NON-WOOD FOREST PRODUCTS

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Non-wood forest products from temperate broad-leaved trees

by

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Rome, 2002

ADDITIONAL DISCLAIMER

This paper discusses some traditional and contemporary uses of non-wood products from trees and shrubs in medicine. This material is presented for information only and does not imply endorsement by the author or by FAO. Use of these products is **not** recommended unless taken under the care and guidance of a qualified physician.

Transport of some non-wood forest products (e.g. foliage, seeds, landscape or ornamental plants) across international boundaries poses a risk of accidental introduction of insects, fungi or other potentially destructive agents. It is recommended that anyone planning to move plant materials across international boundaries check with appropriate authorities in the country from where the products are to be exported and the countries into which the products are to be imported for import permit requirements, phytosanitary certificates or restrictions that might apply.

Movement of certain non-wood forest products across international boundaries may be subject to trade restrictions (both tariff and non-tariff). Appropriate authorities should be contacted prior to planned movement of any non-wood forest products across international boundaries. A review of trade restrictions affecting international trade in non-wood forest products may be found in:

FAO 1995. *Trade restrictions affecting international trade in non-wood forest products*, by M. Iqbal. Non-wood Forest Products, No. 8. Rome.

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FOREWORD

Temperate broad-leaved trees are found in a wide range of ecological zones, located both in the northern and southern hemispheres. According to the FAO Forest Resources Assessment 2000, temperate forests cover some 400 million ha over a large belt along North America, which then stretches from Europe, across Central Asia, up to China and Japan. In the Southern Hemisphere, temperate forests and trees are found mainly in Chile, Argentina, New Zealand and southern Australia. Temperate broad-leaved trees and forests are also important components of many tropical and subtropical mountain ecosystems.

Temperate broad-leaved trees and forests provide a vast array of products. Many species have been domesticated and are represented by major fruit and tree crops worldwide, such as apples, pears, cherries, plums, olives, walnuts, almonds and grapes, just to name a few. In addition to fibre, timber and fuelwood, temperate broadleaf forests offer a wide range of non-wood products, which are of great benefit to human society in both developing and developed countries. However, in spite of this, foresters have so far devoted little attention to enhancing the many non-wood uses of temperate forests.

The focus of this paper lies on broad-leaved trees, as the role of conifers in supplying non-wood forest products was reviewed in an earlier publication in the Non-Wood Forest Products Series (No.12: *Non-wood forest products from conifers*). The objective is to provide a global review of the non-wood uses of temperate broad-leaved trees and to discuss the many issues involved with their development, such as problems associated with the management of the resource, or with the harvesting, processing and trade of the products. Both contemporary and historical or traditional uses are discussed. Where possible, data on levels of production and international trade are given. The intended audience of this publication ranges from interest groups in the forest, agriculture and rural development sectors to conservation agencies in developed and developing countries.

It is hoped that the use of this document will help in promoting the use of non-wood products from temperate broadleaf forests as a valuable component in the process of economic development and poverty alleviation.

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This draft was widely circulated within and outside FAO for peer review, and benefited from the detailed comments of: John Coppen, previously with the Natural Resources Institute, United Kingdom; Steve Wilson, International Flavours and Fragrances, Hangzhou, China; David Pilz, Pacific Northwest Research Station, USDA-FS; and: El Hadji Sene, Christian Hansen, Robert Scharpenberg, Laura Russo, Christel Palmberg-Lerche, Joachim Lorbach and Christopher Prins from FAO. Formatting and layout of the publication were carried out by Tina Etherington and Marco Perri. Updating and adding of some more information and pictures, as well as the overall guidance and coordination for the preparation, editing and publication of the final document was provided by Paul Vantomme, Non-Wood Forest Products Officer, FAO, Rome.

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ABBREVIATIONS AND ACRONYMS

CO_2	-	Carbon dioxide
dbh	-	Diameter at breast height
EU	-	European Union
FAO	-	Food and Agriculture Organization of the United Nations
ha	-	Hectares
ITC	-	International Trade Commission
kg	-	Kilogram
NA	-	North America
NWFP	-	Non-Wood Forest Product
UK	-	United Kingdom
USA	-	United States of America
USDA	-	United States Department of Agriculture
UV		Ultra violet

INTRODUCTION

Those portions of the Earth's surface that are characterized by having distinct warm and cold seasons are known as the temperate zones. The forests that occupy temperate zones are diverse and complex. Conifers dominate some temperate zone forests while other are covered with broad-leaved or deciduous evergreen trees. Many temperate forests are mixtures of both conifers and broad-leaved trees.

The broadleaf forests of the temperate zones are composed of representatives of many plant families and genera. While many of these families and genera are unique to temperate climates, others are found in both the temperate and tropical regions. Moreover, a few families and genera of broad-leaved trees that are characteristic of the tropics are also found in some temperate forests. While some temperate forests, such as the *Fagus sylvatica* forests of central Europe, are composed of a single species, others may contain mixtures of up to 140 distinct species of trees.

The world's temperate broadleaf forests provide a vast array of products that are beneficial to humans. The wood of many temperate broad-leaved trees is highly valued as a source of fuelwood or charcoal. The vast range of strength, durability, hardness, colour and texture of the wood of temperate broad-leaved trees has made them important sources of lumber used in construction, furniture, cabinetry, flooring and cooperage, as well as in speciality products such as gunstocks, turnery, carvings and basketry. Temperate broad-leaved trees are also important sources of non-wood forest products (NWFP), some of which have been used by humanity since prehistoric times. Some NWFP are the product of a single tree or small group of trees and, despite the best efforts of modern science and technology, no adequate substitutes have yet been found. Still others produce edible fruits and nuts and have become important in agriculture worldwide. Broad-leaved temperate trees have also many fungi, insects and other organisms associated with them and several have become commercially important products.

The objective of this paper is to provide a global review of the non-wood forest products provided by trees found in temperate broadleaf forests. Included in this paper is the range of non-wood forest products that this group of tree species provides and the places are indicated where these products are harvested. The products described are organized by the part of the tree from which they are obtained – entire trees, foliage and flowers, bark, resins, fruits, nuts and organisms closely associated with temperate broad-leaved trees. Where possible, data on levels of production and international trade are presented. Problems associated with the sustainable management of these products and compatibility or conflicts with other land uses are also presented. Both contemporary and historical or traditional uses of NWFP from temperate broad-leaved trees are discussed. Emphasis is placed on those species from which NWFP are harvested from either natural or planted forests as opposed to trees planted in orchards (e.g. pome or stone fruits, olives and certain nuts) which are considered to be important agricultural crops.

This information is presented to assist in identifying opportunities for management and production of NWFP as an integral part of economic development and poverty alleviation initiatives in economically depressed regions of the world where trees are an important element in the ecology, economics and human social structure. In addition, this information is also designed to help identify situations where special management of forests and woodlands may be appropriate to maintain or enhance the productivity of traditional or contemporary non-wood forest products or to develop a potentially beneficial new resource.

CHAPTER 1

AN OVERVIEW OF TEMPERATE BROADLEAF FORESTS

THE TEMPERATE ZONE

The Earth's surface is subdivided into five broad latitudinal bands: the Arctic and Antarctic polar zones, the tropical zone and the north and south temperate zones. The temperate zones comprise those regions of the Earth's surface that are located between the Tropic of Cancer and the Arctic Circle in the Northern Hemisphere and between the Tropic of Capricorn and the Antarctic Circle in the Southern Hemisphere. This is the area between north and south latitudes 23.50^0 and 66.32^0 (Lewis, 1977 – Figure 1-A).

The latitudinal bands described in the preceding paragraph coincide roughly with three major thermally defined zones. The "winterless" thermal zone is characterized by having a climate in which no month of the year has a mean monthly temperature lower than 18^0C and coincides roughly with the tropical zone. The two polar thermal zones are characterized by having a summerless climate where no month of the year has a mean temperature higher than 10^0C. The 18^0C isotherm coincides more or less with the distributional limits of plants characteristic of the tropics whereas the 10^0C isotherm coincides roughly with the northern limit of tree growth in the Northern Hemisphere and the southern limit of tree growth in the Southern Hemisphere. The mid-latitude regions of the Earth's surface, those that generally lie between the 10^0C and 18^0C isotherms, are characterized by having distinct summer and winter seasons, and are designated as the temperate zones [Bailey, 1996]. The 10^0C and 18^0C isotherms do not coincide perfectly with the Arctic and Antarctic Circles or the Tropics of Cancer and Capricorn. They are influenced by the oceans and continents and by changes in elevation of the Earth's continents [Bailey 1996]. Therefore, it is possible for areas south of the Tropic of Cancer to have a temperate climate and, conversely, for areas north of the Tropic of Cancer to have a tropical climate (Figure 1.1B).

TEMPERATE FORESTS

Temperate forests are diverse ecosystems composed of mixtures of conifers, broad-leaved evergreen and broad-leaved deciduous trees. Latitude, temperature, moisture and elevation define the distribution of various temperate forests and trees. A large number of families and genera of trees and shrubs are represented in these forests (Table 1.1). Within the temperate zones in the Northern and Southern Hemispheres, there are a number of distinct plant communities or biomes whose distributions are further defined by temperature and moisture. Many attempts have been made to classify the forest regions of the world [Bailey, 1996]. According to data obtained by the FAO Forest Resources Assessment 2000, "temperate" (broadleaf) forests are composed of temperate mountain forests (120 million ha), temperate continental forests (260 million ha) and temperate oceanic forests (30 million ha) (FAO, 2001). For the purpose of this paper, a broad classification of temperate forests into four forest biomes presented by Hora (1981) is used.

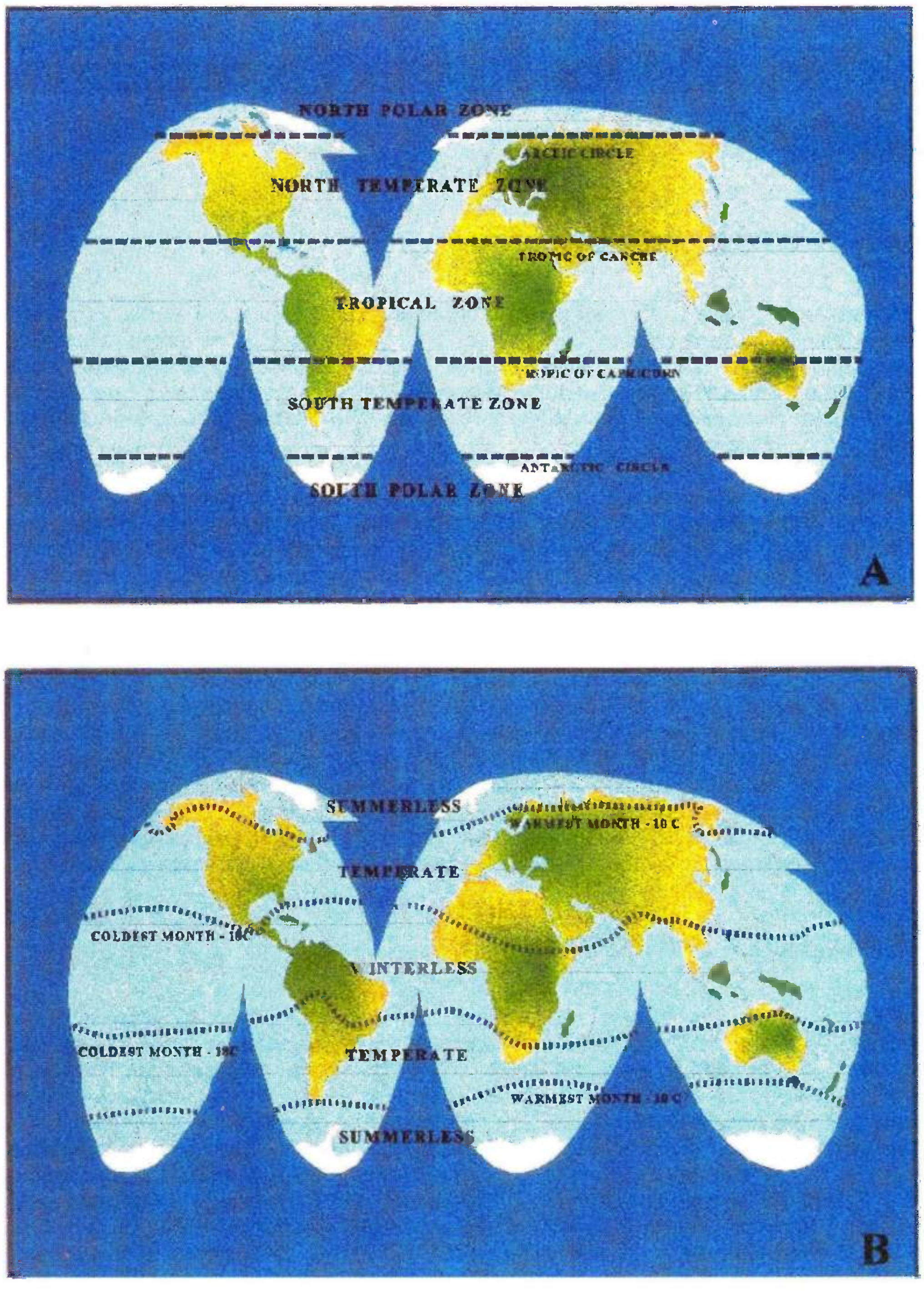

Figure 1.1: Comparison of the Earth's climatic zones as defined by latitude (A) and temperature (B) (adopted from Bailey, 1996): Sclerophyllous-, Warm temperate evergreen-, Temperate deciduous -, and Boreal forests.

Table 1.1 Principal families and genera of temperate broad-leaved trees

Family	Genera	Common names
Aceraceae	*Acer*	Maple
Aquifoliaceae	*Ilex*	Holly
Anacardiaceae	*Pistacia*	Pistachio
Betulaceae	*Alnus*	Alder
	Betula	Birch
	Carpinus	Hornbeam
	Corylus	Filbert, hazel
	Ostrya	Hop hornbeam
Cornaceae	*Cornus*	Dogwood, ossier
Ebenaceae	*Diospyros*	Persimmon
Ericaceae	*Arbutus*	Madrone, strawberry tree
	Oxydendrum	Sourwood
Euphorbiaceae	*Aleurites*	Tung
Fagaceae	*Fagus*	Beech
	Castanea	Chestnut
	Castanopsis/Chrysolepis	Chinquapin
	Lithocarpus	Tanoak
	Nothofagus	Southern beech
	Quercus	Oak
Hamamelidaceae	*Hamamelis*	Witch hazel
	Liquidambar	Sweet gum
Hippocastanaceae	*Aesculus*	Horse chestnut, buckeye
Juglandaceae	*Carya*	Hickory
	Juglans	Walnut
	Pterocarya	Wingnuts
Lauraceae	*Laurus*	Laurel
	Sassafras	Sassafras
Leguminoseae	*Cercis*	Redbud, Judas tree
	Robinia	Locust
	Gleditsia	Honey locust
	Prosopis	Mesquite
Magnoliaceae	*Liriodendron*	Tulip poplar
	Magnolia	Magnolia
Moraceae	*Maclura*	Osage orange
	Morus	Mulberry
Myrtaceae	*Eucalyptus*	Eucalypt
	Myrtus	Myrtle
Nyssaceae	*Nyssa*	Tupelo
Oleaceae	*Fraxinus*	Ash
	Olea	Olive
Platanaceae	*Platanus*	Plane tree, sycamore
Rhamnaceae	*Rhamnus*	Buckthorn, cascara
Rosaceae	*Amelanchier*	Service berry
	Crataegus	Hawthorn
	Malus	Apple, crab apple
	Prunus	Almond, cherry
	Pyrus	Pear
	Sorbus	Mountain ash, rowan
Salicaceae	*Salix*	Willow
	Populus	Cottonwood, poplar, aspen
Simarubaceae	*Alianthus*	Tree of heaven
Tiliaceae	*Tilia*	Lime, linden, basswood
Ulmaceae	*Celtis*	Hackberry
	Ulmus	Elm
	Zelkova	Caucasian elms

Source: Harlow and Harrar,1950; Hora, 1981.

SCLEROPHYLLOUS FORESTS

Sclerophyllous or Mediterranean forests occur in areas where the climate is characterized by warm, wet winters and hot, dry summers. They are located along the western coastal regions of the continents. Annual precipitation ranges between 500 mm and 1000 mm, with an irregular pattern and prolonged periods of low humidity. Much of the vegetation of sclerophyllous plant communities has hard leather-like leaves, an adaptation to periods of prolonged dry weather. These forest communities are known by several names: *maquis* in Mediterranean Europe, *chaparral* in California, *matarral* in Chile, *malee* scrub in Australia and *fynbosch* or *karroo* in southwestern Africa. Heavy cutting of the forest overstorey results in domination of formerly forested sites with dense, evergreen woody shrub vegetation. The vegetation of sclerophyllous forests tends to be rich in species composition but subject to periodic fires and degrading by heavy grazing [Hora, 1981].

The Mediterranean basin of Europe and North Africa is undoubtedly the world's best-known example of sclerophyllous forest. Prior to the development of a heavy human population that severely affected the vegetation of this region, a canopy of holm oak (*Quercus ilex*) and other evergreen broad-leaved trees (Figure 1.2) dominated the original forest cover. Other areas of sclerophyllous or Mediterranean vegetation in the temperate zones include southern California (United States), portions of Chile, the Cape region of South Africa and the southwestern tip of Australia [Hora,1981].

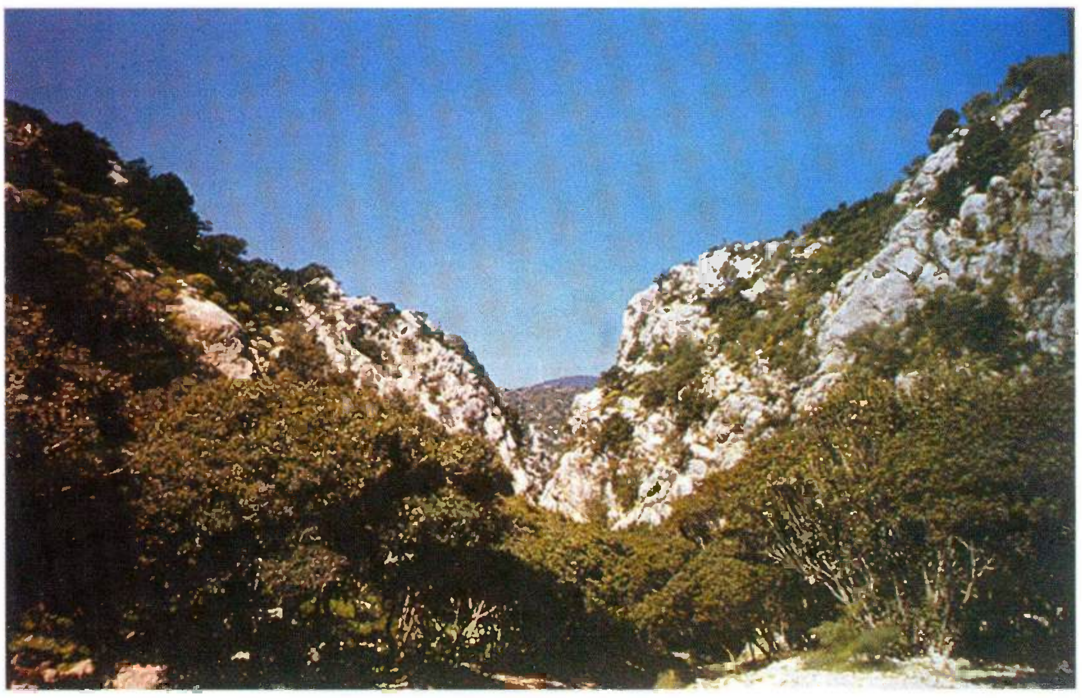

Figure 1.2 A *Quercus ilex* dominated sclerophyllous forest on the island of Sardinia, Italy.

WARM TEMPERATE EVERGREEN FORESTS

Warm temperate forests cover about 100 million ha of land area worldwide and are among the most productive of the world's forests. These forests are found where the mean temperature is between 0°C and 18°C for the coldest month of the year [Dansereau, 1957].

One form of warm temperate forest is an extension of sclerophyll forest into areas where there is no summer drought. A classic example is the Pacific Coast of North America, north of 36°N latitude, which remains moist during the summer due to summer fogs. This forest is dominated by giant conifers including redwood (*Sequoia sempervirens*), Douglas fir (*Pseudotsuga menziesii*), hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*). Broad-leaved trees (both evergreen and deciduous) that occur in this forest include big-leaf maple (*Acer macrophyllum*), vine maple (*A. circinatum*), golden chinquapin (*Chrysolepis chrysophylla),* cascara (*Rhamnus purshiana*) and Oregon myrtle (*Umbellularia californica)*. Other examples of warm temperate evergreen forests that extend from sclerophyllous forests include the *Nothofagus* dominated forests of Chile (Figure 1.3) and the *Eucalyptus diversicolor* forests of western Australia. In the Mediterranean region, a warm temperate evergreen forest occurs around the Black Sea east as far as the Caspian Sea and includes the species rich Tertiary-relict Colic forest of Transcaucasia. This forest lies in a region where summers are mild and wet enough for tea cultivation that has replaced much of the natural forest [Hora, 1981].

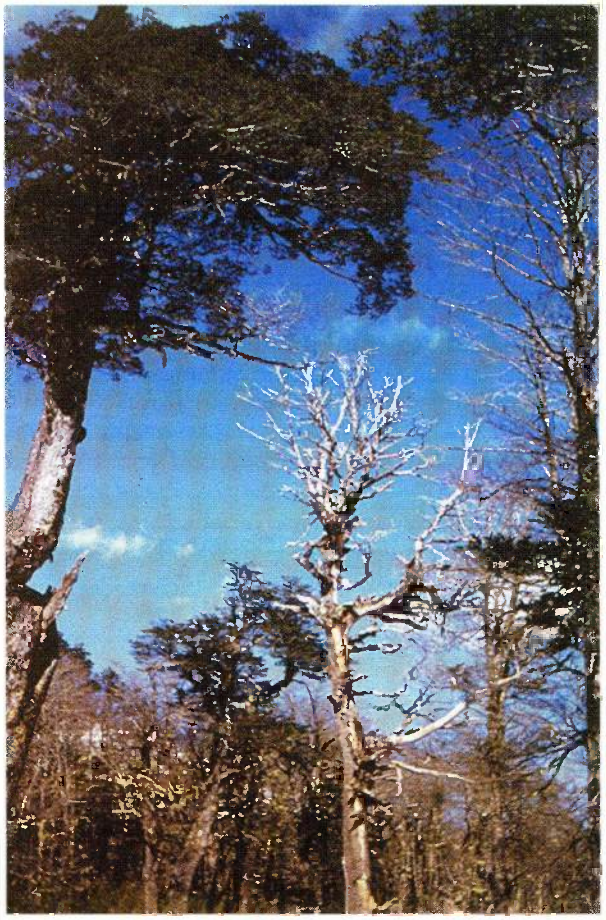

Figure 1.3 The warm temperate, Nothofagus dominated forests of southern Chile contains both deciduous and evergreen species. In this scene, taken in Parque Nacional Villarica, the evergreen tree is *N. dombevi* and the deciduous tree is *N. antarctica*.

Many of the world's warm temperate forests are found along the eastern coastal regions of the continents that are exposed to monsoons or trade winds. Rainfall is abundant (150-300 mm/a) and is well distributed throughout the year. In Southeast Asia, eastern Australia and southern Brazil, there is a continuous gradation with increasing latitude from wet tropical to subtropical to warm temperate conditions. It is, therefore, difficult to distinguish vegetation zones in these forests. Characteristically, penetration of these forests is difficult due to the abundance of vegetation; they are rich in tree species, including some conifers, epiphytes and climbers although less so than tropical forests. Some broad-leaved trees are deciduous. In eastern Australia, it has been shown that tropical forest types extend farthest south on the better soils and more humid sites. Australian moist temperate forests, dominated by *Nothofagus,* occur in Tasmania and Victoria. In Africa, only the Drakensburg mountains of South Africa have suitably moist conditions to support warm temperate forests. The boundaries of the moist temperate forests of eastern North America are also poorly defined because cold air masses move south as far as the Gulf of Mexico. They are generally found along the Atlantic and Gulf of Mexico coastal regions from east Texas and Louisiana north to North Carolina. The tree flora of the North American warm temperate forests is rich and includes both evergreen and deciduous species of oaks (*Quercus* spp.), *Liquidambar stryaciflua*), as well as conifers such as pine (*Pinus* spp.) and bald cypress (*Taxodium distichum*). Another region where warm temperate forests are predominant is New Zealand; they include various species of *Nothofagus* and kauri pine (*Agathis australis*), mixed with subtropical broad-leaved species [Hora, 1981].

Islands of warm temperate forests are also found at high elevations in the tropics. For example, the high elevation cloud forests found in Central America and extending as far south as Colombia in the northern tip of South America contain species of *Quercus* (author's observation; Ramierez Correa, 1988; Figure 1.4).

Figure 1.4 - High elevation Central American cloud forests, such as this one near the summit of the Volcan Mombasha in western Nicaragua, contain several species of Quercus.

TEMPERATE DECIDUOUS FORESTS

The temperate deciduous forests are undoubtedly the best known of the various types of temperate zone forests. They occupy a total area of approximately 800 million ha worldwide and formerly covered most of western Europe and portions of the Near East and Asia. They are still extensive across eastern North America. Temperate deciduous forests are restricted to the Northern Hemisphere apart from a small area at the southern tip of South America and are found where the average temperature is below 0^0C for the coldest month of the year but with an average temperature above 10^0C for the warmest month [Dansereau, 1957].

A characteristic of deciduous temperate forests is leaf fall in autumn, which is an adaptation to the marked but not very prolonged cold season when liquid water is either restricted or unavailable to the plant. Leaf fall is preceded by an often spectacular autumn coloration of foliage, a characteristic that makes many trees of these forests desirable ornamental and garden plants (Figure 1.5). Annual rainfall ranges between 70 cm and 150 cm and is more or less evenly distributed. Evergreen broad-leaved trees do not tolerate winter drought or prolonged cold and are generally absent from these forests.

Figure 1.5 - Spectacular coloration of deciduous foliage prior to leaf fall in autumn is a characteristic of trees in many temperate forests; upper left, *Acer circinatum*, Oregon; upper right, *Populus tremuloides*, Colorado; lower, mixed Quercus forest, Umbria Region, (Italy).

The temperate deciduous forests of western Europe have been reduced to fragments of the original forest due to agriculture, grazing and other human activities. These forests are poorer floristically than other temperate deciduous forests because of the extinction of many species during the Pleistocene ice ages. Pure forests of beeches (*Fagus sylvatica*) (Figure 1.6) dominate the higher elevation forests while *Quercus* spp., *Tilia* spp. and *Fraxinus* are dominant components of lower elevation forests. In Asia, North America and the Near East, there are many more species of trees including representatives of the genera *Acer, Aesculus, Carya, Liriodendron, Liquidambar, Magnolia and Juglans,* as well as outliers of some tropical families (e.g. *Diospyros*) [Hora,1981].

For example, in the temperate deciduous forests of the southern Appalachian Mountains of the eastern United States, there are approximately 140 different species of trees, of which about 60 are commercially important (Figure 1.7; Westveld, 1949).

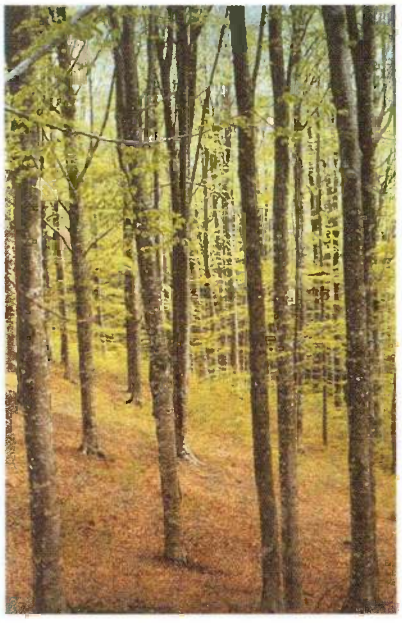

Figure 1.6 - Pure forest of European beech in the Apennine Mountains, Tuscany Region (Italy).

BOREAL FORESTS

The boreal forest region encircles the globe at the northern limits of forests and covers vast areas of North America and Eurasia. The winters are colder and longer than in the temperate deciduous forest zone and much of the region is dominated by extensive conifer forests composed of species of *Abies, Larix, Picea* and *Pinus* or extensive areas of bog or peatlands [Hora, 1981]. Broad-leaved trees are poorly represented in boreal forests although those species that do occur often cover large areas. Families and genera of broad-leaved trees that are found in boreal forests include the Salicaceae (*Salix, Populus*), the Betulaceae (*Alnus, Betula*) and Rosaceae (*Sorbus*) [Vasilevich, 1996]. In the northern limits of the boreal forest, trees are typically reduced to low, shrubby *krumholz* due to the short growing season and severe weather.

Forests composed of typically boreal species extend south into the higher elevations of the Appalachian, Rockies and Cascade mountain ranges in North America and in the Alps, Carpathian and Pyrennees ranges of Europe.

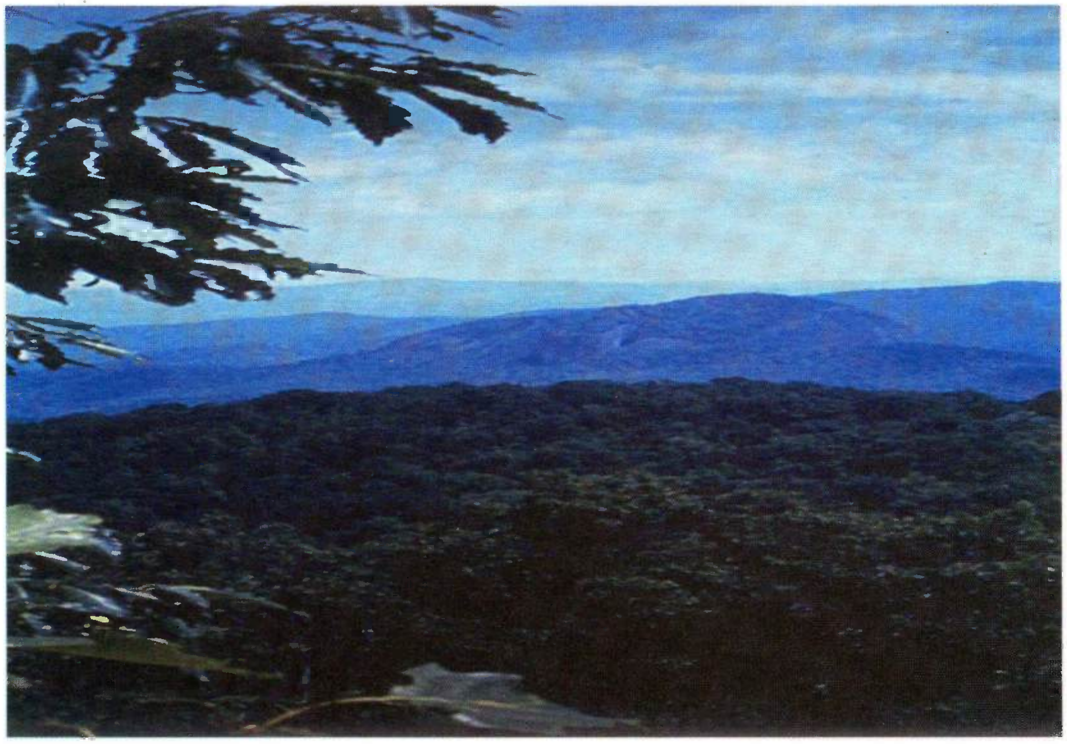

Figure 1.7 - A mixed deciduous temperate forest in the southern Appalachian Mountains of the eastern United States. Forests such as these may contain as many as 140 species of broad-leaved trees (Pisgah National Forest, North Carolina, United States).

CHAPTER 2

TEMPERATE BROAD-LEAVED TREES IN HUMAN CULTURE

Because of their importance to humans since prehistoric times, many temperate broad-leaved trees have been the subjects of legends, folklore, mythology and religion. Some have served as symbols in military organizations or have been associated with wisdom, strength and reliability. There have also been a number of historic temperate broad-leaved trees and forests in both the Old and New World.

FOLKLORE, MYTHOLOGY AND RELIGION

The majestic oaks, *Quercus* spp., with their impressive size and longevity have been revered as sacred trees by many human cultures. The evergreen oaks (e.g. the European *Quercus ilex* and *Q. suber)* were especially favoured and were rated as high as pines in early human societies who worshipped trees as they worshipped other wonders of nature that they could not understand [Mirov and Hasbrouck 1976]. The ancient Hebrews considered the oak sacred because it was under an oak that Abraham gave hospitality to God and two of his angels, who were disguised as travellers. This story is told in Genesis 18; and is one of 60 references to oak in the Bible. The early Gauls worshipped oak as a symbol of their supreme God. To the Druids, an order of priests or ministers of religion among the ancient Celts of Gaul, Britain and Ireland, oak was considered a sacred celestial tree. Both oak and the mistletoe, *Viscum album*, a plant that grows on oaks and other trees, were involved in almost all Celtic-Druid ritual ceremonies [Lust, 1990].

One of the most intriguing aspects of the oak as a sacred tree is its widespread association with thunder gods in various European cultures. This is probably due to the fact that oak seems to attract lightning more than other trees in the forest. To the northern Europeans, it was the tree of life sacred to the thunder god Thor. The oak was also sacred to the principal Greek god Zeus with his thunderbolts and to his Roman counterpart, Jupiter. The oracle of Zeus at Dodana, Greece, mentioned by Homer, was situated in a sacred grove of oak trees. Predictions were made at this oracle by interpreting the rustling of oak leaves. The Slavic countries of eastern Europe had their own versions of a thunder god associated with oak. In Russia, his name was Perun, derived from the Russian word for thunderbolt. In Lithuania, the god of thunder was called Perkunas, a name thought to be taken from an Indo-European name for oak [Lust, 1990]. In William Shakespeare's *King Lear*, reference is made to "oak cleaving thunderbolts" [Walker, 1990].

In Greece and Rome, the oak and the linden, *Tilia cordata*, are associated with the mythical story of Baucis and Philemon, a humble, elderly married couple who extended kindly hospitality to the disguised gods Zeus and Hermes after all of their richer neighbours had refused to do so. The two gods punished the inhospitable neighbours by covering all of the homes in the area with a lake except for the small cottage occupied by Baucis and Philemon, which was transformed into a beautiful temple. The couple held priestly office there until they died. The gods granted their request that they would die at the same time so as not to be separated by death. The couple was then transformed by the gods into two trees growing side by side. Baucus became a linden tree, the symbol of conjugal love. Philemon became an oak, the symbol of hospitality [Lust, 1990].

In England, the name "gospel oak" relates to a time when Psalms and Gospel truths were said under the shade of an oak tree. They were considered resting places in the "beating of parish bounds", a practice that has its origins in a feast to the pre-Christian god Terminus. The ceremony was performed by a clergyman and his parishioners going to the boundaries of the parish and choosing a site, preferably an oak tree, to read passages from the gospels and ask blessings for the people [Grieve, 1931].

Another temperate broad-leaved tree with a rich folklore is the European mountain ash or rowan tree (*Sorbus aucuparia*). Another of this tree's common names is witchwood. In northern Scotland, it was once common practice to plant rowan trees around homes to prevent witches from entering. Another practice involved hanging sprigs of rowan above doors and stables to keep away evil spirits. An old German folk tale says that if you carry a leaf or a bit of wood from the mountain ash in a bag on your person, it will protect you from harm. This belief was brought to northern Pennsylvania by the early German settlers who hiked to the top of the Allegheny Plateau in search of native mountain ash. They collected sprigs of foliage and pinned them to the coats of their children when they left home to go to school [Ciesla, 1990a].

According to old Germanic and Scandinavian folklore, the ash, *Fraxinus excelior,* is believed to be the world tree; the legendary Ygdrasil or the tree that Odin rode. It takes its name from the way Odin came to wisdom. He hung himself by the arms in top of the tree for nine days to learn the secrets of the runes, symbolizing man has always had to struggle for knowledge. The gods had their meetings at the base of this tree and its branches covered the world (Personal communication, Peder Gjerdrum, Norwegian Forest Research Institute, Norway).

To the people of Finland, birch (*Betula* spp.) was a sacred tree. In the *Kalevala*, a Finnish epic, birch was designated as a holy tree of great use to humanity. The Germanic people dedicated the birch to Thor, their god of thunder [Lust, 1990]. "Besom brooms" made of birch twigs were used in England for cleaning out a property believed to be bewitched. The supernatural underworld, however, has a way of turning to its own uses the implements of law and order. Witches discovered that some of the bad spirits became entangled in the twigs. A witch who secured some of these polluted brooms might bind the birch sticks to a handle made of ash wood to make a broomstick on which she could ride across the country, carrying out the duties of her profession. The ash handle protected her against drowning, a fate to which witches were particularly susceptible.

The Romans believed that a person standing under a laurel (*Laurus nobilis*) would be shielded from infection by plague and also from lightning. During the Middle Ages, laurel was believed to provide protection against both lightning and witches [Lust, 1990]. The related myrtle (*Myrtus communis*) was an important tree in religious rituals and ancient festivities. The ancient Persians regarded the myrtle as a holy plant. In Egypt, women wore blossoms of myrtle, pomegranate and lotus on festive occasions. To the Jews, the myrtle was a symbol of peace; to the ancient Greeks, it was sacred to the god Aphrodite; and to the Romans, it was sacred to Venus [deWit, 1967].

Because the silk industry was so important to the early Chinese people, the mulberry (*Morus* spp.) was revered in ancient China as a sacred tree. Some scholars connect it with the *fu-sang* tree, a symbolic tree of life that appears in the mythology and art of the Han Dynasty (202 BC to 220 AD). In another classic legend, the red berries of the mulberry tree acquired their colour after two young Babylonian lovers, Pyramus and Thisbie, bled and died under a white mulberry tree. This legend is the source material for Shakespeare's story of Romeo and Juliet [Lust, 1990].

Several legends concerning the crucifixion of Christ involve temperate broad-leaved trees. The redbud (*Cercis siliquastrum*), a tree that produces brilliant pink-red flowers in early spring (Figure 2.1), and is also known as Judas tree. According to a legend, this was the tree on which Judas, the disciple who betrayed Christ, hanged himself [Hora, 1981]. Before this incident occurred, the tree supposedly produced white flowers. Now it is said to produce pink-red flowers in shame. This legend spread to North America where several species of *Cercis* are native. According to another legend, the cross of the Calvary was hewn from the wood of aspen (presumably *Populus tremula*). This legend also made its way to the United States where the tree was once feared by lumberjacks in the Great Lakes region (Michigan, Minnesota and Wisconsin) where the indigenous *P. tremuloides* is a major component of the forests. They refused to sleep in buildings built of aspen wood [Graham *et al*., 1963].

According to another legend, Christ was beaten by birch rods as he carried the cross to Calvary [Lust, 1990]. Christian people of far northern Europe believed that the birch of the Arctic tundra lay low along the ground out of shame for the birch rods that were used to scourge Christ [Peyton, 1984].

Box 2.1 Legends of the aspen

Two species of aspen,' the Old World *Populus tremula* and the New World *Populus tremuloides* have transcontinental distributions and are among the most widely distributed broad-leaved temperate trees. The leaves of aspens are hinged on petioles that act as a pivot, causing the foliage to move every time a breeze blows. One of the common names for *P. tremula* is the German *Zitterpappel*. In Canada and the United States, *P. tremuloides* is known as quaking or trembling aspen.

This unusual foliage characteristic has been the basis of several legends relating to aspens. According to one, Christ doomed the aspen to tremble when it refused to bow down before him. Another legend says that the cross of Calvary was made of aspen wood and the leaves of the aspen have not stopped shaking since. This Old World legend made its way into the New World via European settlers. Father DeSmet, an early missionary to the north-western United States relates that the French *coureurs du bois* had superstitions about the aspen that originated from this legend [Peattie, 1953; Boom and Kleijn, 1966].

Figure 2.1 Redbuds or Judas trees (*Cercis siliquastrum*) line a street in Padria, on the Italian island of Sardinia. According to a legend, this was the tree on which Judas, the disciple who betrayed Christ, hanged himself.

The hollies, *Ilex* spp. (family Aquifoliaceae) have a wealth of folklore associated with them, both in the Old and New World. They were held by Celtic druids to symbolize the sun, and sprays of their evergreen foliage were taken into the dwellings during the winter months. Holly is still a popular Christmas decoration among Christian cultures. It was also a popular decoration during the Roman Saturnalia. In North America, holly was used as a martial emblem by some indigenous tribes and a celebration known as the "Black Drink" ceremony was based on the emetic properties of *Ilex vomitoria* [Hora,1981].

SYMBOLS

To northern European cultures, the oak leaf cluster is a symbol of heroism and victory. This symbol spread to the United States where it has become a military symbol. The Oak Leaf Cluster is a small bronze decoration consisting of a twig bearing four oak leaves and three acorns. It is given to holders of medals for valour, wounds or distinguished service, in recognition of some act justifying a second award of the same medal. In Rome, the oak wreath crown was a prize for saving a citizen's life in battle [Lust, 1990]. A spray of oak once appeared on English sixpence and one shilling coins [Grieve, 1931].

The hard wood of the oak was equated with incorruptibility. The hard wood, combined with the great age that some oaks can achieve, caused oaks to be associated with both strength and eternal life in many societies. In China, the oak signifies male strength but also signifies weakness because, unlike the willow or bamboo, it remains rigid in storms, therefore breaking under pressure. To some native American tribes, the oak is a symbol of Mother Earth.[1]

During Roman times the fasces, a bound bundle of birch sticks enclosing an axe with the blade projecting, was carried by soldiers in advance of emperors or other important officials. These fasces symbolized the state's power to punish by flogging (the birch sticks) or by putting to death (the axe) [Lust, 1990].

In Christian religions, oak is associated with steadfastness in faith and virtue. The oak is also considered to be a symbol of great achievement accomplished through patience, dedication, perseverance and commitment to the truth.[2] In literature and music, the oak often connotes strength, masculinity, stability and longevity [Lust, 1990]. An example is seen in this verse from a traditional English/American folk ballad known as False Love.

I leaned my back against an oak,
thinking it was a trusty tree.
But first it bowed, and then it broke.
And so my love proved false to me.

In ancient Greece and Rome, the hawthorn, *Crataegus* spp., had happy associations, symbolizing sweet hope, marriage and babies. It was dedicated to Hymen, the god of marriage and was used as a symbol of hope at Greek weddings. Bridal attendants wore its blossoms while the bride carried an entire bough. Also in Greece and Rome, torches carried in wedding processions were made of hawthorn. The Romans put hawthorn leaves in the cradles of newborn babies to ward off evil spirits. In medieval Europe, on the other hand, hawthorn had a very different image. It was generally regarded as an unlucky plant and it was believed that bringing its branches inside would portend the death of one of the household's members. Hawthorn was said to be one of the witches' favourite plants and was especially to be avoided on Walpurgis Night, when the witches turned themselves into hawthorns [Lust, 1990].

The weeping willow, *Salix babylonica*, is a well-known symbol of unlucky love in the western world as exemplified by the words from a traditional folk song from the southern Appalachian Mountains of the USA:

Bury me beneath the willow,
'neath the weepin willow tree,
for when she hears that I am sleepin'
maybe then she'll think of me.

In Asia, however, it has been associated with the springtime regeneration of nature, eternal friendship, patience, perseverance and meekness [Lust, 1990].

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1 Source: Rare Earth International in 1997 (http://www.golden.net/~debrusk/oleaf.htm)

2 Source: Jacksonville University, Florida (USA) in 1997 (http://www.ju.edu/homepages/ju/logo.htm)

The laurel, *Laurus nobilis*, a small to medium evergreen tree of the Mediterranean Region was the symbol and victory and honour. During the Middle Ages, distinguished men were crowned with a wreath of laurel foliage and berries. This ceremony is the origin of the term "poet laureate." University undergraduates are known as "bachelors" from the Latin *baccalaureus*, meaning laurel berry. They were forbidden to marry because it was believed that this would distract them from their studies. By extension of this idea, all unmarried men are referred to as bachelors [Hora, 1981].

The birch is associated with cleansing. Sauna bathers in Finland and Russia slap themselves and each other with *vasta*, bundles of birch twigs tied at the butt end. When steeped in hot water, they give off a sharp, clean, medicinal odour [Peyton, 1984].

The Canadian flag is a red maple leaf on a field of white. This design replaced the Canadian Red Ensign, which was used in various versions between 1870 and 1965. The maple leaf flag was adopted by resolution of the Canadian Parliament (House of Commons) on 15 December 1964 and by the Senate on 17 December 1964. The maple leaf became Canada's official flag on 15 February 1965.[3]

HISTORY

HISTORICAL ANECDOTES

The common name "beech" for the trees of the genus *Fagus*, which is found in various forms throughout the Teutonic dialects, refers to "book". Early books or tablets were made from the wood of this tree [Grieve, 1931]. The modern common name for beech in German is *Buche* [Quartier, 1978] while the word for book is *Buch*.

When the Romans invaded Gaul, they were not prepared for the foreboding oak and beech dominated forests of northern Europe. They were the direct opposite of their idea of civilization. To reduce potential problems of warfare and the mental dread of mystery, darkness and the possibility of an enemy bowman behind every tree, the Romans divided these forests with roads and fields and brought them down to manageable proportions [Miller and Lamb, 1985].

Early English kings saw oaks as a source of wealth and an opportunity for taxing. The number of swine that an oak forest could sustain from its acorn crop was used to determine tax rates [Walker, 1990]. An entry in the Doomsday Book, compiled on the orders of William the Conqueror, around AD 1086, says of a certain village: *"There is wood for forty swine, and the village was taxed accordingly."* [Edlin, 1985].

The oak forests of North America were an important source of cooperage even during the early colonial period. Casks were assembled and disassembled in a prefabricated style and shipped abroad. Some made the journey several times, filled with various liquids. A defiant Englishman named Samuel Maverick, living in colonial America, was aggravated with the British Government over regulations governing stave trade and marketed his material through an agent in Spain. The agent sold Maverick's cargo and forwarded receipts in Spanish coin to an English merchant for English goods needed and not otherwise available in New England. This is how the word "maverick," meaning dissenter, entered the English language [Walker, 1990].

The American live oak (*Quercus virginiana*) was a favoured source of ship's timbers in the United States until metal ships were constructed during the American Civil War. Tree harvesters known as "live oakers" cut large volumes of live oaks in the southeastern United States because their timber was said to have a better grain for shipbuilding than that of the English oak (*Q. robur*). At one time there was a lucrative export market for live oak ship's timbers in Denmark, England, France and other European countries. During early 1800s, American gentlemen in Louisiana and other southern states often settled their differences by duels fought at the site of a live oak tree [Walker, 1990].

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3 Information provided by Vidar John Nordin, Associate Editor, *The Forestry Chronicle*, Ottawa, Canada.

HISTORIC TREES AND FORESTS

Many records exist of temperate broad-leaved trees and/or forests that have historical significance. In the Near East, a specimen of *Quercus coccifera,* known as Abrams' oak, supposedly represents the spot where Abraham pitched his tent. There is a superstition that any person who cuts or otherwise damages this tree will lose his firstborn son [Grieve, 1931].
A grove of some 12 oaks in the state of Mecklenberg-West Pomerania in northeastern Germany is believed to contain some of the oldest living trees in Europe. Known as the Ivenack oaks, the oldest tree in the grove has an estimated age of about 1 200 years. According to a legend, these oaks have a definite prescribed lifespan. It is said that seven nuns from a Cistercian convent broke their vows and were punished by God by being turned into oaks. According to another version of this legend, the nuns were surprised in their sleep by robbers. As they ran half naked through the woods, they called on God for protection and were turned into oaks. After a thousand years, the first oak will die and liberate one nun's soul. Every hundred years thereafter, another oak will die and its human soul will be freed. In 1962, the German Democratic Republic gave protected status to the Ivaneck oaks. This status was maintained after German reunification in 1990 [Bolgiano, 1997].

One of Europe's most famous forests is the Sherwood Forest of central England. This forest is listed in the Norman Doomsday survey of 1086, and at one time encompassed an area that extended for 32 km north of Nottingham and was 12.8 km wide. Today, development has left it in a fragmented condition. Sherwood Forest (Shire Wood) was a prize hunting ground for English royalty and the legendary home of Robin Hood and his band of Merry Men. A massive specimen of *Quercus robur*, known as the Major Oak, is reputed to be Robin Hood's meeting place and is believed to be over 1 000 years old.[4] It is the largest tree in what remains today of the Sherwood Forest and has a circumference of over 10 m [Bourdu and Viard, 1988].

An oak known as the Charter Oak is the symbol of the state of Connecticut in the United States. This tree played a significant role in an event that took place in colonial America. On 9 October 1662, the citizens of the Connecticut Colony received a Royal Charter from King Charles II. This charter granted Connecticut's residents the unique right "to have and to hold forever this place in 'New England in America'." Obtaining such a charter for a colony was an extraordinary diplomatic coup for the citizens of Connecticut. Twenty-five years later, King James II had second thoughts about this charter. After negotiations aimed at persuading the citizens of this colony to surrender their charter failed, the King sent Sir James Andros and an armed force to seize the charter from the colonial government in Hartford. After hours of debate between Andros and the leaders of the colony, with the Charter on the table between opposing parties, the candle-lit room suddenly went dark. When light was restored, the charter was gone. Joseph Wadsworth, one of the colony's leaders had taken it to a hiding place inside a huge, ancient oak on a nearby estate. As a result, Andros returned to England empty-handed and Connecticut's charter remained in the hands of the colonists. The famous oak finally succumbed to a storm in 1856 (Connecticut, 1994). A picture of this oak is depicted on the observe side of a $US 0.25 coin, commemorating the State of Connecticut.

In the southeastern United States, 46 live oaks (*Quercus virginiana*) are on the List of Famous and Historic Trees. The Evangeline Oak, located on the Bayou Teche in St. Martinville, Louisiana (Figures 2.2 and 2.3), is sometimes referred to as "the most famous tree in America". This tree is a living memorial to a tragic episode that occurred during the French and Indian War when the Acadians, people of French-Canadian ancestry, were forced to migrate from eastern Canada to the southeastern United States. This migration is chronicled in Henry Wadsworth Longfellow's epic poem Evangeline. According to a local legend, residents stood under the shade of this massive oak to greet Acadian exiles who landed there. It also marks the spot where Gabriel waited for his lost love Evangeline to arrive. A short distance upstream from the Evangeline Oak is the Gabriel live oak. The Sidney Lanier live oak stands on the edge of the Marshes of Glynn near Brunswick, Georgia. Here, Sydney Lanier, a poet and lyricist, wrote the poem The Marshes of Glynn. The Aaron Burr live oaks form a row at the entrance of Jefferson College in Washington, Mississippi. It

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[4] Source - "Decline of Sherwood" - http//www.sherwoodinitiative.co.uk/decline.html.

was under these oaks that this famous figure in American history was tried for treason in 1807 and acquitted. The County Charter Oak, a live oak in Texas, located east of the Nueces River, was the site of an assemblage of people from a place called Fox's settlement. At this site, they drafted a petition to the State Legislature asking that another county be created since they were so far away from San Patricio, their country seat. On 2 February 1856, the new county was created and named "Live Oak County" [Miller and Lamb, 1985].

During the days of the California gold rush, a massive valley oak (*Quercus lobata*) was designated the "Forty-niner's Tree." The tree later gave name to the Sierra Nevada foothill community of Big Oak Flat. The tree was said to have a diameter of 11ft (3.35 m) and was so sacred to the gold prospectors, they passed a camp ordinance to protect it. Ironically, it was the gold mining activity that eventually destroyed the tree. Mining operations caused the land to slip, carrying the giant oak with it [Peattie, 1953].

Figure 2.2 The Evangeline Oak, St. Martinsville, Louisiana.

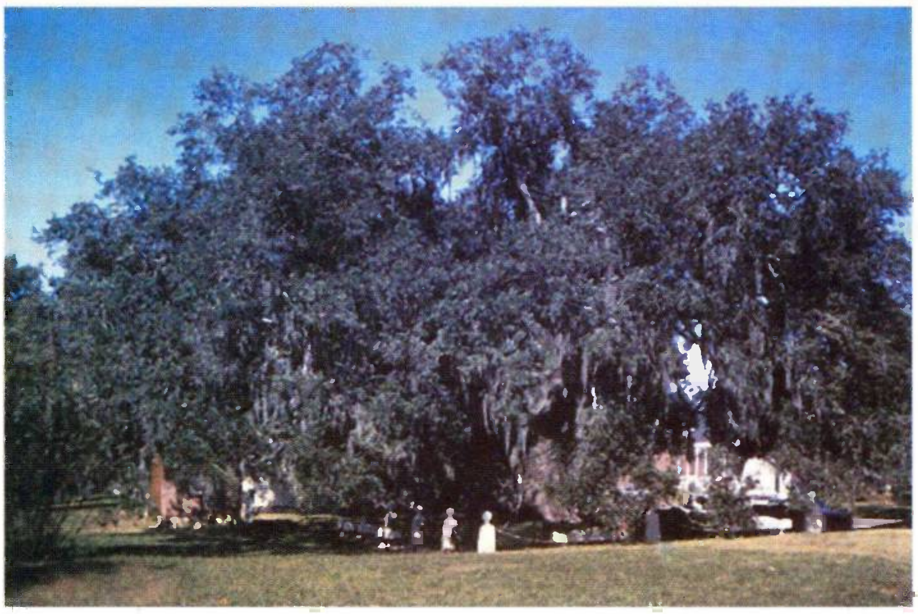

Figure 2.3 Sign describing the historical significance of the Evangeline Oak, St. Martinville.

CHAPTER 3

WHOLE TREES

LANDSCAPE AND ORNAMENTAL TREES

Landscape and ornamental trees are an important part of human life. They provide shade and beauty around homes, schools, markets and shopping areas, places of work, along streets and highways, in city parks and other areas. They also help conserve energy and the quality of air, water and soil.

Virtually all species of temperate broad-leaved trees are important landscape and ornamental plants and fulfil one or more functions in landscape design. As good as all countries have some level of nursery industry that offers for sale planting stock for landscape and ornamental purposes. Small-scale nursery operations are often an excellent opportunity for small business or family-run enterprises.

HISTORICAL ASPECTS

Trees have been used as ornamental plants since the earliest of times. More than 4 000 years ago, the Egyptians wrote about trees being transplanted with a ball of soil around their roots. Some trees were moved up to 2 400 km by boat. In Greece, Theophrastus (370-285 BC) and Pliny (AD 23-79) gave instructions for tree planting and care. Many books on the care of trees and woody shrubs have been written since those early times.

During the Middle Ages, botanical gardens contained primarily plants of medicinal importance. Later, the gardens of private estates contained many exotic plants introduced via trade and travel. Many of these gardens are now public and are great sources of information and recreation.

By the early 1700s, trees were being planted with some frequency in the cities and estates of Europe. During the early settlement of North America, trees were cut to make room for farms and communities. During the late 1700s, however, trees were being planted in town squares. Unfortunately, after the trees were planted, few received care, except perhaps on large estates. As settlers migrated west into the open prairies, they planted seeds of fruit trees and other trees to shelter their homes from high winds.

In the early 1900s, national research institutes in Europe and North America began to study fruit and forest trees and by the 1950s, these institutes began working on problems associated with landscape and ornamental trees. The need for this research was accelerated with the introduction of several major pests and diseases that caused serious problems with both forest and ornamental trees (e.g. Dutch elm disease (*Ophiostoma ulmi*) and white pine blister rust (*Cronartium ribicola*). Experiment stations, botanical gardens, arboretums and some large plant nurseries have long been involved in the introduction and evaluation of landscape materials that are able to tolerate the rigours of the urban environment. These events led to the development of the science of arboriculture – the planting and care of trees and other woody plants [Harris, 1976].

BENEFITS

Ornamental trees provide a basic contact with nature and heighten pleasure in human surroundings. Their value is difficult to quantify in economic terms but some of the aesthetic benefits they can provide are:

1. A variety of colour, form, texture and pattern;
2. Softening of harsh architectural lines;
3. Formation of vistas, frame views, provision of focal points and definition of spaces;
4. Trees can make enticing play areas;
5. Cooling shade, pleasant fragrances, intriguing sounds and serene settings;
6. They can create the impression of a well-established place in new residential areas and reduce the raw "unfinished" look.

Ornamental trees can add to the value of real estates, although there are few examples of accurate assessments. One study in the eastern United States indicated that trees increased the appraised value of undeveloped land by 27 percent and that of 0.2 ha residential lots with houses by 7 percent. Industry officials have found that attractive buildings and landscapes result in above-average labour productivity, lower absenteeism and easier recruitment of workers with hard-to-find skills [Harris, 1976].

Trees can have considerable effects on the microclimate of areas of heavy human population. They absorb heat as they transpire, provide shade that reduces solar radiation and reflection can reduce or increase wind speed, and can increase fog precipitation and snow deposition [Harris, 1976]. Trees can have a significant beneficial effect on the cost of winter heating and summer cooling of buildings. They break up urban "heat islands" by providing shade. It has been estimated that the shade provided by strategically placed trees near a residential home can reduce air conditioning costs by 30-50 percent, and trees planted as windbreaks around buildings can reduce winter heating energy use by 4-22 percent [Ciesla, 1995; Sampson, 1992].

DESIRABLE CHARACTERISTICS

Most temperate broad-leaved trees are used as ornamental and landscape plants in some form. Desirable characteristics of the trees selected for this purpose include genetic variability, foliage colour and density, overall form, growth rate (both fast and slow growing plants may be desired) and ability to grow and survive under a wide range of climatic and soil conditions.

Genetic variability

Genetic variability within species is a desirable trait to have in trees and plants used as ornamentals. Many trees have one or more distinct varieties. Varieties are considered to be one step below the species level in the taxonomic hierarchy. For example *Salix alba* var. *vitellina* is a variety of *S. alba* found in Switzerland that has especially good form and brilliant yellow shoots that are very decorative [FAO, 1979]. They are characterized by having distinct characteristics of foliage or form but are inseparable at the species level. Varieties appear in nature, are genetically stable and reproduce from seed. Cultivars are mutations or distinct forms of plants, initially found in nature, and propagated asexually by cutting or grafting with the objective of maintaining those characteristics for a saleable plant. Cultivars are not part of the classic Linnean taxonomic hierarchy. Cultivar names have been developed by the nursery industry to reflect the characteristics of the plant, the location where it was discovered, its discoverer, etc., but are not always latinized [Harrison, 1975]. For example, a purple leafed form of *Fagus sylvatica,* first cultivated in Germany during the eighteenth century, is designated as *F. sylvatica* Purpurea [Edlin, 1985]. Another well-known cultivar of this tree is *F. sylvatica* Pendula; a weeping form with long branches [Samson and Samson, 1986]. Certain cultivars of *Salix alba* grown commercially in the Netherlands are designated Liempe, Belders and Lievelde. These cultivars are produced vegetatively and are male trees that have good form and are fast growing [FAO, 1979]. Cultivariants are cultivars that appear somewhat different from their vegetative parents due to propagation from non-typical foliage [Harrison, 1975].

Foliage colour

Another desired characteristic of deciduous temperate broad-leaved trees used as landscape or ornamentals is the foliage colour. Several trees such as various cultivars of *Fagus sylvatica* and *Acer palmatum* have deep reddish-purple foliage colour throughout the growing season. Their colours can add interest and variety to a landscape during the entire growing season [Dirr, 1990].

Brilliant foliage colour during the autumn season is another desirable characteristic of landscape and ornamental trees. Many deciduous broad-leaved trees produce brilliant displays of fall colour. For example, the foliage of several oaks, e.g. northern red oak (*Quercus rubrum*), scarlet oak (*Q. coccinea*) and pin oak (*Q. palustris*), turn a brilliant scarlet colour in autumn. Other trees with bright autumn foliage colour include *Acer saccharum* (red-orange), *A. rubrum* (bright red), *Betula* spp. (yellow), *Fraxinus pennsylvanica* (bright yellow or violet depending on cultivars), *Cornus florida* (deep red), *Liquidambar styraciflua* (deep red), *Pistacia chinensis* (bright red) and *Liriodendron tulipifera* (bright yellow) [Ferguson, 1982].

Growth

Rapid growth is a desired characteristic of trees established in new developments so that the harshness of new construction is minimized in as short a time as possible. Silver maple (*Acer saccharinum*) is a popular fast growing shade tree but is susceptible to iron chlorosis when planted on alkaline or iron poor soils [Dirr, 1980]. Other fast-growing trees used in new landscapes include *Alnus* spp., *Catalpa* spp., *Paulownia tomentosa*, *Populus* spp., *Robinia pseudoacacia*, *Salix* spp., *Sapium sebiferum* and *Ulmus* spp. [Ferguson, 1982].

In other situations, trees with relatively slow rates of growth may be required. Examples include small gardens or patios where a fast-growing tree would quickly outgrow available space. Examples of slow-growing trees which would work well in limited space include *Acer palmatum*, *Cercis canadensis, Cornus* spp., certain cultivars of *Prunus, Pistacia chinensis* and *Ostrya virginiana* [Ferguson, 1982].

Colourful flowers and fruits

Flowering trees are especially popular in early spring when some species produce abundant flowers before leafing out. Two outstanding examples are the Japanese flowering cherries (*Prunus serullata* and *P. yedoensis*). Cultivars of these trees were given by the Japanese Government to the United States Government and were planted among several famous monuments in Washington, DC, where the annual cherry blossom display is world famous. Other trees that produce abundant and colourful spring flowers are *Amalachier canadensis, Crateagus* spp., *Cornus florida*, *Sorbus* spp. and flowering crab apples (*Malus* spp.).

Figure 3.1 The flowering dogwood (*Cornus florida*) is a popular ornamental tree because it produces attractive flowers in spring and brilliant red fruits in autumn.

Summer flowering trees continue to provide colour and variety after the spring blossoms have passed. Summer flowering trees include *Catalpa* spp., *Liriodendron tulipifera*, *Magnolia grandiflora* and *Oxydendrum arboreum* [Ferguson, 1982].

Another desired trait is trees that produce flowers in spring and brightly coloured but not necessarily edible fruits later in the season. A good example is the flowering dogwood (*Cornus florida*), which typically produces white blossoms in spring (Figure 3.1) and brilliant red fruits in autumn. Several pink flowering cultivars (rubra and Cherokee Chief) are also available [Dirr, 1990]. Other trees in this category include *Crateagus* spp., *Prunus* spp. and *Diospyros khaki* [Ferguson, 1982].

Ability to tolerate harsh conditions

Landscape and ornamental trees are often established under harsh environmental conditions. These include cities where there are high levels of air pollution, exposure to high levels of reflected heat, and limited open soil surface for air and water. Some temperate broad-leaved trees that are able to tolerate these conditions include *Acer* spp., *Aesculus carnea*, *Carpinus betulinus, Catalpa* spp., *Celtis occidentalis*, *Fraxinus* spp., *Platanus* spp., *Quercus* spp., *Tilia cordata* and *Ulmus* spp.

Ability to withstand salt spray is a factor that must be considered when landscaping near the seashore. Some trees, which can tolerate seashore conditions, include *Acer platanoides, Acer rubrum, Arbutus* spp., *Carpinus betulinus*, *Eucalyptus* spp., *Nyssa sylvatica, Salix alba* var. *vitellina* and *Ulmus parvifolia* [Ferguson, 1982].

USES

The purpose of any landscape is to look pleasing to the eye. Some special uses of broad-leaved trees and shrubs in landscape design are described in the following sections:

Shade and roadside trees

One of the major purposes of broad-leaved ornamental trees is to provide shade. Many temperate broad-leaved trees characteristically have spreading crowns, dense foliage and provide excellent shade. Planting of trees along roadsides in towns and cities provides not only welcome shade on warm summer days, but they also soften the sharp edges of homes, office buildings, factories and other structures.

Figure 3.2 -Plane trees (*Platanus x acerifolia*) provide welcome shade in a marketplace in Hefei, Anhui Province, China.

Many temperate broad-leaved trees are popular shade and street trees throughout the world. The species of *Platanus* (family Platanaceae) are popular street and shade trees in many areas. Not only do they provide good shade, but also their flaky green and white bark is attractive and eye-catching. *Platanus occidentalis* is widely used in many North American towns and cities and *P. orientalis* is often used in the Near East as a shade tree. In some European and Asian cities (e.g. Rome), a tree known as the London plane tree (*Platanus* x *acerifolia*), a hybrid between *P. occidentalis* and *P. orientalis*, is a popular tree for planting along streets, shopping malls and markets [author's observation] (Figure 3.2). This tree can tolerate harsh city conditions and drought and is often pollarded. It does not have bright fall colouring. Another popular street and shade tree is the European lime or linden (*Tilia cordata*). This tree is widely planted in temperate climates. In Berlin, Germany, the famous street *Unter den Linden,* which has many eighteenth and nineteenth century monumental buildings, is named for linden trees, which line the street. Other popular street trees include the horse chestnut (*Aesculus hippocastanum*) and the Norway maple (*Acer platanoides*). The latter has been so widely planted in parts of North America that it is said to have been "overused." This tree requires a lot of room to grow and its roots tend to buckle roadways and sidewalks [Dirr, 1990].

Another popular North American shade tree is the American elm (*Ulmus americana*). Its popularity stems from its graceful, vase-like crown form (Figure 3.3). This tree was once widely planted throughout the eastern and mid-western states but, unfortunately, most of these trees have succumbed to the Dutch elm disease, an introduced disease caused by the fungus *Ophiastoma* (= *Ceratocystis*) *ulmi,* which attacks the trees vascular system and causes a rapid death [Manion, 1991].

Specimen and character trees

The purpose of a specimen or character tree is to have a shape or form that will be attractive to look at throughout the year. They can be used in a variety of different situations such as marking the edge of a vista or characterize a particular space. The size of a specimen tree must be in relative proportion to its surroundings. If the space available is tall and narrow, a tree with a pyramidal or spire-like crown is most suitable.

There are many examples of temperate broad-leaved trees that are excellent specimen or character trees. The pronounced, pendulous form of the weeping willow (*Salix babylonica*) or the golden weeping willow (*S. alba* Tristus) provide interesting silhouettes, and the branches turn a yellow-gold colour in spring just prior to leafing out. The massive *Fagus sylvatica* and its various cultivars are popular specimen trees for college campuses, city parks and golf courses. In the southern United States, two popular specimen trees include *Magnolia grandiflora*, an evergreen with large white flowers that is known as the "symbol of the south" and the stately, spreading live oak (*Quercus virginiana*), a tree that graced many old southern plantations and is the major street tree in several southern cities including Savannah, Georgia [Dirr, 1990; Miller and Lamb, 1985]. Other temperate broad-leaved trees used as specimen and character trees include honey locust, *Gledistsia triacanthos,* Lombardy poplar (*Populus nigra* Italica) and tulip tree *Liriodendron tulipifera* [Ferguson, 1982].

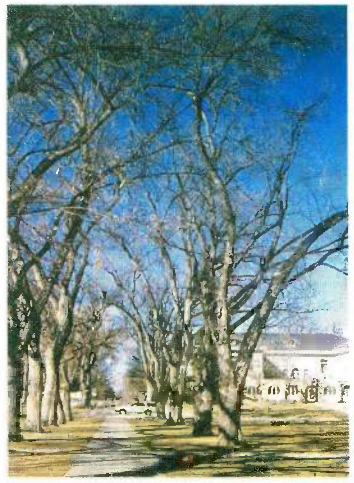

Figure 3.3 American elms (*Ulmus americana*) on the campus of Colorado State University, Fort Collins, Colorado. This graceful tree was once widely planted throughout the eastern and mid-western United States but many have succumbed to the Dutch elm disease.

Shelters, screens and buffers

Shelter plantings are usually designed to protect adjoining areas from effects of wind or frost. The subjects they protect can range from other plants, to homes or greenhouses. Protection may take one of two forms – either overhead protection with overstorey plants or side protection. Trees are also important for screening unsightly areas such as industrial areas. The tall, columnar form of the Lombardy poplar (*Populus nigra* Italica) makes it an excellent choice for this purpose. The broad, spreading form of *Salix babylonica* also makes it a good screen tree. Another tree used for this purpose is *Acer campestre,* which can be grown in hedges [Ferguson, 1982].

Wall trees

Trees with restricted root systems can be used for close planting to walls and homes without fear that the roots will damage foundations. Temperate broad-leaved trees that are good candidates for wall plantings include *Betula* spp., *Carpinus betulus* Fastgiata, *Crateagus phaenopyrum, Ilex opaca* and *Laurus nobilis* [Ferguson, 1982].

PESTS AND DISEASES

A wide variety of pests and diseases affect shade and ornamental trees, many of which can cause significant damage. Because shade and ornamental trees are commonly planted under conditions vastly different from those in their natural ranges, they are often more prone to stress and subsequent invasion by pests and diseases. The widespread death of elms by the Dutch elm disease in Europe and North America has already been mentioned and is a catastrophic example of the loss of a highly valued group of shade trees. The recent introduction into the United States of a long-horned wood-boring beetle (*Anoplophora glabripennis*), an insect native to China, has resulted in the removal of large numbers of *Acer platanoides* and other shade trees in New York City [Haack *et al.*, 1997] and more recently, in Chicago. In many European cities, infection of plane trees (*Platanus acerifolia*) by *Ceratocytis fimbriata*, a vascular fungus native to North America, has caused widespread death of many trees [author's observation].

BONSAI

Bonsai is a technique for retaining the essential growth form of a tree but reducing it to pocket size. A more in-depth treatment of the culture and art of bonsai was presented by the author in the FAO Non-Wood Forest Products Series No. 12 document [Ciesla, 1998].

TEMPERATE BROAD-LEAVED TREES USED IN BONSAI

Like conifers, many temperate broad-leaved trees are popular for bonsai culture (Table 3.1). Many are popular for their hardiness. Some species, such as various cultivars of *Acer palmatum* or *Fagus sylvatica*, are selected because of their deep red to pink foliage colour. The Japanese hornbeam (*Carpinus japonica*) offers a symphony of bronze to yellow foliage colours in autumn. Several temperate broad-leaved hardwoods, such as some members of the family Rosaceae, are popular because of their seasonal flowers [Samson and Samson, 1986].

Table 3.1 Some temperate broad-leaved trees used in bonsai culture

Family and species	Natural range
Aceraceae	
Acer buergerianum (trident maple)	
Acer palmatum (Japanese maple)*	
Aquifoliaceae	
Ilex aquifolium (common holly)	Europe
Ilex crenata (Japanese holly)	Japan
Ilex serrata	
Betulaceae	
Betula nigra (River birch)	Southeast United States
Betula pendula (weeping birch)	Asia, Europe
Carpinus japonica (Japanese hornbeam)	Japan
Carpinus laxiflora	Korea
Fagaceae	
Fagus sieboldii	Japan
Fagus sylvatica (European beech)[1]	Europe
Quercus robur (English oak)	Europe
Quercus petraea	Europe
Quercus pubescens (downy oak)	Europe
Moraceae	
Morus alba (white mulberry)	Asia
Morus issai	
Rosaceae	
Crataegus cuneta	Japan
Malus baccata mandshuria (Manchurian crab apple)	Japan
Malus halliana (Hall's crab apple)	
Malus sieboldii (Toringo crab apple)	China, Japan
Malus himekokoh	Japan
Prunus communis (almond)	Central Asia, Near East
Prunus mume (Japanese apricot)	China, Korea
Salicaceae	
Salix alba	Europe, Near East, North Africa
Salix babylonica (weeping willow)	China, Japan, Korea
Salix nigra (Black willow)	East North America
Ulmaceae	
Celtis bangeana sinensis	Asia
Celtis australis	Mediterranean basin
Ulmus parvifolia (Chinese elm)	South China, Taiwan
Zelkova abelicea	Greece (Crete)
Zelkova carpinifolia	Caucasus
Zelkova sinica	China
Zelkova serrata (Japanese elm)	Japan

1 Various cultivars used
Sources: FAO, 1979; Samson and Samson, 1986

CHAPTER 4

FLOWERS AND FOLIAGE

HONEY

Honey is a sweet, viscous, golden coloured liquid that is "manufactured" by different species of honeybees, such as *Apis mellifera*, from the nectar of flowers. It is stored in wax combs and used by the bees as a food source to feed both immature larval stages and adult bees during winter. Approximately 120 000 bees are required to produce 1 kg of honey and a single bee will produce only about a tablespoon of honey during its lifetime [Thomas and Schumann, 1992].

Honey is also the oldest sweetener known to humans and has been an eagerly sought commodity since prehistoric times. Primitive societies hunted for trees where bees stored honey so that they could obtain a supply of the precious sweetener. Eventually beekeeping or apiculture, the science and art of raising bees in artificial hives, where honey can easily be harvested evolved and today is a major agricultural industry. Modern beekeeping not only provides a supply of a natural sweetener but, more important, makes large numbers of bees available when agricultural crops that depend on insect pollination for production of fruits, nuts and seed are in flower. This is an important agricultural industry because about one-third of the human diet is derived from insect pollinated plants and honeybees are responsible for 80 percent of the pollination [National Honey Board, 1998].

FORMS OF HONEY

Honey can come in a variety of forms. The most common is liquid honey that is extracted from the honeycomb by centrifugal force, gravity or straining. Liquid honey is the most convenient form of honey for cooking or baking and most honey is sold in this form. Creme or spun honey is brought to the market in a crystallised state. The crystallization is controlled so that, at room temperature, the honey can be spread like butter. In many parts of the world, creme honey is preferred to the liquid form. Comb honey is honey that comes as it is produced in the hive, in a honeybee's wax comb. The comb, as well as the honey, is edible. Cut comb honey is honey that has been packaged with chunks of the honeycomb [National Honey Board, 1998].

RELATED PRODUCTS

Related products of honey production are beeswax, bee pollen and royal jelly. Beeswax is sold as a by-product for candles, polishes and as an ingredient in cosmetics. Royal jelly, the secretion of the glands of worker bees, is the queen bee's sole source of nourishment and is promoted as a nutrient for human consumption and energy source. Bee pollen is in demand in Japan as an aphrodisiac [Thomas and Schumann, 1992].

NECTAR SOURCES

The flowers of many plants, including trees, are excellent sources of nectar for honey. The colour and flavour of honeys differ depending on the nectar source visited by the honeybees. The colour ranges from nearly colourless to dark brown and the flavour varies from delectably mild to distinctively bold, depending on where the honeybees worked [National Honey Board, 1998].

The properties of ideal bee forage are the production of large amounts of honey. Flowers must not only produce large amounts of nectar but the nectar must be accessible and produced at the correct time of the year. Moreover, the honey should have a pleasing colour and flavour and be slow to crystallize. In some areas of the world, where finely granulated honey is used, the latter characteristic is of little consequence. However, in the United States where liquid honey is the primary form consumed, it is a valuable attribute [Ayers, 1992].

The flowers of many temperate broad-leaved trees are excellent nectar producers and are capable of producing yields that equal or exceed certain herbaceous plants that are known to be good honey producers (Table 4.1). Up to 40 species of hardwood trees have been listed as important nectar sources in the United States [Jones et al., 2002]. Wild honeys from temperate broad-leaved trees are locally important non-wood forest products in many parts of the world. They often provide a supplemental income source for rural people, and beekeeping is a popular hobby in some countries. Each "wild" honey has its own distinct colour and flavour. In general, lighter coloured honeys are milder in flavour while darker coloured honeys are bolder [National Honey Board, 1998]. The characteristics of honeys obtained from representative temperate broad-leaved trees are described in the following sections.

Table 4.1 Honey production potentials of two temperate broad-leaved trees compared to several herbaceous plants with good reputation as honey producers

Plant or tree	Honey potential (kg/ha)		
Herbaceous plants			
Alfalfa (*Medicago sativa*)	15	–	1060
Yellow sweet clover (*Melilotus officinalis*)	10	–	300
White clover (*Trifolium repens*)	16.2	–	200
Rape (*Brassica napus*)	35	–	500
Temperate broad-leaved trees			
Silver leafed lime (*Tilia tomentosa*)	560	–	1200
Black locust (*Robinia pseudoacacia*)	200	–	1600

Source: Ayers 1992

Eucalyptus spp.

Eucalypts are an important source of honey in Australia, where these trees are native, as well as places where they have been introduced. There is a distinctive flavour to eucalypt honey and between the honeys produced from various species of this genus. These are often kept separate by producers and shopkeepers to meet the demands of customers who have favourite flavours. Jacobs (1979) describes the characteristics of pollen, nectar and honey produced by 36 species of *Eucalyptus*.

The value of plantation eucalypts as a source of honey is being recognized in many countries where various species are widely planted. Plantations often produce far more flowers than do the native eucalypt forests in Australia [Jacobs, 1979].

A unique use of eucalyptus honey is the preparation of the liqueur, *eucalittino*, by the Trappist monks at the *Basilica delle Tre Fontane* (Three Fountains) in Rome, Italy. This liqueur has been prepared and sold at the *Tre Fontane* for more than 100 years [Jacobs, 1979].

Castanea sativa

The flowers of the European chestnut produce a flavourful honey. *Miele di Castanea* is a popular item in speciality food shops in Italy and other European countries. Beehives are often kept in chestnut stands and orchards during the flowering period and provide a supplemental income source for people who own orchards or natural forests of this tree [author's observation].

Liriodendron tulipifera

The tulip poplar is native to eastern North America and has large greenish-yellow flowers that generally bloom in May. Tulip poplar honey is produced from southern New England to southern Michigan and south to the Gulf States east of the Mississippi River in the United States. This honey is dark amber in colour. However, its flavour is not as strong as one would expect from a dark honey [National Honey Board, 1998].

Nyssa ogeche

This locally popular honey is made from the flowers of the Ogeeche tupelo (*Nyssa ogeche*), a tree that grows profusely along the Apalachicola, Choctahatchee and Ochlockonee Rivers and their tributaries in northwestern Florida, United States. Tupelo trees have clusters of greenish flowers, that later develop into soft, berry-like fruits. Tupelo is a leading honey plant in this region, producing tons of honey during April and May. The honey has a mild, pleasant flavour and will not granulate. To gather the nectar to produce this unique speciality honey, bees are placed on bluffs or elevated platforms along the river's edge during April and May. These river valleys are the only places in the world where tupelo honey is produced commercially.

Tupelo honey is a light golden amber colour with a greenish cast. The flavour is delicate and distinctive. Due to its high fructose content, tupelo honey will never crystallize (granulate). Tupelo honey is more expensive than most honeys because it costs more to produce. To gain access to the river location near the tupelo trees requires expensive labour and equipment. In order to ensure the honey is pure tupelo, the bee colonies must be stripped of all stored honey just as the white tupelo bloom begins. Then, the new crop must be removed before the bees can mix it with honey from other sources [National Honey Board, 1998]. One apiary in Florida has a special use permit to place over 2 000 hives in the Appalachicola National Forest for production of tupelo honey [Thomas and Schumann, 1992].

Figure 4.1 Flowers of honey producing temperate broad-leaved trees. Top , black locust (*Robinia pseudoacacia*). Bottom, European linden (*Tilia cordata*).

Prosopis spp.

In the southwestern United States and Mexico, the flowers of mesquites (*Prosopis glanulosa* and *P. pubescens*) are excellent sources of honey. In Arizona, mesquites are rated by beekeepers as the most valuable plant for honey production. Beehives on the Fort Yuma and Cocopah Indian Reservations are often kept in mesquite forests when the bees are not being used to pollinate agricultural crops [Miller, 1997].

The flowers of *P. tamarugo* and *P. chilensis* are locally important sources of honey in the arid northern parts of Chile. Bloom occurs during August, September and part of October. Annual production of *Prosopis* honey averages 9.8 kg/beehive [Garfias Salinas *et al.*, 1995].

Robinia pseudoacacia

This medium to large tree, which is native to the eastern United States, produces large clusters of white flowers that are an excellent nectar source. Honey produced from this tree is of a light golden colour and ranks among the lightest of honeys. It is also exceptionally slow to crystallize [Ayers, 1992]. Black locust honey is popular both in the Unites States and in parts of Europe where this tree has become naturalized [author's observation] (Figure 4.1).

Tilia spp.

Several species of lindens or basswoods are popular sources of honey in Europe and North America. This honey is water white in colour and is often characterized by its distinctive biting flavour. The flowers are cream-coloured and they bloom in late June and July [National Honey Board, 1998].

Other broad-leaved temperate trees that are good honey sources include maples (*Acer spp.*), service berries (*Amalachier* spp.), alders (*Alnus* spp.), various species of wild cherry (*Prunus* spp.) and willows (*Salix* spp.) [Thomas and Schumann, 1992]. The flowers of the sourwood (*Oxydendrum arboreum*) are a popular honey source in the southern Appalachian Mountains [Wigginton, 1973] (see Box 4.1).

PRODUCTION AND TRADE

According to data from FAO, world honey production exceeds 1.1 million t/a and is increasing. This includes honey from all nectar sources (agricultural plants, wild flowers and forest trees). China, Mexico, Russia, Turkey and the United States are among the major honey-producing countries accounting for approximately 55 percent of world production. World trade in honey currently averages 300 000 t/a and exports have been rising steadily since 1975. Germany, Japan, the United Kingdom and the United States are the major markets for honey [Iqbal 1993].

Updated information on production and trade of honey can be obtained from the International Bee Research Association (http://www.cf.ac.uk/ibra) or from the Bees for Development Web site: http://www.planbee.org.uk.

Box 4. 1 Sourwood honey – Pride of the Appalachian Mountains

Ask someone who has lived in the southern Appalachian Mountains about honey and they are quick to tell you that the finest honey comes from the flowers of the sourwood (*Oxydendrum arboreum*). This small to medium tree produces drooping racemes of waxy, white bell-shaped flowers in early July. Their delicate fragrance attracts all the honeybees in the area. The long blooming period of this tree makes it a favourite honey-producing tree, eagerly worked by bees.

Pure sourwood honey is a light straw yellow colour, much like the colour of a fine Italian white wine and has a delicate flavour.

When the author lived in the southern Appalachian Mountains, between 1959 and 1967, he became acquainted with Frank Lambert. Frank was part Cherokee Indian and lived in a cabin on the Qualla Reservation at the foot of the Great Smoky Mountains in Swain Country, North Carolina. Frank was a beekeeper and his bees worked the sourwood trees in the hills that surrounded his cabin. His sourwood honey was regarded as the finest in Swain County and regularly took the highest awards at the county fair.

LEAF OILS AND FLAVOURINGS[5]

EUCALYPTUS OILS[6]

The genus *Eucalyptus* (Family Myrtaceae) is native to Australia and some islands to the north of it and consists of over 500 species of trees. These grow under a wide range of climatic and edaphic conditions in their natural habitat. Eucalypts vary in form from low shrubs and multi-stemmed trees less than 10 m in height (*mallees*) to large single-stemmed trees more than 60 m tall.

Nearly all species of eucalypts have glands in their leaves that produce oils and give the leaves of this group of trees their characteristic odour. These oils are "essential oils" and comprise a range of natural oils that collectively give eucalypt leaves their odour but can be differentiated into separate chemicals that are of value in various industries.

Figure 4.2 Honey produced from the flowers of black locust, *Robinia pseudoacacia*. In Italy it is marked as Acacia honey.

5 The essential oils discussed below are all derived from trees. For information on oils of shrubs as well as of annual plants from temperate zone, consult the following web-page: Specific Oils- http://spas.about.com/travel/spas/msub24oils.htm.

6 If not otherwise indicated, the information is extracted the FAO publication Non-Wood Forest Products Series No. 1, where eucalptus oils are discussed in-depth.

Types of oils and uses

The primary essential oils derived from eucalypts are:

Cineole-rich:	Used in pharmaceuticals and stain removers.
Phellandrene-rich:	Used in industry as a solvent and flotation for metals. Its presence is prescribed by pharmacopoeia in essences intended for pharmaceuticals.
Terpineol-rich:	This oil has a characteristic hyacinth-like scent and is used in perfumery.
Eudesmol-rich:	Used as a fixative in perfumes.
Eudesmyl acetate-rich:	Used as a substitute for bergamot essence and mixes well with lavender essence
Piperitone-rich:	A raw material for production of synthetic thymol and menthol flavourings

Several hundreds of species of eucalyptus have been shown to contain volatile oil, though probably fewer than 20 of these have ever been exploited commercially for oil production. Today, fewer than a dozen species are utilized in different parts of the world, six of which account for the greater part of world production of eucalyptus oils. Those species currently exploited, the percentage of oil in their leaves, the composition of the oil, their uses, as well as the countries in which they are utilized, are listed below. Other species that have been used in the past include *E. cinerea* (medicinal), *E. cneorifolia* (medicinal) and *E. macarthurii* (perfumery).

The value of eucalyptus oil for medicinal purposes lies in its cineole content, which largely determines, also, the price that it fetches. Chinese oil, for example, is commonly traded as "eucalyptus oil 80 percent", referring to the fact that it contains at least 80 percent cineole. In early 1994 the price of standard grade Chinese 80 percent eucalyptus oil had fallen below US$ 3/kg from the US$ 6/kg level in 1989.

The medicinal type of oil is used as an inhalant or chest rub to ease breathing difficulties, as a mouthwash in water to refresh or ease the throat, and as a skin rub to provide relief from aches and pains. Eucalyptus oil is also used as a general disinfectant, cleaner and deodorizer about the house.

For the perfumery oils, aroma characteristics are important. According to published standards for *E. citriodora* oil, the aldehyde content calculated as citronella should be less no less than 70 percent. *Eucalyptus citriodora* is the major of the two principal perfumery oils. It differs from the medicinal oils in containing citrinellal, rather than cineole, as the major constituent. The oil is employed in whole form for fragrance purposes, usually in lower cost soaps, perfumes and disinfectants, but also as a source of citrinellal for the chemical industry. The citrinellal obtained by fractionation of the crude oil may be used as such as an aroma chemical or converted to other derivatives intended for fragrance use. The only other perfumery oil produced in any quantity is that from *E. staigeriana*. No single chemical predominates in the oil and it is used in whole form for perfumery purposes. It has a lemon-type character.

In countries where eucalypts have been planted, *E. globulus* has been the main commercial source of essential oils. Its leaves yield about 1 percent of cineole and eudesmol and this can be considered an adequate return if a massive quantity of leaves can be obtained following tree harvesting operations.

Yields of oil from leaf vary somewhat between species but, on a commercial scale, are of the order of 1 percent on a "fresh" basis. Of more relevance to the economics of production is the yield of oil per ha and this is dependent on the biomass production, as well as the oil yield from the leaf. Production from *E. smithii* in Swaziland yields approximately 15 t/ha of leaf, corresponding to about 150 litres/ha of oil.

There may also be marked differences in oil yield and quality within a species according to the provenance origin of the seed. *E. camaldulensis*, for example, has a very wide distribution in Australia, but only certain northern Queensland provenances (Petford, in particular) yield an oil, which makes the species attractive as a source of medicinal oil. In extreme cases, in their natural habitat even trees within the same provenance may produce oils, which are quite different to each other. *E. dives* is a well-known example and it is possible to obtain seed from cineole and piperitone variants.

Those species of eucalyptus which respond well to coppicing may be grown specifically for oil on a short-rotation cycle. In Swaziland, where oil is obtained from *E. smithii,* the first cut is made 20-24 months after planting. Subsequent cuts of the coppice regrowth are made at approximately 16-month intervals, at which time the plants are 5-6 m tall. Harvesting may continue for many years and in Swaziland some areas of *E. smithii* are still being harvested after 20 years or more.

Table 4.2 Eucalyptus species used for essential leaf oils

Species	Percent oil in leaves	Composition of oil	Uses	Countries[1]
Eucalyptus globulus Labill. (Tasmanian blue gum)	1.0	Cineole and eudesmol	Medicinal	China, Portugal, Spain, India, Brazil, Chile, (Bolivia, Uruguay, Paraguay)
E. smithii R. Baker (gully gum)			Medicinal	South Africa, Swaziland, (Zimbabwe)
E. polybractea R. Baker(syn. E. fruticetorum F. Muell. ex Miq.) (blue mallee)	2.0	Cineole	Medicinal	Australia
E. exserta F. Muell. (Queensland peppermint)			Medicinal	China
E. radiata Sieber ex DC. (syn. E. australiana, E. radiata var. australiana) (narrow-leaved peppermint)	3.0-5.0	Cineole, terpinol	Medicinal disinfectant, flotation	(South Africa, Australia)
E. dives Schauer (cineole variant) (broad-leaved peppermint)	3.0-4.5	Piperitone, phellandrene	Medicinal Manufacture of thymol and menthol	(Australia)
E. camaldulensis Dehnh. (syn. E. rostrata Schldl.) (river red gum)			Medicinal	(Nepal)
E. citriodora Hook. (lemon-scented gum)	0.8-1.0	Citronella	Perfumery, Insect repellent	China, Brazil, India
E. staigeriana F. Muell. ex Bailey (lemon-scented ironbark)			Perfumery	Brazil

[1] The use of parentheses indicates a minor producer.
Source: Coppen, 1995; Jacobs, 1979.

There exists mechanical harvesting of *E. polybractea* in Australia. This system of harvesting was developed in Australia as a means of reducing labour costs and is used to harvest natural stands of *E. polybractea.* The frequency of harvesting is between 18 and 24 months, at which time the shrubs are about 1 m high.

Production and trade

The essential oils derived from *Eucalyptus* are classified in the trade into three broad types according to their composition and main end-use: medicinal, perfumery and industrial. The medicinal types are the most important ones in terms of volume of production and trade.

Plantation eucalypts dominate world production and trade in eucalyptus oils. During the period 1970-1974, only 8.8 percent of the world production came from natural forests in Australia. World production and trade in eucalyptus oils are dominated by the People's Republic of China, which is the largest producer of both cineole-rich medicinal oils (about 70% of world output and trade) and perfumery oil (from *E. citriodora*). During the period 1993 to 1997, Chinese exports of eucalyptus oil averaged approximately 3 800 t/a, with an average annual value of US$ 11.9 million [Coppen, unpublished). Furthermore, several importing countries such as Portugal, Spain and Australia are also producers and processors of eucalyptus oils and re-export much of what they import.

Total world production of medicinal-type eucalyptus oil in 1991 has been estimated at around 3000 t, of which approximately 2 000 t were exported [Coppen and Hone, 1992]. Production and exports of *E. citriodora* oil, the main perfumery oil, for 1991 are estimated at about 1500 t and 500 t, respectively. Globally, the European Community is the largest importer of eucalyptus oils.

Production of *E. citriodora* oil is also dominated by the People's Republic of China. In 1991 it is estimated that the country accounted for approximately two-thirds (1 000 t) of total production, of which perhaps 400 t were exported. Brazil (500 t/a) and India (50 t/a) are the only other producers of this type of oil, with Brazil exporting about half of its production. Brazil is the only supplier to the world market of *E. staigeriana* oil; production is of the order of 60 t/a.

Within Europe, France, Germany and the United Kingdom are the major markets for eucalyptus oil-based products. In 1990 their combined imports amounted to 1 840 t. Imports into the United States, the largest single country market for eucalyptus oils (excluding the People's Republic of China and those countries, which re-export much of their imports after further processing).

Southern Africa is a major producing region for eucalyptus oil, most of it from South Africa but a significant proportion from Swaziland. In South America, Chile and Brazil are the major producers, with smaller amounts coming from Bolivia, Uruguay and Paraguay. In recent years, Chile has exported between 47 t/a and 144 t/a of essential oils, primarily from *E. globulus* (extensive eucalypt plantations) (Table 4. 2) [Garfias Salinas *et al.*, 1995].

Table 4.3 Exports of eucalyptus oils from Chile 1987-1992

Year	Quantity exported (tons)	Value (US$)
1987	66.3	700 000
1988	106.2	1 053 683
1989	144.1	1 305 752
1990	116.7	1 026 040
1991	79.3	700 829
1992	47.5	369 316

Source: Garfias Salinas *et al.*, 1995.

During the same period, the leading producers of eucalyptus leaf oils were countries with Mediterranean climates. Portugal and Spain accounted for 44.2 percent and 12.4 percent of global production, respectively [Jacobs, 1979].

BAY LAUREL

Figure 4.3 Grading of dried bay leaves in Turkey (photo by G. Allard).

Laurus nobilis (Family Lauraceae), known as bay laurel, sweet bay or laurel, is an evergreen shrub or small tree, indigenous to the Mediterranean Basin and the Near East. This plant has been admired for its beauty and aromatic leaves since Greek and Roman times (see Chapter 2).

The dark green leaves of bay laurel are fragrant and aromatic. After drying, they are broken, cracked or cooked to release their characteristic aroma and flavour. Dried laurel bay leaves are used as flavouring in soups, fish, meats, stews, puddings, vinegars and beverages. Oil of bay or oil of laurel leaves is an essential or volatile oil obtained by steam distillation of bay leaves and oleoresin has replaced the dry leaves in some food preparations.[7]

[7] The foliage of some number of plants with the common name " bay" or "laurel" are poisonous and should not be used as a substitute for *Laurus nobilis*. Examples include mountain laurel (*Kalmia latifolia*), sheep laurel (*K. angustifolia*), cherry laurel *Prunus laurocerasus*), bull bay (*Magnolia grandiflora*), bayberry (*Myrica pennsylvanica*) and loblolly bay (*Gordonia lasianthus*) [Simon *et al.*, 1984].

The oil of laurel reaches a content of 1-3 percent on a fresh weight basis. The main constituents of this oil are 1,8-cineole, pinene, sabinene, 1-linalool, eugenol, eugenol acetate, methyleugenol, 1-terpinol acetate, phellandrene, other esters and terpenoids. This oil is generally recognized as being safe for human consumption as a spice, natural flavouring and essential oil extract and is used by the cosmetics industry for creams, perfumes and soaps.

The leaves and berries of *Laurus nobilis* have also been used for treatment of rheumatism, skin rashes, earaches and other medical problems. Further, they are also used as an insect repellent.

Bay leaves are collected from both cultivated and wild plants in many Mediterranean countries. Commercial production centres in the Mediterranean basin include portions of Algeria, France, Greece, Morocco, Turkey and Portugal and Spain (minor producers). Outside the Mediterranean Basin, bay leaves are produced in the Canary Islands, Central America, Mexico and the southeastern United States [Simon *et al.*, 1984].

MINOR LEAF OILS

The foliage of several other species of plants of the family Lauraceae has aromatic foliage. The myrtlewood or California laurel (*Umbellularia californica*) (Figure 4.4), a tree indigenous to southwestern Oregon and northern California, was used as a substitute for bay leaves (*Laurus nobilis*) by the early European settlers in the region [Hora, 1981; Ciesla, 1990b]. An essential oil extracted from this tree contains umbellulone and has been used both as an insecticide and as a condiment. This oil is a mucous irritant and has shown some toxicological properties (see Box 4.2). Myrtlewood oil also contains safrole, a compound that has been shown to have carcinogenic and hallucinogenic properties [Simon *et al.*, 1984].

The dried, ground leaves of American sassafras (*Sassafras albidum*) are known as file gumbo and are used in traditional Creole or Cajun dishes both for their flavouring and thickening properties [Harlow and Harrar, 1950; Hora, 1981; author's observation]. Sassafras leaves do not contain safrole, a carcinogen that is found in the roots and bark of the tree and are safe for human consumption.

The aromatic foliage of *Pemus boldus* (common name, boldo), a tree which occurs in the mountain ranges of central Chile, is rich in alkaloids, flavinoids, tannin, citric acid and related products. Branches containing foliage are harvested with a machete and placed in a shady, clean place to dry for two to three days before the oils are extracted [Garfias Salinas *et al.*, 1995]. The foliage is also the source of an herbal tea which is popular in Chile [author's observation].

Figure 4.4 The foliage of the Oregon myrtlewood (*Umbellularia californica*) is aromatic and has been used as a substitute for foliage of *Laurus nobilis* as flavouring for soups and stews. However, its principle oils constituent, umbellulone, has been shown to be a mucous irritant and has some toxicological properties.

Box 4.2 The headache tree

The smooth, shiny foliage of the myrtlewood (*Umbellularia californica*) has a strong, camphor-like odour. One can smell a grove of these trees before one can see them.

The odour of its foliage is so strong that people have been known to get a headache from sitting under a tree for just a short period of time. The leaves, when crumbled, are also known to be irritating to the nose and throat. One of its many common names is "headache tree." Other common names are California myrtle, California laurel, myrtlewood, pepperwood and spice tree.

This tree, indigenous to southwestern Oregon and northern California, is one of the few broad-leaved trees that is found among the giant conifers that occur in this region [Hora, 1981; Ciesla, 1990].

YERBA MATÉ

Yerba maté is a species of holly, *Ilex paraguariensis* (family Aquifoliaceae), which occurs in the subtropical/warm temperate forests of southern Brazil, Uruguay Argentina and Paraguay. The evergreen foliage of this plant (Figure 4.5) is harvested, dried and ground into a fine powder and is used as a tea. Yerba maté is a popular regional beverage and the foliage is harvested either in small plantations or from natural forests where this plant grows.

Yerba maté has a characteristic mature flavour similar to that obtained from tea (*Camellia sinensis*). The flavour can be described as sweet, bitter, withered leaf-like, and alfalfa-like. The herb contains A, C, E, B1, B2, B complex; carotene; riboflavin; pantothenic acid; biotin; and vitamin C complex. Moreover, it has 15 different amino acids, plus significant amounts of magnesium, calcium, iron, sodium, potassium, manganese, silicon, phosphates, zinc, niacin, sulphur, and chlorophyll, choline and inositol.

To the Guarani Indians, yerba maté is known as the "drink of the gods". They used it for medical purposes such as to boost immunity, cleanse and detoxify the blood, tone the nervous system, combat fatigue, reduce stress and stimulate the mind. Still today, tens of millions of South Americans use yerba maté for its medical properties.[8] The plant has stimulant properties and is supposedly beneficial for headaches, migraine, neuralgia and insomnia. Its stimulant principle is caffeine but it has a lower caffeine content than either tea of coffee [Hora, 1981; Lust, 1990]. Yerba maté is usually sipped from a traditional gourd-like cup, made of wood, with a built-in drinking straw, bombilla, a silver straw with a bulbous filter at its lower end that prevents the leaves from entering the tube (Figure 4.6) [author's observation]. The gourds can range from simple calabashes to carved wooden or silver vessels, some of which have become museum pieces (Berhardson 1996). People can be seen drinking this traditional beverage as far as the Argentine Patagonia, far from the natural range of *Ilex paraguayensis* (author's observation).

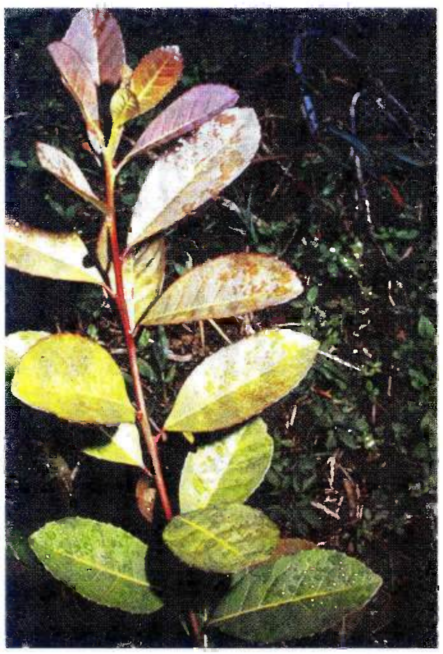

Figure 4.5 The foliage of the yerba maté (*Ilex paraguariensis*) is used in a tea that is a popular regional beverage in southern Brazil, Uruguay, Argentina and Paraguay.

Figure 4.6 Yerba maté is usually drunk from a traditional cup, made of wood, with a built-in drinking straw.

8 Source: Yerba maté (http://www.go-symmetry.com/yerba-mate.htm)
Yerba maté "drink of the gods" (http://www.yerbamate.com/nutrition.html)
Yerba maté – What is it? (http://noborders.net/mate/what.html)

Yerba mate became commercially important during the colonial era on plantations of Jesuit Missionaries established on the upper Parana River. Today, Argentina is the world's largest producer and consumer of mate. Argentines consume an average of 5 kg per person per year, more than four times the average intake of coffee. In Argentina, yerba maté was first grown in experimental plantations in 1903. Cultivation has expanded considerably and during the 1991/92 season, production was 482 000 t with an average yield of 1 800–2 400 kg/ha. Areas where yerba maté production is an important part of the economy include Misiones Province and the northeastern portion of Corrientes Province. The value of the mate production in Argentina was estimated at US$ 80 million, with exports of maté at approximately US$ 28 million for 1998 [Résico, 1995, 2001].

DECORATIVE FOLIAGE

The foliage of many species of temperate broad-leaved trees used in various kinds of home floral decorations and the harvesting of several species provide a supplemental income for rural people.

The foliage of deciduous broad-leaved trees and shrubs is not as durable as the foliage of conifers or evergreen broad-leaved species and cannot be transported for long distances. However, the foliage of some species is locally important. In Germany, for example, the branches and foliage of the North American red oak (*Quercus rubra*), a tree widely planted in some parts of central Europe as a timber producing species, is considered to be a speciality product and is available for sale in some floral markets for home decorations [Ehlers, 1968; Rau, 1969]. Gathering the foliage of deciduous foliage of broad-leaved trees and shrubs for home decoration is often a popular recreational activity both in Europe and North America, especially in autumn when the foliage of many species turns brilliant colours.

In British Columbia, 19 floral greenery products, generated from more than 30 species of forest plants, are identified. Examples include shrubs like *Gaultheria shallon* (salal), *Caccinium ovantum* (evergreen huckleberry), *Berberis nervosa* (Oregon-grape) and *Xerophyllum tenax* (beargrass) [Chamberlain, Bush and Hammet, 1998].

The demand for high-quality beargrass (*Xerophyllum tenax*) has increased. The highest grade beargrass (darkest leaves) grows in areas with overstorey tree canopy closure greater than 60 percent while the most productive plants produce the lowest grade beargrass, and grow in areas with less than 30 percent overstorey tree canopy closure.[9]

These floral greens are important to the economy of the Pacific Northwest. For instance, the regional sale of salal green reached US$ 13 million, the one of beargrass US$ 11.5 million and evergreen huckleberry amounted to more than US$ 1.7 million in 1989 [Chamberlain, Bush and Hammet, 1998]. In British Columbia, exports of salal account for more that those of mushrooms [Tedder *et al*., 2000].

In Christian cultures, the spiny, dark green foliage and brilliant red berries of the American holly (*Ilex opaca*) and the European holly (*I. aquifolia*) are used in the production of Christmas wreaths and garlands. The foliage of *I. opaca*, a tree that has a natural range throughout much of the eastern United States, is harvested primarily from natural forests. In the Pacific Northwestern states (Oregon and Washington), plantations of the European *I. aquifolia* have been established. During the 1930s and 1940s, harvesting of holly foliage was so heavy and damaging to trees in natural forests along the Atlantic coast of the United States that *I. opaca* was practically eliminated from the northern part of its range [Panshin *et al*., 1950].

The foliage of some species of *Eucalyptus* dries well and is popular additions to floral arrangements. The evergreen leaves and branches of *Laurus nobilis,* a Mediterranean species, are used in garlands and wreaths [Simon *et al*., 1984].

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9 Source: Cispus Adaptive Management Area (http://www.fs.fed.us/gpnf/ama/review_1998/beargrass.htm)

MINOR AND TRADITIONAL USES OF FOLIAGE

The stiff, spiny foliage and branches of holly (*Ilex* spp.) were once used in Europe by chimney sweeps [Hora, 1981].

The foliage of several species of elms (*Ulmus* spp.) was once the preferred feed for cattle over large areas. The use of this foliage was frequently mentioned by Roman agricultural writers and persisted in parts of Europe until the early 1900s. The use of *Ulmus wallichiana* foliage as a cattle feed is still important today in the Himalayas [Hora, 1981]. Even now, in many developing countries, foliage of several temperate broad-leaved tree species is cut and dried during the summer for use as cattle feed in the winter (Figure 4.7).

The leaves of *Crataegus laevigata*, a small tree native to Europe and North Africa were used in a leaf infusion tea to reduce high blood pressure. The leaves of this tree were also used as a substitute for tobacco [Hora, 1981].

Willow (*Salix* spp.) foliage contains salicin that becomes salicylic acid in the human body and is the principal ingredient in aspirin (see Chapter 6). The foliage can be chewed to relieve minor pain and fever [Lust, 1990].[10]

Figure 4.7 Temperate broad-leaved trees (including species like *Querqus castaneifolia*, *Fagus silvatica*, *Acer* spp., *Carpinus* spp. and *Ulmus* spp.) with their branches looped for fodder (Elbrouz Mountains in northern Iran). The branches are cut in the summer, dried and tied as fodder along the tree stem for feeding cattle during the winter (photo by P. Vantomme).

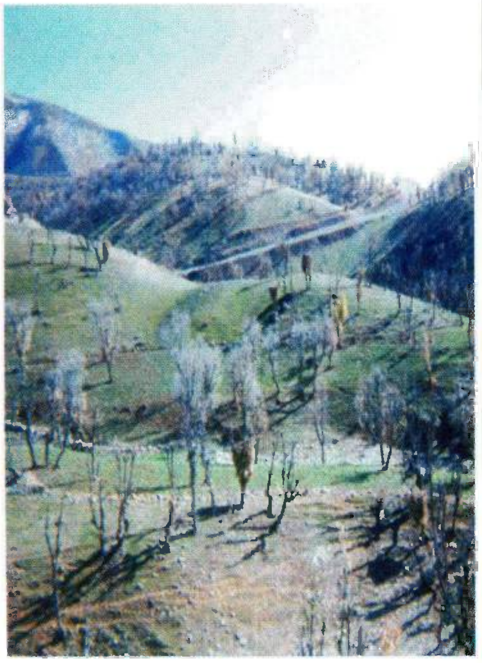

Figure 4.8 Severe degradation of a temperate broadleaf forest (in which all remaining trees have their branches regularly cut-off for fodder) in northern Iraq (photo by M. Malagnoux).

10 Source: The Herbal information Center (http://gic.simplenet.com/dr/herb/whitew.htm)

CHAPTER 5

SAP AND RESIN

SYRUPS, SUGAR AND CONFECTIONERY PRODUCTS

MAPLE SYRUP AND RELATED PRODUCTS

The sap of most maples (*Acer* spp.) contains relatively high levels of sugar (2–5 percent). In eastern Canada and the northeastern United States, maple sap is harvested and evaporated for production of syrup and sugar and is an important regional non-wood forest product.

Historical aspects

Indigenous tribes in eastern North America knew of the high sugar content of maple sap, calling it "sweet water." They harvested the sap using primitive methods such as piercing the trunk of a maple with an axe (tomahawk) and inserting a piece of bark or wood to collect the sap. When the first European explorers and colonists arrived on the North American continent, the local indigenous tribes introduced them to the sweet flavoured maple sap. The pottery of the indigenous tribes did not withstand heat, however. Consequently, they were unable to boil the sap down to produce syrup or sugar. The harvesting of maple products in North America by European settlers is believed to have begun in about 1680. Blocks of maple sugar were first exported from Quebec, Canada, to France in 1691.

When the French settlers arrived in eastern Canada, tapping of maple trees was done with a small axe. A wooden spile was inserted to channel the sap into a receptacle made from the bark of paper birch (*Betula papyrifera*). Around 1885, the wooden spout was replaced by one made of metal and tapping was done with a steel gouge. Roughly five years later, wooden pails suspended by a nail made their appearance and reduced the amount of sap lost.

The first European settlers produced just enough syrup and sugar to meet their own needs. In early spring, when the sap begins to flow in the maple trees, they would sometimes travel considerable distances to reach sugaring sites. Once they arrived, they would build a temporary shelter, install spouts and pails and wait for the sap to flow. Barrels of maple sap were transported by means of an ox-driven sleigh to the boiling shack where it was boiled down in a cast iron cauldron. After 1900, flat-bottomed pans that were placed on enclosed stonewall fires replaced the cauldrons. Later a decantation siphon was added to the flat-bottomed pans and evaporators were developed. Today's systems include integrated thermometers, floaters that control the intake and level of maple sap, a hood to evacuate the steam and oil burners that are replacing wood as a heat source.[11]

Species

Sugar maple (*Acer saccharum*) is the species most frequently tapped for sap production. This tree is a major component of temperate broadleaf forests in eastern Canada and the northeastern of the United States. Black maple (*A. nigrum*) is so similar to sugar maple that it is often not differentiated from sugar maple and is also tapped. The so-called "soft" maples – red maple (*A. rubrum*) and silver maple (*A. saccharinum*) – are also occasionally used for syrup production. However, a major drawback of using these species is that bud development occurs earlier in the spring and the sap becomes unusable before the end of the sap flow season. Studies indicate that Manitoba maple (*A. negundo*) and the European "Norway" maple (*A. platanoidesl*) are also considered to be potential maple syrup producers [Walters, 1982b], and there has been some interest in tapping big-leaf maple

[11] Source: Institut Québécois de l'Érable, Quebec, Canada (http://www.erable.org)

(*Acer macrophyllum*), a tree indigenous to the Pacific Coast of North America [Sednak and Bennick, 1985].

Products

The principal product produced from the sap of maple trees is maple syrup (Figure 5.1). Quite simply, maple syrup is sap that has been boiled until much of the water has evaporated and the sap has become thick and syrupy. At the beginning of the sugar season, when the sap is concentrated, it takes about 20 litres of sap to make 1 litre of syrup. Toward the end of the season, it may take up to 50 litres of sap to make one litre of syrup. Maple sugar, which is about twice as sweet as granulated white cane or beet sugar, is the result of continuing to boil the sap until all of the liquid has evaporated. In-between these two stages, at least two other products can be made: maple honey, which is thicker than syrup but still a liquid, and maple cream or butter, which is thick and spreadable. A less expensive product is maple-flavoured syrup, which is a combination of corn or molasses syrup with a small amount of maple flavouring.[12]

Figure 5.1 Grade A, dark amber maple syrup produced in Vermont and packaged for retail sale.

Maple syrup has about the same calories as an equivalent amount of white cane sugar and contains potassium and calcium along with trace amounts of sodium, iron and phosphorus (Table 5.1).

Table 5.1 Nutritional value of a tablespoon of maple syrup

Nutrient	Amount
Potassium	35 mg
Calcium	21 mg
Sodium	> 2 mg
Iron	Trace
Phosphorus	Trace
B vitamins	Trace
Calories	50*

* Approximately equal to an equivalent amount of cane sugar.

12 Source: Epicurious Food (http://www.epicurious.com/db/dictionary/terms/m/maple-su.html)

Sap collection

Forests where maple sap is collected are referred to as "sugar bushes." Sugar bushes are generally found on privately owned woodlots and consist of maple stands of natural origin. Differences in past cutting practices and land use have resulted in wide variation in the age, density, form and composition of these stands. Most have originated from second or third growth forests or from young stands of sugar maple that naturally seeded on abandoned agricultural lands. Another type of sugar bush is referred to as a non-forest sugar bush. These are individuals or small groups of trees growing in the pasture of small dairy farms or trees growing along roadsides and fence lines [Walters, 1982b]. Under the best conditions, sugar maples reach a tappable size in about 40 years. The number of taps per tree varies by the tree's diameter at breast height (dbh). A guideline for the number of taps is: 25–38 cm, one tap; 39–50 cm, two taps; and 51–64 cm, three taps [Thomas and Schumann, 1992]. A carefully tapped tree will give, drop by drop, about 12 litres of sap on a warm spring day, and could continue to produce sap for a century. During the maple sugaring season, which lasts about six weeks, an average maple tree will yield between 35 and 50 litres of sap. This will produce between 1 and 1.5 litre of pure maple syrup.

The maple tapping season generally lasts from mid-March to mid-April, during the thawing of the ground after winter, but before the buds burst on the maple trees. A good maple season has warm days, but nights below freezing point. Maple sap does not flow during the night.[13]

Sap collection is a labour-intensive process and accounts for more than 40 percent of the total labour involved in syrup and sugar production. Metal buckets are the traditional collection utensils and are still widely used. The most commonly used metal buckets are zinc-coated and hold about 15 litres of sap. Minute amounts of zinc dissolve in the sap and dissolve microbial growth. Aluminium buckets are popular in Canada.

Plastic bags have replaced buckets as sap collectors to some extent and have the advantage of keeping the sap cleaner because they have narrow, covered openings. Moreover, because the plastic bags are transparent, the sterilizing effect of ultraviolet (UV) light from the sun improves sap quality. Plastic bags are lightweight and, because they lie flat, require a minimum of storage space. On the other hand, plastic bags are less durable than metal buckets and are subject to splitting and tearing.

Regardless of whether metal buckets or plastic bags are used, the sap must be collected at regular intervals during the tapping season. Most often, a gathering tank mounted on a sled or wagon is drawn through the sugarbush and the buckets or plastic bags are emptied into the tank. Sap loss from spillage or missed buckets can be a significant factor in the efficiency of a sap-collecting operation.

Figure 5.2 A traditional sugaring-off party in Quebec, Canada (photo courtesy of Victor Brunette, La Fédération des Producteurs de Bois du Québec, Longueuil, Québec, Canada).

Box 5.1 The sugaring off party: A maple country tradition

In both Canada and the United States, the maple syrup industry is dominated by owners of small woodlots, who have managed to carry on many of its colorful traditions.
One of the more colourful traditions is the "sugaring off" party that takes place after the final boiling of the sap has been completed. Friends and neighbours, especially young children are invited to participate. The party usually consists of a hearty feast followed by the making of maple taffy. The steaming hot syrup is taken from the evaporators and poured over clean, fresh snow. The end product is cold and chewy and is a memorable taste experience (Figure 5.2).

13 Source - Canada Maple Products, Plessisville, Quebec, Canada (http://www.ivic.gc.ca)

Plastic pipeline systems of various configurations and pumping systems have been used by sap producers with varying degrees of success although many still use metal buckets or plastic bags for sap collection [Walters, 1982a]. The collected sap is boiled down into syrup in flat metal tanks or evaporators in buildings known as sugar camps or sugar houses and must be boiled the same day it is gathered (Figures 5.3 and 5.4).

Figure 5.3 An evaporator in a sugarhouse in Quebec, Canada (photo courtesy of Victor Brunette, La Fédération des Producteurs de Bois du Québec, Longueuil, Québec, Canada).

Plastic pipelines, that are attached to tapped trees and run to a collecting station or directly to the sugarhouse, were developed during the 1950s and are a means of improving the efficiency of sap collecting. Advantages of a plastic pipeline system include:

1. It permits a better distribution of labour during sugaring;
2. Results in less labour during sap collection;
3. Achieves more sanitary collection and transportation of the sap;
4. Eliminates road building and maintenance in sugar bushes.
5. Increases yields by reducing infection in the taphole by airborne microorganisms.

Figure 5.4 A sugarhouse in Quebec, Canada (Photo courtesy of Victor Brunette, La Fédération des Producteurs de Bois du Québec, Longueuil, Québec, Canada).

Production and trade

The world's supply of pure maple syrup is produced in a relatively small area, including parts of Quebec, Ontario and the Maritime Provinces of Canada and the New England, mid-Atlantic and northern mid-western United States [Sendak and Jenkins, 1982]. Canada accounts for about 75 percent of world production with the remainder being produced in the United States. In Canada, there are about 13 000 maple syrup producers and the Province of Quebec accounts for about 90 percent of all Canadian production. Maple syrup production is Quebec's fourth leading agri-food industry in terms of exports. During the period 1985-1995, average annual production of maple syrup in Canada was 13 851 000 litres (Table 5.2). Approximately 68 percent was exported, valued at 120 million CDN dollars. Eighty-five percent of Canadian exports go to the United States, 10 percent to Europe and 5 percent to Asia. Exports have been increasing at a steady rate as new markets and trading opportunities develop in Asia and Europe for this uniquely North American product.[14] Maple syrup production in Canada has seen an upgoing trend. In 1999, it reached 33 523 t, which represents an increase of 20.9 percent over the previous year.[15]

The marketing of maple products in Canada is centred in a few large cooperatives and marketing syndicates which purchase almost 70 percent of the syrup produced. The largest of these is located in Plessisville, Quebec. This facility purchases all or part of the production of some 5 000 syrup producers. The cooperatives and syndicates are oriented toward a few large buyers of dark maple syrup in Canada and the United States but they also market large quantities of table-grade syrup in bulk lots and small retail containers [Sendak and Jenkins 1982].

During 1991, total maple syrup production in the United States was approximately 6 180 000 litres with a market value of US$ 39 279 000 [Thomas and Schumann, 1992]. Approximately two-thirds of the maple syrup is produced in Vermont and New York. Other states, which produce maple syrup, are Maine, Massachusetts, Michigan, New Hampshire, Ohio and Pennsylvania. In 1999, maple syrup production totalled 1.18 million US gallons.[16] As of the early 1980s, there were about

14 Source: Agriculture Canada (http://aceis.agr.ca)
Natural Resources Canada (http://nrcan.gc.ca/cfs/proj/iepb/nfdp/cp95/data_e/tab56e.htm)
15 Source: 1999/2000 Canadian maple products situation and trends (www.agr.ca)
16 Source: 1999/2000 Canadian maple products situation and trends (www.agr.ca)

4 900 maple producers in the United States with an average of slightly less than 1 000 taps each. Roughly, 60 percent of the syrup produced in the United States is packaged and sold in retail containers by producers. The remainder is sold in bulk drums to processors or packers who package it for retail sales as pure maple syrup or further process it for use in blended maple products or as a flavouring in other products. Marketing cooperatives handle only a small portion of the maple syrup produced in the United States [Sendak and Jenkins, 1982].

Grading

Federal grading systems for pure maple syrup exist in both Canada and the United States. In addition, the states of Vermont and Wisconsin have their own grading systems (Table 5.4). These are based on syrup colour. The highest grades are assigned to the lighter coloured syrups. The Canadian system is based on spectrophotometric values relative to three caramel-glycerine solutions. In the United States, the method of grading is based on the glass colour comparator. Research has shown that these two systems do not yield consistent results. The reason for this is that the colouring agents in maple syrup are somewhat different from pure caramel. A syrup and a caramel-glycerine solution that are visually the same colour will yield different percent transmittances when measured at a single wavelength in a spectrophotometer. Syrups are consistently graded higher using the colour comparator than they are in the spectrophotometer [Sednak and Jenkins 1982).

Table 5.2 Maple Syrup Production – Canada 1985-1995 (thousands of litres)

Year	Province						
	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Total
1985		68	50	9 201	1005		10 324
1986		64	118	9 274	614		10 070
1987		45	100	8 001	536		8 682
1988		95	164	13 274	714		14 247
1989		91	145	14 720	686		15 642
1990	1.36	95	155	12 956	764	0.60	13 972
1991	0.85	82	164	12 515	850	0.28	13 612
1992	1.13	118	768	15 984	1 364	0.74	18 236
1993	1.13	91	374	10 697	936	0.80	12 100
1994	1.10	151	374	18 684	986	1.00	20 197
1995	1.10	117	367	13 727	1 062	3.80	15 278
Average	1.00	92	253	12 639	865	1.00	13 851

Source: Natural Resources Canada

Table 5.3 Canadian exports of maple syrup and sugar 1988-1995

Year	Maple syrup(thousands of litres)	Maple sugar (kg)
1988	5 258 051	1 707 810
1989	5 507 624	1 014 329
1990	7 874 763	577 192
1991	8 233 233	582 794
1992	9 564 950	210 564
1993	11 570 441	385 116
1994	13 973 267	289 864
1995	14 119 877	405 277
Average	9 512 776	646 618

Source: Natural Resources Canada

Table 5.4 Grades of maple syrup in Canada and the United States

Country/State	Standard				
Canada (Federal and Quebec)	*Number 1 Extra Light*	*Number 1 Light*	*Number 1 Medium*	*Number 2 Amber*	*Number 3 Dark*
	Transmittance not less than 75%	Transmittance between 60.5 and 75%	Transmittance between 44.0 and 60.5%	Transmittance between 27.0 and 44.0%	Transmittance less than 27%
United States (USDA)[1]	*Grade A Light Amber* Not darker than light amber colour standard (NDLA)	*Grade A Medium Amber* Not darker than medium amber colour standard (NDMA)	*Grade A Dark Amber* Not darker than dark amber colour standard (NDDA)	*Grade B For reprocessing* Darker than dark amber colour standard (DDA)	Substandard
Vermont	*Fancy* NDLA	*Grade A Medium Amber* NDMA	*Grade A Dark Amber* NDDA	*Grade C* DDA	
Wisconsin	-	*Fancy* NDMA	*A* NDDA	*Manufacturing Grade* DDA	

[1]The states of New Hampshire, New York, Maine, Massachusetts and Pennsylvania have adopted the USDA standard grades with minor definitional changes. Michigan and Ohio do not have state grades.
Source: Sendak and Jenkins 1982

Pests and diseases

Maple decline, characterized by branch dieback, chlorotic foliage, premature fall colouring and occasional tree mortality, is caused by a variety of factors including drought, defoliation by insects, road salt and root fungi [Houston, 1981; Manion, 1991]. A regional decline of sugar maple over portions of Ontario and Quebec began to appear during the late 1970s and increased in intensity during the early 1980s. This condition caused a great deal of concern about the future of the maple syrup industry, especially in Canada. Many hypotheses were suggested for the cause of this decline including timber-harvesting techniques, tree age, tapping for syrup, livestock grazing, soil and air pollution, weather anomalies and insect defoliation. A popular causal hypothesis was that the condition was caused by acid rain. Studies confirmed that the region receives high acid deposition [Linzon, 1988], however a causal relationship between acid rain and maple decline was never established. A cooperative Canadian and American study on sugar maple decline showed an apparent improvement in the health of this species after about 1988 [NAPAP, 1982].

BIRCH SYRUP AND RELATED PRODUCTS

The sap of various species of birch (*Betula* spp.) is also sweet and is tapped in spring for syrup production in the northern forests of Europe and North America. Birch syrup differs from maple syrup in that the natural sugar found in birch is fructose instead of sucrose. The sap flow in birches occurs somewhat later than with maples but is said to flow more copiously. Birch sap is only about half as sweet as maple sap and approximately 100 litres of sap are required to produce one litre of syrup [Peyton, 1994].

Fresh birch sap is said to have just a hint of sweetness, with a slightly minty, wintergreen flavour. In late spring, birch sap can be a good source of moisture for someone travelling through marshy areas where there is no pure water available. Birch syrup resembles molasses and has no hint of wintergreen flavour. Oil of wintergreen is a volatile essential oil and is driven off during the boiling process.[17] In parts of Europe, a beer, wine, spirit and vinegar are prepared from birch sap. Birch wine is produced from birch sap collected in March. Honey, cloves and lemon peel are added and then it is fermented with yeast to make a pleasant tasting cordial [Grieve, 1931].

In Belarus, 2583 t of birch sap were harvested in 1996. This represents only 0.6 percent of the possible resource of 369 000 t. The commercial utilization of sap is directly depending on the birch felling areas and their accessibility [Ollikainen, 1998]. Birch syrup is produced from *Betula papyrifera* in Alaska, United States, where it is used as a sweetener in coffee, on vegetables, pancakes and in breads and desserts.

Birch beer is made from the sap of *Betula lenta* in the southern Appalachian Mountains of the eastern USA. The trees are tapped in the spring when the sap begins to flow. The sap is stored in a ceramic jug and a small quantity of shelled corn is added to promote fermentation [Wigginton, 1973].

Containing same acids and minerals found in some fruits and berries, the birch sap is considered as a healthy product in a growing number of countries. For instance, in eastern Europe and Asian countries, fresh birch sap is pasteurized, bottled and sold as a health drink.

The curative properties of birch sap were referred to already by Baron Pierre-François Percy, the army surgeon and inspector general to Napoleon. His observation was as follows:

> *Throughout the whole of northern Europe ... birch water is the hope, the blessing, and the panacea of rich and poor, master and peasant alike .... It almost unfailingly cures skin conditions such as pimples, scurf, acne, etc., it is an invaluable remedy for rheumatic diseases, the after-effects of gout, bladder obstructions, and countless chronic ills against which medical science is so prone to fail.*[18]

17 Source: Maple sugar boiling month (http://indy4fdl.cc.mn.us/~isk/food/maple/html)
18 Source:Marlene Cameron. 1999 Alaska birch syrup at http://www.birchsyrup.com/aboutbs.html#nutrition

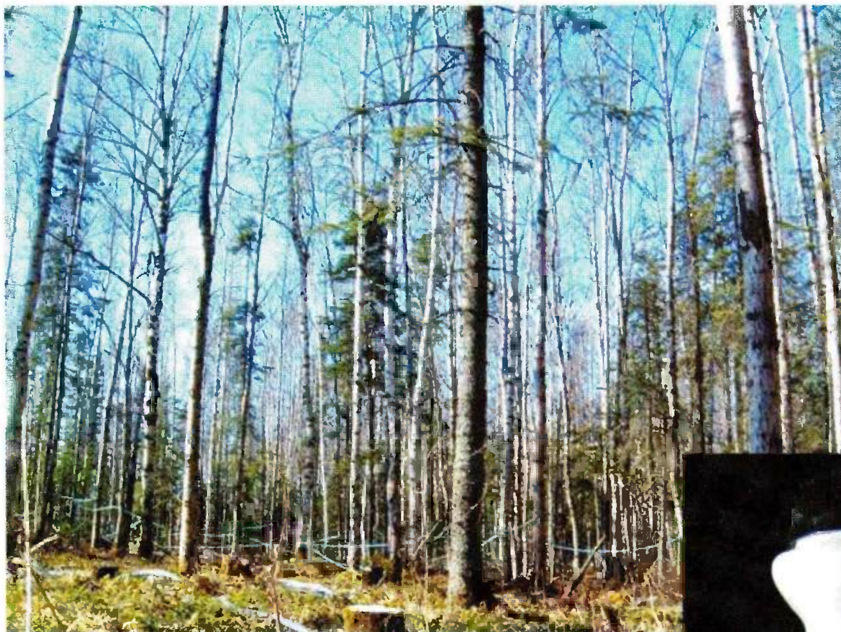

Figure 5.5: (above) A birch-rich forest stand in Alaska. Birch trees are connected with blue hoses to collect the sap to one central location instead of tapping each individual tree. (right) A jar of birch syrup. (Photos courtesy of: http://trailmastersgifts.com).

Box 5.2 Alaskan birch syrup industry

Birch syrup derived from the sap of the paper birch *Betula papyrifera* is commercialized in Alaska. The industry that was initiated ten years ago is today of great potential since the demand for birch syrup and for the value added birch products is growing.

The basic process to make birch syrup is the same as maple though there are some major differences between the two syrups. Compared to the maple, the birch trees tapped are smaller in diameter than maple, the life span of the birch is shorter and the birch is susceptible to heart rot early in life. In addition, the sap season is much shorter for birch than maple. In the south-central part of Alaska the sap run lasts an average of 19-20 days. Since tapping only takes 10-15 percent of the total sap production of the tree, it does not injure the trees.The average sugar content of birch sap is 11 Brix while that of maple ranges from 2 to 41 Brix.[1]

Birch sap contains several acids such as malic, phosphoric, succinic and citric. Further, inorganics including significant amounts of potassium, calcium, manganese and thiamin are present. There is also a difference regarding colour and flavour of the two syrups.

Value-added products with birch syrup as a base are candies, marinade, salad dressing, popcorn, reindeer jerky, coated nuts and flavoured birch syrup.

[1] Brix = percent sucrose by weight at 20°C.

STYRAX

Styrax or storax is a balsamic oleoresin extracted from the inner bark and wood of species of *Liquidambar.*[19] This material is a semi-solid, sticky, brown-coloured material and appears in response to wounds. When the young wood is injured, oil-ducts are formed in which the styrax is produced [Grieve, 1931].

USES

Steam distillation of styrax yields an essential oil that is widely used in the fragrance industry. For instance, it is used as fumigant in mosques and churches. Further more, styrax oil is widely used by the drug and cosmetic industry. For instance, the cosmetic properties of styrax are used in the production of soap and detergents and in perfume manufacturing. Due to its medical properties such as antiseptic and anti-parasitic, styrax is used to boost asthma and bronchitis, as well as to soothe dermatitis and fungal infection [Coppen, 1995; Moussouris and Regato, 1999].

COMPOSITION

The most abundant constituent of styrax is storesin. It exists in two forms, alpha and beta, both free and in the form of a cinnamic ester. Styrax is an amorphous substance, melting at 168°C when it is readily soluble in petroleum benzin. Various esters of cinnamic acid have been identified, including ethyl, phenylpopyl and benzyl esters and cinnamyl cinnamate, the so-called styrasin. The yield of cinnamic acid varies from 6 to 12 percent or even as much as 23 percent of crystallized cinnamic acid can be obtained. Another analysis gives free cinnamic acid, vanillin, styrol, styracin, cinnamic acid-ethyl ester, cinnamic acid-phenylprophyl ester and storesinol, partly free and partly as cinnamic acid ester.

Crude styrax contains from 1 to 9 percent of matter insoluble in alcohol, and up to 30 percent of water. When purified, it is brownish-yellow; viscous and transparent in thin layers; entirely soluble in alcohol (90 percent) and in ether. Boiled with a solution of potassium chromate and sulphuric acid, it evolves an odour of benzaldehyde. It loses not more than 5 percent of its weight when heated in a thin layer on a waterbath for one hour [Grieve, 1931].

SPECIES

Two trees are important commercial sources of styrax. *Liquidambar orientalis*, native to eastern Mediterranean Europe and the Near East, is the source of the product known as Asian styrax; and the sweetgum (*L. styraciflua*), a tree native to the southeastern United States, Mexico and Central America is the source of American styrax. *L. formosana* occurs in southeastern China, where it is used locally but is not important in world trade [Coppen, 1995].

HARVESTING

Styrax is found in the sapwood and inner bark of *L. orientalis.* Asian styrax is harvested by removing pieces of bark and boiling them in water. Additional styrax is obtained by pressing the bark that has been "extracted" to remove any residual material. Some styrax is also harvested by making incisions into the exposed stem wood and collecting the exudate in small cans or scraping it off directly. American styrax is collected by tapping the trees (*L. styraciflua*). A small gutter and a cup are fixed on the tree and a cut is made in the stem where pockets of styrax occur.

Preliminary cleaning of Asian styrax is done by rinsing the crude material in boiling water. The dirty water is removed by decantation and the soft, fluid resin is separated from a lower layer of sand and other foreign materials [Coppen, 1995].

[19] Please note that there exists another internationally traded resin, benzoin, which is obtained from South-East Asian Styrax species. This resin should not be confused with styrax/storax from *Liquidambar.* (see NWFP Series no. 6 "*Gums, Resins and Latexes* of *Plant origin*, FAO 1995)

PRODUCTION AND TRADE

Turkey is the only source of Asian styrax traded internationally. The geographical distribution of the tree in Turkey is southwestern Anatolia. During the decade of the 1960s, exports of Turkish styrax ranged from 50 t/a to 70 t/a. The largest importer was the United Kingdom, followed by Germany, France, Italy and the United States. The United States is the largest importer of American styrax coming from *L. styraciflua*, most of which is produced in Honduras. It can also be found in other parts of Central America and in Mexico [Coppen, 1995].

Exports of styrax from Turkey have declined since its peak in the 1960s. In order to determine the development potential of styrax, a better knowledge is required. If styrax oil production in Turkey becomes uneconomic due to increased labour costs, there is a potential for the production to expand in Southeast Asia (from *L. Formosan*) and Central America [Moussouris and Regato, 1999].

MASTIC GUM

Mastic gum is a natural resin that is extracted from one of the most characteristic evergreen species in the Mediterranean maquis,[20] the *Pistacia lentiscus* var. *Chia* tree. The tree is a slow-growing, cold-sensitive species that grows in limestone soil. In order to obtain oleoresin, it is necessary to make incisions in the trunk. The exuded oleoresin soon solidifies and becomes hard and brittle. At an age of 12–15 years, gum production reaches its full potential. However, gum can be already extracted after the fifth or sixth year.

Even though, *P. lentiscus* is a common species in the Mediterranean region, it is only on the Greek island of Chios, just offshore from Izmir in Turkey, that large-scale production takes place. Smaller quantities of mastic gum are collected in Algeria, Morocco and the Canary Islands.

HARVESTING, PRODUCTION AND TRADE

In Chios, the harvesting period is between June and mid-October. According to regulations regarding mastic gum production, all collection activities have to terminate after 15 October.

Preparations start by cleaning the tree, followed by sweeping and levelling the ground beneath the tree. Subsequently, the first vertical and horizontal cuts are marked on the bark, twice a week for a period of five to six weeks. Collection follows crystallization of the first secreted gum. After that, the second cut is inflicted, and the gums are collected once again.

After collection, the gum is sieved and then given to the cooperative for quality control. The cooperative sends the product to the Union of Mastic Producers, where final processing takes place. Production has fluctuated with an average of 250 000 kg a year during the first half of this century.[21]

The trade in mastic gum is worth US$ 14.4 million per year to the 21 villages involved on the Greek island of Chios, who have monopoly of production. The mastic gum is exported to 50 countries, among which Saudi Arabia is the biggest importer [Moussouris and Regato, 1999].

USES

There are many products of mastic gum, such as mastic oil and rosin, both of which are derived from mastic gum distillation. Further gumdrops, which have a unique pleasant flavour, are sold as chewing gum. Since 1995, a processed packed product in the form of a confection is produced and marketed. In addition, mastic gum is a culinary ingredient in the Mediterranean cuisine and patisserie and is also used in ouzo flavouring.

By-products of mastic gum are used in varnishes and coatings and in a type of cement called asphalt mastic. Moscholivano, a solid essence derived from mastic gum, releases a pleasant odour when

[20] Maquis are evergreen short tree and shrub communities.
[21] Source: Mastic gum resin (http://www.execpc.com/~goodscnt/data/rs1008031.html)

being burned. Moreover, mastic is used in wood coatings, lacquers, adhesives, and printing inks. Artists have used it for many centuries to protect both oil paintings and watercolours.

Moreover, mastic gum is provided with medical properties. Already many ancient writers such as Theophrastus, Pliny the Elder, Galenos and Dioscorides considered it as a panacea for many maladies. Current research confirms the gum's medical properties.[22]

22 Source: Mastic (http://www.plthomas.com/Resinsfram/Mastic.htm)

CHAPTER 6

BARK

CORK[23]

Cork is the soft tissue found in the inner bark of the cork oak (*Quercus suber* – family Fagaceae), an evergreen oak that occurs in the western Mediterranean region. While other trees may contain layers of soft, spongy inner bark, e.g. Douglas fir (*Pseudotsuga menziesii*), no other tree in the world produces the thick layers of cork that *Q. suber* produces. Cork is a unique and important non-wood forest product that has a wide range of uses, including wine and champagne stoppers, insulation, floats for fishing nets and bulletin boards.

HISTORICAL ASPECTS

Ironically, the first people who made use of cork lived in the eastern Mediterranean, a considerable distance from where cork oaks occur naturally. In Egypt, tombs dating back thousands of years were found to contain ceramic amphorae with cork stoppers. The ancient Greeks used the bark of cork oak to make buoys to float fishing nets, for sandals and for stoppers of vessels containing wine and olive oil. The Greek philosopher Theophrastus (fourth and third centuries BC) discovered that one layer of cork was stripped from a tree, a new sheath of better quality was quickly formed. Later, the Romans put cork to a wider range of uses. The scholar Marcus Terentius Varron (116–27 BC) and the farmer Lucio Colmuela recommended making beehives out of cork because of its low heat conductivity. Pliny mentioned roofs made of corkwood plank, something that can still be seen in parts of northern Africa today. His writings also mention the use of cork to float anchor ropes and fishing nets, for sealing vessels containing oil or wine and in the production of women's shoes. Early fishermen in the Mediterranean also used cork to fashion life jackets. Dioscorides, a Greek physician in the second century AD, described some medicinal uses of cork. He recorded a belief that charred cork rubbed on bald patches with the sap of the laurel (*Laurus nobilis*) would make hair grow again, thicker and darker than before.

In Portugal, where extensive forests of *Quercus suber* occur, cork was an economic asset of considerable national importance by the fourteenth century. Cork was first exported to England around 1307 during the reign of Dom Dinis. In 1320 this king undertook tough measures against anyone damaging "his" cork oaks. During the reign of the Portuguese king Dom Fernando, cork was one of the main exports to sail out of the port of Lisbon.

One of the most significant discoveries leading toward the development of a modern cork industry took place during the early 1700s by the French Benedictine Dom Pierre Pérignon, the proctor of the Abbey of Hautvillers, near Epernay. Dom Pierre Pérignon is the person who developed the process of champagne production. He observed that the wooden stoppers, wrapped in hemp and soaked with olive oil, used to seal the containers holding the sparkling wine, often popped out. He tested cork as an alternative stopper and had surprisingly good results. Soon cork became essential for all types of wines. Around the mid-1700s, many French wine producers were using cork stoppers for wine containers. The first cork used to make stoppers is believed to have come from the Landes, Var and eastern Pyrennees regions of France. Around 1750, in the village of Angullane, located near the French border in the Catalonian Region of Spain, the first cork stopper factory opened. Cork production increased significantly during the nineteenth century when bottles replaced wooden barrels, a method used since Roman times to store wine. Today, about 25 billion cork stoppers are used worldwide per year [Moussouris and Regato, 1999].

The replacement of corks by other stoppers that were either cheaper or more eye-catching caused a decline in the cork industry and dampened interest in cork oak culture. However, in 1891 an

23 Much of the information contained in this section is taken from *The Cork* in 1997 http://www.portugal.org/german/doingbus/buyingfrom/products/cork

American by the name of John Smith developed a process for making agglomerated cork and opened up a new world of opportunities for this product. This created a demand for waste cork from the stopper industry.

Box 6.1 The traditional cork stopper is challenged by synthetic substitutes

The defenders of cork and of plastic are set against each other in a wine-industry row. The public battle started when a number of big British supermarket groups flattened that any systematic fault, as corked wine, was as unacceptable in wine as it was in any other product. The term corked wine refers to mustiness or cheesiness in the wine influenced by the contaminant TCA (trichloroanisole), which can affect the taste and flavour of the wine and spoil the wine's bouquet. Thus, the dependability of the cork stopper is questioned.

In Britain the cork's defenders attack the plastic substitutes as imparting their own impurities and claim that their use would destroy the cork-oak forests of Spain and Portugal, together with their dozens of rare species of birds.

After years of increasing prices and decreasing quality, the battle has now forced the cork industry into action. The washes have been changed, quality controls tightened and more care is taken that the corks are not exposed to moisture, which encourages the development of TCA during the manufacturing process. A new process, the so-called INOS, is designed to use its inherent sponginess as a way of squeezing out possible contaminants.

Since the demand for wine in bottles is growing faster than the supply of properly prepared cork, there is room in the market for different types of stoppers. However, the top end of the market still favours cork stoppers since the durability of plastic stoppers, e.g. how well they will retain resiliency over time, is still unknown. In addition, the ritual of opening popping a true cork is closely associated with fine wine, which makes many producers unwilling to use artificial corks.
Source: *The Economist*, 5 June 1999. Plastic wine stoppers – A corking row

CORK OAK

Quercus suber is a large, spreading tree that grows in open woodlands on sandy, chalk-free soils, with low nitrogen and phosphorus levels but rich in potassium and with a pH between 5 and 6. Ideal conditions include an annual precipitation of between 400 to 800 mm, temperatures that never drop below –5°C and an elevation range between 100 and 300 m. These conditions are found in a relatively narrow band along the western coastal areas that bound the Mediterranean Sea. (Figure 6.1). Within this relatively small area, there are approximately some 2.2 million ha of cork oak stands (Table 6.1). Cork oaks are not found east of the Ionian Sea with Sicily and Calabria (Italy) being the eastern-most locations where cork oak occurs naturally. The eastern-most location where extensive stands of cork oaks occur is on the Italian island of Sardinia [author's observation].

Cork oak is one of the commonest indigenous trees in Portugal where it is found throughout the country. However, five districts – Beja, Évora, Portalegre, Santarém and Setúbal – have 87 percent of the country's total cork oak cover. In Spain, cork oak covers extensive areas of the provinces of Badajoz, Cáceres, Cadiz, Huelva, Málaga and Seville in southwestern Spain. The exploitation of cork oak in Spain began in Catalonia, in northeastern Spain, around 1790. By the first half of the nineteenth century, Catalonia's cork oak forests were reduced by 45 percent and have never recovered. In France, the most valuable cork oak forests are found in the Var, between Cannes and Toulon. The French island of Corsica also has extensive forests of this tree. In Italy, the major cork oak resources are found on the islands of Sardinia and Sicily. On the Italian mainland, there are small areas of cork oak in the regions of Lazio, Tuscany and in parts of Calabria.

Cork oak occurs on the African continent in Algeria, Morocco and Tunisia. Algerian cork oak forests are confined to the coastal region between Algiers and Cape Roux and can be found at elevations as high as 1 500 m. In Morocco, the cork oak is found along the entire Mediterranean coast and along the Atlantic coast as far south as Marrakech. In the southern-most part of its range in Morocco, it can be found at elevations of up to 2 200 m. One of the most outstanding Moroccan cork oak forests lies just to the east of the capital city of Rabat. Tunisian cork oak forests are a continuation of the Algerian coastal strip and are concentrated in large stands in Nefza-Mogode and Khroumiria. The unique products of the cork oak and their high value have led to the introduction of *Q. suber* to countries outside of the western Mediterranean region with limited success. These include Russia, where the tree has been introduced into the Crimean Region; in California and other southern states of the United States; Argentina; Australia; Israel; Japan; South Africa; Turkey; and Uruguay.

Table 6.1 Area of *Quercus suber* forests by country [24]

Region and country	Area (ha)	Percent of total
Mediterranean Europe		
France	110 000	5
Italy	90 000	4
Portugal	660 000	30
Spain	440 000	20
Subtotal	1 300 000	59
North Africa		
Algeria	460 000	21
Morocco	350 000	16
Tunisia	90 000	4
Subtotal	900 000	41
Total	2 200 000	100.00

STRUCTURE AND CHARACTERISTICS

Cork is a plant tissue composed of dead cells, generally 14-sided polyhedrons, and an intercell space filled with gas virtually identical to air but lacking carbon dioxide (CO_2). It has a honeycomb-like structure that has a minimal quantity of solid matter and a maximal quantity of gaseous matter. The combination of cellular membranes and the honeycomb-like structure gives cork its unique properties.

Density

Since approximately 89.7 percent of cork tissue consists of gaseous material, the density of cork is extremely low, in the order of 0.12 to 0.20. Cork is lightweight and will float on water. For thousands of years, this has been the cork's most evident and celebrated characteristic. In Ancient Greece and Rome, for example, cork was used in fishing equipment.

Figure 6.1 Harvesting cork on a large *Quercus suber* tree in Portugal.

Elasticity

The cellular membranes of cork are flexible. This makes the cork both compressible and elastic and allows it to return to its original shape after being subjected to pressure. This is the reason why cork has become an indispensable material for stoppers. The cork can be fitted perfectly against the walls of the neck of a bottle. When the cork is

24 Please note that there are different area figures according to different sources. According to Moussouris and Regato (1999) the given Figures differ for certain countries and are as follows: Spain 500 000 ha, Italy 100 000 ha, Tunisia 45 000 ha and France 43 000 ha.

subjected to strong pressure, the gas in the cells is compressed and reduces in volume. When released from pressure, the cork immediately recovers its original volume and bears no trace of having been subjected to appreciable deformation.

Impermeability

The presence of suberin, a complex mixture of fatty acids and heavy organic alcohols, renders cork impermeable to both liquids and gases. Therefore, it is not subject to decay and may be considered the best seal in existence. The presence of tannins and the scarcity of albumenoids make it even more effective as a seal because it is both decay resistant and unaltered by moisture. Pieces of cork exist that have been submerged for centuries without rotting.

Low conductivity

The value of cork is further enhanced by its low conductivity of heat, sound or vibrations. This is because the gaseous component of the cork is sealed in tiny impervious compartments that are insulated from one another by a moisture-resistant material of low specific gravity. Therefore, cork has one of the best insulating capacities of any natural substance.

Other desirable characteristics

Cork is also remarkably resistant to wear and has a high friction coefficient because of its honeycomb structure. It does not absorb dust and, consequently, does not cause allergies or pose a risk to people who suffer from asthma or other respiratory diseases. Cork is also fire resistant and is a natural fire retardant.

HARVESTING AND PROCESSING

Cork oak forests are managed as either high forests or coppice. Trees must be from 15 to 20 or 30 years old (depending on different sources) to be of sufficient size and maturity before the first harvesting of cork can occur [Moussouris and Regato, 1999]. The first harvest is a low-quality cork known as *borniz* or virgin cork that is used exclusively for agglomerate. Subsequent harvests produce what is known as reproduction cork, which is used for bottle stoppers, washers and related products. The second harvest is usually of somewhat better quality than the first one, and the best quality cork is obtained from the third and subsequent peelings. Cork is generally only taken from branches greater than 15 cm in diameter. A tree usually stops producing good-quality cork after 13 to14 barkings [Moussouris and Regato, 1999].

Cork from cork oak forests managed as high forests is harvested at 9- to 10-year intervals. Harvesting operations generally take place from June through September. Peeling cork bark requires a high level of skill. A wrong cut that touches the inner core can wound a tree irreparably and reduce the quality of the cork of future harvests. Trees from which cork has been recently harvested have a characteristic reddish-brown coloured inner bark (Figure 6.2). The outer bark regenerates after stripping [Moussouris and Regato, 1999].

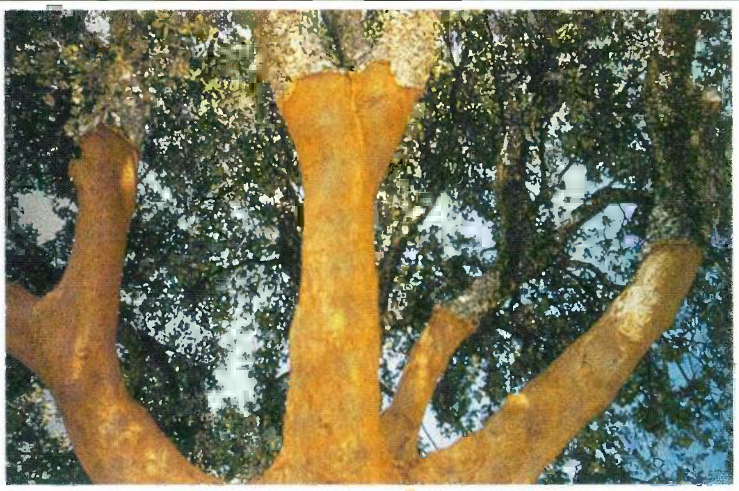

Figure 6.2 A cork oak in Tuscany (Italy) from which planks of cork have recently been harvested

For cork oaks managed under the coppice system, the trees are harvested at 10- to 11-year intervals. The logs are taken to the mill where the cork, which is always virgin cork, is separated from the wood and crushed into agglomerate [Iqbal, 1993].

Cork must be treated properly prior to industrial uses. It is only used in its raw form for traditional products such as beehives or roofing for buildings. When the planks of cork are removed from the trees, they are first sorted, and any material deemed unsuitable is set aside. The planks are then stacked and exposed to the open air for about six months. Exposure to rain, sun and wind triggers chemical transformations that improve the cork's quality. The cork is then layered in large boilers and is boiled in water for 75 minutes in order to remove any extraneous materials and to render the planks softer and more flexible. After boiling, the planks are again stacked for another three weeks. The planks are then trimmed and graded. The best quality planks are used for production of stoppers and related products, while the remainder are used for production of agglomerates (source: http://www.mantoncork.com/aboutcork.htm).

USES

Corkwood planks are used in the manufacture of stoppers, bungs, washers, buoys, floor coverings, facings for walls and ceilings, inner soles of shoes, records, polishing blocks, protector plates and handicraft products (Figure 6.3). One of the earliest uses of cork was in footwear, a use that still is important today.

Figure 6.3 (left) Graded cork slabs ready for next stage of processing. (right) Wine stoppers cut out from cork planks.

Waste cork from the stopper industry and low-quality cork are used to produce ground cork or granules. These are classified according to density and grain size. The finest are used in the production of linoleum, a product that consists of cork, linseed oil, resin, lead oxide or magnesium and colourings. It is extremely resistant to wear, easy to clean and is widely used for flooring and table coverings. Granulated cork is the base material for agglomerated cork. Its uses include champagne corks, more advanced footwear, wall coverings, flooring in the automobile and aeronautical industry, musical instruments and, most recently, as components in spacecraft. Cork granules are also used in building construction as a thermal insulator in double walls, where it can reduce heat loss by 36 percent, and in roofing, where it can reduce heat loss by 53 percent.

Other cork products include bulletin boards, drink coasters, tile floors, decorative panels, linings of safety helmets and sports equipment such as shuttlecocks and fishing rod handles.

PRODUCTION AND TRADE

Average productivity of cork oak forests, based on extraction at ten-year intervals, is approximately 150 kg of cork/ha and can be as high as 2 000 to 5 000 kg/ha in forests of large trees. Today, the centre of the world's cork oak forest is concentrated in southern Europe – France, Italy, Portugal and Spain account for 90 percent of cork oak production. North Africa has the remaining 10 percent.

Actual production of cork in the Mediterranean forests[25] reaches 375 000 t/a, which is much less that potential production estimated at 913 500 t/a [Moussouris and Regato, 1999]. Some 600 cork-producing factories have been built in the western Mediterranean region, and they employ approximately 14 000 workers [Cesaro *et al.*, 1995; Moussouris and Regato, 1999].

Portugal, with only 30 percent of the world's cork oak forests, accounts for more than half of the world's cork production. During the decade of the 1990s, Portugal's average production was 170 000 t/a. Although Portuguese cork is exported to more than 100 countries, most of its production goes to EU countries. Annually cork and cork products sold to Europe and the United States correspond to more than US$ 1.5 billion. Cork stoppers account for US$ 1.1 billion, while the sale of agglomerated cork, cork flooring, and other cork products are valued at US$ 400 million.[26]

During the same period, Spain's cork production averaged 110 000 t/a; Italy, 20 000 t/a; Morocco, 15 000 t/a; Tunisia 9 000 t/a; Algeria, 6 000 t/a; and France, 5 000 t/a. In 1993 the estimated market value of cork in Spain was Ptas 4 647 million, 80 percent of which was produced on farmlands.

PESTS AND DISEASES

There have been recent reports of decline and mortality of cork oak in portions of Italy, Morocco, Portugal, Spain and Tunisia. Symptoms include death of roots and rootlets, epicormic shoots, a tarry exudation and tree death within one or two growing seasons after the onset of symptoms. In southern Spain, dying trees often occur in groups and are associated with streams, depressions or areas where standing water is common. The root fungus (*Phytophthora cinnamomi*) has been isolated from the root systems of symptomatic trees occurring on moist sites. It has been suggested that this fungus, which is associated with a number of tree declines [Ciesla and Donaubauer, 1994], has been recently introduced into this region and is interacting with winter drought and changing land-use patterns to bring about a decline of both *Quercus suber* and *Q. ilex* [Brasier *et al.*, 1993].

TANNIN

HISTORICAL ASPECTS

Tanning animal hides with extracts of bark from trees is an ancient technique dating back at least 5000 years. The oldest evidence of tanning, a tanning yard with tools, pieces of skin and leather, acacia seed pods and fragments of oak bark, was discovered by the Italian Egyptologist C. Schiaparelli, and shows that the Egyptians used a vegetable tanning process similar to that used today. Tanning was depicted in Egyptian tomb paintings from 3000 BC and was known to the Chinese as early as 1000 BC. The Romans tanned with the bark from oak trees. Native Americans used a variety of local plants to make leather from hides of the American bison. The neolithic people of Europe are believed to have tanned hides by immersing them in water holes filled with bark high in tannin content.

Although tanning is an ancient industry, the actual chemicals that cause tanning were not discovered until 1790–1800 in France, when tannins were isolated as distinct chemical compounds [Prance and Prance, 1993].

COMPOSITION AND PROPERTIES

The tanning process is possible because of a property of chemicals known as tannins that allows them to combine with the protein of animal skins, known as collagen, to produce leather. This product is tougher and more permanent than unprocessed (untanned) skins.

25 Algeria, France, Greece, Italy, Morocco, Portugal, Spain and Tunisia are included.
26 Source: Manton Industrial Cork Products (http://www.mantoncork.com/aboutcork.htm)

Tannins are chemically classified into two groups: hydrolysable tannins and condensed or nonhydrolysable tannins. Hydrolysable tannins (gallotannins) are glucosides. They contain a central core of glucose or other polyhydritic alcohol with gallic acid residues attached out from the core. Condensed tannins (polyphenols) are compounds of high molecular weight. They are polyphenolic polymers apparently lacking sugars.

Tannins are acidic and astringent. This property has made them an important ingredient of traditional medicines. In addition to the production of leather, they are used in food processing, fruit ripening and are an ingredient of many beverages (e.g. cocoa, tea and red wine). When mixed with iron salts, tannins produce a black colour that has been used for ink (see Chapter 9). Tannins are also used as mordants in dye [Prance and Prance, 1993].

Tannins are derived primarily from the bark of trees and are considered to be among the most important products from tree bark. Tannins are widely distributed in the plant kingdom. About 500 plant species in 175 families are known to contain varying amounts of tannins. These compounds are particularly abundant in various species of acacias (*Acacia* spp.),[27] hemlock (*Tsuga* spp.), oaks and related genera (*Quercus, Castanea, Lithocarpus*), and certain mangrove species.

PRINCIPAL SOURCES

Among temperate broad-leaved hardwoods, members of several genera of the family Fagaceae (*Castanea, Lithocarpus and Quercus)* have the highest bark tannin content.

Until the early part of the twentieth century, the primary source of tannins in the United States was the bark of the eastern hemlock (*Tsuga canadensis*), a conifer. The hemlock tannin industry was destructive and led to the devastation of hemlock forests in the northeastern United States. During the early years of this industry, only the bark of giant hemlock trees was used because there was no demand for hemlock lumber, and the trees were left in the forests to decay. As the area of hemlock forest declined, the tannin industry moved south and used the bark of *Castanea dentata* and various oaks (*Quercus* spp.) as the primary tannin source [Hergert, 1983; Prance and Prance, 1993]. In the western United States, the bark of the tan oak (*Lithocarpus densiflorus*) was heavily exploited for tannins [Peattie, 1953]. Eventually the American leather tanning industry relied on importation of tannin from foreign sources, or tanning was done by alternative chemical processes [Hall, 1971; Hergert, 1983].

The inner bark of the cork oak (*Quercus suber*) is an important tannin source, and the inner bark of large trees, which have never been stripped for cork, have the highest tannin content. The high demand for cork oak as a tannin source led to the cutting of large numbers of trees, many of which were centuries old. The fine quality of Moroccan leather can be related to the practice of using tannin extracted from the inner bark of this tree (Figure 6.4). There was such a great interest in harvesting this material that large area of Morocco's cork oak forests suffered irreversible damage toward the end of the nineteenth century and the beginning of the twentieth century.[28]

Figure 6.4 A leather merchant in Rabat, Morocco. The fine quality of Moroccan leather is attributed to the use of tannins from cork oak during the curing process.

In India, several species of the family Fagaceae are tannin sources. These include *Lithocarpus fenestrata* (common name, *kala chakma*), *Quercus floribunda* (common name, *kilonj*), *Q. lamellosa* (common name, *bujrat*), *Q. leucotrichophora* (common name, gray or ban oak) and *Q. semicarpifolia* (common name, kharshu oak). These trees are components of the Himalayan moist temperate forests. European and Near Eastern oaks with a high bark tannin content that have been used in tanning include *Q. ilex, Q. infectoria, Q. macrolepis* and *Q. suber.*[29]

27 *Acacia spp.* in the tropical ecosystems will not be mentioned in this paper.
28 Source: *The cork oak in 1997* (http://www.portugal.org/german/doingbus/buyingfrom/products/cork)
29 Source: Dr M.P. Shiva, Centre for Minor Forest Products, Dehra Dun, India.

The bark of *Eucalyptus astringents* is the only eucalypt species in Australia that is sufficiently rich in tannin to warrant export. Other eucalypts that are tannin sources include *E. accedens* and *E. wandoo*. These are the principal sources of tannin in western Australia [Jacobs, 1979].

MINOR SOURCES

The bark of some species of *Alnus* is high in a tannin that has similar characteristics to oak tannin. The bark of European alder (*A. glutinosa*), for example, contains about 20 percent tannin and has been used as a tannin source in Europe, the Near East, Siberia and North America [Hora, 1981], where it has become naturalized [Duke, 1983; Harlow and Harrar, 1950]. The North American speckled alder (*A. rugosa = A. incana)* has also been used as a tannin source [Hora, 1981]. The bark of the common birch of Europe (*Betula alba*) contains only about 3 percent tannic acid but has been used extensively for tanning throughout northern Europe. It gives a pale colour to skins and is used for the preliminary and final stages of tanning [Grieve, 1931]. The bark of the European service tree (*Sorbus domestica*) has been used for tanning leather [Hora, 1981].

DYES

The bark of several species of temperate broad-leaved trees is the traditional source of dyes. One species of oak, the American black oak (*Quercus velutina*), is the source of a once important commercial dye. Procedures for dyeing with bark called for stripping it from trees, chopping it into fine pieces and boiling it [Adrosko, 1971].

QUERCITRON

Quercitron is a brilliant yellow dye that occurs in the mid and inner bark of *Quercus velutina*, commonly known as black oak, a tree found in eastern North American broadleaf forests. It is recognized by its thick, nearly black bark and the orange-coloured inner bark. The latter is very rich in tannic acid. An Englishman, Dr Edward Bancroft, first reported the occurrence of this dye after returning from a journey to the New World during the latter part of the eighteenth century. He named the dye material "quercitron" and suggested that it might be an inexpensive alternative to weld, a yellow dye extracted from *Reseda lutea*, a herbaceous plant indigenous to parts of Europe. In 1785, the British Parliament favoured Bancroft's idea and awarded him an exclusive right to apply quercitron to dyeing and calico printing in England [Adrosko, 1971; Bancroft, 1814; Wickens, 1986].[30]

Even before Bancroft published his discovery, American home dyers probably used the bark of *Q. velutina* for dyeing woollens, cottons and silks bright yellow. However, it was not until this dyestuff was introduced to Europe that quercitron took its place among the important vegetable dyes. Quercitron remained in commercial use until the second quarter of the twentieth century when it was replaced by aniline dyes [Adrosko, 1971]. An extract of quercitron, known as flavine, is free from tannin and produces brighter colours than the pulverized bark [Wickens 1986].

In 1817, quercitron bark priced for export in New York was valued at US$ 45–60/t. Apothecaries and druggists in Pennsylvania sold the dye for US$ 0.125 per pound (US$ 0.275 per kg). Quercitron also contains tannin and was used by tanners as well as dyers. Therefore, home dyers were able to purchase the material from tanners for as little as US$ 0.05 per pound (US$ 0.11 per kg) [Adrosko, 1971].

A wide range of colours can be produced on wools, cottons and silks from quercitron by combining it with other dyestuffs or by using different mordants. For example, a mixture of quercitron with cochineal, a red dye extracted from the female adult of a scale insect (*Dactylopius cocus*), which infests prickly pear cactus (*Opuntia* spp.), produces a brilliant orange dye [Adrosko, 1971; Wickens, 1983] (Table 6.2). Quercitron has also been used to dye splints and reeds for baskets [Bliss, 1981].

Unfortunately, this dye is no longer produced, not even for home dyers who prefer to work with natural rather than synthetic dyes [author's observation].

30 Source:- Ohio's trees - http://www.hcs.ohiostate.edu/ODNR/Education/ohiotrees/oakblack.htm

Table 6.2 Range of colours available from quercitron, a commercial dye from the inner bark of *Quercus velutina*

Colour	Material	Mordant
Yellow to buff	Wool, cotton	Alum
Gold	Wool, cotton	Chrome
Olive-green	Wool, cotton	Copperas*
Orange	Silk	Tin

* Ferrous sulphate

Source: Lust, 1990

TRADITIONAL DYES

The bark of a number of trees of the family Fagaceae were traditional sources of dye and used by dyers in various parts of the world (Table 6.3). Several native North American oaks, in addition to *Quercus velutina*, were traditional dye sources and used by dyers in the eighteenth and nineteenth centuries. For example, the bark of northern red oak (*Q. rubra*) produces a yellow dye; chestnut oak (*Q. montana*) produces red colours; and the bark of *Q. alba* was used to colour wool brown or a tea colour. The dye produced from the bark of *Q. alba* reportedly does not fade when exposed to the sun [Adrosko, 1971]. In Japan, extracts of the nutshell, burr and bark of *Castanea crenata* are used for dyeing or staining. When mordanted with water containing iron, a grey colour is obtained. When ash extract is added to the iron water, a chestnut-brown colour is obtained [Kamazaki, 1984]. Other traditional dyes produced from the bark of trees of the family Fagaceae are summarized in Table 6.3.

The bark of red maple (*Acer rubrum*) was used during the eighteenth century in North America in combination with a copperas mordant to dye worsted and linen fibres a slate blue-grey colour. When used with an alum mordant, it produced a cinnamon-brown colour. This dye bath was used to colour woollen and cotton fabrics [Adrosko, 1971].

The Navajo Indians of the southwestern United States used the bark of alder (*Alnus tenufolia*) to produce dyes ranging in colour from golden tan to dark olive green [Bliss, 1993]. The bark, as well as the nut husks, of various species of *Juglans* is known to produce a rich brown dye (see chapter on Fruits and Nuts) [Adrosko, 1971].

The root bark of the Osage orange (*Maclura pomifera*, family Moraceae), a small to medium-sized tree indigenous to the south-central United States, produces a dye with colours ranging from tan to olive green, depending on the mordant, and was widely used during the First World War for dyeing khaki military uniforms [Bliss, 1993].

Table 6.3 Traditional dyes produced from the bark of trees of the family Fagaceae

Species	Colour/mordant	Where used	Reference
Castanea crenata	Grey to black/iron	Japan	Kamazaki, 1984 Yashiroda, 1984
Fagus grandifolia	Yellow-tan/chrome and alum	North America	Casselman, 1993
Quercus spp.			
Q. acutissima	Brown/none Black/iron	Japan	Yashiroda, 1984
Q. alba	Blue-grey/none Brown/none given	United States (basket splints) United States (wool)	Briggs, 1984 Adrosko, 1971
Q. dentata	Brown/none Black/iron	Japan	Yashiroda ,984
Q. gambelii	None given/alum	Southwest United States (Navajo)	Young, 1978
Q. montana	Red-brown/none	United States	Adrosko, 1971
Q. robur	Grey-black/none	Bosnia-Herzegovina	Ritter-Studnicka, 1984
		Norway United Kingdom	Sverdrup, 1984 Shand, 1984
Q. rubra	Gold/alum High gold/chrome Strong yellow/tin Grey/iron Red-brown/vinegar and tin	Canada United States	Adrosko, 1971 Casselman, 1993
Q. serrata	Brown/none	Japan	Yashidora 1984

CASCARA

Cascara (*Rhamnus* [=*Frangula*) *purshiana*, family Rhamnaceae) is a small- to medium-sized tree found primarily along the Pacific Coast of Canada and the United States. The reddish-brown coloured bark of this tree is considered to be one of the most important natural drugs produced in North America. Cascara is widely used in the production of laxatives and tonics and is marketed under a Spanish name "*cascara sagrada*" [Lust,1990; Panshin *et al.*, 1950]. It was accepted as an important natural medicine by the medical community in 1877 [Panshin *et al.*, 1950] and is the most widely prescribed naturally derived laxative today [Leung, 1977]. Cascara is found in nearly 200 products sold in Canada including some veterinary medicines [Prescott-Allen and Prescott-Allen, 1986].

Cascara bark collection is a local industry in Oregon and Washington (United States) and British Columbia (Canada). Collecting usually begins in mid-April and extends to late August. Yields vary from about 2.25 kg from a tree 7.5 cm in diameter at breast height to about 80 kg from a tree with a diameter at breast height of 42– 44 cm. Daily yields per harvester range from about 45 kg per day to about 135 kg per day. Cascara bark harvesting is often excessive and has been known to kill trees [Prescott-Allen and Prescott-Allen, 1986].

One estimate places the domestic market for cascara bark in the United States at 2 000 t/a with a wholesale price of US$ 0.05–0.80 being paid to the harvester, depending on the age of the bark, its moisture content, time of year and quantity shipped [Thomas and Schumann, 1992]. The dried bark, aged for a year before being used as a laxative, commands a higher price [Prescott-Allen and Prescott-Allen, 1986].

The bark of a European species (*Rhamnus fragula*) has essentially the same properties as *R. purshiana* and is also harvested for its medicinal properties, but to a lesser degree [Grieve, 1931; Panshin *et al.*, 1950].

SAPONIN

The rough bark of *Quillaja saponaria* (common name *quillay*), a tree which occurs in the sclerophyllous forests of central Chile, is a locally important source of a product known as saponin [Donosa Zegers, 1983]. Saponin has a variety of domestic and industrial uses, including photographic products, cosmetics, carbonated beverages, dental products and shampoos. The saponin extracted from the quillay is also an essential ingredient in the manufacture of anti-explosives in fuels used to propel space vehicles [Garfias Salinas *et al.*, 1995].

Only the outer layers of bark are harvested. A three-person crew can harvest between 150 and 200 kg of quillay bark per day. When the bark is dried to a moisture content of approximately 15 percent, it is packed in clean sacks and transported to a storage facility that is dark and cool. It is then packed in containers weighing approximately 80 kg. Quillay harvesting occurs primarily in the V to VIII regions and takes place on about 4 000 ha/a [Garfias Salinas *et al.*, 1995].

MINOR AND TRADITIONAL USES

The ability of the bark of willow (*Salix* spp.) to relieve the suffering of pain and fever has been known for at least 2 000 years. The active ingredient in willow bark is salicin, a glucoside that is converted to salicylic acid in the body. Salicylic acid is a component of acetylsalicylic acid, the active ingredient in aspirin, one of the most widely used medicines in the world (see textbox). Today aspirin is produced from synthetic materials [Lust, 1990].[31]

[31] Sources - Herbal information Center (http:/gic.simplenet.com/dr/herb/whitew.htm) and (http://www. inreach.com/dameron_heart/aspirin.htm).

The bark of the North American paper birch (*Betula papyrifera*) (Figure 6.5) is impervious to water and was used by indigenous tribes in the construction of small, narrow boats known as canoes. Canoes were constructed from large sheets of bark tied together with root fibres of white spruce (*Picea glauca*) and smeared with the resin of balsam fir (*Abies balsamea*) [Hora, 1981]. Containers made from the bark of paper birch were also used as containers for collecting sap during the early days of maple sugaring (see Chapter 5).

Figure 6.5 The bark of the North American paper birch (*Betula papyrifera*). Birch bark had many traditional uses in northern Europe, Siberia and across northern North America.

The Anishinaabeg, an indigenous tribe in the Great Lakes Region of North America, shaped birch bark for cups, bowls, baskets and trays by heating the bark and bending it to the shape needed. It would retain its shape when cooled. Folds were pierced and sewn together with bark of basswood (*Tilia americana*) or roots of spruce (*Picea glauca*). When a watertight container was needed, the seams were caulked with spruce resin. Food was said to keep better in birch bark containers than in containers made from other materials. Berries and corn were dried on sheets of birch bark. Blankets, supplies and equipment were wrapped and bound in birch bark mats for the long and frequent moves of these people. They also wrapped their dead in birch bark, a practice that was also carried out by certain Siberian tribes [Peyton, 1994].

The aboriginal people make traditional products out of birch bark such as quill baskets, lamp shades, birch bed frames and birch bark desk coverings. The bark is sold in two forms: sheets and tubes. Birch bark sheets are cut in various sizes. Bark is also sold by case.

Birch bark is also used as a component in the floral industry, as well as in the design of artificial trees that are incorporated into large commercial spaces such as convention centres and shopping malls. There are markets for birch bark in Canada, United States and Hong Kong. The estimated demand of the birch bark in Hong Kong as a component in the floral industry is estimated at 62 000 ft^2 [National Aboriginal Forestry Association, 1999].

In Siberia and North America, strips of birch bark with slits cut just wide enough for the wearer to see through and bent down to produce just below the eyes, were worn to prevent snow blindness before dark sunglasses were invented. Shoes made of birch bark were standard footwear for the poor in medieval northern Europe [Peyton, 1994].

The twigs and bark of the European birch (*Betula alba*) yield an oil known as oil of birch tar. This oil is used in Russia as a preservative for leather and gives Russian leather its distinct fragrance [Hora, 1981]. This oil also imparts durability to leather. Old books with leather covers that are treated with birch oil will not mould. The production of birch tar oil is a major Russian industry [Grieve, 1931].

The twigs and bark of sweet birch (*Betula lenta*), a tree native to portions of the eastern United States, yield oil of wintergreen. The twigs of this tree are pleasant to chew or can be used as toothpicks [author's observation]. This product is still harvested from *B. lenta* in small quantities; however, a synthetic product has now largely replaced it in commercial trade [Harlow and Harrar, 1950].

According to research results, birch bark has a medicinal potential, more precisely, it is referred to as betulin (15% of the birch bark). This compound can be adapted into betulinic acid and cure and control certain health problems. Betulin in itself may have medicinal properties as well. The University of Minnesota-Duluth (UMD) and its Natural Resources Research Institute (NRRI) hold patents related to the use of betulin from birch bark. Betulin represents a potential weapon against melanoma tumours. Fifty pounds of bark might produce 100 doses of betulinic acid, and a betulin-based treatment might be more effective than the current most popular herpes treatment [Lemay, 1999].

The inner bark of several Asian, European and North American species of *Tilia (T. americana, T. cordata, T. japonica* and *T. tuan*) are used for making mats, cordage and, when plaited, shoes [Hora, 1981].

The aromatic bark and roots of sassafras (*Sassafras albidum*) were at one time widely used in eastern North America for a tea and as a folk medicine. One of its medicinal uses was as a tonic. There was an old saying in the southern Appalachian Mountains: "Drink sassafras during the month of March and you won't need a doctor all year." It was also used as a blood purifier and to sweat out fevers [Wigginton, 1973]. Sassafras bark and roots were also used for flavouring tobacco, for a beverage known as root beer and as a treatment for lice and insect bites. The aromatic oil contained in sassafras bark and roots contains 80 percent of the phenolic compound safrole and is a potential carcinogen. The use of oil taken from the roots and bark of sassafras in food for human consumption has been banned for a number of years because of health risks [Coppen, 1995; Hora, 1991].

The inner bark of slippery elm (*Ulmus rubra*), a species indigenous to eastern North America, is mucilaginous and was chewed by early pioneer woodsmen to quench the thirst [Harlow and Harrar, 1950]. It is also used in medicine as a demulcent to sooth irritations, such as sore throats or inflammations of the digestive tract [Hora, 1981; Lust, 1990]. Slippery elm bark is still gathered for this purpose and there is a domestic market for approximately 100 t/a of this material at a wholesale price to the harvester of US$ 5.50 per kg [Thomas and Schumann, 1992].

Box 6.1 Aspirin – The modern miracle drug

During the 1700s, the Reverend Edward Stone, of Chipping Norton, Oxfordshire, in the United Kingdom conducted experiments on 50 patients with fevers and found that the bark of the willow tree contained a substance that was extremely effective in controlling malaria and other fevers.

Over the next hundred years, chemists gradually determined that the active ingredient in willow bark was salicylic acid. Unfortunately this compound had an unpleasant taste and irritated the stomach. Dr Felix Hoffman made a significant breakthrough when he was working in the Bayer laboratories in Germany. In 1897, he managed to combine salicylic acid with acetic acid and produced acetylsalicylic acid. This material had the same therapeutic properties as salicylic acid but did not have the unpleasant taste.

Over the next century, acetylsalicylic acid became the most widely used drug in the world. It is sold as aspirin and 50 000 t are used annually.

Aspirin was also the first drug to be sold in a tablet form and became extremely popular because it was effective and inexpensive.

Source: http://www.inreach.com/dameron_heart/aspirin.htm

CHAPTER 7

FRUITS

The fruits of many broad-leaved temperate hardwoods provide a variety of beneficial products ranging from edible fruits to industrial oils. Many temperate broad-leaved trees yield fruits that are important agricultural crops, worldwide, and are grown commercially in orchards. Examples include pome fruits such as apple (*Malus pumila*); pear (*Pyrus domestica*); stone fruits, such as cherries, apricots, peaches and almonds; various species of *Prunus*); olives (*Olea europea*); and figs (*Ficus* spp.). Since these fruits are considered to be agricultural rather than forest crops, they will not be discussed in depth in this chapter. Emphasis is placed on those products that are still gathered, at least to some degree, in natural or planted forests.

TUNG OIL

Tung oil or "China wood oil" is a quick-drying vegetable oil extracted from the seeds of the tung tree (*Aleurites fordii*, family Euphorbiaceae), a tree native to central and western China. Similar oils are produced from related species such as *A. montana*, native to southwestern China, and several tropical species of *Aleurites* [Duke, 1983; Panshin *et al.*, 1950]. This tree has been widely planted in areas outside its natural range [Duke, 1983].

HISTORICAL ASPECTS

Tung oil has been used by the Chinese for centuries to protect and beautify timber and regarded as the ultimate oil finish for enhancing the natural beauty and grain of timber. Its properties were not appreciated outside of China until about 1869 when the first shipment reached the United States. This is the year that marks the beginning of world trade in this important industrial commodity [Panshin *et al.*, 1950]. During the Second World War, the Chinese used tung oil as a motor fuel, but it tended to cause gumming of engines. However, when the oil was mixed with gasoline, it worked well and served to extend gasoline, which was in short supply [Duke, 1983].

The importance of tung oil in the paint and varnish industries and the uncertainty of the supply and quality of this product from China led to the establishment of experimental planting of tung trees in the United States. The first successful plantings of tung seeds was made in 1905 by the Division of Foreign Plant Introduction of USDA in Chico, California. The seedlings were used for test plantings across the southeastern and Pacific Coast states. By the 1950s, there were more than 30 000 ha of tung plantations. Most of them were established in Mississippi, followed closely by Florida [Panshin *et al.*, 1950]. However, many tung oil plantations were either destroyed or severely damage when hurricane Camille struck Mississippi in 1969 [author's observation]. The establishment of a tung oil industry in the southeastern United States made a significant contribution to the diversity of a regional agricultural system that was formerly based almost entirely on cotton production; helped to restore wasteland and resolve severe soil erosion problems; and led to the establishment of a regional paint and varnish industry [Panshin *et al.*, 1950].

COMPOSITION

The fruit contains from 14 to 20 percent oil, the kernel 53 to 60 percent and the nut has an oil content of 30 to 40 percent. The components are: elaeo strearic oil (75–80%), oleic oil (15%), palmitic (about 4%) and stearic acids (about 1%). Tannins, phytosterols and saponin are also reported [Duke, 1983].

USES

Tung oil is used in the manufacture of lacquer, varnishes, paints, linoleum, oilcloth, resins, synthetic leather, felt-based floor coverings, greases, brake linings and in cleaning and polishing compounds (Figure 7.1). Tung oil products are used to coat containers for food, beverages and medicines. They are also used for insulating wires and other metallic surfaces such as radios, radar, telephone and other communications hardware [Duke, 1983].

Figure 7.1 (left) Tung oil with fruits. (right) A wood finish made from tung oil on a table finished with this product.

HARVESTING

Tung trees usually begin to bear fruit during the third year after planting and are in commercial production by the fourth or fifth year. They reach maximum production in 10–12 years. The yield of mature trees ranges between 4.5 t/ha and 5 t/ha. The average productive life of a tree in the United States is approximately 30 years. Fruits mature and drop to the ground in late September to early November, at which time they contain about 60 percent moisture. Fruits are left on the ground for three to four weeks until the hulls are dry and the moisture content has dropped below 30 percent. The fruits are gathered by hand into baskets or sacks. An average picker can gather 60–80 bushels of fruit per day, depending on conditions in the plantation. Fruits are usually sacked, placed in the crotch of a tree and allowed to dry for another two to three weeks. Additional drying may be done at the mill because wet fruits contain less oil on a percentage basis and prices would be lower [Duke, 1983].

PRODUCTION AND TRADE

In 1969, world production was 107 000 t, and during the following year it increased to 143 000 t. Production for the 1980s was projected to average 199 000 t/a. Prices for tung oil depend on production, price supports and industrial demands but have recently averaged US$ 0.28/kg wholesale and US$ 0.34/kg for imports to Europe. Growers receive about US$ 51/t of fruit with 18.5 percent oil content and US$ 63/t of fruit with 22 percent oil content.

Major producers of tung oil are Argentina, China, Paraguay and the United States. The largest consumption of tung oil is in the manufacture of paint and varnish [Duke, 1983].

CAROB

The species carob *(Ceratonia siliqua L.)* is a slow-growing evergreen tree with rich, glossy foliage. Carob is native to the Eastern Mediterranean area. The tree blooms in the autumn and carries the young fruit to the end of the next summer. Its fruits/pods are rich in protein and sugar and are used in chocolate and pastry manufacturing and for photographic emulsion. Carob pods are also used as nutritious animal feed, whereas the herbaceous ground cover makes good pasture [Moussouris and Regato, 1999; Russel and Smith, 1950].

Ceratonia siliqua L. bears fruit at the age of six to eight years. At an average, a tree then yields 200-250 lb/a of fruit. The abundance of fruit is greater every second year. Also the seeds are edible and produce a protein-rich flour that contains no starch or sugar and is ideal for diabetics. The endosperm is extracted from the seed to produce galactomannan, which forms locust bean gum, a food additive. The pod is used for high-energy livestock feed and in the production of cocoa products and syrups. These are used as a substitute for cocoa and as a food (also known as *algarroba*, St. John's bread, and locust bean gum) [Goor and Barney]. [32]

Carob is a typical Mediterranean tree species that can be found in the coastal areas. In Lebanon for example it can be found up to 800 m, where it represents an important source of additional revenue to many local farmers. Both wild and cultivated populations can be found, often close to each other or even mixed. The wild populations can be found under very different environmental conditions, showing different growth characteristics. The fruits from carob are harvested in September. In Portugal and Spain, most carob plantings are located on steep, rock sites, unsuitable for other agricultural crops and require hand harvesting. Harvesting represents 30-35 percent of the total production cost. Harvested carob pods are first "kibbled", a coarse grinding process that separates the pod from the unbroken seeds.

Figure 7.2 Pods of the carob tree (*Ceratonia siliqua*) near Limassol, Cyprus.

In large parts of its distribution range, *Ceratonia siliqua* is under increasing pressure, mainly because of urbanization and conversion of areas to agricultural land. This degradation of carob populations seems to be symptomatic of the decline of the whole natural vegetation of the coastal regions [Breugel and Stephan, 1999].

Carob production is presently centered in Portugal and Spain, which have about 100 000 ha of carob trees and process about half of the world's commercial supply. World production is presently about 315 000 tonnes per year and the main producers are Spain (42%), Italy (16%), Portugal (10%), Morocco (8%), Greece (6.5%), Cyprus (5.5%) and Turkey (4.8%).

Carob has been introduced to temperate regions in Central America and also to Australia. More information on Carob is also described in the Non Wood Forest Products Series no. 6: *Gums, Resins and Latexes of Plant Origin* (FAO, 1995).

PROSOPIS PODS

The genus *Prosopis* (family Leguminosae) consists of about 45 species of small- to medium-sized trees or shrubs. Most occur in the Western Hemisphere in semi-arid temperate regions, but three species are found in Asia and Africa [Little, 1979]. The seed pods of several species of *Prosopis* are edible and used as food for human consumption or as a livestock feed.

In the desert regions of Arizona and California, *Prosopis* pods were an important food for indigenous tribes. Large trees with a 40–60 cm basal diameter, growing in riparian zones in this region, can yield up to 40 kg of pods per tree. The pods contain approximately 13 percent protein and 35 percent sugar. They were ground into flour with stone mortars, and the hard seeds were often discarded. The pods of Argentinian species of *Prosopis* were used in a similar manner and research is currently under way in Peru to develop industrial processes that will produce products from the pods of these trees that will appeal to contemporary human societies. In the United

32 Source: Spring tree carob (http://www.springtree.com/carob.html)
Ecology & Evolutionary Biology Conservatory (http://florawww.eeb.uconn.edu/acc_num/199000057.html)
Carob (http://www.humorscope.com/herbs/carob.html)

States, some cottage industries have arisen that make jelly and flour from *Prosopis* pods. The pods have a strong mocha-cinnamon aroma, and a potential exists for producing special baking flour for muffins and fruitcakes. In India, the green pods of *Prosopis cineraria* are a popular human food, and in some locations the crop price in the marketplace is US$2.00/kg, more than half the average daily wage [Felker, 1998].

A current limitation to widespread use of *Prosopis* pods for human food in the United States is the high cost of manual harvest in natural forests. If trees could be grown in straight rows in orchards and pod harvesting could be mechanized, an industry based on production for human use could be developed [Felker, 1998].

In the arid regions of northern Chile (Regions I-III), *Prosopis* spp., principally *P. tamarugo* (common name tamarugo) and *P. chilensis* (common name algarrobo), cover an area of approximately 20 000 ha. The fruits of these trees are an important and nutritious source of fodder for livestock, including cattle, sheep and goats [Garfias Salinas *et al.*, 1995]. In Argentina, the fruits of *Prosopis* spp. are used as a cattle feed and in the production of a fermented beverage [Résico, 1995].

MOUNTAIN ASH AND RELATED TREES – *SORBUS* SPP.

Approximately 80 species of *Sorbus* (family Rosaceae) are found in Asia, Europe and North America. Commonly known as rowans, mountain ashes, whitebeams and service trees, the fruits of this group of trees have been used for a wide variety of purposes [Hora, 1981].

Figure 7.3 - Clusters of bright red fruits of the European mountain ash (*Sorbus aucuparia*). These berry-like fruits can be used for a wide variety of purposes.

Several species of *Sorbus*, including the European mountain ash (*Sorbus aucuparia*), produce clusters of bright-red berry-like fruits (Figure 7.3). The fruit of this species has been used for a variety of traditional foods. Several recipes exist for producing jams and jellies that are said to be excellent accompaniments to cold game or wild fowl. A wholesome cider can be made from the fruit. In northern Europe, the fruits were dried for flour that yielded a strong spirit when fermented. The Welsh once brewed what was said to be a delicious ale from the fruits of rowan but, unfortunately, this recipe has been lost [Ciesla, 1990; Grieve, 1931].

Mountain ash fruits are still gathered in a number of European and Near Eastern countries including Armenia (Ter-Ghazaryan and Ter-Ghazaran, 1998]; Belarus, where approximately 1092 t are harvested annually [Ollikainen, 1998]; Lithuania, 12 t are harvested annually [Rutkauska, 1998]; and Poland, with an annual harvest of 670 t [Kalinowski, 1998]. They have a high tannin content and should not be eaten fresh, but be left ripening after picking to develop a pleasing sweet-sour taste similar to grapes. They may also be eaten after being sun dried for 15–20 days. The berries are also a source of malic acid, which is used as a flavouring and in wine [Bounous and Peano, 1990].

The fruit of the American mountain ash (*S. americana*) has a sharp flavour, is rich in vitamin C and has been used in a variety of herbal medicines [Ciesla, 1990].

The service tree (*Sorbus domestica*), a tree native to southern Europe, north Africa and the Near East, produces brownish-coloured pear-shaped fruits that are sour but edible when overripe or after they have been exposed to frost [Hora, 1981].

PERSIMMONS

The genus *Diospyros* (family Ebenaceae) is primarily tropical and consists of about 485 species. However, a number of species extend into the temperate forests, primarily in China and Japan; and two species; *D. texana* and *D. virginiana,* occur in North America [Little, 1979]. Several temperate species produce a sub-globose berry that is orange coloured and tinged with purple when ripe and are edible [Harlow and Harrar, 1950]. The kaki or Japanese persimmon (*D. kaki*) is widely grown in orchards both in China and Japan for its fruit. In Japan, it is regarded as the country's national fruit [Hora, 1981].

The fruits of the common persimmon (*D. virginiana*), a small to medium tree of the eastern hardwood forests of the United States, remain on trees after the foliage has been shed in autumn. In the southeastern United States, these fruits are commonly gathered after a frost has occurred. Persimmon pie and jelly are traditional local food of this region [author's observation].

HAWTHORN

The various species of hawthorn or thorn apple (*Crateagus* spp., family Roseaceae) produce edible fruits with a taste similar to that of a tart crab apple. Mayhaws (*C. aestivalis, C. opaca* and *C. rufula*) are indigenous to the southeastern United States and produce early ripening, yellow to bright-red fruits with a pleasant flavour. This small tree, which is usually found in low-lying wet areas, may be one of the last fruit-bearing trees indigenous to the United States that has not yet been widely commercialized [Payne and Krewer, 1990; Thomas and Schumann, 1992].

Mayhaws are used to make jellies, marmalades, preserves, salad dressings, wines, syrups, sauces and desserts. Traditional recipes for making these products have been in existence for nearly 100 years. However, there has been some recent renewed interest in this traditional fruit of the southeastern United States, especially in Alabama, Georgia, Louisiana and Mississippi. In 1991, a family-run mayhaw preserve company based in Louisiana purchased about 45 000 kg of mayhaw berries and produced 23 000 cases of mayhaw jelly [Thomas and Schumann, 1992]. Fresh mayhaw fruits currently sell for US$ 2.75–4.40/kg and the jelly for US$ 18.00/litre. There is some interest in the commercialization of this fruit, and one source predicts that the tree may be found in commercial orchards within the next decade. Several cultivars have been developed for use in orchards [Payne and Krewer, 1990]. The fruits of *Crateagus cuneta* are used for the treatment of stomach complaints in China [Hora, 1981].

SEA BUCKTHORN

Sea buckthorn (*Hippophae rhamnoides* L.) is a fast-growing deciduous shrub tree widely distributed in temperate regions that produces valuable fruits for diet and raw material for the pharmaceutical industry. Its fruits contain a wide range of vitamins such as provitamin A, vitamins B (tiamin), B2 (riboflavin), E (okoferol), K (phyllokinon), P, PP and others.

It is native to Europe and Asia and has been known and used by humans for centuries. It is mentioned in the writings of ancient Greek scholars such as Dioscorid and Therophast. In ancient Greece, sea buckthorn was known as a remedy for horses. Leaves and young branches were added to the fodder. This resulted in rapid weight gain and a shiny coat for the horse. This, in fact, gave the name to the plant in Latin *hippo* = horse, *phaos* = to shine [Rongsen, 1992].

The interest in sea buckthorn growing has increased due to the its various uses and has become an important subject for domestication in many countries. In the last years, the shrub tree, which previously grew exclusively in home gardens, has been introduced into plantations. The sea buckthorn industry has been thriving in Russia since the 1940s when scientists there began investigating the biologically active substances found in the fruit, leaves and bark. The first Russian factory for sea-buckthorn product development was located in Bisk. These products were used in the diet of Russian cosmonauts and as a cream for protection from cosmic radiation. The Chinese experience with sea-buckthorn fruit production is more recent, although traditional uses date back many centuries. Research and plantation establishments were initiated in the 1980s. Since 1982 over 300 000 ha of sea buckthorn have been planted in China. In addition, 150 processing factories have been established, producing over 200 products. The sea buckthorn-based sport drinks "Shawikang" and "Jianibao" were designated as the official drink for Chinese athletes attending the Seoul Olympic Games [Rongsen, 1992].

The potential of sea buckthorn in North American markets still remains untapped.

Sea buckthorn is easy to propagate by seed or cuttings. It can grow in arid to very wet conditions and tolerates cold winters. Though it prefers sandy and neutral soil, sea buckthorn survives in soils with pH values from 5 to 9 [Schroeder, 1995] and tolerates seawater flooding. It is a pioneer species and often the first woody species colonizing open areas such as abandoned farmland, wasteland and rocky islands. Sea buckthorn prefers full sunlight, does not tolerate shade and suffers even under sparse tree cover. Like other members of the Elaeagnaceae family, sea buckthorn is also a nitrogen fixer.

Since the discovery of the nutritional value of sea buckthorn, hundreds of sea-buckthorn products made from the berries, oil, leaves, bark and the extracts from them have been developed. In Europe sea-buckthorn juice, jellies, liquors, candy, vitamin C tablets and ice cream are readily available [Bernáth and Földesi, 1992; Wolf and Wegert, 1993].

At present, the largest producers and consumers of sea-buckthorn products are China, Russia, and Mongolia. They all have large-scale processing facilities. Processed products include: oil, juice, alcoholic beverages, candies, ice cream, tea, jam, biscuits, vitamin C tablets, food colours, medicines, cosmetics and shampoos [Iirkina and Shishkina, 1976; Wu, 1991].

Oils and oil extracts are the most important sea-buckthorn products produced in Russia. These oils are processed and sold as essential oils for numerous medicinal and therapeutic uses. Fruit drinks were among the earliest sea-buckthorn products developed in China. These drinks have had strong market demand and excellent consumer acceptance. They have rapidly gained a reputation both as a satisfying drink and as a nutritional beverage that enhances stamina and vitality.

Cosmetic applications of sea buckthorn are well known in Russia and China. In Russia, sea-buckthorn berries are often used in homemade cosmetics. Recipes for moisturizing lotions, dandruff control and hair-loss prevention are widely known and used in Russia [Pashina, 1993]. Sea-buckthorn oils contain high concentrations of palmitoleic acid. This rare fatty acid is a component of skin fat and can support cell tissue and wound healing. It is generally accepted in the cosmetic industry that sea-buckthorn oils have unique anti-ageing properties and, as a result, are becoming an important component of many facial creams manufactured in Asia and Europe. In addition, the UV-spectrum of the oil shows a moderate absorption in the UV-B range which makes sea-buckthorn derived products attractive for sun-care cosmetics [Quirin and Gerard, 1994].

BLACK ELDER

Black elder, *Sambucus nigra* (family Caprifoliaceae), is a fast-growing deciduous shrub native to Europe, western Asia and North Africa. Numerous species of elder or elderberry grow in Europe and North America.[33]

Elderberries have long been used as food, particularly in dried form. Elderberry wine, pie, and lemonade are some of the popular ways to prepare this plant as food. Elder wine is prepared of dried English elder berries. These are preferred to French and other Continental elder berries since they have a more pleasant odour and flavour.

The berries are also used for medicinal purposes. Only those with blue/black berries are medicinal for diseases such as bronchitis, common cold, sore throat, infection and influenza. A tea made of

[33] Source: Elderberry (http://www.gnc.com/wellness/natpharm/Herb/Elderberry.htm)

the dried berries is said to be a good remedy for colic and diarrhoea. In the '*Anatomy of the elder*', it is stated that the berries of the elder are useful in epilepsy. Further, they were held by our forefathers to be helpful in rheumatism and erysipelas.[34]

MEDLAR

Mespilus germanicus (family Rosaceae) is a small, deciduous tree native to southeast Europe and Central Asia and is naturalized in the United Kingdom, as well as in other parts of northern Europe. The medlar tree, which is its common name, blooms and bears fruit when very young. Its fruits are edible and can be made into preserve or are more commonly allowed to rot ('blet') for a few weeks. This latter process is known as bletting and is similar to the riping process of American persimmon. The bletted fruit has flesh with the consistency and taste of apple butter.[35]

BLACK RASPBERRY

Rubus occidentalis L. (family Rosaceae) is native to many parts of Europe. Its fruits, called raspberries, are fragrant, subacid and cooling. They contain crystallizable fruit sugar, a fragrant volatile oil, pectin, citric and malic acids, mineral salts, colouring matter and water. By adding sugar and white wine, the juice of the ripe fruit is used to make an acid syrup called raspberry vinegar. When adding water, it serves as a cooling drink in summer, which also can be used to boost fever as well as for sore throats. A wine can also be brewed from the fermented juice of ripe raspberries. This wine is antiscrofulous, and raspberry syrup dissolves the tartar of the teeth. The fruit is also used for dyeing purposes.[36]

OTHER MINOR FRUITS

The fruits of several species of dogwoods (*Cornus* spp.) are rich in vitamin C and the berries are added to wines and liqueurs in northern Italy as flavourings [Bounous and Peano, 1990].

A tree known as strawberry tree (*Arbutus unendo*), which is indigenous to the Mediterranean region, produces a fruit that is moderately sweet, high in vitamin C and may be eaten ripe or as a jelly (Figure 7.4). It is also used in the production of wines and liqueurs on the islands of Sardinia (Italy) and Corsica (France) [Bounous and Peano, 1990). In Portugal, this fruit is a constituent of *medronho*, a strong alcoholic spirit with a unique flavour [Hora, 1981].

Figure 7.4 Fruits and foliage of the strawberry tree (*Arbutus unedo*), a tree found in Mediterranean Europe. The fruits are moderately sweet and can be eaten ripe or as a jelly

The North American mulberry (*Morus rubra*) produces reddish to purplish coloured fruits that readily drop from branches when they are ripe. The fallen fruits are juicy and sweet and were collected to make jams and

34 Source: Sambucus (http://www.healthlink.com.au/nat_lib/htm-data/htm-herb/bhp727.htm)
Sambucus nigra (http://www.msue.msu.edu/msue/imp/modop/00001315.html)

35 Source: Plant of the week (http://www.bl.rhbnc.ac.uk/plant/medlar.html)
The Medieval medlar (http://www.ars-grin.gov/ars/PacWest/Corvallis/ncgr/cool/medlar.html)

36 Source: Raspberry (http://www.botanical.com/botanical/mgmh/r/raspbe05.html#cul)

jellies. They were an important food source for indigenous tribes and early European colonists in North America [Hora, 1981]. Mulberries are also gathered from wild trees in parts of Pakistan and are dried and sold in markets [author's observation].

The pods and fruits of several species of *Gleditsia* (family Leguminoseae) are used for a variety of purposes. The Caspian locust (*G. caspica* and *G. japonica*), indigenous to Japan, and *G. macracantha,* indigenous to China, are used in the manufacture of soap. The pods of *G. macracantha* are used in tanning. The pods of the North American *G. triacanthos* can be fermented into a beer or fed to livestock [Hora, 1981].

Blue honeysuckle (*Lonicera* L. subsect. *Caerulea* Rehd., family Caprifoliaceae) grows wild in Russia, China, Japan, Canada and in the United States. Its fruits are characterized by a sour-sweet taste and very early maturity, which occurs in June. In Russia, blue honeysuckle is a popular berry crop, which is used commercially and by amateur horticulturists [Plekhanova, 1998; Plekanova and Streltsyna, 1998].[37]

Figure 7.5: Fruits of (from top and from left to right): Black raspberry (*Rubus occidentalis*); Mulberry (*Morus rubra*); Dogwood (*Cornus* spp.); Persimmon (*Diospyros* spp.); Hawthorn (*Crateagus* spp).; and Sea Buckthorn (*Hippophae rhamnoides*).

37 Source: Encyclopedia (http://www.encyclopedia.com/articles/06017.html)

CHAPTER 8

NUTS

Many temperate broad-leaved trees produce a fruit that is hard and oily, commonly known as a nut. As is the case with soft textured fruits, the nuts of many temperate broad-leaved trees are important food sources, and some produce edible oils. Several species of nuts are used for a variety of industrial products. Some nut crops of temperate broad-leaved trees, including English or Persian walnuts (*Juglans regia*), pecans (*Carya illinoinensis*), pistachios (*Pistacia* spp.) and hazel or filberts (*Corylus* spp.), are produced in orchards and are considered to be agricultural rather than forest crops. As was done in Chapter 7, emphasis is placed on those nuts that are gathered, at least to some degree, in natural or planted forests (Figure 8.1).

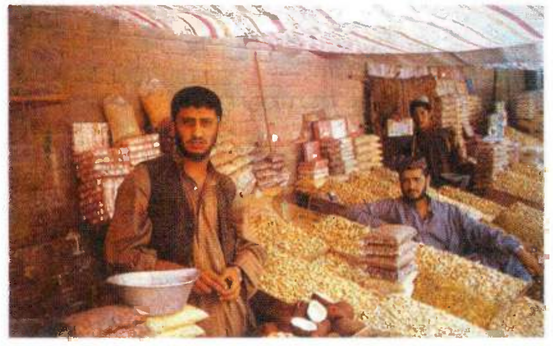

Figure 8.1 A dried fruit and nut market in Quetta, Balochistan Province, Pakistan. Most of the products sold here are from temperate broad-leaved trees. While many of these products are grown in orchards as agricultural crops, others are still gathered in natural or planted forests.

ACORNS

Acorns, the nuts of oaks and related trees (Figure 8.2) have a variety of uses. They have provided a staple food for humans and have been used as feed for livestock. The acorns from most oaks are also an important food for wild game and other wildlife species. Moreover, several species of acorns have been used as a source of natural dyes.

Figure 8.2 - Acorns of *Quercus aegilops*, an oak indigenous to the Mediterranean region of Europe. Isle of Naxos, Greece

HUMAN CONSUMPTION

Acorns have been a traditional food source for many human societies (Table 8.1). They are a source of vitamin C and starch and are reported to be high in magnesium, calcium and phosphorus. When compared to barley and wheat, acorns are slightly lower in carbohydrates and protein content but are higher in fat and fibre content. Therefore they have a higher caloric content per unit weight (average 4 994 calories/kg) than cereal grains. Unfortunately, acorns are also high in tannin content. Tannin imparts a bitter, astringent flavour to the nuts but is easily leached. Acorns have been eaten raw, roasted or boiled. In parts of the American Midwest and Europe, a coffee-like beverage has been made from acorns. Acorn oil is used for cooking in parts of North Africa and acorns have been used for medicinal salves and cooking by the indigenous tribes in eastern North America [Bainbridge, 1986; Burns and Honkala, 1990; Derby, 1980; Wickens, 1995].

Acorn production varies from year to year and in good years can reach levels of 3 000–6 000 kg/ha/a. Individual, open grown trees, e.g. Oregon white oak (*Quercus garryana*) can produce several hundred kilograms in a single growing season [Bainbridge, 1986].

Among their most widespread uses, acorns were used as a staple food by the indigenous tribes of California, who worshipped both the acorn and the oak. Acorns may have been an important food source as early as 5000 BC [Schneider, 1990]. The importance of acorns to these cultures is recorded in the journals of John C. Fremont in his historical second California expedition of 1844 [Peattie, 1953]:

> *"....an Indian village, consisting of two or three huts; we had come upon them suddenly, and the people had evidently just run off. There huts were low and slight, made like beehives in a picture, five or six feet high, and near each was a crate, formed of interlaced branches and grass in size and shape like a very large hogshead. Each of these contained from six to nine bushels. These were filled with long acorns already mentioned, and in the huts were several neatly made baskets containing quantities of the acorns roasted. They were sweet and agreeably flavoured, and we supplied ourselves with about half a bushel, leaving one of our shirts, a handkerchief and some smaller articles in exchange."*

The native vegetation of the foothills of the Sierra Nevada Mountains and coast ranges and the riparian zones of the Central Valley was composed of extensive woodlands and savannahs dominated by several species of oak (Figure 8.3). It is estimated that about 230 kg of acorns per person per year was consumed by indigenous hunter-gatherers. Acorns from a number of species of oaks were used including *Q. agrifolia, Q. douglasii* and *Q. kelloggi*. These tribes made extensive use of fire for a variety of purposes, including making acorn gathering easier. Oak woodlands were typically burned just prior to the time acorns ripened and fell from the trees. The frequent use of fire by these tribes helped to maintain open oak woodland [Burns and Honkala, 1990; Rossi, 1990]

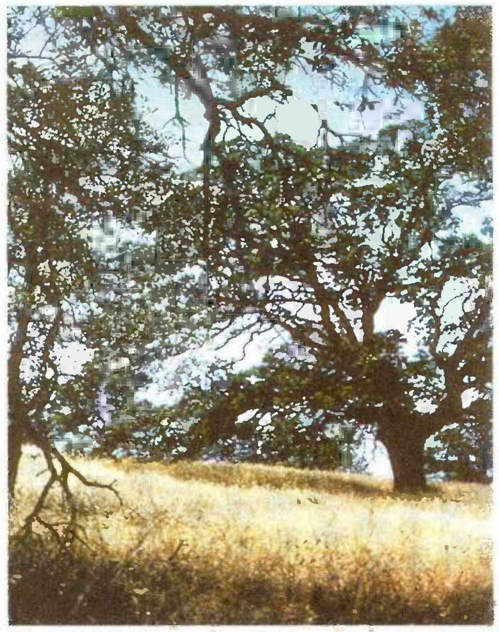

Figure 8.3 A grove of blue oak (*Quercus douglasii*) in the Coast Range of California. The acorns of this and many other North American oaks provided a staple food source for indigenous tribes.

Indigenous tribes in other parts of the western United States also made extensive use of acorns. The area once dominated by the Apaches, which consisted of western Texas, New Mexico and Arizona in the United States and northern Sonora in Mexico, coincides almost exactly with the natural range of *Quercus emoryi*. The acorns of this oak were ground into a sweet-tasting meal and were often eaten raw [Peattie, 1953]. The Kalapuya tribe of the Willamette Valley of Oregon used the acorns of *Q. garryana* as a staple food source and, like their counterparts in California, used fire to clear competing vegetation and make acorn gathering easier [Boyd, 1986]. The indigenous tribes along the Columbia River of Oregon and Washington used urine to cure acorns, which later became known as "chinook olives" by the first European-American settlers in the region.

Acorns are still an important food source in many parts of the world, including Korea [Bainbridge, 1986] and Morocco. In Morocco, the acorns of cork oak (*Q. suber*) are gathered in the fall for human consumption and sold in small baskets along roadsides [author's observation].

The acorns of several species of *Lithocarpus* are also locally important food sources. The acorns of *Lithocarpus edulis*, a species indigenous to Japan, and of *L. corneus*, indigenous to southern China, are rather sweet and edible. [Harlow *et al*., 1979; Wickens, 1995]. In India, *L. xylocarpus*, a component of tropical semi-evergreen and Himalayan moist temperate forests, produces an edible nut that is eaten locally.[38] The acorns of tanoak (*L. densiflorus*) were an important food item for several indigenous tribes in the northern Coast Range of California. In many indigenous communities, the main diet was salmon and tanoak acorns. Flour was made from the acorns that

[38] Information provided by Dr M. P. Shiva, Dehra Dun, India

were ground and then washed in hot water to extract the tannins and bitter flavour. They acorns were cooked into a mush [Fowells, 1965; Peattie, 1953].

Table 8.1 Traditional and contemporary uses of acorns for human consumption

Species	Common name	Distribution	How used
Q. aegilops	Manna oak	Mediterranean Europe, Near	Flour for bread in Iran and Iraq
Q. agrifolia	Coast live oak	East	Raw or roasted, ground for baking
Q. alba	White oak	California, United States	Dried, boiled or roasted, also as a
		E. North America	coffee substitute
Q. coccifera	Kermes oak		
		Mediterranean Africa,	
Q. douglasii	Blue oak	Europe and Near East	Traditional food
Q. emoryi	Emory or blackjack	California, United States	Raw or roasted, ground into meal
	oak, bellota	SW-United States	
Q. floribunda	Green oak, Kilonj	N. Mexico	
Q. frainetto	Hungarian oak	N. India	Coffee substitute
		E. Europe, Balkans	
Q. gambelii	Gambel oak		Ground into meal
Q. garryana	Garry Oak	Southwest United States	Staple food of indigenous tribes
Q. glabra		West coast, North America	Eaten locally
Q. glauca		Japan	
		Himalayas	
Q. grisea	Gray oak		Staple food of indigenous tribes
Q. ilex	Holm oak	SW United States and N.	Occasional food
Q. kelloggii	California black oak	Mexico	Staple food of indigenous tribes
		Mediterranean Region	
Q. libani	Lebanon oak	California, United States	Roasted
Q. lobata	Valley oak		Roasted, traditional food of
		Near East	indigenous tribes
Q. macrocarpa	Bur oak	California, United States	Raw or roasted
Q. macrolepis	Camata, camatina		Boiled or raw
	or valonia oak	E. Central NA	
Q. marilandica	Black jack oak	S. Balkans, Aegean	
Q. nigra	Black oak		Traditional food
Q. oblongifolia	Mexican blue oak	East United States	Traditional food
		E United States	
Q. petraea	Sessile oak	Southwest United States, North	
Q. phellos	Willow oak	Mexico,	
		Europe	
Q. prinus	Chestnut oak	Southeast United States	Traditional food, eaten raw or
			roasted, ground into flour for baking
Q. robur	English oak	East United States	Famine food, coffee substitute
Q. stellata	Post oak		Traditional food, eaten raw or
		Europe	roasted, ground into flour for baking
Q. suber	Cork oak	East-central United States	Sold along roadsides in Morocco for
			food.
Q. virginiana	Live oak	West Mediterranean Europe,	Traditional food, eaten raw or
		North Africa	roasted, ground into flour for baking
		Southeast United States	and a sweet cooking oil.

Sources: Peattie 1953, Little 1979, Miller 1997, Shiva, personal communication, Wickens 1995.

DYES

Fully ripe, crushed acorns of the North American oaks (*Quercus alba*, *Q. rubra* and *Q. meuhlenbergii*) are a dye source and produce a range of colours depending on the mordant used. A tan to medium brown colour is produced with chrome, dark brown with iron and golden brown with chrome and tin [Casselman, 1993].

Box 8.1 Acorns as a "natural" food

There is some interest in the use of acorns as a "natural" food in the United States. Derby (1990) outlines a modern-day procedure for preparing acorn flour that is based on methods used by indigenous tribes prior to the European settlement.

The procedure consists in gathering acorns as they fall from the trees in autumn and placing the acorns in a bucket of water. Only those acorns that fall to the bottom of the bucket are retained. The outer shell is cracked by applying pressure with pliers and peeled away. The brown skin covering the nut should also be removed because it is high in tannin content, and the nuts would leach more rapidly if most of it is removed. Submerging the nuts in water for several hours and rolling them between the palms of the hands can do this.

The acorns are then ground in a mortar or in small amounts in an electric blender with a few teaspoons of water. Soaking and rinsing in clear water leaches the resulting meal. Leaching should continue with fresh water until the rinse water is no longer brown. After leaching the acorn meal, if not used immediately, can be dried on trays in a warm oven. Drying acorn meal in a gas oven with no heat other than the pilot light for two days is generally sufficient. If acorn meal is sun dried, care must be taken to protect it from birds or insects. After the meal is thoroughly dried, it may be stored in a refrigerator or freezer.

FOOD FOR DOMESTIC ANIMALS AND WILDLIFE

Acorns have been a food for hogs since medieval times when they were turned loose in oak forests in England and other European countries to graze [Edlin, 1985]. Similarly in Portugal, the acorns of *Quercus suber* and other oaks have been used to fatten hogs. Hogs are allowed to range freely in oak forests toward the end of October and are collected in late January. They have been known to average a 30-kg increase in weight when fed on acorns.[39]

The acorns of many species of oaks are an important wildlife food. Studies indicate that in Wisconsin the acorns of *Q. bicolor* were found to make up 27 percent of the diet of wild ducks. Other animals that feed on acorns include various songbirds, pigeons, quails, turkeys and rats, bears and deer [Burns and Honkala, 1990].

BEECH NUTS

The nuts of beeches (*Fagus* spp., family Fagaceae) are triangular in shape and usually occur in two within a bur covered with small spines (Figure 8.4). They mature in a single season.

HUMAN CONSUMPTION

The nuts of American beech (*Fagus grandifolia*) are sweet and have a protein content of about 20 percent [Thomas and Schumann, 1992). The nut can be readily opened with a thumbnail and is reported to be one of the sweetest, most delicious products of northern forests. Collection of beechnuts in northeastern forests was once a popular activity. They were collected in large numbers in the fall and sold commercially. Today beechnuts are rarely found in markets as a commercial product because of "modern sophistication" [Fernald *et al.*, 1958]. A disadvantage of beechnuts as a food item for human consumption is that the fresh nuts spoil quickly.

Figure 8.4 Foliage and nuts of the European beech (*Fagus sylvatica*), Parco Nazionale Abruzzo, Abruzzo Region, Italy

39 Source - http://www.portugal.org/german/doingbus/buyingfrom/products/cork/

They can be dried in full sun for one to two days or roasted in a small oven to prolong storage [Thomas and Schumann, 1992].

BEECH NUT OIL

The nuts of European beech (*F. sylvatica*), on the other hand, have never been a popular food item for human consumption and were only eaten when driven by extreme hunger. An important use of beechnuts in Europe, however, was as a source of oil, especially in France. During the early 1800s, some beech forests produced as much as two million bushels of nuts that, when properly treated, yielded oil equal to 1/6 the bulk of the original nuts. Beechnut oil was said to be equal to olive oil in flavour [Fernald *et al*., 1958].

Production of beechnut oil involves grinding the nuts into a paste from which the oil is extracted. The oil ages well if stored in clay jars and buried in sand in a cellar. It will keep for up to ten years, and oil over six years is considered to be the best [Fernald *et al*., 1958].

Roasted beechnuts have also been used as a substitute for coffee in Europe [Ferruled *et al*., 1958].

FOOD FOR DOMESTIC ANIMALS AND WILDLIFE

The nuts of European beech (*Fagus sylvatica*) have been used to fatten hogs [Harlow and Harrar, 1950; Hora, 1981]. Beechnuts are also a valuable food for wildlife including squirrels, mice, pigeons, pheasants and jays [Edlin, 1985]. Nuts of American beech (*F. grandifolia*) were a favourite food of the now extinct North American passenger pigeon.

CHESTNUTS

Chestnut is a fast-growing, long-lived deciduous tree and its nuts represent one of the most important nut crops in the temperate zone. Chestnuts are also gathered in natural forests. Species of *Castanea* (family Fagaceae) are indigenous to all three continents of the Northern Hemisphere, and the chestnut has long been cultivated throughout China, Korea, Japan and the Mediterranean basin.

HISTORICAL ASPECTS [40]

Chestnuts have been cultivated for at least 3000 years in the Mediterranean region. The ancient Greeks are thought to have been among the first to cultivate the nut (Chua and Klinac, 1992]. The Romans introduced this tree to Britain during their period of domination and colonization between AD 42 and 410 with the objective of raising the familiar nuts that were, in Italy, a staple food for their legionaries. However, the cooler climate of the British Isles was not conducive to good chestnut harvests [Edlin, 1985]. In Asia, the Japanese chestnut (*C. crenata*) has been cultivated since at least the eleventh century, and the Chinese chestnut (*C. mollissima*) possibly as long ago as 6000 years (Chua and Klinac, 1992].

IMPORTANT SPECIES [41]

Species of *Castanea* that have either been or are currently important in commercial production include the American chestnut (*C. dentata*), the Chinese chestnut (*C. mollisima*), the Japanese chestnut *C. crenata*) and the European chestnut (*C. sativa*) [Wickens 1995].

Castanea dentata is native to the eastern United States and adjoining portions of Canada. This is the tallest member of the genus *Castanea,* capable of achieving heights of approximately 20–35 m

40 For further information on historical aspects of chestnuts (*Castanea dentata*) consult, for example the following web page: American Chestnut (http://ncnatural.com/NCNatural/trees/chestnut.html).

41 Much of the information provided in this section was obtained from data accessed via the Internet from the American Chestnut Cooperators Foundation (http://ipm.ppws.vt.edu/griffin/accfcast.html)

(Harlow and Harrar, 1950] and has nuts that are sweeter than most other species. The burs usually contain three nuts each. American chestnut was also a prime timber producing species, however, this tree is no longer a viable source of nuts or other forest products because it has been decimated by an introduced fungus, *Cryphonectria (Endothia) parasitica* that causes chestnut blight (see textbox 8.2).

Box 8.2 : Chestnut blight: A devastating disease

Chestnut blight, caused by the fungus *Cryphonectria (Endothia) parasitica*, attacks the stems of species of *Castanea* and causes varying degrees of damage depending on the relative susceptibility of the species. The fungus is native to China, and both the Chinese and Japanese chestnuts are resistant to attack but not immune.

The fungus was accidentally introduced into North America during the early part of the twentieth century on Chinese chestnut nursery stock and was first observed in the New York Zoological Park in 1904. The American chestnut was highly susceptible to this fungus, and over a period of 50 years it destroyed most of the native chestnut forests in the eastern United States (Boyce, 1961; Manion, 1991).

The American chestnut occupied a unique position among American trees. There are few, if any, native trees that could compare with this tree in terms of vigour, growth and yield of a great variety of wood and non-wood products including lumber, poles, railroad sleepers, barrels, paper and fibreboard, tannin and nuts. Two major American non-wood products industries were doomed as a result of this devastating disease, the tannin extract industry in the southern Appalachian Mountains and the nut industry (Boyce, 1961). Most present-day Americans are no longer familiar with chestnuts as an edible nut.

Chestnut blight was first discovered in Europe during 1938. The European chestnut is susceptible to the disease, but the effects of the disease were not as devastating it was on the American chestnut. While many trees have been killed and chestnut production has been reduced, there is still a viable nut production industry in Europe today (Chua and Klinac, 1992; Hora, 1981).

Castanea mollisima is native to China with a natural range that extends from south China to north of Beijing and is considered to be the hardiest of the Asian chestnuts. This tree is more resistant to the chestnut blight fungus than other species of *Castanea.* Its nuts are sweeter and finer textured than those of *C. crenata*, and it is currently the major commercial nut-producing species. Several horticultural varieties, with varying degrees of hardiness, have been developed. This tree does not have good form and is not important as a timber-producing species.

The Japanese species (*C. crenata*) is found in hilly and mountainous regions. It is not as tall as *C. dentata*, and its nuts are intermediate in size between those of *C. dentata* and *C. sativa*. The nuts are large and coarse-textured. They lack the flavour of other chestnut species.

The European or Spanish chestnut (*Castanea sativa*) is a tree that has a similar growth habit to that of *C. dentata* and can reach similar heights. This tree is found in southern Europe, North Africa and the Near East. In the eastern part of Peloponnese peninsula in southern Greece, there are about 1 000 ha of *C. sativa* groves. The trees grow naturally but are also cultivated in plantations [Moussouris and Regato, 1999]. In the mountainous regions of Italy, it forms pure or nearly pure stands at mid to high elevations [author's observation]. This tree is somewhat less susceptible to chestnut blight than the American species but can suffer serious damage that has resulted in reduced nut yields [Wickens, 1995]. The nuts of *C. sativa* are about the same size as those of *C. crenata* but sweeter in flavour.

Other species of *Castanea* have smaller nuts and have been used locally as traditional sources of food while others are important as wildlife food. The nuts of the Chinese species *C. henryi* are small but have an excellent flavour. The "chinquapins" of eastern North America (*C. ozarkensis* and *C. pumila*) produce small, sweet nuts that have a good flavour but are difficult to shell. The nuts of these trees are used to fatten hogs [Wickens, 1995].

NUTRITIONAL VALUE

Chestnuts are both a tasty and healthy food and compare in nutritional value to wheat and brown rice. They are high in carbohydrates and have the lowest fat content of all major edible nuts (1–3%

compared to 50% for some other nuts). Chestnuts contain quality protein and no cholesterol.[42] The nutritional value of chestnuts varies by species and by the manner in which they are prepared [Wickens 1995] (Table 8.2).

PRODUCTION AND TRADE

Chua and Klinac (1992) discuss global commercial production and trade in chestnuts by major producing regions of the world in a paper (Table 8.3).

China

China is currently the world's largest producer and exporter of chestnuts. From southern to northern China, 300 different cultivars are grown under diverse and variable climatic conditions and environments, but only about 50 cultivars are produced commercially. Yields from *Castanea mollissima* average about 75 nuts/kg. There are some exceptionally large cultivars (40 nuts/kg) but these are not common. Average yield is ca 8 t/ha, with up to 15 t/ha possible from dense plantings (3 x 2 m) and high yielding cultivars (figure 8.5).

Figure 8.5 Burrs of the Chinese chestnut (*Castanea mollisima*) Henan Province, China

China's statistics are not very reliable if local consumption is included. In 1991, national export figures were 58 000 t (fresh and processed), but local consumption is high. A conservative estimate of total production is 80 000–120 000 t. Another source estimates production at 100 000 t/a to 240 000 t/a.[43] However, in a country of over one billion people, nobody seems to know for sure.

Castanea crenata is grown in Kirin Province with Japanese joint-venture interests. These nuts are cut by hand in a special way, leaving the raw flesh free of the inner skin (pellicle), a method that has been introduced by Japanese technicians sent to China. China has been chosen over Korea because labour is cheap (US$ 1.50 per day) and cutting is highly labour intensive. Hong Kong is the biggest importer of fresh and dried pellicle-free chestnuts, taking about half of China's export and then re-exporting to Southeast Asia. Most are consumed by overseas Chinese who eat them throughout the year, but more so around October, November, and December when fresh nuts are available for roasting. Chinese cuisine uses chestnuts in high-class dishes. The dragon-boat festival around May uses up most of the dried chestnut crop.

Table 8.2 Nutritional value of chestnuts[1]

Form	Water (%)	Protein (%)	Fat (%)	Carbohydrates (%)	Calories (per kg)
Fresh raw	44	4	1	49	2253
Dried	9	7	2	80	3626
Boiled/steamed	62	3	1	34	1549
Roasted	40	4	1	52	2934

1 Species not given
Source: USDA data presented by Great Lakes Chestnut Alliance[44]

42 Source : The Farm Store (http://www.square.com/the Farm Store/htm/cooking/html.)
43 Great Lakes Chestnut Alliance - http://www.traverse.com/earthkeepers/potential.html
44. Source: Traverse (http://www.traverse.com/earthkeepers/chsfact.html)

Table 8.3 Annual chestnut production by principal producer countries[1]

Region/Country	Annual production (tons)
Asia and Pacific	
Australia	538
China	100 000 – 240 000
Japan	60 000
Korea	70 000 – 80 000
Europe	
Croatia	70 000
France	20 000 – 25 000
Greece	18 000
Italy	> 50 000
Spain	20 000
Turkey	52 000

[1] Data are for the period 1978 to 1991.
Source: Great Lakes Chestnut Alliance, Chua and Klinac 1992.

Korea

The world's second largest producer of chestnuts is Korea, with a production of up to 80 000 t/a, of which up to 30 000 t are exported to Japan. Most natural stands of chestnut were largely destroyed in the 1950s as a result of war and chestnut gall wasp epidemics. Since then, more than 200 000 ha of orchard have been established, mostly in the south and west, on poor soils. Yields of 2–10 t/ha are reported at 400 trees/ha with one-third of the trees used as pollination sources. Blocks of trees are planted in 25-year cycles, with peak production around year 15. Chestnuts are a major export earner for Korea (US$ 80 million/year compared to US$ 64 million for all other fruit exports combined) and much effort has been devoted to developing the early-harvest, dark, even-sized chestnuts preferred by the Japanese market.

However, since 1977 the rate of planting has dropped due to increasing labour costs (especially peeling) that in turn has led to increasing mechanization, where possible. Most production is by *Castanea crenata x crenata* (Japanese cultivar) crosses, grown on rootstocks.

Japan

Japan is one of the largest chestnut consuming countries in the world and the biggest chestnut importer. Japan has a long history of chestnut cultivation and the development of new, high-performance cultivars. In practice, however, they face severe production problems due to blight and especially to insect pests, such as the gall wasp that entered Japan in 1941. From 1959 to 1964, the area of chestnuts in production doubled, but because of the gall wasp production levels remained almost unchanged. In 1978, domestic production exceeded 60 000 t, with another 23 000 t being imported. Today's Japanese market is basically segmented into several components. First is the current national production of *C. crenata* of 40 000 t/a. Japanese chestnut prices range from US$ 6.75 to US$ 8.50 per kilogram for ordinary cultivars. Through many years of habit and attachment to their winter festivals where food made of chestnut paste are widely eaten, Japanese prefer chestnuts as a winter food.

The second major source of chestnuts after Japan is China. Chinese chestnuts are imported during winter and well liked because their pellicle can be easily removed after roasting or boiling. The period of import supply is from October to December. They arrive in 60-kg jute bags. Total 1991 importation was approximately 28 000 t. Prices set by the Chinese National Export Corporation are about US$ 2.75/kg at the wholesale level.

Third in importance are supplies of chestnuts from Korea. Korean chestnuts are similar to Japanese cultivars, but Korea provides mainly hand-cut chestnuts. The cutting process is labour intensive, and great importance is attached to the manner of cutting. The product is priced as first or second quality according to the cut, and the Japanese have sent expert women cutters to Korea to train locals. A top cutter produces 10 kg/day of cut chestnuts. All pellicle and outer skin surface is removed, leaving only the white flesh. Large chestnuts are preferred but pricing is by weight. The annual supply for this type of cut chestnut is 15 000 t.

About 1 500 t of Italian chestnuts (*Castanea sativa*), without shell and pellicle, are also imported into Japan. These are used mainly for *marrons glacés* and also in paste form for confectionery. For *marron Glico*, the nut is stored for a period (chilled) that allows the shell and pellicle to be removed more easily from the nut by steam blasting. The nut is then re-frozen for export. For paste, the Japanese are very wary about the preservatives used. Italian-shelled chestnuts are shipped in 11-kg cartons.

Europe

Chestnut blight and phytophthora root rot have had a dramatic effect on chestnut production in Europe. From about the turn of the century, when chestnut blight was introduced, most of the traditional chestnut-producing areas of Europe have often shown a progressive decline in chestnut production. Both France and Italy suffered about an 85 percent decline between the turn of this century and 1965. This has been partly due to urbanization and population drift toward the cities; partly to increasing labour costs and the difficulties of mechanization in many production areas (trees are most often on steep slopes); but mostly due to the spread of the disease. Expensive and prolonged research efforts into breeding new, disease resistant cultivars, improved disease controls and the development of better rootstocks and cultivation methods have apparently helped stabilize this decline in recent years. High prices for processed, peeled and frozen chestnut products, especially in the United States where they sell for more than US$ 6.00/kg, have prompted moves to expand the chestnut industry in many countries.

An illustration of some of these changing trends can be seen in chestnut production in France. At the beginning of the century, France grew nearly 400 000 t of chestnuts. By the 1960s this had dropped to 45 000 t/a and to 27 000 t/a in the 1970s. By 1978, France was producing 20 000–25 000 t/a and importing about 10 000 t/a. Over the same time period, fresh consumption declined, while that of processed products increased proportionately. Within the European Community, France is now the biggest chestnut importer, mostly from Italy, but also from Spain and Portugal. In 1993 the value of Italian and Spanish chestnut production reached Lit 56 452 million (35 721 t) and Ptas 2 650 millions (52 300 t), respectively [Cesaro *et al.*, unpublished].

Italy is currently the largest chestnut producer in Europe, at over 50 000 t/a. Italy is also the world leader in the production of marrons and processed chestnuts. Most exports go to France. Within Italy, the traditional use of dried chestnuts as flour in cooking is declining, but overseas the popularity of these and similar products is increasing, especially in the United States. As a result, production is being increased, with new orchards being established and research continuing on the development of new and improved cultivars. Extra income is generated in some chestnut orchards by the production of honey and/or the edible mycorrhizal fungus, *Boletus edulis*, which is sometimes worth more than the chestnut crop itself (see section on edible mushrooms in Chapter 9).

Spain is the next highest European producer after Italy and France. In 1986, 120 000 ha of chestnuts were being grown, mostly in northern and western Spain, producing more than 20 000 t. In addition to having a large local market, peeled nuts are exported to Italy and France.

Elsewhere in Europe, some chestnut production is reported from Turkey (52 000 t/a), Greece (18 000 t/a) and Croatia (70 000 t/a). In Switzerland, 44 000 ha have been planted with chestnuts, mostly south of the Alps. All Swiss production is consumed locally, with an additional US$ 10 million worth imported annually.

United States of America

In the United States, the first European settlers found extensive native forests of American chestnut (*Castanea dentata*). European chestnuts were introduced in the early 1700s, Japanese chestnuts by 1860, and Chinese chestnuts in the late 1800s. However, the introduced chestnut blight destroyed almost all natural *C. dentata* forests and most *C. crenata* and C. *sativa* plantings by the 1950s. Therefore, many present-generation Americans are unfamiliar with chestnuts.

Presently in the United States, there are an estimated 800 ha of nut-bearing chestnut plantings, and perhaps 2 000 ha of non-bearing trees. Most production is concentrated in the western states of California, Oregon and Washington. The objective of the United States chestnut industry is to increase plantings to 120 000 ha. This is the area that would be required to bring American consumption to the European levels. At present, the United States import US$ 20-40 million chestnuts annually, mostly from Italy.

Because chestnut blight killed off almost all native trees, extensive efforts are under way to re-establish the "natural" chestnut forests of the country. This is the main concern of many chestnut researchers and supporters, and emphasis is placed on forest- rather than orchard-related problems. Tree form and timber production often takes priority over nut production.

Nevertheless, an organized chestnut industry is developing. Plantings on the West Coast are mostly *C. sativa x C. crenata.* East of the Rocky Mountains, most growers plant the blight resistant Chinese chestnut or its hybrids. Production guidelines to growers are based on 1.8-3.6 trees/ha at maturity (12–15 years) and a return of around US$ 4.00/kg wholesale. In parts of the country, chestnut production is replacing the more traditional growing of hazelnuts.

Australia

Australian chestnut production is estimated at 538 t/a from approximately 250 growers. By 2001, production is expected to reach 3 600 t, all sold locally. Much Australian chestnut production is concentrated in the state of Victoria, where there are sometimes serious disease and storage problems, and many of the older, inferior chestnut selections are now being replaced with newer material.

CULTIVATION

Most commercial production of chestnuts is in orchards although some are still gathered in the wild (Figure 8.6). They have traditionally been grown on hilly land that is unsuitable for other agricultural crops. The preference of chestnuts for lighter soil provides an opportunity to utilize land that is marginally productive. Chestnuts prefer a well-drained, slight acidic (pH 5.0–6.9) soil and tend to thrive in sandy soils. Chestnut trees on heavier (clay) soils have been noted to perform in outstanding fashion if the drainage patterns prevent standing water or soil saturation for extended periods. Chestnut trees do not like "wet feet" and should not be planted in flood plains. Established trees are quite drought tolerant.

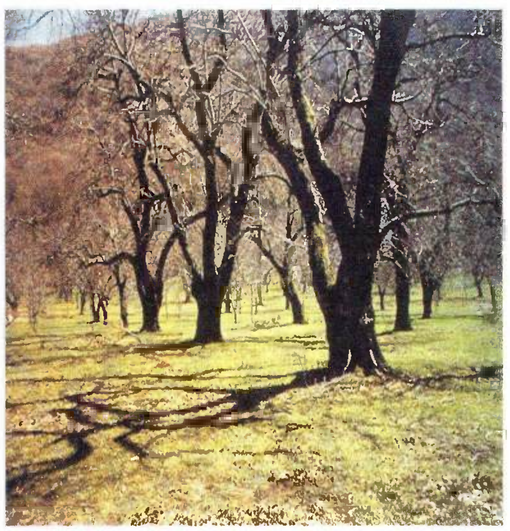

Figure 8.6 A *Castanea sativa* orchard, Lago di Vico, Lazio Region, Italy.

The nutrient requirements of chestnuts are similar to those of other tree crops. They respond to an early spring application of nitrogen with accelerated growth. In bearing years, nitrogen helps ensure larger nuts. For other nutrients, a soil test is recommended so that any deficiencies can be identified. Some producers recommend applying boron to ensure nut set. Most soil types have proven sufficient to some level of chestnut production. The Koreans and Chinese have discovered that a dormant application of phosphate (late November to early April) increases the ratio of female-to-male blossoms, perhaps accounting in part for the rather stunning production figures reported from Asia (9 to 11.2 t/ha).[45]

[45] Great Lakes Chestnut Alliance - http://www.traverse.com/earthkeepers/potential.html.

HARVESTING AND STORAGE

Chestnuts are hand harvested in the major production areas of Europe and Asia with methods little changed over the past 2000 years. However, high labour costs in regions such as Europe and North America and changing cost structure in agriculture may dictate the need for mechanically assisted harvesting options such as mechanical tree shakers. Fortunately, new orchards can be planned and managed to maximize the benefits of mechanized harvesting.

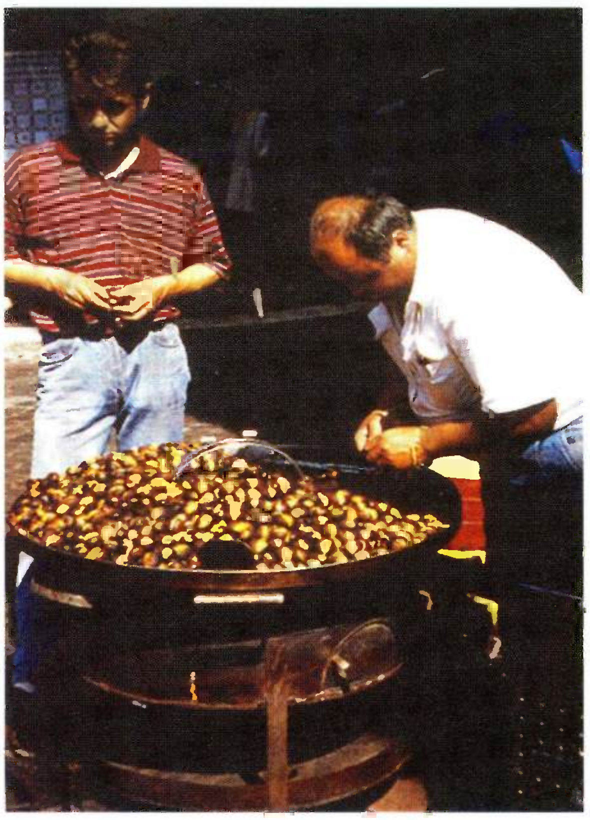

Figure 8.7 A street vendor selling fresh roasted chestnuts, Piazza di Spagna, Rome, Italy.

The simplest harvesting method is to let the nuts fall to the ground naturally, then pick them up by hand or gather them on tarps. New, low-cost polypropylene net tarps have helped reduce harvesting costs for other orchard crops. The use of tarps to catch naturally falling nuts, however, is limited to small orchards of 4 ha or less. As the size of the chestnut orchard increases, the harvest becomes more difficult to manage. A large orchard of seedling trees would have a natural nut drop period of 10–15 days most years but may range up to 30 days in some years, depending on environmental conditions. During extended harvest periods, the nuts are subject to fungal infection if stored improperly. Fallen nuts have to be picked up at least every few days.

Chestnuts add half of their final weight during the last two weeks on the tree. To maximize the orchard yield and nut quality, a mechanical harvest (shaking) must be accomplished after the nuts reach maturity and before natural nut fall begins.[46]

Harvested nuts may be held in refrigerated storage at 0-1°C in well-ventilated polyethylene liners up to several months. Damage by weevils (Coleoptera: Curculionidae) may occur during storage. However, it is not possible to remove infested nuts by flotation prior to storage. The risk of low-level fungal infection increases if visible moulds are absent or at low levels and are not detected. Fresh nuts can dry out and harden if not stored properly and cannot be roasted unless regenerated by soaking [Wickens, 1995].

PREPARATION AND USE

Chestnuts are starchy and a short curing period of three to four days is required to allow some of the starch to convert to sugar. This is especially true if the nuts have been refrigerated. Eating quality is best during harvest time. In Europe it is traditional for street vendors to roast chestnuts over charcoal fires and sell them in small quantities (Figure 8.7). Shelled nuts can be ground into flour and eaten as a bread or porridge. They can be roasted or boiled and eaten as a vegetable or used as poultry dressing. In France, a traditional way to serve chestnuts is to preserve them in syrup as *marrons glacés* or other sweets [Wickens, 1995]. Before cooking, an "x" should be cut into the flat side of the chestnut with a small knife in order to avoid bursting the shell during cooking.

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46 Great Lakes Chestnut Alliance - http://www.traverse.com/earthkeepers/potential.html.

NUTS OF *CASTANOPSIS* AND *CHRYSOLEPIS*

The genera *Castanopsis* and *Chrysolepis* are closely related members of the family Fagaceae. Some authorities list them under a single genus (*Castanopsis*). The primary difference between the two genera is that the nuts of *Castanopsis* require one year to mature and the inflorescence spikes are unisexual whereas the nuts of *Chrysolepis* require two years to mature and the sexes are mixed on a single inflorescence spike [Hora, 1981].

Trees and shrubs of the genus *Castanopsis* (Fagaceae) are widely distributed throughout the tropical and temperate forests of Asia. Many species produce nuts that can be are eaten raw, roasted or boiled. Several temperate forest species are used in confectionery [Wickens, 1995] (Table 8.5).

The nuts of the North American *Chrysolepis (Castanopsis) chrysophylla* are sweet and have been used as a food source by indigenous tribes [Wickens, 1998]. However, crops are not sufficiently reliable for a staple food source. Moreover, they are difficult to extract from their spiny hulls [Peattie, 1953]. The nuts of *C. sempervirens*, another North American species, were also used as a food source by indigenous tribes and are reported to be good tasting when roasted and served with butter and salt [Wickens, 1995].

Table 8.4 Edible nuts from temperate forest species of *Castanopsis* spp.

Species	Common Name	Distribution	Remarks
C. argyophylla		India	
C. boisii		Vietnam (northern)	Locally important
C. chinensis		China	
C. cuspidatus		China, Korea	Eaten boiled or roasted
C. echinocarpa	Berangan duri	India	
C. hysteris	Katunj	Eastern Himalayas	
C. indica	Indian chestnut	India	
C. sclerophylla		China	Locally important
C. tibetana		China (Tibet)	Locally important

Sources: Hora, 1981; Wickens, 1985; Shiva – Personal communication.

HAZELNUTS

Hazelnuts, also known as filberts or cob, are the nuts of various species of *Corylus* (family Betulaceae). They have a pleasant flavour, and dry nuts contain about 16.3 percent protein, 61.2 percent fat and 11.5 percent carbohydrates. The nuts are sold in shell to consumers or shelled for use in various food products, especially for nut chocolate. The nut kernels may be ground into flour and baked as filbert bread. In addition to being edible, hazelnuts are the source of both edible and industrial grade oils. Two species, the European hazel (*C. avellana*) and, to a lesser extent, the Turkish filbert (*C. maxima*) are grown in orchards and are an important agricultural crop in several countries with 70 percent of world production coming from the Black Sea area of Turkey. World hazelnut production has almost doubled from 1980 (421 136 t) to 1998 (771 827 t). Other areas of production include the coastal regions of Italy (20%), the Mediterranean coast of Spain (7%) and western Oregon and Washington (3%) [Wickens, 1995). Greece, France and Portugal are countries with small shares of world hazelnut production. Germany has been the main hazelnut importer reaching 43 percent of world imports in 1997. More than half of the world hazelnut export goes to European countries [Sengül and Sengül, 1999].

In some areas of Eastern Europe and the Near East, hazelnuts are still gathered from wild trees that grow in the forest. In Lithuania, they are gathered by families to satisfy household needs in conjunction with edible forest mushrooms and various berries [Rutkausas, 1998]. In Belarus, 24 t of hazelnuts were harvested in forests during 1996 and there is an estimated potential crop of 809 t annually [Ollikainen, 1998]. Hazelnuts are also collected on a small scale in Armenia [Ter-Ghazaryan and Ter-Ghazaryan, 1998].

HICKORY NUTS

Trees of the genus *Carya* (family Juglandaceae), commonly known as hickories, are found in North America and Asia. It is a fast-growing deciduous tree; several species produce edible nuts, and the nut kernels of at least one species are the source of edible oil.

Pecans, produced by *Carya illinoensis*, a tree native to the southeastern United States, Mexico and parts of South America, are an important agricultural crop. The nut meats are widely used in confectioneries and desserts. The wild trees produce edible fatty nuts (dry druoes), which Indian tribes in these areas eat.[47] The nuts of the North American shagbark hickory (*C. ovata*) and of the shellbark hickory (*C. laciniosa*) were important food sources for the indigenous tribes and are still collected and marketed on a small scale in some parts of the eastern United States. Other North American species of *Carya* that produce edible nuts and have been used as food for human consumption include *C. aquatica, C. carolinae-septenrionalis, C. cordiformis, C. glabra, C, myristiciformis, C. ovalis, C. pallida, C. texana* and *C. tomentosa*. The nuts of several of these species are astringent, bitter tasting, have small nuts or shells that are difficult to crack (Thomas and Schumann, 1992; Wickens, 1995].

Asian species of *Carya* that produce edible nuts include *Carya cathayensis* of eastern China and *C. tonkinensis* of southern China, northeastern India and Viet Nam, the nuts of which produce an edible oil that is also used in lanterns [Wickens, 1995].

Hickory nuts should be gathered as soon as they fall from the trees, hulled and placed on screens to dry. When the kernels are crisp, they should be stored in mesh bags in a cool, airy location [Thomas and Schumann, 1992].

PISTACHIOS

The genus *Pistacia* (family Anacardiaceae) consists of about 10 species that are indigenous to Eurasia, North America and the Canary Islands and have edible nuts. *Pistacia vera* is cultivated as an agricultural crop in Mediterranean Europe, the Near East and California.

World production of pistachios is increasing. During the period 1979–1981, world production averaged 109 000 t/a and in 1993 it increased to 354 000 t. Major producing and exporting countries are Iran, Turkey, Syria and the United States. These four countries produce 90 percent of pistachio world production. Other countries that export pistachios include Afghanistan, Greece, India, Italy, Pakistan and Tunisia. Countries such as Germany, Belgium, Luxembourg and the United Kingdom import pistachio nuts in order to re-export them to other countries [Wickens, 1995; Sengül and Sengül, 1999].

In some regions of the Near East, pistachios are still gathered from wild trees. For example, in Balochistan Province, Pakistan, pistachios are gathered from natural forests of *Pistacia kinjac* by local tribes for their own consumption or sold in marketplaces [author's observation].

The nuts of *P. terebinthus*, native to the Mediterranean region; *P. texana*, native to New Mexico and Texas; and *P. mexicanus*, native to Mexico and Guatemala, also produce edible nuts but are not grown commercially [Little, 1979; Wickens, 1995]. The fruit husks of *Pistacia vera* are used as a mordant and tannin source [Wickens, 1995]. *Pistacia atlantica* is native to, and common in, Algeria where its nuts are called *elkhordiri*. These nuts contain energetic oil, which is usually mixed with dates and can be eaten all day along with milk [Belhadj, 1999].

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47 Source: Hickories (http://www.planet-pets.com/treehick.htm)

WALNUTS

HUMAN CONSUMPTION

The nuts of most species of *Juglans* (family Juglandaceae), a genus of trees indigenous to Asia, Near East, North and South America, are edible. The English or Persian walnut (*Juglans regia*) produces a large, sweet, meaty nut that is being cultivated and is an important agricultural commodity in parts of Europe and North America, especially California. This tree still occurs in natural forests of Turkey, Iran, Afghanistan, Central Asia and in the Himalayan range up to Bhutan, where nuts are gathered from this tree. In the Central Asian Republic of Krygyzstan, for example, natural forests of *J. regia* are found on the southern slopes of the western Tyan Shan Mountains. These forests are state-owned but the rights to harvesting walnuts are leased to private individuals under a concept of collaborative forest management. In exchange for the harvesting rights, individuals agree to manage and protect the forest (Haldimann et al 2000).

The nuts of North American black walnut (*Juglans nigra*) and the California walnuts (*J. californica* and *J. hindsii*) have a flavour that is stronger and richer than that of the English walnut. This property makes it the nut of choice for baking candy and ice cream products. The nut kernels are high in fats, protein and carbohydrates and compare favourably with meat in the amount of vitamins A and B and riboflavin. These trees are not normally grown in orchards for their nuts [Thomas and Schumann, 1992].

Butternut (*J. cinerea*), also indigenous to eastern North America, is a slow-growing, deciduous tree that grows best in moist soil but does tolerate dry, alkaline soil. It is similar to black walnut *(Juglans nigra)* and is also called white walnut or oilnut. The tree produces a thin, fragrant, oily kernel that can become rancid quickly and must be shelled and used soon after having been dried. The nuts serve as food both for people and animals (e.g. squirrels and other rodents). They are sweet and good tasting when eaten straight from the shell or can be roasted or baked in cakes and pastries [Thomas and Schumann, 1992]. They are especially popular in New England for making maple-butternut candy. The nuts occur singly or in clusters of two to five and remain usually on the tree until after leaf fall.

Other temperate species of *Juglans* that have edible nuts and are at least locally important food sources include *J. ailanthifolia* of China and Japan, *J. australia* of Argentina and southern Bolivia, *J. boliviana* of Bolivia and Peru, *J. cathayensis* of central China, *J. duclouxiana* of the mountainous regions of Asia, *J. kamaonia*, of the western Himalayas, J. *major* of the southwestern United States and adjoining parts of Mexico, *J. mandchuriana* of northern China, *J. microcarpa* of western North America and *J. subtropica* of the Andean Cordillera. The nuts of several species of walnuts are used for extraction of cooking oil [Wickens, 1995].

DYE

The hulls of the nuts of *Juglans regia, J. nigra, J. cinerea* and other walnuts provide fast brown dyes that can be used to dye both plant and animal fibres. The Ancient Romans introduced *J. regia* to Europe both for its value as a food item and as a dyestuff. The early American colonists soon realized the value of both *J. nigra* and *J. cinerea* as a dye source. The hulls of *J. nigra* yield the most pigment and provide the darkest colours. Hulls of *J. cinerea* were used to dye the uniforms of Confederate soldiers during the American Civil War [Buchanan, 1987].

In the *altiplano* of northern Ecuador, weaving is an important local enterprise. Almost every home has at least one loom and production of hand-woven tapestries, table linens and related items are an important/art of the local economy. Most colours are now obtained from chemical dyes. Two natural dyes still remain in the repertoire of the *altiplano* weavers, however; indigo, an important blue dye source, and walnut hulls, collected from *Juglans neotropica*, an indigenous tree. Weavers are able to obtain a range of colours from deep chocolate brown to beige from the hulls of these nuts that are used to make intricate designs in tapestries [author's observation] (Figures 8.8 and 8.9).

Figure 8.8 *Juglans neotropica* growing near Otovalo, on the Ecuadorean altiplano. The nut hulls of this tree are an important local dye source

Figure 8.9 Wool is dyed rich brown colour in a dyebath made from the nut hulls of *Juglans subtropica*, Otovalo, Ecuador

The hulls of all walnut species can be dried for storage or used fresh. A few dozen nuts will dye several hundred grams of fibre. The hulls can be soaked overnight and simmered or boiled for more intense colours. However, this process gives off strong odours [Buchanan, 1987].

OTHER PRODUCTS

The processed shells of *J. nigra* are used for a variety of industrial products including:

- *Metal cleaning and polishing* – A soft grit abrasive made from processed walnut shells is used for cleaning jet engines, electronic circuit boards, ships and automobile gear systems. This product is also well suited for air-blasting operations, deburring, descaling and polishing operations because of its elasticity and resilience. The shell is non-toxic and dust free and can be used on plastic, aluminium and soft alloys because it produces a smooth surface without scarring.
- *Oil well drilling* – Black walnut shell is widely used in oil well drilling and in making and maintaining seals in fracture zones and unconsolidated formations.
- *Paints* – The paint industry uses the shells for plaster-effect paint. Paints and varnishes mixed with walnut shells are far superior to ordinary sand paint
- *Explosives* – Black walnut shell is used by manufacturers of explosives as filler in dynamite. It is compatible with other materials and works well for this use.
- *Cosmetic cleaners* – Black and English walnut shell is ideal as the gritty, rough agent in soaps, cosmetics and dental cleansers [Thomas and Schumann, 1992].

HARVESTING AND PROCESSING

Unlike the English walnut, which is grown in orchards, black walnuts are collected from wild or roadside trees and forest plantations grown for high-quality walnut logs. In the mid-western United States, *Juglans nigra* is often grown as a forest plantation species by small private landowners and the nuts can provide an additional source of income. This tree is sometimes grown as an agroforestry species in conjunction with wheat, milo, soybeans or fescue. In California, *J. californica* is a commonly planted roadside species where nuts can be readily gathered [Thomas and Schumann, 1992].

The walnut husk must be removed before decomposition begins to saturate the shell, giving the nut meat a bitter flavour. In the absence of processing machinery, this is a messy and cumbersome project. One way is to place the nuts on a hard surface and either step on them or run an automobile over the nuts. Washing in a garbage container several times can then clean the nuts.

The hulled nuts are dried in shallow layers for several weeks and stored in their shells in mesh bags in a cool location [Thomas and Schumann, 1992].

There are two plants in the United States that commercially shell black walnuts. These are located in Lodi, California, and Stockton, Missouri. The plants purchase walnuts from farmers of the area. These plants market the nut meats that retail for up to approximately US$ 6.50/kg, nearly twice that of commercially grown English walnuts. They also market the shells, which sell for US$ 60–90/t [Thomas and Schumann, 1992].

PRODUCTION AND TRADE

World walnut production increased by 37 percent from 1980 to 1998 when it reached the quantity of 1 095 041 t. China (22.9%), United States (18.7%), Turkey and Iran are the main producers. United States are the largest exporter (shelled walnuts), accounting for around 50 percent of total world exports, followed by China and France. The main importers are United Kingdom, France and Germany [Sengül and Sengül, 1999].

ALMONDS

As for walnuts, almonds are regarded as an agricultural crop and will not be discussed in detail in this document.

World almond production has increased by 45.1 percent from 1980 (919 620 t) to 1998 (1 334 442 t). United States (30%), Spain (15–25%) and Italy are the main producers. Other producing countries are Iran, Morocco, Greece, Syria, Tunisia, Pakistan and Turkey. World shelled almond export doubled during the period 1980–1997, from 105 616 t to 216 286 t.

The United States is the largest exporter and accounted for 70.3 percent in 1997, whereas Spain is the largest exporter among the Mediterranean countries. The main importer is the European Union with more than 50 percent of total world almond imports. Germany accounted for 27 percent of world imports, followed by France and Japan [Sengül and Sengül, 1999].

MINOR NUTS

The fruit of the Southern Hemisphere temperate broad-leaved trees of the genus *Nothofagus* are one-seeded nuts [Hora, 1981]. The nut of *N. alpina (= procera)* (common name *rauli*), indigenous to Argentina and Chile, are reportedly edible [Wickens, 1995]. The nuts of *N. glauca* (common name *hualo*), also indigenous to Argentina and Chile, are more than 1 cm long, one of the largest nuts of the genus *Nothofagus* [Donoso Zegers, 1983]. These nuts were used as food by indigenous tribes that inhabited the area.[48]

Several species of *Pterocarya*, a genus of Asian trees closely related to *Carya* and *Juglans* (family Juglandaceae), produce edible nuts that are locally important. Known as wing nuts, they include *P. franxinofolia,* indigenous to the Caucasus; *P. rhoifolia*, of Japan; and *P. stenoptera*, of China [Wickens, 1995]. The wing nut is approximately 3/4" in diameter and grows suspended in long, stringed spikes from the tree. The nuts are ripe in autumn when they turn tan in colour.[49]

The nuts of yellow buckeye (*Aesculus octandra*), as well as of other species of this genus, contain much starch but are not suitable for food because they contain a poisonous glucoside called aesculin. However, several indigenous American tribes roasted the nuts among hot stones, thus loosening the shells. The nuts were then peeled, mashed and leached with water for several days. This apparently removed the aesculin and resulted in a highly nutritious food. The seeds of both *A. octandra* and *A. glabra* are poisonous to livestock [Fowells, 1965].

48 Information provided by Friedrich Schlegel, formerly of FAO and Universidad Austral, Valdivia, Chile.
49 Source: University of Alabamba (http://www.uah.edu/admin/Fac/grounds/WINGNUT.HTM)

Figure 8.10 Nuts of (from top and from left to right): *Fagus sylvatica; Corylus avellana; Carya spp.* (hickory); *Pterocarya* spp.; *Aesculus* spp.; *and Castanopsis* spp.

CHAPTER 9

NON-WOOD PRODUCTS FROM ORGANISMS ASSOCIATED WITH TEMPERATE BROAD-LEAVED TREES

A wide range of beneficial non-wood products are derived from organisms that are closely associated with broad-leaved temperate trees, either as parasites, symbionts or saprophytes. These include edible mushrooms, products from insects that feed on this group of trees and parasitic plants. It should be noted that this chapter contains some overlaps with, as well as updates to, a previous publication in the FAO Non-Wood Forest Products Series No. 12 [FAO, 1995] since several mushrooms grow both with broad-leaved trees and conifers.

EDIBLE MUSHROOMS

Mushrooms are the reproductive structures of fungi and are also known as sporocarps or fruiting bodies. While some mushrooms are highly toxic and can be fatal if eaten, many species are edible. Some are so flavourful that they are major food items in many human cultures throughout the world. Many species of edible mushrooms occur in forests and are harvested either commercially or as an outdoor recreation activity.

Fungi are lower plants that lack chlorophyll. They are, therefore, unable to manufacture nutrients from sunlight through photosynthesis as do green plants. In order to survive, fungi must function either as parasites, often causing disease in higher plants or animals; saprophytes, causing the breakdown of dead organic matter; or as mutualists or symbionts with green plants. In the case of mutualism or symbiosis, both the fungus and the green plant derive benefits from the association.

The predominant form of symbiosis between fungi and trees occurs with tree roots producing structures called mycorrhizae. Mycorrhiza means "fungus-root" and describes the association of specialized soil fungi with the tiny feeder roots of forest trees and shrubs. Mycorrhyzal fungi function as an extension of the plant's root system and are the means by which almost all higher plants take up water and minerals from the soil. Only a few higher plants are known to lack mycorrhizal associations [Manion, 1991]. The uptake of phosphorus and nitrogen are particularly important functions of these fungi. Mycorrhizal fungi directly enhance tree survival and growth [Molina *et al.*, 1993].

Many species of forest fungi produce delicately flavoured edible mushrooms that are harvested in large quantities, and some are cultivated under semi-artificial conditions. Primarily mycorrhyzal fungi produce them, but several saprophytic and parasitic fungi also produce highly flavourful mushrooms.

BOLETUS EDULIS

Boletus edulis is a mycorrhyzal fungus that grows in association with a wide variety of trees, including both conifers and broad-leaved species. The mushrooms produced by this fungus are widely used in a number of cuisines, especially in Europe where it is one of the most sought-after edible mushrooms. It goes by many common names including *cep* or *cepe de Bordeaux* (France), king bolete or penny bun mushroom (English), *porcino* (Italy), *Steinpilz* (Germany), *zhutui mo* (North China) and *dajiao gu* (South China).

The mushroom produced by this fungus is highly variable, and some mycologists have split the fungus into a number of distinct species. A common characteristic of the mushroom is a wide, barrel-shaped stem that has a fine reticulate pattern on its surface.[50]

Distribution

Boletus edulis occurs in temperate zone forests throughout the northern hemisphere and produces fruiting bodies from the soil as scattered individuals or in small groups [Molina *et al.*, 1993]. It is found throughout North America as far south as Mexico, in Europe from the northern part of the Nordic countries south to southern Greece; Italy; and, in the Near East, as far east as Afghanistan. It is also found throughout China. In the United Kingdom, *B. edulis* is found associated with birch (*Betula palustris*), oaks (*Quercus robur* and *Q. petraea*) and beech (*Fagus sylvatica*). In China it grows under mixed forests of pine and oak [Dickinson and Lucas, 1979].

Historical aspects

The strong, distinctive flavour of this mushroom has been appreciated since Roman times. Dishes containing boletes were often used by the Romans to conceal poisons used to assassinate politicians and other public figures. They were also believed to have a number of medicinal properties, including the removal of freckles and blemishes, and a salve was prepared from boletes to treat dog bites [Dickinson and Lucas, 1979].

Harvesting and use

Boletus edulis is harvested in the wild. In Poland, it is the principal wild mushroom harvested [Grochowski, 1966]. In the Casentino, a mountainous area in the region of Tuscany, Italy, income and benefits derived from harvesting *B. edulis* are considered to be significant. About 20 percent of the total harvest is for personal use, and the remainder is sold to restaurants, local stores and wholesalers. Mushroom collectors are mostly from the lower to middle income classes; women are the most numerous group of collectors and nearly half of the collectors are between 50 and 60 years old [Farolfi, 1990]. Chestnut (*Castania sativa*) orchards are a favourable habitat for growth of *B. edulis* in Italy, and in some cases the yield of edible king boletes harvested from these orchards is worth more than the chestnut crop.[51]

Figure 9.1 Dried *Boletus edulis* mushrooms. Their firm, meaty texture makes them popular ingredients for stews, casseroles and sauces, and they can be stored in dried form for several years.

Boletes are harvested in British Columbia, mainly from Haida Gwaii (Queen Charlotte Islands) and the Prince George area. In a good fruiting year, approximately 100 000 kg of fresh boletes are harvested. While in a bad year there may be no harvest at all.[52] On average, pickers are paid $Can 2.50/lb of boletes and exporters receive around US$8/lb of boletes landed and fresh, around US$75.00/kg of dried and landed, and around US$5.00-6.00/kg of frozen.

Approximately 90 percent of all harvested boletes are exported dried or frozen and only around 10 percent of the harvest is exported fresh. Boletes are one of the first wild food mushrooms to be attacked by pests, and there is currently a world shortage of king boletes [Russel and Lipsey, 1999].[53]

50 Source: Ian Hall, 1993 – Invermay Agricultural Centre, New Zealand (halli@crop.cri.nz).
51 Source: Great Lakes Chestnut Alliance (ttp://www.traverse.com/earthkeepers/wrldprod.html)
52 The estimates for "good" and "bad" year harvest quantities are based on two sources – averages of buyer estimates at field station for their regions taken in the fall of 1997 and import data from the consuming countries. The same is valid also he harvest of morels and chanterelles in British Columbia.
53 Source : Farm business management (http://www.fbminet.ca/bc)

This mushroom has a firm, meaty texture that stands up well to prolonged cooking. Consequently it is a popular ingredient in a variety of stews, casseroles and sauces. *B. edulis* can also be easily dried, a form that permits storage for extended periods (Figure 9.1). In some parts of Europe they are dried on strings and stored for winter use. It is also a common ingredient in dried soup mixes [Dickinson and Lucas, 1979].

TRICHOLOMA MAGNIVELARE

The fungus that produces the northwest matsutake mushroom (*Tricholoma magnivelare*), forms ectomycorrhizal associations with many tree species throughout its natural range in western North America, especially various species of *Pinus* [Molina *et al.*, 1993; Ciesla, 1998]. In the Pacific Northwest region of the United States, it is the most valuable of the commercially harvested edible mushrooms [Schlosser and Blatner, 1995]. This mushroom is sold in large quantities to Japan where it is an acceptable substitute for the Japanese matsutake (*Tricholoma matsutake*), a species that grows in *Pinus densiflora* forests and commands exorbitant prices.

The matsutake mushroom is robust and white in colour when first formed. Later it develops pale brown to yellow stains. The stout stem is solid, tough and fibrous. It is smooth above and scaly below the thick, sheathing ring that flares out in young specimens. The mushrooms have a distinct spicy-aromatic odour, reminiscent of sweet cinnamon [Mollina *et al.*, 1993].

T. magnivelare is also associated with forests of tanoak (*Lithocarpus densiflorus*) in northern California and western Oregon. Among the Karuk, Yurok and Hupa people, three indigenous tribes which occupy portions of northern California, *T. magnivalare* is known as the *tanoak* mushroom and is considered to be an important traditional food. In the Karuk language, *T. magnivelare* is known as *haiwish*. The earliest documentation of the Karuk use of tanoak mushrooms dates from ethnobotanical field studies conducted in 1939, which reported: "A certain mushroom, found in November, is cooked on coals and eaten." [Richards, 1997; Schenck and Gifford, 1952].

The high demand for *T. magnivelare* mushrooms in Japan led to a massive increase in commercial harvesting of this species on public lands in the western United States beginning in the late 1980s. Until about 1991, there was little commercial mushroom harvesting on Karuk ancestral lands. As commercial pickers arrived in greater numbers, local tribal members complained that their traditional gathering sites, many of which were on lands administered by USDA Forest Service, were being overharvested. In early 1993, the Karuk tribe appealed a decision made by the Klamath National Forest in northern California to allow a commercial mushroom harvest season. As a result, no commercial permits were issued, and studies on resource values assigned to this mushroom and the basis for the resource conflict were established. Resultant work, some of which is still in progress, indicate that the Karuk had developed mushroom hunting techniques based on knowledge of favourable sites, weather and phenology of associated plants. They also engaged in harvesting practices that they believed would sustain the population of the fungus. These practices included twisting off the mushrooms so as not to disturb the fungus mycellium, leaving small mushrooms to grow and fruit and replacing leaf litter in sites where mushrooms have been harvested in order to maintain soil moisture and a more favourable habitat for production of fruiting bodies. The effect of these traditional harvesting practices on sustainability of mushroom harvests requires testing in replicated field trials [Richards, 1997].

TRUFFLES

Truffles (*Tuber* spp.) are rounded, potato-shaped mushrooms with a subterranean habit. They are the fruiting bodies of mychorrhizal fungi associated with the roots of various species of beech, oak and other broad-leaved trees [Dickinson and Lucas, 1979]. One species, *T. gibossum*, is associated exclusively with Douglas fir (*Pseudotsuga menziesii*) in the Pacific coast of North America [Molina *et al.*, 1993].

Important species

Several European species are considered to be prized delicacies. The black Périgord truffle (*Tuber melanosporum*) is widely used in Italian and French cuisines. This truffle is found in oak forests throughout much of Europe but the centre of production of the mushrooms is southwestern France where they occur in light, porous, clay marl. In Italy it is known as *tartufo nero*, and in the region of Umbria it is an ingredient in pasta dishes and in an *amaro*, an after-dinner liqueur [author's observation]. The white Piedmont truffle (*T. magnatum*) is the most sought-after species in Italy, where it is added in thin slices to a variety of pasta dishes to which they impart a distinctive, musky flavour. This truffle is produced in the region from the Astigiano to the Canallese rivers in Alba (Piedmont Region), where most collection occurs from October through December [Moora, 1955]. The summer truffle (*T. aestivum*) occurs in the beech forests in the chalk downs of the United Kingdom, where a cottage industry based on truffle hunting existed during the eighteenth century. Truffles were collected and marketed until the 1930s but are now considered to be too small to merit collection [Dickinson and Lucas, 1979].

Historical aspects

The unusual habitat and appearance of truffles caused considerable debate as to their origin. The Roman naturalist and writer Pliny described truffles as "calluses of the soil". The Greek biographer Plutarch explained that their existence was the combined action of thunder, rain and the warmth of the soil. During the sixteenth century, it was widely believed that truffles were the result of the semen of rutting deer. During the nineteenth century, they were believed to be a gall produced by oak roots. Later in that century a theory was postulated that the truffle fly, an insect commonly associated with the fruiting bodies, stung the roots of oak trees causing the gall-like truffles to grow [Dickinson and Lucas, 1979].

Commercial cultivation

While much truffle gathering occurs in natural forests, the black Périgord truffle has been grown in a more or less organized fashion since about 1810, using an indirect cultivation procedure. A French farmer by the name of Joseph Talon established an oak plantation by planting acorns. After a few years, truffles began to appear in the plantation. When he repeated the exercise several years later with the specific intent to produce truffles and succeeded, he had begun an indirect method of truffle cultivation. Today a sizeable portion of truffles harvested from France and exported are obtained through establishment of new oak plantings [Dickinson and Lyons, 1979]. At present truffles are the only ectomycorrhizal food fungus which is in widespread cultivation in the Pacific Northwest (only in Washington and Oregon states) [Russel and Lipsey, 1999].

Harvesting

The subterranean habitat of truffles presents some unique challenges for harvesting. Pigs and dogs are often used to sniff out truffles. While pigs are reputed to have the keenest nose for truffles, they are not easily led and tend to go astray. Moreover, they tend to eat the truffles they detect. A well-trained dog is preferable because it can detect truffles from 30 to 50 m and will not eat the mushrooms. Once detected, the truffle is lifted out of the ground with a spiked stick.

The secrets of where, when and how to collect truffles are jealously guarded, and knowledge of the best places to find truffles is passed down from father to son, generation after generation. While Italian law specifies that truffles are public property, about 80 percent of the white truffle harvest is handled by one family [Dickinson and Lucas, 1979].

In 1992, approximately 32 000 kg of Oregon white truffle *(Tuber gibbosum)* were harvested in Oregon and Washington. At an average the price reached US$ 32/lb [Russel and Lipsey, 1999].

Production, trade and regulation

In France, truffle production toward the end of the nineteenth century was estimated at 200–250 t/a. This gradually grew to 1 200 t/a by the mid-1960s without any concern for overproduction [Cagnairt, 1968]. French truffle production has declined in recent years, however, and by 1988 was down to about 20 t [Iqbal, 1993].

Cultivation

The shiitake mushroom grows naturally on logs of beech (*Fagus* spp.), chestnut (*Castanea* spp.), oak (*Quercus* spp.) and hornbeam (*Carpinus* spp.). Shiitake cultivation is carried out on specially cut branches from suitable trees.

In its most primitive form, logs are placed in contact with naturally infected wood, and the fungus spreads to the fresh substrate. All that is required is a favourable site to stack logs so that fruiting is encouraged. A more systematic regime involves soaking logs in water and pounding them to break the bark. Another procedure involves making holes in the bark with a broad drill or specially designed hammer. The logs are then inoculated with a spore suspension that is prepared from mature fruiting bodies or a spawn made from mycelium grown on wood chips or sawdust. The infected logs are placed in a carefully selected site in a forest known as a "laying yard." The choice of site is important. If it is too moist, natural wood decaying competitors would be favoured and the shiitake crop would be reduced or lost. The best laying yards are in ventilated clearings at the edges of a forest. The logs are placed crosswise and at slight angle to the ground.

The cultivation of shiitake is a comparatively long process. Logs remain in the laying yard for five to eight months and are watered when dry. They are then removed to a raising yard, usually in winter, where environmental conditions favour fruiting. The raising yard is more heavily shaded and watered regularly, and the logs are stacked in an upright position against fences. The first mushroom crops appear the following spring. Once logs have begun to produce mushrooms, they will continue to do so for several years in spring and autumn. The maximum cropping period on a given set of logs is about six years [Dickinson and Lucas, 1979].

One of the advantages of shiitake production is that it makes use of logs and limbs that are too small to be suitable for other purposes. Logs must be live, cut during the dormant season and free from disease [Thomas and Schumann, 1993].

Harvesting and processing

For maximum flavour and texture, the mushrooms are harvested when young. Most of the shiitake crop is dried either in the sun or in specially constructed drying houses. Shiitakes are normally exported in dry form although some are canned or pickled [Dickinson and Lucas, 1979].

Production and trade

Shiitake cultivation is widely practised in Asia, with China, Korea, Japan, Singapore, and Thailand being producers of this mushroom. Several western countries including Brazil, Canada, the Netherlands, the United Kingdom [Slee 1991] and the United States have begun commercial production.[55]

Japan currently produces about 90 percent of the world's shiitake mushrooms [Thomas and Schumann, 1993]. Shiitake cultivation in Japan is currently a major non-wood forest enterprise and increased production has been a significant factor in the increased contribution of non-wood forest products to total forest earnings. In 1960, only 3–4 percent of total forest earnings were from non-wood products. By 1980, the contribution had increased to 13 percent. Changes in eating habits of the Japanese people after the Second World War have had a significant influence on the demand for shiitake. These changes included a shift toward non-staple foods including mushrooms, an increased trend toward eating out and a shift toward processed and already cooked foods. Prior to the 1950s, shiitake mushrooms were produced largely for export to China and Southeast Asia, and domestic demand was low. In addition, the supply was kept low because of inefficiencies in cultivation. Edible mushroom production is considered to be an important source of income for rural household economies, especially during periods when the demand for wood products is in decline. Moreover, shiitake cultivation has filled a void left by declining demands for charcoal, once a key source of income for mountain villagers [Noda, 1988].

55 Source: Lexxa (http://www.lexxa.com.br/sunshiitake/cogumelo2.html).

France, Spain and Italy are the major exporters of black truffles. In Spain truffle hunting was a local enterprise until about 1954 when black truffles were exported to France to meet a growing demand [Nicolas, 1973]. Currently, approximately 15 t/a to 30 t/a are collected in Spain. In 1993 its economic value reached Ptas 411 million (25 361 t) [Cesaro *et al.*). Other principal importers of black truffles are Germany, Switzerland and the United States. White truffles, which are less known, are exported primarily to restaurants in the United States [Ciani, 1990], but markets for this higher priced truffle have developed in Belgium, France, South Africa and Switzerland [Morra, 1955]. In 1989, the United States imported 5.4 t of fresh or chilled truffles, mainly from Italy and France at a value of US$ 1.48 million or US$ 273/kg [Iqbal, 1993].

The high prices that truffle commands has led to instances of fraud necessitating regulation of this industry. French law restricts the word *truffe* to members of the genus *Tuber*. Marketed black truffles must consist of only *T. melanosporum* and *T. brumales* (winter truffles). *T. uncinatum* may comprise up to two percent of fresh, labelled black truffles because identification among closely related species is not possible without magnification. The use of summer white truffles (*T. aestivum*) in pâtés is also regulated. Artificial colouring of white truffles to make them appear black is illegal [Cagniart, 1968].

In the Alba area of the Piedmont Region of Italy, where white truffles are harvested, some 12 t of truffles are officially collected at an average value of US$ 2000/kg. A similar quantity is collected illegally and sold unofficially. The collection of truffles along with other agricultural products, especially wine, gives Alba one of the highest percentages of agricultural workers and, at the same time, one of the highest average income rates. In addition to the truffle collecting, related activities such as food-processing industries, restaurants and on-farm tourism (*agriturismo*) are all growing rapidly.

The Umbria Region of Italy, an area with extensive oak forests and woodlands, is a major area for black truffle production. Rules and regulations that govern the harvesting, cultivation and conservation and marketing of truffles have been developed. Truffle collectors have open access to the forests and other lands not under cultivation but must be licensed before they can legally gather truffles. Truffles under managed production are the property of the landowner and are subject to separate regulation. Seasons for collecting each of nine species of indigenous truffles are stipulated. Immature truffles are protected, and no truffle hunting is to take place at night. Excavations are to be covered immediately after truffles are harvested. Before a licence is issued, truffle hunters must pass an examination about collection methods; conservation; local and national laws; and the biology and identification of local species. The government of Umbria is required to fund training for technical personnel to oversee truffle harvests; conduct research and public education; and to conduct marketing initiatives. Fines are established for hunting truffles without a trained dog, illegal digging, harvesting of small truffles and improper terracing of hillsides [Giunta Regionale del'Umbria, 1987].

SHIITAKE

Shiitake (pronounced sheeta'kay) is the fruiting body of the fungus *Lentinula edodes*. This is a saprophytic fungus that colonizes the dead wood of various species of trees. In Japan, it is found primarily on *Quercus cuspidata*, commonly known as *shii* [Wolf and Wolf, 1947]. Shiitake is the second most widely cultivated mushroom in the world, second only to *Agaricus mellia*.

The shiitake mushroom has a round cap with a diameter that can reach up to 15 cm. Coloration varies from dark brown with patterns formed by white spots around the edges of the cap.

Historical background

The oldest record regarding the shiitake mushroom dates back to the year AD199 at the time of Emperor Chuai in Japan. The cultivation of shiitake mushrooms has its origins in China, however, during the Sung Dynasty (AD 960–1127). The cultivation technique was extended to Japan where it was later perfected. In both China and Japan, shiitake is considered to be an "elixir of life" and is widely consumed.[54]

[54] Source : Lexxa (http://www.lexxa.com.br/sunshiitake/cogumelo2.html).

Uses

The shiitake mushroom is the most widely cultivated speciality mushroom in the world and is both a prized medicine and a culinary delight. In Japan, shiitake is one of the most popular sources of protein whereas it is a major staple in China and other parts of the Pacific Rim. By being appetizing, nourishing, dietetic and healthful, shiitake is a highly valuable food source. Shiitake has adequate nutritional qualities to serve as a main dish, and it adapts well to recipes as a meat substitute.

Shiitake has also medicinal properties and has traditionally been used in folk medicine by having antifungal, anti-tumour and antiviral effects. It is believed to fortify the immune system's combating of viruses and bacteria through its polysaccharides which increase the level of macrophage activity [Russel and Lipsey, 1999]. Current research reveals that the mushroom combats hepatitis B and certain types of cancer. Shiitake might also be an effective treatment for the HIV-virus; however this is still unproved.[56]

Box 9.1 Shiitake production: A family enterprise

The Krogmeier family of Spring Point, Iowa, are an example of successful shiitake producers. They began with a 200 log operation in 1987 with relatively little capital investment. They purchased their spawn through a shiitake mushroom producers association that was formed in Iowa because of a growing interest in shiitake production. The Krogmeier's initial supply of oak wood was free because a family member owned a small woodlot. They used a garage to store logs and force the shiitake fruiting.

First year results were so successful that they quickly increased their production to a 3 000 log operation. This size of operation requires cutting of 600-700 new logs per year. Yield is 0.11- 0.22 kg mushrooms per log. Approximately 15 to 20 hours of labour are required per week and a net profit of $US10 000-12 000 is realized.

The mushrooms are sold through the same association from which they obtained the spawn. The association can sell virtually any amount of mushrooms grown. Most are sold to food processing companies at ca $US13.00/kg of which the association receives 80 percent (Thomas and Schumann , 1993)

Korea has a small shiitake industry but, production is currently hampered by the small scale of cultivation, lack of efficient technology, low labour productivity and lack of consistent management [Park, 1984]. A shiitake-producing industry has developed in the United States over the past 20 years. Cultivation is typically a family-run operation and provides a supplemental income for rural families [Thomas and Schumann, 1993]. In Brazil, the commercial cultivation of shiitake began during the early 1990s, mostly by small producers where the wood of *Eucalyptus* spp. has been found to be a good growth medium.[57]

MORELS

Morels (*Morchella* spp.) are saprophytic fungi that are found in both conifer and broad-leaved temperate forests. All of the species in this genus are edible and delicious and, with the possible exception of truffles, are considered the most delectable of mushrooms [Alexopoulos, 1962]. They are highly prized for their culinary uses, particularly as a gourmet food and are used in gravies, sauces and soups. Morels are not only delicious, they are also a healthy and nutritious food. They contain 42 percent protein on a dry weight basis, are low in calories and rich in minerals [Iqbal, 1993]. Some individuals may have adverse reactions from eating morels, however, especially when they are consumed with alcohol. Morels should never be eaten raw [Molina *et al.*, 1993].

The mushroom produced by the morel fungi has a characteristic appearance although the mushrooms of several closely related fungi have somewhat similar appearances. They have been likened to a pine cone perched on a stem. The fertile cap (pine-cone portion) is honeycombed with pits and ridges. The cap and stem are hollow and the cap rises continuously from the stem. The

56 Source: Lycos (http://webmd.lycos.com/content/article/1677.53)
Shiitake mushrooms (http://www.shiitakecenter.com/health/health.html).

57 Source: Lexxa (http://www.lexxa.com.br/sunshiitake/cogumelo2.html).

stem colour ranges from white to pale brown, and the colour of the cap ranges from pale yellow-brown through tan, brown and grey-brown. The pits are typically the same colour as the ridges or slightly darker [Molina *et al.*, 1993].

Morels grow in the temperate forests of Asia, Europe, the Near East and North America and are associated with many temperate trees [Iqbal, 1993]. They tend to be abundant after a wildfire has passed through an area and appear in early spring, shortly after snow melt. In Europe, fires have been deliberately started in forests in hopes that they would encourage development of morels [Arora, 1986; Molina *et al.*, 1993; Phillips, 1991]. Some species, such as *M. angusticeps*, are common in forests of pine, Douglas fir or various species of *Populus*. *M. esculenta*, a white morel, is found associated with forests of *Carya* and *Liriodendron tulipifera* in the eastern United States [Phillips, 1991].

In a good year, 225 000 kg of morels are harvested in British Columbia and in the Yukon, whereas it might fall to 10 000–20 000 kg in a bad year. In the Pacific Northwest the harvest reaches 602 649 kg [National Aboriginal Forestry Association, 1999].

Pickers receive on average $Can 3.00/lb of fresh morels. For fresh and landed morels the exporters receive US$ 18.00–22.00/lb and for dried and landed in the Unites States and Europe US$ 150 to $200/kg. Morels are exported fresh only about two weeks of the entire growing season because they are rapidly attacked by pests [Russel and Lipsey, 1999].

Total world production of morels is estimated to be about 150 t dry weight, equivalent to 1.5 million t of fresh morels. India and Pakistan are the major producing countries, each producing about 50 t/a of dry morels, all of which are exported. Afghanistan and China are two additional countries that trade morels internationally. All are gathered in forests although some research is under way to develop means of artificial cultivation. In Pakistan, there is a race between men, women and children to see who can handpick the greatest quantity of morels. These are sold fresh or in dried form to local hopkeepers, who dry them. No further processing is involved until they reach the wholesalers/exporters. The price for dried morels in Pakistan in 1991 was US$ 133 per kg, with gatherers receiving one-half to two-thirds of this price. The exporters de-stalk, grade and sometimes fumigate the morels before they are exported. France, Germany and Switzerland are the main importers of dried morels from India and Pakistan. According to unpublished records of the ITC, the import of dried morels to Switzerland and member countries of the European Union ranges between 100 t/a and 120 t/a [Iqbal, 1993; National Aboriginal Forestry Association, 1999].

International trade in fresh morels is limited because of the short life of these mushrooms. However, short distances between some producing countries and markets make trade in fresh morels possible, for example between Turkey and western Europe [Iqbal, 1983].

CYTARRIA SPP.

The fungi of the genus *Cytarria* are parasites of various species of *Nothofagus* in South America. They infect the twigs, branches and occasionally the main stems of host trees and sometimes cause growth loss and deformity. Some species produce edible mushrooms known as *digüeñe, caracucha or pinatra.*[58] In southern Chile, fruiting bodies of *C. darwinii* are sold along roadsides and markets and are a popular ingredient in salads [author's observation] and are also good tasting when fried in butter. *C. darwinii* has been a traditional food of the indigenous people of Tierra del Fuego at the southern tip of South America [Wolf and Wolf, 1947]. The mushroom is round, white, yellowish brown or orange in colour with a dimpled texture and resembles a golf ball (Figure 9.2). They appear in clusters on infected portions of host trees in spring, coinciding with leaf flush on various species of *Nothofagus* including *N. antarctica, N. dombeyii, N. obliqua* [Baldini, 1994; Minter *et al.*, 1987].

According to Gamundi and Horak (1995), four species of *Cytarra* are found in the forests of Argentine Patagonia, *C. darwinii, C. johowii, C.hookeri,* and *C. harioti.* While *C. darwinii* is good tasting, *C. johowii,* and *C.hookeri* have a mouldy flavour. The fruiting bodies of *C. harioti* were used by indigenous people of the region for production of an alcoholic drink.

[58] Information provided by Dr Hernan Peredo, Forest pathologist, Universidad Austral de Chile, Valdivia Chile.

Figure 9.2 Fruiting bodies of: (starting from top and from left to right) *Boletus edulis, Tricholoma magnivelare; Tuber melanosporum; Morchella conica; Lentinula edodes* and *Cytarria darwinii*, (on *Nothofagus* spp).

TRAMETES VERSICOLOR

Trametes versicolor is a wood-rotting polypore that grows on the side of felled oak logs and other dead or dying hardwoods.

Trametes versicolor has medicinal properties and is used in cancer treatments, both as preventative and as curative. The mushroom accounts for around 16 percent of Japan's national expenditures on anti-cancer agents. The species ingredients are also thought to enhance T-cell proliferation and are taken in the Asian countries as a nutraceutical. Furthermore, *Trametes versicolor* is used as immune stimulant; antibiotic; against pulmonary disorders; as antiviral; against hepatitis; and for the infections of the respiratory, urinary and digestive tracts.

In Japan a nutritional supplement containing *T. versicolor* is generally used as a health food, and testing in Japan has shown that it has cholesterol-lowering properties. Other names used for *Trametes versicolor* are *Yun-Zhi, Kawaratake* and *Coliolus versicolor* [Russel and Lipsey, 1999; Tedder, Mitchell and Farran, 2000].[59]

MINOR FUNGI

Other fungi of medicinal interest are species such as *Formitopsis pinicola, Laetiporus sulphureus* (common name: chicken of the woods), *Ganoderma Tsugare* and *Ganoderma appalanatum*. The latter grows both with broad-leaved and coniferous trees and is mostly found in the temperate zones of the Northern Hemisphere[60] [Tedder, Mitchell and Farran 2000].

59 Source: http://www.amoeba.com/mstravers.html

60 Source: http://cygnus.tamu.edu/PLPA/Projects/1/ganoderma_applanatum.html

INSECTS

SILK

Silk is a fibre produced by certain caterpillars when they spin cocoons in which to pupate. It is the most luxurious of fibres, with an unsurpassed natural beauty, lustre and softness. It takes dyes well and, while seemingly delicate, it is one of the strongest, toughest and durable fibres known.

There are two types of silk known, “domestic” silk and “wild” silk. Domestic silk is the product of the domestic silkworm (*Bombyx mori*), which feeds on the foliage of mulberry (*Morus* spp.). This insect has been cultivated for centuries for its ability to produce a fine-quality white silk, which is called mulberry silk. *Bombyx mori* has become so domesticated that it has lost its natural pigmentation and its ability to grasp foliage so that it must be raised under artificial conditions. It can no longer survive in the wild. “Wild” silk, on the other hand, is produced by a number of species of caterpillars, many of which feed on the foliage of temperate broad-leaved trees. The silk they produce is usually not white but ranges in colour from light yellow, light to medium beige to dark grey. The colour comes from the diet of the wild caterpillar. If it happens to feed on foliage that is high in tannin content, the tannin becomes part of the silk and colours it [Kolander, 1985].

Historical aspects

Silk production has its origins in China. A writing from AD 90 by Ss-ma Ch'ién tells a story of Siling, the wife of a fabled “Yellow Emperor,” Huang-ti. One day, according to the story, she dropped a cocoon into her cup of hot tea. It began to unravel and gave her the idea of unreeling the cocoons into long floating threads of fibre. Silk was undoubtedly in use in China long before this story was written, however. A symbol for silk was part of the Chinese written language at the time of Huang-ti and Si-ling, about 2600 BC.

Although silk cultivation began in China and fragments of silk as old as 1 500 BC have been found in this country, the oldest written record of the use of silk comes from India. The *Ramayana* and the *Mahabharata* speak of silk weaving. These Sanskrit epics are the sacred texts of the Aryans who in 2000 BC or so came down from the northern plains and eventually established an empire from India west to the Mediterranean. The first mention of silk in western literature is by Aristotle about 300 BC, where he mentions that the source of silk is a “curious horned worm.” By the time of the Han Dynasty (around 200 BC to AD 200), silk had become so abundant in China that it was part of a soldier's wages.

The establishment of the Silk Road across China, the Near East and finally the Mediterranean region (Che Muqi, 1989] marks the beginning of abundant silk in the West. However, the culture of silkworms was kept a carefully guarded secret by Asian cultures. In Rome, wealthy women unravelled the Chinese silks with their heavy designs and rewove them into revealing gauzes or into tapestries. The Persian merchants soon established themselves as the sole middlemen between East and West in silk trade. The actual culture of silk by western civilizations resulted when war broke out between Byzantium and Persia around AD 500 and the west was cut off from its supply. It is said that two Nestorian monks, who had once lived in China, offered to return and smuggle out the starts of sericulture: silkworm eggs and white mulberry seeds. Two years later, they returned to Constantinople (Istanbul) where they were housed in palace grounds and slowly began the culture of silkworms. All races of European silkworms through the 1700s descended from these first eggs.

The Arabs were influential in the spread of silk throughout the Mediterranean Region. From its establishment in Turkey and Greece, they introduced it into the Italian Island of Sicily. Silk culture went hand in hand with silk weaving wherever this fibre was introduced. Eventually silk found its way into the British Isles, but sericulture was unsuccessful because of the cold, damp climate of this area.

Silk culture was introduced into Japan around AD 200 when a Chinese emperor exchanged gifts with Japanese envoys. The most treasured of the gifts were silkworm eggs. At this time sericulture was a closely guarded secret. Soon after, an exiled Chinese prince, his household and his followers fled to Japan. There they took up silk weaving as their livelihood and thus transplanted the traditional skills of China into Japan were a silk industry developed that took on its own character.

Synthetic fibres such as nylon and rayon replaced silk as a fibre in the United States market during the second world war when the sources of silk were cut off. The Government of the United States subsidized the nylon industry because it needed a silk substitute for balloons and parachutes. Despite the availability of low-cost synthetic substitutes, there is still a high demand for silk products [Kolander, 1985].

Box 9.2 Silk culture comes to India

The domesticated silkworm of China is said to have been introduced into India sometime prior to AD 200.

It is said that a Chinese princess, married off to a distant foreign king, smuggled silkworm eggs out of China in her head-dress, possibly because she wanted to continue her sericulture and weaving, the preferred pastimes of Chinese women. Perhaps she also shrewdly planned to bring a dowry to her husband that was so valuable, she would never be slighted.

While India has many species of wild silkworms, the delicacy and shimmering whiteness of the domestic silkworm, *Bombyx mori*, has always been admired (Kolander, 1985)

Silkworm culture

Silk has always been an expensive commodity because the raising of silkworms is a labour-intensive process, one that has not changed significantly over time (Figure 9.3). Approximately one month is required for the silkworm larvae to complete their feeding cycle and transform into silk-covered pupal cocoons. During this time, the larvae must be fed ever-increasing amounts of handpicked mulberry leaves. If the leaves are dirty, they must be washed before being feed to the caterpillars.

Figure 9.3 Workers remove diseased larvae and provide fresh mulberry foliage to a domestic silkworm colony, Daton Cooperative, Hanoi, Vietnam.

Damp weather or a sudden onset of cold weather can cause disease among the larvae [Kolander, 1985]. Mature larvae must be fed two to three time per day [author's observation] and diseased individuals must be removed by hand in order to prevent the spread of disease to healthy larvae (Figures 9.4 and 9.5).

Figure 9.4 Mature larvae (left) and coccoons (right) of the domestic silkworm, *Bombyx mori* - Daton Cooperative, Hanoi, Vietnam.

Approximately two full-grown mulberry trees and 4 000 silkworm eggs are required to produce 5.5 kg of silk. The proportion of raw, reeled silk to cocoons varies because the reliability of the cocoons depends on the strength of the fibre and its uniformity, the proportion of silk to pupa and whether or not the cocoons are weighed fresh or dry. The usual ratio is 12:1, i.e. 12 kg of cocoons equal about one kg of reeled silk and an equal amount of unreliable spinning silk. In Japan, where great care is given to silk production, the ratio is about 6:1; and in Italy, at the height of its silk industry at the turn of the century, supposedly cocoons with a reliability ratio of 3:1 to 4:1 were produced.

Figure 9.5 Domestic silkworms (*Bombyx mori*) being raised in large, flat baskets. Daton Cooperative, Hanoi, Vietnam.

Modern breeding and management techniques of both mulberry and silk worms in Japan have doubled the production of silk per hectare of mulberries during the past 20 years. The average annual crop averages 675 kg/ha, yielding slightly more than 100 kg of raw reeled silk plus some spinning fibre. These numbers are based on two rearing periods per year, one in early spring and a second in late fall. The mulberries are trimmed as bushes to allow easy picking of foliage [Kohlander, 1985].

Production

World production of silk is nearly as great as at any previous time in human history and is increasing. Japan produces about 20 000 t/a of raw-reeled silk and imports an additional quantity. India produces large amounts of both cultivated and wild silk, most of which are used domestically. In many parts of India, sericulture and silk weaving are still done on a small village scale. China has historically produced more silk than any other area of the world, but today only a small portion is used domestically. Most of China's silk crop is exported to Europe [Kohlander, 1985].

Wild silk

Wild silk, also known as *tussah* silk, is an abundant form of silk. There are many kinds of wild silks, each with its own characteristics. For example, some wild silks are dark coloured but dye well. Others are nearly white in colour but do not take dyes. Some are fine, others are strong; some are reliable, whereas others are not; and some have distinctive odours. Silk-producing caterpillars can be found anywhere although some of the best known occur in tropical, subtropical and warm temperate regions of Asia. Several species of caterpillars, capable of producing wild silk, feed on the foliage of temperate broad-leaved hardwoods (Tables 9.1 and 9.2).

Table 9.1 Asian wild silkworms that feed on temperate broad-leaved trees and shrubs

Species	Range	Hosts	Remarks
Chinese monthly *Bombyx sinensis*	China	*Morus* spp.	Small cocoon, prolific.
Chinese tussah *Antheraea pernyi*	China	*Quercus* spp.	Colour and quality of silk depend on climate and soil.
Yama-mai silk *Antheraea yama-mai*	Japan	*Quercus* spp.	White silk but does not dye well. Very strong and elastic
Muga silk *Antheraea assamensis*	Assam	Various hosts	Dark in colour takes dyes well. Once reserved for the exclusive use of the Rajas.
Cynthia moth *Attacus cynthia*	China	*Alianthus glandulosa* *Prunus* spp., *Platanus* spp. *Syringa vulgaris*	Somewhat domesticated, introduced into North America

Source: Kolander, 1985

Table 9.2 North American wild silkworms that feed on temperate broad-leaved trees and shrubs

Species	Hosts	Remarks
Polyphemus moth *Telea polyphemus*	*Betula* spp. *Quercus* spp.	Potentially the most valuable of NA silkworms.
Cercropia moth *Hyalphora cercropia*	Various hosts	Quality of the silk depends on host plant fed upon by the larvae.
Promethea or spice bush moth *Calasoma promethia*	Various hosts	
Luna moth	*Carya* spp. *Juglans* spp. *Liquidambar styraciflua*	
Io moth *Automeris io*	Various hosts	

(Source: Drooz, 1985; Kolander, 1985)

Wild silk is a coarser fibre than cultivated silk. This makes it more durable and more practical for clothing. Traditional uses include pile fabrics and carpets. Because it grows without cultivation and needs only to be gathered and processed, wild silk is usually less expensive than cultivated white silk. It is also rarely reeled in order to ensure a continuing supply.

The cocoons are gathered after the moth has emerged. Spinning, rather than reeling, makes for less cost and means that yarns can be made in sizes like wool or cotton, heavy enough to be attractive to hand craftsmen.

In China, tussah silk produced by the Chinese tussah or tussur moth (*Antheraea pernyi*) is semi-cultivated. This silk is also called tassar. The larvae feed on various species of oaks (*Quercus* spp.). The oaks on which the caterpillars feed are pruned into shrubs 1.5–2 m high on which the larvae are raised. Two annual crops are obtained. The small spring crop is used exclusively as breeding stock for the large autumn crop. The silk of the autumn crop is mostly reeled. Yields average approximately 45 kg/ha of reeled fibre and about 68 kg/ha of spinning fibre [Kolander, 1985]. The city of Dandong, in Liaoning Province has been a center for tussah silk production for two centuries and in 1980 provided about 70 percent of China's output. Tussah silk production fluctuates; in 1980, 75 000 tons were produced and about 50 000 tons were produced each year between 1987 – 1989 (Peigler 1999).

The tensan silk moth, *Antherraea yamamai*, has been cultivated in Japan for more than 1000 years. It was introduced into Austria in the 1860's by Baron de Bretton. Although not used commercially in Europe today, the moth has established itself in oak forests of lower Austria and northern Italy and is considered a pest. Today tensan silk is produced in only a few places in Japan. It has great cultural and ritualistic significance. Items produced from this silk include small tablecloths, neckties, belts, cloths for Buddhist altars and family frames. Many of these items cost the equivalent of thousands of $US (Peigler 1999).

Box 9. 3 Silkworms and the gypsy moth

The gypsy moth (*Lymantria dispar*) is an insect native to Europe and Asia that feeds on a wide range of host plants including birches, poplars, oaks and other temperate broad-leaved trees. In 1869, a French scientist by the name of L. Troulvelot brought egg masses of this insect from France into Massachusetts for the purpose of cross breeding them with the domestic silkworm and develop an alternative source of silk. His experiments failed, but during the course of his research, some gypsy moth larvae escaped and became established in the surrounding oak forests. Within 20 years, the insect spread over an area of 900 km^2 around Boston, causing severe damage to forest, shade and fruit trees. The insect has become one of the most serious forest and urban pests in the northeastern United States and Canada and in some years, millions of hectares have suffered serious damage (Drooz, 1985; Leonard, 1981).

DYES

Several scale insects (Homoptera: Coccidae) infest oaks in the Mediterranean region and are the source of a brilliant red-crimson dye. The most important is *Kermococcus vermilis* (= *Kermes ilicis*), whose primary hosts are the foliage of *Quercus coccifera* and *Q. ilex* [Schetky, 1984; Wickens

1986]. Both are evergreen oaks that are widely distributed in Mediterranean Europe and the Near East (Figure 9.6). The pigment is kermesic acid and the colour descriptors, crimson in English, carmoisine in French, *karmir* in Armenian, *kirmiz* in Persian and *kirmima* in Sanskrit [Gerber, 1978; Green, 1995]. The dye source is the female adult stage of this insect [Green, 1995]. At one time these insects were raised commercially in southern France, Spain and other areas of Mediterranean Europe [Adrosko, 1971]. The insects were harvested before dawn by women carrying lanterns and picking the insects from the leaves with fingernails that were kept long for this purpose [Wickens, 1986].

Figure 9.6 A stand of kermes oak (*Quercus coccifera*) near Krytsos on the isle of Crete, Greece. This tree is a host of kermes scale, once the major source of a red-crimson dye.

Kermes, also referred to as "dyers coccid," is a dye of ancient origins, and there are records of its widespread use in the Mediterranean and Near East for dyeing wool and silk before other red dye sources were available [Green, 1998]. It may even be the oldest dyestuff known, and its use can be dated back as early as 1400 BC by the Phoenicians. Kermes colours produced by the Phoenicians were prescribed for the appointments of the tabernacle and for the "holy garments" of Aaron [Gerber, 1978]. According to Schetky (1984), alum and urine were used in the preparation of dye baths. In the Near East, a traditional scarlet fez was dyed with kermes, as was a cap of the same colour in Greece. During the Renaissance, the city of Venice, Italy, was the principal centre for kermes trade; and the dye, known as *écarlate de Venise* (Venetian scarlet), was quite famous. Many reds in Gothic tapestries were produced with kermes. Dyeing with kermes became known as *grain* or *ingrain* dyeing, and in William Shakespear's *Twelfth Night* he uses the phrase: *Tis ingrain, Sir! 'Twill endure wind and weather* [Wickens, 1986]. The dye was widely used until the middle of the sixteenth century when cochineal, a crimson dye extracted from the female adult stage of yet another scale insect, *Dactylopius coccus,* was discovered [Green, 1995]. This insect, which feeds on various species of prickly pear cactus (*Opuntia* spp.) in Mexico and Guatemala, produced higher yields of dye than could be obtained from kermes.[61] One estimate indicates that 12 times as much kermes was required to equal one part of cochineal [Bancroft, 1814]. The use of cochineal as a dye source declined with the advent of aniline dyes during the early twentieth century [Adrosko, 1971].

Today, use of kermes is restricted to a few hobbyists who prefer to work with natural dyes, and the material is difficult to obtain. According to Green (1995), while there is occasional interest in reviving kermes as a food colorant, there is little realistic prospect of it ever regaining commercial significance because of the high cost of collecting female scales.

GALL NUTS

Galls are abnormal growths on the foliage, stems and branches of trees. They can be caused by a variety of agents including virus, bacteria and insects. Several kinds of insects produce galls on trees and shrubs including aphids, flies (midges) and wasps. Gall insects have a hormonal effect on plants and can alter growth patterns. Each gall insect produces a gall of a unique morphology from which the insect species can often be identified [Berenbaum, 1994; Felt, 1940]. Heavy infestations of gall insects can cause a valued ornamental tree to be unsightly and, in extreme cases, can cause tree deformity. On the other extreme, a number of galls are the source of materials beneficial to humans and have been used to produce inks and dyes, tannin, medicinal products and food for human consumption.

[61] No estimates could be found on the dye yield from the kermes scale. However, the higher yielding cochineal requires about 154 000 insects to produce one kg of dye. One ha of planted *Opuntia* yields about 300 kg of cochineal insects (Adrosko, 1971)

Galls caused by wasps are common on oaks, and many are high in tannic and gallic acids (Figure 9.7). The high content of tannin and other materials give a number of beneficial properties to oak galls. These have been known for centuries, and some oak galls have been harvested in large quantities to be used as ingredients in medicine, inks, dyes and as a tannin source.

Aleppo gall

The most important of the insect galls is the Aleppo gall. Also known as *Turkey gall*, *Levant gall*, *gall-nut*, *gall of commerce* and *ink marble*, they have a spherical shape, are hard and brittle, about the size of a wild hickory nut, and appear on the stems and branches of *Quercus aegilops*, *Q. infectoria*, *Q. pendiculata* and other oaks. The gall is produced by a wasp of the family Cynipidae (*Cynips tinctoria*), which is found in eastern Europe and the Near East, including portions of Greece, Hungary, Iraq and Turkey. This gall has been of commercial importance since the time of Ancient Greece and has been used for a variety of purposes [Fagan, 1918; Felt, 1940].

Figure 9.7 Insect galls on oak near Dunrobbia, Umbria Region, Italy. Galls such as these have a high tannic and gallic acid content and have been widely used in the production of inks, dyes and tannin

The primary use of Aleppo gall was in the manufacture of an ink known as iron gallo-tannate ink or iron-gall ink. There are many published recipes (see Box 9.4), but the defining components of these inks are iron, in the form of an iron salt such as ferrous sulphate, tannic and gallic acids. The addition of an iron salt to tannic acid produces a brown to black colour. Gum arabic, another non-wood forest product, is added to the ink to delay the saturation of the paper. This ink flows well and can readily be applied to paper or parchment with a pen. The bonding of iron-gall ink with paper or parchment made it superior to carbon ink, an ink made from lampblack, for use on documents because it could not be washed from the surface as gum bound carbon ink could [Burandt, 1994]. The Aleppo gall has a particularly high tannic acid content and also contains gallic acid (Table 9.3). The acids are extracted from the Aleppo gall by soaking and boiling and were highly regarded because they produced permanent inks that did not fade. When durable ink was required, as in the case of legal documents, local laws often required that the records be made of inks produced from Aleppo gall. Ninth and tenth century monks who used it for copying manuscripts knew ink made from gall-nuts. Even as late as the early part of the twentieth century, inks purchased by the Treasury of the United States, Bank of England, the German Chancellory and the Danish Government were required to be made from acids extracted from the Aleppo gall [Fagan, 1918].

Table 9.3 Chemical content of the Aleppo gall

Component	Percent
Tannic acid	65.0
Gallic acid	2.0
Ellagic acid and luteo-gallic acid	2.0
Chlorophyll and volatile oil	0.7
Brown extractive matter	2.5
Gum	2.5
Starch	2.0
Woody Fibre	10.5
Minor components	1.3
Sugar, Albumen	
Potassium sulphate/gallate	
Potassium, Phosphate	
Gallate and Oxalate of lime	
Moisture	11.5
Total	**100.0**

Source: Fagan 1918.

The brown to black solution produced when an iron salt is added to a tannic acid solution was also widely used as a dye. Again, the favoured tannin source was Aleppo gall. This dye was widely used for dyeing furs and leather. Another popular use was for dyeing hair black. As recently as 1914, Aleppo gall nuts valued at US$ 17 000 were imported into the United States from Baghdad, Iraq, for dyeing seal-skin furs [Berenbaum, 1994; Fagan, 1918].

The earliest use of Aleppo gall was in medicine by the Greeks and Romans. In Greece, Aleppo gall was known to be of medicinal value by Hippocrates in the fifth century BC and by Theophrastus in the third century BC. According to the Roman Pliny, Aleppo gall was used in some 23 remedies, including treatment of ulcerations of the mouth, gum disease, malformed nails, hang nails, toothache and burns. Because of their high tannic acid content, Aleppo galls were also a highly regarded tannin source for tanning hides and skins. Over 2 000 years ago, the Roman naturalist, encyclopedist and writer Pliny wrote that Aleppo galls were widely used for tanning hides [Berenbaum, 1994; Fagan, 1918].

Box 9.4 An ancient recipe for ink

According to an old Italian recipe for production of ink, ingredients include a source of tannin, an iron salt, a solvent, a thickening agent and an anti-fermentation agent. Recommended sources of tannin include gall nuts, wood and bark of oak, bark of chestnut or grape skins. Recommended iron salts are ferrous or ferric sulphate. Gum arabic, white grape skins, honey, olive oil or nut oil may be used as a thickening agent and vinegar is suggested as an anti-fermentation agent (Tiburzi, 1993).

Other galls

Many galls on oaks indigenous to Europe, North Africa and the Near East contain tannic and gallic acids and have been used for the same purposes as the Aleppo gall. Another gall that resembles the Aleppo gall and is produced by the Cynipid wasp (*Cynips insana*) contains 26 percent tannic acid and 1.6 percent gallic acid. The gall is known as the *mad apple of Sodom*, *Dead Sea fruit*, *Mecca gall* or *Bussorah gall* and is found on various species of *Quercus* in southeastern Europe and the Near East. This gall has been used in the production of a dye known as *Turkey red*. The knoppern or acorn gall, caused by *C. quercus-calycis*, occurs on several oaks in Austria, Bosnia-Herzegovina, Hungary, Serbia, Slovenia, Greece and less frequently in France, Germany, Italy and the Netherlands. This gall ranked second in importance to the Aleppo gall. In Austria it has been used by tanners and has been substituted by dyers to the Aleppo gall. The knoppern gall contains about 45-50 percent tannin. The Devonshire gall is caused by *C. kollari* and occurs on various oaks in central and southern Europe, North Africa and the Near East. In 1858 or so, this insect was introduced into England where concern was initially expressed about its potential to cause severe damage to oak forests. However, it was later discovered to be an excellent source of tannin for making inks [Fagan, 1918].

Some oak galls (species unspecified) are sources of hues other than the black produced by the Aleppo and related galls. When used with an alum mordant, they produce a yellow dye, when used with a chrome mordant they produce a greenish yellow colour and, when used with no mordant, can produce yellow to yellowish brown hues [Bliss, 1981]. The Navajo, an indigenous tribe of the southwestern United States, used many native plants and minerals occurring in their native area to dye wool for traditional weavings. A cone-shaped gall found on *Quercus pungens*, a small to medium scrub oak found in portions of western Texas, Southern New Mexico, southeastern Arizona and northern Mexico, was one of their dye sources. When used with an alum mordant, the green or brown galls produce a light gold or light yellowish-tan colour [Bryan *et al.*, 1978; Little, 1976].

There has been little interest in the use of galls occurring on New World oaks as ingredients in inks and dyes or as a tannin source although several have been shown to have high tannin levels. Oak galls, caused by *Disholcaspis weldi* on *Quercus reticulata*, have reportedly been sold in fruit stands in Mexico; and the gall known as *oak apple* is said to be sweet and tasty. The gall known as *black oak wheat*, caused by *Callirhytis* spp., has been used in Arkanas and Missouri as feed for cattle, hogs, sheep, turkeys and chickens [Fagan, 1918].

MISTLETOES

The leafy mistletoes of temperate deciduous forests (*Viscum album* in Europe, northern Africa and the Near East and various species of *Phoradendron* in North America) are parasitic plants that infest many temperate broad-leaved trees. These plants have fascinated people for centuries. Their ability to stay green in winter and their seemingly magical ability to live without roots, never reaching the ground, led ancient human cultures to believe that they were divine gifts, perhaps created by thunderbolts. Mistletoes have an important place in many ancient religious rituals among tree worshippers of Western Europe, including the Celtic Druids, early Scandinavians and Germans. Ceremonies of both the summer and winter solstices involved the harvest of mistletoe plants. Druid priests cut the mistletoe with a golden sickle onto a white cloth to keep the plant from touching the ground. Mistletoe harvest was also part of Norse ceremonies involving Balder, the son of Odin. Because of its role as a parasite of the all-powerful oak (see Chapter 2), mistletoe became a symbolic source of protective and medicinal powers. The burning of oak logs, human sacrifice and the harvest of mistletoe were intertwining ceremonies. Mistletoe was also brought into houses for protection of the house and its occupants [Schumann, 1991].

In contemporary Christian cultures, the female mistletoe plant containing white, berry-like fruits, is part of the Christmas tradition. A sprig of mistletoe is often hung over a doorway and, when a man or woman walks through the doorway, it is appropriate for a member of the opposite sex to pick a berry and kiss the person. Mistletoe sprigs, collected in forests, are a popular decorative item sold during the Christmas holiday season in Europe and North America. The mistletoe sprigs are often harvested from the crown of tall trees by shooting them out with a shotgun [author's observation]. An early use of the berries of *Viscum album* was to make a product known as birdlime. This is a sticky material that was spread on twigs and branches of trees by fowlers to trap birds.

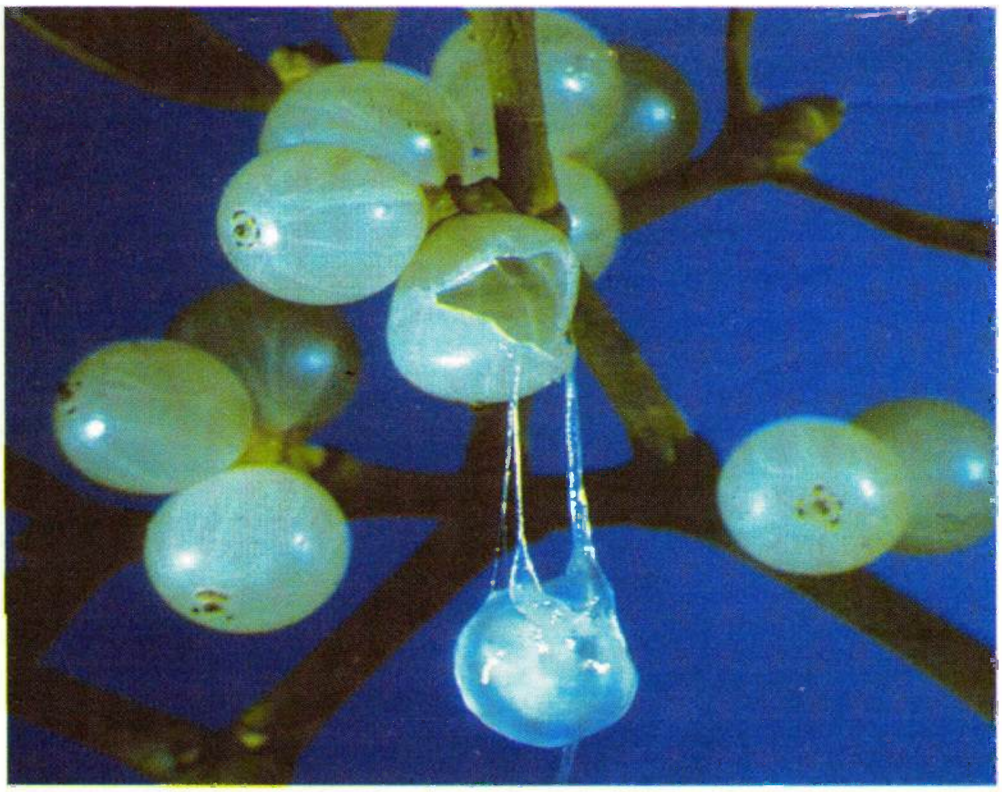

Figure 9.8 Berries of *Viscum album*.

CHAPTER 10

SUMMARY AND CONCLUSIONS

The world's temperate broadleaf forests are composed of a diverse and economically important group of trees that have provided humans with a wide range of both wood and non-wood products. Many of these trees (e.g. oaks, laurel, birches and mountain ash) have also become integral parts of human cultures throughout the world and have important places in folklore, mythology and religion or as symbols of bravery, valour, reliability and authority. The leaf of one temperate broad-leaved tree, the sugar maple (*Acer saccharum*) appears on the national flag of Canada.

Temperate broad-leaved trees are the source of many important and, in some cases, unique NWFP. They come from virtually every part of these trees: flowers, foliage, bark, sap, fruits and nuts. Other important NWFP come from organisms closely associated with these trees either as parasites, symbionts or saprophytes. Examples include edible mushrooms and products such as silk and natural dyes, which come from insects that use these trees as host material. Virtually all temperate broad-leaved trees are important, to some degree, as ornamental and landscape plants, and many are popular for the ancient art of bonsai.

The fruits and nuts of many broad-leaved temperate trees are edible and have been used as food by humans since prehistoric times. Today, many are important agricultural crops and are grown throughout the world. Examples include the pome fruits, such as apples and pears; stone fruits, such as cherries, peaches, apricots and plums; various nuts, such as almonds, English or Persian walnuts, pecans and pistachios; and olives. The edible fruits or nuts of some temperate broad-leaved trees, such as chestnuts or hazelnuts, may be grown in orchards in some regions of the world but in other areas are still gathered in the forests. Still other edible fruits and nuts, such as the fruits of mountain ash, persimmon, hawthorn, black walnuts and hickory nuts, are still gathered almost entirely from natural or planted forests. The nuts of some temperate broad-leaved trees are also important sources of edible and, in some cases, industrial grade oils. Examples are walnuts, hazelnuts, olives and oil from the Asian tung tree.

Temperate broad-leaved trees produce many NWFP that are commercially important today and are significant factors in many local and regional economies. These include wild honeys; essential oils and flavourings from the foliage; syrup and related products from maple and birch trees; cork; tannins; medicinal products; and edible nuts. Cork, the soft, spongy inner bark of *Quercus suber,* is a particularly interesting product because it is the only product acceptable for use as bottle stoppers in fine wines and champagne. Commercially important products from organisms closely associated with temperate broad-leaved trees include edible mushrooms, produced by fungi, and silk, produced by caterpillars feeding on the foliage of mulberry or other broad-leaved trees.

Some NWFP of temperate broad-leaved trees are of sufficient importance to be subject to grading standards and harvesting regulations. Both Canada and the United States have national standards for grading maple syrup based on colour. In the Mediterranean region, cork is graded for use as bottle stoppers and related products or for agglomerate. France, Italy and Spain have strict rules governing the harvesting and labelling of truffles, and Italy requires that truffle hunters be licensed.

The use of some non-wood forest products of temperate broad-leaved trees is expanding. The development of products from agglomerated cork in the late nineteenth century resulted in a significant expansion of the cork industry. The introduction of tung tree into the southeastern United States resulted in a significant expansion of the use of tung oil and the development of a regional paint and varnish industry. The shiitake mushroom, once a strictly Asian delicacy, is now widely cultivated in western countries. There is an increasing demand for North American maple syrup in Europe and Asia and for European truffles in the United States.

Opportunities also exist for additional expansion of certain NWFP of broad-leaved temperate trees. A potentially important enterprise is the expansion of a viable chestnut industry in the United States based on blight-tolerant or resistant varieties of chestnut, as well as development of this industry in places such as Australia, New Zealand, Argentina and Chile. Another is the expanded use of

Carob and *Prosopis* pods as a food for human consumption. Additional opportunities include increased production of silk from wild silkworms and the development of additional edible fruits, such as the hawthorn in the southern United States.

This group of trees is also the source of many products that were important in the past but have been replaced by cheaper or more effective synthetic alternatives. The development of aniline dyes during the early part of the twentieth century, for example, provided a cheap alternative source for many natural dyes, including quercitron, which was once an important source of a bright yellow dye. Similarly, the carmine or bright red dye obtained from the oak kermes scale was first replaced by the larger, easier to rear cochineal insect and later by synthetic dyes. Gathering of the summer truffle in the United Kingdom became less profitable because of increased labour costs and their relatively small size. Beech nuts, once a popular edible nut in northeastern North America, are no longer important on a commercial scale because of their small size and the fact that they were replaced by other foods. Salicylic acid, one of the ingredients of aspirin, was once extracted from willow bark but is now produced from alternative synthetic sources. Moreover, several non-wood forest products from temperate broad-leaved trees were of great importance to primitive, aboriginal societies but are of little more than academic interest today. Examples include the use of acorns from various species of *Lithocarpus* and *Quercus* by indigenous tribes in North America and the use of birch bark for shelters, canoes, drinking cups and other products across the boreal forests of the Northern Hemisphere.

The value of many NWFP of temperate broad-leaved trees has been appreciated for thousands of years. Use of tannin from oak bark for curing hides, for example, was known by the Egyptians at least as early as 3000 BC. Silk may have been a commodity in China as early as 2600 BC. The unique properties of cork were known by the Greeks and Romans as early as 100 BC. Indigenous North American tribes used the sap of both birch and maple trees as a sweetener long before the Europeans arrived, and a permanent ink, made from oak galls, was used in Europe as early as the ninth and tenth centuries.

The use of some NWFP of temperate broad-leaved trees, on the other hand, is of relatively recent origin. For example, the use of the bark of *Rhamnus purshiana* as a natural laxative was not appreciated until the late nineteenth century. The same is true of the use of *Ulmus rubra* bark to soothe irritations.

Some uses of NWFP of temperate broad-leaved trees have resulted in overharvesting, unsustainable practices, land-use conflicts and introduction of destructive pests. These have had adverse effects on trees that are sources of non-wood products. Examples include overharvesting of oak, chestnut and tanoak for tannin in North America; overharvesting of cork oak for both cork and tannin in Mediterranean Africa and Europe; and harvesting of cascara bark in the Pacific Northwest region of the United States. Increased demand for the American matsutake mushroom by Japan has resulted in conflicts between commercial mushroom harvesters and traditional harvesting by indigenous tribes in California. Introduction of the Asian chestnut blight into both Europe and North America has had devastating effects on native chestnut forests, especially in North America, where chestnuts have almost been forgotten as a food source. Introduction of the Dutch elm disease, another Asian pathogen, into Europe and North America has had devastating effects on a favourite group of ornamental and shade trees. Gypsy moth was purposely introduced from Europe into the United States in an attempt to develop a hybrid silkworm that would feed on oaks. Instead, this insect has been responsible for defoliation of millions of hectares of broadleaf forests across eastern North America, and the area of infestation continues to expand.

There are many opportunities, worldwide, to develop or expand profitable, sustainable and environmentally sound NWFP enterprises in conjunction with economic development projects either as primary or supplemental sources of income. Obviously, the development of such an enterprise must be based on the availability of an existent forest resource or the existence and availability of sites capable of supporting tree plantations. An appreciation of NWFP or the presence of traditional uses of NWFP by local residents is a significant advantage when developing such enterprises. In addition to the potential economic benefits to be derived from development and expansion of NWFP enterprises, other factors to consider are that the management and harvesting practices are sustainable and that the harvest is compatible with other forest uses.

BIBLIOGRAPHY

Adrosko, R.J. 1971. *Natural dyes and home dyeing*. New York, Dover Publications. 154 pp.

Alexopoulos, C.J. 1962. *Introductory mycology*. New York, John Wiley and Sons Inc. 163 pp.

Anonymous, 1997. *Carob agroforestry in Portugal and Spain*. The Australian New Crops Newsletter, Issue No. 7. University of Queensland, Queensland, Australia, 4 pp.

Aris, P. 1990. *Recipes from a Spanish village*. London, Conran Octopus Ltd. 144 pp.

Arora, D. 1986. *Mushrooms demystified*. Berkeley, California, Ten Speed Press. 958 pp.

Ayers, G.S. 1992. Characteristics of black locust as bee forage. In *Proceedings: International Conference on Black Locust Biology, Culture and Utilization, 17-21 June 1991* Department of Forestry, Michigan State University, East Lansing, Michigan. pp 243-257.

Bailey, R.G. 1996. *Ecosystem geography*. Springer. 204 pp.

Bainbridge, D.A. 1986. *Quercus*, a multipurpose tree for temperate climates. The Int. Tree Crops Jour. 3: 291-298.

Baldini, U.A., Le-Quesne, G.C., Puentes, M.O. & Ojeda, G.P. 1994. *Daños bióticos en roble, raulí y coihue: Guia de reconocimiento*. Chile, Corporación Nacional Forestal.

Bancroft, 1814. *Experimental researches concerning the philosophy of permanent colours and the best means of producing them by dyeing, calico printing, etc.* Philadelphia, Thomas Dobson.

Belhadj, S. 1999. Pistachio situation in Algeria. *FAO-IHEAM Nucis Newsletter* 8: 30.

Berenbaum, M.R. 1994. *Bugs in the system*. Helix Books, 377 pp.

Bernardson, W., 1996. *Argentina, Uruguay & Paraguay* – A Lonely Planet Travel Survival Kit. Hawthorn, Victoria, Australia, Lonely Planet Publications. 759 pp.

Bernáth, J. & Földesi, D. 1992. Sea-buckthorn (*Hippophae rhamnoides* L.): a promising new medicinal and food crop. *J. Herbs, Spices & Medicinal Plants* 1(1/2): 27-35.

Bliss, A. 1981. *A handbook of dyes from natural materials*. New York, Charles Scribner & Sons. 180 pp.

Bliss, A. 1993. *North American dye plants*. Loveland, Colorado, Interweave Press. 288 pp.

Bolgiano, C. 1997. Sylvan regards. *American Forests* 103(2): 35-36.

Boom, B.K. & Kleijn, H. 1966. *The glory of the tree*. New York, Doubleday.

Bounous, G. & Peano, C. 1990. Frutti dimenticari. *Monti e Boschi* 41(4): 23-32.

Bourdu, R. & Viard, M. 1988. *Arbres souverains*. Paris, Editions du Mai. 207 pp.

Boyce, J.S. 1961. *Forest/athology*. New York, McGraw-Hill Book Company Inc. 572 pp.

Boyd, R. 1986. Strategies of Indian burning in the Willamette Valley. *Can. J. of Anthropology* 5:65-86.

Brasier, C.M., Robredo, F. & Ferraz, J.F.P. 1993. Evidence for *Phytophthora cinnamomi* involvement in Iberian oak decline. *Plant/athology* 42: 140-145.

Breugel, P. van & Stephan, J. 1999. Carob distribution in Lebanon. *FAO-IHEAM Nucis Newsletter* 8: 30.

Briggs, R.T. 1984. Plymouth colony's dye plants. *Plants and Garden - Brooklyn Botanic Gardens Record* 20(3): 39-40.

Bryan, N.G., Young, S. & Shirley, C.K. 1978. *Navajo native dyes, their preparation and use*. Palmer Lake, Colorado, Filter Press. 75 pp.

Buchanan, R. 1987. *A weaver's garden*. Loveland, Colorado, Interweave Press. 230 pp.

Burandt, J. 1994. An investigation toward the identification of traditional drawing inks. *The Book and Paper Group Annual*: 13 (Accessed via the Internet).

Burns, R.M. & Honkala, B.H., technical coordinators. 1990. *Silvics of North America*, Vol. 2., Hardwoods., Washington, D.C., USDA Forest Service. 877 pp.

Cagniart, P. 1968. Commerce et réglementation de la truffe. In: *Atti del I congresso internazionale sul tartufo, 24-25 May 1968, Spoleto, Italy*. pp 1-6.

Cameron, M. 1999. *Establishing an Alaskan birch syrup industry: Birch syrup – it's the un-maple*. 10 pp.

Casselman, K.L. 1993. *Craft of the dyer – Color from plants and lichens*. New York, Dover Publishers. 249 pp.

Cesaro, L., Linddal, M. & Pettenella, D. 1995. The economic role of non-wood forest products and services in rural development. *Medit* 6(2): 28-34.

Cesaro, L., Linddal, M. & Pettenella, D. unpublished. *Regional differences in benefits of non-wood forest products and services in Europe*. 12 pp.

Chamberlain, J., Bush, R. & Hammet, A.L. Non-Timber Forest Products The OTHER forest products. *For. Pro.* J. 48(10)
Ciani, A. 1990. Il circuito commerciale del tartufo in Italia. *In* M. Bencivenga & B. Granetti, eds. *Atti del II congresso internazionale sul tartufo, Spoleto, Italy.* Comunità Montana dei Monti Martani e del Serano. pp 621-631.
Ciesla, B. 1990a. Rowan, tree of waxwings and witches. *Forest World* 6(3): 27-31.
Ciesla, B. 1990b. Myrtlewood, magnificent hardwood of the big timber country. *Forest World* 6(2): 20-23.
Che Muqi. 1989. *The silk road, past and present.* Beijing, Foreign Languages Press. 319 pp.
Chua, C.S. & Klinac, D.J. 1992. World chestnut production. *New Zealand Chestnut Conference, November 1992* (Accessed via the Internet).
Coppen, J.J.W. Unpublished. *National Statistics.*
Coppen, J.J.W., ed. *Medicinal and aromatic plants: Industrial Profiles – Eucalyptus.* Amsterdam, Harwood Publishing. In preparation
Dansereau, P. 1957. *Biogeography, an ecological perspective.* New York, Roland Press Co. 394 pp.
David, E. 1987. *Italian food.* London, Barrie & Jenkins. 240 pp.
della Croce, J. 1996. *Salse di pomodoro.* San Francisco, Chronicle Books. 132 pp.
Derby, J.A., 1980. Acorns for modern man. In: *Ecology, management and utilization of California oaks, 26-28 June 1979, Claremont, California.* USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Berkeley, California. General Technical Report PSW-44, pp. 360-361.
deWit, H.C.D. 1967. *Plants of the world - The higher plants.* Vol. 2. New York, E.P. Dutton & Co. Inc.
Dickinson, C. & Lucas, J., eds. 1979. *The encyclopedia of mushrooms.* New York, G.P. Putnam's Sons. 280 pp.
Dirr, M.A. 1990. *Manual of woody landscape plants: Their identification, ornamental characteristics, culture, propagation and uses.* Champaign, Illinois, Stipes Publishing Company. 1007 pp.
Drooz, A.T. 1985. *Insects of eastern forests.* USDA Forest Service, Miscellaneous Publication 1426. 608 pp.
Duke, J.A. 1983. *Handbook of energy crops.* Unpublished data accessed via http://www.hort.purdue.edu/newcrop/duke_energy/.
Edlin, H.L. 1985. *Broadleaves.* Forestry Commission Booklet 20. London, Her Majesty's Stationery Office. 104 pp.
Ehlers, H.-U. 1968. Der Wald als Schmuckgrünlieferant. *Forst- und Holzwirt* 22(24): 528-530.
Escoffier, A. 1982. *2 000 favourite French recipes.* London, Treasure Press. 884 pp.
Fagan, M.M. 1918. The uses of insect galls. *American Naturalist* 52: 155-176.
FAO. 1979. *Poplars and willows in wood production and land use.* Rome. 328 pp.
FAO. 1979. *Eucalypts for planting*, by M.R. Jacobs. FAO Forestry Series No 11, Rome. 677 pp.
FAO. 1993. *International trade in non-wood forest products: An overview*, by M. Iqbal. Rome. FO: Misc/93/11. 100 pp.
FAO. 1994. *Decline and dieback of trees and forests: A global overview*, by W.M. Ciesla & E. Donaubauer. FAO Forestry Paper No. 120, Rome
FAO. 1995. *Climate change, forests and forest management – An overview*, by W.M. Ciesla. FAO Forestry Paper No. 126, Rome. 128 pp.
FAO. 1995. *Edible nuts*, by G.E. Wickens. FAO NWFP Series No. 5. Rome. 198 pp.
FAO. 1995. *Natural colourants and dyestuffs*, by C.L. Green. FAO NWFP Series No. 4, Rome. 116 pp.
FAO. 1995. *Gums, resins and latexes of plant origin*, by J.J.W. Coppen. FAO NWFP Series No. 6. Rome. 142 pp.
FAO. 1998. *Non-wood forest products from conifers* by W.M. Ciesla. FAO NWFP Series No. 12, Rome.
FAO. 2001. *Global Forest Resources Assessment 2000.* FAO Forestry Paper No. 140. Rome. 479pp.
Farolfi, S. 1990. Ruolo economico dei prodotti secondari spontanei del bosco: un'indagine nel Casentino. *Monti e Boschi* 41(1): 49-52.
Felt, E.P. 1940. *Plant galls and gall makers.* Ithaca, New York, Comstock Publishing Company.
Felker, P. 1998. The value of mesquite for the rural southwest. *J. of For.* 96(3): 16-20.
Ferguson, B., ed. 1982. *All about trees.* San Francisco, Ortho Books, Chevron Chemical Company.

Fernald, M.L., Kinsey, A.C. & Rollins, R.C. 1958. *Edible wild plants of eastern North America*. Harper & Row. 452 pp.

Fowells, H.A. 1965. *Silvics of forest trees of the United States*. USDA Forest Service Agriculture Handbook 271. 762 pp.

Gamundi, I. And E. Horak, 1995. Fungi of the Andean Patagonian forests. Buenas Aires: Vazquez Mazzini Editores, 141 pp.

Garfias Salinas, R., Carmona Cerda, R., Barros, D., Cabello, J.A. & Balidini U.A. 1995. Chile. In: *Memoria – Consulta de expertos sobre productos forestales no maderos para América Latina y el Caribe, Santiago, Chile*. FAO Regional Office for Latin America and the Caribbean, Serie Forestal #1, pp. 200-208.

Gerber, F.H. 1978. *Cochineal and the insect dyes*. Ormond Beach, Florida, self- published. 70 pp.

Giunta Regionale dell'Umbria, 1987. Norme concernenti la disciplina della raccolta, coltivazione, conservazione e commercio dei tartufi. Bollettino Ufficiale della Regione dell'Umbria 18 (81 - parts 1,2 and 3): 2156-2161.

Graham, S.A., Harrison Jr., R.P. & Westell Jr., C.E. 1963. *Aspens – Phoenix trees of the Great Lakes Region*. Ann Arbor, University of Michigan Press. 272 pp.

Grieve, M. 1931. *A modern herbal*, Vols. 1 & 2. New York, Dover Books. 902 pp.

Grochowski, W. 1966. Les productions forestières secondaires en Pologne. *Revue Forestière Française* 18(3): 160-170.

Haack, R.A., Law, K.R., Mastro, V.C., Sharon Ossenbruggen, H. & Raimo, B.J. 1997. New York's battle with the Asian long-horned beetle. J. of For. 95(12): 11-15.

Haldimann, E., J. Carter, R. Kuranaliev and M. Kamytov, 2000. *The potential for collaborative forest management in the juniper (archa) forests of Kyrgyzstan*. Paper presented at the International Symposium on Juniper Forest Management Problems, Osh, Kyrgyzstan, 7-11, August 2000.

Hall, J.A. 1971. *Utilization of Douglas-fir bark*. USDA Forest Service Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Harlow, W.M. & Harrar, E.S. 1950. *Textbook of dendrology*. New York, McGraw-Hill Book Co. 555 pp.

Harlow, W.M., Harrar, E.S. & White, F.M. 1979. *Textbook of dendrology*. 6th edition. New York, McGraw-Hill Book Co.

Harris, R.W. 1976. *Arboriculture: Care of trees, shrubs and vines*. Prentice Hall Inc. 688 pp.

Harris, V., 1996. *Recipes from an Italian farmhouse*. London, Conran Octopus Ltd. 160 pp.

Harrison, C.R. 1975. *Ornamental conifers*. New York, Hafner Press. 224 pp.

Hergert, H.L., 1983. The tannin extraction industry in the United States. *J. of For.* History 27: 92-93.

Hora, B. 1981. *The Oxford encyclopedia of trees of the world*. Oxford, Oxford University Press.

Houston, D.R. 1981. *Stress triggered tree diseases: The diebacks and declines*. USDA Forest Service Northeastern Forest Experiment Station, NE-INF-41-81.

Iirkina, M.I. & Shishkina, E.E. 1976. Sea-buckthorn food products. *Sadovodstov* 8: 29.

Jones, E.; McLain, R. and Weigand, J. 2002. *Nontimber Forest Products in the United States*. University Press of Kansas. 445pp.

Kalinowski, M. 1998. Non-wood forest products in Poland. In *Sustainable Development Of Non-wood Goods And Benefits (NWGB) From Boreal And Cold Temperate Forests. Proceedings of the International Workshop Joensuu, Finland 18-22 January 1998*. European Forest Institute, EFI Proceedings No. __

Kamazaki, A. 1984. Plant dyeing peculiar to Japan. *Plants and Garden – Brooklyn Botanic Gardens Record* 20(3): 41-44.

Kohlander, C. 1985. *A silk worker's notebook*. Loveland, Colorado, Interweave Press. 155 pp.

Lemay, K. 1999. The giving tree – Medicine may soon join birch's long list of gifts. *Lake Superior Magazine*, Apr.-May.

Leonard, D.E. 1981. Bioecology of the gypsy moth. In: *The gypsy moth: Research toward integrated pest management*. USDA Expanded Gypsy Moth Research and Development Program. Technical Bulletin 1584, pp. 9-29.

Leung, A. 1977. Cascara sagrada: new standards are needed. *Drug and Cosmetic Industry* 121(6): 42-44, 143-145.

Lewis, W.H. 1977. *Ecology field glossary*. Westport, Connecticut, and London, Greenwood Press. 152 pp.

Little, E.L. Jr. 1976. *Atlas of United States Trees*, Vol .3 Minor western hardwoods. USDA Forest Service Miscellaneous Publication 1314.

Little, E.L. Jr. 1979. *Check list of United States Trees (Native and Naturalized).* USDA Agriculture Handbook 541. 375 pp.

Lust, J. 1990. *The herb book.* Bantam Books. 659 pp.

Manion, P.D. 1991. *Tree disease concepts.* Engelwood Cliffs, New Jersey, Prentice-Hall. 402 pp.

Miller, H.A. & Lamb, S.H. 1985. *Oaks of North America.* Happy Camp, California, Naturegraph Publishers Inc. 327 pp.

Miller, R.K. 1997. Southwest Woodlands: Cultural uses of the "forgotten forest." *J. of For.* 24(11): 24-28.

Minter, D.W., Cannon, P.F. & Peredo, H.L. 1987. South American species of *Cytarria* (A remarkable and beautiful group of edible ascomycetes). *The Mycologist* 21(1): 7-11.

Mirov, N.T. & Hasbrouck, J. 1976. *The story of pines.* Indiana University Press. 148 pp.

Molina, R., O'Dell, T., Luoma, D., Amaranthus, M., Castellano, M. & Russell, K. 1993. *Biology, ecology, and social aspects of wild edible mushrooms of the Pacific Northwest: A preface to managing commercial harvest.* USDA Forest Service, Pacific Northwest Research Station PNW-GTR-309, 42 pp.

Morra, F. 1955. La produzione ed il commercio dei tartufi. *Allionia* 2(2): 51-55.

Moussouris, Y. 1999. *Cork certification according to FSC principles and criteria.* WWF. 26 pp.

Moussouris, Y. & Regato, P. 1999. Forest harvest: *An overview of Non-Timber Forest Products in the Mediterranean Region.* WWF. 25 pp.

NAPAP (National Acid Precipitation Assessment Program). 1992. *Assessment program 1982.* Report to Congress, Chapter 5. pp. 65-73.

National Aboriginal Forestry Association, 1999. *Non-Timber Forest Products: Exploring opportunities for aboriginal communities.* National Aboriginal Forestry Association. 137 pp.

National Honey Board. 1998. http://www.nhb.org. Longmont, Colorado, USA.

Nicolas, J.J. 1973. La trufa. *Boletín de la Estación Central de Ecología* 2(3): 3-28.

Noda, H. 1988. Policy relating to special forest products. *In* R. Handa. *Forest policy in Japan.* Tokyo, Nippon Ringyo Chosaku.

Ollikainen, T. 1998. Belarus forestry strategic plan and the non-wood forest products. In: *Sustainable development of non-wood goods and benefits (NWGB) from boreal and cold temperate forests. Proceedings of the international workshop. Joensuu, Finland 18-22 January 1998.* European Forest Institute, EFI Proceedings No. _23_

Park, M.K. 1984. A study on the investment effectiveness of oak mushroom cultivation. *Journal of the Korean Forestry Society* 63: 61-68.

Panshin, A.J., Harrar, E.S., Baker, W.J. & Proctor, P.B. 1950. *Forest products - Their sources, production and utilization.* McGraw-Hill Book Company, Inc. 549 pp.

Pashina, L. 1993) *Plants and cosmetics.* Minsk, Byelorussia 130 pp.

Payne, J.A. & Krewer, G.W. 1990. Mayhaw: A new fruit crop for the South. *In* J. Janick & J.E. Simon, eds. *Advances in new crops.* Portland, Oregon, Timber Press pp. 317-321.

Peattie, D.C. 1953. *A natural history of western trees.* Boston, Houghton Mifflin Company. 751 pp.

Peigler, R.S., 1999. Wild silks of the world. Spin-Off, 23 (4): 62-71.

Peyton, J.L. 1994. *The birch, bright tree of life and legend.* Blacksburg, Virginia, The McDonald and Woodward Publishing Company.

Phillips, R. 1991. *Mushrooms of North America.* Little, Brown and Company. 319 pp.

Piir, R. & Kelt, K. 1998. Chemical composition of *Hippophae rhamnoides* fruits in Estonia. In: *Metsanduslikud Uurimused XXX forestry studies International Conference wild berry culture: An exchange of western and eastern experiences 10-13 August 1998.* pp.134-139

Plekanova, M.N. 1998. *Lonciera Subsect. Caerulea* (Caprifoliaceae) genetic resources in Russia and neighbouring countries. In: *Forestry Studies XXX International Conference wild berries culture: An exchange of western and eastern experiences 10-13 August 1998.*

Plekanova, M.N. & Streltsyna, S. 1998. Fruit chemical composition of *Lonicera subsect. Caerulea* (Caprifoliaceae) species. In: *Forestry studies XXX International Conference wild berries culture: An exchange of western and eastern experiences 10-13 August 1998*

Prance, G.T. & Prance, A.E. 1993. Bark: *The formation, characteristics and uses of bark around the world.* Portland, Oregon, Timber Press. 174 pp.

Prescott-Allen, C. & Prescott-Allen, R. 1986. *The first resource: Wild species in the North American economy.* New Haven, Connecticut, Yale University Press. 529 pp.

Quartier, A. 1978. *Bäume + Sträucher.* Munich, BLV Verlagsgesellschaft, 259 pp.

Quirin, K.W. & Gerard, D. 1993. *Sea-buckthorn pulp and kernel oils: Valuable lipids for skin care.* Unpublished Report, Flavex Naturextrakte Co. 8 pp.

Ramierez Correa, L.A. 1988. *Agentes causales del secamiento del roble (Quercus humboldtii) en el norte de Antioquia*. INDERENA, Servicio Nacional de Protección Forestal 2: 2-14.

Rau, R. 1977. Erfahrungen beim Absatz von Waldgrün und Weinachtsbäumen. *Allgemeine Forstzeitung* 32(46): 1139-1142.

Résico, C. 1995. Argentina. In: *Memoria – Consulta de expertos sobre productos forestales no maderos para Americana Latina y el Caribe. Santiago, Chile*. FAO Regional Office for Latin America and the Caribbean, Serie Forestal #1, pp. 125-128.

Richards, R.T. 1997. What the natives know - Wild mushrooms and forest health. *J. of For.* 95(9): 5-10.

Riotte, L. 1975. *Nuts for the food gardener*. Carlotte, Vermont, Garden Way Publishing. 179 pp.

Ritter-Studnicka, H. 1984. Old recipes, recent tests – A study of dye plants formerly used in Bosnia and Herzegovina. *Plants and Garden – Brooklyn Botanic Gardens Record* 20(3): 57-58.

Rongsen, A. 1992. *Seabuckthorn a multi-purpose plant species for fragile mountains*. ICIMOD Occasional Paper No. 20, Khathmandou. 62 pp.

Rossi, R.S. 1990. History of cultural influences on the distribution and reproduction of oaks in California. In: *Ecology, management and utilization of California oaks*. 26-28 June 1979, Claremont, California. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Berkeley, California, General Technical Report PSW-44, pp 7-15.

Russel, M.W. & Lispey, R.G. 1999. *An economic strategy to develop non-timber forest products and services in British Columbia*. Forest Renewal BC Project No. PA97538-ORE. (Accessed via the Internet).

Rutkausas, A. 1998. Non-wood resources and utilization in Lithuanian forests. In: *Sustainable Development of non-wood goods and benefits (NWGB) from boreal and cold temperate forests. Proceedings of the International Workshop Joensuu, Finland 18-22 January 1998.* European Forest Institute. EFI Proceedings No. 23.

Salas Estrada, J.B. 1993. *Arboles de Nicaragua*. Managua, Instituto Nicaragüense de Recursos Natrales y del Ambiente. 388 pp.

Sampson, R.N., Moll, G.A. & Keilbaso, J.J. 1992. Opportunities to increase urban forests and the potential impacts on carbon storage and conservation. In: *Forests and Global Change*. Washington, DC, American Forests. pp 51-67.

Samson, I. & Samson, R. 1986. *The creative art of bonsai*. Ward Lock. 168 pp.

Schenck, S.M. & Gifford, W. 1952. Karok ethnobotany. *Anthropological Records* 13: 377-392.

Schetky, E. McD. 1984. The ageless art of dyeing. In: Handbook of plants and dyeing. *Plants and Gardens* 20(3): 4-7.

Schlosser, W.E. & Blattner, K.A. 1995. The wild edible mushroom industry of Idaho, Oregon and Washington: A 1992 survey of processors. *J. of For.* 93(3): 31-36.

Schneider, M. 1990. Acorns as a staple food – Different types and change of exploitation through time. *Bodenkultur* 41(1): 81-88.

Scholtz, E. 1984. Dye plants around the world. In: Handbook of plants and dyeing. *Plants and Gardens* 20(3): 38-76.

Schroeder, W.R. 1995. *Improvement of conservation trees and shrubs*. PFRA Shelterbelt Centre Supp. Rpt. #95-1, 42 p.

Schumann, G.L. 1991. *Plant diseases: Their biology and control*. St. Paul, Minnesota. ASP Press. 397 pp.

Sednak, P.E. & Jenkins, W.L. 1982. Market structure of the maple industry and syrup grading standards. In: *Sugar maple research: Sap production, processing and marketing of maple syrup*. USDA Forest Service, Northeastern Forest Experiment Station, Broomal, PA, General Technical Report NE-72. pp. 98-102.

Sednak, P.E. & Bennick, J.P. 1985. *The cost of maple sugaring in Vermont*. USDA Forest Service, Northeastern Forest Experiment Station, Broomal, PA, Research Paper NE-565. 14 pp.

Sengül, S. & Sengül, H. 1999. The nut sector in Turkey. *FAO-IHEAM Nucis Newsletter* 8:30. December 1999

Shand, W.A. 1984. Dyeing wool in the Outer Herbrides. *Plants and Garden – Brooklyn Botanic Gardens Record* 20(3): 62-65.

Shizou Tsujii. 1984. *Japanese cooking, a simple art*. Tokyo, Kodansha International. 517 pp.

Simon, J.E., Chadwick, A.F. & Craker, L.E.1984. *Herbs: an indexed bibliography, 1971-1980. The scientific literature on selected herbs and medicinal plants of the temperate zone*. Hamden, Connecticut, Archon Books. 770 pp.

Slee, R.W. 1991. The potential of small woodlots in Britain for edible mushrooms production. *Scottish Forestry* 45(1): 3-12.

Skifkas, G. 1991. *Trees and shrubs of Greece.* Efstathiadis Group S.A. 213 pp.
Siimisker, T. 1998. Sea-bucktorn cultivar trials at Rõhu Testing Station. In: *Metsanduslikud Uurimused XXX forestry studies International Conference wild berry culture: An exchange of western and eastern experiences 10-13 August 1998.* pp.162-168.
Stowell, J.P. 1966. *Bonsai - Indoors and out.* D. Van Nostrad Company Inc. 134 pp.
Sverdrup, S. 1984. Using plants for dyes in Norway. *Plants and Garden – Brooklyn Botanic Gardens Record* 20(3): 66-68.
Tedder, S., Mitchell, D. & Farran, R. 2000. *Seeing the forest beneath the trees: The social and economic potential of non-timber forest products and services in the Queen Charlotte Islands/Haisa Gwaii, South Moresby Forest Replacement Account.* (Accessed via the Internet).
Ter-Ghazaryan, G. & Ter-Ghazaryan, K. 1998. Non-wood forest products (NWFP) in Armenia. In: *Sustainable development of non-wood goods and benefits (nwgb) from boreal and cold temperate forests. Proceedings of the International Workshop Joensuu, Finland, 18-22 January 1998.* European Forest Institute, EFI Proceedings No. 23.
The Economist. 1999. Plastic wine stoppers a corking row. 5 June.
Thomas, M.C. & Schumann, D.R. 1992. *Seeing the forest instead of the trees - Income opportunities in special forest products.* Kansas City, Missouri, Midwest Research Institute.
Tiburzi, P. 1993. *Appunti sul corso di tecniche di conservarzione legature e restauro.* Città del Vaticano (Vatican City), Biblioteca Apostolica Vaticana di Biblioteconomia.
Vasilevich, V.I., 1996. Birch forests in Russia. *In* S.K Majumdar, E.W. Miller & F.J. Brenner. *Forests - A global perspective.* The Pennsylvania Academy of Science. pp. 444-456.
Walker, L.C. 1990. *Forests, a naturalist's guide to trees and forest ecology.* John Wiley and Sons. 288 pp.
Walters, R.S. 1982a. Sugar maple sap collection. In: *Sugar maple research: Sap production, processing and marketing of maple syrup.* USDA Forest Service, Northeastern Forest Experiment Station, Broomal, PA, General Technical Report NE-72, pp 16-24.
Walters, R.S. 1982b. Sugarbush management. In: *Sugar maple research: Sap production, processing and marketing of maple syrup.* USDA Forest Service, Northeastern Forest Experiment Station, Broomal, PA, General Technical Report NE-72, pp 25-37.
Westveld, R.H. 1949. *Applied silviculture in the United States.* Ann Arbor, Michigan, Edwards Brothers Inc. 590 pp.
Wickens, H. 1986. *Natural dyes for spinners and weavers.* London, B.T. Batsford Ltd. 96 pp.
Wigginton, E., ed. 1973. *Foxfire 2.* Garden City, New York, Anchor Press/Doubleday. 410 pp.
Wolf, F.A. & Wolf, F.T. 1947. *The fungi.* Vol. 2. New York, John Wiley & Sons Inc. 353 pp.
Wolf, D. & Wegert, F. 1993. Experience gained in the cultivation, harvesting and utilization of sea-buckthorn. In: *Cultivation and utilization of wild fruit crops.* Bernhard Thalacker Verlag GmbH & Co. pp. 23-29 (in German).
Wu, F. 1991. A series of *Hippophae* drugs in the USSR. *Hippophae* 2: 38-41.
Yashiroda, K. 1984. Home dyeing, a hobby in Japan today. *Plants and Garden – Brooklyn Botanic Gardens Record* 20(3): 39-40.

APPENDIX 1

GLOSSARY OF KEY TERMS

Agglomerate	Sheets of cork made from cork granules agglutinated with resin.
Apiculture	The science and art of raising bees (mostly *Apis mellifera)* in hives for production of honey and/or pollination of agricultural crops.
Arboriculture	The science and art of planting and caring for trees and other woody plants for their products or for landscape and ornamental purposes.
Astringent	A substance that contracts the tissues or canals of the body, therefore diminishes blood flow.
Bonsai	An ancient art form with origins in China and Japan that involves cultivation of trees and shrubs in tiny pots. The objective of bonsai is to produce miniature plants that retain their original growth form.
Copperas	A common name for ferrous sulphate, a chemical commonly used as a mordant for dyes.
Coppice	A silvicultural technique that involves regenerating trees from stump sprouts.
Cultivar	A mutation or distinct form of a plant, initially found in nature and propagated asexually with the objective of maintaining those characteristics.
Cultivariant	Plant cultivars that appear somewhat different from their vegetative parent due to propagation from non–typical foliage.
Decoction	The end result of boiling a substance in water in order to extract certain properties.
Demulcent	A substance that is usually mucilaginous and has soothing or mollifying properties.
Essential oils	Volatile, aromatic oils extracted from the foliage, wood or other parts of a plant that are used in the manufacture of cosmetics, flavourings, medicinal products, perfumes and cleaning products.
File gumbo	The powdered, dry leaves of *Sassafras albidum*, which are used as a flavouring in stews and gumbo, a traditional seafood stew in the southern United States.
Glucoside	An extensive group of compounds that yield glucose and some other compounds when treated with a dilute acid or when decomposed by fermentation or an enzyme.
Mordant	A chemical added to a dye bath to alter the colour of the dye or change its ability to penetrate a fibre.
Mycorrhizae	Certain fungi which form a symbiotic relationship with higher plants. They form extended root systems and help the host plant take in nutrients. The fruiting bodies or sporocarps of many species of mycorrhizae are edible and commercially important.
Nut	Generally a one celled, one seeded fruit with a bony, woody, leathery or papery wall and usually partially or wholly encased in a husk.
Parasite	An organism that is dependent on another living organism (host) for its nourishment, often resulting in stress, disease or death of the host.
Pellicle	A thin skin or membrane such as the inner skin of a nut.
Planks	Strips of corkwood removed from the cork oak, *Quercus suber*.
Pollard	A technique of severe tree pruning that involves removal of all of the branches. This results in the production of a dense mass of new branches.

Quercitron A yellow dye extracted from the inner bark of the North American black oak, *Quercus velutina*.

Reproduction cork Cork planks obtained from the second and subsequent harvests of cork oak trees. Reproduction cork is generally of good quality and can be used for production of bottle stoppers and related products.

Saponins Amorphous, glucosidal compounds of steroid structure that are obtainable from many plants. Aqueous solutions of some saponins foam like soap and are used as detergents.

Saprophyte An organism that causes the breakdown of dead organic matter (e.g. certain fungi that produce edible mushrooms).

Sericulture The art and science of raising silkworms, *Bombyx mori*, for production of silk.

Sporocarp The reproductive stage of a fungus. Many sporocarps are commonly known as mushrooms. Some species are edible and important NWFP while others are poisonous.

Sugarbush A maple forest dedicated to collection of sap for syrup and sugar production.

Sugarcamp A building or site where maple sap is boiled down into syrup.

Symbiont An organism that co–exists with another organism for the mutual benefit and survival of both organisms (e.g. mychorrhyzal fungi on tree roots).

Tannin A group of astringent compounds taken from plants or insect caused plant galls that are used in the curing of leather.

Taphole A hole made in the trunk of a maple tree from which sap is collected for production of syrup or sugar.

Tussah Silk produced by certain species of wild silkworms (Lepidoptera: Saturniidae) indigenous to China and India.

Variety A plant population that has distinct morphological characteristics but is not separable at the species level. Varieties are one step below species in the taxonomic hierarchy, appear in nature, are genetically stable and reproduce from seed.

Virgin cork The cork obtained from the first harvest of a mature cork oak tree. Virgin cork is of inferior quality to reproduction cork and is used in the production of agglomerate.

APPENDIX 2

SELECTED RECIPES

MAPLE SYRUP

MAPLE PECAN PIE

3 slightly beaten eggs
250 ml pure maple syrup
150 grams packed maple sugar
30 ml melted butter
32 grams all-purpose flour
1 teaspoon vanilla, salt
75 to 125 grams chopped pecans
1 unbaked 23 cm pie shell

Mix eggs, syrup, sugar, butter, flour, vanilla and salt. Beat until smooth with a rotary beater. Stir in nuts. Fill pastry shell. Bake at 180° C for about 40 minutes.

ACORNS

ACORN COOKIES - CALIFORNIA, USA

125 grams brown sugar
100 grams shortening
2 eggs
250 ml buttermilk
10 ml vanilla
2.5 grams salt
1 cup acorn meal

250 grams flour
2.5 grams nutmeg
5 grams cinnamon
5 grams baking powder
5 grams baking soda
125 grams instant oatmeal

Cream sugar, shortening and eggs. Stir in vanilla, add buttermilk alternatively with dry ingredients. Mix well. Stir in oatmeal and acorn meal. Drop teaspoonfuls onto a greased baking sheet. Bake for 12 minutes at 190 °C (Derby, 1990).

CHESTNUTS

COOKING CHESTNUTS [62]

Prior to cooking chestnuts, a small "x" should be cut through the shell into the flat side of the nut with a small, sharp knife. This will prevent the nuts from bursting during cooking.

For fireplace roasting, use a long handled pan or a fireplace popcorn basket. Do not crowd the chestnuts because all sides should be in contact with the pan. Shake the pan and hold it just above the flames, not in the flames. Cook in this manner for about 15 minutes or until the outside shell is black. Remove the nuts from the pan to an area where they can cool. When they are cool enough to touch, peel and eat. The interiors should have a creamy texture

For oven roasting, lay the nuts in one layer in an ovenproof dish. Bake at 180°C for about 30 minutes. For stovetop cooking, cook in a heavy, cast-iron pan. Again, do not crowd the chestnuts. Cook over moderate heat and shake the pan. Cook until shells appear cooked or you can smell the nuts.

[62] The Farm Store (http://www.square.com/the Farm Store/htm/cooking/html).

CHESTNUT STUFFING – USA

Chestnut stuffing has been an accompaniment to the traditional roast turkey served during the Thanksgiving holiday season in North America.

0.5 to 0.75 kg loaf of bread, dried
125-250 ml cooking oil
5 grams salt
2.5 grams pepper
½ cup minced onion
32 grams poultry seasoning
½ kg chestnuts cooked and chopped

Cut sliced bread into 2.5 cm cubes. Toss all ingredients together lightly. Stuffing may be baked in an oiled ring mold or loaf pan if you do not want to bake it with fowl or meat. When stuffing is removed from the ring mold, hot cooked vegetables may be placed in the center.

CHESTNUT, MILK AND RICE SOUP - *MINESTRA DI RISO, LATTE E CASTAGNE* - ITALY

200 grams fresh chestnuts
150 grams pudding rice
500 ml milk
30 grams unsalted butter, salt

Pierce the chestnuts with a fork, put them in a pan, cover with lukewarm water and boil for 5 to 8 minutes. Drain, then remove the shell and soft inner skin. Place in a large pan with about 1 ½ liters of salted water and boil over medium heat for 2 ½ hour or until the nuts are disintegrating and the liquid halved.

Add the rice and cook for another 12 minutes or until the rice is half cooked, then add the milk and butter. Cook until the soup is very thick and creamy, then season and serve hot. Serves 4 (Harris 1989).

PERSIMMONS

PERSIMMON JAM –USA

5-6 average-size very ripe **persimmons**
1 cup water
1 package pectin
½ cup lemon juice
6 cups sugar

Prepare fruit by cutting into small pieces and then pureé. Measure fruit and water into large kettle. Stir in pectin and lemon juice. Bring to a full rolling boil and boil for 30 seconds. Add sugar and again bring to a rolling boil for exactly 4 minutes, by the clock. Stir constantly. Remove from heat and pour into sterilized containers. Makes 6 jars of jam.[63]

63 Source: Chef Mike, chefmike@persimmon.com 1997, Persimmon IT, Inc.

EDIBLE MUSHROOMS

BORDEAUX STYLE CÈPES (*CÈPES À LA BORDELAISE*) - FRANCE

0.5 kg fresh cèpes (*Boletus edulis*)
oil, salt, pepper
5 grams chopped shallot
16 grams breadcrumbs
lemon juice
chopped parsley

Wipe the cèpes, trim the heads and chop the stalks. Add a little seasoning. Heat some oil in a sauté pan and cook the cèpes until they begin to brown. Add the shallot and breadcrumbs. Sauté all together for a few minutes. Put in a serving dish, add lemon juice and sprinkle with parsley or, if preferred, add two tablespoons of melted meat jelly (Escoffier 1992).

CÉPES WITH CHEESE (*CÉPES AU FROMAGE*) - FRANCE

Canned cèpes (*Boletus edulis*)
Salt, Pepper
Flour
Oil
Butter
Grated cheese
Tomato sauce

Rinse and dry the cèpes and cut into thin slices. Season, coat with flour and cheese and sauté in oil or butter. Put into small cocettes, sprinkle with cheese and cover with the tomato sauce. Add a little melted butter and put into a moderate oven for a few minutes (Escoffier 1992).

TRUFFLES COOKED UNDER CHARCOAL CINDERS (*TRUFFES SOUS LE CENDRE*) – FRANCE

Choose some nice fresh truffles, clean them carefully but do not peel. Salt them sparingly and add a dash of brandy.

First wrap each truffle in a thin slice of pork fat, then in aluminium foil. Place them on a bed of hot charcoal cinders and cover with another layer of cinders. On top of this, place a sheet of iron containing more cinders, so that a regular heat may be sustained.

Cook for 30-45 minutes, depending on the size of the truffles.

Remove the foil and serve on a folded napkin with butter (Escoffier, 1992).

BOILED RICE WITH WHITE TRUFFLES (*RISO IN BIANCO CON TARTUFI BIANCHI)* – ITALY

This is one of the classic ways of eating the white truffle of the Piedmont Region of northern Italy.

Prepare a dish of boiled rice, pour over it a large quantity of the best grated Parmesan cheese, an equally generous amount of fresh, unsalted butter and raw truffles cut in the finest of slices (David, 1987).

APPENDIX 3

SUMMARY OF MAJOR NON-WOOD FOREST PRODUCTS OF TEMPERATE BROAD-LEAVED TREES BY FAMILY, GENUS AND SPECIES

FAMILY ACERACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use[1]
Acer buergerianum	Trident maple	East China	Bonsai Ornamental	C C
Acer campestre	Common or field maple	Europe	Ornamental	C
Acer nigrum	Black maple	East North America	Syrup (sap)	C
Acer palmatum	Japanese maple	Japan	Bonsai Ornamental	C C
Acer platanoides	Norway maple	Europe	Ornamental	C
Acer rubrum	Red maple	East North America	Dye (bark) Ornamental	T C
Acer saccharum	Sugar maple	East North America	Ornamental Syrup (sap)	C C
Acer saccharinum	Silver maple	East North America	Ornamental	C

FAMILY AQUIFOLIACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Ilex aquifolia	Holly	Europe	Decorative greenery Ornamental	C C
Ilex opaca	American holly	East United States	Decorative greenery Ornamental	C C
Ilex paraguariensis	*Yerba maté*	North Argentina South Brazil Paraguay	Herbal tea	L
Ilex vomitoria	Yaupon	Southeast United States, Mexico	Ceremonial	T

[1] C – Commercially important at regional or international level, L – Commercially important in individual countries or portions of countries, T - Traditional, historic use or in current use by tribal cultures. A - Agricultural crop.

FAMILY ANACARDIACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Pistacia kinjac	Pistachio	Afghanistan Pakistan	Edible nuts	L
Pistacia terebinthus		Mediterranean	Edible nuts Tannin (galls) Turpentine	L T T
Pistacia texana	Texas Pistachio	Texas, United States, Central Mexico	Edible nut	L
Pistacia vera	Pistachio	Near East	Edible nut Mordant (fruit husks) Tannin (fruit husks)	A T L

FAMILY BETULACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Alnus glutinosa	Black alder	Europe Near East Siberia	Tannin (bark)	T
Alnus rugosa	Speckled alder	North America	Tannin (bark)	T
Alnus tenufolia	Mountain alder	North America	Dye (bark)	T
Alnus spp.			Honey Ornamental	C C
Betula alba	European birch	Europe	Essential oil (bark) Tannin (bark) Syrup (sap)	L T L
Betula lenta	Sweet birch	East United States	Essential oil (twigs and bark) Birch beer (sap)	L L L
Betula nigra	River birch	Southeast North America	Bonsai	C
Betula papyrifera	Paper birch	North North America	Syrup (sap), Ornamental Canoes, shelters, etc., (bark)	L C T
Betula pendula	Weeping birch	Europe	Ornamental Bonasi	C C
Carpinus betulus	European hornbeam	Europe Near East	Ornamental	C
Carpinus laxifolia		Korea	Bonsai	C
Carpinus japonica	Japanese hornbeam	Japan	Bonsai	C
Corylus avellana	European hazel	Europe	Edible nut (cultivated) Edible and industrial nut oil	C, A C
Corylus maxima	Turkish filbert	Near East	Edible nut (cultivated) Edible and industrial nut oil	C C
Ostrya virginiana	American hop hornbeam	East North America	Ornamental	C

FAMILY CORNACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Cornus florida	Flowering dogwood	East North America	Ornamental	C
Cornus mas	Cornelian cherry	South Europe	Fruit added to wines and liqueurs	L
Cornus sanguiensis	Dogwood	South Europe	Fruit added to wines and liqueurs	L
Cornus stolonifera	Red-osier dogwood	North America	Ornamental	C

FAMILY EBENACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Diospyros khaki	Japanese persimmon	Japan	Edible fruit	A
			Ornamental	C
Diospyros virginiana	Common persimmon	Southeast United States	Edible fruit	L

FAMILY ERICACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Arbutus unendo	Strawberry tree	Mediterranean	Jellies, wines, liqueurs	L
Oxydendrum arboreum	Sourwood	East United States	Honey	L
			Ornamental	C

FAMILY EUPHORBIACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Aleurites fordii	Tung	Central-west China	Tung oil (seeds)	A
Aleurites montana	Tung	Southwest China	Tung oil (seeds)	L

FAMILY FAGACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Fagus grandifolia	American beech	East North America	Edible nut	T
			Dye (bark)	T
Fagus sieboldii		Japan	Bonsai	C
Fagus sylvatica	European beech	Europe	Nut oil	L
			Ornamental	C
			Bonsai	C
Castanea crenata	Japanese chestnut	Japan	Edible nut	A
			Dye (nut hull, bark)	T
Castanea dentata	American chestnut	East North America	Edible nut	T[2]
			Tannin (bark)	T[2]
Castanea henryi		China	Edible nut (small)	L
		Japan	Edible nut	
Castanea mollisima	Chinese chestnut	China	Edible nut	A
Castanea ozarkensis	Ozark chinkapin	South-central United	Edible nut	L

[2] Destroyed by Asian chestnut blight.

Castanea pumila	Allegheny chinkapin	East United States	Edible nut	L
Castanea sativa	European chestnut	Mediterranean Europe Near East	Edible nut Honey Ornamental Tannin (bark)	A C C L
Castanopsis/ Chrysolepis spp.[3]	Golden chinkapin (USA)	Asia, Western North America	Edible nut	L, T
Lithocarpus densiflorus	Tan oak	California, Oregon, USA	Edible nut (acorn) Tannin (bark)	T T
Lithocarpus fenestra	*Kala chakma*	India	Tannin (bark)	L
Nothofagus alpina	*Rauli*	Argentina, Chile	Edible nut	T
Nothofagus glauca	*Hualo*	Argentina, Chile	Edible nut	T
Quercus spp.	Oak		Dye (bark) Edible nut (acorn) Tannin (bark)	T[4] L,T[5] L,T
Quercus aegilops	Valonea oak	Mediterranean Europe Near East	Tannin (galls)	T
Quercus coccifera	Kerm or holly oak	Mediterranean Europe Near East	Dye (kermes scale)	T
Quercus coccinea	Scarlet oak	East North America	Ornamental	C
Quercus floribunda	*Kilonj*	India	Tannin (bark)	L
Quercus ilex	Holm oak	Mediterranean Europe Near East	Tannin (bark, galls) Dye (kermes scale) Ornamental	L, T T C
Quercus infectoria	Lusitania oak	Mediterranean Europe Near East	Tannin (bark, galls)	T
Quercus lamellosa	*Bujrat*	India	Tannin (bark)	L
Quercus leucotrichophora	Gray or ban oak	India	Tannin (bark)	L
Quercus palustris	Pin oak	East North America	Ornamental	C
Quercus pendiculata	Common oak	Europe	Tannin (galls)	T
Quercus rubra	Northern red oak	E NA	Ornamental Dye Tannin (bark)	C T T
Quercus semicarpifolia	Kharshu oak	India	Tannin (bark)	L
Quercus suber	Cork oak	West Mediterranean	Cork (bark) Tannin (bark)	C C
Quercus velutina	Black oak	East North America	Quercitron dye (bark)	T
Quercus virginiana	Live oak	Southeast United States	Ornamental	T

[3] See table 8.5 for detail.
[4] See Table 6.3 for detail.
[5] See Table 8.1 for detail.

FAMILY HAMAMELIDACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Liquidambar formosiana		Southeast China	Styrax (resin)	L
Liquidambar orientalis	Liquidambar	Mediterranean Europe Near East	Styrax (resin)	C
Liquidambar styraciflua	Sweet gum	East United States Mexico, Honduras	Styrax (resin) Ornamental	C C

FAMILY HIPPOCASTANACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Aesculus hippocastanum	Horse chestnut	Europe Near East	Ornamental	C
Aesculus octandra	Yellow buckeye	Eastern United States	Edible nuts[2]	T

[2] Contain poisonous glucosides and require leaching before use.

FAMILY JUGLANDACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Carya spp.	Hickory	Asia, North America	Edible nut	A, L, T
Juglans alianthifolia		China, Japan	Edible nut	L
Juglans australia		Argentina South Bolivia	Edible nut	L
Juglans boliviana		Bolivia Peru	Edible nut Edible nut	L C
Juglans californica	California walnut	California, USA	Edible nut	L
Juglans cathayensis		Central China	Edible nut	L
Juglans cinerea	Butternut	East North America	Dye (nut hulls) Edible nut	T T
Juglans duclouxiana		Asia	Edible nut	L
Juglans hindsii	North California walnut	North California	Edible nut	C
Juglans kamoniana		West Himalaya	Edible nut	
Juglans major	Arizona walnut	Arizona North Mexico	Edible nut	L
Juglans mandchuriana		North China	Edible nut	L
	Little walnut	Central-southwest United States	Edible nut	L
Juglans microcarpa				
				L
		Ecuador	Dye (nut hulls)	L
Juglans neotropica		Peru	Edible nut	L
	Black walnut	Eastern North America	Industrial products from nut hulls	C
Juglans nigra				
			Edible nut	C
			Dye (nut hulls and bark)	T
			Edible nut	
	English or Persian walnut	Europe, Near East	Dye	A
Juglans regia			Edible nut	T
	Wingnuts	Asia, Near East		L
Pterocarya spp.				

FAMILY LAURACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Laurus nobilis	Laurel	Mediterranean	Decorative greenery Flavouring, foliage	C C
Sassafras albidum	Sassafras	East United States	Flavouring (foliage)	L
Umbellularia californica	Myrtlewood	California, Oregon	Flavouring (foliage) Honey	L C

FAMILY *LEGUMINOSAE*

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Cercis canadensis	Redbud	East United States	Ornamental	C
Cercis siliquastrum	Judas tree	Mediterranean Europe Near East	Ornamental	C
Gleditsia caspica	Caspian locust	Near East	Soap (pods)	L
Gleditsia japonica	Japanese locust	Japan	Soap (pods)	L
Gleditsia macracantha		China	Soap (pods) Tannin (pods)	L L
Gleditsia triacanthos	Honey locust	East United States	Beer (pods) Ornamental	T C
Prosopis chilensis	*Algarrobo*	North Chile	Fodder (pods) Honey	L L
Prosopis cineraria		India	Edible pods	C
Prosopis glandulosa	Honey mesquite	Southwest United States North Mexico	Edible pods Honey Jelly, flour (pods)	T L L
Prosopis pubescens	Screwbean mesquite	Southwest United States North Mexico	Honey Jelly, flour	L L
Prosopis tamarugo	*Tamarugo*	North Chile	Fodder (pods) Honey	L L
Robinia pseudoacacia	Black locust	East United States	Honey Ornamental	C C

FAMILY MAGNOLIACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Liriodendron tulipifera	Yellow poplar	East United States	Honey Ornamental	L C
Magnolia acuminata	Cucumber tree	East United States	Ornamental	C
Magnolia grandiflora	Evergreen magnolia	Southeast United States	Ornamental	C

FAMILY MORACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Maclura pomifera	Osage-orange	South-central United States	Dye (root bark)	T
Morus alba	White mulberry	Asia	Bonsai Food for silkworms (foliage)	C C
Morus issai		Asia	Bonsai	C
Morus rubra	Red mulberry	East North America	Edible fruit	L

FAMILY MYRTACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Eucalyptus spp.	Eucalypts	Australia Papua New Guinea	Decorative greenery Essential oils[2] Honey Liqueur	C C C L
Eucalyptus accedens	Powder bark wandoo	Australia	Tannin (bark)	L
Eucalyptus astringens	Brown mallet	Australia	Tannin (bark)	L
Eucalyptus wandoo	Wandoo	Australia	Tannin (bark)	L
Myrtus communis	Myrtle	Mediterranean Europe Near East	Decorative	T

[2] See Table 4.2 for detail.

FAMILY NYSSACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Nyssa ogeche	Ogeechee tupelo	Florida, Georgia	Honey	L
Nyssa sylvatica	Black tupelo	East North America	Ornamental	C

FAMILY OLEACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Fraxinus spp.	Ash	Asia Europe NA	Ornamental	C
Olea europea	Olive	Mediterranean	Edible fruit (cultivated) Edible oil (cultivated)	C

FAMILY PLATANACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Platanus x acerifolia	London plane	Hybrid	Ornamental	C
Platanus occidentalis	American sycamore	East United States	Ornamental	C
Platanus orientalis	Oriental plane	Southeast Europe Near East	Ornamental	C

FAMILY RHAMNACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Rhamnus fragula	Alder buckthorn	Europe	Medicinal (bark)	L
Rhamnus purshiana	Cascara buckthorn	Pacific Coast, NA	Medicinal (bark)	C

FAMILY ROSACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Amalanchier spp.	Service berry	Asia Europe North America	Ornamental	C
Crataegus spp.	Hawthorn	Asia Europe North America	Edible Fruit Ornamental	L C
Crataegus aestivalis *Crataegus opaca* *Crataegus rufula*	Mayhaw	Southeast United States	Edible fruit	L
Crataegus cuneta		Japan	Bonsai	C
Malus pumila	Apple	Europe Near East	Edible fruit	A
Malus spp.	Crabapple	Asia Near East	Bonsai Edible fruit Ornamental	C L C
Prunus amygladus	Almond	Asia	Edible nut	A
Prunus avium	Sweet cherry	Asia Europe	Edible fruit	A
Prunus domestica	Plum	Asia Europe	Edible fruit	A
Prunus persica	Peach	Near East	Edible fruit	A
Prunus serullata	Japanese flowering cherry	Japan	Ornamental	C
Prunus yedoensis	Japanese flowering cherry	Japan	Ornamental	C
Pyrus domestica	Pear		Edible fruit	A
Sorbus americana	Mountain ash	East North America	Bird lime (fruit) Edible fruit Ornamental	T T, L C
Sorbus aucuparia	Mountain ash, rowan	Europe	Herbal medicine (fruit)	T, L
Sorbus domestica	Service tree	North Africa, Europe	Edible fruit	T, L

FAMILY SALICACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Salix alba	White willow	Europe	Medicine salicylic acid (bark) Ornamental	T C
Salix babylonica	Weeping willow	Asia	Ornamental	C
Salix spp.			Honey	L
Populus alba	White poplar		Ornamental	C
Populus nigra 'Italica'	Lombardy poplar		Ornamental	C

FAMILY TILIACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Tilia americana	American basswood	Europe	Honey Mats, cordage (bark)	C L
Tilia cordata	European linden	East North America	Honey Mats, cordage (bark) Ornamental	C L C
Tilia japonica		Japan	Mats, cordage (bark)	L
Tilia tomentosa	Silver leafed lime	Europe	Honey	C
Tilia tuan			Mats, cordage (bark)	L

FAMILY ULMACEAE

Genus and Species	Common name(s)	Natural Range	Principal NWFP	Type of use
Celtis australis	Nettle tree	Mediterranean	Bonsai	C
Celtis bangeana sinensis		Asia	Bonsai	C
Celtis occidentalis	Hackberry	East North America	Ornamental	C
Ulmus americana	American elm	East North America	Ornamental	C[2]
Ulmus parvifolia	Chinese elm	China	Bonsai Ornamental	C C
Ulmus rubra	Slippery elm	East North America	Medicinal (bark)	C
Zelkova			Bonsai[3] Ornamental	C C

[2] Use limited by Dutch elm disease
[3] See Table 3.1 for detail.

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Temperate broad-leaved trees grow in very different ecosystems in the northern and southern hemispheres, but are also found extensively in many tropical and subtropical mountain areas. A wide range of non-wood products are derived from temperate broad-leaved trees, and their description is organized in this volume according to the part of the tree from which they are obtained (whole tree, foliage, flowers, etc.). This information is presented in order to raise awareness on, and assist in identifying, opportunities for the management and production of non-wood products from temperate broad-leaved trees. The intended audience of this publication ranges from interest groups in the forest, agriculture and rural development sectors to conservation agencies in developed and developing countries.

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