. However, this Greek suffix means loving and suggests teleology, an old idea that there is a cause or reason for everything. Trees do not have intelligence and cannot love water. In biology generally, and particularly in ecology, one must be careful not to seek a purpose underlying each adaptation or peculiar structure.

PLANT COMMUNITIES

In the vegetation the plants arrange themselves in groups or communities. Any group of plants in a place or common habitat can be called a *plant community*. This term has no restrictions in size.

A *plant formation* is a plant community of the highest rank, characterized by a definite appearance or physiognomy and composed of plants with a definite growth form; for example, the rain forest or the paramo.

The formation is composed of smaller units, the associations. A *plant association* is a division of a formation with a definite floristic composition and with certain dominant species. The forest types of the foresters correspond to the plant associations of the ecologists; for example, a forest of *Podocarpus*. Some associations are limited in extent by climatic factors and others, the edaphic associations, by the factors of the soil.

Plant communities are constantly changing though sometimes very slowly. Great changes in the composition of a community follow changes in the environment, which in turn may be caused by the organisms living there. The term *succession*, or *plant succession*, is given to the changes in the plant communities, one following another, at the same place. The succession leads to the *climax association*, which is the highest, most complex, and most nearly stable community existing in the climate of that area. Where the highest vegetation of the succession is limited by edaphic factors rather than climate, the climax association, such as on a particular soil type, is called an *edaphic climax*. The mangrove swamp forest is an example.

Plant successions are of two main kinds: primary and secondary. A *primary succession* begins on a bare area previously without vegetation, such as a new island, a new volcano, or a landslide area. A *xerarch succession*, or *xerosere*, is one beginning with a dry, bare habitat and leading to a climax. A *hydrarch succession*, or *hydrosere*, starts with a wet habitat and continues to a climax. The climax has medium moisture conditions, rather than extreme. Virgin forests represent climaxes or normal developmental stages.

A *secondary succession* is that following a disturbance in the normal, primary succession; for example, after cultivation, cutting of forests, fire, overgrazing, or wind damage. In densely settled regions most of the vegetation has been disturbed by man's activities. Few areas of virgin forest remain and the forests are largely secondary. Ultimately the secondary succession leads to the same climax as the primary succession, but the rate depends upon the degree of disturbance. If great, such as when soil formed during thousands of years is eroded away, the recovery is very slow.

GROUPS OF PLANT FORMATIONS OF THE WORLD

The plant formations of the world can be arranged into four or five large groups:

1. *Forests*, characterized by trees.
2. *Grasslands*, characterized by grasses.
3. *Deserts*, characterized by shrubs, spiny trees, cacti, etc., and by scarcity of water.
4. *Tundras*, characterized by lichens, mosses, etc., and by very low temperatures.
5. *Oceans*, characterized by seaweeds or algae.

Some botanists place mountains in a distinct group, but they have a mixture of the formation groups.

The vegetation is a result of the climate of a region and also of the soil and other factors, such as the plants and animals, mankind, and fire. Thus, the plant formations are indicators of the climate. A map of the vegetation serves equally to show the climate.

There are some studies on the vegetation of the world that attempt to classify it on the basis of temperature and rainfall. A good classification of the climates of the world is that of C. Warren Thornthwaite (1933). His map is useful also for the plant formations of the world. Another system of classification of the plant formations of the world was proposed by L. R. Holdridge (1946).

THE CLIMATE OF FORESTS

In dendrology we are particularly interested in the forests. The climate of forests is characterized by four essentials: (1) a vegetative season sufficiently long; (2) a vegetative season sufficiently *warm*; (3) sufficient *water all the year*, or soil and subsoil both humid; and (4) humid winters (in temperate zones). It is unimportant to the forest (1) when the rain falls or whether it is in the growing season or not; (2) whether the precipitation is uniform in distribution or not; and (3) where the soil water originates, whether it be from rainfall or from rivers or from subterranean sources. Damaging or injurious to the forest are (1) dry and windy winters (in the temperate zones) and (2) a short growing season.

VEGETATION OF LATIN AMERICA

Among the classifications of the vegetation of tropical America may be mentioned the illustrated articles by A. C. Smith and I. M. Johnston (1945) and by J. S. Beard (1944).

The general scheme of classification used by Smith and Johnston (1945) is as follows:

I. Forests or wooded regions
   1. Tropical and subtropical rainforest
   2. Tropical deciduous forest
   3. South Brazilian forest and savanna zone
   4. Palm forest
   5. Subantarctic beech forest
   6. Thorn forest

II. Grasslands and savannas
   1. Savanna regions
      a. True savannas

b. Uruguayan savannas
c. Cargo
2. Pampean grassland
III. Deserts or semidesert regions
1. Coastal deserts of Pacific South America
2. Patagonian-Fuegian steppe
3. Desert scrub
4. Transitional vegetation of central Chile
5. California chaparral
IV. Montane zone
1. Mexico, Central America, and the larger West Indies
2. Northern Andes
3. Southern Andes
V. Maritime or littoral zone

Beard's (1944) summary of formations of climax vegetation in tropical America, grouped into five formation series, in both English and Spanish, is listed below. The first, rain forest, is a formation not divided into series.

ENGLISH	SPANISH
1. **Rain Forest**	**Selva pluvial**
2. **Seasonal Formations**	**Formaciones estacionales**
Evergreen seasonal forest	Selva varanera siempreverde
Semievergreen seasonal forest	Selva varanera semideciduo
Semideciduous seasonal forest	Selva varanera semideciduo
Deciduous seasonal forest	Selva varanera deciduo
Thorn woodland	Espinar
Cactus scrub	Caronal
Desert	Desierto
3. **Dry Evergreen Formations**	**Formaciones siempreverdes aecas**
Xerophytic rain forest	Selva pluvial xerofítica
Littoral woodland	Bosque de playa
4. **Montane Formations**	**Formaciones de montañe**
Lower montane rain forest	Selva pluvial intermedia
Montane rain forest	Selva nublada
Palm brake	Matorral de palmeras, Manecal
Elfin woodland	Bosque ensno
Frost woodland	Bosque de helada
Mountain pine forest	Pinar de montañe
Bamboo brake	Bamboal
Paramo	Péramo
Tundra	Tundra
5. **Swamp Formation**	**Formaciones de pantano**
Swamp forest	Selva de pantano
Palm swamp	Pantano de palmeras
Herbaceous swamp	Pantano herbáceo
Mangrove woodland	Manglar
6. **Marsh or Seasonal Swamp Formations**	**Formaciones de lodasal o de pantano estacional**
Marsh forest	Selva de lodezal
Marsh woodland	Bosque de lodezal
Palm marsh	Lodezal con palmeras, Morichal
Savanna	Sabana