The Role of Coastal Forests and Trees for Protecting against Wind and Salt Spray

*Eugene S. Takle**
T.-C. Chen, and Xioaqing Wu
Iowa State University
Ames, Iowa USA

*Professor of Atmospheric Science
*Professor of Agricultural Meteorology
gstakle@iastate.edu

Photo compliments of Dixie Stine (used with permission)

Outline

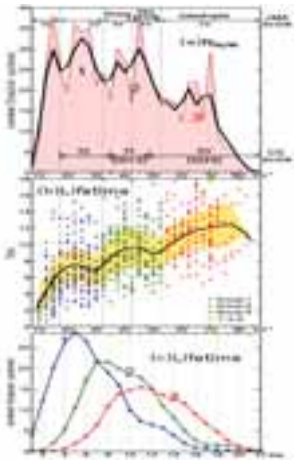
- Winds leading to damage from sea spray and salt transport
- Wind reduction by a simple, uniform shelterbelt
- Design factors for multi-species shelterbelts
- Sea-spray generation over the ocean
- Spray and salt particle capture by shelterbelts
- Recommendations for coastal forests and shelterbelts
- Conclusions

Characteristics of Tropical Cyclones in the Western Pacific Ocean

(a) Cyclone population vs. wind-speed intensity

(b) Cyclone lifetime vs. wind-speed intensity

(c) Cyclone population vs. lifetime

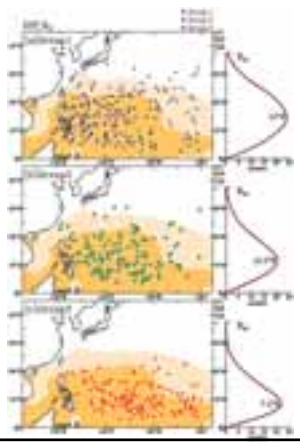


Location of Genesis of Tropical Cyclones in the Western Pacific Ocean

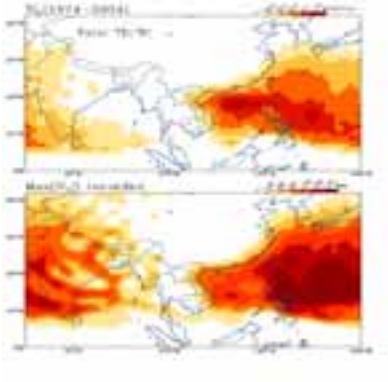
Group 1 = Tropical storms

Group 2 = Typhoons

Group 3 = Intense typhoons

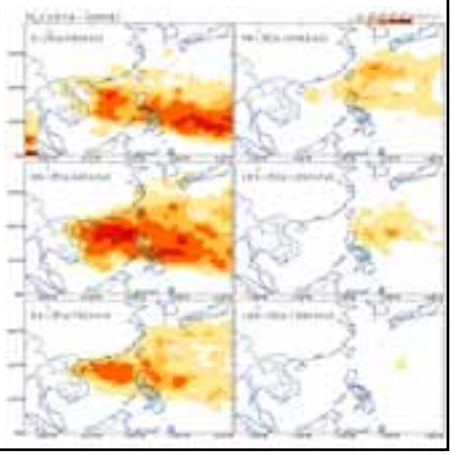


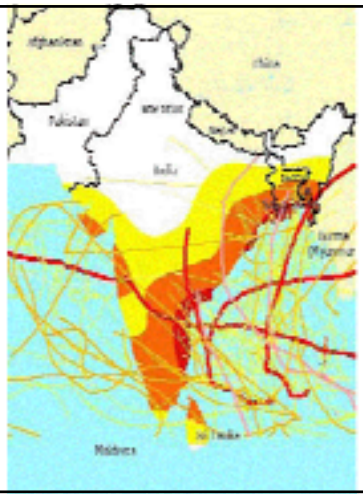
Upper: Occurrence frequency of tropical cyclones from 1974-2004 in number of occurrences per year for each 1-degree latitude by 1-degree longitude box.



Lower: Maximum wind speed of typhoon ever recorded in the period 1974-2004.

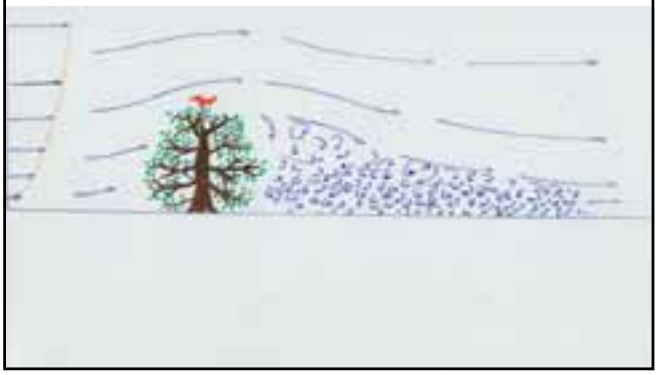
Frequency of occurrence for tropical cyclones whose wind speed is within the range given at the upper-left corner.





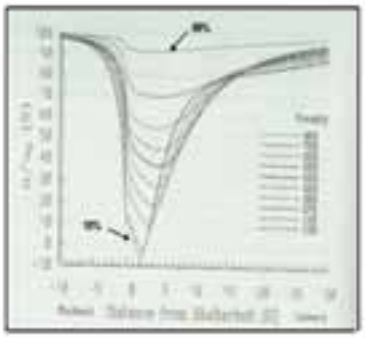
Map shows storm risk in India. Dark red are showing high risk and light yellow are showing low risk\n

Wind Reduction by a Simple, Uniform Shelterbelt



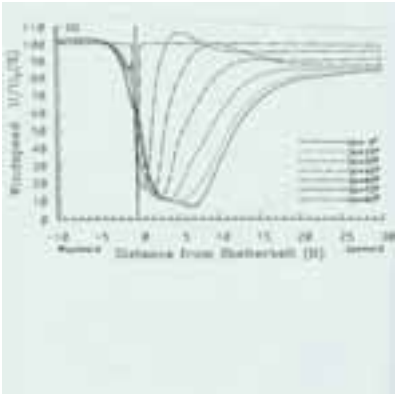
Density of the Shelterbelt Determines its Leeward Wind Speed Reduction

* Very porous shelters have only modest wind speed reduction
* Very dense shelters reduce wind substantially but have a reduced sheltered region
* Shelters of intermediate density are optimal



Orientation of the Shelter to the Prevailing Wind Influences it Effectiveness

* Orienting the shelter perpendicular to the prevailing wind optimizes the sheltering effect
* Winds oblique to the shelter have only a narrow shelter zone in the lee

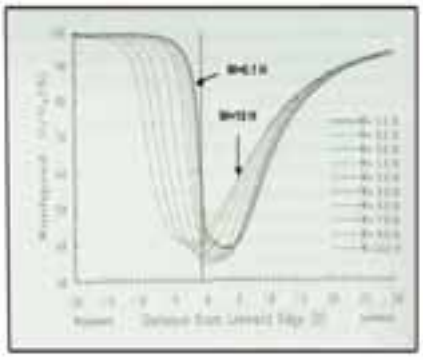


Width of the Shelter Influences the Wind Speed Recovery in the Lee

•Wide shelters allow wind to begin recovery before exiting the shelter

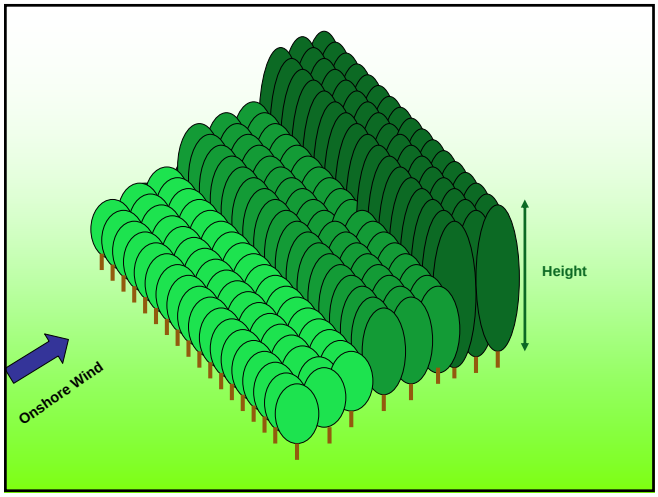
•Narrow shelters have longer protected region

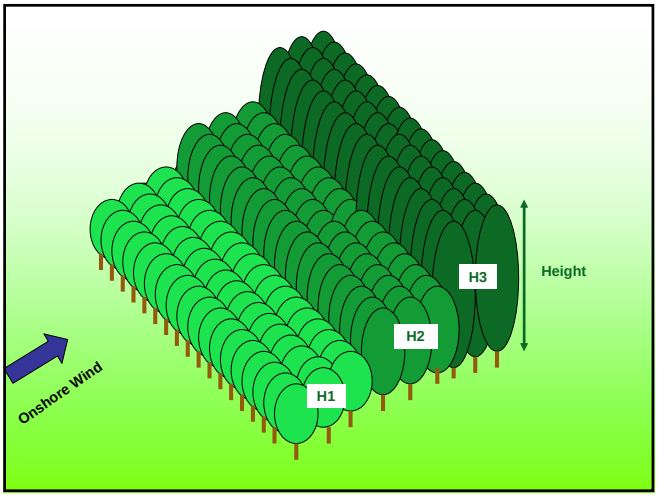
•Shelters of intermediate width have optimal effectiveness

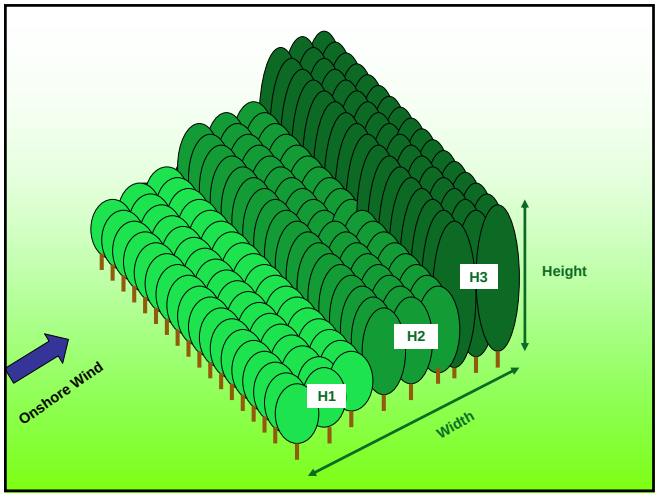


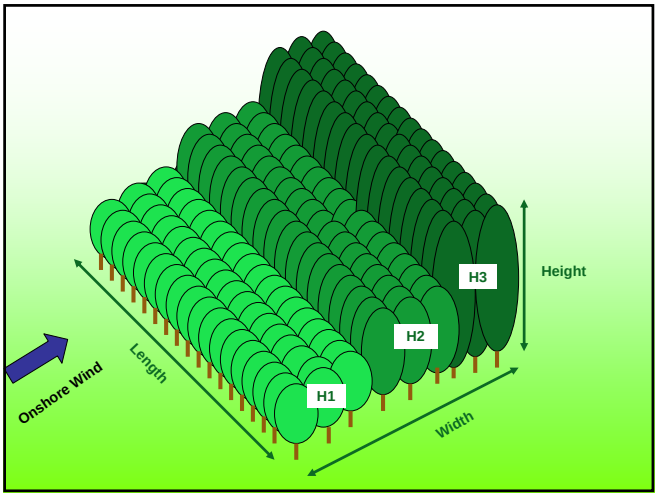
Design Factors for Multi-Species Shelterbelts

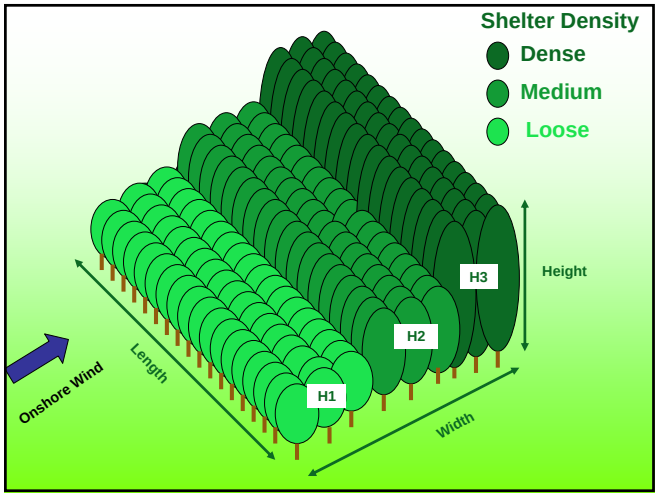
- Height
- Width
- Length
- Density
- Orientation to the prevailing wind
- Cross-sectional profile
- Continuity
- “Edge” effects

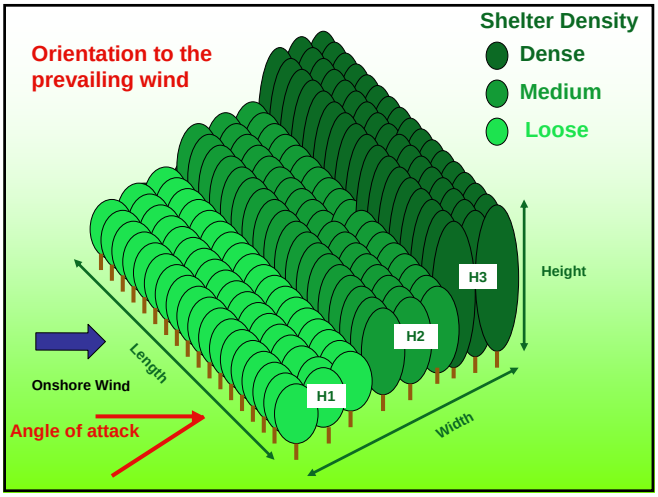

Height
Onshore Wind

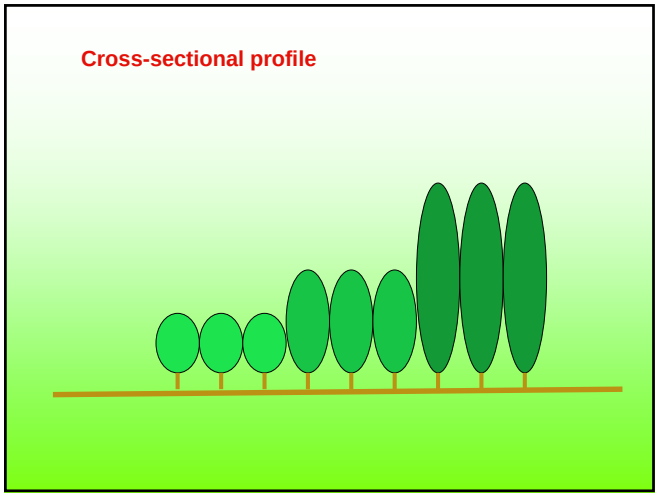

H3
Height
H2
H1
Onshore Wind

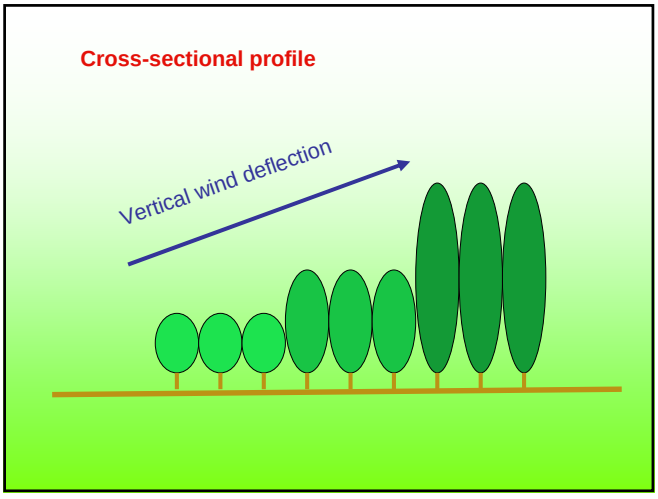

H3
Height
H2
H1
Onshore Wind
Width

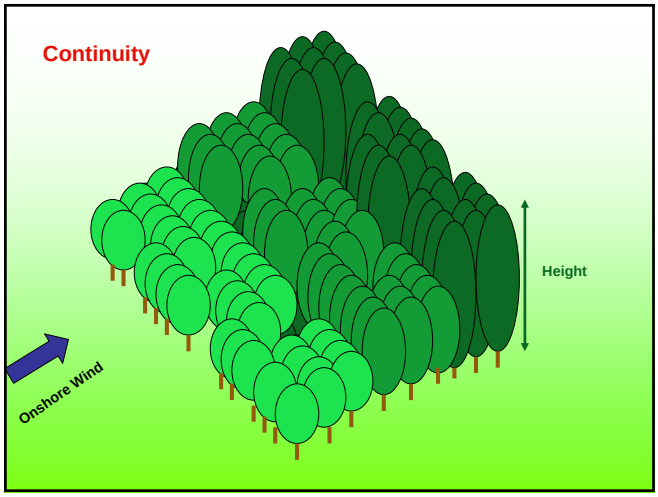

H3
Height
H2
Length
H1
Onshore Wind
Width


Shelter Density
Dense
Medium
Loose
H3
H2
H1
Height
Length
Width
Onshore Wind


Orientation to the prevailing wind
Shelter Density
Dense
Medium
Loose
H3
H2
H1
Height
Length
Width
Onshore Wind
Angle of attack

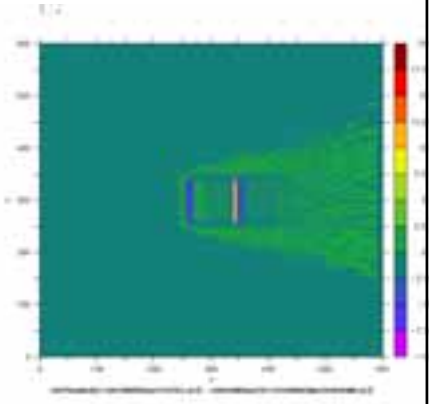

Cross-sectional profile

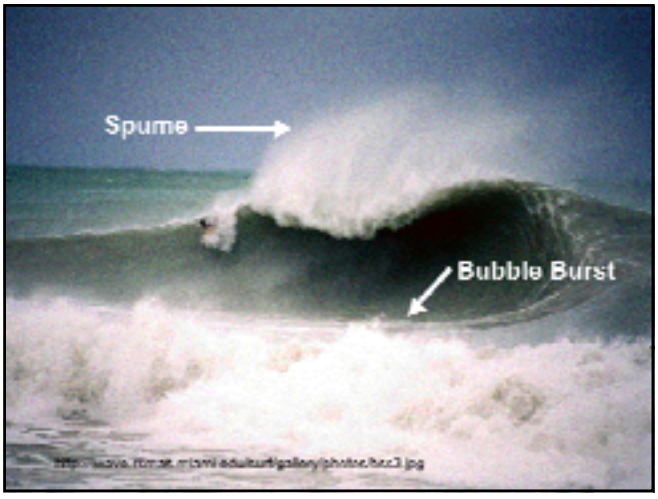

Cross-sectional profile
Vertical wind deflection



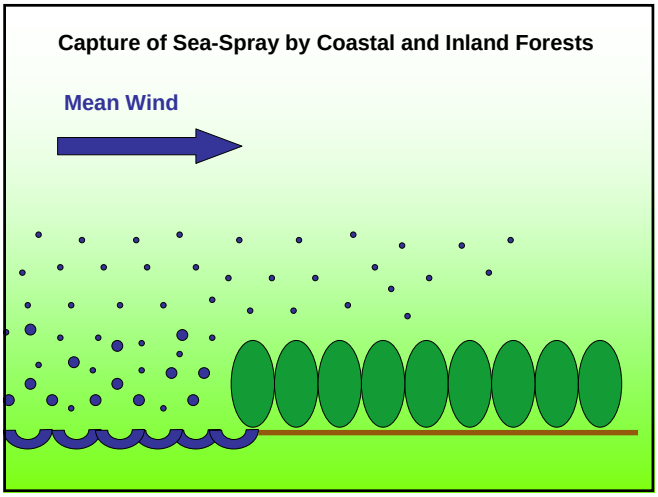
Forest Edge Effects

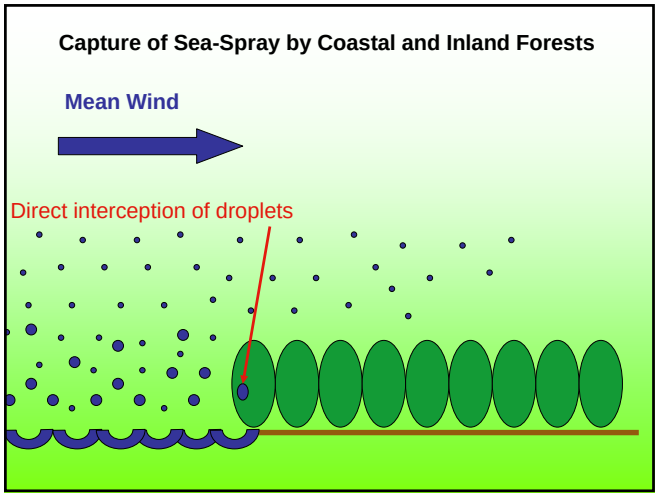
Simulation of particle deposition due to an artificial barrier surrounding a field. Light green regions reveal enhanced particle deposition beyond the edges of the protected

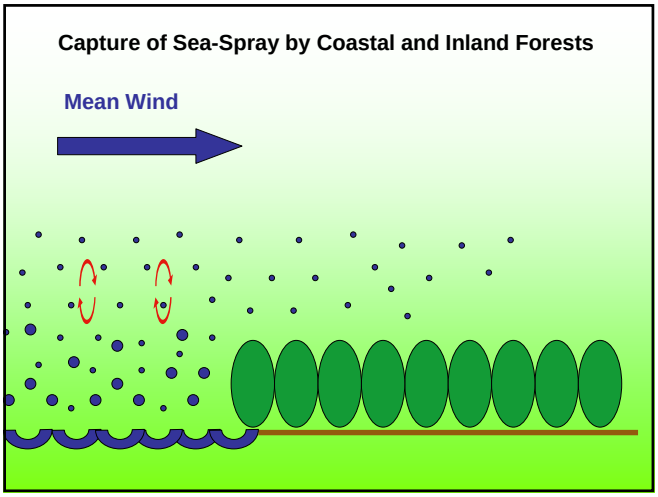


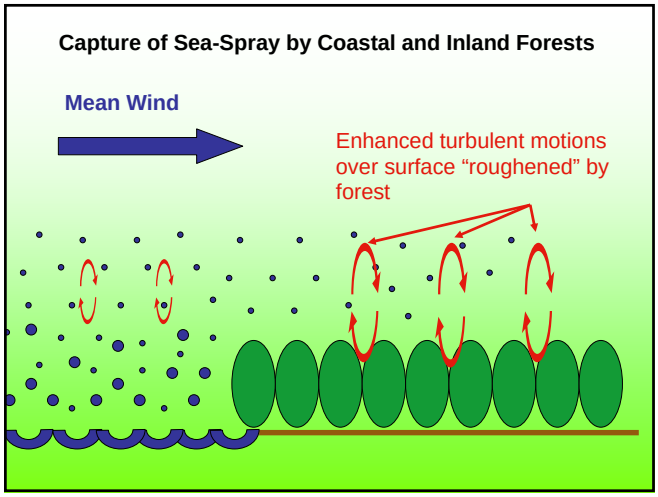


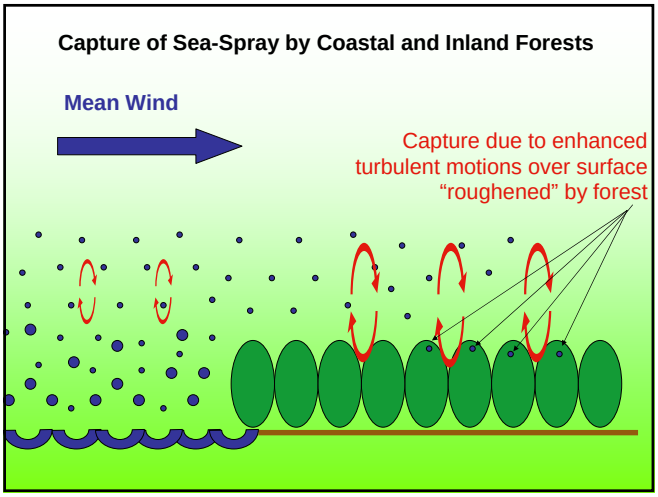

Bubble Burst


Capture of Sea-Spray by Coastal and Inland Forests
Mean Wind


Capture of Sea-Spray by Coastal and Inland Forests
Mean Wind
Direct interception of droplets


Capture of Sea-Spray by Coastal and Inland Forests
Mean Wind





Guidelines for Establishing Coastal Shelterbelts and Forests

- Orient the shelter or forest perpendicular to the prevailing winds
- Consider the coastal curvature
- Plant as far into the ocean as possible
- Species selection
  - Plant shorter species on sea-ward edge
  - Create highest porosity (lowest density) at the sea-ward edge
  - Plant successively taller species in the landward direction

Candidate Species for Establishing Coastal Shelterbelts and Forests

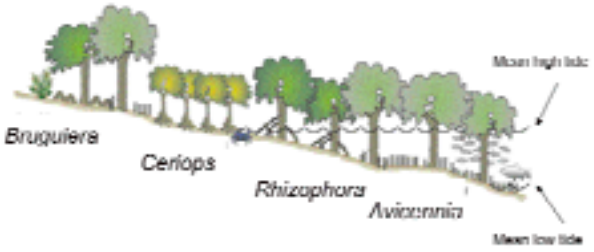
- Mangroves (over 50 species grow throughout SE Asia)
  - *Avicennia marina*
  - *Rhizophora apiculata*
  - *Rhizophora mucronata*
  - *Bruguiera*
  - *Ceriops*
- Casuarina
- Palm
- Coconut

Candidate Species for Establishing Coastal Shelterbelts and Forests*

- *Anacardium occidentale L.* (Cashew nut)
- *Azadirachta indica A. Juss.* (Neem tree)
- *Bambusa arundinacea (Retz.) Roxb.* (Thorny bamboo)
- *Bixa Orellina L.* (Saffron)
- *Borassus flabellifer L.* (Palm)
- *Cassia fistula L.* (Indian Laburnum)
- *Casuarina equisetifolia Forst.* (Horse tail tree)
- *Clerodendrum serratum (L.) Moon*
- *Cocos nucifera L.* (Coconut)
- *Hibiscus tiliaceus L.* (Coast cotton tree)
- *Pogamia pinnata L.* (Indian beach tree)
- *Salvadora persica L.* (Tooth brush tree)
- *Sapindus emarginatus Vahl* (Soap nut)
- *Thespesia populneoides Kostel* (Indian tulip tree)
- *Vitex negundo L.*

* Recommended by the M. S. Swaminathan Research Foundation for use in bioshields

Example of a Coastal Multi-Species Shelter Used on Simeulue Island



Adapted from La Cerva and McAdo, 2006: Simeulue Island mangrove rehabilitation assesment.Department of Geology, Vassar College, Poughkeepssie, NY. 12 pp.

Conclusions

- Vulnerability to extreme winds (both speed and direction) should be assessed for each particular location
- Choice of species and planting arrangements for constructing multi-species shelterbelts and forests should follow design considerations developed from simulation models and observations
- Sea spray and salt particles should be captured as near to the coast as possible to reduce salinization of inland soils

Acknowledgements

The Food and Agriculture Organization of the UN and its manuscript review team are acknowledged for their constructive comments on manuscript drafts. The US Department of Agriculture National Research Initiative provided partial support for this work.