CHAPTER 1

Introduction to Taxonomy

THE ***best management practices applied to a forest are based on forest ecology concepts, and forest ecology is first and foremost based on correct field identification of woody plant species and knowledge of their ecological characteristics.***

IMPORTANCE OF CORRECT PLANT IDENTIFICATION

The study of every science begins with the identification of basic units. In chemistry, these are the elements; in geology, minerals and rocks; in soil science, the profile and texture; in biology, cells and organs; and in wildlife management, the basic units are animals. In other sciences such as ecology, forestry, and many other land or resource management fields, study usually begins with basic identification of trees and shrubs and progresses toward a knowledgeable understanding of their ecological tolerances, how they interact and compete, where they are located in time and space, and what combinations make up community types.

Trees and shrubs are usually adapted to a range of light and soil moisture conditions. Within this range, individual woody plants are able to survive, grow, and develop (complete their life cycle). Outside this range, the mortality rate is high. Thus, before variation in forest composition as influenced by soil and topography can be studied, before silvicultural activities such as tree planting, thinning, or timber stand improvement can be applied, and before wildlife habitat can be manipulated, the resource manager must be able to identify the important plants of the community. The success of management, whether for economic return and sustainability or for ecosystem restoration, in terms of survival, growth, and development of trees and animals, often depends on correct plant identification.

The next step after identification is the development of a flora, a list of all plants within an area possibly as large as a national forest or park or as small as a watershed, natural area, or protected nature preserve. Actually, a list of species is just the beginning of a flora. A flora as presently perceived includes considerably more, such as plant ranges, descriptions, phenology (timing of seasonal and life cycle events such as bud break, leafing out, flowering, pollination, fertilization, seed-set, seed distribution, senescence, etc.), names, infraspecific variation, endemism, environmental conditions, and information on genetics (e.g., chromosome numbers, hybrids), cytology, and morphology (Morin et al. 1988).

Although this book deals with identification of woody plants only, they are an important component of nearly every flora. During the past several decades, there has been considerable discussion at the local, state, and federal levels regarding a national biological survey as part of a study of biological diversity (Kosztarab 1988). Unless the current situation in forest (plant and animal) communities is assessed, there is no reliable method for determining the loss of species or change over time. Paralleling this discussion is the development of a *Flora of North American*, initiated by the Missouri Botanical Garden in St. Louis. Several volumes of this *Flora* have already been published (Flora of North America Editorial Committee 1993a, 1993b, 1997).

Floras can be used in a number of ways by various professional workers. A flora can be used in environmental assessment and land management, in management of reserves and restoration, in determining the naturalness of a forest community following distribution and expansion of native and exotic species that are becoming naturalized, and in supporting protection status and identifing wetlands and ecologically sensitive sites. A flora can be used by botanists, foresters, silviculturalists, ecologists, zoologists, biologists, wildlife managers, ecological consultants, environmental engineers, construction (e.g., road) engineers, environmental lawyers, restoration biologists, researchers, and teachers, to name but a few professionals (Morin et al. 1988).

DEFINITION AND SCOPE OF TAXONOMY

The identification of woody plants falls within the oldest area of science dealing with plants, that is, systematic botany or, as it is commonly called, plant taxonomy or plant systematics. The term *taxonomy* comes from the Latin word *taxis*, which means an arrangement or order, and the ending *nomy*, which refers to knowledge. Thus, plant taxonomy is the study of the arrangement or classification of plants. However, as a discipline, taxonomy is much broader, for in order to classify plants, they must be described and assigned names at the same time they are arranged into the classification system.

To a large extent, description and identification are the primary concern of the beginning botanist, taxonomist, ecologist, or forester, and much information is drawn from the field of plant morphology, the study of form (Latin: *morpho* = form). The taxonomist concentrates on the areas of classification and nomenclature and generally deals with the placement of a larger plant group or taxon (plural, taxa), such as an order, family, or genus, within a classification system. Inasmuch as most plants have been described, identified, classified, and named, except for those in tropical regions, it might appear that there is a reduced need for taxonomic expertise.

The need for modern taxonomy has not changed, but modern studies have changed taxonomy. As a result, concepts and methodology have been incorporated from fields such as ecology, genetics, cytology, biochemistry, phytogeography, paleobotany, computer science, and geology. Ecology is the study of the interrelationships between plants and environment; it is common knowledge that differences in environment can cause changes in the appearance (form) of two individuals of the same species and can change the entire species population through the natural selection process. Genetics and cytology provide principles and information on hybridization, inheritance, reproduction, and chromosome number, which assist in determining how plants are related and classified.

Geology has furnished considerable information on past life, fossils, climate, and landforms (paleotaxonomy). For example, during times of glacial advance, ocean levels were greatly reduced and land bridges, such as that across the Bering Sea between North America and Asia (Beringia), permitted the migration of some plants. A notable example of a recent major change in taxonomic thinking occurred some 30 years ago with the development of the science of plate tectonics and the concept of continental drift. Until that time, taxonomists believed that similar plant species on different continents were the product of a parallel evolutionary sequence. The concept of a single land mass existing millions of years ago suggests that many similar species came from a common ancestor.

More recent developments (since the 1960s) in plant taxonomy have greatly assisted in understanding the relationships between taxa (groups). A number of books review such approaches in more detail (Stace 1980; Sivarajan 1991; Quicke 1993), but these methodologies are of limited importance here and are only briefly noted. Numerical taxonomy developed in the 1960s. This approach applied mathematical procedures to encode various qualitative states for a given characteristic. The idea here was to have a more objective evaluation of differences between taxa so they could be arranged into a hierarchy. However, the approach did not provide satisfactory information.

In the 1960s and 1970s the earlier work of Henning, a German entomologist, was first applied to plant taxonomy. His analysis was based on the concept that evolutionary relationships (a phylogenetic tree diagram) can be based only on shared derived characteristics. This approach became known as cladistics, and the diagrams that were developed came to be known as cladograms (Quicke 1993). This area of taxonomy is called evolutionary taxonomy.

More recently, biochemistry has provided a means to solve some taxonomic and evolutionary puzzles. This approach, called chemotaxonomy, uses various compounds produced within the plant to identify evolutionary relationships and improve classification; it is one of the more rapidly expanding areas of plant taxonomy (Stace 1980; Quicke 1993). With the development of advanced laboratory methods, information-carrying molecules such as DNA, RNA, and protein are being analyzed through amino acid sequence mapping to construct evolutionary relationships. This approach appears to hold considerable promise for providing information, but much interpretation will continue to remain with the researcher. Most taxonomists must still measure visible plant characteristics, but in evaluating the data, statistics and computer analysis are invaluable; this field is known as taxometrics.

All of these fields assist in working toward several major objectives of plant taxonomy: 1) the identification of all plants and their placement in a classification system, 2) the development of a classification system based on genetic and evolutionary relationships, and 3) the preservation of gene pools to maintain biodiversity within the ecosystem.

HISTORY OF CLASSIFICATION

The inherent curiosity of the human mind, the need for orderliness in knowledge, and the desire to communicate effectively has stirred interest in plant study and classification for centuries. According to Lawrence (1951), the earliest system of classification, proposed by the Greeks and herbalists, was based on the forms of plants: trees, shrubs, herbs, vines, and so on. This system prevailed from about 300 B.C. to the middle of the eighteenth century and became somewhat more elaborate as new information and concepts were incorporated.

From about 1500 to 1700, gross flower characters such as ovary position (superior vs. inferior) and petal structure (petalous vs. apetalous, polypetalous vs. sympetalous, and regular vs. irregular flowers) became important. During this period, Joseph Pitton de Tournefort (1656–1708) developed the modern "genus" concept, and many of his names, including *Salix, Populus, Fagus*, and *Acer* are still valid. Another botanist, John Ray (1628–1705), developed a system based on gross morphology of plant structures. He divided plants into woody and non-woody and recognized monocots and dicots within each division. Further subdivisions were based on fruit type—coniferous, berry or berry-like, nut-bearing, and so forth—and leaf and flower characters. This approach subsequently formed the basis for the more modern classification systems developed by Bernard de Jussieu and Carolus Linnaeus.

Carolus Linnaeus (1707–1778) is considered the father of modern plant and animal taxonomy. Prior to 1700, lengthy descriptive names were assigned to plants and it was difficult to relocate plants that had been previously described. Linnaeus was a prolific writer and an extraordinary taxonomist. In *Hortus uplandicus* (1730), he proposed what he called a sexual system of plant classification. This system was a major contribution because it was simple and based on plant taxonomic relationships. However, the system was artificial, because the emphasis was primarily on numerical relationships of flower parts; thus, similar plants often fell into widely separated classes. Later, in *Genera plantarum* (1737), he revised this system and included a list of natural plant orders and their genera. The publication of his famous *Species plantarum* in 1753 is considered the starting point of present-day nomenclature (naming of plants). In this treatise, Linnaeus proposed assigning two names, a Latin binomial, to each plant. Many of the names he assigned to plants during his lifetime remain valid and in use today, as can be seen by observing the species names found in the chapters of Parts II and III.

Near the end of the eighteenth century, systems based on form (morphological) relationships began to appear. These new systems were called natural systems, as plants having similar combinations of characters were placed together. They were not based on evolutionary relationships, but ordered plants along more natural lines while serving as an aid in identification. The taxonomists of this period included Antoine Laurent de Jussieu (1748–1836), three generations of de Candolles, the most important being Augustin Pyrame, and two botanists who collaborated on a system, George Bentham (1800–1884) and Sir Joseph Dalton Hooker (1817–1911). There was a marked similarity in the systems of these taxonomists. In particular, all were based on the concept of species immutability; that is, species were created and therefore they could not change. However, the systems still represented scientific progress.

The systems of de Jussieu and Bentham and Hooker divided the seed plants into three classes: Dicotyledoneae, Monocotyledoneae and Gymnospermae. The Dicotyledoneae class was further divided in the Polypetalae (corolla of separate petals), Gamopetalae (corolla of fused or partially fused petals, sympetalae), and Monochlamydeae (no petals, apetalous). These classes appeared relatively natural, and the divisions remained part of taxonomic classification until about 40 years ago (refer to Harlow et al. 1978).

The theories of Alfred Wallace and Charles Darwin around the middle of the nineteenth century began a new period in taxonomic investigation and classification. The new systems were based on phylogeny or on the evolutionary development and genetic relationships between plants. The Engler and Prantl system of classification was developed during this period, although it was not phylogenetic in a modern sense. This system divided the seed plants into the Gymnospermae and the Angiospermae, the latter being divided into the Monocotyledoneae and the Dicotyledoneae. The dicots were then divided into subclasses (Apetalae, Gamopetalae, and Polypetalae). Each subclass was divided into orders of presumably related families. There was some objection to the system, but it was widely accepted because Engler and Prantl applied it to the plants of the world, the result being a 20-volume work.

Charles Bessey (1845–1915) was the first American taxonomist to make a contribution to classification by developing a system that was truly phylogenetic (Lawrence 1951). In essence, he realigned the system developed by Bentham and Hooker according to evolutionary principles but also included some of the principles of Engler and Prantl. Other systems that were developed include one by John Hutchinson of England, which is closely aligned with that of Bentham and Hooker and that of Bessey, and one by Oswald Tippo of the University of Illinois (Fuller and Tippo 1954), which incorporated the latest developments in phylogeny.

The classification systems of Bentham and Hooker, Engler, Bessey, Hutchinson, and Tippo are in use throughout the world. The Engler system is widely used in herbaria in the United States, but the other systems are more accurate. No doubt these systems will continue to be revised as new scientific information becomes available.

The most recent classification system was proposed by Cronquist (1981). He considered only the division Magnoliophyta (angiosperms), which was split into two classes: Magnoliopsida (dicots; six subclasses) and Liliopsida (monocots; five subclasses). The species are clustered into these subclasses based on best available evolutionary evidence, so that some orders and families once considered relatively close have now been separated. Perhaps the most notable change is the breaking up of the old Amentiferae (catkin-bearing woody plants); the Fagaceae (oak, beech), Juglandaceae (hickory, walnut), and Betulaceae (birch) families are in subclass Hamamelidae, while the Salicaeae (aspen, cottonwood, poplar) has been placed in subclass Dilleniidae, because although the inflorescences are similar, the origins of the unisexual flowers are apparently different. The Cronquist system has been readily accepted and used; thus, we also have used it in this book.

Before leaving this short historical account of the development of taxonomy, the reader should contemplate for a moment the problems and frustrations encountered by early botanists. Prior to the modern systems, it must have been extremely difficult to describe, identify, and classify plants. It is likely that for a long period, every new plant added to the list of known species somehow changed the ideas and the concepts of the botanist, and the classification system changed accordingly. Consider the problem of keeping track of plants and their names before the standardized system of nomenclature was developed. Letters to distant colleagues must have been filled with long descriptions and probably many sketches. As compared with the effort required during the early 1700s, the identification of an unknown plant and relocation of specimens within a herbarium is now relatively simple.