

See also: Genetics and Genetic Resources: Propagation Technology for Forest Trees. **Silviculture:** Natural Regeneration of Tropical Rain Forests. **Soil Biology and Tree Growth:** Tree Roots and their Interaction with Soil. **Tree Physiology:** Root System Physiology.

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TROPICAL ECOSYSTEMS

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Tropical Pine Ecosystems and Genetic Resources

Acacias

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Introduction

Acacias are emblematic landscape trees, whether they are the flat-topped trees that pepper the African savanna, the swollen thorn ant acacias of Central America or the wattles of the Australian outback.

Many acacias are adapted to poor soils and disturbed conditions, often in hostile environments, where they are colonizers. It is these conditions that are often faced by tropical foresters, especially where human activities have modified the environment. Thus, acacias, particularly the Australian species, are important forestry trees and multipurpose tree species in the tropics. Acacias belong to the speciose genus *Acacia* and the monotypic genus *Faidherbia*. It is the purpose of the present article to introduce the basic systematics and distribution of the acacias, together with data on genetic variation and hybridization. The

ecological and reproductive diversity of the acacias is presented, together with an overview of their utility.

Systematics

Acacia is a widespread genus of tropical–subtropical tree and shrub legumes distributed from Central/South America through Africa to Southeast Asia and Australia. Macrofossils (wood, leaves, phyllodes, flowers) attributed to *Acacia* have been reported from the Dominican Republic (Early Miocene/Late Eocene) and Australia (Early Pleistocene/Lower Pliocene). In contrast, microfossils (pollen) have been reported from Cameroon (Late Eocene), Puerto Rico (Oligocene), New Zealand, Patagonia, and Sudan (Miocene), and Australia (Late Middle Eocene to Quaternary).

Table 1 Characters that separate subgenus *Acacia* and the monotypic genus *Faidherbia* (*F. albida*, synonym *A. albida*)

Character	Subgenus <i>Acacia</i>	<i>Faidherbia</i>
Leaf phenology	Lost in dry season	Present in dry season
Seedling morphology	Pinnate eophyll	Bipinnate eophyll
Petiolar gland	Present	Absent
Stamen fusion	Free	Shortly fused
Polyad structure	Commonly 16	26–32 (rarely 16)
Pollen pores	Three	Four
Pollen exine	Smooth/reticulate	Areolate
Pollen size	23–64 μm	90–124 μm
Wood rays	Multiseriate	Uniseriate
Involucel	Present	Absent
Pod fibers	One layer	Two layers
Cotyledons	Petiolate	Sessile

More than 5000 *Acacia* names have been described, comprising some 1300 species; more than 950 species occur in Australia, with approximately 230 species in the New World, 135 species in Africa, 18 species in India, and a few others in Asia and as island endemics. The genus *Acacia* is one of two members (the other is the African monotypic genus *Faidherbia*) (Table 1) of the mimosoid legume tribe, Acacieae. The Acacieae is closely related to the tribe Ingeae, although there appear to be no consistent characters that distinguish them.

Acacia species are woody trees, shrubs, or lianas which may have prickles. The leaves are bipinnate or modified as phyllodes (rarely reduced or absent). Petiolar glands are usually present, as are stipules that may be spinescent. Flowers are tetramerous or pentamerous, with white or yellow (rarely pink) petals and are either all hermaphrodite or a hermaphrodite–male mixture on a single tree. Flowers are organized into heads, and flower heads organized into axillary, racemose or rarely paniculate inflorescences (Figure 1). Flowers have free to united sepals, with numerous stamens that are usually free (rarely united at the base into a very short tube) and a single (usually), sessile or stalked ovary. Pods are dehiscent or indehiscent, usually flattened, and very variable in shape, ranging from straight to highly contorted. Seeds are unwinged and nonendospermous, usually with a hard seed coat and with or without an aril.

Acacia taxonomy has been in a state of flux since the genus was first described by Miller in 1754, although it was not until Bentham's work in the mid-1800s that the present generic limits were



Figure 1 Globose and spicate inflorescences in the genus *Acacia*. (a) Globose inflorescence of *A. schaffneri* (Mexico); (b) spicate inflorescence of *A. amentacea* (Mexico).

established. Bentham divided *Acacia* into six series (Table 2), based primarily on vegetative characters (foliage and spinescence) and secondarily on inflorescence characters; fruit was largely ignored. In the 1970s, Vassal recognized three subgenera (*Acacia*, *Aculeiferum*, and *Phyllodineae*) (Table 2), and moved the African species *Acacia albida* to the monotypic genus *Faidherbia*. In the mid-1980s, Pedley concluded that the genus *Acacia* was too broadly conceived and three genera should be recognized (although most botanists have not accepted these changes): *Acacia* (= *Acacia* subgenus *Acacia*), *Senegalia* (= *Acacia* subgenus *Aculeiferum*), and *Racosperma* (= *Acacia* subgenus *Phyllodineae*) (Tables 2 and 3).

Most recent evolutionary studies, whether based on DNA or morphological data, concur with Pedley that the genus *Acacia* is not monophyletic. However, the appropriate division of the genus is unclear. Some workers suggest that subgenera *Aculeiferum* and *Phyllodineae* group together and are distinct from

subgenus *Acacia*, others have suggested that subgenera *Aculeiferum* and *Acacia* group together and are distinct from subgenus *Phyllodineae*, whilst more radical still is the suggestion that the currently circumscribed *Acacia* should be split into five different genera. The formal splitting of the genus *Acacia* is likely to result in a large number of changes of scientific names.

Complex patterns of morphological variation, the paucity of material, poor understanding of distribution in some species and the recognition of numerous infraspecific taxa (e.g., *A. tortilis* and *A. nilotica*) can confound species delimitation. For example, *A. farnesiana* is prostrate in Mexican sand dunes, whilst *A. longifolia* subsp. *sophorae* shows a similar habit in the sand dunes of southwestern Australia. Some species have very wide distributions (*A. tortilis*, throughout tropical Africa and into the Middle East and India), whilst other species have very restricted distributions (e.g., *A. dorseanna*, known only from one area in Western Australia).

Table 2 Major classifications of the genus *Acacia*

Bentham	Vassal	Pedley
<i>Acacia</i> series <i>Gummiferae</i>	<i>Acacia</i> subgenus <i>Acacia</i> Section <i>Acacia</i>	<i>Acacia</i>
series <i>Vulgares</i>	subgenus <i>Aculeiferum</i> Section <i>Monacantha</i> Section <i>Aculeiferum</i>	<i>Senegalia</i> Section <i>Senegalia</i>
series <i>Filicinae</i>	Section <i>Filicinae</i>	Section <i>Filicinae</i>
	subgenus <i>Phyllodineae</i>	<i>Racosperma</i>
series <i>Botrycephalae</i>	Section <i>Uninervea</i>	Section <i>Racosperma</i>
series <i>Phyllodineae</i>	Section <i>Heterophyllum</i>	Section <i>Plurinervia</i> Section <i>Lycopodiifolia</i>
series <i>Puchellae</i>	Section <i>Pulchelloidea</i>	Section <i>Pulchella</i>
	<i>Faidherbia</i>	<i>Faidherbia</i>

Table 3 Major subgeneric characteristics of the genus *Acacia*

Characteristic ^a	Subgenus <i>Acacia</i>	Subgenus <i>Aculeiferum</i>	Subgenus <i>Phyllodineae</i>
Distribution	New World, Africa, Asia [Australia]	New World, Africa, Asia [Australia]	Australasia [Hawaii, Mascarene Islands]
Phyllodes	Absent	Absent	Present, rarely absent
Stipular spines	Present	Absent	Absent, rarely present
Prickles	Absent	Present, rarely absent	Absent
Anther gland	Present or absent	Present or absent	Absent
Pod fibers	Single layer	Two layers	Two layers
Pollen	Colporate	Porate [extraporate]	Extraporate [porate]
Ploidy	2x, 4x, 8x +	2x, rarely 4x, 8x	2x, rarely 4x, 6x
Mean 1C DNA content (standard error)	1.130 (0.032)	0.997 (0.074)	1.435 (0.011)

^aSquare brackets indicate that characteristic is rarely found.

Genetics

Chromosome number and structure varies across the genus from $2n=2x=26$ to $2n=16x=208$, with homogeneous to heterogeneous karyotypes, and nuclear DNA contents (1C, i.e., the amount of DNA in the haploid set of chromosomes) from 0.53 pg to 2.1 pg. Chromosome number in subgenus *Acacia* ($2x$, $4x$, $8x$ +) is more variable than the other two subgenera, whilst 1C DNA content is greater in subgenus *Phyllodineae* than either of the other two subgenera (Table 2). However, variation in chromosome numbers can be found within species; for example, tetraploid individuals occur in populations of the normally diploid *A. dealbata*.

Differences in chromosome numbers would imply that polyploidy has been important in the evolution of the genus *Acacia*. The origin of the Australian allohexaploid *A. colei* is thought to have been through allopolyploidy, involving the diploid *A. neurocarpa* and the tetraploid *A. elachantha*, through a triploid, presumably sterile, intermediate. In the case of the African triploid *A. laeta*, this is thought to have arisen through hybridization between the two diploid species, *A. mellifera* and *A. senegal*. In general, natural hybridization between *Acacia* species appears to be relatively rare, although putative hybrids have been recorded from all the major areas of the genus's distribution. Furthermore, hybrids may have considerable potential in forestry; for example, the hybrid between the economically important species *A. auriculiformis* and *A. mangium*, has desirable commercial characteristics.

Few investigations of the distribution of genetic variation within and among natural populations of

acacias have been conducted; those that have been undertaken have mainly used allozyme markers (Table 4). The occurrence of ploidy differences, particularly in subgenera *Aculeiferum* and *Acacia*, means that genetic diversity investigations are complicated by the possibility of more than two alleles at a locus within an individual and hence in the calculation of allele frequencies (e.g., high genetic diversity and low population differentiation in *A. karroo* may be a reflection of this problem). This may be one of the reasons that the majority of investigations of neutral marker diversity have focused on diploid Australian *Acacia* species. Furthermore, estimates of genetic diversity may be affected by population sampling and choice of loci (e.g., *Faidherbia albida*, *A. mangium*). Acacias tend to show high levels of genetic diversity and differentiation compared to other long-lived, woody perennials (Table 4). High genetic differentiation appears to be associated with disjunctions in genetic diversity, for example, the genetic differentiation of *A. melanoxylon* populations in eastern Australia into northern and southern types or the disjunction of genetic diversity between East and West African populations of *Faidherbia albida*. Such disjunctions have been interpreted as the result of changes in population size following major environmental perturbation. In the diploid *Acacia* species, low differentiation appears to be associated with restricted distributions (e.g., *A. anomala*).

Acacia mangium is one of the most widely planted and economically important *Acacia* species, yet very low levels of neutral genetic diversity and population differentiation have been reported. This illustrates the importance of having knowledge of both neutral

Table 4 Examples of the patterns of genetic diversity and population differentiation in natural populations of *Acacia* species sampled from across their native ranges and based on allozyme data

Taxon	Number of populations	Number of loci	Mean population diversity	Total genetic diversity	Population differentiation
<i>Faidherbia albida</i>	22–30	6–10	0.128–0.454	0.286–0.516	0.123–0.422
<i>Acacia acuminata</i>	6	16	0.237	0.266	0.108
subsp. <i>acuminata</i>					
<i>A. acuminata</i> subsp. <i>burkittii</i>	5	16	0.287	0.318	0.098
<i>A. anomala</i>	6	15	0.336	0.356	0.056
<i>A. aulacocarpa</i>	22	30	0.111	0.298	0.626
<i>A. auriculiformis</i>	13–18	18–22	0.098–0.122	0.134–0.149	0.181–0.270
<i>A. mangium</i>	11–13	18–30	0.017–0.064	0.025–0.070	0.086–0.311
<i>A. mearnsii</i>	19	22	0.179	0.201	0.108
<i>A. karroo</i>	12	10	0.84	0.88	0.050
<i>A. melanoxylon</i>	27	30	0.215	0.345	0.377
<i>A. oldfieldii</i>	2	16	0.166	0.178	0.069
Long-lived, woody perennials	Mean = 9.2	Mean = 18.1	0.148	0.177	0.084

and adaptive variation before conservation and utilization decisions are made. Furthermore, *A. mangium* is the *Acacia* species for which the most comprehensive genetic map is available.

Ecology

The ecological diversity of the genus *Acacia* is reflected in its morphological diversity, where species occupy habitats as diverse as the arid centre of Australia and wet neotropical forests. *Acacia* species are important ecosystem components, especially in Australian and African savannas where they may be important colonizing species (e.g., *A. melanoxylon*). However, *Acacia* species tend to be more abundant in arid and semi-arid areas than in wet ecosystems. The majority of *Acacia* species show adaptations to water stress, for example, reduced photosynthetic surface areas (e.g., the Australian *Acacia* species *A. willardiana* of the Sonoran Desert), although some are adapted to periodic flooding (e.g., *A. xanthophloea*). Some species (e.g., *A. erioloba*), survive the extremes of the desert environment, including freezing, and may have very long (6–12 m) tap roots. The ant acacias show a mutualistic arrangement, where ant colonies protect the plant from herbivory and the leaves may produce Beltian bodies (protein-rich structures) as an ant food source. The association between ants and *Acacia* species appears to have arisen on more than one occasion, on at least two continents; the Central American swollen thorn ant acacias (e.g., *A. melanoceros*) support *Pseudomyrmex* colonies, whilst the African whistlet-horn acacias (e.g., *A. seyal*) support *Crematogaster* colonies. African and Australian *Acacia* species are also important hosts for members of the parasitic angiosperm families Loranthaceae and Santalaceae.

Dominant acacias (e.g., *A. aneura*) may have important roles in the landscape, although changes in human activities (e.g., pasture management) may cause considerable changes in an *Acacia*-dominated landscape; for example, the Central American ant acacia *A. melanoceros* is sensitive to forest fragmentation. In contrast, some species are very tolerant of human-mediated disturbance; for example, *A. dealbata* regenerates freely following windthrow. Such differences appear to be at least partially related to life-history traits. For example, *A. melanoceros* matures in 8–14 years compared to the 4–5 years of *A. dealbata*, whilst the resprouting ability of *A. melanoceros* is poor compared to the vegetative regeneration of *A. dealbata*. Furthermore, *A. melanoceros* seeds germinate quickly compared to those of *A. dealbata* that form a long-lived seed bank. Another major effect of humans on the distribu-

tion of acacias has been the intercontinental movements of species, for example, Australian species being moved to Africa and the New World and African species being moved to Australia. The consequences of such movements have been unpredictable; some species are highly productive (e.g., *A. mangium* in India), whilst others are very destructive (e.g., *A. nilotica* in Australia).

Distributions of *Acacia* species and range limitations may depend on soil and climatic factors; for example, *A. erioloba* is confined to soils of the Kalahari sand sheet in southern Africa, whilst the northern limit of *A. farnesiana* in the USA may be due to low temperatures. However, more complex interactions may occur; for example, phyllode size in the coastal species *A. melanoxylon* appears to be related to both distance from the coast (aridity) and seasonal rainfall patterns. Seasonality reveals additional patterns of ecological variation in acacias. Some species lose their leaves all at once, e.g., Sudanese *A. nubica* (at the end of the long dry season), whilst *A. tortilis* sheds its leaves progressively as the dry season advances. Most Australian acacias are adapted to fire; thus germination may be facilitated by fire or vegetative regeneration may be stimulated, as with some African acacias, where coppice growth is facilitated (e.g., *A. stolonifera*).

Acacias, as legumes, are generally capable of forming symbiotic relationships with the bacterial genus *Rhizobium*, producing root nodules and fixing atmospheric nitrogen. However, both nodulating and nonnodulating species are found in the genus *Acacia*. Nonnodulation is restricted to the southern USA, Central and South American, African and Asian members of subgenus *Aculeiferum* section *Monoacantha* (e.g., *A. brevispica*); nonnodulation is unknown in Australian *Acacia* species. In addition to root nodules, acacias also have mycorrhizae.

Thirty-five *Acacia* taxa are listed as under threat by the IUCN, although this is likely to be an underestimate given that no Australian *Acacia* species are represented. Of those species under threat, the majority are threatened due to either agriculture or habitat degradation. Secondary effects of large mammal conservation may also have effects on *Acacia* conservation; as an example, the introduction of giraffes into South African savannas has driven accessible *A. davyi* populations to extinction.

Reproductive Biology

In *Acacia* species, the pollination unit is the flower head and pollen is released as polyads. Three

mechanisms to promote outcrossing predominate in *Acacia* species:

1. Protogyny, where the stigma is receptive to pollen before pollen in the same flower is released.
2. Andromonoecy, where male and hermaphrodite flowers occur on the same plant, e.g., 17–50% male flowers are found per head in *A. suaveolens*.
3. Gametophytic self-incompatibility, where successful fertilization is determined by the genotype of the pollen, e.g., *A. retinoides*.

The structure of the *Acacia* inflorescence suggests that the majority of species are pollinated by insects, including Coleoptera, Diptera, Hymenoptera, and Lepidoptera, although others are pollinated by small mammals and nectarivorous birds; there is evidence that *A. nigrescens* is giraffe-pollinated. Genetic investigations of *Acacia* mating systems have shown that the species are highly outcrossed. However, reports of isolated individuals (e.g., *A. karroo*, *Faidherbia albida*) setting seeds imply that selfing may occur, whilst reports of polyembryony (e.g., *A. karroo*, *A. farnesiana*, *A. nilotica*) suggest that apomixis may also be important in some species.

In addition to sexual reproduction, some *Acacia* species also reproduce asexually by root suckering. For example, allozyme analysis of two disjunct regions of the rare Australian species *A. anomala* supports the view that one region is primarily outcrossing and the other is clonal, where each population in the latter region contains individuals with identical, multilocus genotypes.

Seed dispersal in acacias is usually by gravity or mechanical means. However, both insects and vertebrates may play important roles in seed dispersal and the facilitation of germination. In a few species, bird dispersal seems to be a common strategy. For example, the Central American ant acacias often have brightly colored fleshy arils that may attract birds, whilst the attractiveness of some species (e.g., *A. cyclops*) may be enhanced by seeds being suspended from the pod. In addition, it has been suggested that the aril of acacia seeds may be attractive to ants. For example, in the mechanically dispersed Australian species *A. linifolia*, secondary ant-dispersal may occur. Browsing vertebrates, particularly in Africa, play an important, if less selective role in seed dispersal; elephants and antelopes ingest large numbers of seeds which are then deposited in their faeces (e.g., *A. erioloba*). Such treatment scarifies the seed and provides a fertile germination medium. Other species, e.g., *Faidherbia albida*, appear to be dispersed by water, the fruits being buoyant, and deposit their seed when rotted,

although the relative importance of water versus mammal dispersal in this case is unclear. Humans are an important means of long-distance dispersal of acacia seed, whether it is seed for establishing plantations, movement of multipurpose species with human migration, or transport by their livestock.

Many *Acacia* seeds have hard seed coats and need to be scarified before they will germinate; there are reports of acacia seed remaining viable in the soil for up to 60 years. The seeds of other species (e.g., *A. harpophylla*) lack impervious seed coats, lose viability rapidly, and have short lifespans. Despite their hard seed coats, many acacia seeds may be lost through infection of developing ovules by beetle larvae (Bruchidae) at the early stages of fruit development. Such losses are more significant in the New World and African acacias than in the Australian acacias, where the diversity of Bruchidae is relatively low.

Silviculture

Acacia diversity is reflected in the range of silvicultural practices applied to species management. The most widely planted *Acacia* species (*A. auriculiformis*, *A. mangium*, and *A. melanoxylon*) are generally light-demanding and adapted to a range of soil types. For example, *A. mangium* grows on acidic soils, whilst *A. auriculiformis* is particularly adaptable and grows well on sandy to heavy clay, often shallow soils. Furthermore, *A. auriculiformis* will tolerate flooding and very acidic soils, e.g., acid mine spoil in northern Australia.

Acacia saplings may be raised by vegetative propagation, although grafting may not be suitable for large-scale sapling production and stem cutting may only be possible from seedlings. Therefore, acacia plants are usually raised from seed. Acacia seeds can be stored for long periods, although they usually need scarification before they will germinate. Scarification may occur naturally by passage through animal guts, which has been promoted as a means of obtaining seed for plantation establishment. However, for most purposes other scarification treatments are necessary (e.g., mechanical or chemical damage to the seed testa or treatment with boiling water). Burning may also promote the germination of acacia seeds and is a common silvicultural practice, since accumulated litter is removed, even-aged stands are produced, and pests are destroyed. However, the practice may also increase the likelihood that some species become problem invaders, due to loss of seed dormancy (e.g., *A. brevispica*, *A. catechu*).

Acacia plantations are usually established from container-grown plants inoculated with rhizobia;

saplings are usually transplanted at about 6 months old. However, direct sowing of seed has been recommended in some cases, for example, *A. decurrens* in South Africa, where a well-developed taproot may be damaged during transplantation. Acacia seedlings are usually frost-sensitive, although once established species may be frost-hardy; for example, *A. melanoxylon* plantations will withstand frosts to -7°C .

Optimal spacing depends on the species and the products of interest. In order to produce high-quality *A. mangium* logs it is necessary to plant at densities that range from 900 to 1680 stems ha^{-1} which, combined with regular pruning and extensive thinning, will yield suitable timber after 15–20 years. In contrast, plantations for chipping, pulpwood, and firewood are not generally pruned or thinned and are harvested at 6–7 years.

Plantation management will depend on the species. *Acacia auriculiformis* responds well to pollarding and can be coppiced, whilst *A. mangium* is generally unsuitable for multiple rounds of coppicing. *Acacia melanoxylon* is susceptible to windthrow and must be sheltered if high-quality timber is to be produced; for example, in Tasmania it is grown with either *Pinus radiata* or *Eucalyptus* species. Rotation times will depend on the species; for example, *A. auriculiformis* produces stems of 15–20 cm diameter after 10–12 years, whilst *A. melanoxylon* will produce stems of more than 50 cm diameter after 70 years.

Utilization

Wood Products

In general, *Acacia* species have good biomass potential and, because of their high calorific value, are good fuelwoods. Large plantations of *A. mangium*, for paper pulp production, occur in Indonesia and Malaysia, where it is also an important building and furniture timber. *Acacia auriculiformis* is used for fuelwood, whilst the *A. mangium* $\times$ *A. auriculiformis* hybrid also has very good wood properties. *Acacia melanoxylon* is the best-known and highly valued temperate *Acacia* timber species, with harvesting from natural Tasmanian forests and plantations in New Zealand, South Africa, and Chile. *Acacia* species are important timber species in their native countries, e.g., *A. galpinii* and *A. nilotica* in Africa. In Western Australia, *A. acuminata* and *A. trachycarpa* are important *Santalum* hosts in commercial sandalwood production.

Tannin

Acacia mangium bark is a major source of vegetable tannin (used in leather and adhesive manufacture),

the main producers of which are Brazil, China, Kenya, India, South Africa, Tanzania, and Zimbabwe. *Acacia decurrens* is also used, whilst historically *A. mearnsii* was planted for its tannin-rich bark.

Human Food

Acacia seeds typically have high nutritional values and few toxic or antifeedant compounds. Seeds of Australian tropical arid zone species, e.g., *Acacia colei* and *A. tumida*, are showing promise as a human food sources in semi-arid regions of the Sahel, where they were originally introduced for fuelwood and amenity planting. In Australia, *Acacia* (e.g., *A. murrayana*, *A. victoriae*) seeds are used as flavourings in the developing bushfood industry. African *Acacia* species (e.g., *A. senegal* and *A. seyal*) are important sources of edible gums.

Fodder

Acacia species are an important food component for African savanna mammals, whilst there are significant economic uses of *Acacia* foliage and green pods as livestock fodder, especially in times of drought (e.g., *A. tortilis*). In Australia, the *A. aneura* group is a particularly important fodder for sheep in the arid-zone rangelands, whilst *A. saligna* has been used outside Australia as fodder for sheep and goats in North Africa and South America. However, the foliage for some species is very toxic to livestock (e.g., *A. georgiana*). *Acacia* species may also be important fodder for wild species (e.g., *A. erioloba* in South Africa).

Ornamentals, Oils, and Medicines

In southern Europe, Australian *Acacia* species (e.g., *A. dealbata*, *A. retinodes*) have extensive ornamental value. In southern France, oil from *A. dealbata* and *A. farnesiana* flowers is used as a fixative and blending agent in perfume manufacture. Traditional medicines are extracted from some *Acacia* species, particularly *A. nilotica* and *A. catechu* in India.

Land Amelioration

Acacia species have been used for sand stabilization, *Imperata cylindrica* control, mine spoil rehabilitation, and improvement of soil quality. For example, *A. saligna* has potential for the mitigation of salinity, whilst *A. ampliceps*, *A. maconochieana*, and *A. stenophylla* have been very successful in highly alkaline, saline soils in Pakistan. *Acacia karroo* is an important species for land reclamation in southern Africa, and *A. dealbata* and *A. melanoxylon* are important species for sand dune stabilization in Chile.

Weediness

Some *Acacia* species have become serious weeds. Exotic Australian *Acacia* species (e.g., *A. saligna*, *A. cyclops*, *A. melanoxylon*, and *A. dealbata*) have caused serious weediness problems in South Africa, Portugal, and Chile, whilst New World and African *Acacia* species (e.g., *A. farnesiana*, *A. nilotica*) have caused problems in Australia. The weediness of *Acacia* species means that their use in agroforestry and amenity situations must be considered very carefully.

See also: **Biodiversity:** Biodiversity in Forests. **Ecology:** Reproductive Ecology of Forest Trees; Molecular Biology of Forest Trees; Population, Conservation and Ecological Genetics. **Landscape and Planning:** Landscape Ecology, Use and Application in Forestry. **Medicinal, Food and Aromatic Plants:** Edible Products from the Forest; Forest Biodiversity Prospecting; Medicinal and Aromatic Plants: Ethnobotany and Conservation Status. **Tree Breeding, Practices:** Tropical Hardwoods Breeding and Genetic Resources. **Tropical Forests:** Monsoon Forests (Southern and Southeast Asia); Tropical Dry Forests; Tropical Moist Forests; Woody Legumes (excluding *Acacias*).

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Bamboos, Palms and Rattans

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Taxonomy/Genetics

Bamboos: Poaceae (Gramineae)

The family Poaceae comprises about 12 000 species in about 700 genera. Twelve subfamilies are recognized, of which the Bambusoidea is one. This subfamily includes approximately 1200 species within the tribes Bambuseae (woody bamboos) and Olyreae (olyroid or herbaceous bamboos).

Bamboos are forest grasses. The most ancient grasses were tropical forest dwellers but, as the higher grasses diversified into open areas, the true bamboos were the only major lineage of the family to adapt to the forest habitat. Bamboos are set off from other grasses by the predominance of certain 'bambusoid' structural characters, many of which are considered to be 'primitive'. The most easily recognizable vegetative features that distinguish the bamboos are the prominent development of a rhizome system, the woodiness and strong branching of the culms, the presence of petioles on the leaf blades, and the difference in form between the sheaths clothing young culm shoots and those borne on the leafy twigs. To these may be added floral characters such as well-developed lodicules, in most species three in number, and a style consisting typically of a single column, bearing one, two, or three (rarely more) stigmas.

The bambusoid grasses are naturally distributed in all continents except Europe and Antarctica. Bamboos appear more or less prominently in the natural vegetation of many parts of the tropical, subtropical, and mild temperate regions. The approximately 1100 species of woody bamboos are distributed from 46°N to 47°S latitude and from sea level to 4300 m in equatorial highlands, whereas the approximately 110 species of herbaceous bamboos occur overwhelmingly in the New World, with only two Old World representatives. The herbaceous bamboos occur principally in moist forests between 29°N and 34°S latitude and are only occasionally found above elevations of 1000 m, rarely to 2700 m. The natural distribution of bamboo in the world has been greatly modified by human intervention.

Of the 60–70 genera of woody bamboos, only *Arundinaria* occurs in both the Old World and New World. Currently, 20 genera of solely New World