Tree species for wind prone areas

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Introduction

Wind is a strong stress factor for trees growing in wind exposed areas. Coastal areas are always prone to strong winds. Wind velocity as well as prevailing wind direction vary during the year. Trade winds have a predictable direction and are rarely strong. Monsoons can be quite strong and carry heavy rain. Typhoons[1] or hurricanes can achieve extreme velocities and bring along strong precipitation, so-called rain storms and often result in flooding. Typhoons, as well as other strong winds, occur during distinct seasons. During the peak season, typhoon- prone areas may encounter typhoons once or twice a week. Each typhoon has a duration of 12 – 18 hours with peak velocities experienced for a few hours. Prevailing wind directions leave some coast lines directly exposed while the opposite side is sheltered by land. Wind speed reduces with distance from the sea, as land morphology, vegetation and constructions slow down the wind speed. Consequently, the direct effect of wind exposure and encountered derived effects such as salt and sand flow decline with distance from the sea. Coastal shelterbelts may thus significantly reduce both the direct and indirect impact.

High altitudes are exposed to strong winds, in particular mountain peaks and plateaus with no shelter. Inland and highland winds do not carry salt spray, but in dry areas wind increases desiccation and at high altitude winds are cold and may accentuate frost damage. Wind exposed areas can thus have a very different type of vegetation than sheltered areas.

Trees create shelter and are thus creating a micro-environment for their own as well as for less wind hardy species. However, species suitable for wind prone areas are not always suitable as shelterbelt plants.

[1] Depending on location and strength, tropical storms are referred to as hurricanes, cyclones or typhoons.

Measuring wind velocities

Wind speed is a measure of the horizontal movement of air over a fixed point. Wind speed is traditionally measured by an anemometer, which consists of a rotating vane connected to a counting device. There are several types of numeric indications of wind speed. The former Beaufort scale (1-12) is now mostly replaced by indications in meter per second (m/s) or occasionally in km/h or mph. A strong breeze is 10-14 m/s; a storm is 25-28 m/s. Hurricanes, cyclones or typhoons have wind speed of 30-40 m/s with exceptional blows of more than 100 m/s (360 km/h or 225 mph)).

Physiological adaptations to growth in wind prone areas

Wind imposes a direct mechanical stress and carries with it salt and other particles all of which are directly proportional to its velocity. Large objects are more exposed to wind damage than small objects. This means that the stress factor of the tree may increase with size and age. Individual trees may be able to adapt to a certain level of wind exposure for example by forming strong root systems (some species including buttresses), thick branches, and smaller leaves. Wind exposed trees often tend to have a stunted growth; thereby sheltering their own shoots (fig. 1b). Some of these characters, and several others, are prevalent in trees adapted to growing in wind prone areas. Mechanical stress affects all parts of the tree, but via phenological adaptations leaves, flowers and fruits may escape during periods of the strongest winds. The mechanical impact of strong wind may be alleviated by structural flexibility of stems, branches and petioles. Rather than breaking and being uprooted during strong wind, adapted trees may sway and move with the wind blow. The risk of uprooting depends on the root grip of the soil.

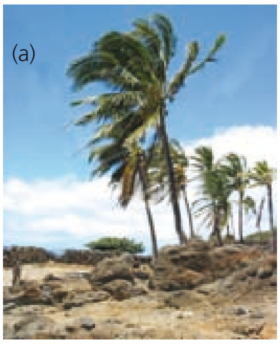
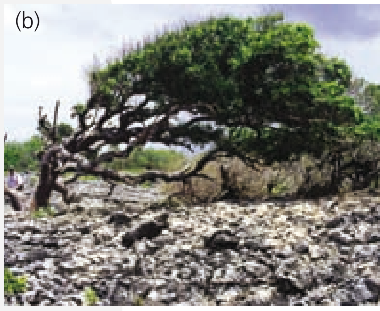


Figure 1. Strong winds affect both species and their growth form. Cocos nucifera *(a) experiences extremely high wind velocities in coastal areas but strength and stem flexibility combined with divided strong leaves make the species very wind hardy. Highland trees (b), often exhibit a peculiar one-sided growth habit away from the prevailing wind direction. The reason is that buds, shoots and branches on the windward side are killed by wind effects.*



Deep, wide and extensive root systems prevent uprooting; in addition several tropical species growing on shallow, poor, water-logged or otherwise unstable soils develop large buttresses. Risk of uprooting or stem breaking is closely connected to effective 'air drag' of the canopy; a large, wide crown has a relatively large air drag. Evergreen conifers in wind prone highlands are at high risk of wind throw. The cone- or steeple shaped crown form of spruces and pines are interpreted as an adaptation to reduce the air drag and consequent wind throw.

Leaves are particularly prone to wind damage. Species adapted to growing in wind exposed areas tend to have small leaves or divided leaves. Sand flow in particular is stressful to leaves and softer parts. Small structures are again the best protection. Salt spray is carried by wind and causes osmotic desiccation of leaves; salt tolerance is prevalent in species in coastal, wind prone areas. However, rains dilute and wash away salt, and the potential damage by salt is thus also a function of rainfall. In heavy rainfall areas salt-spray by seawater may affect a few hundred meters from the coast, while in dryer climates salt may affect many kilometers inland.

Moving sand may cover low vegetation parts including young trees and low branches. An adaptation for growing in moving sand is the ability to re-grow after coverage (figure 2).

Figure 3. Some morphological adaptations to wind stress.
Left: large rainforest trees often lack deep roots; instead they form large and wide buttresses for support.
Centre: Conical or steeple shape in many highland conifers is an adaptation to reduce wind drag.
Right: Divided leaves easier escape damage by tearing and lodging during strong winds.

Figure 2. Species growing in moving sand has an ability to tolerate partly exposure of the roots and will re-grow if covered by sand.

List of species adapted to wind exposed areas

Species occurring in wind prone areas show generally high wind resistance. However, many species show a high within-species variation, where wind hardiness is strongly dependent on ecotype or provenance. Following species list is divided into 3 classes, because salt spray in coastal areas, drought in inland areas, and low temperature in upland areas are closely connected to wind tolerance in these respective areas.

Mainly Inland	Mainly coastal areas	Mainly highland (> 1000masl)
Acacia holoserica	*Acacia mearnsii*	*Agathis damara*
Acacia mearnsii	*Acacia salicina*	*Araucaria cunninghamia*
Acacia senegal	*Anacardium occidentale*	*Callitris colummellas*
Albizia lebbek	*Azadirachta indica*	*Casuarina glauca*
Anacardium occidentale	*Barringtonia asiatica*	*C. junghuhniana*
Areca spp.	*Bixa orellina*	*Cryptomeria japonica*
Azadirachta indica	*Borassus aethiopum*	*Cunninghamia lanceolata*
Barringtonia asiatica	*Borassus flabillifer*	*Cupressus arizonica*
Borassus aethiopum	*Cassia fistula*	*Cupressus lucitanica*
Casuarina equisetifolia	*Casuarina equisetifolia*	*Cupressus macrocarpa*
Cocus nucifera	*Cocus nucifera*	*Cupressus turulosa*
Dalbergia sissoo	*Pandanus spp.*	*Elaeagnus angustifolia*
Eucalyptus camaldulensis	*Phoenix canariensis*	*Eucalyptus botryoides*
Eucalyptus terreticornis	*Pongamia pinnata*	*Eucalyptus globulus*
Hardwickia binata	*Sabal palmetto*	*Eucalyptus maculata*
Lagerstroemia indica	*Salvadora persica*	*Leucaena diversifolia*
Leucaena leucocephala	*Spindus emarginatus*	*Magnolia grandiflora*
Madhuca indica	*Syzygium jambos*	*Parkinsonia aculeata*
Phoenix dactylifera	*Tamarix aphylla*	*Paulownia tomentosa*
Pinus canariensis	*Terminalia catappa*	*Pinus canariensis*
Pinus carribaea		*Pinus elliottii*
Prosopis juliflora		*Pinus merkusii*
Senna siamea		*Podocarpus latifolius*
Tamarindus indica		*Populus deltoids*
Tamarix		*Prosopis juliflora*
		Prosopis tamarugo
		Tamarix aphylla
		Taxodium ascendens

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