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NON-WOOD FOREST PRODUCTS

12

# Non-wood forest products from conifers

Food
and
Agriculture
Organization
of
the
United
Nations

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# Non-wood forest products from conifers

by

**William M. Ciesla**

European Forest Institute

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Rome, 1998

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This paper discusses both traditional and contemporary uses of products from conifers. This material is presented for information only and does not imply endorsement by the author or by FAO. Some of those products have medicinal purposes; however, they should only be used under the care and guidance of a qualified physician.

Transport of certain non-wood forest products (e.g. foliage, Christmas trees, seeds and landscape or ornamental plants) across international boundaries poses a risk of accidental transport and 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 which the products are to be exported and the countries into which the products are to be imported for import permit requirements or restrictions which might apply.

Movement of 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 Non-Wood Forest Products No. 8, 1995.



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# FOREWORD

Conifers are capable of growing under a wide range of ecological conditions and dominate large areas of the world's forests. Conifer forests are especially abundant in the boreal and temperate regions of the Northern Hemisphere, but are also important components of many tropical and sub-tropical forest ecosystems in both humid and semi-arid zones. In 1995, almost two thirds of the world's total industrial roundwood production came from conifers according to the statistics in FAO's Forest ProductsYearbook. In addition to their huge wood production potential, many conifers are capable of providing a wide range of non-wood products that are of great benefit to human society. However, despite this, foresters have so far dedicated little or no attention to enhance the many non-wood uses of conifer forests.

The objective of this paper is to provide a global review of the non-wood uses of conifers and to discuss the many issues involved with their development. Problems associated with the sustainable management, harvesting and utilization of these products and compatibility or conflicts with timber production and other land uses are presented. Both contemporary and historical or traditional uses of non-wood products from conifers are discussed. Where possible, data on levels of production and international trade are given. The document also identifies opportunities for the special management of conifer forests and woodlands where either traditional or contemporary non-wood forest products are presently or potentially an important economic or social resource. The prospective audience for this publication includes foresters, rural development decision-makers, and conservation agencies in both developed and developing countries.

Through the use of this document, it is hoped that opportunities for promoting non-wood conifer products as an integral part of economic development and initiatives to alleviate poverty will be enhanced. In addition, the information provided should facilitate the incorporation of non-wood goods and services from conifers into forest management planning, valuation and implementation activities.

I have great pleasure to release this publication, in the hope that it will serve as a useful reference for all concerned with the sustainable development of non-wood uses from conifer forests in both developing and developed countries.

Karl-Hermann Schmincke
Director
Forest Products Division

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# ACRONYMS

| | |
|---|---|
| BLM | Bureau of Land Management |
| BMS | Bristol-Myers Squibb Company |
| EIS | Environmental Impact Statement |
| EOA | Essential Oil Association of the United States |
| FAO | Food and Agriculture Organization of the United Nations |
| FAS | Foreign Agriculture Service (USDA, USA) |
| FDA | Food and Drug Administration of the United States |
| FMA | Fragrance Materials Association of the United States |
| ISO | International Standards Organization |
| NCI | National Cancer Institute |
| NCTA | National Christmas Tree Association |
| NTFP | Non-timber forest product |
| NWFP | Non-wood forest product |
| RAAN | *Región Autónomo Atlántico Norte* (Nicaragua) |
| Tbsp | Tablespoon |
| tsp | Teaspoon |
| USA | United States of America |
| USDA | United States Department of Agriculture |
| USDI | United States Department of the Interior |

# INTRODUCTION

Conifers dominate large areas of the world's forests. They are especially abundant in the boreal and temperate regions of the Northern Hemisphere and are also important components of many tropical and sub-tropical forest ecosystems. Conifers are capable of growing under a wide range of conditions. Many can tolerate moisture stress and, therefore are able to survive in semi-arid and arid regions. Others are capable of growing on barren or nutrient poor soils or in extremely cold climates. Some species have co-evolved with naturally occurring wildfires and can co-exist with these catastrophic disturbances. And, most important, many conifers are capable of producing both wood and non-wood products, which are of great benefit to human society.

The objective of this paper is to provide a global review of the **non-wood** uses of conifers. For the purposes of this paper, conifers are defined as trees and shrubs of the botanical orders Coniferales, Taxales and Ginkgoales (Rushforth 1987). Although some services are briefly mentioned, the focus of this paper is on **products** which conifers provide species, which are important sources of non-wood forest products, and places where these products are harvested. With the exception of essential oils, which can be obtained from several parts of the tree, the products described are organized by the part of the tree from which they are obtained (e.g. foliage, bark and roots, resin, seeds and cones). 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 non-wood products from conifers are discussed.

This information is presented in order to assist in identifying opportunities for management and production of non-wood conifer products as an integral part of economic development and poverty alleviation initiatives in economically depressed regions of the world where conifer forests, either natural or planted, exist. In addition, this information is also designed to help identify opportunities for special management of conifer forests and woodlands where either traditional or contemporary non-wood forest products are presently or potentially an important economic or social resource.

# 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.

Many conifers are important landscape and ornamental plants and fulfil many functions in landscape design. Virtually all countries have some level of nursery industry, which offer for sale planting stock, including conifers, for landscape and ornamental purposes. Small-scale nursery operations are often an excellent opportunity for small business or family run enterprise.

### 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 and fruit and nut trees. 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 those 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 disease, which 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:

# CHAPTER 1
# AN OVERVIEW OF THE CONIFERS

## WHAT ARE CONIFERS?

Conifers are trees and woody shrubs, which are members of the plant class Gymnospermae (Gymnosperms). Gymnosperms are characterized by having naked seeds in contrast to the Angiosperms which have seeds enclosed in an ovary (Harlow and Harrar 1950). This diverse and extremely valuable group of higher plants is generally considered to consist of three botanical orders under the class Gymnospermae: the Coniferales, the Taxales and the Ginkgoales. Within these orders are eight families, 55 to 65 genera and more than 600 individual species (Rushforth 1987, Vidakovic 1991).

Conifers receive their name from the shape of the fruit or "cones" produced by many species within this group, especially members of the families Araucariaceae and Pinaceae (order Coniferales). The term "conifer" is also descriptive of the conical crown form which is characteristic of many trees in this class of plants. Other characteristics include the presence of needle-like or scale-like foliage and a preponderance of species with evergreen foliage (exceptions - *Larix, Metasequoia* and *Taxodium*). The conifers include the world's oldest known trees (*Pinus longaeva*) and the world's most massive trees (*Sequoiadenron giganteum*) (See textbox) (Figs 1.1, 1.2).

Figure 1.1: The world's largest conifer, the General Sherman Tree, Sequoia-Kings Canyon National Park, California (USA).

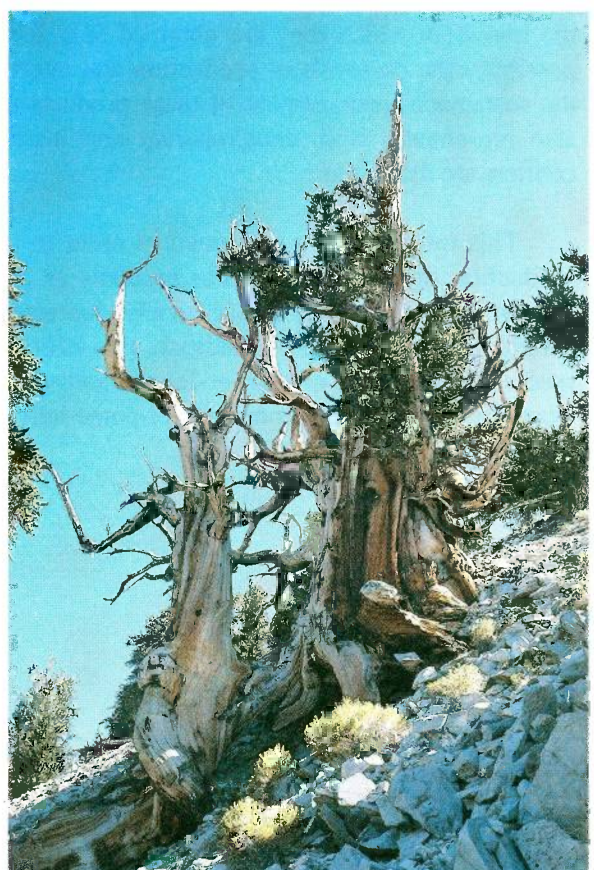

Figure 1.2: *Pinus longaeva* in California's White Mountains are the oldest known trees.

## DISTRIBUTION AND ABUNDANCE

Various species of conifers, principally members of the family Pinaceae (e.g. *Abies, Larix, Picea, Pinus)* are often the dominant forest cover over extensive areas of boreal and temperate forests of the northern hemisphere. Conifer forests, principally *Pinus* spp, are also the dominant forest cover over much of Mexico and the northern portions of Central America. Extensive forests of *Juniperus* spp., *Cupressus* spp. and *Pinus* spp. dominate semi-arid forests in western North America, Mediterranean Europe and the Near East. In other parts of the Northern Hemisphere, conifers are frequently found in association with broad-leaf trees. In the Southern Hemisphere, conifers tend to have more restrictive natural ranges but are equally varied. Species of the genera *Araucaria* and *Agathis* are locally abundant and important. In other areas of the Southern Hemisphere, the genus *Podocarpus* and several members of the family Cupressaceae (e.g. *Australcedrus, Callitris, Widdringtonia*) are locally abundant (Fig 1-3).

Many conifers have exceptionally wide natural ranges. *Juniperus communis*, for example, has a circumpolar distribution and is found across Asia, Europe and North America. *Pinus sylvestris* is distributed from the British Isles across the European and Asian continents to Siberia, while the natural ranges of *Larix laricina*, *Picea glauca* and *P. mariana* extend across the boreal forests of the North American continent from the Atlantic Ocean to the Pacific Ocean.

Because of their many uses and relative ease of planting, conifers have been widely established in forest plantations. Many species, such as *cupressus lusitanica, pinus elliottii, p. Radiata, p. Taeda,* and *p. Patula* have been established over large areas outside of their natural ranges. The genus *pinus* is the second only to *eucalyptus* in terms of area of plantations established in the tropics (4.49 million ha as of 1990) (fao 1993). Chile and New Zealand each have in excess of 1.5 million ha of *pinus radiata* plantations.

**THE WORLD'S OLDEST AND THE WORLD'S MOST MASSIVE TREES ARE BOTH CONIFERS**

The world's oldest known tree is the bristlecone pine, Pinus longaeva, a species which occurs near the summits of high, arid mountain ranges in eastern California and Nevada, United States. A forest of bristlecone pines near the summit of the White Mountains of the Inyo National Forest, California, contains the Methuselah Tree which has been documented to be at least 4 600 years old. This stand also contains at least 17 more trees in excess of 4 000 years (Menninger 1967).

The world's most massive living tree is a giant sequoia, Sequoidendron giganteum, known as the General Sherman Tree. This tree is located in a grove of giant sequoias in the Sequoia-Kings Canyon National Park in the Sierra Nevada Mountains of California, United States. This tree has a height of 83.8 meters, a circumference at ground level of 31.3 meters and a trunk volume of 1486.6 $m^3$ *.

Ironically, the world's oldest and the world's most massive trees are located within an air line distance of 100 km of each other.

Information obtained from Sequoia-Kings Canyon National Park, USDI, National Park Service, California, United States.

## USES

Throughout human history, conifers have provided a wealth of products beneficial to human society. The wood of many species has been used for structural lumber, production of paper and related products, fuelwood, posts, poles and myriad other products. Conifers have also provided a wide range of beneficial non-wood products including essential oils, resin, fragrant and attractive foliage, ornamental plants, decorative objects, edible seeds, flavourings and medicinal products. In many cases, both wood and non-wood products from conifers have been over-exploited to the point where extensive damage or loss of forest area has resulted. On the other hand, conifers have been revered by many human cultures and have been used as both religious and political symbols. They are also the subject of a rich mythology and folklore and are well represented in arts.

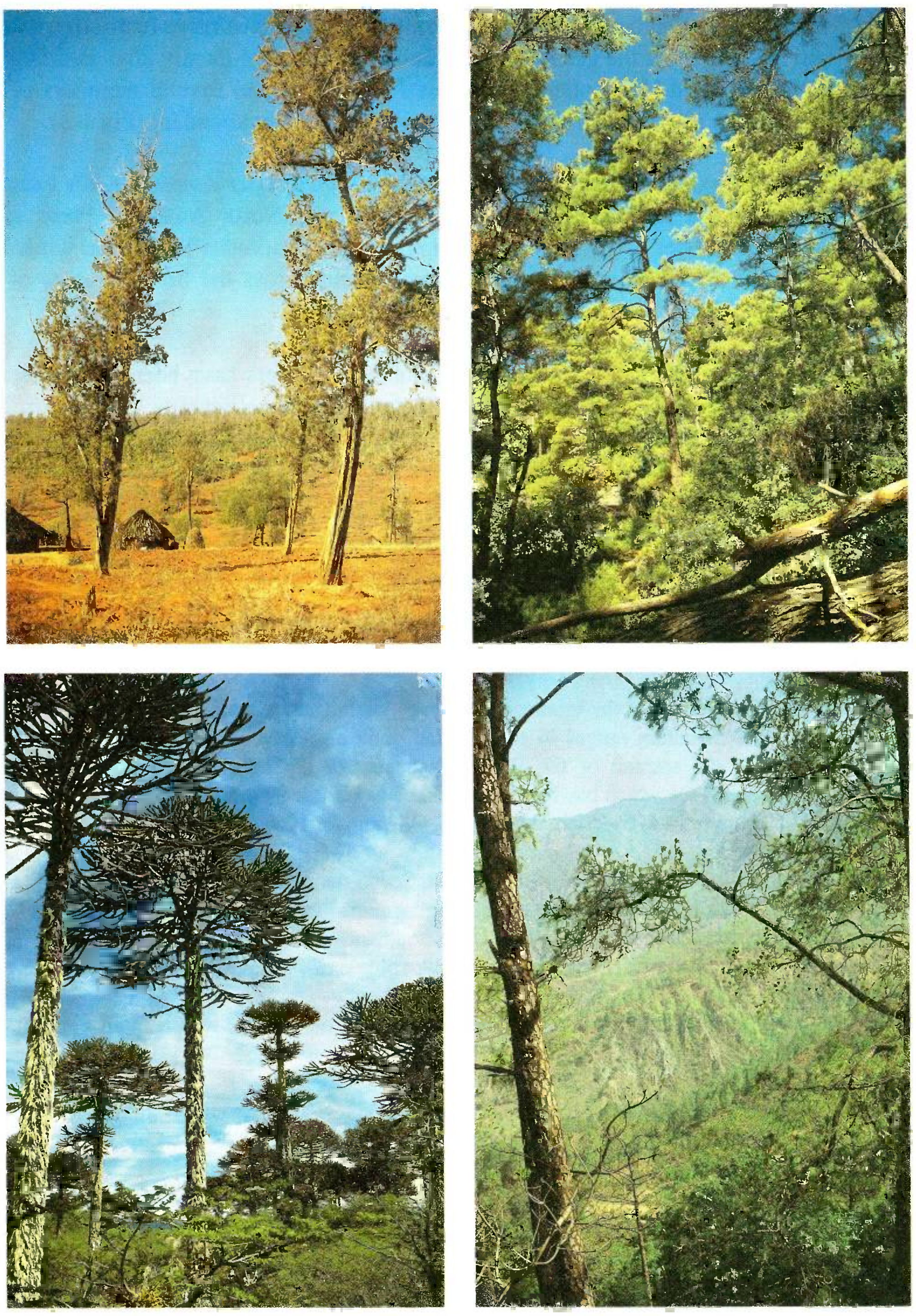

Figure 1.3: Natural conifer forests: A. *Juniperus procera*, Maralal, Kenya, B. *Pinus brutia*, Isle of Rhodes, Greece, C. *Araucaria araucana*, Conguillio National Park, Chile, D. *Pinus roxburgii*, Uttar Pradesh, India.

# CHAPTER 2
# CONIFERS IN HUMAN CULTURE

As might be expected of a group of plants that have provided a wealth of beneficial products, which have significantly enhanced the quality of life of human societies world-wide, conifers have played an important role in human culture. They have been the subjects of folklore and mythology. Conifers have also served as political and religious symbols and have played a prominent role in art.

## FOLKLORE AND MYTHOLOGY

Conifers, especially pines, have been a subject of the folklore and mythology of many cultures. Examples are described in the following paragraphs.

According to an ancient Greek legend, the forests and glades of Greece were home to nymphs and dryiads and of many minor male gods including Pan. Among the nymphs was Pitys, whose duty was to tend pine trees. She had a lover, Boreas, god of the north wind. Boreas was a big, burly fellow, quite different from the happy, flute playing Pan. Pitys flirted with both Pan and Boreas. One day, Boreas asked Pitys what was going on between her and Pan. Her reply was evasive. In the quarrel that followed, Boreas seized Pitys and tossed her against a rocky ledge. Instantly she was turned into a pine tree. The resin droplets often seen on the wounded limbs of a pine tree broken by the wind are said to be tear drops shed by Pitys when she thinks of her youth, her lover Boreas and, most likely, of Pan. The pine species *Pinus pityusa,* of the Black Sea region, (synonym - *P. brutia)* commemorates this legend (Mirov and Hasbrouck 1976).

The pine tree was sacred to Zeus and an attribute to Serapis. It was beloved of virgins. The *Pinea corona* was the emblem of virginity, which Daphne took from Chloe and placed on her own head. In ancient Rome, the chaste Diana was crowned with a chaplet of pine. Because pine was so important and sacred, the Roman poet Ovid referred to pine branches as cut from *arbore pura*, a pristine tree. The pole of Bacchus is described by Roman writers as an inflammable and fragrant pine pole (Mirov and Hasbrouck 1976).

In an ancient Phrygian legend, Attis, lover of Cybele, the mother of gods, was changed into a pine tree after his death. The cult of Cybele was adopted by the Romans during imperial times and the sacred pine tree became an object of worship during a spring festival in Rome each year on 22 March. A pine tree (*Pinus pinea* or *P. nigra*) was cut in the forest and carried into the sanctuary of Cybele, where it was worshiped. The trunk was then buried. Three days later, the divine resurrection was celebrated with an outburst of glee. In Scandinavia and in northern Russia, a spring festival based on this tradition is held at the end of June. These festivals celebrate the resurrection of life after a long winter (Mirov and Hasbrouck 1976).

According to another legend, when Adam was dying, he sent his son Seth to the Garden of Eden to beg the angel on guard for a little of the precious juice from the tree of life. Instead, the angel gave him a small portion of the tree, which was later planted, on Adam's grave. This tree eventually grew into one with three branches, one cypress (*Cupressus*), one cedar (*Cedrus*) and one olive. It is from these three trees that the cross on which Christ was ultimately crucified is said to have been made; the upright beam was cedar, the cross arm of cypress and the title of olive. In another version of this legend, when the Queen of Sheba visited Solomon, she was asked to cross a marshy piece of ground by means of a bridge built of cedar (*Cedrus*) wood. She refused to step on the bridge because she would not tread on wood which she had dreamt would some day bear the crucified body of the Christ (Maheshwari and Chhaya Biswas 1970).

Another legend tells of an angel who took refuge under a massive cedar (*Cedrus*) tree during a severe storm. After the storm abated, he prayed to God that this tree, whose wood was so fragrant and shade so refreshing might, in the future, bear some fruit to benefit the human race. The fruit was the sacred body of Jesus. Being regarded as a tree of good fortune, its wood has always been a favourite for making sacred icons (Maheshwari and Chhaya Biswas 1970).

In China, cedars (genus not designated) are called the "trees of faithful lovers" because of a legend about a king who sent a good man to prison in order that the latter's beautiful wife be available to him. The imprisoned man died of grief and his wife killed herself. Although their bodies were buried far apart from each other at the king's express command, cedar trees grew from each grave, attained vast heights and lovingly interlaced their branches and roots (Maheshwari and Chhaya Biswas 1970).

The indigenous cultures of the Pacific Coast of North America believed that the Pacific yew, *Taxus brevifolia*, could impart its strength to the people and was traditionally used where strength was required. Young men of the Swinomish tribe used smooth yew sticks to rub themselves to gain strength. The Swinomish also used the boughs of Pacific yew to rub themselves after bathing. The people of the Chehalis tribe would crush the foliage of Pacific yew in a bath for old people and children to make them sweat and improve their condition (Gunther 1973).

## RELIGION

Humans encountered pines and other conifers in many places in the Northern Hemisphere. In contrast to deciduous trees, which shed their leaves in fall, most conifers remain green and were re-assuring. Evergreen pines were eternal. Only evergreen oaks rated as high as pines with early human societies who worshiped pines as they worshiped other wonders of nature that they could not understand. Initially, pines were worshiped for themselves. Later, they became the abode of gods and spirits. As human civilization advanced, nations were formed and temples built, humans continued to worship pines as the most sacred of trees (Mirov and Hasbrouck 1976).

The Delphic oracle of Greece commanded the Corinthians to worship a particular pine equally with god (Dionysius) so they made two images of Dionysius, with red faces and gilt bodies. In art this god or his worshipers commonly carries a wand tipped with a pinecone because the pine tree was particularly sacred to him.

The pinecone appeared on many ancient amulets and had a phallic meaning. It is said that the pinecone was most used in the cult of Venus. Pinecones were regarded as symbols of fertility and even now the tops of wooden bedposts are often embellished with carved pinecones. At the festival of Demeter, the Greek goddess of the fruitful earth and happy marriage, pinecones were offered "for the purpose of quickening the ground and the wombs of women." Assyrian priests on ancient bas -reliefs are shown offering pinecones to the altars of gods. Pine cones on these carvings and the tips of priest's staffs appear to be those of the stone pine, *Pinus pinea* (Mirov and Hasbrouck 1976).

Pines have been, and perhaps still, are believed to possess supernatural powers. The anonymous author of *Cultus Arborum* wrote:

*"The pine was supposed by some to be inhabited by wind spirits, like Ariel, owing to the whispering noises proceeding from it in the breeze. The legend was that it was the mistress of Boreas and Pan, an idea acceptable to Germans in the consequence of its holes and knots, which were believed to be the means of ingress and egress for the spirits. It is told that a beautiful woman of Småland, who was really an elf, left her family through a knothole in the wooden house wall. "Frau Fichte (spruce)," the pine of Silesia, is believed to possess great healing powers, and its boughs are carried about by the children on Mid-Lent Sunday, adorned with coloured papers and spangles. It is also carried with songs and rejoicing to the doors of stables where it is suspended in the belief that it will preserve the animals from harm."*

In some parts of Silesia (Germany), people burn rosin all night between Christmas and New Year in order that the pungent smoke may drive witches and evil spirits from the house (Mirov and Hasbrouck (1976).

In Siberia, a ritual was performed at Epiphany during which crosses were made over every door with the smoke of pine torchwood to protect houses and stables from evil spirits. Later votive tapers became a more convenient instrument for this ritual, which is still practised by some Russian Orthodox priests and housewives (Mirov and Hansbrouck 1976).

The yew, *Taxus baccata*, is deeply woven into the religion folklore of the British Isles. The ancient Britons held the tree sacred and the Druids perpetuated the religious association by erecting temples near yew trees (Harrison 1975).

In Mexico and Central America, pines were worshiped by indigenous people long before Spanish conquest. The Aztecs considered *Pinus teocote* to be the pine of the gods and burning its incense-fragrant rosin as an offering in the temples was the privilege of priests and kings. In the highlands of Guatemala, some Mayan people avoid, even now, the killing or harming of pines because they are considered not only living but animated beings. For household use and for their pagan-Christian ceremonies, the Mayans lop the side branches of pines, leaving a sizeable tuft of foliage on the top of the tree so it will continue to live. In Guatemala, Mayan people still burn pine rosin in religious rituals (Mirov and Hasbrouck 1976).

The Buriats, a Mongolian people living in the vicinity of the southern end of Lake Baikal in eastern Siberia, often viewed groves of *Pinus sylvestris* as sacred. These "shaman" forests were scattered over dry grassland. Before the Soviet revolution of 1917, it was a tradition to approach and ride through the groves in silence to avoid offending the gods and spirits of the woods. Solitary trees near the Buriat villages were always sacred and adorned with talismans, ribbons or sacrificial sheepskins. These trees were often called pines, although some were actually larches, *Larix* spp. (Mirov and Hasbrouck 1976).

The use of a non-wood product from a conifer is mentioned at least once in the Holy Bible. At the time of the Great Flood, God instructed Noah to "Make thee an ark of gopher wood; rooms shalt thou make in the ark, and shall **pitch** it within and without with **pitch**" (Mirov and Hasbrouck 1976).

To the indigenous tribal cultures of south-western United States and adjoining parts of Mexico, the piñon, *Pinus edulis,* was an important part of religious ceremonies literally from the cradle to the grave. When an infant Apache outgrew her cradleboard, her mother would place it in the east side of the crown of a young piñon pine. She would then tell the tree, *Here is the baby carrier. I give this to you, still young and growing. I want my child to grow up as you do.* Among the Navajo, the cradleboard of a dead child was placed in the crown of a dead piñon, as were the worn cradle laces of healthy children. On the ninth day of *Keldzi Hatal*, the Night Chant, the Slayer of Alien Gods and the Child of the Water placed their corn husk cigarettes in the shade of a piñon. After the ceremonial of the male initiation, ritual items were placed in a young piñon pine at sunrise and the initiates were instructed not to visit ancient ruins, not to injure a young piñon and not to stand over another person. On the fourth day of the Night Chant, when performed for male initiates, the Talking God carried in his hand a piñon sapling stripped of its branches. The burning of pitch from the piñon provided the incense of the Night Chant. The ceremonial wands and pokers were of piñon wood, selected from branches that grew on the east, north, west and south sides of the tree (Lanner 1981).

In the Himalaya region of Uttar Pradesh, India, *Cedrus deodara* is considered sacred and plays an important role in religious ceremonies. Thin slices of its wood are burned with butter and other plants after chanting the "mantras" on the occasion of births, marriages, deaths and other occasions. This ceremony is called *hawan*. The bright yellow pollen grains are used for brightening metallic idols and as a *pitham*, a small mark over the forehead for certain religious occasions (Singh *et al.* 1990).

## POLITICAL SYMBOLS

The national symbol of Lebanon is the cedar of Lebanon, *Cedrus libani*. This tree, with its characteristic multi-stemmed form and massive, spreading crown appears on the national flag, on coins, postage stamps and military insignias. Unfortunately this tree has been over-exploited and few native stands remain in the country. It is said that today there are more cedars of Lebanon on flags, coins and postage stamps than there are in Lebanon's forests (Chaney and Basbous 1978). The eastern Mediterranean Island of Cyprus is believed to have derived its name from the extensive forests of *Cupressus sempervirens*, which once existed there. These forests are said to have been a deterrent to the development of agriculture until copper was discovered on the island. Then the forests were cut for fuel to smelt copper (Brey and Müller 1993).

Early American colonists expressed their affection for the pine by making it an emblem on historic flags. In 1775, both the Continental and the Pine Tree flags were decorated with the green, conical shape of the eastern white pine, *Pinus strobus*. Today, the Vermont State seal bears the likeness of a pine tree with 14 branches representing the original 13 colonies plus Vermont. Maine is called the "pine tree state" where eastern white pine is the official tree and appears on both the state seal and the state flag (Mirov and Hasbrouck 1976).

## ART

The Chinese may have been among the first to paint pines on panels and silk scrolls to decorate their homes. Later pine forests or individual trees became a favourite subject for artists in many countries. The Renaissance painters used pines as the background for their lovely Madonnas or as illustrations for stories as Botticelli did with the Ravenna pines. There are many Victorian paintings depicting Scots pines, *Pinus sylvestris* (Mirov and Hasbrouck 1976).

One of the most fascinating pieces of art depicting a conifer is a Roman fountain in the shape of a giant, bronze pinecone. It is most likely modelled after the cone of *Pinus pinea*. The cone was cast in the first century AD by Publius Cincius Salvius, a bronze worker who left his signature at the base of the cone. This bronze was found near the baths of Agrippa and probably decorated a fountain near the Temple of Isis. During the eighth century, this massive cone was situated in the portico of Constantine's Basilica of St. Peters in Rome, Italy, where the water, emerging from holes in the points of the scales, was used to refresh pilgrims. During the seventeenth century it was moved to the *nicchione*, designed by Pirro Ligoro, in the famous Bramante courtyard of the Vatican Museum. Today, the portion of the courtyard housing this giant bronze pinecone is known as the *Cortile della Pigna*, the courtyard of the pinecone (Hersey 1993, Metropolitan Museum of Art 1975).

The cones of *Pinus pinea* are featured in wall paintings, sculpture and in mosaics in the ruins of Pompeii and Herculaneum, two ancient Italian cities destroyed by an eruption of Mt. Vesuvius. Pinecones are also figured in household altars and paintings at Pompeii (Meyer 1980).

The famous Dutch impressionist, Vincent Van Gogh, is perhaps best known for his bold, colourful paintings of sunflowers. He was also intrigued by the columnar cypresses, *Cupressus sempervirens*, which, even today, are an integral part of the landscape of the region of Tuscany, Italy and the south of France. In 1890, he painted "Lane with cypresses under a starry sky," an oil of a single cypress along a country lane with a dark sky in the background. Another of his works containing cypress trees is "Wheatfield and cypress" and "Cypresses" both painted in 1889. The latter consists of a grove of columnar cypresses being tossed by a summer mistral in southern France (Zurcher 1985). These masterpieces now hang in the Rijksmuseum in Amsterdam, the Netherlands.

In a letter to his brother, Theo, in 1899, Van Gogh wrote:

> *"I am totally preoccupied with the cypress. I would like to create something similar to my sunflower paintings with them. I find it strange that they never have been painted in the way that I see them. They are as beautifully proportioned as an Egyptian obelisk."*

In southern Brazil, the tall, stately Paraná pine, *Araucaria angustifolia*, with its characteristic umbrella-shaped crown, is a regional symbol. In the city of Curitiba, the capital of Paraná State, the characteristic profile of *A. angustifolia* appears in patterned sidewalks made of tiny black and white stones (Ciesla 1986) (Fig 2.1). Its characteristic silhouette also appears in many art forms including photographs, paintings and pictorial landscapes pieced together from inlaid local woods of various colours and textures (Fig 2.2).

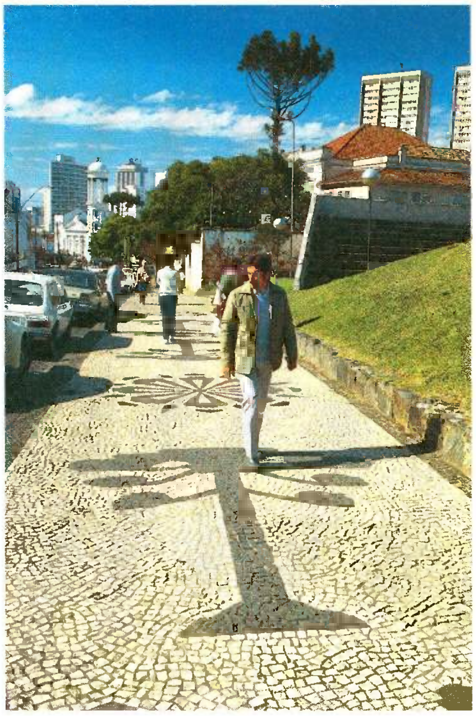

Figure 2.1: Tile silhouette of *Araucaria angustifolia* in a sidewalk, Curitiba, Brazil.

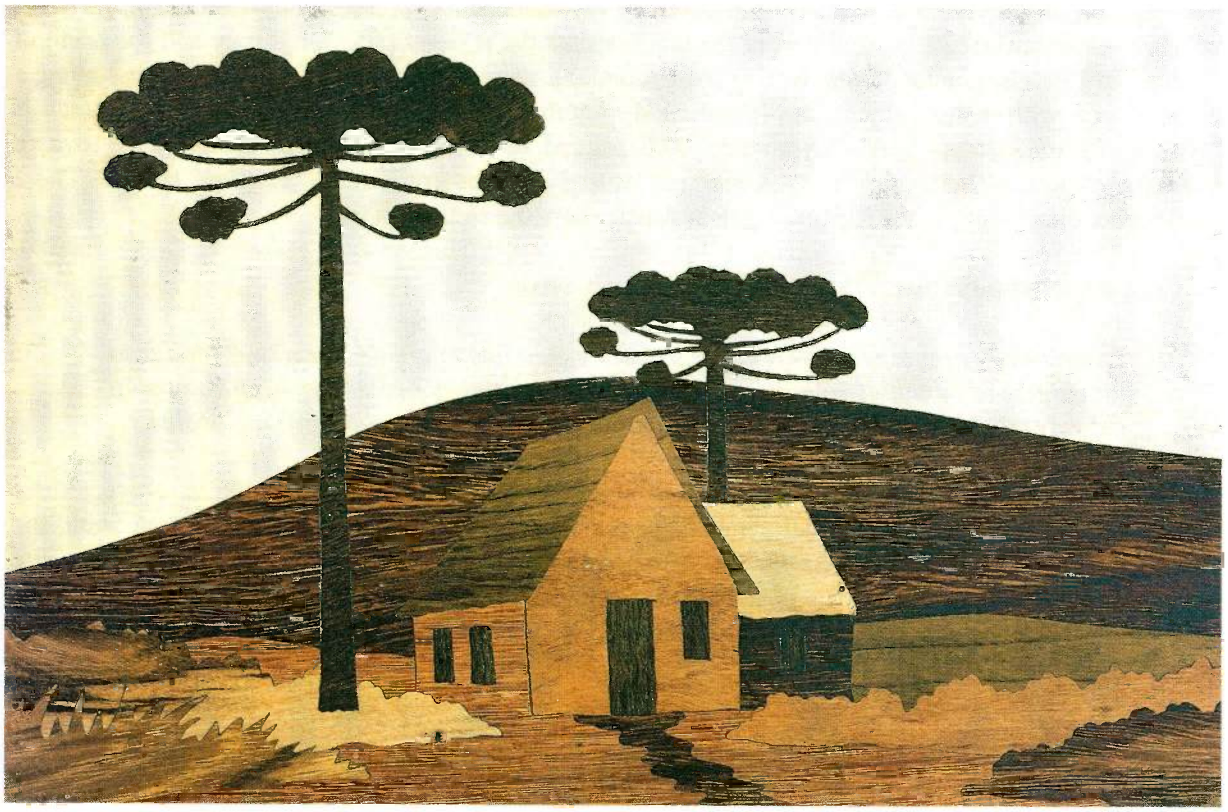

Figure 2.2: Landscape with *Araucaria angustifolia* made of inlaid woods, southern Brazil.

Perhaps the ultimate form of using conifers in art is the ancient Japanese tradition of bonsai. Bonsai is a three dimensional, living art form in which trees are subjected to special growing techniques and the application of principles of design to develop them into miniature *objects d'art* (Stowell 1966). Many species of conifers, especially pines and junipers are popular plant materials for bonsai. The fine art of bonsai is described in greater detail in Chapter 3.

- a variety of colour, form, texture and pattern;
- softening of harsh architectural lines;
- formation of vistas, frame views, provision of focal points and definition of spaces;
- trees can make enticing play areas;
- cooling shade, pleasant fragrances, intriguing sounds and serene settings;
- 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 estate, 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 significant 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 to 22 percent (Ciesla 1995, Sampson *et al.* 1992).

## Species

Many conifers are used as ornamental and landscape plants. Desirable characteristics of plants selected for this purpose include 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. Some species with relatively restricted natural ranges, suggesting that they are not adaptable to wide range of conditions, have become popular plants for landscape and ornamental purposes in many parts of the world. A classic example is the Colorado blue spruce, *Picea pungens,* which occurs in mid- and high-elevation riparian zones in the states of Colorado, Utah, south-eastern Idaho and Wyoming, United States. The unusual blue-grey colour of its foliage has made it a highly desired landscape and ornamental tree and its ability to grow under a wide range of conditions, despite its limited natural range, has allowed it to be widely planted across Europe and North America.

Genetic variability within species is another desirable trait in trees and plants used as ornamentals. Many conifer species have one or more distinct **varieties**. Varieties are considered to be one step below the species level in the taxonomic hierarchy (e.g. *Cupressus arizonica* var. *glabra*) and 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 (Harrison 1975). For example, *Juniperus communis*, a tree found in boreal and cold temperate forests of the Northern Hemisphere, has eight recognized varieties based on foliage and form characteristics (Vidalokovic 1991) (Table 3.1). **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 (Harrison 1975). Cultivars are not part of the classic Linnean taxonomic hierarchy. Cultivar names have been developed by the nursery industry to reflect the characteristic of the plant, the location where it was discovered, its discoverer, etc., but are not always latinized. Examples of cultivar names include "Blue Pacific, Gold Splash, Erecta, Pyramidalis, Weckii." **Cultivariants** are cultivars, which appear somewhat different from their vegetative parents due to propagation from non-typical foliage (Harrison 1975).

**Table 3.1**
**Varieties of *Juniperus communis* and their characteristics**

| Variety | Characteristics | Natural Range |
|---|---|---|
| *Depressa* | Prostrate form up to 1 m high, shoots ascending, needles up to 15 mm long, often directed upwards. | Canada, northern United States. |
| *Hemisphaerica* | A dense alpine shrub, more or less globose, up to 2.5 m high. Needles 5-12 mm long, sharply pointed. | Algeria, Italy (Sicily and Appenine Mts,) S.E. Europe, Crimea, Caususus. |
| *Hondoensis* | Prostrate form with broad foliage, 1.7-2 mm wide, fruit globose and flat topped. | Japan (Mountains on islands of Hokkaido and Honshu). |
| *Intermedia* | Shrub up to 1 m high with slender branches. Needles 7-10 mm long, less curved and thinner than *montana*. | Europe (Alps, Carpathian and Sudeten Mts, Yugoslavia in Gorski Kotar and Dinaric Alps, Macedonia). |
| *Jackii* | Prostrate shrub with branches up to 1 m long. Needles thick; 10 mm long and 2.2 mm wide, sickle formed, sharply pointed with a blue-white band above. | Mountains of northern California, Oregon and Washington, United States (rare). |
| *Montana* | Very prostrate, 20-50 cm high, branches densely arranged, branchlets short. Needles ascending along the shoot, 4-8 mm long, 1-2 mm wide. | Europe (Alpine and subalpine regions, often in peat bogs), North Asia, North America. |
| *Nipponica* | Similar to *montana* but with less curved needles, 1-1.2 mm wide, fruit globose, rounded at the top and containing only one seed. | Japan (Mountains of Hokkaido and Honshu Islands). |
| *Viminalis* | First order branches horizontally spreading while others are pendulous. | Yugoslavia. |

Source: Vidakovic (1991)

Many species of the genus *Juniperus* have a large number of recognized varieties and cultivars, which are popular landscape materials. They range from low, prostrate forms that are popular for borders, edging and ground cover, to small trees with pyramidal or columnar forms. In addition, there are cultivars with variegated yellow and green foliage. The same is true for the species of the genus *Chamaecyparis*, especially *C. lawsoniana*, which has over 200 recognized cultivars based on tree form and foliage colour (Vidakovic 1991). This species was once a major component of a large nursery and landscape industry in the Pacific north-western United States until a virulent root pathogen, *Phytophthora lateralis*, appeared in the nurseries where this species was being grown during the late

1930s and destroyed the viability of this species as a landscape material in the Pacific north-west (Hepting 1971). Blue spruce, *Picea pungens*, has 38 described cultivars, many of which (e.g. Argentea, Glauca, Koster, Moerheim and Thomsen) have a foliage colour that is a more distinctive silver-blue than is normally seen in natural forests of this species (Vidakovic 1991).

Dwarf conifers, which may be less than a meter high when mature, are a valuable group of landscape materials. They can be either varieties or cultivars and can appear in a wide range of genera and species. They are popular in rock gardens, around garden pools, in small, formal gardens and as ground cover plants (Welch 1979). In any given location, exotic conifers are often popular landscape materials. This is especially true of people interested in growing plants who prefer to have something "new and different." Many North American conifers, such as *Picea pungens,* which has already been mentioned, *Thuja occidentalis* (see textbox) and *Chamaecyparis lawsoniana* have become popular landscape and ornamental trees in Europe.

**HOW THE ARBORVITAE CAME TO EUROPE**

"Arborvitae", which means "tree of life", in Latin is a common name for *Thuja occidentalis*, a tree found in eastern Canada and the United States. The name is said to have been given to this species by the king of France during the early sixteenth century.

The name originates from the French expedition into Canada led by Jacques Cartier, which led to the discovery of the St. Lawrence River. During the expedition, the members of Cartier's team were affected by scurvy. Friendly natives they encountered along the way gave them a decoction believed to be made from an extract of the foliage of this tree. Believing themselves to be cured by the extract, in gratitude they carried specimens of this tree back to France.

It is in this way that the first North American tree may have been introduced into Europe, where it soon found favour as an ornamental (Harlow and Harrar 1950).

Members of the genus *Abies* are popular coniferous ornamentals because of their conical growth, v-shaped crown and dark green foliage and are widely used in Europe, North America and Asia. Widely used species include *A. alba* (Europe), Spanish fir, *Abies pinaspo*, Greek fir, *Abies cephalonica*, Algerian fir, *A. numidica*, *A. cilicica* of Asia Minor, Nordmann fir, *A. nordmanniana.* Popular Asian species are *A. firma, A. homolepis, A. veitchii*, and *A. koreana.* In the United States, *A. concolor, A. grandis, A. amabilis, A. magnifica* and *A. procera* are popular ornamentals. Many dwarf forms are available for rock gardens and ornamental purposes (Tang-Shui Liu 1971).

Norfolk Island pine, *Araucaria heterophylla,* is widely used in many tropical areas as a landscape plant, especially in the Hawaiian Islands and the Philippines (Ntima 1968) [1]. It is popular because of its symmetry and regular whorls of branches. Among other areas, it is commonly planted along Australia's East Coast (Boland *et al.* 1984) (Fig 3.1).

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[1] According to Little and Skolmen (1989), most of the Araucaria planted in the Hawaiian Islands is actually *Araucaria columnaris*, a closely related species indigenous to New Caledonia.

Figure 3.1: *Araucaria columnaris* is widely used as a landscape tree in the tropics (Lanai City, Lanai, Hawaii, United States).

## Uses

The purpose of any landscape is to look pleasing to the eye. Landscapes can be attractive if they consist of only conifers or a mixture of conifers and broad-leaved trees but tend to have a greater year round appeal if they include a portion of conifers. This is especially true in temperate climates where most broad-leaved species are deciduous. Some special uses of conifers in landscape design are described in the following sections.

***Foliage effect***

Conifers are desirable trees to plant because of the varied foliage colours that they have to offer. These range from different hues of green, grey or blue to exotic golds or silvers. The purpose of different foliage colours in a landscape is to create interest and variety. Too much green, while restful to the eye, can become tiring and uninteresting (Rushforth 1987). A number of conifers, such as *Picea pungens, Cryptomeria japonica* and *Cupressus arizonica* have foliage with a blue cast. Others, such as *Abies concolor,* have foliage with a distinct grey-green colour. Still others, such as *Taxus baccata*, *Tsuga canadensis* and *Pinus radiata* have a deep green foliage colour. A number of cultivars have golden or yellow coloured foliage. Several conifer genera, *Larix, Pseudolarix, Metasequoia* and *Taxodium*, can add fall colouring to a landscape.

***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 including marking the edge of a vista or characterizing 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. A large, open space would be the perfect setting for a large, multi-stemmed *Cedrus libani.* However, this tree would not work well in a small area because of the massive sizes it is capable of achieving (Rushforth 1987).

There are a number of examples of the effective use of specimen or character trees. Several cultivars of *Cupressus sempervirens,* which have a columnar form, have been introduced into Italy where they line roadsides or accent large estates and castles. This tree has been so widely planted in the region of Tuscany that it has become an integral part of the character and charm of this beautiful and enchanting region (Fig 3.2). Similarly, the umbrella-like crown form of *Pinus pinea* has been used with great effectiveness to line streets and major arteries leading into Rome (author's observation). In southern Brazil, the umbrella-like crown of *Araucaria angustifolia,* an indigenous species, appears in parks, golf courses and along roads and is an integral part of the landscape of this region (Ciesla 1986) (Fig 3.3).

Figure 3.2: Extensive plantings of columnar cultivars of *Cupressus sempervirens* in the Tuscany region of Italy has given the landscape a special character.

***Shelter, screening and backcloth plantings***

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 overstory plants or side protection. In many open, arid regions of the world, where there is a frequent occurrence of high velocity, desiccating winds, various drought tolerant species of *Juniperus* are often used in combination with other broad-leaved trees as windbreak or shelterbelt plantings. Screening is similar to providing shelter, except that the objective is to shut out a particular intrusion such as an unsightly industrial facility. Plantings can also be used for visual screening or to trap dust and debris. While not particularly effective at screening out sounds, they can reduce the perceived sound because the source is no longer visible. The objective of backcloth planting is to display a plant or other item to best effect. Many attractive plants are best displayed when placed against a dark background. Conifers with dense, dark green foliage are best suited for this purpose (Rushforth 1987).

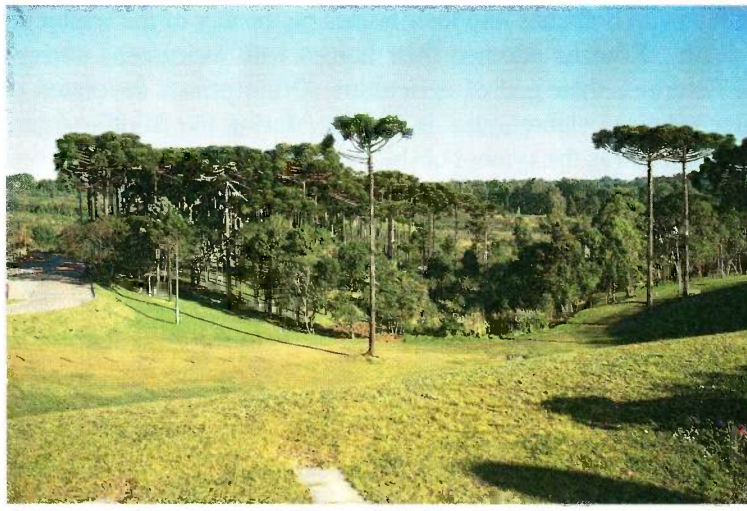


Figure 3.3: Planting of *Araucaria angustifolia* along a golf course, Curitiba, Brazil.

***Hedges***

Conifers can make very useful hedges. Ideal requirements for a hedge plant is that it will grow on a wide range of soils, be easily trimmed to the right size, be evergreen, make an effective barrier throughout the year, not need too much trimming and be fully hardy and pest and disease resistant. The hedge should also be quick to establish, which in practice competes with the need for not too frequent trimming. Many species of the family Cupressaceae are excellent materials for hedges (Rushforth 1987). In Kenya and other eastern and southern African countries, the Mexican cypress, *Cupressus lusitanica,* has been widely used for ornamental hedges and living fences around homes in rural settings designed to keep out free ranging livestock, wildlife and human intruders (author's observation). Unfortunately, the viability of this species has been reduced by the recent introduction of a destructive insect, the cypress aphid (Ciesla 1991). In eastern United States, *Tsuga canadensis* is a popular hedge species (Rushforth 1987).

## CHRISTMAS TREES

Christmas trees are an important seasonal commodity in countries where Christianity is the predominant religion and the birth of Jesus Christ is traditionally celebrated with a colourfully decorated tree in the home. Production and sale of Christmas trees is a multi-million dollar industry. Christmas trees are harvested from natural forests or trees grown in plantations established specifically for Christmas tree production. A number of commercial Christmas tree growers now offer customers the opportunity to select and cut their trees. In the United States, special permits may be obtained to harvest a Christmas tree in selected areas on public lands (National Forests or public lands administered by the Bureau of Land Management).

### Historical aspects [2]

The tradition of a Christmas tree inside the home is generally associated with the Christian celebration of the birth of Jesus Christ. However, the tree used as a symbol of life, is a tradition much older than

[2] Information in this section was obtained from the National Christmas Tree Association (NCTA) of the USA via the World Wide Web at: http://christree.org/dir/US.IA.SweaCity.html.

Christianity and is not exclusive to any one religion. Long before there was a Christmas celebration, Egyptians brought green palm branches into their homes on the day of the winter solstice as a symbol of life's triumph over death. Romans adorned their homes with evergreens during Saturnalia, a winter festival in honour of Saturnus, their god of agriculture. Druid priests decorated oak trees with golden apples for their winter solstice celebrations. In Europe, during the Middle Ages, the Paradise tree, a conifer hung with red apples, was the symbol of the feast of Adam and Eve held on 24 December.

The first recorded reference to the Christmas tree dates back to the sixteenth century. In Strasbourg, France, families both rich and poor decorated fir trees, *Abies alba*, with coloured paper, fruits and sweets. At this time, the first retail sales of Christmas trees were also made, usually by older women, who would sell trees harvested from nearby forests. This tradition gradually spread throughout Europe.

By now a well-established European tradition, Christmas trees were introduced to the United States by German settlers and by Hessian mercenary soldiers who fought in the revolutionary war. In 1804, American soldiers stationed at Fort Dearborn, the present day location of the city of Chicago, cut trees from the surrounding forests and brought them to their barracks at Christmas. Charles Minnegrode first introduced the custom of decorating trees at Christmas in Williamsburg, Virginia in 1842. In 1851, Mark Carr hauled two ox-driven sleds loaded with trees harvested in the Catskill Mountains of New York State to the streets of New York City and opened the first retail lot for Christmas tree sales in the United States.

A German also introduced Christmas trees into Canada. In 1781, General Von Reidesel planted the first Christmas tree in Quebec. The custom spread during the Victorian period, although it was limited to the middle class. After 1920, the practice began to appear in large cities but in the rural areas of Canada, decorated trees did not become a familiar sight until the 1930s [3].

## Species

Many conifers are popular Christmas trees and preference varies with location. Local climatic conditions also affect the kind of trees that can be grown. The following sections highlight some of the more popular species, their desirable and undesirable characteristics (Hill 1989, Chapman and Wray 1979).

Characteristics that define a good Christmas tree include:

1. **Needle colour** - Christmas trees should have a rich, dark green or blue-green colour. Trees with thin or chlorotic (yellow) foliage are especially undesirable.
2. **Needle retention** - Needles should remain on a tree for a long time after they are cut.
3. **Needle sharpness** - Needles should be relatively soft and easy to handle.
4. **Branch thickness** - Branches should be capable of supporting Christmas ornaments but not so thick that it is difficult to hang ornaments. Branches should be sufficiently durable to tolerate shipment.
5. **Odour** - Foliage should have a pleasant fragrance and be free from pungent odours.

[3] The Christmas tree comes to Canada, at http:// www.chin.gc.ca/christmas/sap intro.htm

6. **Overall form** - Trees should be conical in form and with sufficient foliage and branch density to appear full crowned.

7. **Growth** - Growth should be sufficiently rapid to produce an attractive tree of saleable size in 7-10 years.

***Abies spp.***

The pleasing fragrance, colour, form and exceptionally long-needle retention after being cut, of the true firs make them highly prized Christmas trees both in Europe and North America (Tang-Shui Lui 1971).

Balsam fir, *Abies balsamea*, occurs naturally over a large area of eastern Canada and portions of north-eastern United States and is one of the most popular Christmas trees. It has a pleasant fragrance, a deep green needle colour and needles that are retained for a long time even in warm, dry rooms. In Canada, many balsam fir Christmas trees are still harvested from natural forests and shipped long distances to the United States, Mexico, Venezuela and Germany. Balsam fir is also a popular plantation grown Christmas tree. The southern balsam or Fraser fir, *Abies fraseri*, is closely related to *A. balsamea* and is endemic to the high mountain regions of the southern Appalachian Mountains (United States), and is also highly favoured as a Christmas tree.

Several western North American species of *Abies* are also popular Christmas trees. White fir, *A concolor,* is found in California and south-western United States where it is a popular regional Christmas tree. It has long needles (up to 4 cm) which are a grey-green colour. This tree has a relatively slow growth rate and trees cannot be harvested until they are at least 10 to 12 years old. Grand fir, *A. grandis,* is well known for its fragrant foliage and is widely grown in Christmas tree plantations where it is often sheared. Noble fir, *A. procera*, is considered a premier Christmas tree both in Europe and North America. This tree is native to north-western United States and adjoining portions of Canada and is widely planted in Christmas tree plantations. Noble fir tends to have an open crown, stout branches and luxurious, green needles. It is a popular tree for hanging large ornaments.

The Caucasian fir, *Abies nordmanniana*, of southern Europe is the principal species grown for Christmas trees in Denmark (Hansen *et al.* 1997). *A. alba* is also a popular Christmas tree in Denmark and other European countries.

***Picea spp.***

The spruces are considered traditional Christmas trees, especially in Europe but have several undesirable characteristics, primarily poor needle retention. The foliage of several species also has pungent odours, which are unpleasant when brought into a home.

Norway spruce, *Picea abies,* was one of the first trees to be used as a Christmas tree in Europe and still remains a popular choice. This species has been introduced into the north-eastern parts of North America where it is widely planted for a number of purposes including Christmas trees. Its needles are dark green; the tree has a good natural form and requires little shearing. Its one serious weakness is poor needle retention.

White spruce, *Picea glauca*, a native of the North American boreal forest, has several desirable features including good form, slender branches and a grey-green needle colour. Although slow growing, it does well in plantations. Unfortunately, white spruce has poor needle retention and the foliage has an unpleasant odour when crushed.

Red spruce, *P. rubens,* another tree native to eastern North America has dark green foliage. It has good form but, like most spruces, suffers from poor needle retention. It is not widely grown because it generally takes 20-30 years to reach a saleable size. Black spruce, *P. mariana*, another component of the North American boreal forest, has very short needles. This tree is harvested for Christmas trees and often spray painted various colours for a speciality market. Colorado blue spruce, *P. pungens*, has an excellent blue-green needle colour and good form but has very sharp needles which makes this tree difficult to decorate.

***Pinus spp.***

Many species of pines are popular Christmas trees. They are particularly suitable for trees grown in plantations because of their relatively fast growth rates.

In the United States the Scots pine, *Pinus sylvestris*, is an extremely popular species. This native Eurasian pine was introduced into North America as a potential timber species with disappointing results. However, this tree responds well to shearing which results in a Christmas tree with a dense, conical crown and can be grown in cold climates. Because of its extensive natural range, there is considerable variation in form, growth rates and needle colour of this species, and provenance is an important criteria in selecting seedlings for Christmas tree production. Some forms are subject to fall yellowing which reduces their marketability as a Christmas tree. Ironically, this tree, which is so popular in North America, is not used as a Christmas tree in Europe.

*Pinus nigra*, another European species, is grown on a small-scale in the United States for Christmas trees; however, there is limited demand for this species. Needles are a rich green colour and growth rate is rapid that trees must be sheared in order to ensure good form. Undesirable characteristics include needles that are long and stiff and the presence of thick, stiff branches, which makes handling difficult.

Eastern white pine, *Pinus strobus*, is a highly favoured tree in eastern North America. It has needles with a uniform bluish-green colour, which remain on the tree for a long time after cutting. This species also has a rapid growth rate and must be sheared to ensure good form and foliage density. Unfortunately, it has somewhat brittle branches and does not lend itself well to long-distance shipping.

Radiata pine, *Pinus radiata*, is the most widely planted of all pines and has several characteristics that make it a desirable Christmas tree. It is fast growing and has rich dark-green foliage. It is not suitable for planting in cold climates, dry climates or climates with a summer rainfall pattern. Virginia pine, *Pinus virginiana,* is a tree native to portions of south-eastern United States. This tree has become a popular Christmas tree locally because it responds well to shearing. Other pines, which have been used as Christmas trees (primarily in the United States), include *Pinus resinosa, P. thunbergiana, P. banksiana, P. rigida, P. taeda* and *P. echinata.*

***Pseudotsuga menziesii***

Douglas fir is a popular Christmas tree, especially in western North America where it is native. It has all of the qualities desired in a Christmas tree. Needles are about 1 cm long and needle colour varies from grey-green or blue-green to deep green. Needle retention is good in warm rooms. Response to shearing is good, resulting in a more symmetrical tree with dense foliage. Its growth rate is relatively slow and more than ten years are required to produce a saleable tree. Douglas fir is the most popular Christmas tree in north-western United States and is gaining popularity in other markets as well.

***Other species***

Eastern red cedar, *Juniperus virginiana,* is a locally important species in south-eastern United States where it is grown in plantations. Further north, the foliage tends to take on a purplish cast during winter, which reduces its desirability for Christmas tree use. *Cupressus arizonica*, a species with blue-green foliage, is becoming a popular Christmas tree in south-eastern United States.

In southern Brazil, *Araucaria angustifolia* is a popular Christmas tree (Reitz *et al.* 1979). *A. columnaris*, a species native to New Caledonia (frequently referred to as Norfolk Island pine, *A. heterophylla)* is widely planted as a Christmas tree in the Hawaiian Islands (USA) and has been exported to the Pacific coastal regions of the United States as a novelty Christmas tree (Little and Skolmen 1989).

## Production and trade

The United States is a major producer of Christmas trees with an annual harvest of about 35 million trees during 1993-96. Most trees are harvested for domestic use. Christmas trees are grown in all 50 States on a total area of about 400 000 ha. The principal Christmas tree producing-states are Oregon, Michigan, Wisconsin, Pennsylvania, California and North Carolina. Most Christmas trees are produced in plantations although some are still harvested from natural forests. There are about 15 000 Christmas tree growers in the United States and over 100 000 people are employed either full time or part time in this industry [4].

Canada is another major Christmas tree producer with an annual production of about 4 million trees valued at US$38-45 million. Approximately 50 percent of Canada's Christmas trees are exported, with the United States being the largest market. In 1994, some 2 million of Canada's total export of 2 118 500 trees were exported to the United States (Table 3.2). Other countries receiving large numbers of Canadian Christmas trees were Panama, the Netherlands Antilles, Venezuela and Bermuda. Unlike the United States, most Canadian Christmas trees are harvested from natural forests (primarily *Abies balsamea*) but the number of Christmas tree plantations is on the increase. The Province of Quebec is Canada's biggest producer of Christmas trees followed by Ontario, Nova Scotia, New Brunswick and British Columbia (Fig 3.4). Canada also imports about US$3 million in Christmas trees annually from the United States (National Forestry Database Program 1996).

**Table 3.2**
**Christmas tree production, exports and imports**
**Canada, 1993-94**

| Year | Number of trees (000) | Value (US$) (x1000) | Number exported (000) | Value (US$) (x1000) | Imports (US$) (x1000) |
|---|---|---|---|---|---|
| 1993 | 4 188 | 38 429 | 2 057 | 24 734 | 3 262 |
| 1994 | 4 257 | 45 479 | 2 118 | 25 548 | 3 109 |

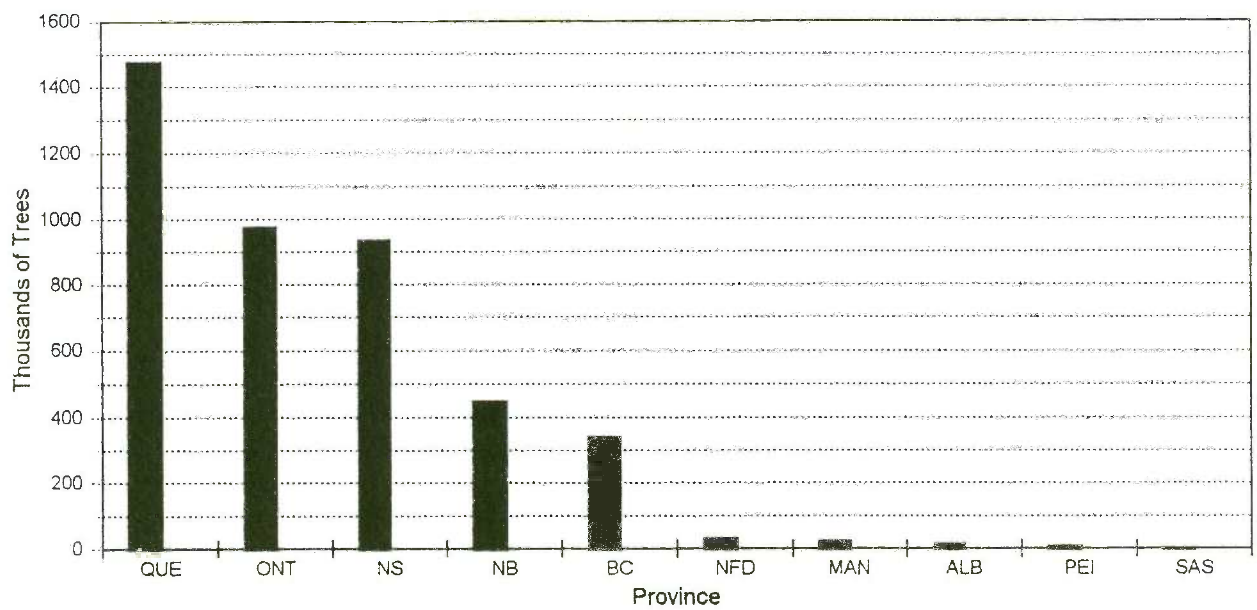
Source: National Forestry Program DataBase (1996)

In Europe, Christmas trees were first produced while thinning undergrowth. Although this may still be the case in a few occasions, the bulk of the Christmas tree production is produced in specialised plantations. Denmark is the leading producer of Christmas trees[5] in Europe. In 1994, the Danish

[4] Data obtained from the National Christmas Tree Association (NCTA) via the World Wide Web.

[5] Data obtained from the Danish Forestry Research Institute, Copenhagen at http://www.fsl.dk/.

Christmas industry had an income of approximately US$110 million (green foliage and trees) accounting for about one-third of the country's total forestry income (Hänsen *et al.* 1997). In the Århus Forest District, for example, 36 percent of total receipts were derived from the sale of non-wood forest products, including Christmas trees. In Denmark, Christmas trees are almost exclusively produced on very intensively managed plantations (Munk Plum P. 1998, personal communication). Germany is also a major Christmas tree producer. Hartwig (1977) estimated the share of decorative greens and Christmas trees together at 0.4 percent of the total value of receipts from sales of forest products.




*QUE - Quebec, ONT - Ontario, NS - Nova Scotia, NB - New Brunswick, BC - British Columbia, NFD - New Foundland, MAN - Manitoba, ALB - Alberta, PEI - Prince Edward Island, SAS - Saskatchewan.*

Figure 3.4: Christmas tree production in Canada by Province – 1994.

Source: National Forestry Program DataBase (1996)

Mexico has recently become a major market for Christmas trees. Over a two-year period, Mexican Christmas tree imports virtually doubled (Table 3.3) and by 1993, Mexico imported over US$6 million in trees, 95 percent of which came from the United States, primarily the Pacific north-western States (Oregon and Washington). The remainder is imported from Canada. Noble fir, *Abies procera,* accounted for 60 percent of the sales because of its longer needle retention. *Pseudotsuga menziesii* and *Abies balsamea* were also important. Some vendors attempted to market *Pinus sylvestris,* but Mexican consumers, because of its sharp needles, did not favour this species. Domestic Christmas trees are available from the states of Mexico, Michoacan, Durango and Chihuahua. However, the most significant problem facing this sector is the scarcity of specialized Christmas tree growers. A few Christmas tree plantations exist and their numbers are growing, especially in the states of Puebla and Mexico. Statistics on Christmas tree production and consumption in Mexico do not exist at present (USDA 1995).

**Table 3.3**
**Mexican imports of Christmas trees, 1991-93**

| Source | 1991 | | 1992 | | 1993 | |
|---|---|---|---|---|---|---|
| | Value 1000 US$ | Volume Tonnes | Value 1000 US$ | Volume Tonnes | Value 1000 US$ | Volume Tonnes) |
| Canada | 800 | 312 | 600 | 935 | 300 | 365 |
| USA | 2 300 | 2 338 | 3 400 | 5 900 | 5 900 | 9726 |
| Total | 3 100 | 2 650 | 4 000 | 6 838 | 6 200 | 10 092 |

Source: USDA (1995)

## BONSAI

Bonsai is a technique for retaining the essential growth form of a tree but reducing it to pocket size. Many species of conifers are used in bonsai, which can be cultivated either outdoors or indoors (Rushforth 1987).

### Historical aspects

The word "bonsai" has its origins in China where it was derived from two words, *bon*, meaning a tray or pot and *sai*, meaning a plant (Stowell 1966). Bonsai literally means a plant or tree growing in a tray or pot. The practice of growing trees in pots can be traced to Egypt about 4000 years ago. The purpose of planting trees in pots at that time was for mobility. The Greeks, Babylonians, Persians and Hindus subsequently adopted this practice.

The first records of growing small trees in pots are from China during the Tsin era (third century BC). On the tomb of Zhang Huai, the second son of the empress Tang Wu Zeitan, there is a figure of a woman carrying a bonsai in both hands. Later, during the Tang dynasty (618-907 AD) and the Song dynasty, public records refer to a man who "had learned the art of creating the illusion of immensity enclosed within a small space and all this contained within a single pot." During this same period, Buddhist monks are said to have carried the *p'en-tsai* (trees taken from natural surroundings and replanted, just as they were, in ornamental pots) throughout the Far East.

Bonsai, as it is known today, originated in Japan. The first references to bonsai began to appear in Japan between the twelfth and mid fourteenth centuries. There is a famous scroll of the Buddhist monk, Honen, which is decorated with bonsai and dates roughly from the twelfth century. The period of Edo (1615-1867) was a period of growth in interest of colourful trees grown in trays. The *bonkei* were landscapes on trays and bonsai trees grown in pots. The well-to-do classes in Japan gradually developed an attachment for bonsai and the trees they succeeded in growing took pride of place in their homes. Soon the cultivation of bonsai as a hobby spread through all of Japan's social strata, with the last to adopt the practice being the poorer classes. Today, bonsai culture is practised throughout all of Japan.

**BONSAI - A FOUNTAIN OF YOUTH?**

There is an old Japanese tale about a sage who explained his smooth and youthful features by his devotion to bonsai. When he contemplated his work, he could not grow old because "while flowers may fade in winter, in his home they were always in bloom".

Bonsai is an inward image, a symbol of eternity. It is said to abolish time and reflects the harmony between man and nature and heaven and earth (Samson and Samson 1986).

Bonsai first began to appear in Europe in the fourteenth century when it was introduced by travellers to the Far East but was largely forgotten by the eighteenth century. This art form enjoyed a renaissance in Europe during the nineteenth century when several serious essays appeared on means employed by the Japanese to develop dwarf trees (Samson and Samson 1986).

The cultivation of bonsai was first brought to North America by Japanese immigrants, many of who settled along the Pacific Coast (Stowell 1966).

## Bonsai as an art form

Bonsai is a three dimensional, living form of art. Through special techniques and the application of the principles of design, plants are developed into *objets d'art.* Bonsai is something of nature evoked in miniature and is meant to communicate the idea of a windswept tree clinging to a rocky crag; an ancient rugged pine that has survived years of wind, sun and rain or a group of such trees or of some lovely distant landscape. Bonsai should never appear grotesque or unnaturally distorted; it should simply reproduce nature in miniature. Bonsai differs from ordinary potted plants in that woody or somewhat woody plants are always used. The growth is trained and controlled so as to produce a miniature tree. Bonsai is an aesthetic use of horticultural material, an abstraction of nature on a reduced scale (Stowell 1966).

In every bonsai, one should find the shape of the triangle (Fig 3.5). Bonsai joins heaven and earth and becomes a concrete allegory by leading humans along the pathway of spiritual values. Four main groups of bonsai are recognized (Samson and Samson 1986).

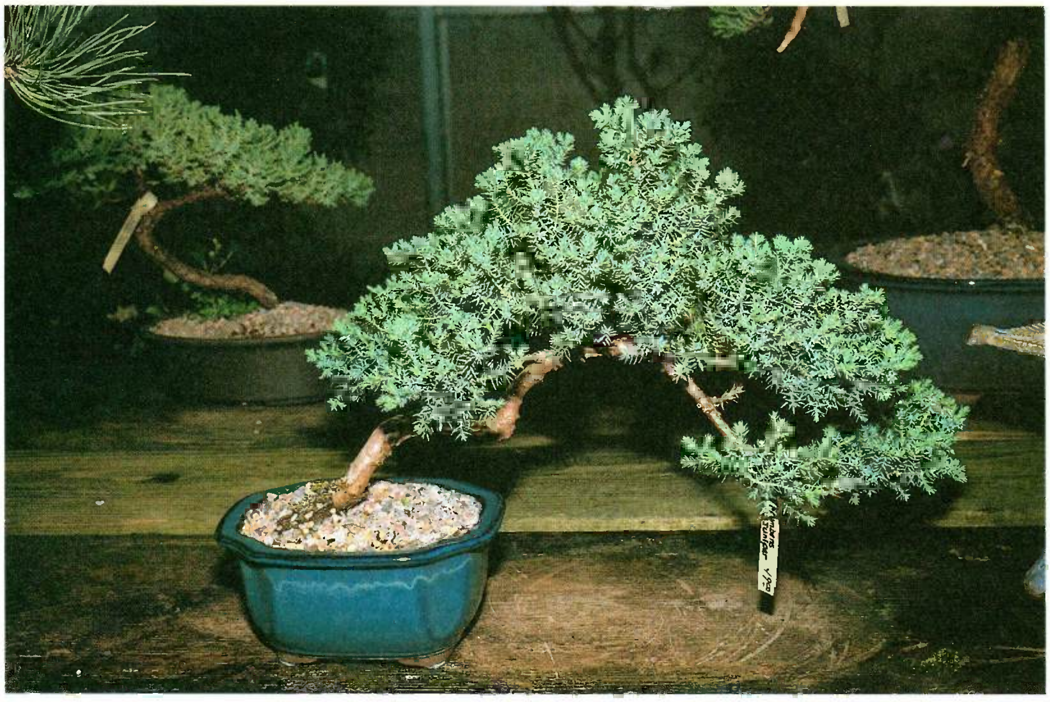


Figure 3.5: A *Juniperus procumbens* bonsai in the shakan style (Photo taken at the Bonsai Nursery, Denver, Colorado).

1. **Group 1** - A single trunk

    *Chokkan* - The formal upright style where the tree grows upward toward the sky.
    *Shakan* - The trunk bends and may do so to the extent of being semi-cascade.
    *Kengai* - A cascade style, plunging downwards.
    *Bankhan* - The trunk winds around itself like a twisted cord.

    A number of sub-styles are derived from these four basic styles.

2. **Group 2** - Multiple stems from a single root

    *Sôkan* - A double trunk.
    *Kabudachi* - Multiple trunks grouped around a single root.
    *Kôrabuki* - Multi-trunked style.
    *Ikadabuki* - Straight line style; a horizontal trunk forms the stump.
    *Netsunagari* - Sinuous style with several trunks growing from a single sinuous root.

3. **Group 3** - Multiple trunks or Group plantings

    *Sôju* - Twin trunks.
    *Sambon-Yô*se - Three trunks.
    *Gohon -Yô*se - Five trunks.
    *Nanahon - Yô*se Seven trunks.
    *Kyûhon - Yô*se - Nine trunks.

*Yôse - Ue* - More than nine trunks.
*Yomayori* or *Yomayose* - A natural grouping.
*Tsukami - Yôse* - Clustered group style - multiple trunks springing up from the same place.

4. **Group 4** - These are not bonsai in the strict sense but are miniature landscapes, grass plantations and seasonal plants.

## Bonsai cultivation

Bonsai can be propagated from seeds or seedlings, cutting, layering or grafting. Techniques have evolved over many years, which allow the grower to change the height and direction of the tree's growth and in some cases to dwarf the foliage of the tree. Trees selected for bonsai are kept small by pruning of new growth, root pruning and limiting growing space. While there are certain classic or traditional forms that can be followed, the rule of thumb for a personal bonsai is "if you like the way it looks, it's a good bonsai".

A popular misconception about bonsai is that the trees are always old. In actuality bonsai can be any age. Years are not a factor that relates to quality in bonsai. There are techniques in the development of bonsai that can give a young tree a much older appearance (Stowell 1966).

## Species

Both broad-leafed trees and conifers are used in bonsai. Because bonsai should look like mature trees in miniature, commonly used species typically have small leaves or needles so that the trunk, branches, twigs, leaves and roots will be in scale in overall composition (Stowell 1966).

A large number of conifers of the families Cupressaceae and Pinaceae are good candidates for bonsai (Table 3.4). Initially this art form was confined to Asian species. However, as it became popular with western cultures, it was learned that a number of European and North American species also lent themselves to this form of cultivation. Members of the genus *Juniperus* are especially popular for bonsai because they are relatively easy to care for and are especially popular with beginners.

**NATURALLY OCCURRING BONSAI**

Bonsai exist in nature. They are commonly seen on high mountains or in rocky places were there is little or no soil. Other factors, which may cause natural bonsai, are chronic drought, wind, avalanches or heavy browsing. The first bonsai trees were taken from the natural environment. To remove a tree from its natural habitat, part of the roots were cut over a period of two to three years, usually in the spring. The removal of naturally occurring bonsai was an art form in itself. However, this practice is forbidden today in many places (Samson and Samson 1986).

## Current status

Today, bonsai are sold and cultivated in many parts of the world. Many large cities have at least one organization for bonsai enthusiasts (Stowell 1966). In addition to Japan, bonsai clubs are found in North America, most western European countries, Australia, Brazil, New Zealand and South Africa.

Bonsai can be purchased in either speciality shops or sometimes in stores, which sell gardening supplies. In some countries, bonsai can be purchased in street markets. A small, young bonsai, in a simple pot, can sell for as little as US$ 20. Larger, more elaborate bonsai can sell for US$1 000 and up. Some dealers sell 6 to 8 cm starter plants for approximately US$ 3-5.

**Table 3.4**
**Some conifers used for bonsai**

| Family | Asian Species | European Species | North American Species |
|---|---|---|---|
| Ginkgoaceae | *Ginkgo biloba* | | |
| Cupressaceae | *Chamaecyparis obtusa*<br>*Cryptomeria japonica*<br>*Juniperus chinensis*<br>*Juniperus procumbens*<br>*Juniperus rigida*<br>*Juniperus sargenti* | | *Juniperus virginiana*<br>*Thuja occidentalis* |
| Pinaceae | *Cedrus* spp.<br>*Larix decidua*<br>*Picea jezoensis*<br>*Picea orientalis*<br>*Pinus parviflora*<br>*Pinus pumila*<br>*Pinus thunbergiana*<br>*Pseudolarix kaempferi* | *Picea abies*<br>*Pinus montana*<br>*Pinus nigra*<br>*Pinus sylvestris* | *Picea glauca*<br>*Picea mariana*<br>*Pinus flexilis*<br>*Pinus ponderosa*<br>*Pinus rigida*<br>*Pinus strobus* |
| Taxaceae | *Taxus cuspida* | | |

Sources: Menage 1975, Samson and Samson 1986, Stowell 1966, Yashiroda 1960, Bonsai Nursery Inc., Denver, Colorado, USA.

## TOPIARY

Topiary is the creation of sculpture out of a living, growing plant. Species used as a basis of this art form need to be able to withstand repeated clipping. Ideally, they are tough and hardy evergreen plants. Several conifers are used in topiary. One especially popular species is *Taxus baccata,* which is particularly desirable because it is slow growing and requires less trimming to achieve the desired shape.

In topiary, plants can be trimmed to make a variety of forms, ranging from pocket battleships, animals or regular cones suitable for very formal gardens (Rushforth 1987).

Figure 3.6: Bonsai, *Pinus parviflora*, for sale in a street market in Hefei, Anhui Province, China.

## CONIFERS AS HOUSE PLANTS

Some conifers can be used as houseplants and some species survive indoor conditions quite well. This is the only practical means of growing tropical conifers in temperate climates although not all conifers will tolerate indoor conditions well.

Conifers that do well as houseplants are those which can meet the following conditions:

- able to grow under relatively low-light intensities;
- do not require exposure to a pronounced cold period;
- can tolerate alternate wetting and drying of the soil;
- can tolerate diurnal temperature variations.

The Norfolk Island pine, *Araucaria heterophylla*, is a tree widely used for indoor culture. Other species of *Araucaria* can also be grown indoors. The cultivar "Goldcrest" of *Cupressus macrocarpa* is often sold as a houseplant as are juvenile forms of several species of *Pinus* (e.g. *P. canariensis* or *P. pinea*) (Rushforth 1987).

# CHAPTER 4
# FOLIAGE

## EVERGREEN BOUGHS

Decorative floral greenery is a non-wood forest product with a rapidly expanding market. A wide variety of plants are harvested in conifer forests to provide a green backdrop for floral arrangements, bouquets and other household floral products, such as fern leaves. The predominant form of decorative greenery harvested from conifers is a bough. This is largely a seasonal product with highest demand being during the Christmas season (Thomas and Schumann 1992). Evergreen boughs from conifers are also a key component for cemetery and grave decorations.

### Uses

In many places of the world, but particularly in North America and Europe, the most extensive use of evergreen boughs is for making wreaths. In the United States many states have sizeable wreath making enterprises. For example, in Minnesota, the bough and wreath business has about US$10 million in sales for both small- and large-scale commercial enterprises (Thomas and Schumann 1992). One plant in western Washington reportedly produces 100-150 Christmas wreaths per day between mid-October and early December and consumes more than 18 000 kg of boughs per day (Savage 1995). Other products include garlands, swags and table decorations.

### Species

In addition and in combination with several other plant species like ferns, many North American conifers produce attractive boughs. In the Pacific north-west, boughs are harvested from *Abies amabilis, A. lasiocarpa, A. procera, Pinus contorta, P. monticola, Pseudotsuga menziesii, Juniperus* spp., *Calcocedrus decurrens* and *Thuja plicata* (Thomas and Schumann 1992). *A. procera* accounts for about75 percent of the *Abies* bough harvest in this region. Desirable properties of this species include durability, density and colour of foliage, symmetrical branching and excellent needle retention (Murray and Crawford 1982). *A. procera* and *Thuja plicata* are the two major species harvested in terms of total tonnage per year (Schlosser *et al.* n.d). In eastern North America, *Abies balsamea* and *Pinus strobus* are popular species for bough harvesting. Prices paid for boughs vary according to species and quality (Thomas and Schumann 1992). Sample specifications and prices are provided in Table 4.1.

**Table 4.1**
**Prices paid to bough harvesters for selected North American conifers**

| Species | Price (US$/kg) |
|---|---|
| *Abies procera* | 0.44 |
| *Calcocedrus decurrens* | 0.66 |
| *Chamaecyparis lawsoniana* | 0.26-0.46 |
| *Juniperus* spp. (with ripe berries) | 0.46 |
| *Pinus contorta* | 0.22 |
| *Thuja plicata* | 0.26 |

Source: Thomas and Schumann (1992).

In Denmark, principal species used for production of ornamental conifer foliage are *Abies nordmanniana* and *A. procera* (Salo 1995).

In Germany, *Abies procera* is considered to be the premium source of boughs and there is also a high demand for boughs of *Pinus strobus.* Other popular species include *Pseudotsuga menziesii, Picea abies, Abies grandis* and *Chamaecyparis* spp. Boughs of *Thuja* and *Cupressus* are not as popular (Ehlers 1968, 1970).

## Harvesting, management and trade

Christmas greens are harvested in fall and winter, usually from October to early December. Boughs are clipped from young trees because older trees do not provide the type of branches required by the industry. Harvests are often conducted in regenerating stands and can be done as frequently as every two to three years (Schlosser *et al.* n.d). Boughs of *Chamaecyparis lawsoniana* are harvested year round (Fitzgerald 1986).

One report describes the collection and processing of boughs of *Abies procera* in western Washington, United States, using helicopters and refrigeration warehouses (Savage 1995). A Hughes 500 helicopter, equipped with a cable and cargo hook is used to haul baled *A. procera* boughs, each weighing approximately 400 kg from the harvest site to a landing where they are loaded on trucks. The helicopter is able to transport some 36 000 kg of boughs to the landing in about three hours and the boughs are delivered to a large cold storage plant where they are sorted and packaged and sold wholesale throughout the United States to florists and wreath manufacturers.

Another study in western Washington indicates that timber production and bough harvesting in *Abies procera* plantations can be compatible management objectives. Bough harvests can begin when the plantation is eight years old and can be sustained for up to 25 years. Open grown, sapling size trees have the best quality and greatest quantity of foliage. Stand mortality can be prevented by intermediate Christmas tree harvests but in general harvesting for boughs is more profitable than selling Christmas trees. In the study presented, bough harvesting began at age 13 and the annual harvest over a ten year period was 1 930 kg/ha/yr or about 2 kg/tree/yr. Approximately 55 percent of the trees had boughs harvested at least once. A pre-commercial thinning in this plantation at stand age 24 provided a final opportunity for bough harvesting providing an estimated yield of 12 260 kg/ha of boughs. Based on a 1980 market value of US$ 0.20/kg, the boughs resulting from the thinning were worth US$2 452/ha. A three-stage thinning procedure is suggested when combining a bough harvest with stocking control. First stage is the selection of crop trees for ultimate timber harvesting and marking trees to be removed. Secondly, bough cutters strip any marked tree of saleable boughs. In the final stage, a thinning crew can cut all marked and/or stripped trees. This paper also reports results of a similar study in Denmark where a 21-year-old stand of *A. procera*, harvested for 13 years for boughs, gave annual yields of 1.8 kg/tree (Murray and Crawford 1982).

A report from Germany also discusses the feasibility of managing forests to produce both timber and Christmas boughs. *Pseudotsuga menziesii*, *Picea abies* and beech, *Fagus sylvatica* are grown in mixed plantations. When *P. menziesii* is spaced at no less than 2 x 2 meter intervals, the trees yield a continuous harvest of greenery until they are pruned and thinned at about age 25. Best yields require lighting on all sides of the trees which keeps foliage from turning yellow. Harvesting of greenery begins in the fifth or sixth year after planting. Where *Picea abies* is grown in combination with *Pseudotsuga menziesii,* the former species is harvested for both Christmas trees and decorative greens. In the first ten years, these stands may produce as much as DM6 330 (aboutUS$3 500)/ha undiscounted net profit with *Pseudotsuga menziesii* contributing about 40 percent of the net value (Grabensted 1969).

Trade barriers in foreign markets have been a major concern of United States' evergreen bough marketers, especially claims of concern over possible hazards associated with the introduction of potentially destructive pests and diseases into Europe via imported boughs.

Denmark ranks first in Europe in production of greens with 7 367 ha under production, yielding 27 000 tonnes of ornamental foliage annually (Salo 1995). Major countries to which Christmas greens (boughs and Christmas trees) are exported are Germany (approximately 80-90 percent), Austria, Sweden and the Netherlands. Between 1960 and 1980, exports rose from 6 000 to more than 23 000 tonnes (Christensen 1982).

The demand for conifer boughs is especially high in Germany. As early as 1968, annual consumption of conifer greens was estimated at 5 kg/family/yr, amounting to 50 000-60 000 tonnes annually. Selected, uniform, fresh foliage in 10-kg bundles is the preferred market quantity. Major urban areas with wholesale foliage and flower markets are Hamburg, the Ruhr region, Frankfurt, Stuttgart and Munich (Ehlers 1968).

Conifer boughs are harvested commercially in several areas of Germany. Major domestic sources are in Schleswig-Holstein and the Black Forest region (Ehlers 1968). In 1967-68 decorative greens constituted 18.4 percent of the average timber income in Schleswig-Holstein (Ehlers 1970). A report from the state of North-Rhein-Westphalia (Rau 1969) indicates that demand for forest greenery has grown steadily. Market tests in 1967 for conifer greens indicated strong consumer demand but individual suppliers could not supply the product regularly. A later report (Rau 1977) indicates that a Decorative Green Growers Association had been formed and had sponsored research on sales of decorative greens. Average household consumption of greens in North Rhein - Westphalia was estimated at 5 kg annually and total sales equalled DM16.1 million (about US$10 million).

**MEXICO'S SACRED FIR**

The sacred fir, *Abies religiousa*, known to the people of Mexico as *oyamel, abeto* or *arbolito de Navidad*, is a large tree which forms pure, or nearly pure forests at elevations between 2 700 and 3 400 meters in the mountains of central Mexico. Like most species of *Abies*, this tree has fragrant foliage of a rich, green colour.

Both the scientific and common name of this tree originate from a Mexican tradition of people going into the mountains to gather the branches of this tree to decorate churches and homes during religious festivals (Fig 4.1). This practice is carried out throughout the year and during the Christmas season, bright red bows are added to the branches.

Several groves of *Abies religiousa* in the state of Michoacan, are the overwintering sites of the migratory monarch butterfly, *Danaus plexippus*. Each autumn, thousands of adult monarchs, from as far away as eastern Canada, migrate south to spend the winter in these groves (Ciesla 1988).

Figure 4.1: A rural resident in the State of Toluca, Mexico, returns home with boughs of *Abies religiousa.* Greenery from this tree is used to decorate churches and homes during religious festivals.

Another report from North-Rhein - Westphalia analyses the means for acquiring boughs for retail sales. Three major strategies are suggested: gathering greens using a company's own personnel, contracting for green collection or obtaining greens from a wholesaler. Studies show that contracting for collection of greens is the most efficient but it is recommended that each company conduct its own analysis. Most of the work is seasonal by nature with delivery for most products from October through December. Average productivity per contracted worker per hour for gathering greenery ranges from 50 kg for finely branched greens such as those harvested from *Chamaecyparis lawsoniana* to 150 kg for *Pseudotsuga menziesii* and *Pinus strobus* when bundled into 5-kg packages. State forest workers were 40-50 percent less efficient than contracted workers who were paid for piece work (Möhrer 1977).

International exports in perishable greenery products could increase substantially if more efficient means of product preservation were developed for the more perishable products. Boughs must not be allowed to dry out. Foliage of some members of the family Cupressaceae (*Calcocedrus, Chamaecyparis, Thuja*) will sour if not kept cool and moist (Thomas and Schumann 1992). In addition, the foliage of *Pseudotsuga menziesii* often turns yellow after packing and it is difficult to maintain the blue colour of the foliage of *Picea pungens* (Möhrer 1977).

## PINE NEEDLES

### Mulch

Opportunities for harvesting pine needles for mulch in south-eastern United States, where fast growing pine forests and plantations are abundant (*P. elliottii, P. palustris, P. taeda*), is reviewed by Beckwith *et al.* (1995) and Stanton and Hamilton (1993). In this region, the use of pine needles for mulches in landscaping has become popular. Consequently, the carpet of pine needles under a pine stand has become a valuable resource and harvesting and selling of pine "straw" has become a profitable enterprise for forest farmers. Since the pine mulch breaks down rapidly and must be replaced at 1-2 year intervals, there is an almost unlimited market for this product.

The needles of *P. elliottii* and *P. palustris* are long and can be readily baled. The needles of these pines provide an excellent ground cover. *Pinus taeda* needles are shorter and more difficult to bail but are also an excellent ground cover.

Needles fall throughout the year, but in south-eastern United States, heaviest needle shedding occurs between September and October during normal weather conditions. December, January and February are good months for gathering pine straw, provided that the bales are delivered directly to the dealer or stored under a shelter.

Pine straw is usually gathered into piles with a pitchfork or mechanical rake for bailing. Where the understory vegetation prevents the use of tractor mounted rakes, pine straw is raked and piled entirely with pitchforks. Baling pine straw is a labour-intensive process. One person loads the straw into the baler with a pitchfork and another ties the wire that binds the bale and a third person stacks the bales. A three-person crew can produce from 250 to 300 bales per day. Higher production can be achieved if partial windrows can be formed and the straw then fed into the pickup reel of the baler, where it is mechanically tied with twine. The most efficient production is attained when the straw is raked into long, clean windrows, picked up mechanically, baled and pushed out to the side. Production by this method can achieve 1 000 bales per day.

Pine straw harvesting can begin in pine plantations as early as age six when yields as high as 110 150 bales/ha, every two years, have been reported. Fifteen-year-old pine forests can yield in excess of 440 bales/ha. Vigorous young to mid-age forests will yield more pine straw that older, lower vigour forests. A low annual yield is 110 bales/ha, an average yield is 150 bales/ha and a high yield is 220 bales/ha.

Yields of pine straw can be increased through fertilization. Bales free of cones, hardwood leaves and limbs are the most desired. To produce clean bales of pine straw, stands should be free of undergrowth and debris. Mechanized bailing operations on good sites can produce 1 000 bales/day. Bales of pine straw currently sell for US$2.50 wholesale and US$4.00 retail. Many forest landowners often sell their pine straw to producers who do the raking and baling. The producer pays by the bale with prices ranging from US$0.25 to US$1.00 per bale.

Advantages of pine straw harvesting in pine forests include:

- it provides a source of income while trees are being grown for timber or pulpwood;
- weed control and fertilization to increase pine straw production may improve timber productivity;
- forest land owners can obtain a reasonable income with little personal input by leasing pine straw bailing rights to a commercial producer.

Potential disadvantages to harvesting of pine straw include:

- removal of pine straw could alter the nutrient balance of forests;
- a clean understory may reduce wildlife populations in forests managed for pine straw production;
- potential damages to trees through mechanized straw harvesting and bailing in the forest.

A problem that has been encountered in this relatively new enterprise is illegal entry on private lands by pine straw harvesters. Legislation has recently been introduced into the state legislatures of the States of Georgia and North Carolina to regulate pine straw gathering. In Georgia a bill has been drafted which requires a person selling pine straw to a dealer to present a valid business license or state tax identification number. In North Carolina a bill has been drafted which would make trespassing on land used for pine straw production a crime[6].

## Decorative baskets

Decorative baskets are made from pine needles by several indigenous forest dwelling tribes. In Nicaragua, the Misketa Indians, a tribe that inhabits areas dominated by forests of *Pinus caribaea*, in the Regiôn Autónomo Atlántico Norte (RAAN) produce small baskets made from the needles of this tree. These baskets are made from long coils of pine needles approximately 0.75 cm in diameter. The coils are held together with a fine brown coloured thread. A basket, about 8 cm high and 12 cm in diameter sells for approximately US$5.00 in Puerto Cabezas, Nicaragua (Author's observation) (Fig 4.2).

Figure 4.2: Baskets made from the needles of *Pinus caribaea* by the Misketa Indians, Puerto Cabezas, Nicaragua.

[6] Information obtained from the Georgia House of Representatives and the North Carolina General Assembly via the World Wide Web.

Several tribes make baskets of a similar design in southern United States. The needles of *Pinus taeda* are used for baskets by the Alabama and Cushatta Indians, two tribes which jointly occupy a reservation in east Texas, United States (Author's observation). They make intricate baskets that resemble indigenous animals of the region (e.g. turtles, crawfish and skunks). Pine needles for basket construction are gathered and dried thoroughly in the sun. Before basket construction begins, the needles are soaked in warm water for at least one half hour to allow them to regain their flexibility[7].

## OTHER USES OF CONIFER FOLIAGE

In India, pine needles from which essential oils (see Chapter 7) have been extracted are known as "pine wool." This material has been used for stuffing mattresses, upholstery and coarse matting (Maheshwari and Konar 1971). Pine needles are also used as packing for apples in Northern India (P. Vantomme, FAO, Rome, personal communication).

In Germany and other European countries, it was once a common practice in conifer stands to gather needles of Pines and/or other conifers like *Picea abies* from the forest floor to use in barns as bedding for livestock or as organic material for agriculture croplands or for preparing compost for the cultivation of flowers, such as *Azaleas.* In Lithuania, from 1962 to 1990, meal produced from pine and spruce needles was used as an admixture to cattle fodder (Rutkauskas A. 1998).

The fragrant foliage of *Abies balsamea* is used as stuffing for souvenir pillows which are often sold in curio shops (Tang-Shui Liu 1971).

The Thomson and Lilloet Interior Salish people of the interior regions of British Columbia, Canada, used conifer boughs as scrubbers and scents in washing the body or sweat bathing during puberty rites, in preparation for hunting or shamanistic healing (Turner 1988). The Sannish Indians, a branch of the Coastal Salish which occupied Vancouver Island, British Columbia, hung the highly scented branches of *Juniperus scopulorum* around the walls of houses when people became ill in order to drive away the disease (Turner and Bell 1971).

The foliage of several species of *Taxus* are potentially important sources of taxol or analogues of taxol, a drug that is effective in treating certain types of cancer (see Chapter 5 for details).

An extract from the foliage of *Ginkgo biloba,* designated as EGb 761, has been used in Europe to alleviate symptoms associated with cognitive disorders. Recently, a study was conducted in the United States that suggests that this extract appears capable of stabilizing and sometimes improving the cognitive performance and social functioning of patients suffering from mild to severe dementia due to Alzheimer disease (LeBars *et al.* 1997).

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[7] Information obtained from Tara Prindle, University of Connecticut, Storrs CT, USA via the World Wide Web.

# CHAPTER 5
# BARK AND ROOTS

Virtually since the beginning of human civilization, the bark and roots of conifers have been used for a variety of purposes. For example, across Eurasia, a product known as *pettu*, made from the inner bark of *Pinus sylvestris,* was used as survival food (Johnson Gottesfeld 1992). The inner bark of *P. sylvestris* also formed a considerable portion of the diet of the Laplanders (Gaertner 1970). In Japan, the bark of *Cryptomeria japonica* was used as roofing material (Hora 1981). Tannin, taken from the bark of several species of conifers, has been used to tan animal skins and produce leather. Recently, taxol, a product from the bark of *Taxus brevifolia,* has been found to be valuable in the treatment of certain cancers. In addition, initiatives to increase utilization of large volumes of waste bark from the wood products industry have resulted in a number of innovative uses, including decorative ones.

## TRADITIONAL USES

### Inner bark as food

Several forest dwelling, indigenous tribes of north-western British Columbia, Canada, obtained a staple food by processing the cambium and inner bark of the western hemlock, *Tsuga heterophylla,* into "cakes." These were stored in a dried form and could be reconstituted by soaking chunks of dried cake into water. The Haisla and Gitksan devoted considerable attention to obtaining and processing hemlock cambium. Suitability of a tree was determined by making a test scraping of the bark and tasting it for tenderness and sweetness. Certain sites were known for their high quality cambium.

The Haisla gathered western hemlock bark in late June or July. Trees about 60 cm in diameter were chosen for harvest. Bark was removed and the inner bark was scraped off of the inside of a bark section with a special curved knife. The tree was usually felled or stripped and girdled while standing. A single tree yielded 2-3 baskets of cambium. Each basket could be processed into 4-5 cakes. The cambium was pit-cooked overnight and was then pounded to soften it. The pounded bark was formed into cakes and sun dried or smoked. Each family stored about 30-40 cakes for winter. A more contemporary version of this technique involves processing the cambium in canning jars. These cakes were used as a sweetener for other foods.

The cambium of lodgepole pine, *Pinus contorta*, was second in importance to hemlock cambium as a food source. It was used by the Wet'suwet'en and Gitksan tribes in the interior of north-western British Columbia. The inner bark was harvested from young standing trees in May and June, a time when the bark is of maximum sweetness and is loose and easy to harvest (Johnson Gottesfeld 1992).

Other indigenous tribes across North America also made use of conifer bark as food. The Adirondack indians of northern New York State used the bark of a number of conifers for food. Bark was such an important part of their diet that their name in the Mohawk indian language means "tree eaters" (Gaertner 1970).

### Medicinal uses

The bark of several species of indigenous conifers were used by the Gitskan, Haisla and Wet'suet'en tribes of north-western British Columbia, Canada, to help cure a variety of illnesses (Table 5.1). In some cases, extracts of pure bark were used. In other cases, bark was mixed with the foliage of devil's club, *Oplopanax horridus* and other shrubs.

**Table 5.1**
**Uses of conifer bark for medicinal purposes by indigenous tribes of North-western British Columbia, Canada**

| Species | *Illness* | *Tribes which used remedy* |
|---|---|---|
| *Picea engelmanni x glauca* | Tonic, flu, colds | Gitksan, Wet'suet'en |
| *Abies lasiocarpa** | Tonic, flu, colds | Gitksan, Wet'suet'en |
| *Abies amabilis** | Tonic, sickness | Haisla |
| *Pinus contorta** | Tonic, unspecified | Gitksan |
| *Tsuga heterophylla* | Cleaner, gall bladder, Swallowed sharp objects | Gitksan |

* Often mixed with foliage of devils club, *Oplopanax horridus* and other shrubs.
Source: Johnson Gottesfeld (1992).

The Quinault tribe of north-western Washington and the Karuk tribe of northern California, United States, peeled, dried and boiled the roots of the Pacific yew, *Taxus brevifolia*, to make tea. The Quinaults drank the liquid as lung medication (Gunther 1973), while the Karuk used it to relieve stomach aches and kidney problems (Davis and Hendrix 1992).

The bark of *Cedrus deodara* has been used in India as a medicine for fevers, diarrhea and dysentery (Maheshwari and Chhaya Biswas 1970).

## Natural dyes

The inner bark of eastern hemlock, *Tsuga canadensis*, is cinnamon red to purplish in colour and is the source of a natural dye. In the Southern Appalachian Mountains of the United States, hemlock bark has been used for dying wool a brown colour. Hemlock bark also dyes leather a reddish tone. The bark from the roots of this tree is used to dye basketry materials and produces a range of colours depending on the chemical mordant used in the dye bath. Hemlock root bark dyes raffia[8] pink without a pre-mordant, pink-tan with alum, rust with chrome and brown with copper sulphate (Hart and Hart 1976). In the New England States, both indigenous tribes and early European settlers used also bark of this tree as a dye source (Hussey 1974).

The bark of the western hemlock, *Tsuga heterophylla*, produces a reddish dye that the Coastal Salish indians of Vancouver Island, British Columbia, Canada, used for several purposes. Young girls used this dye to paint their cheeks. Indigenous tribes in Washington, United States, to colour paddles also used dye from the bark of western hemlock, fish nets and spears (Turner and Bell, 1971).

In India, the roots of *Juniperus communis* are used to produce a purple-coloured dye.[9]

[8] Raffia is a material used in basketry made in Madagascar by cutting palm leaves before they uncurl, stripping the undersides of the leaves, drying the strips and splitting them into desired widths (Hart and Hart 1976).

[9] Information provided by Dr. M.P. Shiva, Centre of Minor Forest Products, Dehra Dun, India.

## Other uses

The inner bark of the western red cedar, *Thuja plicata,* and Alaska yellow cedar, *Chamaecyparis nootkatensis,* were used for a variety of items by the indigenous tribes of the Pacific north-western region of North America. During the transition from spring to summer, women went into the forest and sought out young cedar trees. After saying a prayer for the tree's soul, they notched the bark near the base, loosened it carefully and tried to tear a long strip of bark free, tearing upward. The inner, lighter bark was separated from the rough outer bark and brought home to be used in various ways. Raw bark was often transformed into a water ladle or a small canoe. Of greater importance, however, was the prepared bark that was beaten until it became a soft fibre. It was then separated into strips and bands of varying width. This fibre was one of the raw materials used for coarser woven products such as mats, baskets and shawls, cord for hanging fish in the smokehouse and lashings for shelters (Bruggmann and Gerber 1989).

The bark of *Thuja plicata,* pounded into a soft fibre with a special stone or whalebone tool, was used for bandages and diapers by the Haisla and other coastal tribes. Spun bark fibre was twined into clothing, blankets and capes and was also used for string. The Haisla revered the inner bark of *Chamaecyparis nootkatensis* because this tree had a superior softness. Only nobility wore the fibre of this tree. Whole red cedar bark was stripped from trees in sheets to serve as roofing and for tarpaulins. The Wet'suwet'en tribe used the bark of spruce, *Picea glauca* and *Picea engelmanni*, for roofing shelters. It was more available than cedar bark, but less durable. (Johnson Gottesfeld 1992).

Baskets and various articles of clothing were made from strips of cedar bark, often used in combination with other materials such as fine, peeled roots of spruce, *Picea sitchensis,* and grasses. A twined weaving technique using fibre of cedar bark and dried grasses was done by the Nootka Indians, who inhabit Vancouver Island, Canada, and the north-west corner of the Olympic Peninsula of Washington, to make baskets. Roots of spruce and cedar were well suited for the coil technique, which guaranteed a watertight weave. When using this method, the weaver works with two weft strands, which are crossed over each other at each warp strand. This process results in a tighter weave than the less useful plaiting technique (Bruggmann and Gerber 1989).

Weavings made from roots of spruce are works of art. Examples include watertight whaler's hats woven by Haida weavers such as Isabella Edenshaw (1858-1926) and painted by her husband Charles Edenshaw, a famous Haida artist (1838-1920). Typical designs depict animals indigenous to the region such as ravens, whales, salmon etc. Several contemporary artists have maintained the tradition of spruce root basket weaving. These include Haida weavers Holly Churchill-Burns and her sister April Churchill-Varnell of Ketchikan, Alaska, who learned the technique from their grandmother, Selina Peratrovich of Masset, Queen Charlotte Islands, British Columbia, Canada (Bruggmann and Gerber 1989). Haida hats woven from cedar bark currently sell for around US$295.

The Tlingit of south-eastern Alaska also made spruce root baskets. The women of the Chikat Tlingit made decorative hats from spruce roots. A hat for a chief would be decorated on top with the skin of an ermine and painted with intricate designs such as cylindrical rings which are said to represent the number of potlatches (a traditional festival) hosted by the wearer. Tlingit baskets woven from spruce roots and multicoloured grasses contained intricate patterns. A blue colour for the patterns was created from crushed huckleberries (Bruggmann and Gerber 1989).

Local indigenous tribes which occupied what is now known as the New England States of north-eastern United States used the fine roots of *Picea glauca, P. mariana* and *P. rubens* to make robes, tackle, woven mats and thread (Hussey 1974).

In California, United States, the Pomo Indians used the roots of *Tórreya californica*, an endemic conifer, to make baskets (Burke 1975).

The Cahuilla Indians, a tribe that once occupied the Mojave Dessert of California used the fibrous bark of *Juniperus californica* to diaper infants[10].

The Thomson and Lilloet Interior Salish of British Columbia, Canada, used sheets of bark for various purposes. The smooth bark of *Abies* spp. was used for roofing and canoes. The bark of *Picea engelmannii* was used for roofing, canoes, baskets and utensils, the bark of *Thuja plicata* was used for roofing, wall lining and mats and the bark of *Pinus contorta* was used for lodge coverings (Turner 1988).

Today, most bark products of the indigenous forest dwelling people of the Pacific north-west region of North America have been replaced by either manufactured or agricultural products. However, some uses still persist, especially uses of medicinal barks gathered by older people for self-treatment or treatment of friends and relatives. Bark of cedar and willow, *Salix* spp., are still preferred cords for hanging fish in smokehouses. Cedar and spruce basketry are enjoying a revival as handicrafts for cash sale. Their functional importance, however, is virtually nil because of manufactured substitutes (Johnson Gottesfeld 1992).

Strips of outer bark of *Juniperus excelsa* have been a traditional roofing material in villages in the Province of Balochistan, south-western Pakistan, which are located in close proximity to forests of this species. This material is still widely used today (Author's observation).

## TAXOL

### Description and uses

Taxol is a plant-derived anti cancer drug. Its anti cancer properties were discovered during clinical trials conducted by the National Cancer Institute (NCI) of the United States. This compound was first isolated from the bark of the Pacific yew, *Taxus brevifolia*, a slow growing, small to medium tree which is a component of the understory of old growth forests of the Pacific north-west region of Canada and the United States (Fig. 5.2, 5.3). Taxol is also found in the bark and needles of related species of *Taxus* throughout the world.

Clinical studies of taxol first began in 1983 and, by 1988, preliminary results suggested that this material was active against ovarian cancer, a form of cancer generally resistant to chemotherapy and from which nearly 12 500 women die each year. Tests on more than 200 patients with recurrent ovarian cancer indicated that at least 30 percent of the patients had responded to some degree. These studies also indicated that taxol has potential for treating other types of cancer, including advanced breast cancer. In 1992, the Food and Drug Administration of the United States (FDA) approved a new drug application for taxol from the bark of *Taxus brevifolia* for commercial use (NCI 1992).

As a result of this research, there was a sudden, high demand for the bark of Pacific Yew and during the late 1980s, NCI contracted to have yew bark collected from National Forest lands, primarily in Oregon and Washington. Approximately 60 000 kg of bark were subsequently collected. NCI then contracted with a private pharmaceutical company, Bristol Myers-Squibb (BMS), to develop the drug, find a reliable taxol source and bring the drug to market. BMS then harvested over 700 000 kg of dry

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[10] Information obtained from Joshua Trees National Monument, USDI, National Park Service, California, USA.

yew bark from federal forest lands (Forest Service and Bureau of Land Management [BLM]) in 1991 and 1992. Collection of yew bark provided jobs for 550 workers from local communities from May through August 1991 and for 1 115 workers for the same period in 1992 (Wolf and Wortman 1992).

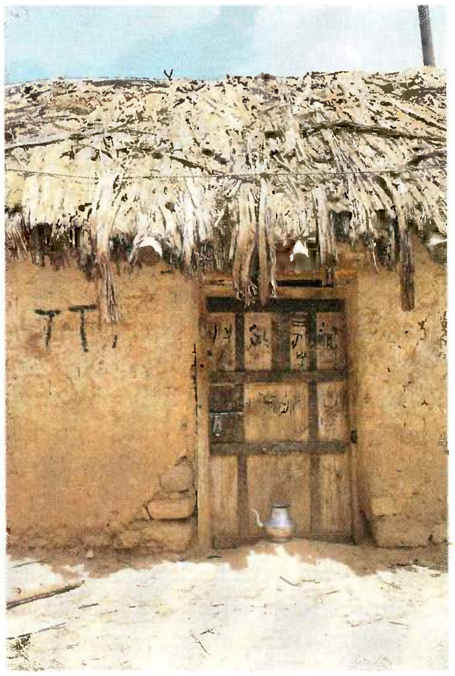


Figure 5.1: A building in Balochistan Province, Pakistan with roof made from strips of the bark of *Juniperus excelsa.*

Because of concern over the potential adverse environmental impacts of an increased demand for slow-growing trees with limited natural range, the Federal Pacific Yew Act (Public Law 102-335 106 Stat. 859) was passed by the United States Congress and signed into law in August 1992. This act ensured that the Forest Service and BLM would carry out efficient collection and utilization of Pacific yew for taxol, specify conditions of sale of Pacific yew from federal forest lands, ensure long-term conservation of Pacific yew and prevent waste of this resource. An environmental impact statement was prepared jointly by USDA Forest Service, the USDI Bureau of Land Management and the Food and Drug Administration of the United States Department of Health to examine alternative harvesting schedules for Pacific yew. For the five-year period 1993-1997, the EIS defined an annual harvest level from federal forest lands to be from 117 000 to 175 000 kg of dry bark and/or from 312 000 to 468 000 kg of dry needles, approximately, from an estimated number of 52 000 to 78 000 yew trees (USDA Forest Service 1993).

The Ministry of Forests, Government of the Province of British Columbia, Canada, shared the concern for accelerated harvesting of yew where there was also a sudden, increased pressure on the *Taxus brevifolia* population due to the discovery of the medicinal properties of taxol. A policy was formulated to "support and promote the orderly harvesting of bark from western yew [11]." Guidelines for the harvesting of yew bark were designed to facilitate the long-term survival of yew and to maintain its genetic diversity. These provided for yew harvesting in the following areas:

[11] Government of British Columbia, Canada, Ministry of Forests, Ministry Policy Manual - Policy 8.12 - Yew Bark Harvesting and Collection - Special Forest Products dated 1 October 1993.

1. Areas approved for harvesting under an existing agreement, with the consent of the agreement holder.
2. Areas that will be imminently approved for harvesting under an agreement, with a free use permit issued by a District Ranger.
3. Areas reserved from conventional harvesting, with a free use permit issued by the District Manager that will authorize the harvest of yew bark but require a minimum number of stems to be left in a range of age and size classes.
4. In young stands, with a free use permit issued by the District Manager that will authorize harvest of yew bark but require a minimum number of stems to be left.

The harvesting of yew needles is administered in the same manner under this policy. Needles may be harvested from 50 percent of the yew trees by diameter class in a clump and no more than 50 percent of the foliage may be removed from any one tree. Current policy does not require harvesters of yew bark or needles to make payments to the Crown for these products. However, if yew logs are removed, the logs must be scaled and stumpage will be charged.

## Harvesting methods

During the late 1980s and early 1990s only bark was collected from *Taxus brevifolia* for recovery of taxol. Needles could be harvested but there was no current demand and no approved FDA process for extracting taxol from needles. Harvesting of yew bark is done by stripping the bark from live trees. The bark can be stripped from standing trees or from trees that have been recently felled. The bark is stripped from all of the trunk and limbs down to a diameter of about 2.5 cm. Yew bark is harvested in the spring and early summer when there is more available taxol in the bark and the bark is easier to strip. At other times of the year, the lack of fluid in the bark reduces the taxol content and causes the bark to stick to the tree. Yew bark can be harvested as soon as the sap begins to flow in the spring. The stripped bark is packed out by humans, draft animals or, where access is possible, by all-terrain vehicles (USDA Forest Service 1993).

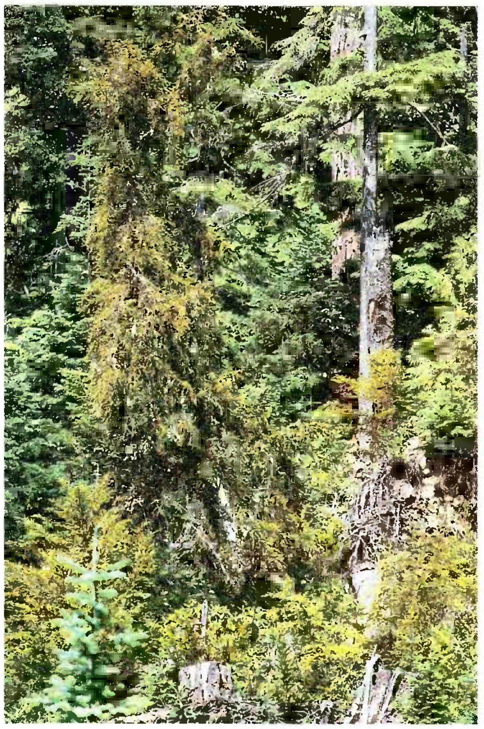

Figure 5.2: A western yew, *Taxus brevifolia,* is the prime source of the anti-cancer drug taxol.

Fig 5.3: Close-up of the foliage of *Taxus brevifolia.*

## Alternative sources

As part of its research and development programme for taxol, BMS aggressively pursued alternative methods for producing this material in order to decrease its dependence on the bark of *Taxus brevifolia* growing in natural forests. The company recognized that naturally occurring Pacific yew is a finite resource and did not consider it to be a sustainable source for long-term taxol production. Research directions that were pursued included:

- extraction of taxol from renewable sources;
- semi-synthesis: chemical conversion of natural materials similar to taxol into taxol;
- plant cell culture, in which taxol would be produced in the laboratory from cells of yew tissues;
- total synthesis, which chemically duplicates the taxol molecule. The taxol molecule is extremely complex and this alternative was considered to be very difficult.

Taxol has been found in other species of *Taxus* around the world. For example, the foliage of *T. cuspida*, a species found in Japan, Korea, Manchuria, China (Vidakovic 1991) and the Russian Far East (de Beer n.d.) has recently been found to contain significant amounts of taxol (Fett Neto and DiCosmo 1992). However, the varying amounts of taxol found in these species and the difficulties associated with handling and storing the biomass created problems more difficult than harvesting the bark of Pacific yew. In addition, BMS subsequently explored the large-scale cultivation of various species of *Taxus* in nurseries and use of clippings from ornamental yews (Bristol Myers-Squibb 1993). Another promising alternative to taxol is taxotere, a related compound or analogue. Taxotere is produced by chemically altering a compound extracted from the needles of *Taxus baccata,* the European yew. The needles of this species are abundant, easily collected and renewable and the yield of taxotere from needles is greater than that of taxol from the bark of *T. brevifolia.* This material has shown promises in early clinical trials (NCI 1993).

In January 1993, BMS announced that, as a result of significant progress with alternative approaches, the company no longer needed to purchase large quantities of yew bark from federal forest lands, thus relieving pressure on a limited forest resource (USDA Forest Service 1993).

## TANNIN

### Historical background

Tanning hides with extracts of bark from trees is an ancient technique dating back at least 5 000 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 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 dating from 3000 BC and was known to the Chinese as early as in 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, which 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.

Tannins are chemically classified into two groups, the hydrolysable tannins and the 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 very 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 blue-green colour, which is the basis for the production of inks. Tannins are also used as mordant in dyes (Prance and Prance 1993).

### Sources

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., hemlock, *Tsuga* spp., oaks and related genera, *Quercus, Castanea, Lithocarpus*, and certain mangrove species.

One of the primary coniferous sources of tannins is the bark of the eastern hemlock, *Tsuga canadensis*, a tree that is widely distributed across eastern North America. The bark of this tree has a tannin content of about 10-12 percent and was used to tan sheepskins and heavy leather for shoes in the United States during the late nineteenth and early years of the twentieth centuries. The trees were felled and the bark removed in spring with a bark spud when the sap was flowing and the bark was easiest to peel. A four-person barking crew was used for this work and consisted of a spudder, a feller and two "bucklers" who chipped off chunks of bark roughly 1.2 meters in length and 45 cm wide. The bark was then dried and the tannin extracted by open diffusion or percolation (Prance and Prance 1993).

In 1900, 1.2 million cords of hemlock bark was harvested in the United States and accounted for 72 percent of all tannins used. Harvesting operations were carried out over an area of roughly 400 000 ha across eastern United States. About 2.5 cords of bark were required to tan 100 hides. The industry was a destructive one, which ultimately led to extensive deforestation of hemlock forests (Hergbert 1983, Prance and Prance 1993). During the early years of hemlock bark harvesting, the remainder of the trees was not utilized because there was no demand for hemlock lumber. The barked logs were simply left to decay in the forest. Eventually, the logs were marketed as a by-product of the tanning industry.

By the 1930's, hemlock supplied only 18 percent of the raw material for the American tanning industry. As the area of hemlock forest declined, the industry moved further south into the forests of oak and chestnut to draw upon an alternative source of supply. Eventually, the American leather tanning industry relied on importation of tannin from foreign sources or tanning was done by alternative chemical processes (Hall 1971, Hergbert 1983).

The bark of the western hemlock, *Tsuga heterophylla*, a tree indigenous to the north-western United States and adjoining portions of Canada and Alaska, was used as a source of tannin during the early years of this century but on a relatively small scale. Later, research indicated that the bark of three western North American conifers: *T. heterophylla, Pseudotsuga menziesii* and *Sequoia sempervirens* were potentially strong sources of tannin. As a result, some plants were built during the 1950s to supplement supplies of imported tannins. However, most of the product was used as dispersant to control the viscosity of oil well-drilling fluids (Hergbert 1983).

According to a report from Chile, the bark of *Pinus radiata* contains approximately 10-11 percent tannin. In an attempt to utilize this resource in conjunction with harvest of timber products from the country's 1.5 million ha of pine plantations, a tannin extraction plant was developed in the VIII Region, in the heart of Chile's pine plantations. This plant has the capacity to produce 600 tonnes of tannin/year. Unfortunately, the market for Chilean-produced pine tannin is limited and the plant is presently not operating (Garfias Salinas *et al.* 1995).

In Europe, the bark of *Picea abies* has been used as a source of tannin in the leather industry (Hora 1981).

## EFFORTS TO INCREASE UTILIZATION OF WASTE BARK

With the exception of the specialized products described in the preceding sections, tree bark was generally considered to be a waste product of the timber industry, which required disposal. This was typically done by burning bark, along with wood residues (sawdust, shavings, wood chips, etc.) in a device commonly known as a "tepee" or "wigwam" burner. These devices frequently caused smoke pollution, especially in the mountain valleys of timber-producing regions where concentrations of sawmills and other wood processing plants are typically located. At one stage, the annual volume of bark requiring disposal in the United States was estimated to be between 7 and 20 million tonnes, while in New Zealand, for example, between 0.25 and 0.50 million tonnes of waste bark were generated annually (Ellis 1973).

During the late 1960s and early 1970s, the need for increased utilization of tree bark was recognized as a means of reducing volume of waste bark requiring disposal. This led to the development of a number of new by-products of the timber industry.

## Absorption of oil spills

In recent years, oil spills, especially in salt water, have resulted in pollution episodes of disastrous proportions, involving losses of wildlife and fisheries resources as well as damage to beaches, boats, docks, marinas, etc. The ability of bark to absorb oil was first reported in Sweden following an accidental oil spill. Investigations following this discovery measured the amount and rate of oil sorption by various bark particle sizes and species (Fahlvik 1967, Anon 1968). In 1968, the Texas Forest Service Forest Products Laboratory of the Texas State Forest Service began to investigate the capacity of bark from southern yellow pines (*Pinus echinata* and *P. taeda*) to absorb accidental oil spills. Initial studies indicated that southern yellow pine bark absorbed up to four times its weight in oil, with the sorption rate dropping off hyperbolically as bark particle size increased. It was also found that the bark itself contributed some pollutants to cold water but these pollutants do not appear serious if bark is properly applied (Martin *et al.* 1973). A three-step processing of pine bark was subsequently developed which involves breaking bark into small fragments, drying the bark and screening it. Processed bark could be delivered to coastal areas in Texas for about US$ 20-30/tonne. This product could be used with ship mounted booms to act as barriers to oil slicks and to absorb and hold the oil. Oil soaked bark is then retrieved manually with special nets or mechanically by pumps (Weldon 1973).

Effective use of pine bark as a means of containing and absorbing oil spills requires the availability of a huge volume of bark. For example, it was estimated that a spill the size of the Torrey Canyon spill would have required at least 30 000 tonnes of pine bark. This represented a volume equal to total bark production of every pinewood processing plant in Texas for a period of three weeks (Weldon 1973).

## Particleboard

Manufacturers in several countries (Finland, Germany and the United States) have developed a process of making particleboard either entirely or partially from bark. As early as 1961, a report from the former German Democratic Republic (East Germany) indicated that 20 000 tonnes of spruce bark were used annually in the manufacture of particleboard. A similar product was produced in the Czech Republic (Hall 1971).

Suggested uses of particleboard made from bark include:

- roof insulation of panel homes;
- heat and sound insulation under wooden floors;
- middle layers of crosspieces;
- vertical and horizontal insulating elements in industrial and agricultural buildings.

According to Pollard (1973), the investment costs of making a bark board product over a wood-based particleboard is increased in that additional drying is required. Operating costs are somewhat higher due to the need for more drying capacity, higher resin consumption and higher freight costs because of the higher density of this material. Several plants in north-western United States produced this product. However, when a surplus of pulp chips appeared on the market, bark based particleboards received stiff competition (Hall 1971).

## Use of bark as a soil amendment and in landscaping

Finely milled, clean softwood bark *(Abies, Picea, Pinus, Pseudotsuga)* is becoming accepted as a substitute for peat moss as a mulch and soil amendment. The pH of conifer bark is generally around 3.8 -4, which is almost exactly that of peat moss. Bark tends to be more uniform than peat moss, which varies depending on where it is harvested. The nursery industry is becoming a large buyer of pine bark as a substitute for peat moss (Thomas and Schumann 1992).

The soil-less growing media used by the greenhouse industry contains about 10-60 percent conifer bark (Thomas and Schumann 1992).

In the United States, a number of bark products are sold as landscaping materials to conserve soil moisture, reduce weed growth, moderate soil temperature and prevent erosion. **Pine mulch** consists of fine particles of conifer bark. **Pine nuggets** or **decorative bark** consists of pieces of thick "western pine or fir" (*Pinus ponderosa* or *Pseudotsuga menziesii*) bark, coarsely subdivided by mechanical means and smoothed and rounded by an abrasive process (Hall 1971). Up to three grades of coarseness are available: small, medium and large. This material is commonly spread across plant beds for decorative purposes and as a means of weed control. A common procedure is to cover plant beds with a heavy grade black plastic, then spread a layer of bark chips over the plastic. This results in an attractive, weed-free landscape. Shredded "cypress" or "western cedar" (*Thuja plicata*) bark is also sold for the same purpose. This product is also popular for covering walkways in formal gardens. Decorative bark chips are commonly sold in garden shops or plant nurseries in 2-3 cubic foot (56-84 litre) bags and sell for approximately US$3.50-6.00 each. This material can also be purchased in bulk quantities from dealers who sell sand and gravel (Author's observation).

## Silvacon

Silvacon is the trademark of products derived from the bark of *Pseudotsuga menziesii* by a patented fractionation method. This produces three basic components:

- pliable spongy cork flakes;
- tough, needle-like fibres;
- fine amorphous powders.

This line of products was developed by the Weyerhaeuser Corporation beginning about 1947 and has a wide range of uses (Hall 1971). These include:

- phenolic moulding compounds;
- adhesive extenders;
- rubber products;
- additive to foundry sands;
- vinyl products and flooring;
- thermoplastic resin extension;
- asphalt products and coatings;
- manganese cement composition.

Unfortunately, many of the uses of this product were not developed to a great degree and, over time, changes in technology changed processes and products. For example, the uses of the cork fractions have been greatly reduced by increased use of plastics. Consequently, this venture has been only moderately successful (Hall 1971).

## Other uses of conifer bark

Other uses or potential uses of conifer bark include:

1. Fuel for power generation or domestic uses (Hall 1971);
2. Charcoal production (Hall 1971);
3. Extraction of chemicals and waxes (Hall 1971);
4. Capture of odours from Kraft paper mills (Martin and Crawford 1973);
5. Culture of orchids (Allen and Eng 1973).

# CHAPTER 6
# RESIN

Most conifers will exude resin if wounded. Others will exude resin spontaneously from branches and cones. Several genera of conifers produce resin in copious quantities, which are then harvested and put to a wide variety of uses. These have made resin one of the most important non-wood products from conifers. The following sections describe some of the more important sources and uses of conifer resins.

## RESIN FROM PINES

The resin harvested from various species of *Pinus* is undoubtedly the oldest and most important of the non-wood products from conifers. This subject has been discussed in-depth in a previous paper in this series (Non-Wood Forest Products Series nr. *2: Gum Naval Stores: turpentine and rosin from pine resin,* Coppen and Hone 1995). Therefore, only a brief review will be given in this paper on pine resins, complemented by a review of resins obtained from other conifers. Resins obtained from non-coniferous trees are described in Non-Wood Forest Products Series nr. 6: *Gums, resins and latexes of plant origin,* Coppen 1995b.

### Sources

Resin products from pines are commonly called **naval stores**. This term dates back to the days when the British Royal Navy used large quantities of resin products from pines to waterproof ships (Mirov and Hasbrough 1976). Today, three classes of naval stores are recognized based on their source (Coppen and Hone 1995):

1. **Gum Naval Stores** - These are obtained by tapping the trunks of living pine trees. This is the traditional source of resin and is a labour intensive process.

2. **Sulphate Naval Stores** - Are obtained during the conversion of pine wood chips to pulp via the sulphate or Kraft pulping process. Sulphate turpentine is condensed from the cooking vapours. A product known as **tall oil** is obtained from alkaline liquors and fractionated into products such as tall oil rosin and tall oil fatty acids.

3. **Wood Naval Stores** - Are obtained from resin saturated pine stumps long after a tree has been felled.

### Primary products

Distillation of pine resin yields two products: turpentine and rosin.

***Turpentine***
It is a clear liquid with a pungent odour and bitter taste and is composed of a number of organic compounds, primarily a series of volatile fractions known as terpenes. The chemical composition of turpentine can vary significantly depending on the species of *Pinus* from which it is harvested. In some pines, the terpene composition is relatively simple and consists mainly of two common terpenes: alpha and beta pinenes. Other pine species contain different terpenes, which may significantly affect the composition and use of the turpentine. The resin of the North American pine, *P. contorta,* contains phellandrene, a terpene contained in plants of the parsley family and has a grassy fragrance. The resin

of the Mediterranean species, *P. pinea,* and some North American species contain limonene. *P. ponderosa* resin contains a sweet smelling terpene, known as 3-carene. Two pines endemic to Pacific coastal regions of North America: *P. sabiniana* and *P. jeffreyi,* have no terpene components in their resin. Instead, they contain aldehydes which are much diluted with a gasoline-like material heptane which has no fragrance but is explosive (See textbox - "The gasoline tree"). Aldehydes mixed with heptane provide the characteristic vanilla-like odour associated with *P. jeffreyi* forests (Mirov and Hasbrough 1976).

## THE GASOLINE TREE

At the beginning of the American Civil War, when Union forces were cut off from their normal turpentine sources in south-eastern United States, turpentine production was started in the pine forests of the California foothills. All went well if the resin was taken from ponderosa pine, *Pinus ponderosa,* but what turpentiners did not know was that the resin of Jeffery pine, *P. jeffreyi,* contained heptane, the same inflammable product found in petroleum. Even a trained forester or botanist can have difficulty separating these two species. Firing up primitive turpentine still loaded with pitch from Jeffrey pine was like building a fire under a gasoline truck. Heptane had to be distilled very carefully.

In 1890, a California druggist named D.F. Fryer, distilled heptane from Jeffrey pine in his laboratory and sold it as "Abietine" (oil of fir). In the 1900s, chemists determined that Jeffrey pine turpentine is 95 percent n-heptane ($C_7H_{16}$).

In 1924, the gasoline industry began tests that would ultimately result in smoother gasolines. A supply of heptane was needed for the research. Heptane from Jeffery pine was used in these tests for about two years, then a less complicated method of testing motor fuels was discovered. However, it was with the help of a pine tree that Dr Graham Edgar, then Research Director of the Ethyl Corporation, devised his now famous "octane" scale for measuring knocking qualities of gasoline (Mirov and Hasbrouck 1976).

***Rosin***

It is the major product obtained from pine resin. It is the involatile residue that remains after the distillation of turpentine. Rosin is a brittle, transparent, glassy solid insoluble in water but soluble in a number of organic solvents (Coppen and Hone 1995).

## Historical aspects

Pine resin has been an important commodity at least since biblical times, as attested to by the story of Noah receiving instructions from God to "pitch the ark within and without with pitch". The Roman statesman and poet Ausonius wrote about the tapping of pines for resin in Aquitania in the south-eastern part of France. The pine he referred to is *Pinus pinaster.*

The importance of pine resin to the British shipbuilding industry has already been mentioned. During the fifteenth and sixteenth centuries, when America was a series of British Colonies, the capacity of two indigenous pines: *Pinus elliottii* and *P. palustris*, to produce resins of excellent quality and quantity was recognized and naval stores became an important export commodity from the South Carolina and Georgia colonies. The tapping of resin from these pines was, until recently, a major industry in south-eastern United States when high labour costs reduced its profitability. Today, resin is produced in this region either via the sulphate pulping process or by extraction of resin from saturated pine stumps.

Pine resin was used in California long before the territory became part of the United States. The origin of the name "California" may be linked to pine trees and the resin they produced. Padre Arroyo, one of the early priests who converted the indians of California to Christianity and ultimately wrote a vocabulary of the California Indian languages, told an officer of Captain Beechey's expedition in 1826 that the word "California" was a corruption of the Spanish word *colofón* meaning "resin" and that it was suggested by the numerous pines, *Pinus radiata,* that produced resin around the old Spanish capital of Monterrey (Mirov and Hasbrouck 1976).

In India, commercial tapping of resin from pines began in 1896 following a series of preliminary experiments from 1890 to 1895. The development of resin tapping in India has been entirely the work of the State Forest Departments but the idea for tapping the indigenous pine forests of the Himalayas originally arose after observing the extraction of crude resin by local people (Chaudhari 1995). In Bhutan, tapping of pines is often combined with the extraction of the essential oil "citronella" from lemon grass (*Cymbopogon flexuosus*), common in Chir pine forests (*Pinus roxburgii*) (Chamling 1996).

## Species

Virtually all pines will yield resin if tapped. Key factors that determine feasibility for tapping are the quality (terpene content) and quantity of resin obtained. Today, only the diploxylon[12] (hard) pines are commercially tapped. Both plantations and natural stands are tapped for resin and in some tropical or Southern Hemisphere countries where pines are not native, extensive pine plantations have proven to be excellent resin sources. Species, which are important resin sources today, are summarized in Table 6.1.

## Effects of resin tapping on pines

If done properly, using methods which involve removal of bark only, tapping trees causes no damage to pines and they may be tapped for up to 20 years or more. Even the more traditional methods of tapping which involve some removal of woody tissue may not affect tree survival and trees can be seen in the wild with old tapping scars that seem otherwise quite vigorous. The risk of damage is heightened if excessive wood tissue is removed (Coppen 1995a).

In south-eastern United States, two insects are attracted to turpentine scars. The black turpentine beetle, *Dendroctonus terebrans* (Coleoptera: Scolytidae) is attracted by terpenes released by stumps and injured trees. Trees weakened by fire, logging or adverse climatic conditions or which have exposed resin due to naval stores operations are highly prone to attack. The turpentine borer, *Buprestis apricans* (Coleoptera: Buprestidae) deposits eggs on exposed wood, especially at the edges of turpentine faces or

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[12] Botanists subdivide the genus Pinus into two broad groupings: the soft or haploxylong pines and the hard or diploxylon pines. The soft pines have deciduous needle sheaths, most species have needles in fascicles of five (exception, the piñon pines, which have needles in fascicles of one to three needles), soft, unarmed cone scales and relatively soft white-coloured wood. The hard pines have persistent needle sheaths, most species have needles in fascicles of two to three (rarely five-eight), hard cones scales, mostly armed with spines an dwood that is relatively hard and of a yellowish colour (Harlow and Harrar 1950).

fire scars. The larvae tunnel in the sapwood and heartwood. This insect was very destructive when turpentine orchards were common in the United States. Borer riddled trees were so weakened that they became subject to wind breakage. The lumber value of these trees was virtually destroyed and gum production was reduced. Acid treatment to increase gum flow in naval stores operations eliminated dry faces that were attractive to these insects; thus preventing attacks (Drooz 1985).

**Table 6.1**
**Pines that are important commercial sources of resin**

| Species | *Countries where important* |
|---|---|
| *P. brutia* | Turkey |
| *P. caribaea* | Kenya*, South Africa*, Venezuela* |
| *P. elliottii* | Argentina*, Brazil*, Kenya*, South Africa* |
| *P. halepensis* | Greece |
| *P. kesiya* | China |
| *P. massoniana* | China |
| *P. merkusii* | China, Indonesia, Vietnam |
| *P. oocarpa* | Honduras, Mexico |
| *P. pinaster* | Portugal |
| *P. radiata* | Kenya* |
| *P. roxburghii* | India, Pakistan |
| *P. sylvestris* | Lithuania, Poland, Russia |

* Introduced species.
Sources: Coppen (1995a), Coppen and Hone (1995), Author's observations.

## Uses

### *Unprocessed resin*

Whole, **unprocessed resin** has a number of traditional uses.

In Asia there are numerous records of the use of pine resin for medicinal purposes. In the Karnali Zone of Nepal, the resin of *Pinus roxburghii,* known locally as *Ahule sallo,* is used to relieve the symptoms of a cough. About two grams of resin and an equal amount of common salt are boiled in 250 -300 ml of water and drunk warm before bedtime for 2-4 days. In addition, the resin from *Pinus wallichiana* is used as a plaster for bone fractures. The resin is also mixed with an equal amount of butter and is warmed to make a paste. This ointment is applied to the affected parts regularly before bedtime to soften scar tissue (Bhattarai 1992). In Uttar Pradesh State, India, the resin of *P. roxburghii* was applied to boils, heel cracks and on either side of the eye to reduce swelling (Singh *et al.* 1990). A report from northern Thailand describes a traditional remedy for urinary problems. This consists of pitch from *Pinus merkusii,* mixed with the fruit of screw pine, *Pandanus lucratus*, and three river rocks collected from underneath a bridge. The mixture was boiled and drank (Anderson 1986).

In south-western United States, the Pueblo and Navajo Indians used the resin of various species of piñon pines to give their stone griddles a non-sticking surface, something like the Teflon of today. The Hopi Indians, of American south-west, used resin to repair broken ceramic pottery (Lanner 1981).

The Paya Indians of Honduras use the resin of *Pinus oocarpa* to kill "worms", presumably the larvae of bot flies which burrow into the skin of humans and domestic animals (Lenz 1993).

In Greece, the addition of pine resin to white wine (retsina) is a national tradition (see textbox).

***Rosin and Turpentine***

For many years, both rosin and turpentine were used in an unprocessed form in the manufacture of soaps, papers, paints and varnishes. Today, they are the raw material used in the production of a wide range of products (Table 6.2).

Most rosin is presently modified and used in paper sizing, adhesives, printing inks, rubber compounds and surface coatings (Coppen and Hone 1995). Rosin is also applied to the bows of string instruments and to belting to reduce slipping. It is also used in brewing and mineral beneficiation (Chaudhari 1995).

A number of chemical products are derived from turpentine and rosin (Forbes and Meyer 1956).

**RESIN ADDED TO WHITE WINE: A GREEK TRADITION**

To a non-Greek, the first sip of retsina usually has a mysterious, sometimes unpleasant, taste. One must acquire a taste for this traditional Greek wine. Retsina is made as all wines except that it is lightly resinated, 2 parts/1 000 of pine resin is added to the must at the start of fermentation.

Retsina is a traditional appellation by law. No other country in the world is allowed to produce it.

Adding resin to wine is a process that dates back to antiquity when either pitch, pine resin or a combination of plaster and resin was used to make impermeable clay vases (*amphorae*) in which wine was transported. Ancient Greeks observed that pine resin not only helped seal the amphorae from moisture, but also helped to preserve the wine within. Pine resin may have also been used to squelch the scent of goatskin, in which wine was locally transported.

Cone wine is mentioned frequently in ancient Greek literature and Dionsysus is sometimes depicted with a pinecone at the end of his staff.

The resin is collected from aleppo pine, *Pinus halepensis*. The best resin comes from the Attica Region, near Athens. Approximately 85 percent of retsina is made from two varieties of grapes: Savtiano and Rhoditis. Retsina accounts for about 40 percent of total wine production in Greece. Most retsinas come from the wine growing regions that dominated the ancient trade: Euboea, Attica, Boeotia and Peloponnisos.

Retsina production has been declining slightly because more growers realize that the exotic, sometimes bitter-tasting Greek speciality, is not always welcomed by foreign palates. There has been a trend to produce lighter retsinas, well-crafted white wines with just a hint of resin (Kochilas 1990).

These include:

| | |
|---|---|
| Alpha pinene | Terpene alcohols: |
| Beta pinene | Terpineol |
| Camphene | Borneol |
| Dipentene | Geraniol |
| Maleopimaric acid | Linalool |
| Maleic and phenolic resins | Modified rosins |
| | Metallic resinates |

As has already been mentioned, the composition of turpentine can vary considerably according to the species of pine from which it is harvested and this greatly influences its value and end use. The alpha and beta pinene constituents of turpentine are the starting materials for the synthesis of a wide range of fragrances, flavours, vitamins and polyterpene products and form the basis of a substantial and growing chemical industry. The biggest single turpentine derivative is synthetic pine oil, which is used in disinfectants, cleaning agents and other products with a "pine" odour. Other derivatives include isobornyl acetate, camphor, linalool, citral, citronellol, citronellal and menthol and are used either alone or in the elaboration of other flavour compounds (Coppen and Hone 1995).

**Table 6.2**
**Principle uses of turpentine and rosin**

| Turpentine | Rosin |
|---|---|
| Chemicals and pharmaceuticals | Paper and paper sizing |
| Gums and synthetic resins | Chemicals and pharmaceuticals |
| Paint, varnish and lacquer | Ester gums and synthetic resins |
| Products for railroads and shipyards | Paint, varnish and laquer |
| Shoe polish and related materials | Soap |
| Rubber | Linoleum and floor coverings |
| Printing inks | Adhesives and plastics |
| Adhesives and plastics | Oils and greases |
| Asphaltic products | Rubber |
| Furniture | Printing inks |
| Insecticides and disinfectants | Shoe polish and related materials |

Source: Forbes and Meyer (1956).

## Production and trade

Total world-wide production of rosin is currently about 1.2 million tonnes annually. Of this total, approximately 720 000 tonnes, about 60 percent, is gum rosin (valued at around US$420 million at first half 1994). Most of the remainder is tall oil rosin (35 percent) and the rest is wood rosin. World production of turpentine currently stands at 330 000 tonnes from all sources. Of this total, almost 100 000 tonnes (30 percent) is estimated to be gum turpentine (valued at US$50 million) and the bulk of the remainder is sulphate turpentine (Coppen and Hone 1995). The United States and China are currently the world's largest producers and consumers of turpentine. Most United States requirements are presently met by domestic sulphate turpentine production but some gum turpentine is also imported for fractionation and conversion into derivatives. Chinese requirements are met by the country's own production of gum turpentine.

As labour in the developed countries has become more expensive and fewer workers are willing to undertake the jobs of tapping, gum naval stores production has declined and its centres of production have shifted. During the early 1960s, the United States and former USSR were leading producers of resin and several European countries (France, Greece, Poland, Portugal and Spain) were also major producers (Table 6.3) (Chaudari 1995). Presently, China and Indonesia are leading producers and only one European country, Portugal, is still regarded as a major producer (Table 6.4).

**Table 6.3**
**Major rosin and turpentine producing countries, 1964-1966**
(Country production in percentage of World Average Total Production)

| Country | Rosin (%) | Turpentine (%) |
|---|---|---|
| USA | 47.0 | 42.5 |
| USSR | 15.8 | 13.3 |
| China | 8.6 | 14.4 |
| Portugal | 7.2 | 6.4 |
| Mexico | 3.7 | 2.9 |
| Spain | 3.0 | 3.5 |
| France | 2.9 | 3.0 |
| India | 2.8 | 2.2 |
| Poland | 2.2 | 2.1 |
| Greece | 1.9 | 2.0 |
| 14 other countries | 4.9 | 11.2 |

Source: Chaudari (1995).

Today the focus of naval stores production is Asia. The People's Republic of China has been the world's dominant producer for a number of years. In the early 1980s, Indonesia had a dramatic increase in resin production and today is the second largest producer of gum rosin and turpentine in the world. In 1993, Chinese gum naval stores production accounted for approximately 430 000 tonnes (60 percent) of world gum rosin production; Indonesia accounted for an additional 69 000 tonnes or about 10 percent of world production. Chinese production is unlikely to increase further. However, Indonesia has sufficient area of pine forests available for tapping and the potential to increase production significantly in the future, if it wished to do so (Coppen and Hone 1995). Abnormally high rainfall in Indonesia in 1995 and 1996 led to reduced production in those years but it is hoped that production will recover (personal communication, Coppen, 1997).

The People's Republic of China and Indonesia also dominate world trade in gum rosin and turpentine. Chinese exports of gum rosin during 1993 was approximately 277 000 tonnes (70 percent of world trade) and Indonesian exports amounted to about 46 000 tonnes. Portugal is the third largest exporter of gum rosin and exports most of its production. A much smaller proportion of turpentine produced in the People's Republic of China is exported (about 5 500 tonnes). Both Indonesia and Portugal export more turpentine (Table 6.5) (Coppen and Hone 1995).

**Table 6.4**
**Major crude resin, rosin and turpentine producing countries, 1990-1993**
(Country production in percentage of World Average Total Production)

| Country | Crude Resin (%) | Rosin (%) | Turpentine (%) |
|---|---|---|---|
| China | 59 | 60 | 50 |
| Indonesia | 10 | 10 | 12 |
| Russia | 9 | 9 | 9 |
| Brazil | 7 | 6 | 8 |
| Portugal | 3 | 3 | 5 |
| India | 3 | 3 | 4 |
| Argentina | 3 | 3 | 4 |
| Mexico | 3 | 3 | 4 |
| Honduras | <1 | 1 | 1 |
| Venezuela | <1 | <1 | <1 |
| Greece | <1 | <1 | <1 |
| South Africa | <1 | <1 | <1 |
| Vietnam | <1 | <1 | <1 |
| Others | <1 | <1 | <1 |

Source: Revised from Coppen and Hone (1995).

**Table 6.5**
**Estimated exports of gum rosin and turpentine**
**1990-1994**

| Country | Rosin (Tonnes) | Turpentine (Tonnes) |
|---|---|---|
| China | 277 000 | 5 500 |
| Indonesia | 46 000 | 7 500 |
| Russia | 1 000 | 500 |
| Brazil | 13 000 | 3 000 |
| Portugal | 26 000 | 6 000 |
| Argentina | 10 000 | 2 000 |
| Mexico | 5 000 | ? |
| Honduras | 5 000 | 500 |
| Vietnam | 1 000 | -- |
| Total | 384 000 | 25 000 |

Source: Coppen and Hone (1995).

Resin tapping has become an important industry in a number of developing countries where labour costs are low. In Vietnam, resin tapping is often a women's enterprise (Fig 6.2). In addition to providing a source of income for women, local resin tapping enterprises also provide an incentive to not over-exploit pine plantations for fuelwood, which is a scarce commodity in this country (Author's observation). In Cuba, three species of pine, *P. caribaea, P. tropicalis* and *P. cubensis*, are tapped for resin. During the period 1989-1993, US$1 028 000 of resin products were exported (Ruiz 1995). In Honduras, resin tapping is conducted in five *Departamentos* by 29 individual enterprises. During 1993, this industry employed nearly 2 000 people and provided direct benefits to an additional 9 800 individuals (Table 6.6) (Barcenas 1995). In Lithuania, commercial resin tapping started in 1935 and was constantly increasing from 200 tonnes to 1 830 tonnes in 1965. Then it started decreasing to 146 tonnes in 1994. In 1995 resin tapping stopped for economic reasons. The potential resin production by pine tapping in Lithuania is estimated at about 1 500 tonnes per year (Rutkauskas 1998).

**Table 6.6**
**Status of the pine resin tapping industry in Honduras - 1993**

| Department | *Numberof Enterprises* | *Direct Participants* | Indirect Beneficiaries |
|---|---|---|---|
| Francisco Morazán | 10 | 1 118 | 5 590 |
| El Paraíso | 9 | 539 | 2 695 |
| Comayagua | 7 | 239 | 1 195 |
| Olancho | 1 | 24 | 120 |
| Chouteca | 1 | 22 | 110 |
| Yoro | 1 | 20 | 100 |
| TOTAL | 29 | 1 962 | 9810 |

Source: Barcenas (1995).

In Africa, several countries now produce turpentine and rosin, all of relatively recent origin. Zimbabwe began resin tapping operations in 1976, Kenya in 1986 and South Africa in 1986. Between the three countries, they produce about 4 000 tonnes of crude resin a year (Coppen 1993). Other African countries have extensive areas of untapped pine plantations including Malawi, Uganda, Tanzania and Zambia which have the potential to provide resin and provide employment for a number of people (Coppen and Hone 1995).

## RESINS FROM OTHER PINACEAE

### Resins from *Abies* spp.

*Abies balsamea* is noted for producing a resin rich in terpenes. This resin is known commercially as **Canada balsam, Strasburg turpentine, Canada turpentine** and **balsam of fir.** It can be harvested by puncturing and draining resin blisters which form on the smooth bark of young trees with a hollow metal tube about 10 mm in diameter through which the balsam drains into a can.

After purification by straining, the resin is sold as Strasburg turpentine of commerce. It is used in the preparation of finer varnishes, artist colours, etc. A fine oil of turpentine is distilled from the crude material. The residue forms coarse rosin. Canada balsam is a transparent liquid, pale yellowish green in colour and slightly fluorescent. A thin, colourless film is present. It is completely soluble in ether, chloroform, carbon tetrachloride, benzol and turpentine and partially soluble in absolute alcohol, and is used in the manufacture of medicinal compounds and varnish, as a mounting medium in the preparation of microscope slides and for cementing lenses in optical instruments. Canada balsam was of importance in optics because of its refractive index (1.53 for the sodium D lines), being close to that of glass (Tang-Shui Liu, 1971). Collection of liquid resin from bark blisters of *Abies balsamea* was once an important local enterprise in certain sections of eastern Canada (Harlow and Harrar 1950) but now appears to have declined.

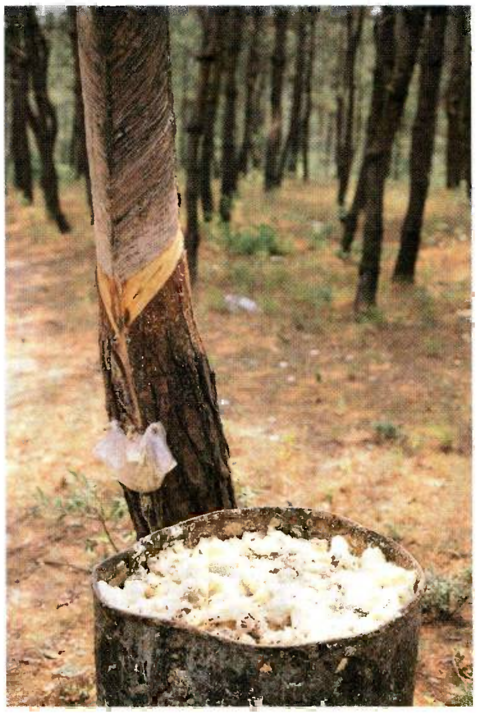

Figure 6.1: Resin collection on *Pinus massoniana*, Anhui Province, China.

Figure 6.2: A woman collects resin from *Pinus merkusii*, Vinh Province, Vietnam.

The Coastal Salish of Vancouver Island, British Columbia, Canada, collected resin from the blisters of *Abies grandis*. This was rubbed on canoe paddles and other wooden articles. The articles were then scorched to provide a good finish. One group of Coastal Salish mixed the resin of *A. grandis* and other conifers with venison suet to make an ointment. This was rubbed on the skin to cure psoriasis and other skin problems and as a salve for cuts and bruises (Turner and Bell 1971).

*Abies spectabilis*, a tree native to the eastern Himalayas, yields a resin that is mixed with oil of roses and applied externally to relieve symptoms of neuralgia[13]

## Resins from *Picea* spp.

Resin collected from *Picea abies* in Europe was known as Burgundy pitch (Hora 1981).

The indigenous forest dwelling people of north-eastern United States and Canada used the resin exudations from various species of *Picea* as a chewing gum. Early European settlers to the region quickly adopted this habit. Lumps of spruce gum were sold commercially during the early 1900s making it the first commercial chewing gum sold in the United States[14]. In the Fort Yukon area of Alaska, United States, the Gwich'in Athabaskan Indians chew lumps of resin from *Picea glauca*. If chewed regularly, it is said to prevent toothaches and headaches (Holloway and Allexander 1990). The Coastal Salish indians of British Columbia, Canada, used gum from *Picea sitchensis* for chewing and for cementing tools such as harpoons (Turner and Bell 1971).

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13 Information provided by Dr. M. P. Shiva, Centre of Minor Forest Products, Dehra Dun, India.

14 Information obtained from the William Wrigley Jr. Company via the World Wide Web.

Resins from various species of *Picea* have also been used as traditional medicines world-wide. In Uttar Pradesh, India, the resin of *Picea smithiana* is applied on cracks in heels to promote healing (Singh *et al.* 1990). In Alaska, United States, the Athabaskan Indians use the resin of *Picea glauca* to prevent infections in cuts and sores. The resin is heated gently, then poured on cloth, caribou skin or adhesive bandages and applied to the wound. Sometimes the resin is mixed with the foliage of *Artemisia frigida* to make a poultice for cuts. In the past, pitch was melted onto a large cloth and placed on legs to soothe the pain of arthritis. It was also spread on the chest for a week or more to relieve pain (Holloway and Allexander. 1990).

In the New England States of the United States, local indians used the pitch from several indigenous spruces, *Picea glauca, P. mariana* and *P. rubens,* to caulk their canoes (Hussey 1974).

### Other resins

Resin once harvested from eastern hemlock, *Tsuga canadensis*, was known as Canada pitch (Hora 1981).

Small quantities of resin are harvested from Douglas-fir, *Pseudotsuga menziesii.* The resin, known as Oregon fir balsam, is collected from felled trees by placing a small drum under the ends of freshly cut logs or from natural wounds by inserting a tube into the wound. This resin is used occasionally in perfumery as a faintly fragrant fixative or in low-cost lemon perfumes for soaps (Good Scents Company 1997).

Indigenous tribes and early European settlers in New England, United States, used resin exuding from the cones of *Larix laricina* to heal wounds (Hussey 1974).

The resin of *Cedrus libani*, a tree indigenous to the Near East, was often used in embalming and to coat coffins and papyrus (Chaney and Basbous 1978).

## SANDARAC

Sandarac is obtained primarily from the resin of *Tetraclinis articulata* (synonym - *Callitris quadrivalis*) (Cupressaceae) (Good Scents Company 1996, Hora 1981), a tree endemic to the mountainous regions of North Africa (Algeria, Tunisia, Morocco) with isolated populations occurring in Malta and near Cartagena, Spain (Vidakovic 1991). An Australian sandarac is produced from various species of *Callitris: C. calcarta* and *C. preissi* (=*C. verrucosa*) (Audas 1952).

The resin is obtained by making incisions in the trunk and branches, causing the viscous sandarac to flow out and quickly solidify when exposed to air. The hardened resin can be then harvested by peeling it from the trees. Sandarac is used in the production of fine lacquers and varnishes (Good Scents Company 1997).

An essential oil can be obtained by steam distillation of this resin or by dissolving the resin in a solution of potassium hydroxide. It is also possible to isolate the essential oil from a neutralized alcoholic solution of sandarac. The alcohol is then evaporated and the alkaline solution is extracted with ethyl ether. After removal of the ether, a small amount of essential oil is left. Sandarac oil is pale yellow or almost colourless and has a slightly balsamic odour (Good Scents Company 1997).

## MANILA COPAL

The genus *Agathis* consists of about 20 species that occur in Australia, south-east Asia, New Caledonia and New Zealand. This genus of Southern Hemisphere conifers, known collectively as Kauri pines, has the most tropical distribution of all of the conifers. A characteristic of the trees of this genus is to exude copious quantities of resin, either spontaneously or from injuries. The resin accumulates on branches, trunks and at the base of trees (Hora 1981). This resin is known in world trade as **manila copal** (Whitmore 1980). Other names for this product include **copal damar, dammara** and **kauri gum** (Hora 1981). Manila copal is white to yellow to dark brown in colour. It hardens with age and eventually becomes brittle. It is soluble in alcohol to a varying degree, has a melting point between 115 and 135$^{o}$ C and is a complex mixture of mono-, di- and sesquiterpenes (Whitmore 1980).

Before wide-scale use of oil-based synthetics, manila copal was an important component of varnishes and, when mixed with linseed oil, was widely used in the manufacture of linoleum. There is still a steady demand for manila copal for specialized uses, for example, varnishes for labels on food tins, for colour prints, as an ingredient in the paint used to paint lines on roads and for fluxes. Besides production for export, there has been a local demand for *Agathis* resin nearly everywhere trees of this genus are found (Whitmore 1980).

The first production of resin from *Agathis* spp. was in New Zealand. This was largely the harvest of a so-called fossil gum dug out of the ground, mainly in the Northern Peninsula of the North Island, a region where *A. australis* occurs (see following section on fossil resins). The New Zealand resin industry reached its peak in 1905 when some 11 000 tonnes were recovered. By 1924, production had declined to 7 000 tonnes and finally ceased in 1950. New Zealand's "gum lands" are estimated to have yielded a total of 500 000 tonnes of raw material (Whitmore 1980). Today, resin production in New Zealand is of historic interest only.[15]

Production of Manila copal from *Agathis dammara*, a tropical rain forest species, peaked during the late 1930s and then declined considerably. Before World War II, trade in Manila copal was through Makassar (presently known as Ujungpandang), on the island of Sulawaesi, Indonesia, Ternate, on the island of Halmahera, Indonesia, or Singapore. In 1926, production totalled 18 000 tonnes of which approximately 85 percent came from the Dutch East Indies (now Indonesia) and by 1941, production in the Dutch East Indies increased five times over the 1931 level. During 1936-38, world production was 43 396 tonnes but by 1957-1959, production had dropped by 65 percent to 19 830 tonnes. In 1973, Indonesia exported approximately 2 500 tonnes of Manila copal (Whitmore 1980). See Non-Wood Forest Products Series nr. 6: *Gums, resins and latexes of plant origin* (Coppen 1995b), p. 64, for more recent data.

Some Manila copal was obtained by probing the ground below *Agathis* trees with long rods. It was obtained mainly, however, by tapping the tree, usually the bole though in Sabah and New Zealand, cuts were also made on the limbs so that huge, pendulous masses of resin developed. Average annual yields of 10-12 kg/tree can be obtained. Yield increases during the first six months of tapping and, as is the case with pines, resin flow can be stimulated with the application of sulphuric acid (Whitmore 1980).

Manila copal has been an important cash crop for many rural people in the tropical Far East. In response to strong demand from industrial nations, destructive tapping increased production. There were reports of *Agathis* trees being killed over large areas of Indonesia and attempts were made to introduce controls in the 1930s. Trees respond to intensive tapping by forming cancerous growths. As

[15] Information provided by Gordon Hosking, New Zealand Forest Research Institute, Rotorua, NZ.

of 1980, the island of Irian Jaya was the principal Indonesian source of Manila Copal. Trees are utilized only for resin. Small plantations have been established and the Forest Department controls the industry that has developed a non-damaging tapping system. A resin tapping industry is also being developed in the Sepik River drainage in north-western Papua New Guinea (Whitmore 1980).

Copal is one of three non-wood forest products gathered and sold as a cash crop by the Tagbanua, an indigenous group of about 7 000 forest dwelling people on the island of Palawan in the Philippines. As early as the turn of the century, the Tagbanua had become dependent on cash received from the sale of copal, beeswax and rattan to pay off their debts. What had once been a moderate activity, carried out only during the dry season when it was easier to reach sites producing these commodities and agricultural activity was at a low ebb, had become a year round activity. This forced many Tagbanua to abandon their farming activities (Conelly 1985).

*Agathis dammara* occurs mostly on well-drained slopes at higher elevations on Palawan. Walking time to these sites is from 2 to 5 hours. Collectors use machetes to make incisions in the sides of trees from which the copal resin slowly leaks into sacks. As of mid 1980s, this was a reasonably profitable endeavour, averaging 18 Philippine pesos (approximately US$2.25) per day, more than could be earned by working in agricultural areas (Conelly 1985).

By 1984, collection of copal and the other non-wood forest products on Palawan Island had become so intense that two communities had exhausted their sources of beeswax and copal in the surrounding forest areas. Other factors contributing to the problem was a rapid increase in the Tagbanua population and resource extraction by large-scale mining and logging concessions. Although it is a valuable timber species, logging of *A. dammara* is illegal. Many trees are cut, however, during the course of road construction and/or land clearing for mineral extraction. One, presumably overly pessimistic, report predicted that the population of *A. dammara* could be eliminated from the island within a five-year period. Older Tabanua confirm that productive copal bearing trees are becoming more difficult to locate. The productive copal sites, 1-3 hours walk from the villages, are now over exploited. Some trees have died and the remaining are said to produce inadequate amounts of resin. Consequently, copal gatherers must travel to more distant trees in the interior of the island; a 4 to 5 hour walk (Conelly 1985).

## MINOR SOURCES OF RESIN

In Brazil, as of the late 1970's, the resin of *Araucaria angustifolia* was a locally important material for varnishes, turpentine, acetone and other chemical products (Reitz, *et al.* 1979).

Resin of *Agathis vitiensis*, known in Fiji as *dakua*, is an alternative ingredient to the resin of *Canarium harveyi* var. *harveyi* , known as "Fijian glue," a material used in the construction of ocean going canoes. The resin is extracted from pieces of bark by heating the bark in a can over an open fire. The glue is applied hot and the excess is stirred and reheated for later use. *A. vitiensis* resin is used primarily on the island of Vitu Levu where the tree occurs naturally (Banack and Cox 1987).

## FOSSIL RESIN

Amber, or resinite, consists of solid, discrete, organic materials derived from resins of higher plants. These materials are found in coals and other sediments as macroscopic and microscopic particles that have been incorporated into these sediments. The chemical properties of amber are a consequence of both its biological origins and the geologic environment onto which the resin has been deposited and where it has subsequently matured. Various types of amber frequently carry geologic names based on their locality, chemical composition or discoverer. Examples include bitterfieldite, burmite, chemanwinite, glessite, schilerseeite, settlingite, simetite and succinite. As a material of organic origin, amber is unique because of its exceptional preservation, and for the preservation of living organisms within it (e.g. insects, plants parts) (Anderson and Crelling 1995).

The point at which resin becomes amber is a controversial and still unanswered question. Modern resins are continuously deposited into sediments world-wide but have not been considered part of the fossil record. There are products known as "young amber" or "sub-fossil resin" (Anderson and Crelling 1995).

## Sources

Resins from both *Gymnosperms* (conifers) and *Angiosperms* are known to produce amber. According to Langenheim (1995), five families of conifers and 12 families of *Angiosperms* are either known or potential sources (Table 6.7). Of the five families of conifers known to produce resin which can eventually become amber, only two families: the *Araucariaceae* and the *Pinaceae*, are known to be important sources. There is some evidence that small pieces of amber, deposited in the late Cretaceous and Pliocene Periods, may be derived from the family Taxodiaceae (*Metasequioa, Sequoia or Sequoidendron*). Mid Eocene amber from Washington State, United States and British Columbia, Canada may have originated from *Metasequoia* (Langenheim 1995).

**Table 6.7**
**Families of resin producing plants that are sources of amber**

| Gymnosperms | Angiosperms | |
|---|---|---|
| Pinaceae* | Leguminoseae* | Zygophyllaceae |
| Araucariaceae* | Burseraceae* | Euphorbiaceae |
| Taxodiaceae* | Dipterocarpaceae* | Rubiaceae |
| Cupressaceae | Hamamelidaceae* | Guttiferaceae |
| Podocarpaceae | Anacardiaceae* | Palmaceae |
| | Styraceae | Betulaceae |

* Good evidence of amber production, for other families, limited evidence.
Source: Langenheim (1995).

In most plants of the family *Pinaceae*, abietane and pimarine diterpenoid acids dominate trunk resins. These compounds tend to be subject to oxidative degradation or dehydrogenation. Consequently, they are not good candidates for production of amber. Members of the family *Araucariaceae*, on the other hand, contain labdatriene communic acid that readily polymerizes. The conifer genus *Agathis* is particularly interesting from the standpoint of amber production because it produces resin in great quantity and several species have been tapped for commercial resin production (see previous section on Manila copal).

*Agathis* spp. may be a significant source of the world's amber for the following reasons:

1. Chemical similarities of ambers from different origins and different geographic locations to resin of *Agathis australis,* a tree which presently occurs in New Zealand.

2. Several species of *Agathis* produce copious amounts of resin with diterpenoid labdatrienes that polymerize into durable material, similar to leguminoid genus *Hymenaea* resulting in massive accumulations of amber.

3. Several characteristics of *Agathis* resins suggest involvement of *Agathis,* or a relative, as the botanical source of the predominant amber Succinite from the Baltic Sea Region of northern Europe.

Amber from *Agathis* spp. is reported from Australia and New Zealand and Oliocene and Miocene amber deposits in New Zealand have been determined to be derived from the resin of *A. australis.* In addition, deposits of *Agathis*-derived amber have been reported from several locations in Austria and France (Langenheim 1995).

It has been hypothesized that the extensive deposits of amber in the Baltic Region of Europe, known as Succinite, may be the result of prehistoric forests of *Agathis* or an *Agathis*-like tree. Arguments in favour of this hypothesis include:

1. The chemistry of Baltic amber is generally similar to that of the resin from extant *A. australis* in New Zealand.

2. The Baltic amber deposits consist of massive accumulations with many large pieces. This is similar to the character of amber deposits underneath from extant *A. australis* forests in New Zealand.

3. Baltic amber deposits contain fossil evidence of plant life similar to that that occurs in some extant Pacific subtropical-tropical forests where *Agathis* occurs today.

Arguments against *Agathis* spp. being the source of Baltic amber include:

1. Baltic amber contains succinic acid. This compound is absent in extant *Agathis* resin.

2. The only resin producing plant parts included in Baltic amber deposits or associated with it are from other coniferous sources.

3. Wood from the Baltic region with enclosed succinite is considered to be "Pinaceous." Yet pine resins do not have constituents that readily polymerize.

The genus *Agathis* appears to have been a significant source of amber from the early Cretaceous through the Tertiary in various locations throughout the world, based on chemical evidence, which is corroborated in a few cases with associated plant parts of *Agathis.* The botanical source of succinite in Baltic amber is an enigma. The possible involvement of *Agathis* is supported by the considerable chemical similarity of succinite and resin from extant *A. australis*, the massive accumulation of *A. australis* resin and Asian and tropical affinities of numerous floral inclusions in the amber. However, the lack of succinic acid in extant *Agathis* or *Agathis* plant remains in the amber make this source questionable. The many pinaceous remains in the amber lead to a hypothesis that it could have been derived from an araucarian type ancestor or common progenitor and that the araucarian chemical properties of the resin were carried along with other characteristics as pinaceous plants evolved (Langenheim 1995).

## Geographic occurrence

The most extensive deposits of amber (succinite) discovered to date are located in the Baltic Sea region of northern Europe, including portions of Denmark, Norway, Sweden, Germany, Poland, Russia, Lithuania, Latvia and Estonia. A small outlier of Russia, an area called the Samland in the Kaliningrad Oblast has the largest known concentration of Baltic amber. Kaliningrad is believed to have supplied over two-thirds of the world's amber and 99 percent of the Baltic amber in recent years.

The amber deposits of the Baltic region of Europe have been known since prehistoric times and had a significant influence on early European history. Amber of Baltic origin has been found in Egyptian tombs that date back to 3200 BC, suggesting that barter and trade routes between Egypt and northern Europe were established at that time. Germany, Poland, Lithuania, Latvia and Estonia have Neolithic burial sites in which amber has been included. Amber "The Gold from the North" was a major trade item when the Vikings dominated European Sea trade between 800 and 1000 AD. As amber became an increasingly valuable commodity in the Baltic Region, dukes, kings and Teutonic knights tried to control its collection and sale. Recovery rights were granted and rescinded by the "Amber Lords" as early as 1264 AD. When amber was collected without the supervision of a "Beach Master" or "Beach Rider," the violators were hung. Amber guilds were formed in the fourteenth century to create rosaries and other works of art from material supplied by the Amber Lords.

The most plentiful source of amber outside of the Baltic region is the Dominican Republic. This amber is known as retinite and contains no succinic acid.

Small quantities of amber have also been found in the United Kingdom along the English coast of Kent, Essex and Suffolk. This material is usually golden or cloudy yellow in colour and its plant source is not known.

Several Asian sources of amber are known. Chinese amber is highly favoured because of its reddish colour. Burmite, an amber found in Myanmar, has been used by Chinese craftsmen as early as the Han Dynasty (206 BC to 220 AD). In Japan, amber is found in coal beds. Other sources of amber include Canada, Greenland, Mexico, Romania, Sicily (Italy), Tanzania and the United States.

## Uses

The finished products of amber are jewellery, smoking articles, objects of art and religious articles. Jewellery includes necklaces, bracelets, brooches, earrings, pendants, rings, cufflinks etc. Smoking articles include cigar/cigarette holders and mouthpieces for pipes. During the 1920s, about one-half of the production of amber was used for the manufacture of articles for smokers. Objects of art include carvings, jewellery boxes, cups and dishes, writing utensils, ornaments, chess sets, mosaic pictures and chandeliers. Religious items include rosaries and prayer beads, sacred figures and amulets.

Amber is also used in the production of varnish and lacquers. In ancient times, it was burned as incense to camouflage the odour of spoiled food. Fine amber varnish is applied to violins. Balls of amber can be used to remove lint from clothing because of its ability to generate static electricity by rubbing.

Occasionally, plant and animal materials are preserved in amber. These are of great scientific value. Insects and insect remains, in particular, are often found preserved in amber and represent the finest fossil remains of prehistoric insects known. These provide opportunities to study evolution, biogeography, environmental reconstruction and extinction. A range of information about past insect faunas, as well as other plants and animals, of particular global areas, can be extracted from fossil amber. Insects preserved in amber are normally preserved with such clarity that they can be compared in minute detail with closely related groups living today. Amber fossils provide the earliest known records of some insect orders and families plus numerous genera and species. These are important in reconstructing insect phylogenic lines. Insects preserved in amber show irrefutably what characteristics were present at particular times in the earth's history. They can also provide data on the behaviour of extinct insects, the structures of their biological communities and past symbiotic associations. Fossil amber provides the scientific community with a unique opportunity to discover many details of the past world of small organisms that is unavailable through other types of fossils (Poinar 1993).

# CHAPTER 7
# ESSENTIAL OILS

## DEFINITION

**Essential oils** are the concentrated aromatic oils of plant leaves, flowers, seeds, bark, roots and the rinds of some fruits. They evaporate on contact with air and are also known as **volatile oils**. They vary in strength but are always very potent and generally smell best when diluted. Essential oils obtained from trees are generally produced by a lengthy steam distillation process applied either to the resin, the chopped wood or the foliage and branch ends.

Essential oils have great many uses and may be obtained from either wild or cultivated plants. An estimated 3 000 essential oils are known of which approximately 300 are of commercial importance. The majority are obtained from agricultural plants but a number of oils are collected from wild sources including trees (Iqbal 1993). One commercial source of essential and fragrance oils lists over 50 different oils; 25 of which are used in cooking and over 20 are used in potpourri, crafting, cosmetics, massage, aromatherapy and other uses. Still other essential oils are used to repel insects and other arthropods that are pests of humans, livestock and pets (mosquitoes, fleas, ticks, etc.) (Thomas and Schumann 1992).

## COMMERCIAL EXTRACTION METHODS

Removal of essential oils from plant material is accomplished by various methods, depending on the quality of the oil present and the stability of the aromatic constituents. The tendency of some constituents to undergo changes when subjected to high temperatures makes it necessary in some cases to use special methods of extraction to obtain the desired product without decomposition or alteration.

Four major methods of extraction are generally used:

- hydro or water distillation - only water is used;
- water and steam distillation - both water and steam are used;
- direct steam distillation - only steam is used;
- solvent extraction - a solvent is used.

In hydro distillation the plant material is in direct contact with water while in steam distillation, live steam is used. In water and steam distillation, both water and steam are used but the plant material is not in direct contact with water. In solvent extraction, the plant material is extracted with a solvent and then the oil is separated from the solvent. Each of these extraction methods can be carried out at reduced pressure, atmospheric pressure or excess pressure.

Before distillation, the plant material is often field cured, partially dried or disintegrated to some extent. This latter disintegration process, commonly referred to as comminution or size reduction, is used in the extraction or distillation of herbs or for their incorporation into food products. The reduction in particle size exposes as many oil glands as possible to the solvent or steam. It reduces the thickness of the plant material through which diffusion must occur, greatly increasing the rate of spread of vaporization and distillation of the essential oils (Thomas and Schumann 1992).

## "CEDAR" OILS

Several members of the family Cupressaceae, which are important sources of essential oils, are commonly known as "cedars." These include members of the genera *Cupressus, Juniperus* and *Thuja.* The members of the genus *Cedrus* (family Pinaceae) are also known as "cedars" or "true cedars." Since the essential oils extracted from this group of trees are used for similar purposes, they will be discussed collectively in the following section.

### Cedar leaf oil

Cedar leaf oil has been an item of commerce for over 100 years and is produced from the ends of branches and adherent foliage of the northern white cedar or arborvitae, *Thuja occidentalis,* and the western red cedar; *Thuja plicata.* According to one producer, this oil contains approximately 60 percent thujone ($\alpha$-thujone, $\beta$-thujone and fenchone)[16]. Cedar leaf oil is a common ingredient in pine and cedar blends that are used in room sprays, talcs and insecticides. This oil is also a component of embalming fluids, microscope slide slips, industrial cleaners, deodorants, pharmaceuticals, cleaning fluids, salves, liniments, perfumes, shoe polishes and soaps. One of the principal uses of cedar leaf oil is in the preparation of patent medicines such as cold-remedy salves, which help clear the nose and chest. Another use of this oil is to "re-odorize" sawdust which is in sawdust logs or instant fire logs.

The primary areas of production of cedar leaf oil have been north-eastern United States (New York, Vermont and, to a lesser degree, the Upper Peninsula of Michigan) and adjoining portions of Canada (eastern Quebec and south-eastern Ontario). Cedar leaf oil is also produced in British Colombia, Canada. Production of this oil has been a small industry controlled by local farmers who distil the oil in fairly crude equipment during times when they are not doing other farm work. In 1978, cedar leaf oil was selling at about US$21.00/kg. In 1984, an estimated 25 tonnes were produced in Canada and the United States (Thomas and Schumann 1992). One company, based in Quebec, Canada (Huiles Essentielles Branchex Ltd) produces about 4 500 kg of cedar leaf oil annually which it wholesales in 45 gallon drums. In January 1998, Cedar leaf oil retail price was US$7,87 for 1/3 oz. (see also at http://www.gritman.com/p169.htm for retail prices of this and other essential oils).

### Essential oils from Juniperus and Cupressus

A number of essential oils are derived from the foliage, fruits and wood of various species of *Juniperus* and *Cupressus* world-wide. The oils distilled from the heartwood of *Juniperus* are used in the production of the majority of perfumes and colognes on the world market. More than 400 fragrances, or almost 60 percent of the fragrances produced, contain cedarwood oil (Anderson 1995). Several are important commodities in the international market.

***Species***

In the United States, essential oils are presently harvested from two species of *Juniperus*: the eastern red cedar, *J. virginiana*, of the eastern states and the Ashe juniper, *J. ashei*, a tree found in portions of Arkansas, Missouri, Oklahoma and Texas. The latter species is often referred to as *J. mexicana;* however, according to Little (1979), this taxonomic designation is not valid.

The oil harvested from *J. virginiana* is known in the essential oils trade as **Virginian cedarwood oil** or **Cedarwood oil Virginiana** and is recovered through the process of partial pressure steam

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[16] Data provided by Huiles Essentielles Branchex Ltd, Quebec, Canada, via the World Wide Web. (http://www.belin.qc.ca/branchex/branchex.html).

distillation of sawdust, wood shavings, old stumps and chipped logs, materials which would otherwise be considered waste. Waste products from cedar furniture manufacturing plants are a prime source of material for extraction of this oil. Most production today comes from the state of North Carolina, United States, although at least one processor in Texas (Texarome Inc) also manufactures this oil[17]. Virginia cedarwood oil is widely used in the fragrance industry in soaps, air fresheners, floor polishes, and sanitation supplies. It is also used in deodorants, insecticides (see textbox), mothproof bags, and janitorial supplies. In addition, a large percentage of this oil is used as a starting material for cedrol and cedryl acetate (Thomas and Schumann 1982).

The oil harvested from *J. ashei* is known as **Texas cedarwood oil**. This oil has different uses and does not compete with the Virginia cedarwood oil. The chemical composition of the two oils is similar, but Texas cedarwood oil is used almost exclusively as feedstock for the manufacture of chemical derivatives whereas Virginia cedarwood oil is used primarily in fragrance formulas. Unlike the Virginia cedarwood oil, the Texas cedarwood oil is not a by-product of the furniture industry. This tree is felled by ranchers to clear land for grazing. Cedar trees and stumps from these land-clearing operations are sold to distillation plants. Approximately 70 to 80 percent of this oil is used for cedrol isolation and subsequent acetylation (Thomas and Schumann 1982).

In China, **Chinese cedarwood oil** is extracted primarily from *Cupressus funebris*, a small tree or shrub that is found in Guizhou, Gansu and Sichuan Provinces. Other species used for production of this oil include *Juniperus chinensis, J. formosana* and *J. vulgaris* (Coppen 1995). This oil competes with the Virginian and Texas cedarwood oils and generally sells for a lower price. Price data given by Thomas and Schumann (1982) indicate that the price for Texas cedarwood oil was about US$6.05/kg while the lower grade Chinese oil was being offered in New York at US$3.74/kg. Mid-1997 spot prices (New York) for the three oils were US$4.60/kg (Chinese), US$15.20/kg (Virginian) and US$8.60/kg (Texas).

Commercial juniper berry oil is produced from the berries of *Juniperus communis* by steam distillation of the crushed, dried or partially dried berries. The spent berries from gin production (see Chapter 8) are generally used for this purpose. Juniper berry essential oil contains mainly the terpenes pinene, myrcene, sabinene and limonene[18]. This oil is a watery white or very pale yellow, mobile oil, having a fresh, yet warm, rich balsamic woody sweet and pine needle like odour and is used in aftershave fragrances and other perfumery products (Good Scents Company 1996).

**Oil of Savin** is obtained by distilling the fresh leaves and shoots of *J. sabiniana,* a Mediterranean species. This oil is a powerful diuretic and has been used as an abortifacient (Hora 1981).

Destructive distillation of the wood of *J. oxycedrus*, another species indigenous to Mediterranean Europe and the Near East yields **Oil of Cade** or **Juniper tar oil**. Rectified Cade oil is a clear orange-brown to dark-brown oily liquid with an intense tar like, smoky phenolic odour. Its use in perfumery is limited to situations where a smoky, leathery, woody phenolic, dry and warm note is required (e.g. scented notepaper, leather products, pine for men's fragrances, etc.). Cade oil has certain disinfectant properties that allow it to be used in soap perfumes. Cade oil is also occasionally used to impart a smoky flavour to meat and seafood (Good Scents Company 1997). This oil has been used for treatment of skin diseases, especially psoriasis but is now largely replaced by coal tar derivatives (Hora 1981).

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[17] Information provided by Texarome Inc, Leaky, Texas, USA via the World Wide Web.

[18] Information provided by Frontier Cooperative Herbs via the World Wide Web.

## CEDARWOOD OIL - A NATURAL PESTICIDE?

Cedarwood oil is under investigation as a natural pesticide or repellent. The wood of several species of *Juniperus*, especially *J. virginiana,* is known to be decay resistant. Fences made from cedarwood posts are still sound after several decades of use. Cedar chests are known to be safe places to store woollen articles and protect them from the ravages of cloth moth larvae. Extracts from the wood of *Juniperus recurva* in Nepal have also been shown to have insecticidal properties (Adams 1993). Recent laboratory studies by USDA Forest Service indicate that cedarwood oil and perhaps cedar leaf oil may be effective termiticides when absorbed into other woods (Adams *et al.*1988). Numerous herbal and pet shampoos and natural repellents contain cedarwood oil as an active ingredient (Anderson 1995).

An essential oil is extracted from the heartwood of *Juniperus macrocarpa,* on a limited scale, in Yugoslavia where it is an ingredient of soap perfumes, detergents and disinfectants (Good Scents Company 1997). At one time, cedarwood oil was extracted from the wood of *Juniperus procera*, a tree indigenous to Kenya and other eastern African countries. This is no longer done because commercial timber harvesting of natural forests of this tree has been suspended in Kenya where the most extensive forests of this tree are found.

In addition to *Juniperus ashei* and *J. virginiana*, other North American species of *Juniperus* are potential future sources of cedarwood oils. Adams (1987) investigated cedarwood oil yields from 11 North American species of *Juniperus* with widespread distributions and significant biomass by steam distillation. He found that cedarwood oil yields from two species, *J. erythrocarpa* and *J. scopulorum* compared favourably with those of *J. ashei* and *J. virginiana. J. erythrocarpa* is a multi-stemmed tree that occurs from west Texas to New Mexico and Arizona. *J. scopulorum* is a common tree of the Rocky Mountain region and is closely related to *J. virginiana.* He concluded that neither species would be competitive with the primary North American cedarwood oil producing species but could possibly support small, local distillation facilities.

### *Production standards*

International (ISO) standards exist for both the Texas and Virginia cedarwood oils. For the former, the alcohol content, expressed as cedrol and in the range of 35-48 percent, is specified with a minimum cedrol content of 20 percent. For the Virginia cedarwood oil, a maximum cedrol content of 14 percent is stipulated. In the United States, recent FMA standards have replaced older EOA standards and are available for Chinese, Texas and Virginia cedarwood oils. These standards specify that for the Texas and Virginia oils the alcohols content (cedrol and related isomers) must range between 25-42 percent for the Texas oil and between 18-38 percent for the Virginia oil. The Chinese oil must have a minimum alcohol content of 8 percent (Coppen 1995).

### *Production and international trade*

World-wide production statistics for the major essential oils of *Cedrus* (see following section), *Cupressus* and *Juniperus* are reported by Lawrence (1985) for the year 1984 (Table 7.1) and indicate a total production of about 2 117 tonnes.

Three of the oils discussed in this section: Chinese cedarwood oil, Texas cedarwood oil and Virginiana cedarwood oil are traded internationally in substantial volumes. According to Coppen (1995), Western Europe, Japan and the United States are the major markets for these oils. The United States utilizes much of its Texas and Virginia cedarwood oils and also imports a significant quantity of Chinese cedarwood oil (320-400 tonnes/year). Japan imports about 170 tonnes of cedarwood oils, mostly from the United States. In Europe, the primary demand is for Chinese cedarwood oil.

**Table 7.1**
**Global production of major essential oils from**
***Cedrus, Cupressus* and *Juniperus* - 1984**

| Country | Source of essential oil | Production (Tonnes) |
|---|---|---|
| China | *Cupressus funibris* | 450 |
| India | *Cedrus deodara* | 20 |
| Kenya[19] | *Juniperus procera* | 0 |
| Morocco | *Cedrus atlantica* | 7 |
| USA | *Juniperus ashei*<br>*Juniperus virginiana* | 1400<br>240 |
| TOTAL | | 2117 |

Source: Lawrence (1985).

## Essential oils from *Cedrus* spp.

The genus *Cedrus* contains four species distributed across Northern Africa, the Near East and the Indian subcontinent and is part of the family Pinaceae (Vidakovic 1991). The essential oils derived from these trees are often considered as substitutes or alternatives to essential oils produced from members of the conifer family Cupressaceae. For this reason, they are discussed with the cedar oils.

In Morocco, the wood of *Cedrus atlantica* is steam distilled to obtain an essential oil that has a lasting balsamic odour. It is used for scenting of soaps and for fixing of odours. Medicinal uses of this oil include external and internal treatments against bronchitis, tuberculosis, skin diseases and gonorrhoea.

Destructive distillation of *C. deodara* wood yields a thick tar-like oil. In India, this is used for rubbing on inflated hides commonly used for crossing rivers. It is also a remedy for ulcers and eruptions for mange in horses and sore feet in cattle. This oil is also used to some extent for cremations (Maheshwari and Chhaya Biswas 1970).

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19 Extraction of cedarwood oil in Kenya ended when timber harvesting operations in natural forests was no longer permitted.

Steam distillation of *C. deodara* wood yields a reddish-brown oil with a characteristic balsamic odour due to the presence of *p* - methyl - $\Delta^3$ - tetrahydroacetophenone and steam distillation of sawdust yields a pale yellow oil with a pleasant odour and is designated as **Himalayan cedarwood oil**. The residue, which remains after the distillation of the oil, can be used as a fuel that burns without giving a sooty flame. This oil has been found to be an effective substitute for cedarwood oil from *Juniperus virginiana* which had been imported into India for manufacture of perfume, scenting soaps, room sprays, disinfectants, etc. It is also used as a tissue-clearing agent in animal and plant histological work and for use with oil emersion lenses. This oil is also suitable for detailed cellular examinations of sections under an oil immersion lens (Maheshwari and Chhaya Biswas 1970).

Production of Himalayan cedarwood oil began in India during the late 1950s (Coppen 1995a) when the Kashmir State drug industry undertook large-scale production of Himalayan cedarwood oil which is now used in large quantities in perfumery and soap industries in place of cedarwood oil Virginiana (Maheshwari and Chhaya Biswas 1970). Twenty years later, production was estimated to be 25 tonnes per year with most of the product being consumed domestically (Coppen 1995a).

In Nepal, an essential oil extracted from the foliage of *Cedrus deodara* is massaged regularly on affected parts to relieve rheumatic pain (Bhattarai 1992). In the state of Uttar Pradesh, India, oil extracted from the heartwood of *C. deodara* is used as an insect repellent. It is smeared on the bodies of domestic animals to repel fleas and lice (Singh *et al.* 1990).

## ESSENTIAL OILS FROM THE PINACEAE

Several species of the genus *Abies*, a group of trees well known for their aromatic foliage (Tang Shui Lui 1971) are sources of fragrant essential oils. Most of these oils are extracted from the foliage and are pale yellow to colourless liquids. **Balsam fir oil**, or **fir needle essential oil** is a product of *A. balsamea*, a tree found in eastern Canada and adjoining portions of the United States. This oil is extracted from the foliage by steam distillation. It has a pleasant, fresh, turpentine-like odour and is highly volatile and is used in air fresheners and disinfectants. Huiles Essentielles Branchex Ltd of Quebec, Canada, produces about 4 500 kg of balsam fir oil annually.

**Fir Siberian oil** is steam distilled from the foliage of *A. sibirica,* a component of the boreal forests of Siberia and is an ingredient in air fresheners and inhalants. An essential oil is water or steam distilled from the crushed cones of *A. alba*. This oil is produced in Austria, Germany, Switzerland and Yugoslavia but only on a modest scale. It has a fresh, sweet odour said to resemble bitter orange oil and is used in colognes. In France, an essential oil known as ***essence de sapin*** is extracted by volatile solvent extraction from the needles of *A. alba.* This oil has a fruity balsamic odour that is said to recall the fragrance of a fir forest and is used in bath preparations and leather products (Good Scents Company 1997). Distillation of the foliage of *Abies pindrow*, a western Himalayan species, yields a pale yellow, aromatic oil with a balsamic odour, which is locally important for scenting soaps, deodorants, disinfectants and inhalants[20].

Several essential oils are distilled from *Pinus* spp. These oils are steams distilled from the fresh twigs and needles that have a sweet, evergreen aroma. **Pine Norway oil** is extracted from *Pinus sylvestris,* a tree widely distributed across Europe and Siberia. This oil is almost colourless, mobile and has a strong turpentine-like balsamic odour. The dryout characteristic of this oil is of particular interest because there is no odour left on a blotter after 24 hours. It is used primarily in room fresheners,

[20] Data provided by Dr. M.P. Shiva, Centre of Minor Forest Products, Dehra Dun, India.

disinfectants, soaps, detergents and vaporizer liquids. **Pine mountain oil** is a product of the steam distillation of foliage and twigs of *Pinus montana*, a high elevation European pine. This watery white oil has a slightly spicy odour said to resemble juniper berry oil and is somewhat unique among pine oils in this regard. Mountain pine oil is used in perfumes but can be irritating (Good Scents Company 1997).

Another use for pine oil is in aromatherapy. Pine oil is used in saunas, steam baths and massages to ease the pain of sore muscles.

In Northern Europe, pine oil distillation takes place from spring through winter. The needles and branch tips are gathered when forests are thinned or mature trees are harvested for timber. The mountain forests of the Tyrol area of Austria have a reputation for producing the finest pine oils. Production is not enough to meet world-wide demand, however. Consequently, pine essential oil comes from a variety of locations in Europe and Russia[21].

**Hemlock oil**, also known as **spruce oil**, is steam distilled from the foliage and twigs of the eastern hemlock, *Tsuga canadensis,* a tree widely distributed across eastern Canada and the United States. The oil is pale yellow or almost colourless and has a pleasant, balsamic, fresh odour with a sweet and slightly fruity cast. This oil is used for room spray perfumes, bath preparations, air fresheners, disinfectants, detergents and other household products (Good Scents Company 1997).

## OTHER ESSENTIAL OILS FROM CONIFERS

Sandarac resin produced from *Tetraclinis articulata*, a small conifer found in Malta, North Africa and Spain, is the source of an essential oil known as **sandarac oil**. It can be obtained either from steam distillation of sandarac resin or, because the resin acids are soluble in aqueous potassium hydroxide, it can be isolated from a neutralized alcoholic solution of sandarac. The alcohol is evaporated and the alkaline solution is extracted with ethyl ether. After removal of the ether, a small amount of essential oil remains, unaffected by exposure to high distillation temperatures. Sandarac oil is a pale yellow or almost colourless mobile liquid of a turpentine- like, fresh resinous and slightly balsamic odour, which is used as a fixative in woody perfumes, pine fragrances, incense or oriental bases (Good Scents Company 1997).

**Araucaria wood oil** is steam distilled from the wood of a small tree, *Neocallitropsis araucariodes* (Synonym *Callitropsis araucariodes*). This tree is a member of the family Cupressaceae and is endemic to New Caledonia (Vidakovic 1991). The oil is grainy, pale yellow to olive green in colour with a delicate, woody, rich and sweet floral odour. It is used in perfumes (Good Scents Company 1997).

[21] Data obtained from Frontier Cooperative Herbs via the World Wide Web.

# CHAPTER 8
# SEEDS, FRUITS AND CONES

## PINE NUTS

A number of species of the genus *Pinus* produce large seeds that are edible and highly nutritious. Edible nut producing pines are found in Asia, Europe, the Near East and North America. Wherever they occur, they have become important staple foods, at least locally. Several species produce nuts, which today are considered to be a delicacy, that are ingredients in a wide variety of traditional dishes and are important in international trade.

### Species which produce edible nuts

Approximately 29 species of *Pinus* produce seeds, which have been used as a food item, at least by indigenous tribal cultures. Most of the edible nut bearing pines are haploxylon (soft) pines although several species are of the diploxylon (hard) pine group (Tables 8.1 and 8.2).

**Table 8.1**
**Pine species with edible nuts**

| Species | Natural Range | Remarks |
|---|---|---|
| **Haploxylon (soft) pines** | | |
| *P. ayacahuite* | Mexico, Central America | Traditional food for indigenous tribes |
| *P. albicaulis* | Western Canada and United States | Traditional food for indigenous tribes |
| *P. cembra* | Europe (Alps and Carpathian Mountains) | Locally important |
| *P. flexilis* | Western Canada and United States | Traditional food for indigenous tribes |
| *P. gerardiana* | E Afghanistan, Pakistan, N India | Important in international trade |
| *P. koraiensis* | E China, Japan, Korea, SE Siberia | Important in international trade |
| *P. lambertiana* | Western United States (California, Oregon) | Traditional food for indigenous tribes |
| *P. monticola* | NW United States and adjoining Canada | Traditional food for indigenous tribes |
| Piñon pines | N Mexico, SW United States | A complex group of about 13 species. Many are important food sources (See table 8.2) |
| *P. pumila* | E Siberia, E China, Korea, N Japan | Locally important |
| *P. sibirica* | Russia (Central Siberia), Mongolia | Nuts are ground into cooking oil |
| *P. strobiformis* | N Mexico, SW United States | Traditional food for indigenous tribes |
| **Diploxylon (hard) pines** | | |
| *P. coulteri* | United States (California) | Traditional food for indigenous tribes |
| *P. pinea* | Mediterranean Europe and Near East | Important in international trade |
| *P. ponderosa* | W Canada and United States | Traditional food for indigenous tribes |
| *P. sabiniana* | United States (California) | Traditional food for indigenous tribes |
| *P. roxburghii* | India | Traditional food source |
| *P. torreyana* | United States (California) | Traditional food for indigenous tribes |

Sources: Critchfield and Little (1966), Lanner (1981), Maheshwari and Konar (1971), Mirov and Hasbrouck (1976), Perry (1991), F.P. Shiva, Centre for Minor Forest Products, Dehra Dun, India.

In Europe, *Pinus pinea* has been so widely planted throughout the Mediterranean region for its edible nuts that it is difficult to establish the true natural range of this species (Mirov 1967). Remains of pine nuts, presumably from *P. pinea*, have been found in the ruins of Pompeii (Maheshwari and Konar 1971). Several large forests of this species were planted in Italy in response to Papal decrees. For example, a large forest of *P. pinea* was established in 1666 near Fregene, a coastal community north of Rome at the initiative of Pope Clement IX and has been protected because of its scenic value and edible nuts (Mirov 1967). This forest still exists today. The nuts of *P. cembra* are used for food in Switzerland (Maheshwari and Konar 1971).

**Table 8.2**
**The piñon pines of Mexico and the United States**

| Species | Natural Range | Remarks |
|---|---|---|
| *P. catarinae* | **Mexico** - Nuevo León | Seeds collected locally for food |
| *P. cembroides* | **Mexico** - Northern Sonora and Chihuahua south to Puebla | Nuts have very thick shells, sold in markets in Mexico |
| *P. culminicola* | **Mexico** - Nuevo León | |
| *P. discolor* | **Mexico** - E Sonora, Chihuahua, Durango, San Luis Potosi<br>**USA** – S Arizona, S New Mexico | Not sought after by humans because seed crops are generally small and seed coat is very hard |
| *P. edulis* | **USA** – Arizona, Colorado, New Mexico<br>**Mexico** - NW Chihuahua | Important producer of pine nuts |
| *P. quadrifolia* | **Mexico** - Baja California Norte<br>**USA** – S California | Locally important. Nuts have very thin seed coats |
| *P. juarezensis* | **Mexico** - Baja California Norte<br>**USA** - Extreme S California | Seeds sold in markets along with seeds of *P.edulis* and *P. monophylla* |
| *P. johannis* | **Mexico** - Localized in Coahuila, N Zacatecas, S. Nuevo León | Seeds edible |
| *P. lagunae* | **Mexico** – Found only in a single restricted area in Baja California Sur | |
| *P. maximartinezii* | **Mexico** – Isolated in the mountains of S Zacatecas, extremely rare | Large seeds; 20-25 mm long, unusually large, heavy cones |
| *P. monophylla* | **Mexico** - Baja California Norte<br>**USA** - S California, Nevada, W Utah | Important producer of nuts. Only pine in the world with a single needle per fascicle |
| *P. nelsonii* | **Mexico** – Nuevo León, Tamaulipas, San Luis Potosi | Seeds collected with *P. cembroides*. Superior in flavour to *P. cembroides* |
| *P. pinceana* | **Mexico** – Coahuila, Hidalgo, Querétera, Zacatecas | Seeds collected for food |
| *P. remota* | **Mexico** – Chihuahua, Coahuila<br>**USA** – W Texas | Common name is "papershell piñon." Thin seed coat makes them especially attractive for human consumption |

Sources: Lanner 1981, Perry 1991.

In Asia and the Near East, *Pinus gerardiana, P. koraiensis , P. pumila* and *P. sibirica* are important pine nut producing species. The nuts of *P. sibirica* and *P. koraiensis* are pressed commercially for the production of cooking oil (de Beer n.d., Lanner 1981, Mirov and Hasbrouck 1976).

The greatest number of pine species which bear edible nuts are found in North America, the largest group being the piñon pines of northern Mexico and south-western United States. These are a complex and highly variable group of small to medium sized trees that occur in localities with a semi-arid climate. About 13 species of piñon pines are known (Table 8.2) (Lanner 1981, Perry 1991). Three species, *Pinus cembroides, P. edulis* and *P. monophylla* have relatively widespread distributions and, even today, are important regional food items (Fig 8.1). Other piñons have more localized distributions and, therefore, a more limited and localized importance as food sources. Other North American pines which produce edible nuts include *Pinus albicaulis, P. flexilis* and *P. strobiformis* of the Rocky Mountains and Great Basin regions and *Pinus coulteri, P. lambertiana, P. sabiniana* and *P. torreyana,* species indigenous to California, United States and Baja California del Norte, Mexico (Lanner 1981).

Figure 8.1: Edible nuts of *Pinus edulis.*

## Nutritional value

Pine nuts are of exceptional nutritional value. The edible nuts of piñons and other pines compare quite favourably with pecans, peanuts and walnuts in protein, fat and carbohydrate content. Of the piñon pines, *P. cembroides* is richest in protein and lowest in starch content. *P. edulis* tends to be richest in fats and is comparable to *Pinus pumila* which, in Russia, is pressed commercially for production of cooking oil (Table 8.3). One-half kg of shelled *P. edulis* nuts provides 2 880 calories, more than the food energy in an equivalent amount of chocolate and nearly as much as one-half kg of butter. The protein content of some pine nuts (e.g. *P. edulis, P. pinea*) exceeds that of all other commercial nuts, except the cashews and is comparable to that of beefsteak. Protein quality of pine nuts is also high. Proteins are composed of amino acids. All 20 of the amino acids are found in the protein of the nuts of both *P. edulis* and *P. monophylla.* The value of *P. edulis* in the diet of the indigenous tribes of the American south-west may lie partially in the fact that of the nine amino acids essential to human growth, seven are present in greater quantity in piñons than in cornmeal (Lanner 1981).

**Table 8.3**
**Dietary value of several species of pine nuts in comparison with other commercially important nuts**

| Type of Nut | Protein (%) | Fat (%) | Carbohydrate (%) |
|---|---|---|---|
| **Pines:** | | | |
| *P. edulis* | 14 | 62-71 | 18 |
| *P. monophylla* | 10 | 23 | 54 |
| *P. cembroides* | 19 | 60 | 14 |
| *P. quadrifolia* | 11 | 37 | 44 |
| *P. sabiniana* | 30 | 60 | 9 |
| *P. strobiformis* | 28 | 52 | 7 |
| *P. pinea* | 34 | 48 | 7 |
| *P. sibirica* | 19 | 51-75 | 12 |
| *P.gerardiana* | 14 | 51 | 23 |
| Pecan (*Carya illinoensis*) | 10 | 73 | 11 |
| Peanut (*Arachis hypogaea*) | 26 | 39 | 24 |
| English Walnut (*Juglans regia*) | 15 | 68 | 12 |

Percentages are approximate and based on shelled nuts.
Source: Lanner 1981.

The fats of the piñons are also of high food quality. The most abundant fatty acids in the nuts of *P. edulis* and *P. monophylla* are unsaturated oleate, linoleate and linolenate. These comprise about 85 percent of the total fat content. The nuts of *P. edulis* are rich in phosphorus (1 245 mg/kg), which is equivalent to soybeans. They also contain significant amounts of Vitamin A, thiamine, riboflavin and niacin (Lanner 1981).

A paper by Farris (1993) concludes that the nutrient value of the nuts of *Pinus sabiniana*, which was used as a food by the indians of California, is similar to that of *Pinus pinea* and suggests that this species could be developed into a contemporary food source.

Another desirable characteristic of pine nuts is that if stored in a dry, well-ventilated area, they can be kept for several years without spoiling (Ciesla 1989, Lanner 1981).

## Historical aspects

Records indicate that humans have eaten the nuts of various pines since prehistoric times. In south-western United States, for example, seed coats of piñon pines have been found in the remains of human shelters in central Nevada. Carbon dating techniques have estimated these remains to be about 6000 years old. Piñon seed coats have also been found among human artefacts in sites in north-western Utah, United States, which are estimated to be about 3000 years old (Lanner 1981).

In Siberia, tribes gathered nuts of *Pinus siberica, P. pumila* and *P. koriaensis*. Russian settlers in Siberia also pressed oil from the nuts, which was called "nut oil." Before the introduction of sunflower, cottonseed and corn oil (all three from North America), pine nut oil was important in Siberia where it was considered a delicacy. Before the revolution of 1917 it was used for cooking during Lent when eating of animal fats was forbidden (Mirov and Hasbrouk 1976). Also prior to the 1917 revolution, ten percent of all hard currency in Russia was based on the trade of pine oil. Most of the trade was with France, which traditionally uses nut oil in cooking. Pine nut oil is also reportedly an excellent bread preservative when a small amount is added to the dough (Lloyd 1996).

The nuts of *Pinus pinea* have been used in the Mediterranean region as a food item for over 2000 years. In Italy it is known as *pino domestico* or *pinone;* in France, *pignion* and in Arabic, this tree is known as *sanawar* (Farris 1983). In ancient Rome, a wine was made from the nuts of *Pinus pinea.* This tradition may partially account for the orgiastic nature of the rites of Cybelle which ancients compared to those of Dionysius (Mirov and Hasbrouk 1976). Evidence from the ruins of Pompeii and Herculaneum, at the base of Mount Vesuvius in southern Italy, indicates that the nuts of this species were widely used. One recipe recovered from these ruins calls for using crushed pine nuts, almonds and vinegar in a type of mustard. Pine nuts were also used in sausages, salads, turnover sweets, and as seasoning for boiled bulbs and various sauces (Meyer 1980). Pine nuts were preserved in honey and eaten (Maheshwari and Konar 1971). The cones of this tree were used for rubbing the interiors of wine vats (Meyer 1980).

The seeds of *P. gerardiana*, a pine which occurs in Afghanistan and Pakistan where it is known as *chilgoza* or *nioza,* has been a traditional food of nomadic tribes. The large cones of this tree were collected by means of long, hooked poles. They were then gathered and stacked in heaps while still unripe and were roasted over an open fire. The resin in the cones would catch fire and the resultant heat would open the cones and release the seeds (Maheshwari and Konar 1971).

Various indigenous tribes in California, United States, used the nuts of *Pinus coulteri, P. lambertiana, P. sabiniana,* and *P. torreyana* for food (Lanner 1981). In British Columbia, Canada, the Shuswap Indians collected seeds of *Pinus ponderosa, P. monticola* and, less frequently, *P. albicaulis* and *P. flexilis* (Mirov and Hasbrouck 1976). The first Spanish explorers visiting California were offered seeds of *P. sabinana* by friendly indians. Later, Spanish priests tried to discourage mission indians from using wild foods including the gathering of pine nuts. However, in a number of early Roman Catholic missions, the use of pine nuts eventually became accepted as a supplement to "civilized" foods (Farris 1983).

Some anthropologists believe that the piñon pine of America south-west was such an important food item to the indigenous tribes of this region that its presence allowed them to evolve into an agricultural society (Fig 8.2). Piñon nuts became an early staple food and may have been used as a trade item to acquire corn, beans and squash from tribes living further south. There is even some evidence that the use of piñon nuts as a trade item may have affected the natural range of at least one species of piñon pine. An isolated stand of *P. edulis* pine occurs in a place called Owl Canyon, north-west of Fort Collins, Colorado. This stand is approximately 150 km north of the nearest stands of piñon and may have originated from pine nuts carried by humans along an ancient trading route (Lanner 1981, Ciesla 1989) (Fig 8.3). An isolated forest of *Pinus flexilis* in the western part of the state of North Dakota, United States (Critchfield and Little 1966) may be the result of a similar occurrence.

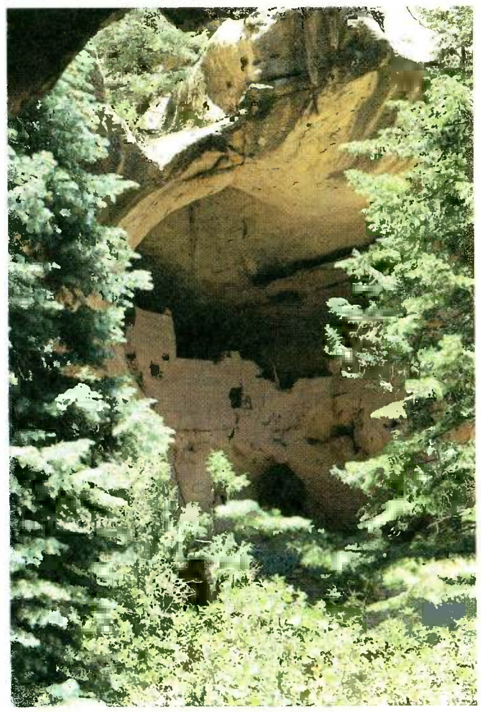

Figure 8.2: An Anasazi cliff dwelling in northern New Mexico, United States. Some anthropologists believe that it was the occurrence of *Pinus edulis*, which provided a stable food source that allowed an advanced civilization to develop in this region.

Methods of harvesting pine nuts by indigenous tribes in North America varied considerably. Among the people of the Pueblo cultures of south-west United States, collection of piñon nuts was a family affair. Temporary camps were established in the mountains in autumn when seed fall began. Nuts were either picked off of the ground or trees were shaken to release the seeds on blankets spread underneath the trees. An efficient nut gatherer could harvest from 5 to 10 kg of nuts in a single day. The completed harvest was packed in wagons and taken home. When they arrived at home, the nuts were roasted on a griddle and put away in earthenware jars for the winter. Gathering of pine nuts in piñon forests is still done today by many people of the Pueblo cultures. The indigenous tribes of the Great Basin region (Nevada and Utah, United States) collected cones with hooked sticks and either stored seeds in cones for the winter or opened the cones by the heat of a fire for immediate use (see textbox) in a manner similar to what was done by nomadic tribes of Afghanistan. Piñons were basically a winter food for the Pueblo cultures and could be eaten raw, roasted or boiled. The Navajo mashed the nuts into a paste the texture of butter that was spread on hot corn cakes (Lanner 1981).

## Contemporary uses

Today pine nuts are considered a delicacy in many of the world's cultures. In addition to being eaten raw or roasted, they are an ingredient in a variety of dishes including breads, candies, cookies, sauces and cakes as well as vegetable and meat dishes (Appendix 2). The most widely used pine nuts today are those harvested from *Pinus pinea*, *P. koraiensis* and *P. gerardiana. Pinus edulis* and other piñon pines indigenous to Mexico or south-western United States are important regional foods but are not widely exported.

Figure 8.3: A forest of *Pinus edulis* in Owl Canyon, near Fort Collins, Colorado, United States. This stand is about 150 km north-east of the main distribution of this species and may be the result of indigenous people accidentally spilling seed along an ancient trade route.

Data on world production of pine nuts are not available. In south-western United States, annual crops of *Pinus edulis* are estimated to average between 454 000 and 907 000 kg and can reach 3.6 million kg in an exceptionally productive year. In some years, however, commercial crops can be non-existent (Ronco 1990). During the years 1976-1980, the United States imported an average of US$800 000 of pine nuts, annually.

The most important pine nut imported was the nut of *P. pinea* (Wickens 1995) (Fig 8.4). This accounted for 68 percent of the imports. Spain and Portugal were the major source of nuts of this pine species. The remainder were *P. koraiensis* nuts imported from China. China is the world's largest producer and exporter of seeds of *Pinus koraiensis* and *P. sibirica* (Fig 8.5). The nuts of these species are also harvested in Siberia, Russia, where there is a high domestic demand (de Beer n.d).

The seeds of *Pinus gerardiana* are long and boat-shaped with one sharp end. *Pinus gerardiana* seeds are preferred by the confectionery industry because they are easier to insert into cakes and sweets than are the blunt nuts of the piñon pines or *Pinus pinea* (Mirov and Hasbrouck 1976).

Prices for pine nuts vary according to quality and location. In New Mexico, United States, half pound packages of roasted *Pinus edulis* nuts sold for US$4.95 (US$22/ kilo) during the spring of 1996 (author's observation). In Rotterdam, the Netherlands, where about 100 tonnes of pine nuts are imported annually from China and Pakistan, well sorted, well packaged, fresh skinned pine nuts would sell for between US$4.00-5.00/kg (de Beer n.d.). In Italy, March 1998 retail price for 50 gr packages of first quality, big seized *Pinus edulis* nuts was close to 7 000 Italian lira/package (1US$/1 800 Lira). In 1996, pine nut oil, pressed from the nuts of *P. koraiensis,* had a market price of US$20/ litre (Lloyd 1996).

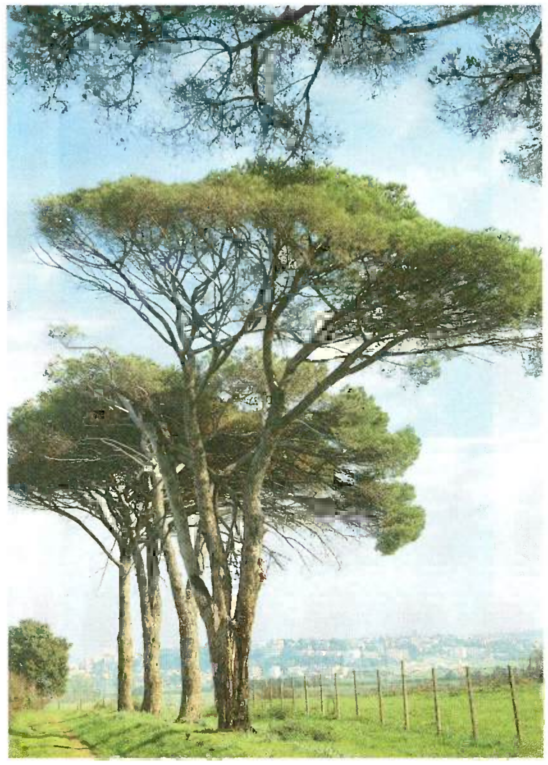

Figure 8.4: A grove of *Pinus pinea*, south of Rome, Italy. The edible seeds of this species are important in international trade.


Figure 8.5: Packaged nuts of *Pinus koraiensis*. Its nuts are harvested in China and exported world-wide.

Figure 8.6: *Chilgoza*, the edible nuts of *Pinus gerardiana*, for sale in a market in Quetta, Balochistan Province, Pakistan.

## HARVESTING PIÑON NUTS

The following description of piñon nut harvesting by the Mono Lake Paiute Indians of California was made by famous American conservationist John Muir around 1870:

*"When the crop is ripe, the Indians make ready the long beating-poles; bags, baskets, mats and sacks are collected; the women out at service among the settlers, washing or drudging, assemble at the family huts; the men leave their ranch work, old and young, all are mounted on ponies and start in great glee to the nut lands, forming curiously picturesque cavalcades; flaming scarves and calico skirts stream loosely over the knotty ponies, two squaws usually astride of each, with baby midgets bandaged in baskets slung on their backs or balanced on the saddle-bow; while nut baskets and water jars project on each side, and the long beating-poles make angles in every direction. Arriving at some well-known point where grass and water are found, the squaws with baskets, the men with poles ascend the ridges to the laden trees, followed by the children. Then the beating begins right merrily, the burrs (cones) fly in every direction, rolling down the slopes, lodging here and there against the rocks and sage brushes, cached and gathered by the women and children with fine natural gladness. Smoke-columns speedily mark the joyful scene of their labours as the roasting fires are kindled, and, at night, assembled in gay circles garrulous as jays, they begin the first nut feast of the season."*

Source: Lanner (1981)

## ARAUCARIA NUTS

The genus *Araucaria* consists of about 18 species of trees that are found in the Southern Hemisphere. They occur in Australia, New Guinea, New Caledonia, New Hebrides, Norfolk Island and South America in tropical, sub-tropical and temperate climates (Ntima 1968). The seeds of three species, *A. araucana, A. angustifolia* and *A. bidwelli* are large and edible. These are locally important food sources for humans and the seed of one species is an important livestock feed.

*A. araucana,* is a component of the high elevation forests of southern Chile and south-western Argentina (Vidakovic 1991) where it is known as *pehuén* or *piñón*. Its seeds, known locally as *piñones*, are important as a food source for indigenous tribes especially a Chilean tribe known as the Pehuenches. They grind the seeds into flour, which is used as a staple food. They also cook the seeds in various ways or ferment them for a drink (Chandrasekharan *et al.* 1996). *Piñones* are sold in local markets in southern Chile, especially in places like Concepción, Temuco and Valdivia, where they generally appear in April. The seeds are eaten raw or they are boiled for about 1 and ½ hours and eaten[22].

The Paraná pine, *A. angustifolia,* is found in the southern states of Brazil, particularly in the hilly portions of Paraná State where it reaches its best development and from where it gets its common name. This tree is also found in the Brazilian States of Santa Catarina, Rio Grande do Sul, Mato Grosso, Sao Paulo and Minas Gerais as well as small areas of neighbouring Paraguay and Misiones Province, Argentina (Ntima 1968). It is highly prized for both its excellent quality lumber and its edible and nutritious nuts. *A. angustifolia* produces large cones, each averaging 17 cm in diameter and weighing an average of about 2.4 kg. The cones contain an average of 112 sound seeds which have an average length of 5.8 cm (Fig 8.7) (Malinovski 1977).

Figure 8.7: Nuts of *Araucaria angustifolia,* these are an important food item in southern Brazil and adjoining portions of Argentina.

[22] Information provided by Jorge Urrutia, Universidad Austral, Valdivia, Chile, and Frederich Schlegel, FAO, Rome, Italy.

The first Spanish and Portuguese explorers to visit southern Brazil and northern Argentina reported that the nuts of *A. angustifolia* were an important food item for the indigenous tribes that inhabited the region. The nuts were harvested during March, April and May and were eaten either roasted or were ground into a paste which was boiled (Rodrigues Mattos 1972).

Today, the nuts of *A. angustifolia*, known locally as *pinhões*, are an important local delicacy. The nuts are harvested by climbing the trees with long ladders and knocking the cones out of the trees with a stick. The harvest usually begins in April. *Pinhões* are readily available in local markets between April and June where they sell for about US$1-2/kg. Unfortunately, the seeds of this tree do not store as well as do the seeds of the piñon pines of Mexico and south-western United States and are not available as a food source throughout the year [23].

*Pinhões* are eaten in a variety of ways. They can be boiled either in a pot or pressure cooker. Cooking time is reduced by about one third if the *pinhões* are left soaking in water overnight. *Pinhões* can also be roasted on a metal sheet or baked in an oven. *Passoca de pinhões* is a traditional recipe, which calls for grinding the nuts, boiling them and serving them with milk. *Farinha de pinhões*, another traditional dish, is a bread made with *pinhões* and almonds (Rodrigues Mattos 1972).

The seeds of *A. angustifolia* are also a nutritious and locally important feed for livestock, cattle, swine and horses in the south of Brazil (Rodrigues Mattos 1972).

*A. bidwelli*, known locally as Bunya-bunya pine, occurs in the coastal regions of Queensland, Australia. This tree produces large, egg-shaped seeds. There are about 60 seeds/kg. The seeds are a traditional food of the aborigines and are so highly valued that aboriginal families claim ownership of individual trees (see textbox). Good seed crops occur on the average of once every three years (Audas 1952).

**PASSING TREES FROM GENERATION TO GENERATION**

The nuts of the Australian Bunya-bunya pine, *Araucaria bidwelli*, are so revered by the aborigines that individual families claim ownership to certain trees. Ownership of these trees is so sacred that if an outsider is caught harvesting nuts from a tree claimed by a family, it is, at least, the basis for a serious quarrel.

The aborigines travel over 150 km to areas in Queensland where groves of Bunya pines occur when the seeds ripen, usually in January.

Trees with notches cut into the trunks to assist climbers can be seen in the Bunya Mountains National Park in south-eastern Queensland.

The right to collect seed from individual trees is passed from father to son (Audas 1952, Boland *et al.* 1984).

[23] Information provided by Attilio Disperati, Universidade Federal do Paraná, Curitiba, Brazil

## SEEDS OF *TÓRREYA* SPP.

The genus *Tórreya* (Family Taxaceae) is comprised of small to medium sized trees that have somewhat localized ranges. Six species are known: two from North America, one from Japan and three from China. The North American species are known as "stinking cedar" or "stinking yew" because of the disagreeable odour of their foliage when crushed. Several species of this group have edible seeds.

*Tórreya nucifera* is native to the mountainous regions of central and southern Japan where it is known as *kaya*. The nuts of this tree are edible. They are said to posses an agreeable, slightly resinous flavour and are widely sold in Japanese markets in autumn. They are eaten either raw or roasted and are a popular dessert item. The primary use of these nuts is the production of a cooking oil known as *kaya-no-abura*. According to one report, at one time these nuts were exported through Shanghai and Guangzhou (Canton), China. This is probably unlikely, however, because this tree does not occur in China. The nuts of a Chinese species, *T. grandis*, are also edible and may have been harvested and exported at one time. *T. grandis* nuts are also reported to have some medicinal properties. The fruits and foliage of *T. nucifera* contain 6-hydroxydehydroabietinol, a substance with marked estrogenic activity and may have potential pharmaceutical uses (Burke 1975).

*Tórreya californica* is endemic to California, United States, where it occurs along the western slopes of the Sierra Nevada and Coast Ranges (Griffin and Critchfield 1972). The nuts of this tree were used as a food by local indian tribes. They are said to be rich and oily and when eaten raw resemble the taste of coconut. When roasted, the nuts reportedly have an agreeable taste similar to groundnuts. They were considered a highly prized food item and sometimes gathered in large quantities (Burke 1975). The Costanoan indians, a tribe which once occupied the coast ranges of central California between the present day locations of San Francisco and Monterrey, was one of the tribes that made use of the nuts of this tree. They pulverized the nuts, mixed them with animal fat and rubbed the mixture on the temples to treat headache. The same mixture was rubbed on the body to treat chills and swelling. The nuts were chewed as a remedy for indigestion (Bocek 1984).

## GINGKO FRUITS AND SEEDS

The gingko or maidenhair tree, *Gingko biloba* (Family Gingkoaceae) is a tree native to China where it has survived for almost 200 million years, but now widely planted as an ornamental tree. Its name is derived from the Japanese word for this tree and its nuts which are considered to be a delicacy in Asia (Hora 1981). In China, leafs, fruits and seeds of this tree have been used since about 2800 BC, both for food and medicine (Tyler 1993). The fruits are rich in carbohydrates, fat, protein and a number of vitamins (Iqbal 1993). *Gingko biloba* leaves contain a wide variety of phytochemicals, such as alkanes, lipids, sterols, benzenoids, carotenoids, phenylpropanoids, carbohydrates and flavonoids.

The use of extracts of the fruits of *Gingko biloba* for medical purposes is of relatively recent interest in the western world. In Germany, medicines made from the fruit of the gingko are now among the most widely used and are sold both as an over-the-counter drug or via prescription. In 1988, doctors in Germany wrote more prescriptions for drugs containing extracts of gingko than for any other plant-derived drug. Medicines containing gingko are most effective as concentrated extracts, either in the liquid or tablet form. Gingko has been shown to have beneficial effects on the circulatory system, particularly among elderly people. Other studies indicate that it can help memory loss, headache, tinnitus (ringing in the ears) and depression by improving blood flow in the arteries and capillaries (Tyler 1993). Total annual production of gingko fruits in China is estimated at about 5 000 tonnes, much of which is exported at a value of some US$7 million (Iqbal 1993).

## JUNIPER BERRIES

Juniper berries, principally from *Juniperus communis*, are an important spice in many European cuisines, especially in areas where junipers grow abundantly. These berries are the **only** example of a spice that comes from a conifer. Juniper berries are commonly used as flavouring in sauerkraut, a traditional French and German dish. The primary use of crushed juniper berries, however, is to impart a sharp, clear flavour to wild game birds or venison (Grausman 1988, Van Waerbeek 1996). Some cooks prefer to use the dried, mature berries, which can be purchased in European markets. However, at least one culinary specialist prefers to use the fresh berries, picked green from juniper trees. When used fresh, juniper berries will impart a stronger taste of resin and a slightly bitter flavour to the meat (Grausman 1988).

Juniper berries contain a volatile oil that acts as an irritant to stimulate kidney filtration and output. Therefore, they have been used as a diuretic to treat conditions involving the kidneys and bladder, to increase urine output and for relief of symptoms of gout and kidney stones. When eaten raw, they are believed to act as a stimulant to increase the appetite and also serve as a traditional remedy for rheumatism and arthritis. Juniper berries are generally considered a "safe" medication except for pregnant women, who may suffer from increased contractions of the uterus, or those suffering from chronic kidney ailments [24]. Some indigenous North American tribes (Turner 1988) also knew the diuretic properties of juniper berries.

The principal flavouring of the alcoholic spirit gin is an infusion of fully-grown but unripe berries from *Juniperus* spp., primarily *J. communis* (Hora 1981). The English word "gin" is an abbreviation of the word "geneva", a corruption of either the French word "genièvre" or the Dutch word "jenever", both meaning "juniper."

Gin was developed by Franciscus de la Boe (1614-1672), also known as Dr Sylvius, a physician and professor of medicine of some renown at the University of Leyden in the Netherlands. Dr Sylvius' objective in developing this spirit was strictly medicinal. Knowing about the diuretic properties of the oil extracted from the fruit of *Juniperus communis,* he believed that by redistilling a pure alcohol with the juniper berry, he could obtain its therapeutic oil in a form that would provide an inexpensive medicine. He succeeded in producing a drink which became very popular because the flavour which the juniper berries imparted to the spirit masked its harsh taste. Within a few years, all of the Netherlands found itself suffering from various ills that could only be cured by Dr Sylvius' medicine (Grossman 1976). The low cost and ready availability of this new "medicinal" spirit led to many cases of alcohol abuse in the Netherlands and other parts of Europe. The expression "Dutch courage" has its origins in the practice of British soldiers and sailors taking a drink (or two) of gin before going into battle.

Three different categories of distilled gin are recognized today. *Jenever* is distilled primarily in the Netherlands and Belgium from spirit and juniper berries. After distillation, the gin is matured to give it a heavier flavour. *Jenever* is generally drunk straight in short glasses as an aperitif or with a beer chaser. London Dry Gin is the most popular form of this spirit and is well known for its light flavour and complex character which is due to the fact that in addition to juniper berries, it contains several other botanicals. A good quality London Dry Gin will almost always contain juniper berries, coriander seeds, angelica root and other ingredients known usually only to the distiller, to give it additional complexity. Plymouth gin is also distilled with several botanicals and is often slightly heavier in flavour than London Dry Gin. Plymouth gin can be distilled only in Plymouth, United Kingdom.

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[24] Data obtained from Smart Basics Inc, California (smartnet@sirius.com) via the World Wide Web.

Virtually all juniper berries are harvested in the wild. Two growing seasons are required for the berries to ripen and the bluish-purple fruits are about 0.12 cm across when ready to harvest (Fig 8.8). Northern Italy and Yugoslavia produce some of the best quality juniper berries with a high resin and sugar content. The largest Italian berries are sold at a premium as a special culinary item for sauces and preserves but most of the harvest is used for production of gin. The fermented, spent berries from the gin distillation are re-distilled to produce an essential oil (see Chapter 7)[25]. Juniper berries are also harvested in Denmark (Salo 1995). Berries and juniper berry oil are also available from Turkey, Iran and Pakistan.

In India, the berries of *Juniperus communis* are used to produce a brown coloured dye[26].

Figure 8.8: The fruits of *Juniperus communis* are an important ingredient in the manufacture of gin and a traditional spice in a number of continental European dishes.

## CONES

Conifer cones are generally collected for two purposes, collection of seed for reforestation and for decoration. Since cone collection for seed is primarily to reforest areas for timber production, only decorative cones will be discussed in this section.

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[25] Data obtained from Frontier Cooperative Herbs via the World Wide Web.

[26] Date obtained from Dr. M. P. Shiva, Centre of Minor Forest Products, Dehra Dun, India.

## Uses

A wide variety of cones are used in floral, wreath and potpourri products. They are used in gift and fragrance items, as ornaments and table decorations. There are also a variety of small niche markets such as jewellery, bird feeders etc. Cones can also be used as fire starters in fireplaces or crushed and moulded into presto-log shapes (Thomas and Schumann 1992). In some areas, cones can be made into curio items for sale to tourists. For example, in the foothills of the Himalayas in Uttar Pradesh State, India, the cones of *Pinus roxburghii* are fashioned into birds and sold in local markets (author's observation) (Fig 8.9).

Virtually all species of conifer cones that do not have deciduous scales and remain intact after they have cast their seeds are marketable. There is even a market for the deciduous cone scales of *Abies nobilis*, which are used in the potpourri industry. In the floral market, large cones are generally more marketable while in the potpourri market, small, mid-sized and large cones may all be used. Small cones are generally more valued for making wreaths (Thomas and Schumann 1992). In Nicaragua, the cones of *Pinus oocarpa* are collected in large quantities, spray painted various colours and sold in local markets just before the Christmas season (author's observation).

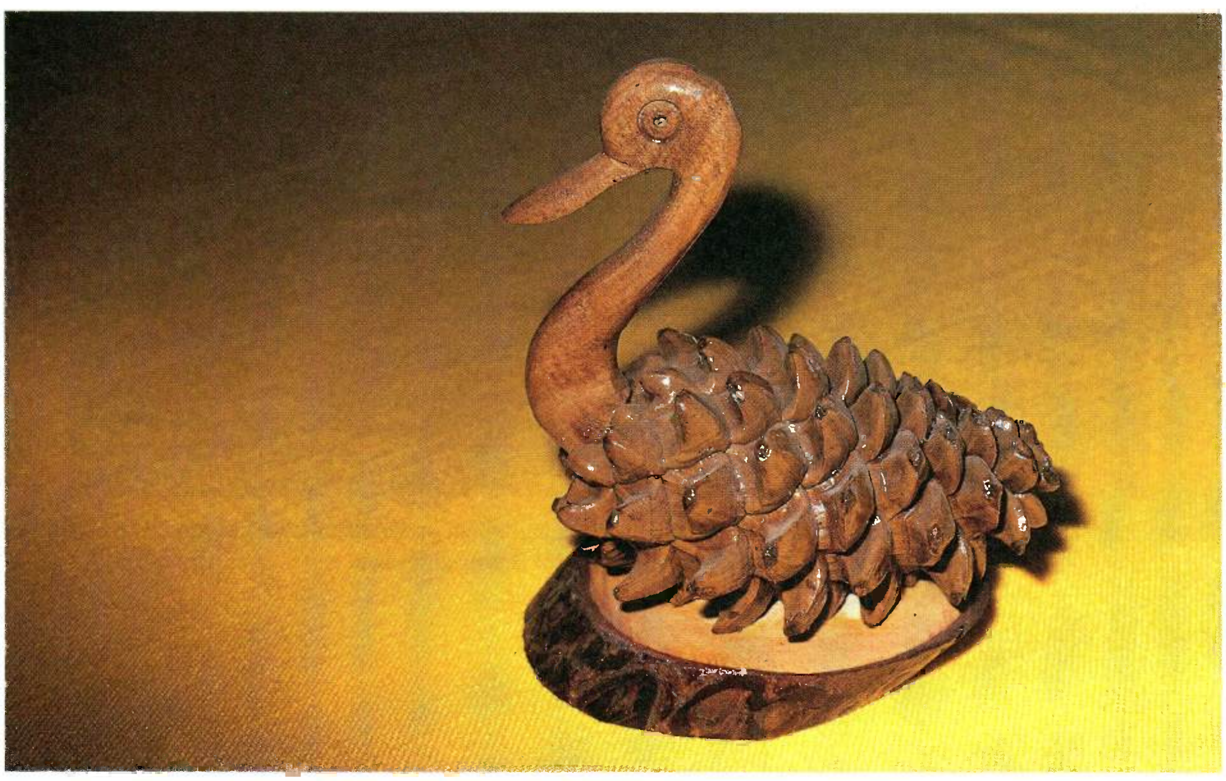

Figure 8.9: Bird curio made from a cone of *Pinus roxburghii*, Uttar Pradesh, India.

The cones of the eastern Himalayan species, *Abies spectabilis*, yield a purple or violet dye that is locally important in parts of India[27].

[27] Data provided by Dr. M.P. Shiva, Centre for Minor Forest Products, Dehra Dun, India.

## Sources and markets

Thomas and Schumann (1992) provide a comprehensive discussion of the decorative cone market in the United States. Many manufacturers of cone products, especially potpourri manufacturers, obtain cones from seed extraction plants after the seed has been removed. Certain soft bodied cones such as Norway spruce, *Picea abies*, are too fragile to survive seed extraction and other cones which are extremely large, e.g. *Pinus lambertiana*, *P. coulteri*, or *P. sabiniana* can only be obtained from people who make a living from collecting cones known as "wildcrafters."

Prices paid for decorative conifer cones is subject to annual variation, as well as location and species of cone. In the United States, prices will generally range from US$0.37 to 0.52 per pound (US$0.81 to 1.15/kg) for semi-dried cones. In the United States, this market has seen a fairly steep upward curve in prices during 1991 and 1992. In the state of Wisconsin, United States, during the fall of 1991, wildcrafters were earning the following prices for cones:

| | |
|---|---|
| *Picea glauca* | US$2.50/ bushel |
| *Pinus resinosa* | US$1.75/ bushel |
| *Picea mariana* | US$0.50/ bushel |
| *Larix decidua* | US$1.00/ pound |

In south-eastern United States, cone buyers typically paid between US$0.50 and 1.50 per bushel in 1991 for a trailer load (2 400 bushels) of cones. It takes about five people five days to pick a trailer load of large pinecones with each individual gathering about 100 bushels per day. At this rate, they could each earn roughly US$200/day in a good location. A wildcrafter working in the United States must make a minimum of US$75 per day in order to stay in business and good wildcrafters can average about US$120 per day. An example of prices of decorative conifer cones sold on the United States retail market is given in Table 8.4.

In the United States, there are four primary regions for decorative cone's sales; Tennessee, Minnesota, the East Coast and California. As of 1992, the market for large cones was increasing while the market for small cones was declining. One of the largest-selling cones world-wide is the cone of the North American *Pinus contorta*, primarily because of its availability. In southern-eastern United States, the cones of *Pinus palustris* are popular because of their large size. Outside the United States, Europe is becoming a strong market for decorative cones. For cones and most botanical products, entrepreneurs have noted that the German market is about ten times that of the United States' market. There are opportunities in developing countries with extensive conifer forests (e.g. Mexico and Central America or Eastern Europe) to help meet the demand for decorative cones.

In the United States, it is better for wildcrafters to sell cones and related products to brokers or wholesalers rather than to try to deal directly with large manufacturers. Brokers perform an important function in keeping the supply even and the market steady. A wholesaler or broker can also meet the large quantities needed. For example, a medium sized company buying cones for Christmas holiday gift packs may require 30 trailer loads of cones per year or about 7 200 bushels at between US$0.50 -1.50 per bushel. The broker, who receives cones from a number of wildcrafters, can readily meet this demand.

**Table 8.4**
**Retail prices for conifer cones**
**Pacific north-western, United States – 1991**

| Species | Price / pound (unless otherwise noted) (US$) |
|---|---|
| *Tsuga* spp. | 1.50 |
| *Larix* spp. | 1.80 |
| *Sequioadendron giganteum* | 0.60 |
| *Calcocedrus decurrens* | 1.80 |
| *Thuja plicata* | 1.50 |
| *Pseudotsuga menziesii* | 0.25-0.35 |
| *Pinus sabiniana* | 0.45* |
| *Pinus jeffreyi* | 0.18* |
| *Pinus attenuata* | 0.12* |
| *Pinus contorta* | 0.40 |
| *Pinus palustris* | 0.15-0.25 |
| *Pinus ponderosa* | 0.30-0.45 |
| *Pinus lambertiana* | 0.45-0.60 |
| *Pinus strobus* | 0.70 |
| *Picea mariana* | 0.70 |
| *Picea abies* | 0.10* |
| *Picea sitchensis* | 0.65 |
| *Picea glauca* | 0.40-0.65 |

* Price per cone
Source: Thomas and Schumann (1992)

# CHAPTER 9
# NON-WOOD PRODUCTS FROM ORGANISMS ASSOCIATED WITH CONIFERS

A number of plants and animals associated with conifers and conifer forests are the source of valuable non-wood products, several of which are important in local and regional economies. Others are important traditional products. In this chapter, non-wood forest products from plants that are directly associated with conifers and conifer forests are discussed. Examples are edible mushrooms, edible insects, lichens and dwarf mistletoes. The latter is a group of plants that are parasites of conifers. Products and services from animal origin (furs, trophies, hunting) and berries, such as *Vaccinium* spp., *Sorbus* spp., *Rubuss* spp., and *Fragaria* spp. and medicinal plants are not included in this review.

## EDIBLE MUSHROOMS

Mushrooms, the reproductive structures of fungi (also known as sporocarps or fruiting bodies) are a major food item 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. Both natural and planted conifer forests are important sources of edible mushrooms world-wide.

### Types of fungi

The fungi are a large group of 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**, causing disease in higher plants, as **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 derives benefits from the association.

The predominant symbiosis between fungi and trees takes place 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. The mycorrhyzal fungi basically function as an extension of the plant's root system and are the normal 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 fungi produce highly favoured, edible wild mushrooms, which are harvested in large quantities. Of the several types of mycorrhizae, only fungi forming "ectomycorrhizae" (a type that forms a distinct fungal mantle around the exterior of the root tip) produce edible mushrooms (Molina *et al.* 1993). Some forest fungi, which are either parasitic or saprophytic, also produce edible mushrooms.

The conifers of the family Pinaceae have a large complex of mycorrhiza associates and some produce abundant and highly prized forest mushrooms. In the Pacific Northwest region of the United States and adjoining portions of Canada, the coniferous genera *Abies, Larix, Picea, Pinus, Pseudotsuga and Tsuga* are all known to have species of ectomycorrhizae associated with them. Douglas-fir, *Pseudotsuga menziesii*, for example, is known to have nearly 2 000 species of ectomycorrhizal associates (Molina *et al.* 1993).

## Edible mushrooms associated with conifers

A few of the common genera of ectomycorrhizae, which are associated with conifer forests and also produce edible mushrooms, include *Boletus, Cantharellus, Craterellus, Suillis* and *Tricholoma* (Molina *et al.* 1993). It must be acknowledged that the following review is not intended to be a comprehensive listing of species of edible mushrooms associated with conifer forests, but rather a description of some of the best known ones.

The Japanese matsutake mushroom, *Tricholoma matsutake*, ccurs in association with forests of *Pinus densiflora* in Japan, and is also found in Korea and northern China. This dark brown mushroom has a dense, meaty texture and a nutty (spicy) fragrant flavour that is highly prized by the people of Japan. It is available fresh from late fall to mid-winter and can be found only in Japanese markets or speciality product stores. Canned matsutake mushrooms are also produced. They can be cooked by a variety of methods including braising, grilling, steaming and frying. The Japanese matsutake is considered to be the most expensive food in the world. One hundred grams of good quality matsutake mushrooms sell in Japanese markets for as much as 10 000 yen (approximately US$80).

The indigenous matsutake mushroom is so popular in Japan that cultural measures, such as regulation of light to the forest floor, thinning and removal of understory vegetation, have been attempted to increase productivity (Hosford *et al.* 1995, Nishuda and Ishikawa 1967). Korea has recently become an important source of supply for the Japanese and there also has been an increased demand for the American matsutake mushroom, *T. magnivelare* (Pilz *et al.* 1997). The American matsutake is currently in such great demand in Japan that it can command a price as high as US$100/kg. Between 1989 and 1992, Japan imported 7 740 tonnes of *T. magnivelare* from various sources (Aguilar Hernández 1995).

Europeans, especially the French and the Germans, consume large quantities of chantrelles, *Cantharellus* spp. Declines in availability of chantrelles in Western Europe have spurned the growth of exports of *Cantharellus* spp. from Canada and the United States.

Edible forest mushrooms harvested from pine forests in Mexico are a traditional food. A recently conducted survey indicates that the species most frequently encountered in local markets were golden chantrelles, *Cantharellus cibarius* and king boletes, *Boletus edulis*. About 70 percent of the mushroom gatherers are women and children (Villarreal and Pérez-Moreno 1989a).

In India, several species of edible mushrooms harvested from conifer forests are locally important foods. These include the sporocarps of ectomycorrhizal fungi, fungi that can cause root disease, and wood decay (Table 9.1).

*Flammolina velatupis* a fungus that causes decay in *Picea* spp. and other trees is another highly prized mushroom in Japanese cuisine and is widely cultivated in Japan. This mushroom is also found in the Russian Far East where it is known as *ilmak*. This mushroom is easy to preserve by canning and is also sold dried (De Beer n.d., 1995).

Edible saprobes or parasitic edible conifer mushrooms include "Morchella", among the commercially most important ones.

## Production and trade

Commercial harvesting of edible mushrooms increased significantly during the 1980s in the Pacific north-west region of the United States and British Columbia, Canada, and is currently a multimillion dollar industry with several thousand tons harvested annually (Molina *et al.* 1993). The increase is largely due to increased demand from Japan and Europe. Chantrelles, *Cantharellus* spp., and the American matsutake, *Tricholoma magnivelare*, are the principal species of economic importance. The American matsutake mushroom is, by weight, the most valuable mushroom in the region after "truffles" (which are edible fungi). Most of the crop harvested from the northern interior of British Colombia, Canada, to northern California is exported to Japan where it is considered a viable substitute for the Japanese matsutake, *T. matsutake* (Hosford *et al.* 1995). Commercial harvesting of this species is concentrated in forests of *Pinus contorta* (Molina *et al.* 1993). Other ectomycorrhizal mushrooms gathered in conifer forests in this region include *Boletus* spp., two species of truffles; *Leucangium carthusiana* and *Tuber gibbosum* and a species known as "hedgehogs," *Hydnum repandum* (Amaranthus and Pilz 1996).

**Table 9.1**
**Edible mushrooms harvested from conifer forests in India**

| Species | *Forest Type and Location* |
| --- | --- |
| *Agaricus campestris* | High elevation meadows in the Himalayas |
| *Amanita phalloides* | Conifer forests |
| *Armillaria mellea* | Conifer forests |
| *Cantharellus cibrosius* | Conifer forests (Himachal Pradesh) |
| *Clavatia elata* | Conifer forests |
| *Collybia maculata* | *Abies* and *Pinus* forests |
| *Letinus lepidens* | From bark of *Cedrus deodara* |
| *Morchella esculenta* | Conifer forests (under snow cover) |
| *Pleurotes ostreatus* | *Picea* spp. |
| *Polyporus sulphureus* | Conifer forests (Uttar Pradesh, Jammu and Kashmir |
| *Sparassis crispa* | At base of various conifers |

Source: M.P. Shiva, Centre for Minor Forest Products, Dehra Dun, India.

Commercial harvesting of mushrooms in western United States is a relatively young industry. A study conducted during 1992 indicates those mushroom harvesters, processors and shippers had been in business for an average length of nine years. Processors employed an average of five workers in 1992 and purchased from an average of 112 individual harvesters. An average total of about 25 000 kg were harvested and the average value of purchases per processor was US$278 000. A total of 1.78 million kg of mushrooms was purchased by the industry in 1992. Of this total, more than half was purchased from harvesters in western Oregon and Washington. The gross value of the industry's production for 1992 was estimated at US$41.1 million: US$25.1 for Oregon, US$11.9 million for Washington and US$1.6 million for Idaho. This provided either full-time or part-time employment for nearly 41 000 people (Schlosser and Blatner 1995). Prices paid to pickers can vary from US$6.50 to 100/kg depending on mushroom species and quality (Table 9.2).

**Table 9.2**
**Average price per kilogram paid to mushroom pickers in the Pacific North-western United States - 1992**

| Species | Price/Kg. (US$) |
|---|---|
| American matustake, *Tricholoma magnivelare* | 17.50* |
| Golden chantrelle, *Cantharellus cibarius* | 6.50 |
| Boletes, *Boletus* spp. | 10.00 |
| Truffles, *Leucangium carthusiana* and *Tuber gibbosum* | 65.00 |
| Hedgehogs, *Hydnum* spp. | 6.50 |

* Prices of up to US$100 were paid for young mushrooms of outstanding quality
Source Amaranthus and Pilz (1996)

In 1992 most of the edible mushrooms harvested in the Pacific north-west were sold to international markets. Ninety one percent of the American matsutake harvest was exported, mostly to Japan. Forty one percent of the chantrelle harvest was sold to European markets and 30 percent was sold in western United States (Schlosser and Blatner 1995, Table 9.3).

**Table 9.3**
**Key final markets as a percentage of the total volume of edible ectomycorrhizal mushrooms from conifer forests in the Pacific north-west, United States – 1992**

| *Edible Mushroom* | *Key Final Market* | *Percentage* |
|---|---|---|
| Chantrelles | Western USA | 30 |
| | Germany and France | 14 |
| | Canada | 9 |
| | Other Europe | 27 |
| | Other international markets | 20 |
| Matsutake | Japan | 70 |
| | Canada | 21 |
| | Other | 9 |
| Boletes | France | 28 |
| | Other Europe | 12 |
| | Western USA | 27 |
| | Eastern USA | 15 |
| | Japan | 12 |
| | Other | 6 |

Source: Schlosser and Blatner (1995)

Until recently, most trade in edible forest mushrooms in Mexico was for domestic use. Between 1984 and 1987, there was a limited export, primarily to the United States, which totalled US$410 000 (Villarreal and Pérez-Moreno 1989a). However, because of the demand for the American matsutake mushroom in Japan, a vigorous mushroom industry has developed in Mexico since 1985 (Villarreal and Pérez-Moreno 1989b). In Mexico, the American matsutake mushroom is found in pine forests, principally *Pinus tecote,* and fruiting bodies appear during the rainy season between July and October. Commercial harvesting presently takes place in the States of Mexico, Hidalgo, Michoacan, Oaxaca and Veracruz. Potential distribution of this mushroom in Mexico includes Baja California de Norte, Chiapas, Chihuahua, Coahuila, Durango, Guerro, Guantuato, Jalisco, Nayarit, Nuevo León, Queretaro, Sonora, Tlaxacala and Zacatecas. Between 1989 and 1992, some 35.8 tonnes of American matsutake mushrooms were exported from Mexico to Japan. The 1993 harvest alone was 12 tonnes, yielding a return of US$375 000 to appoximately 3 000 families involved in the harvest. Japan imported 8.4 tonnes of that harvest for a value of US$465 000. Mexico's participation in the Japanese mushroom market currently stands at 0.25 percent. Approximately 35 000 hectares have been designated as potential mushroom habitat in Mexico, but harvesting currently occurs on only 48 percent of the habitat. A potential annual harvest of 30 tonnes is projected from the States of Hidalgo and Veracruz alone (Aguilar Hernández 1995).

Japan places strict standards on the quality of American matsutake mushrooms that are imported into the country. Mushrooms must be plucked whole by hand and cleaned (Japanese will not buy matsutake that have been cut). They must be kept fresh and undamaged, be free of maggots and be stored at the proper humidity. Shipping occurs in storage containers kept at a constant temperature of 8° C from the collection point to the packing station and 4°C when shipped abroad (Villarreal and Pérez Moreno 1989b).

The mushrooms produced by the fungus *Boletus luteus* appear spontaneously (unintentional nursery inoculation or spores from nearby plantations) in *Pinus radiata* plantations in Argentina, Chile and Spain. The first fruiting bodies appear during the fourth year after planting and reach peak production in the seventh year. The yield then continues at a more or less constant level until the plantation reaches age 15 and the dense crown foliage prevents penetration of sufficient solar radiation to the forest floor (Ibqal 1993). In Chile, sporocarps of *Boletus luteus* develop in *Pinus radiata* plantations between the ages of 6 and 20 years. Yields between 0.3 and 1.5 tonnes/ha have been reported (Chandrasekharan *et al.* 1996). These nutritious mushrooms can be gathered by local people, dried in the sun to reduce moisture content down to 35 percent and are sold to exporters. Exports of sliced, dehydrated or preserved *B. luteus* and other mushrooms have been rising. In 1981, Chile exported 943 tonnes of this mushroom at a value of US$2 031 863. The primary markets were France, Peru and the United States with smaller quantities being exported to Ethiopia, the Netherlands, Italy and Switzerland (Iqbal 1993). Statistical data on exports of edible Chilean mushrooms (primarily from pine forests) for the years 1990-93 are given by Garfias Salinas *et al.* (1995) (Table 9.4).

Commercial harvesting of edible mushrooms, principally of the genus *Boletus*, in pine plantations became an important local enterprise in Ecuador during the late 1980s. In Ecuador, pines are not native but plantations of exotic pines occur in the *altiplano* between 2 000 and 4 000 meters above mean sea level and presently cover approximately 30 000 ha. Most mushrooms are sun-dried and shipped directly to supermarkets and delicatessens in larger cities. In 1991, a commercial mushroom dehydration facility was developed in the community of Salinas (Bolívar Province). However, sun drying remains the primary means of processing the harvested mushrooms. In 1993, some ten tonnes of mushrooms were harvested from pine plantations. During the following year, production increased to 14 tonnes. Dried mushrooms are packaged in commercial lots of 10 kg and sold for an average price of US$5/kg. They are repackaged for individual sale in packages of 50 grams and sold at an average price of US$0.50/package. Commercial harvesting of mushrooms from pine plantations is now an important rural enterprise, especially for women. Depending on location, fresh mushrooms can be sold for up to 1US$/kg. Sun dried mushrooms sell for as much as US$2.00/kg (Rojas and Mansur 1995).

**Table 9.4**
**Exports of edible mushrooms from Chile**
**1990-1993**

| Product | 1990 | | 1991 | | 1992 | | 1993 | |
|---|---|---|---|---|---|---|---|---|
| | Vol.* | Value (US$) | Vol. | Value (US$) | Vol. | Value (US$) | Vol. | Value (US$) |
| Dried | 356 | 1 153 148 | 423 | 1 228 799 | 447 | 2 197 331 | 435 | 3 029 621 |
| Salted | 2 093 | 1 591 263 | 4 019 | 3 236 925 | 2 424 | 2 123 662 | 1 226 | 909 963 |
| Refriger-Ated | 484 | 468 129 | 453 | 564 373 | 1 270 | 1 505 197 | 1 144 | 1 383 146 |
| TOTAL | 2 993 | 3 212 540 | 4 895 | 5 030 097 | 4 141 | 5 826 190 | 2 805 | 5 322 730 |

* Tonnes
Source: Garfias Salinas (1995)

Commercial harvesting of wild mushrooms from woodlots in the United Kingdom is still considered to be a small industry but in northern Scotland, *Cantharellus cibarius* and *Boletus* spp. are harvested in sufficient number to be shipped to south-eastern England and continental Europe (Slee 1991).

Poland is the largest European exporter of edible mushrooms and supplies 70 percent of the German market imports (Acker 1986).

## Problems associated with harvesting of edible forest mushrooms

In the Pacific north-west region of the United States, commercial harvesting of forest mushrooms offers seasonal income and supplemental income in areas where unemployment is presently high due to a depressed timber industry. However, the industry has caused some problems and concerns including (Acker 1986):

- conflicts between forest users;
- mushroom pickers often work on Federal and state-owned forest lands and have not been required to pay for harvests. This is considered to be a private gain from public resources;
- concern about the sustainability of intensive mushroom harvests.

A study of harvesting of American matsutake mushrooms on portions of two National Forests in southern Oregon and northern California, United States, where nearly 2 000 mushroom harvesting permits were issued, indicates that conflicts arose between urban-based non-local mushroom pickers of south-east Asian origin and rural native American pickers. The intensified commercial collection, aimed at maximizing the harvest may be threatening the viability of locally directed harvests at traditional family gathering sites. Recommended actions to ensure a sustained level of harvest include automated issuance of permits and monitoring of harvest levels, enforcing compliance of harvesting regulations and conducting studies to clarify the interactions between the permit process, market dynamics and picker demand for the matsutake resource. The authors of this study warn, however, that current USDA Forest Service policy to reduce staff and funding based on reduced timber harvest levels will decrease the likelihood that an adequate investment can be made to ensure a sustainable mushroom harvest (Richards and Creasy, in press).

The state of Washington implemented licensing requirements for wild mushroom buyers and dealers in 1989. California recently stopped all mushroom harvesting, including recreational picking, in many state parks to help control habitat disturbance. USDA Forest Service is developing management guidelines for mushroom harvest and monitoring the resource for sustained productivity on National Forest lands in California, Oregon and Washington (Molina *et al.* 1993).

Extensive timber harvesting and mushroom picking has led to concern about the sustainability of the commercial wild mushroom harvest in the Pacific north-west region of the United States. There is additional concern that mushroom harvesting at high rates could lead to reduced forest health and productivity or affect food webs for wildlife species. Much of this concern comes from Europe where a decline in populations of mycorrhizal fungi has been observed over the past three decades (Amaranthus and Pilz 1996). A paper by Arnolds (1991), for example, provides evidence that in some European forests, ectomycorrhizal fungi are producing fewer sporocarps, notably in the oldest forests (more than 40 years old) and, in particular, conifers. He discusses a number of causal factors that might be responsible for this phenomenon including harvesting of edible mushrooms. He points out that, with the exception of *Cantharellus cibarius*, most of the species with declining numbers of sporocarps are not harvested for human consumption and concludes that there is no evidence to suggest that removal of sporocarps affects survival of the mycelia of ectomycorrhizal fungi. He also cites similar studies from Sweden, which have arrived at the same conclusion. He suggests that other factors such as air pollutants ($SO_2$, $NH_x$), soil acidification and nitrogen eutrophication may be responsible for declines in sporocarp production.

In Mexico, there is concern that harvests of the American matsutake mushroom from *Pinus teocote* forests of the intensity experienced in recent years may be reducing the viable wild populations to the point of threatening their survival. In many areas, this species is now rare. Damage reportedly occurs when the basidiocarps (mushrooms) cannot release a sufficient number of spores to start new colonies before they are picked. The fungus mycelia are damaged by collection of the reproductive fruiting bodies and soil compaction. Conservation of this species requires retention of forest cover and a better understanding of the biology and ecology of this fungus (Villarreal and Pérez-Moreno 1989b).

In 1989, the Governments of the Mexican States of Hidalgo and Veracruz signed accords with Japanese importers and local mushroom harvesters in an attempt to ensure adequate conservation measures. The accord in Hidalgo was subsequently annulled, however, because of lack of due legal process. Some efforts are underway to train collectors about the best harvesting methods (Villarreal and Pérez-Moreno 1989b).

Another concern is the effect of thinning and other silvicultural operations on future yield of edible mushrooms. In north-western United States, dense, overstocked stands of *Pseudotsuga menziesii*, and *Tsuga heterophylla* which are in need of thinning presently yield high volumes of edible forest mushrooms. Studies are underway by research scientists of USDA Forest Service to estimate yields after thinning (Pilz *et al.* 1997).

## EDIBLE INSECTS

Human societies throughout the world have made use of insects as an everyday dietary supplement, occasional delicacies and replacements for more common foods in times of shortages. In at least one instance, an insect that feeds on the foliage of pine is a traditional food source. The insect is known as the Pandora moth, *Coloradia pandora*. This insect occasionally reaches epidemic proportions and causes severe defoliation of *Pinus contorta, P. jefferyi* and *P. ponderosa* in western United States. Recently, there have been outbreaks of this insect in northern Arizona, southern California and central Oregon. To the people of the Paiute tribe of the Owens Valley/Mono Lake area of California, the larval stage of this insect, known as *piuga*, is a preferred food and attempts on the part of officials of the USDA Forest Service to control outbreaks with insecticides have met with stiff opposition from tribal people (Blake and Wagner 1987).

The pandora moth has a two-year life cycle. The adults appear in late June - early July and eggs hatch in August. The larvae feed on the foliage (Fig 9.1) and overwinter, as partially grown larvae, at the bases of the needle in the crowns of host trees. They can remain active during the winter months and feed whenever the days are warm and sunny. They mature the following summer and drop to the forest floor to pupate. The pupae remain in the soil for about one year, then emerge as moths to repeat the cycle (Furniss and Carolin 1977).

Figure 9.1: Mature larva of the pandora moth, *Coloradia pandora*. This insect defoliates several pine species in western North America and is a traditional food of the Paiute tribe of the Owens Valley - Mono Lake area of California, United States.

Every other year, during the second or third week of July, the Paiute people search for evidence of *piuga* around the base of large *Pinus jeffreyi* trees. *Piuga* trees are located by the presence of frass pellets (larval droppings) on the forest floor or raining down from the tree crowns. When the trees are located, the people return to their homes and wait for the larvae to mature. They return to the infested trees in early July to collect the mature larvae as they are migrating from the tree crowns to the forest floor to pupate. Collection of *piuga* is a traditional family activity that can last for as long as three weeks. The larvae are collected in trenches and are gathered by hand once or twice a day. The collected larvae are processed on site by roasting and drying. A mound of sandy soil is made and a fire is built on and around it to heat the soil. When the coals die down, the mound is opened and the live larvae are thrown in and mixed with the hot sand for 30 minutes to one hour. This effectively removes the setae (fine hairs) on the bodies of the larvae. The larvae are then sifted from the hot sand, washed, sorted and checked to see if they are properly cooked.

Dried *piuga* are stored in a cool, dry place where they will keep for at least one year and possibly for as long as two years. The dried larvae are prepared by boiling in plain or salted water for about one hour to soften their bodies. The aroma of the cooking larvae has been described as being similar to that of mushroom soup or scrambled eggs and mushrooms. The entire larva, except for the head, is eaten as a finger food. Many people also drink the broth and some use it to make a stew with vegetables and *piuga*. These larvae are considered to be a tasty, nutritious food that is especially good for sick people. A nutritional analysis indicates that they are rich in proteins (11.78 percent) (Blake and Wagner 1987).

## LICHENS

Lichens are another example of a symbiotic relationship between a fungus and a green plant (algae). These unique plants are frequently associated with conifer forests. They grow on the branches and trunks of trees, on rocks or on the forest floor. Some species of lichens associated with conifers have been used as sources of natural dyes, others have been used for food. Lichens are currently harvested on a commercial scale for forage for reindeer, floral decorations and to simulate green foliage in architectural models.

### Dyes

Many species of lichens have been used as dyestuffs. Among the best known of dyes of lichen origin is orchil, which produces a range of vivid purple or magenta hues. This dye is derived from lichens of the genus *Rocella*, which grow on rocks along the Mediterranean coast, the Canary Islands, the Cape Verde Islands, India and Ceylon. Orchil was the most important lichen dye used by ancient and medieval dyers (Wickens 1983) and was also widely used as a fabric dye in Europe and North America during the eighteenth and nineteenth centuries (Adrosoko 1971).

Several lichens associated with conifers are also sources of natural dyes. The most widely used dye lichen in North America is the eye catching wolf lichen, *Letharia vulpina*, which commonly grows on *Pinus* spp. and other conifers (Figure 9.2). This lichen yields a bright yellow dye and was highly prized by the Chilkat Tlingit indians of coastal Alaska who traded commodities such as fish oil for wolf lichen to dye their intricately designed dancing blankets. These blankets are still worn by Chilkat dancers in their traditional performances (Sharnoff 1997). Old man's beard, *Usnea longissima*, a common lichen associate of conifers in western North America, yields a yellow-grey to yellow-white dye. Lungwort, *Lobaria pulmonaria*, a lichen found either on *Tsuga heterophylla* or on rocks in south-eastern Alaska, United States, yields a yellowish-brown dye (Bliss 1981). The Coastal Salish tribes of Vancouver Island, British Columbia, used a dark-coloured filamentous lichens of the genus *Bryoria* as a source for a yellow dye (Turner 1977).

### Food

The use of a lichen known as black tree moss, *Bryoria fremontii*, by indigenous tribes of western North America is described by Turner (1977). This lichen is found from Alberta and British Columbia, Canada south, to Baja California, Mexico, with outlying populations in Colorado and the Black Hills of South Dakota, United States. Characteristically a dark coloured, filamentous lichen, it hangs from the branches of a number of conifers including *Larix occidentalis, Pinus contorta, P. ponderosa* and *Pseudotsuga menziesii*. This lichen was widely used as a food by indigenous tribes across British Columbia, Canada and portions of northern California, Idaho, Montana, Oregon and Washington, United States. Tribes that used this lichen for food included the Coeur d'Alene, Columbia-Wenatchi, Flathead, Kalispell, Spokane, Kitskau, Klamath, Kootenay, Lilloet and Nez Perce.

The most common means of preparing this lichen was to clean it, soak it in water and cook it in an underground-steaming pit lined with large, red-hot rocks. Layers of damp vegetation were placed over the rocks and the lichen was heaped on top followed by more damp vegetation and a thick layer of soil. Cooking often lasted two or more days.

Reports on the palatability of this lichen are mixed. When properly prepared, it is said to be delicious and was considered by some tribes to be a luxury food. Other reports indicate that it is rather tasteless and even has a soapy flavour. A more detailed assessment of its taste indicates that it has a bland flavour. Some tribes added the bulbs of nodding onion, *Allium cernum* or camas, *Camassia quamash*, to the lichen to give it more flavour. After European settlement, indigenous tribes added sugar or molasses. Elk and other large mammals also eat *Bryoria fremontii*. Cattle have been known to feed on it during times of scarcity of other forage.

A closely related species, *Byroria tortuosa*, occurs in the coastal regions of western North America. This species contains vulpinic acid, has a bitter flavour and can be poisonous. In areas where the ranges of the two overlap, local tribes were well aware of the difference between the two species.

Figure 9.2: The wolf lichen, *Letharia vulpina*, is a traditional source of yellow dye for the Tlingit Indians of Alaska.

## Forage, floral decorations and simulated foliage

Harvesting of the lichen *Cladonia stellaris,* a species that is a frequent associate of *Pinus sylvestris,* is done on a commercial scale in three Nordic countries: Finland, Norway and Sweden. Primary uses include forage for reindeer, an addition to floral arrangements and as simulated foliage in architectural models (Kauppi 1979, 1993). In Germany, branches of *Larix decidua* covered with lichens are a popular speciality product (Ehlers 1968).

Total exports of *C. stellaris* from the three Nordic countries in recent years totalled 2 000 tonnes, annually. Since 1988, Sweden has exported more lichen than Finland, but the Finnish product is more valuable. Finnish exports alone peaked in 1970 with 2 000 tonnes then fell dramatically to less than 1 000 tonnes in 1974 and, since 1987, to less than 500 tonnes. Reductions in harvest are the result of reduced foreign demand accompanied by a fall in prices. Germany is the principal market for exports of *Cladonia stellaris* and receives 83 percent of the total harvest from the three Nordic countries. Denmark is a distant second and receives about 10 percent of the harvest (Kauppi 1979).

In Finland, the lichen processing industry is centred in Oulu. In Norway, Lillehammer is the centre of lichen production and the Swedish lichen industry is centred in Sveg. The lichens are collected between May and November. Most of the material is dried into easy-to-handle blocks and packed into transport trays. Moist lichens are exported only in autumn and comprise about ten percent of the total crop. Annual income from lichen in a productive forest is usually greater than the value of timber from the same forest (Kauppi 1979).

The commercial harvesting of lichen in Finland began in 1910 and national regulation, in the form of laws controlling exports, began in 1931 (Kauppi 1979). In Finland, decorative lichens are considered to be the property of the landowner, unlike berries and mushrooms that are considered public property (Saastamoinen 1984). As of 1979, the level of employment in the Finnish lichen industry was estimated at 500 people working full time for five months of the year. Additional workers are employed temporarily during the summer when school is not in session. About 8 000 person-days are required to harvest and process the Finnish lichen crop. People on the island of Hailuoto, off Oulu, derive one-third of their income from harvesting of lichens (Kauppi 1979, 1993).

Problems associated with maintaining the sustainability of lichen harvesting include site deterioration from over-harvesting, clearcutting, gravel quarrying and trampling. Research studies show that only about 20 percent of the lichen should be harvested at any one time and picking should be at five to six year intervals in any one area (Kauppi 1979).

Studies in Norway indicate that commercial harvesting of *Cladonia* spp. in *Pinus sylvestris* forests can have a variety of effects. Pine regeneration tends to be more prolific on sites where lichens had been removed or thinned. On dry, exposed sites with coarse soils and more rapid water loss, removal of lichen results in added evaporation of soil moisture and reduces tree growth. On sites characterized by fine textured soils, removal of lichen has no effect on tree growth. This study concludes that while the high export value of lichen makes joint production of wood fibre and lichen a highly desirable operation, the harvesting of a speciality product can affect other forest resources (Aakre 1966).

## DWARF MISTLETOE SHOOTS

Dwarf mistletoes, *Arceuthobium* spp., are parasitic plants that infect many conifers of the families Pinaceae and Cupressaceae. They cause growth loss, deformity and, in extreme cases, tree mortality. Most dwarf mistletoes are found in North America (western Canada, Mexico and western United States) but several species occur in Central America, the Caribbean, the Mediterranean Region of Europe and Northern Africa, eastern Africa, the Near East and Asia (Hawksworth and Wiens 1996).

A number of traditional uses of dwarf mistletoes have been documented and are summarized by Hawksworth and Wiens (1996). In northern Maine, French and English women used twigs of spruce, *Picea* spp. infected with *Arceuthobium pusillum* in their hair at the mid-winter festival and ball. There is no established linkage between this custom and the European tradition of hanging a sprig of mistletoe, *Viscum album*, over a doorway at Christmas. Young women of the Okanagan and Colville tribes of

British Columbia, Canada and Washington, United States, boiled branches of *Pseudotsuga menziesii* infected with *A. douglasii* to make a hair wash that they believed gave them long and thick hair. The indigenous tribes of California, United States prepared a decoction of *A. occidentale*, a parasite of *Pinus sabiniana*, (Fig 9.3) to treat stomachache. An undetermined species of *Arceuthobium* was used by California natives for treatment of haemorrhage of the lungs and mouth, tuberculosis, emaciation, stomachache, cough, colds and rheumatism. The Bella Coola natives of coastal British Columbia, Canada, used shoots of *A. tsugense* and the Navajos of New Mexico and Arizona, United States, used both *A. divaricatum* and *A. vaginatum* in the treatment of several illnesses.

Figure 9.3: Aerial shoots of the dwarf mistletoe, *Arceuthobium occidentalis*, a parasite of *Pinus sabiniana*. This plant was used for medicinal purposes by indigenous tribes in California, United States.

Dwarf mistletoes have also been used to treat a variety of illnesses in Mexico. *A. vaginatum* has been used for treatment of cough in Veracruz. Indigenous people living in the vicinity of Tepehuanes, Durango State, used a decoction of *A. vaginatum* for treatment of rheumatism and lung disorders. *A. globosum* was used for the treatment of diarrhoea and nervous, pulmonary and lung disorders. *A. globosum* has also been burned as incense in religious ceremonies in Mexico but the basis for this practice is not known.

The dwarf mistletoe, *Arceuthobium oxycedri*, (Fig 9.4) infects a number of species of *Juniperus* across its natural range from the Mediterranean Region of Europe and North Africa, to the Near East and Asia. The shoots of this plant are highly nutritious and are reportedly collected and used as fodder for goats and sheep in Turkey and Pakistan (Ciesla 1993, Zakaulla and Badshah 1977) and Turkey (Actaay 1954). Acatay (1954) expresses concern that in Turkey this practice is damaging because infected trees are felled. Zakaullah and Badshah (1977) report that in the Province of Balochistan, Pakistan, shepherds usually cut mistletoe infected shoots of juniper for feeding their animals at the site or they may carry them to their hamlets in the forest. They suggest that the latter practice, if done during the period when the fruits of the dwarf mistletoe plants are mature, could introduce this damaging parasite to new areas.

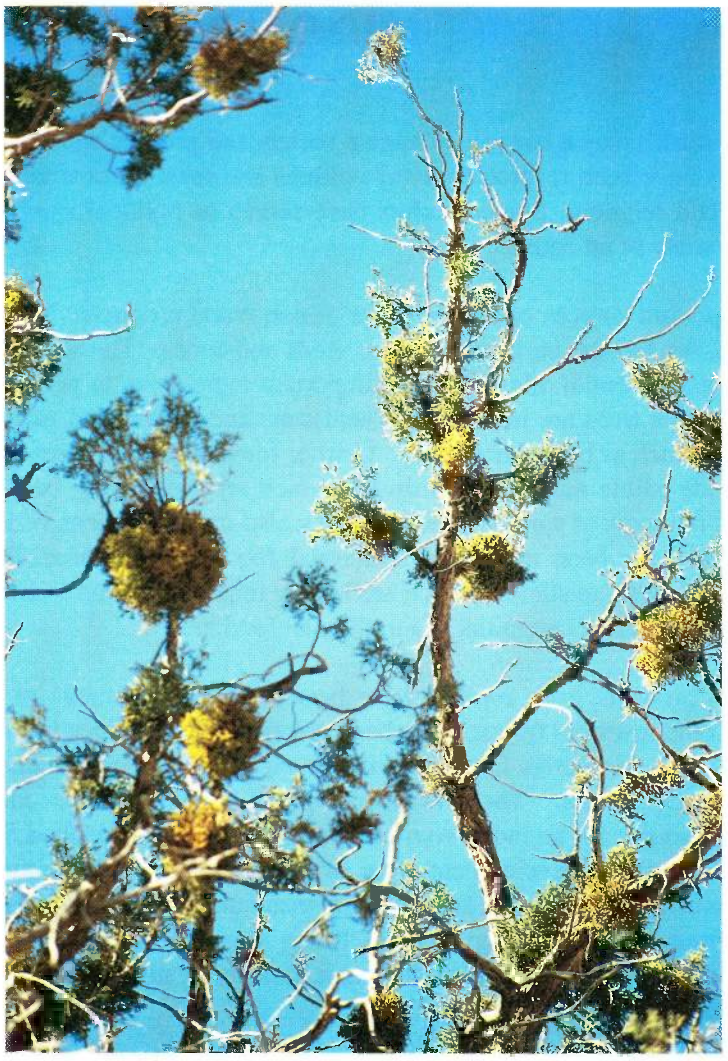

Figure 9.4: Dwarf mistletoe, *Arceuthobium oxycedri* infections on *Juniperus excelsa*, Balochistan Province, Pakistan. The shoots of this parasitic plant are gathered by herdsmen as food for livestock.

# CHAPTER 10
# SUMMARY AND CONCLUSIONS

Coniferous trees and shrubs play a key role in human society and provide wealth of both wood and non-wood products. They have been revered by many cultures and have become an integral part of human folklore, mythology and religion. Some conifers have served as political symbols, while others have been important in a variety of art forms.

Conifers are important sources of a wide range of non-wood products. They come from virtually every part of the tree, the foliage, bark, roots, resin, seeds and cones. The wood, foliage and resin of a number of conifers yield essential oils, which are important ingredients in perfumes, disinfectants, and cleaning products. Whole trees are important as landscape and ornamental materials, Christmas trees and speciality products such as bonsai or topiary. Conifer forests are the source of additional non-wood products. They include edible mushrooms, many of which are the fruiting bodies of ectomycorrhizal fungi associated with the roots of various conifers. They also include lichens which grow on stems and trunks of conifers and have been used as a traditional food, a dye source, livestock feed and for decoration and parasitic dwarf mistletoes which are locally important sources of livestock fodder. In at least one instance, a pine feeding caterpillar is a traditional food item.

Many non-wood products from conifers have been used for thousands of years. For example, tapping of pines and other conifers for resin has been practised at least since biblical times. The edible nuts of several pines and Araucarias have been important food sources in many parts of the world, probably since pre-historic times. The presence of pines, which produce edible nuts, provided a reasonably stable food source for an indigenous culture in south-western United States. This may have been a key factor permitting the development of an advanced culture, which ultimately evolved into an agricultural society with a complex social structure and many unique art forms. Traditional uses of bark and roots by indigenous forest dwelling societies living along the Pacific coastal regions of North America for food, medicine, construction, clothing and basketry is still another example of a long-term use of a non-wood product from conifers.

It is interesting to note the similarity of some traditional uses of non-wood conifer products in different parts of the world. The Fijians used resin from an indigenous conifer as an ingredient of a glue to build their ocean going canoes. The indigenous people of some North American cultures also used conifer resins to caulk their canoes. Similarly, the diuretic properties of the berries of *Juniperus communis* were known to Europeans, the people of the Indian sub-continent and the indigenous people of North America.

Some food items from conifers or conifer forests, which were once considered traditional staple foods of forest dwelling people, have become delicacies in today's society. Pine nuts are now an ingredient in a number of "gourmet" dishes in the cuisines of Asia, southern Europe and south-western United States. The same is true of the nuts of *Araucaria araucana* in Chile, *A. angustifolia* in southern Brazil and *Tórreya nucifera* in Japan. Juniper berries flavour a number of traditional European dishes, especially those that include wild game and are also a key ingredient of the alcoholic spirit, gin. Edible mushrooms harvested from conifer forests have become an important item in international trade and the Japanese matsutake mushroom, which grows in forests of *Pinus densiflora* in Japan, is presently regarded as the world's most expensive food.

Several non-wood products from conifers are of a more recent origin. A classic example is the recent discovery of the anti-cancer agent, taxol, in the bark of *Taxus brevifolia.* Other examples include the use of pine straw and bark chips as mulches and soil amendments. In addition, some long-term uses of a non-wood conifer product in one culture have recently become appreciated by other cultures. A case in point is the recent interest in the medicinal properties of extracts from the fruits and foliage of *Ginkgo biloba* in Germany and other European countries, something that has been used in Asia for thousands of years.

Some non-wood conifer products are presently major items in international trade. These include Christmas trees, evergreen boughs, essential oils, resins, certain species of pine nuts, edible mushrooms and decorative lichens. These products provide additional sources of income for people in many countries including a number of developing countries. On the other hand, the development of alternative sources of a non-wood conifer product by a developing country could reduce the need for that country to import that product. This has the advantage of reducing the need for foreign exchange required to import that commodity plus providing additional jobs. The development of a local cedarwood oil industry in India based on *Cedrus deodara*, which provides an acceptable substitute for imported cedarwood oils from China or the United States, is a good example of such an initiative.

While there has been an expansion in the development of some non-wood products of conifer forests, production levels of others have declined. In many cases, these declines have been regional in nature and are based on regional or local factors. For example, the decline in production of gum naval stores in countries such as France and the United States is directly related to the high labour costs associated with industrial economies which reduces the profitability of harvesting gum resins, a labour intensive process. Consequently, other alternatives such as the production of tall oil as a by-product of the Kraft pulping process or the extraction of resin from saturated pine stumps have become more economically viable resin sources.

Tapping of live trees for resin is still a viable alternative in developing countries, however, where labour costs are low. There are opportunities to further develop the resin tapping industry in places like Indonesia, China and several African countries that have a significant pine plantation resource. Decline of the tannin industry in eastern United States during the early part of this century was directly due to unsustainable harvesting *Tsuga canadensis* for bark, resulting in a shortage of raw material from which to produce tannin. This forced the industry to seek alternative sources of supply. In other cases, alternative products have been able to successfully compete with non-wood conifer products, for example, the use of excess pulp chips in place of bark residues for production of panels.

Enterprises based on non-wood products from conifers have provided many opportunities for employment for women. Collection of pine resin, sorting and grading of conifer boughs, harvesting of edible mushrooms, decorative cones and lichens, production of Christmas wreaths and related items, are examples. Women have also been directly involved in the use of non-wood conifer products for traditional uses, such as harvesting of bark for food, medicinal or artistic purposes, processing and storage of pine nuts and production of curious and artistic products (e.g. baskets and other items from conifer roots, bark or pine needles).

Non-wood products from conifers, which have enjoyed an increased demand in recent years, are evergreen boughs, certain medicinal products (e.g. *Ginkgo biloba*), decorative cones, edible mushrooms and lichens. Increased demand for these products has created new job opportunities in many areas. In the Pacific north-west region of the United States, employment opportunities created by increased demand for evergreen boughs, edible mushrooms and decorative cones has partially offset unemployment caused by a decline in the wood products industry due to the reduced availability of timber from public forest lands.

The increased demand for certain non-wood conifer products, such as evergreen boughs and edible mushrooms, is driven largely by a few, select industrialized countries such as Germany and Japan. As other countries develop economically and the quality of life of their people improves, there could be additional demands for these and other non-wood products from conifers. An example of this trend is the recent, sudden increase in demand for Christmas trees by the people of Mexico.

There is clear evidence that the harvesting of some non-wood forest products from conifers is compatible, perhaps even beneficial, to other forest management objectives. There are indications, for example, that harvesting of decorative lichens in the Nordic countries can increase success of pine regeneration and result in increased growth of pines on dry, exposed sites, thus making lichen gathering and wood fibre production compatible resource management objectives. The compatibility of harvesting evergreen boughs and Christmas trees from forests managed for wood production has been demonstrated both in Germany and the United States. The harvesting of pine straw in south-eastern United States can provide an income from pine plantations long before they are ready to harvest for pulpwood or timber. Harvesting of non-wood forest products from conifers also provides opportunities to utilize materials that were formerly considered to be waste products, which required disposal. The extraction of cedar wood oils from sawdust and other residues from the cedar wood products industry or from trees, which have been felled to create pasture for livestock grazing, are good examples. Another example is the initiatives of governments and the wood products industry to develop viable products to utilize huge volumes of waste bark, much of which was formerly disposed of by burning in tepee burners, often resulting in widespread air pollution.

Unfortunately, in other cases, unsustainable and damaging practices have been associated with the harvesting of certain non-wood forest products from conifers. In eastern United States, the harvesting of the bark of *Tsuga canadensis* for production of tannin is an outstanding example. This practice resulted in the virtual decimation of the old growth *Tsuga canadensis* forests that once covered extensive areas of this region. Another example of a non-sustainable harvesting practice is the intensive gathering of copal by the Tagbanua, a forest dwelling people on the island of Palawan in the Philippines. This activity is contributing to the gradual demise of the *Agathis dammara* forests on this island. There are indications too, that some lichen harvesting in Nordic countries may be too heavy to be sustainable. Furthermore, the harvesting of dwarf mistletoe branches for use as fodder, from infected *Juniperus* spp., in Pakistan and Turkey, has reportedly resulted in excessive cutting of host trees and the transport of this material could result in the spread of this parasite.

Harvesting of certain non-wood conifer products has also resulted in land use conflicts. A case in point being the conflict between commercial pickers of edible mushrooms and indigenous people harvesting in traditional sites in western North America. Illegal entry into pine plantations for harvesting of pine straw is another example of a conflict associated with the harvesting of a non-wood product from conifers.

Factors other than the harvesting of non-wood conifer products could affect their sustainability. There is evidence from Europe, for example, that a decline in production of fruiting bodies of ectomycorrhizal fungi, some of which are harvested as edible mushrooms, may be the result of soil acidification and nitrogen eutrophication. Not only could this affect future harvest of edible mushrooms, but because of their symbiotic relationship with conifers, could adversely affect overall forest health and productivity.

More recently, programs leading toward the expansion of existing non-wood conifer products or the development of new products have attempted to identify and address potential problems in the long-term sustainability of these products. The potential impact of increased demand for the bark of *Taxus brevifolia,* a small tree which occurs in limited quantities in the Pacific north-west region of the United States and British Columbia, Canada, for extraction of the anti-cancer ingredient taxol, was recognized early. This resulted in an immediate search for alternative sources of this material. The search for alternative sources of taxol has been successful to the point that there is now a reduced demand for yew bark and the pressure on a limited resource has been eased. Concern has been raised about the potential impact of increased harvesting of edible mushrooms from conifer forests on the sustainability of this increasingly important resource in several countries and research is already underway in the United States to look into this question. In addition, some concerns have been raised about the long- term effects of regular harvesting of pine straw on the soil nutrients in pine plantations and should be investigated.

There are many opportunities world-wide to develop or expand profitable, sustainable and environmentally sound non-wood conifer products enterprises in conjunction with economic development projects. Obviously, the development of an enterprise which involves use of non-wood products from conifers must be based on the availability of an existing conifer resource (natural or planted) or the existence and availability of sites capable of supporting conifer plantations. An appreciation of conifers and non-wood products derived from conifers by local people is also an important factor to consider when planning such enterprises. In addition to the potential economic benefits to be derived from the harvesting of non-wood products from conifers, other factors to consider are that the management and harvesting practices used will ensure the sustainability of the non-wood resource and that its harvest is compatible with other existing or planned uses of the forest.

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# APPENDIX 1
# ORDERS, FAMILIES AND GENERA OF CONIFERS*

| Order | Family | Genus | Approximate number of species | |
|---|---|---|---|---|
| | | | Rushforth 1987 | Vidakovic 1991 |
| Ginkgoales | Ginkgoaceae | *Ginkgo* | 1 | 1 |
| Coniferales | Araucariaceae | *Agathis* | 13 | 20 |
| | | *Araucaria* | 18 | 18 |
| | Cupressaceae | *Actinostrobus* | 3 | 3 |
| | | *Austrocedrus* | 1 | 1 |
| | | *Callitris* | 14 | 16 |
| | | *Calcocedrus* | 3 | 1 |
| | | *Chamaecyparis* | 8 | 7 |
| | | *X Cupressocyparis* | 3 | ** |
| | | *Cupressus* | 25 | 15-20 |
| | | *Diselma* | 1 | 1 |
| | | *Fitzroya* | 1 | 1 |
| | | *Fokienia* | 1 | 1 |
| | | *Juniperus* | 60 | 60 |
| | | *Libocedrus* | 5 | 5 |
| | | *Microbiota* | 1 | 1 |
| | | *Neocallitropis* | 1 | 1 |
| | | *Papuacedrus* | 2 | 3 |
| | | *Pilgerdendron* | 1 | 1 |
| | | *Platycladus* | 1 | *** |
| | | *Tetraclinis* | 1 | 1 |
| | | *Thuja* | 5 | 6 |
| | | *Thujopsis* | 1 | |
| | | *Widdringtonia* | 3 | 3 |
| | Pineaceae | *Abies* | 55 | 40 |
| | | *Cathaya* | 1 | 1 |
| | | *Cedrus* | 4 | 4 |
| | | *Ketereeria* | 10 | 4-8 |
| | | *Larix* | 15 | 10 |
| | | *Picea* | 37 | 40-50 |
| | | *Pinus* | 120 | 100 |
| | | *Pseudolarix* | 1 | 1 |
| | | *Pseudotsuga* | 8 | 20 |
| | | *Tsuga* | 10 | 10-18 |

| Order | Family | Genus | Approximate Number of Species | |
|---|---|---|---|---|
| | | | Rushforth 1987 | Vidakovic1991 |
| Coniferales | Podocarpaceae | *Aomopyle* | 2 | 1 |
| | | *Dacrycarpus* | 9 | |
| | | *Dacrydium* | 25 | 20 |
| | | *Decussocarpus* | 12 | |
| | | *Falcatifolium* | 5 | |
| | | *Halocarpus* | 3 | |
| | | *Lagarostrobus* | 2 | |
| | | *Lepidothamus* | 3 | |
| | | *Microcachrys* | 1 | 1 |
| | | *Microstrobus* | 2 | 2 |
| | | *Parasitaxus* | 1 | |
| | | *Phyllocladus* | 5 | 7 |
| | | *Podocarpus* | 94 | 100 |
| | | *Prioymopitus* | 10 | |
| | | *Saxegothaea* | 1 | 1 |
| | Taxodiaceae | *Athrotaxis* | 3 | 3 |
| | | *Cryptomeria* | 2 | 1 |
| | | *Cunninghamia* | 2 | 3 |
| | | *Glyptostrobus* | 1 | 1 |
| | | *Metasequoia* | 1 | 1 |
| | | *Sciadopitys* | 1 | 1 |
| | | *Sequoia* | 1 | 1 |
| | | *Sequoiadendron* | 1 | 1 |
| | | *Taiwania* | 2 | 3 |
| | | *Taxodium* | 3 | 3 |
| Taxales | Taxaceae | *Austrotaxus* | 1 | 1 |
| | | *Pseudotaxus* | 1 | 1 |
| | | *Taxus* | 10 | 10 |
| | Cephalotaxaceae | *Amentotaxus* | 4 | 4 |
| | | *Cephalotaxus* | 9 | 8 |
| | | *Tórreya* | 7 | 6 |

* Sources Rushforth 1987, Vidakovic 1991

** "Several spontaneous hybrids."

*** If no number is given, the genus is not recognized by the author.

# APPENDIX 2
# SAMPLE RECIPES WHICH CALL FOR INGREDIENTS FROM CONIFERS

## PINE NUTS

### *TORTA DELLA NONNA* (GRANDMOTHER'S CAKE) (Italy)

*Torta della nonna* is a traditional dessert from the regions of Tuscany and Umbria.

For the cream filling:

| | |
|---|---|
| 2 egg yolk | 75 gr caster sugar |
| 135 gr plain white flour | 575 ml milk |

slivered almonds and/or **pine nuts** for the topping

For the pastry:

| | |
|---|---|
| 350 gr plain white flour | 1 egg & 1 egg yolk |
| 75 gr caster sugar | 100 gr butter |
| 1 ½ tsp baking powder | |

First make the cream. Heat the milk until it starts to boil, then remove from the heat. Beat the egg yolks and sugar together until they form a ribbon. Stir in the flour, blending well. Add one tablespoon of the hot milk to the yolk, sugar mixture and blend in well with a wooden spoon. Add the mixture to the milk and return to heat, stirring until the cream thickens. When thickened, pour into a clean bowl and brush the surface with some melted butter to stop a skin from forming. Allow to cool.

Toast a generous handful of almonds and pine nuts on a baking sheet until they are slightly browned.

To make the pastry, sift the flour and baking powder into a mound an a pastry board or other work surface. Make a well in the middle and put all the other ingredients into the well. Work everything into the dough with your hands. Form the dough into a ball and chill in a refrigerator for 30 minutes. When ready to use, cut the dough in half, roll out one half into a circle 3 mm thick and place in a 20.5 cm greased pie plate. Make sure that there is about 1 cm hanging over the plate's edge. Pour the cream onto the pastry base making sure that the middle is somewhat higher than the edges. Fold the pastry rim inwards and brush with water. Roll the remaining piece of dough out to fit and place gently on top of the cream. Press well onto the pastry border and trim off any excess. Top with the almonds and pine nuts and bake in a preheated oven at 180° C for 25 to 30 minutes until golden brown. Cool and sift with plenty of icing sugar before serving.

Source: Forbes (1989)

### PIÑON NUT COOKIES (south-western United States)

| | |
|---|---|
| 3/4 Cup **piñon nuts,** shelled | ½ teaspoon vanilla |
| 1 cup flour, sifted | ½ cup sugar |
| ½ cup butter | ½ teaspoon cinnamon |
| ½ cup shortening | |

Cream the butter, shortening and vanilla. Mix the flour with the sugar and cinnamon and add along with the nuts to the butter mixture. Blend well. Drop by the spoonful onto an ungreased cookie sheet. Bake at 425 degrees (F) for about ten minutes or until light brown. Makes about 24 cookies (Douglas 1981).

**PESTO SAUCE** (Italy)

3 cups loosely packed fresh basil
3/4 cup Olive oil
1/4 cup **Pine nuts**
3 Garlic cloves
1 tsp Salt
½ cup Parmesan cheese -freshly grated
3 Tbsp Romano pecorino cheese OR
Parmesan cheese

Put basil, oil, pine nuts, garlic and salt into a blender or food processor. Process until smooth. Pour sauce into small bowl. Add Parmesan cheese and Romano pecorino cheese or extra Parmesan cheese. Mix to blend. Taste and adjust for seasoning. If you plan to freeze the sauce, add the cheese after the sauce has thawed. Yield: one serving.

Source: Mealmaster computerized database for recipes.

**BEEF WITH PEPPERS AND PINE NUTS** (China)

450 g sirloin steak
1 Tbsp Chinese wine
2 Tbsp light soya sauce
1 Tbsp ginger juice
1 tsp sugar
1 red pepper
1 green pepper
2 Tbsp cornflower
20 mm knob fresh ginger
3 cloves garlic
300 ml vegetable oil
**75 g pine nuts**
2 Tbsp oyster sauce
300 ml chicken stock
Salt to taste
Freshly ground black pepper

Cut the sirloin into cubes and place in a shallow dish. Mix together the soya sauce, wine, ginger juice, sugar and half the cornflower and pour over the beef. Set aside for 30 minutes.

Cut the red and green peppers into small squares, chop the ginger and crush the garlic. Heat one tablespoon of oil in a wok and stir-fry the red and green peppers for one minute. Pour the remaining oil into the pan and fry the pine nuts until they turn slightly yellow, then remove ands set aside. Add the beef to the same pan, stir well and cook for 20 seconds, then drain and set aside.

Pour most of the oil from the wok, add the garlic and ginger and stir-fry for one minute, the replace the beef and cook over a very high heat for a further 20 seconds. Then add the red and green pepper and stir well. Add the oyster sauce and chicken stock and bring to a boil. Season with salt and pepper, add the pine nuts and mix well. Finally, mix the remaining cornflower with a small quantity of cold water and stir into the sauce to thicken slightly (Mark 1991).

## JUNIPER BERRIES

**JUNIPER BERRY SAUCE (*SOS JALAKOWY*)** (Poland)

1 ½ tsp butter
1 ½ tsp flour
1 cup beef broth
1 bouillon cube
1/4 cup Madeira wine
Salt and pepper to taste
1 tsp ground **juniper berries**

Melt the butter, thicken with flour and stir until smooth. Add broth in which the bouillon cube has been dissolved and simmer at least 15 minutes. Add the wine, juniper berries and seasoning and simmer another 15 minutes. Sauce should be medium thick. Makes one generous cup of sauce. Serve with venison pâté or *chaud-froid* of game birds (Ochorowicz-Monatowa 1958).

**VENISON STEAKS WITH GIN AND JUNIPER BERRIES *(COTELETTES DE CHEVREUIL AU GENIEVRE)*** (Belgium)

Salt and coarsely ground pepper to taste
2 tsp minced fresh thyme or
1 tsp dried thyme
6 Tbsp unsalted butter
2 Tbsp vegetable oil
1/4 cup genever (Belgian gin), Bombay gin or Cognac
8 venison tenderloin steaks (0.5 kg each)
1 ½ cups heavy (or whipping) cream
**10 juniper berries, crushed**
1 Tbsp green peppercorn, crushed (optional)
2 tsp fresh lemon juice
8 slices (2.5 cm thick) brioche or best-quality white bread, cut into rounds slightly larger than the steaks.

Rub the salt, pepper and thyme onto the venison steaks.

Heat three tablespoons of the butter and the oil in a large heavy skillet over high heat until hot but not smoking. Add the steaks and quickly sear on both sides, one minute per side. Reduce the heat to medium and continue cooking until medium rare, 3-4 minutes per side. Remove the steaks to a warmed platter and set aside.

De-glaze the pan over medium heat with the gin and add the cream. Add the juniper berries, green peppercorns and salt to taste. Simmer over medium heat until the sauce is somewhat reduced and coats a wooden spoon. Remove from the heat, add the lemon juice and adjust the seasoning.

While the sauce is reducing, melt the remaining three tablespoons of butter in a large skillet and fry the bread until golden on each side. Place each venison steak on a slice of bread and spoon some of the sauce over the top (Van Waerebeek 1996) .

# APPENDIX 3
# Scientific Names, Common Names, Principal NWFPs and Type of Use for Conifers Mentioned in this Paper

## GENUS *ABIES*

| Genus and Species | Common name(s) | Principal uses | Type of use* |
|---|---|---|---|
| ***Abies*** | | | |
| *A. alba* | European silver fir | Essential oils | C |
| | | Christmas trees and boughs | C |
| | | Landscape material | C |
| *A. amabilis* | Pacific silver fir | Bark (medicine) | T |
| | | Boughs | L |
| *A. balsamea* | Balsam fir | Essential oils | C |
| | | Christmas trees and boughs | C |
| | | Curios (pillows filled with foliage) | L |
| | | Landscape material | C |
| | | Resin | T |
| *A. cephalonica* | Greek fir | Landscape material | C |
| *A. concolor* | White fir | Christmas trees | L |
| | | Landscape material | C |
| *A. firma* | Japanese fir, Momi fir | Landscape material | L |
| *A. fraseri* | Fraser fir | Christmas trees | L |
| | | Landscape material | L |
| *A. grandis* | Grand fir | Christmas trees and boughs | C |
| | | Landscape material | L |
| | | Resin (Medicine and wood finish) | T |
| *A. homolepis* | Nikko fir | Landscape material | L |
| *A .koreana* | Korean fir | Landscape material | L |
| *A. lasiocarpa* | Subalpine fir | Bark (medicine) | T |
| | | Boughs | L |
| *A. magnifica* | California red fir | Landscape material | L |
| *A. normandiana* | Caucasian fir | Christmas trees and boughs | C |
| *A. procera* | Noble fir | Christmas trees and boughs | C |
| *A. pindrow* | West Himalayan fir | Essential oil | L |
| *A. pinsapo* | Spanish fir | Landscape material | L |
| *A. religiousa* | Sacred fir, *Oyamel, Abeto* | Boughs | T |
| *A. sibirica* | | Essential oil | C |
| *A. spectabilis* | East Himalayan fir | Dye (Cones) | L |
| | | Resin | T |
| *A. veitchii* | Veitch's silver fir | Landscape material | L |

* C - Commercially important at a regional or international level , L - Commercially important in individual countries or portions of countries, T - Traditional, historical use or in current use by tribal cultures.

## GENERA *AGATHIS* AND *ARAUCARIA*

| Genus and Species | Common name(s) | Principal uses | Type of use* |
|---|---|---|---|
| ***Agathis*** | | | |
| *A. australis* | Kauri pine | Amber; Resin | L; L |
| *A. dammara* | Dammara | Resin | C |
| *A. vitiensis* | | Resin (Fijian glue) | T |
| ***Araucaria*** | | | |
| *A. araucana* | Monkey puzzle tree | Landscape material | C |
| | | Edible nuts | L,T |
| *A. angustifolia* | Paranà pine | Landscape material | L |
| | | Edible nuts | L,T |
| | | Resin; | L |
| *A. bidwelli* | Bunya pine | Edible nuts | T |
| *A. columaris* | | Christmas trees | L |
| | | Landscape material | L |
| *A. heterophylla* | Norfolk Island pine | House plant | C |
| | | Landscape material | C |

* C - Commercially important at a 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.

## GENERA *CALCOCEDRUS, CALLITRIS, CALLITROPSIS, CEDRUS* AND *CHAMAECYPARIS*

| Genus and Species | Common name(s) | Principal uses | Type of use* |
|---|---|---|---|
| ***Calcocedrus*** | | | |
| *C. decurrens* | Incense cedar | Boughs | L |
| ***Callitris*** | | | |
| *C. calcarta* | Cypress pine | Resin (Australian sandarach) | L |
| *C. preissi* | Cypress pine | Resin (Australian sandarach) | L |
| ***Callitropsis*** | | | |
| *C. araucariodes* | | Essential oil | C |
| ***Cedrus*** | | | |
| *Cedrus* spp. | True cedars | Bonsai | C |
| *C. atlantica* | Atlantic cedar | Essential oil | C |
| | | Landscape material | C |
| *C. deodara* | Deodar cedar | Bark (medicine) | T |
| | | Essential oil | C |
| | | Landscape material | C |
| *C. libani* | Cedar of Lebanon | Landscape material | C |
| | | Resin | T |
| ***Chamaecyparis*** | | | |
| *C. lawsoniana* | Port Orford Cedar | Boughs | C |
| | | Landscape material | C |
| *C. nootkatensis* | Alaska yellow cedar | Bark (Clothing, canoes, woven products) | T |
| *C. obtusa* | Hinoki cypress | Bonsai | C |

* C - Commercially important at a regional or international level , L - Commercial important in individual countries or portions of countries, T - Traditional, historic use or in use by tribal cultures.

## GENERA *CUPRESSUS, CRYPTOMERIA* AND *GINGKO*

| Genus and Species | Common name(s) | Principal uses | Type of use* |
|---|---|---|---|
| ***Cupressus*** | | | |
| *C. arizonica* | Arizona cypress | Christmas trees | L |
| | | Landscape material | C |
| *C. funebris* | | Essential oil | C |
| *C. lusitanica* | Mexican cypress | Landscape material | C |
| *C. macrocarpa* | Monterrey cypress | Landscape material | C |
| *C. sempervirens* | Mediterranean cypress | Landscape material | C |
| ***Cryptomeria*** | | | |
| *C. japonica* | Japanese cedar | Bonsai | C |
| | | Bark (Construction) | T |
| | | Landscape material | C |
| ***Gingko*** | | | |
| *G. biloba* | Gingko, Maidenhair tree | Bonsai | C |
| | | Landscape material | C |
| | | Medicinal uses | C |

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## GENUS *JUNIPERUS*

| Genus and Species | Common name(s) | Principal uses | Type of use* |
|---|---|---|---|
| *Juniperus* spp. | Junipers | Boughs | L |
| *J. ashei* | Ashe juniper | Essential oil | C |
| *J. californica* | California juniper | Bark (diapers for infants) | T |
| *J. chinensis* | Chinese juniper | Bonsai | C |
| | | Essential oil | C |
| *J. communis* | Common juniper | Berries (seasoning, gin) | C |
| | | Essential oil | C |
| | | Dye | L |
| *J. erythrocarpa* | Redberry juniper | Essential oil (potential source) | L |
| *J. formosana* | Formosan juniper, Prickly cypress | Essential oil | C |
| *J. macrocarpa* | Plum juniper | Essential oil | C |
| *J. oxycedrus* | Prickly juniper | Bonsai | C |
| *J. procera* | African pencil cedar | Essential oil | T |
| *J. procumbens* | Nana juniper | Bonsai | C |
| *J. rigida* | Needle juniper | Bonsai | C |
| *J. sabina* | Savin | Essential oil | C |
| *J. sargentii* | Sargent's juniper | Bonsai | T |
| *J. scopularum* | Rocky Mountain juniper | Boughs (shamanistic healing) | L |
| | | Essential oil (potential source) | |
| *J. virginiana* | Eastern red cedar | Bonsai | C |
| | | Christmas trees | L |
| | | Essential oil | C |
| *J. vulgaris* | | Essential oil | C |

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## GENERA *LARIX* AND *PICEA*

| Genus and Species | Common name(s) | Principal uses | Type of use* |
|---|---|---|---|
| ***Larix*** | | | |
| *L. decidua* | Japanese larch | Bonsai | C |
| *L. laricina* | Eastern larch, Tamarack | Resin (medicine) | T |
| ***Picea*** | | | |
| *P. abies* | Norway spruce | Bonsai | C |
| | | Christmas trees and boughs | C |
| | | Landscape material | C |
| | | Resin | T |
| | | Tannin | T |
| *P. engelmanni* | Engelmann spruce | Bark (medicine, construction) | T |
| *P. glauca* | White spruce | Bark (medicine, construction woven products) | T |
| | | Bonsai | C |
| | | Christmas trees | L |
| | | Resin | T |
| *P. mariana* | Black spruce | Bark (woven products) | T |
| | | Bonsai | C |
| | | Christmas trees | C |
| | | Resin | T |
| *P. orientalis* | Oriental spruce | Bonsai | C |
| *P. rubens* | Red spruce | Bark (woven products) | T |
| | | Christmas trees | L |
| | | Resin | T |
| *P. sitchensis* | Sitka spruce | Roots (basketry) | T |
| *P. smithiana* | West Himalayan spruce | Resin (medicine) | T |
| *P. pungens* | Colorado blue spruce | Landscape material | C |
| *P. jezoensis* | | Bonsai | C |

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## GENUS *PINUS*

| Genus and Species | Common name(s) | Principal uses | Type of use* |
|---|---|---|---|
| *Pinus* spp. (13 species) | Piñon pines | Edible nuts (See Table 7.2) | C, L, T |
| | | Resin | T |
| *P. albicaulis* | Whitebark pine | Edible nuts | T |
| *P. ayacahuite* | Mexican white pine | Edible nuts | T |
| *P. banksiana* | Jack pine | Christmas trees | L |
| *P. brutia* | | Resin | L |
| *P. canariensis* | Canary Island pine | House plants | L |
| | | Landscape material | L |
| *P. caribaea* | Caribbean pine | Curios (needle baskets) | T |
| | | Resin | C |
| *P. cembra* | Swiss stone pine | Edible nuts | L |
| *P. contorta* | Lodgepole pine | Bark (food, construction) | T |
| | | Boughs | C |
| | | Cones | C |
| *P. coulteri* | Coulter pine | Edible nuts | T |
| *P. cubensis* | Cuban pine | Resin | L |
| *P. echinata* | Shortleaf pine | Bark (oil spill absorption) | L |
| | | Christmas trees | L |
| *P. elliottii* | Slash pine | Resin | C |
| | | Pine straw | L |
| *P. flexilis* | Limber pine | Bonsai | C |
| | | Edible nuts | T |
| *P. gerardiana* | Chilgoza pine | Edible nuts | C |
| *P. halepensis* | Aleppo pine | Resin | L |
| *P. jeffreyi* | Jeffery pine | Resin (heptane) | T |
| *P. kesiya* | | Resin | C |
| *P. koraiensis* | Korean pine | Edible nuts, pine nut oil | C |
| *P. lambertiana* | Sugar pine | Boughs | L |
| | | Edible nuts | T |
| *P. longaeva* | Bristlecone pine | | |
| *P. massoniana* | Masson pine | Resin | C |
| *P. merkusii* | | Resin | C |
| *P. montana* | Mugho pine | Bonsai | C |
| | | Essential oil | C |
| | | Landscape material | C |
| *P. monticola* | Western white pine | Boughs | C |
| | | Edible nuts | T |
| *P. nigra* | Austrian pine | Bonsai | C |
| | | Christmas trees | L |
| *P. oocarpa* | Oocarpa pine, *pino oocarpa* | Resin | C,T |
| *P. palustris* | Longleaf pine | Resin | C |
| *P. parviflora* | Japanese white pine | Bonsai | C |
| *P. pinaster* | Maritime pine, *pin maritime* | Resin | C |

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## GENUS *PINUS* (CONTINUED)

| Genus and Species | Common name(s) | Principal uses | Type of use* |
|---|---|---|---|
| *P. pinea* | Italian stone pine | Edible nuts | C |
| | | House plants | L |
| | | Landscape material | C |
| *P. ponderosa* | Ponderosa pine | Bark (Landscaping) | L |
| | | Bonsai | C |
| | | Edible nuts | T |
| | | Resin | L |
| *P. pumila* | Japanese stone pine | Bonsai | C |
| | | Edible nuts | L |
| *P. radiata* | Monterrey pine, radiata pine | Bark (tannin) | L |
| | | Landscape material | C |
| | | Resin | C |
| *P. resinosa* | Red pine | Christmas trees | L |
| *P. rigida* | Pitch pine | Bonsai | C |
| | | Christmas trees | L |
| *P. roxburghii* | Chir pine | Edible nuts | T |
| | | Resin | C,T |
| *P. sabiniana* | Digger pine | Edible nuts | T |
| *P. sibirica* | Siberian stone pine | Edible nuts, pine nut oil | L |
| *P. strobus* | Eastern white pine | Christmas trees and boughs | C |
| | | Landscape material | C |
| *P. sylvestris* | Scots pine | Bark (food) | T |
| | | Bonsai | C |
| | | Essential oil | C |
| | | Resin | C |
| *P. taeda* | Loblolly pine | Bark (oil spill absorption) | L |
| | | Pine needle baskets | T |
| | | Pine straw (mulch) | L |
| *P. torreyana* | Torrey pine | Edible nuts | T |
| *P. thunbergiana* | Japanese black pine | Bonsai | C |
| | | Christmas trees | L |
| *P. tropicalis* | Tropical pine | Resin | L |
| *P. virginiana* | Virginia pine | Christmas trees | L |
| *P. wallichiana* | Blue pine | Resin | T |

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## GENERA *PSEUDOLARIX, PSEUDOTSUGA, SEQUOIA* AND *SEQUOIADENDRON*

| Genus and species | Common name(s) | Products | Type of use* |
|---|---|---|---|
| ***Pseudolarix*** | | | |
| *P. kaempferi* | Golden larch | Bonsai | C |
| | | Landscape material | C |
| ***Pseudotsuga*** | | | |
| *P. menziesii* | Douglas-fir | Bark (landscaping, Silvacon) | C |
| | | Boughs | C |
| | | Christmas trees | C |
| | | Resin | L |
| ***Sequoia*** | | | |
| *S. sempervirens* | Redwood | Tannin (Potential source) | L |
| ***Sequoiadendron*** | | | L |
| *S. giganteum* | Giant sequoia, Big tree | | |

## GENERA *TAXUS* AND *TÓRREYA*

| Genus and Species | Common name(s) | Principal uses | Type of use* |
|---|---|---|---|
| ***Taxus*** | | | |
| *T. baccata* | English yew | Foliage (Taxotere) | C |
| | | Landscape material | C |
| | | Topiary | C |
| *T. brevifolia* | Pacific yew | Foliage (Taxol) | C |
| | | Bark -(Taxol) | C |
| *T. cuspida* | Japanese yew | Bonsai | C |
| | | Taxol (potential source) | |
| ***Tetraclinis*** | | | |
| *T. articulata* | | Essential oil | C |
| | | Resin (Sandarach) | C |
| ***Tórreya*** | | | |
| *T. californica* | Stinking yew | Edible nuts | T |
| | | Roots (basketry) | T |
| *T. grandis* | Chinese torreya | Edible nuts | L |
| *T. nucifera* | Japanese torreya | Edible nuts | C |
| | *Kaya* (Japanese) | | |

## GENERA *THUJA* AND *TSUGA*

| Genus and Species | Common name(s) | Principal uses | Type of use* |
|---|---|---|---|
| ***Thuja*** | | | |
| *T. occidentalis* | Northern white cedar, Arborvitae | Bonsai | C |
| | | Essential oil | C |
| | | Landscape material | C |
| | | Medicinal uses | T |
| *T. plicata* | Western red cedar | Bark (clothing, canoes, woven articles) | T |
| | | Boughs | L |
| ***Tsuga*** | | | |
| *T. canadensis* | Eastern hemlock | Bark (dye, tannin) | T |
| | | Landscape material | C |
| *T. heterophylla* | Western hemlock | Resin | T |
| | | Bark (food, dye, medicine, tannin) | T |

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Conifers are abundant in the boreal and temperate regions of the Northern Hemisphere, but are also important components of many tropical and subtropical forest ecosystems. Many conifer species provide a wide range of non-wood products. Although some services are briefly mentioned, the focus in this volume is on the products that conifers provide. With the exception of essential oils, which can be obtained from several parts of the tree, the products described in this volume are organized according to the part of the tree from which they are obtained (e.g. whole tree, foliage, bark and roots, resin, seeds and cones). The information is presented to assist in identifying opportunities for management and production of non-wood conifer products. The publication will be of interest to foresters and rural development workers in both developed and developing countries.

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