# SUMMARY

Mangrove ecosystems function at the edge of land and sea, often covering large intertidal areas along (sub)tropical coastal regions worldwide but also in a wide array of other topographical settings. Once or twice a day, tides move seawater in and out, consecutively submerging and exposing the intertidal surface, while freshwater now and then, at moments of heavy rainfall, may enter the system from the land. Mangroves can live in these highly dynamic and demanding environmental conditions via a series of remarkable adaptations such as aerial roots (pneumatophores), specialized cells in their leaves to excrete salt and the production of buoyant seeds and fruits (propagules) that disperse at the ocean surface (*i.e.* hydrochory). With their dense root networks, mangroves present a natural breeding ground and nursery for juvenile fish and provide shelter to many other animal species, rendering mangrove systems ecologically invaluable. From a socio-economical point of view, these forests sustain fisheries, provide firewood and wood for charcoal and construction. They may offer coastal protection to natural disasters such as storm surges and under certain conditions against tsunami. Despite their ecological and economical value, about 40 % of original mangroves have been lost worldwide during the last 50 years due to excessive exploitation and development. Deforestation, degradation and conversion to other land uses like intensive shrimp farming and agriculture have reduced and fragmented these ecosystems at an alarming rate. Climate change, probably most pronouncedly via changes in sea level, poses another important threat.

In this dissertation we investigate some understudied but important aspects of the dispersal process in mangroves, with as the main objective the reduction of parameter and model uncertainty. In this way more reliable predictions of dispersal patterns and long-term population dynamics under different climate change scenarios can be expected.

Meta-analysis of peer-reviewed literature on propagule release timing for mangroves reveals phenological complementarity between the northern and southern hemispheres, with a peak in propagule fall corresponding to the boreal and austral summers, respectively. Additionally, the data show strong positive correlations between mangrove propagule release and rainfall, with 72 % of compiled data reporting release during the wet season. At higher latitudes than the equatorial zone, propagule release is also correlated with temperature. In the equatorial zone (*i.e.* 10° N to 10° S), propagules fall from parent trees throughout most of the year, showing no pronounced production peaks, and no significant correlation with rainfall or temperature.

Dispersal experiments in the field and in a flume racetrack show that the pronounced morphological variation in propagules produced by different mangrove species explains interaction with the landscape matrix, contributing to strong differences in dispersal capacity among species and morphological types. Retention rates increase with propagule size and obstacle density in the landscape matrix, while waves and increasing water velocity reduce retention. Besides the interaction with the landscape matrix, dispersal in the forest is constrained by major tidal currents.

Results suggest that in open water, propagule traits (density, morphology, and floating orientation) determine the effect of water and wind currents on dispersal dynamics. This has important implications for inter- and intraspecific variation in dispersal patterns and the likelihood of reaching suitable habitat patches within a propagule's viable period. The low-density propagules of *Heritiera* *littoralis* are most affected by wind, while the high-density vertically floating propagules of *Ceriops tagal* and *Bruguiera gymnorrhiza* are least affected. *Avicennia marina*, and horizontally floating *Rhizophora mucronata* and *C. tagal* propagules behaved similarly. Morphological propagule traits, such as the dorsal sail of *H. littoralis*, explain another part of the interspecific differences. Within species, differences in dispersal velocities can be explained by differences in density and for *H. littoralis* also by variations in the shape of the dorsal sail. Hence, from a very same origin, propagules of different species could be expected to follow different trajectories, depending on the balance between hydrochory and pleustochory.

We introduce the concept of Biological Window of Opportunity (BWO), *i.e.* the timeframe during which effective dispersal can take place. This window begins at the end of the obligate dispersal period and extends until the end of the maximum flotation period or the maximum viability period, depending on whichever is shortest.

These insights allow for parameterization of dispersal models. Ideally, the position of the propagule producing species in the intertidal ecotone is included, because this defines access to the dispersal vector, with barriers to be traversed.

Finally, we initiate, develop and explore the potential of a model to predict passive dispersal at or near the ocean surface. In this model we integrate knowledge on the dispersal vectors at play and use the highest resolution global oceanographic and wind current data that is currently available. By performing runs for a particularly complex marine area relevant to our study, the Mozambique Channel, we establish that wind can strongly influence the dispersal trajectory of propagules, with considerable implications for long-term biogeographic patterns. Morphological features may facilitate or counteract hydrochorous dispersal, depending on the relative interaction of water and wind currents. Hence, under strong onshore wind conditions, the vertically floating propagules of *Rhizophora mucronata, Ceriops tagal* and *Bruguiera gymnorrhiza* have a higher probability for long distance dispersal as compared to for example *Heritiera littoralis* propagules.

We provide novel insight relevant to the biogeography of mangroves and to the drivers of distribution patterns. There is a potential applicability in any other system where propagules are dispersed passively at or near the ocean surface. Additionally, our results hold important considerations for conservation and management and will help to assess the potential of natural expansion of current mangrove fragments, as well as to explain and predict current and future distributions of mangrove forests.