INTRODUCTION

What is dendrology? The term dendrology 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. Originally, dendrology included all aspects of trees, and in that time there was no science of forestry. Now, especially in Europe, dendrology also includes shrubs, but in the United States it is still usually restricted to trees.

In actual use, dendrology is limited to the botany of trees or, more 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.

Dendrology is a tool for becoming acquainted with and studying 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.

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.

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 BC), 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. Gonzalez Vale as Terminologia Forestal (Gonzalez Vale 1950), are modified slightly here.

- **Tree (arbol):** 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 diameter at breast height (dbh) of 7 to 10 in (18 - 25 cm).
- **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.

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.

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. Also, there is confusion because the same common name can be used for different species in various parts of its natural range.

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 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 most 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 hook 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 Swietenia 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 stares 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.

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.

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: Regnum Vegetable Divisio Classis Ordo Familia Genus Species (Varietas)

English: Plant Kingdom Division Class Order Family Genus Species (Variety)

Spanish: Reino Vegetal División Clase Orden Familia Genera Especia (Variedad)

At the end is not a category, but 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 Spermarophytes (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, such as Guttiferae.

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 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 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 Catalog 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, **Shahbaz S.E. (2007). Pinales with a field guide to the trees and shrubs of Kurdistan Region of Iraq. Spirez Press and Publisher.Duhok. P175.**

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.

Classification	Definition
Kingdom	All living things are classified into kingdoms (e.g. plants and animals). Trees are in the plant kingdom.
Division	This is the first category of the plant kingdom and is based on the plant's means of reproduction. Trees, in the Spermatophyte division, reproduce through seeds.
Class	Trees are then divided into two classes, Gymnosperms and Angiosperms, by the method they use to develop the seeds used for reproduction. Gymnosperms, such as conifers, produce an open seed on a structure such as a cone. Angiosperms are flowering trees that have seeds enclosed in an ovary.
Order	Trees are further classified into orders according to certain other characteristics of seed reproduction. Angiosperms are divided into two major groups, monocotyledons and dicotyledons, based in part on the number of primary leaves (one or two) present in the seed plant. The *Sabal palmetto* is an example of a monocotyledon. Most trees are dicotyledons, such as members of the walnut or oak families.
Family	A group of closely related trees, usually including one or more genera (plural of genus) make up a family. The rose family, Rosaceae, is a family in the dicot group, and includes cherry, apple, and pear trees.
Genus	A collection of closely related species is a genus. The species usually are structurally similar or have common ancestry. Examples are the cherry and plum trees that are a genus, *Prunus*, of the rose family.
Species	A collection of individuals with characteristics so similar that they suggest common parentage, a species is a tree distinct and unlike others. The black cherry, *Prunus serotina,* is a species of the genus *Prunus*. Species is the basic, and probably most important (Dirr 1990) unit of taxonomy or classification of a tree.