Reading 12-1
Forest Crops

Because different tree species are adapted to different climates and soil types, many kinds of forests occupy the earth today. This has not always been the case. Primitive forests of several hundred million years ago consisted of fewer kinds of trees. In fact, the earliest "trees" (psilophytes), which grew nearly 500 million years ago, were like giant clubmosses. They lacked true roots and consisted of a tangle of specialized branches that clambered over rocky ground. Fifty million years later came the dense forests of tree ferns that prevailed in tropical climates of that era. The forerunners of modern conifers were on the scene 300 million years ago, when plant life abundantly colonized marshy land, building the tremendous coal and oil reserves so important today. By 200 million years ago, seed plants had evolved, and many trees assumed an appearance quite similar to those of today. By the time the dinosaurs roamed the earth some 180 million years ago during the Cretaceous period, seed-bearing trees had evolved that shed their leaves in winter; from these have sprung the angiosperms and our present deciduous forests.

The ability to produce seeds that can survive unfavorable seasonal cycles was a significant evolutionary advance that occurred at about the end of the Paleozoic era. These primitive plants (related to the seed ferns) bore seeds not entirely unlike those of the modern conifers, which are gymnosperms. Consider the familiar pine tree as an example of the gymnosperms. Two ovules are borne on the upper side of each pine cone scale, fertilized by pollen from separate, smaller male cones, carried by the wind directly to the exposed ovule. The ovule matures into a free seed, which drops to the ground when ripe. The fundamental distinction between such gymnosperms and the later-evolving angiosperms is that the angiosperm ovule is surrounded by a fleshy protective tissue through which a pollen tube must grow, and which becomes a fruit that encloses the seed. Typical of the angiosperms are such deciduous trees as the oaks (*Quercus*), maples (*Acer*), ashes (*Fraxinus*), and palms (*Cocos* and others).

Gymnosperms and angiosperms are distinguished by the lumbermen as well as the botanist; the gymnosperms are the "softwoods" of the lumber industry, the dicotyledonous angiosperms the "hardwoods." In temperate climes, hardwoods are readily distinguishable in the forest from softwoods; they usually have flat, broad leaves rather than needles or scales, and they shed their leaves annually. There are discernible differences in wood anatomy, too. The wood of gymnosperms has a less complicated structure, lacking certain distinctive cells (vessels) characteristic of angiosperms and often having resin canals that hardwoods lack. (Some hardwoods develop resin canals when injured, however.) Gymnosperms comprise the bulk of commercial temperate-zone forests; angiosperms generally predominate in tropical forests. There are fewer gymnosperm species than angiosperms, and the commercially important trees are confined almost entirely to the order Coniferales (the needle-bearing gymnosperms, or conifers). In the United States about two-thirds of the commercial forest land is in softwoods, accounting for nearly 80% of the timber cut. Softwoods also predominate at high elevations in the tropics and at high latitudes in northern Europe, Siberia, and Japan. In winter-wet temperate climates like those of the Pacific Northwest, from which most old growth timber is harvested, conifers (being evergreen) enjoy the advantage of better utilizing the large pulses of nutrients leached in winter compared to deciduous trees that have shed their leaves by then.

In temperate regions, hardwoods such as birch (*Betula*) and aspen (*Populus*) mingle with

softwoods in forests that consist mainly of gymnosperms (Fig. 1). Hardwoods predominate only at middle and subtropical latitudes. The great diversity of angiosperms, especially in tropical forests, leads to some practical difficulties in managing and marketing. Total yields per unit of land are frequently great, but production consists of small lots of a myriad of species, and for some there is not a ready market. Temperate hardwood forests predominate in a central belt of the United States, roughly between Tennessee and the Great Lakes, and in central and southern Europe eastward to southern Siberia and Korea; tropical hardwood forests are circumtropical wherever there is sufficient rainfall. Tropical hardwood forests are perhaps the greatest remaining timber reserve in the world, and no doubt they will become increasingly more important as a source of forest products.

In the humid tropics, luxuriant forests (Fig. 2) represent, as the ecological climax, the world's most complex biotic community. There are, worldwide, nearly 1 billion hectares (about 2.5 billion

Fig. 1. The Manistee National Forest in Michigan as it appeared around 1900 when it was first being logged. [Courtesy U.S.Forest Service.]

Fig. 2. Logs being harvested from a tropical rainforest in Gabon Unfortunately, much of this harvest of virgin timber is not replaced by new growth under sustained-yield practices. [Photograph by Alain Prott/CIRIC, courtesy World Bank.]

acres) of such forests. The virgin forests of southeastern Asia are especially rich. In one hectare of Malayan rainforest, 227 species with a girth of 10 centimeters or greater were counted. Note the tremendous productivity of the tropical forest compared with other types (Table 1). It is difficult and usually uneconomic (particularly in view of the limited human and material resources) to reject the wealth of the tropical forest in favor of annual cropping systems that are frequently inappropriate for the soil and the climate. Yet that is an all too familiar approach.

Indeed, tree crops are the logical use for most marginal lands, a use that has been much neglected. Since primeval times the tropical forest has been a vast storehouse of natural wealth, not only for wood, but for extractives. A genus such as *Manilkara* yields not only excellent timber, but a latex (balata) of export value, and fruit useful at least to wildlife. Rubber, resins, waxes, oils, nuts, and medicinal or insecticidal alkaloids long have been important forest products. Among timber trees, West Indies mahogany (*Swietenia mahagoni*) has for centuries been a prized cabinet wood; rosewood (*Dalbergia*), Spanish cedar (*Cedrela*), balsa (*Ochroma*), African mahogany (*Khaya*), and several others likewise have been selectively much harvested but seldom planted. Only the vastness of the forest has generally prevented their complete exhaustion.

Nonetheless, it is encouraging that in many places tropical authorities are beginning to adopt a more far-sighted approach. After centuries of cutting and depletion, reforestation with select species is being undertaken. Teak (*Tectona grandis*) is often used. In salubrious tropical climates the cycle from planting to harvest is probably much less than the 50 or so years deemed necessary for maturing a forest in temperate localities. For the teak plantations, scrub forest is first cleared (the wood often made into charcoal) and the land cropped with food plants for a year before teak trees from a nursery are planted. Food cropping may be continued between the trees until they are tall enough to shade the crop. Thinnings useful for poles and fencing are had in as little as four years, and small lumber stock not long after. In much the same way, quick-covering *Eucalyptus* and *Leucaena* have been successfully introduced into many subtropical parts of the world, and Monterey pine (*Pinus radiata*) is a reforestation mainstay from New Zealand to southern Africa. Sometimes introductions succeed so well that they become pests, as with *Casuarina*, *Melaleuca*, and *Schinus* in the Florida everglades.

As nations have developed, the regard in which they hold their forests seems to pass through three stages. First, the forests are obstacles to colonization—hurdles to be surmounted. Land is cleared, and the trees are piled and burned in order to provide necessary living space and agricultural land. During the next stage, they become storehouses to be exploited. They are merely sources of energy and construction materials. In the last stage, forests are finally recognized as a renewable resource and are husbanded, protected, and increased (Fig. 3).

Table 1. The productivity of forest types and other forms of vegetation.

Vegetation	Net primary production (g carbon/m^2/year) Range	Mean
Forests		
Tropical (wet)	450–1600	990
Temperate	270–1125	560
Boreal	180–900	360
Savannahs	90–900	400
Grasslands	90–675	270
Cultivated land	45–2800	290

Forests Around the World

Before examining North American forests, which are of greatest concern to most readers of this book, a glance at forest conditions around the world is in order.

In heavily populated Europe, most virgin forest has been cut and replaced by planted species, especially Scotch pine (*Pinus sylvestris*) and Norway spruce (*Picea excelsa*). Birches, as an impor-

tant hardwood, mingle with the conifers in the Scandinavian countries, which are still heavily forested (Finland, for example is two-thirds "woods"). The forests of central Europe are very well managed. In parts of southern Europe, such as Yugoslavia, forests are mostly state-owned; about three-fourths of the timber is hardwood, although conifers are being introduced. In the Mediterranean basin, most of the original forest has long been cut, although small stands persist in the mountains. Wood is very much at a premium in this area, as it is down through the Sahara to the rainforests of central Africa (which are now becoming badly overcut). Only in southern Africa is sensitive forestry practiced sufficiently to assure wood for the future.

The Near East is lightly timbered, and once abundant forests (such as the famous "Cedars of Lebanon") have been almost obliterated. However the USSR has more than 1 billion hectares in forest (about 2.5 billion acres), of which about one-quarter is under management. The forests of Siberia are only partly exploited, and often poorly known. Three-quarters of the Siberian forests are coniferous, accounting for almost half of the world's total. Much of the timber is mature, but it is dwarfed in this rigorous environment. In European Russia, with good soils and ample rainfall, forests flourish. But the country there is heavily populated, and demands for other land uses are great, so forest reserves are not extensive. Across the continent, in southeastern Siberia adjacent to Korea, forests become rather luxuriant–far more productive than in the cold, frozen-soil taiga belts to the north. As in Europe, pine and spruce mingle with birch in Siberia, while larch, fir, and "cedar" are also found. Southward, oaks (*Quercus*), maples (*Acer*), lindens (*Tilia*), and hazelnut (*Corylus avellana*) begin to dominate, and many familiar genera provide a rich botanical assortment. Overall, *P. sylvestris* is probably the most important commercial species in northern Eurasia.

In Southeast Asia, dense populations practicing shifting cultivation, combined with extensive warfare, have materially degraded what in the virgin state were some of the world's most magnificent forests. From China south through the Malay Peninsula and on into the East Indies, luxuriant tropical hardwoods once prevailed. In China, most forest has long been exhausted, although there is some government-sponsored replanting, especially for shelter belts. A few of the East Indian islands, such as Borneo, are still generously forested, and not all of the timber trees have even been identified. The most important family is Dipterocarpaceae, which supplies about 90% of the export timber (reaching the United States as "Philippine mahogany"). There are at least 150 species in the family Dipterocarpaceae, which yields the chief timber trees from the East Indies westward along the southern flank of the Himalayas (especially species of *Shorea*).

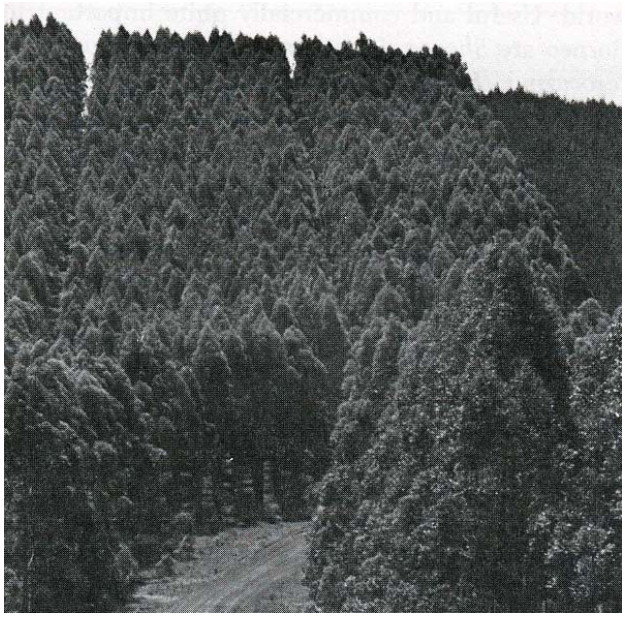

Fig. 3. A productive, planted forest of introduced species in southern Africa, yielding timber products where none were before. [Photograph by John Moss for International Development Association, courtesy World Bank.]

By modern forestry standards, such immensely diverse and little-explored forests as those of Borneo are underutilized. Transpor-

Forest Ecology

The influences that shape forest regeneration are only beginning to be understood. Forest change is often a continuing process, and foresters attempt preservation of what is a successional stage. This, of course, is not possible without some form of management. In many instances there may be no stable climax, since the overall environment is being altered by human activity and perhaps by climatic change.

Fire as all influence on forest succession has been recognized as having both beneficial and negative effects. It has always been an integral part of the forest environment, and it has contributed to a mosaic of successional subclimaxes within an overall species climax. For example, fire in a redwood forest may promote the growth of grassland, which is only slowly reconverted to redwood, depending upon the frequency of subsequent fires.

The succession that occurs in the northern Rocky Mountain forests is influenced by fire. Lodgepole pine is the offspring of fire, occurring in even aged stands after burning. If fire does not reoccur, species of Picea and Abies come to dominate, and, if fire control is exercised, they come to constitute the climax. The fact that lodgepole pine will not reproduce under its own canopy helps to explain the even aged stand.

On the other hand, wildfire can alter soil conditions so much that it prevents succession. This has been demonstrated in stands of ponderosa pine in the Southwest, where no new ponderosa catch occurs after burning even though reproduction takes place on land not burned. The soil constituency following fire—or for that matter after clear-cutting and the exposure this procedure brings—may materially depauperate the biological composition and influence forest quality far into the future.

In north-central Colorado, an outbreak of spruce beetles caused death of large-diameter spruce trees in patches, and altered the species composition of the forest in favor of fir and lodgepole pine. The outbreak developed in logging slash (and was thus an upset caused by people), but it remained epidemic for only 2 years, until natural competitors (for example, such parasites as nematodes, and woodpeckers, which lent great assistance) responded sufficiently to control the beetles.

tation and human labor are both limited in the jungle, and careless procedures are employed in harvesting the trees. Undoubtedly many fine timber trees are wasted, simply because the wood is not known in outside markets and because familiar species (such as those of the family Dipterocarpaceae) continue to be called for in specifications. Facilities for local processing are crude, and in spite of an abundance of some of the world's finest woods, quality lumber (as is needed for making furniture) must be imported from traditional trade sources.

Under these primitive circumstances it is no wonder that very little is known about regeneration of cutover land or the quality that can be expected from second-growth forest. The prevailing custom is to girdle and kill all large trees (those more than 2 meters in girth) left after selective logging in the belief that they will be overmature by the next cycle of rotational harvesting. It is not known which species will regenerate under prevailing ecology, what the shade requirements of desirable species might be, nor what rotational cycle is best fitted to these particular forests (the forest authorities presume an 80-year cycle). In Malaysia, where forestry is more advanced than in Borneo, and the virgin forest is similar, it has been found that smaller trees of the families Lauraceae, Myristicaceae, Rosaceae, and Leguminosae, as well as certain oaks, once considered

useless, are of considerable value in providing cover that allows a new stand of dipterocarps to emerge. When the forest composition has been changed on cacao lands, there have been serious consequences, such as lowering of the water table and slow debilitation of the plantation crop.

Aside from teak (*Tectona grandis*, Verbenaceae) timber trees from the tropical hardwood forests of Southeast Asia are largely unknown in the Western world. Useful and commercially quite important to Borneo are *Shorea*, *Parashorea*, *Dryobalanops*, *Dipterocarpus*, *Koompassia*, *Cratoxylum*, *Anthocephalus*, and several other genera, including species of the families Leguminosae and Sapotaceae, as well as Dipterocarpaceae.

Australia is quite limited in the extent of its forests because of the inhospitable climate of the interior. The chief indigenous forest, along the moister, eastern coast, is dominated by *Eucalyptus*. New Zealand has abundant beech (*Nothofagus*) forest on the South Island, of local usefulness but rather little commercial value; and the magnificent kauri (*Agathis australis*) forests on the North Island, of which logging of natural stands was forbidden in 1958, are now decimated and of little commercial importance. A few snatches of virgin kauri forest have been preserved, which show the indigenous trees to grow 50 meters (more than 160 feet) tall and 12 meters (nearly 40 feet) in girth. With exhaustion of her original forests, New Zealand has turned to tree planting, successfully utilizing such species as California's Monterey pine, *Pinus radiata*.

Across the Pacific, South America has seen exhaustion of many of its forests, particularly the paraná pine (*Araucaria*) of southern Brazil and the limited stands of mixed hardwoods in northern Argentina. In recent years massive efforts to settle and exploit the Amazon basin have caused great devastation there, arousing fears that alteration of this, the most extensive tropical rainforest in the world, may have serious consequences not only locally but for world climate. As in Amazonia, clearing and cutting continues northward through Central America into Mexico, so that very little of what was once a vast strip of virgin tropical forest remains.