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Book of Abstracts

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MMM5 Book of Abstracts

Welcome to MMM5! This has been the largest mangrove conference yet, with 321 abstracts submitted. The accepted abstracts can be found in the following pages, listed in alphabetical order according to the lead author. This document is searchable using 'Ctrl F' and searching for the *title* or the *presenting author*.

All abstracts underwent a rigorous review process, and we would like to thank the Scientific Committee (chaired by Chua Siew Chin, National University of Singapore):

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Come Rain or Come Shine, Come Crane or Come Swine

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Mangroves dwell between the terrestrial and marine realms. Much has been studied on their connectivity to other coastal or marine ecosystems, such as coral reefs and seagrass meadows. The interface between mangroves and terrestrial ecosystems, by contrast, is still widely understudied, possibly being one of the reasons for mismanagement and ill compartmentalization of the coastal sea- and landscapes. The present research aims to enhance the understanding of how mangroves and terrestrial ecosystems relate to, and interact with, each other, taking into consideration regions on both sides of the Atlantic where the dry season is long and hot. We hypothesise that (1) runoff water plays an important role in the transport of nutrients and organic matter during rainy season, resulting in a uni-directional flow from land towards the sea; and (2) the motile megafauna supplant that role in the dry season, potentially driving bi-directional fluxes. For testing the above-mentioned hypotheses, samples of surface sediment, runoff and porewater, leaves of the main vegetation species, and faeces of the motile megafauna will be collected along nine transects, six in Brazil and three in Senegal. Analyses will take into account nutrients, the content, structure and origin of organic matter, environmental DNA, and sediment grain characteristics. We expect to find a gradient of influence (mangrove - salt flat - terrestrial forest), according to the above hypotheses, indicating that the path for a better ecological understanding of mangrove ecosystems includes their terrestrial-most margins.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A001
Presentation mode: Poster

Avoided Emissions and Conservation of Scrub Mangroves: Potential for a Blue Carbon Project in the Gulf of California, Mexico

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Mangroves are considered ideal ecosystems for Blue Carbon projects. However, because of their short stature, some mangroves ("scrub" mangroves, < 2m) do not fulfil the current definition of "forests" which makes them ineligible for emission reduction programs such as REDD+. Short stature mangroves can be the dominant form of mangroves in arid and poor nutrient landscapes, and emissions from their deforestation and degradation could be substantial. Here, we describe a potential Blue Carbon project in the Gulf of California, Mexico, to illustrate that projects which avoid emissions from deforestation and degradation could provide financial resources to protect mangroves that cannot be included in other emission reduction programs. The goal of the project is to protect 16,058 ha of mangroves through conservation concessions from the Mexican Federal Government. The cumulative avoided emissions of the project are 2.84 million Mg CO_2 over 100 years, valued at $US 426,000 per year (US$15 per Mg CO_2 in the California market). The funds could be used for community-based projects that will improve mangrove management, such as surveillance, eradication of invasive species, rehabilitation after tropical storms, and environmental education. The strong institutional support, secure financial status, community engagement, and clear project boundaries provide favourable conditions to implement this Blue Carbon project. Financial resources from Blue Carbon projects, even in mangroves of short stature, can provide substantial resources to enhance community resilience and mangrove protection.

Session: T008 - Blue carbon
Abstract ID: T008-A009
Presentation mode: Oral

Status, Threats and Management of Mangroves at a Southern Distributional Limit

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A status assessment of mangrove area cover was completed in 2018 and changes described in relation to threats and pressures. Because of the high energy coastline, mangroves in South Africa occur in 31 of the sheltered estuaries distributed along the ~3000 km coast. Although small in total extent (1 685 ha) these ecosystems are important for biodiversity conservation as they serve as critical habitat for invertebrates and fish. Harbour development has removed 438 ha of mangrove in Durban Bay; however a larger area (682 ha) area has established in an estuarine bay (Mhlathuze) as a result of the construction of an artificial mouth to the sea and expansion of intertidal habitat. This novel ecosystem now houses 762 ha of mainly Avicennia marina. The second largest area of mangrove occurs in St Lucia Estuary (210 ha), these are fast disappearing as restoration of the freshwater inflow to this system has created fresh, turbid conditions. Thus the management of mangroves in these dynamic South African systems poses some challenges. Other threats include encroaching development, harvesting for wood and browsing by goats and cattle that roam free in rural areas. Recent mangrove die-backs have been recorded in response to multiple stressors, namely drought, freshwater abstraction and browsing. The former leads to mouth closure of estuaries, causing inundation and flooding of mangroves. Mangroves along the east coast form the interface between subtropical and warm temperate regions and are expected to be significantly influenced by climate change. Ongoing monitoring and research is tracking these changes. South Africa has some of the best environmental legislation in the world; but it is the lack of implementation that fails to protect estuaries and their mangroves. This study addresses the country's management responses using a DPSIR framework.

Session: T003 - Mangrove loss and deforestation
Abstract ID: T003-A025
Presentation mode: Oral

What Lies Beneath? Quantifying Mangrove Crab Bioturbation Potential in Hong Kong Mangroves

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Crab burrow morphology has been argued to impact several important biogeochemical processes. A larger, more complex burrow may provide a different impact on nutrient and organic matter distribution and water flow than a simple small burrow, by increasing belowground surface area, or bacterial microhabitat, and volume. Burrow morphology has been shown to be similar across species within the same family but variable between families. Therefore, the potential ecosystem impact of burrowing crabs depends on their community structure and composition. However, a detailed quantification of the scale to which different families impact the mangrove ecosystem through such mechanisms has not been done. Here we quantified the bioturbation potential of five crab species belonging to three families, in three Hong Kong mangroves. Using a polyester resin to cast burrows, 3D-scanning and the MeshLab Open-Source Mesh Processing Tool, we obtained the mean species-specific burrow surface area, volume and depth of three Ocypodid, one Sesarmid (*Parasesarma bidens*) and Varunid species (*Metaplax longipes*). Next, we assessed burrow density (openings m-2) and identified their ownership. By combining these data, we found the increase in surface area per unit area of burrow contribution to be substantial. *Parasesarma bidens*, the most abundant sesarmid species in Hong Kong, has complex and large burrows, which can increase the surface area on average by 50–200%, depending on density. The burrows of *M. longipes* increased the surface area by 50%, on average, while the Ocypodid species increased surface area by 10-25 % across sites. The created volume due to *P. bidens* burrows showed 6.5 to 13 times larger than *M. longipes* and the Ocypodid species, across sites. Our data show that, by incorporating burrow species-specific characteristics, we could accurately quantify their bioturbation potential and demonstrate that previous studies have underestimated the impact of such potential on mangrove ecosystem functioning.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A015
Presentation mode: Oral

Unravelling the Complex Food Web of Highly Biodiverse Mangroves Using Stable Isotopes of Amino Acids

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The determination of the vertical and horizontal levels of a food web is crucial to unravel how ecosystem functioning might be affected by consumptive interactions across trophic levels and/or competition within levels. However, the precise determination of the trophic niche of a species remains a challenge mostly due to the absence of robust empirical methods to assess the feeding behaviour of an organism, especially for omnivores. This is probably why the determination of a reliable food web for Indo-Pacific mangroves proves to be very difficult using traditional techniques. In fact, the dominant species in this environment, sesarmid crabs, are opportunistic feeders and, although their crucial role in the food chain has been demonstrated, it remains difficult to ascertain their trophic niche. Analysis of d15N and d13C from individual amino acids is a cutting-edge technique that provides an accurate and precise estimate of the trophic position of aquatic and terrestrial organisms. We applied this method to build a holistic high-resolution conceptual model of the food web characterising the Tung Chung forest, Hong Kong, and compare with the commonly used δ15 N and δ13C bulk analysis. We sampled a total of eight common mangrove crab and ten gastropod species, as well as macroalgae, sediment and decaying yellow and green leaves of the four most abundant mangrove trees in the forest. This method allowed us to determine that C3 plants (i.e., mangroves) are indeed the primary source of nitrogen for this specific food web. Furthermore, we determined snails to occupy an unexpectedly high level in the food web. Our high-resolution food-web model, once applied in other Indo-Pacific mangroves, could provide decision-makers with critical information regarding ecosystem health and functionality. Additionally, this allowed for the identification of vulnerable links in the food chain, which can be used to focus conservation efforts more efficiently.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A022
Presentation mode: Poster

Global Distribution of Forest Gaps in Mangroves: A Review

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Forest gaps have been observed in tropical and sub-tropical mangrove ecosystems across the globe, including Panama, Papua New Guinea, the Dominican Republic, Australia, Florida, Malaysia, French Guiana and South Africa. However, no comprehensive survey of the global distribution of these gaps has been undertaken. Furthermore, the cause of gap formation is not fully understood, although in some cases it has been linked to the death of old trees (senescence) or to various episodic events (e.g. insect attacks, diseases, windthrows, and lighting). As yet, no attempt has been made to correlate gap distribution with environmental processes or extreme weather events. This study provides the state of knowledge on mangrove forest gap distribution based on a literature review and a global spatial survey using satellite imagery (ArcGIS basemaps and Google Earth). To evaluate the potential impact of those gaps on the mangrove ecosystems, we quantify the number of gaps and their area relative to the mangrove stands in which they occur. Using an approach derived from predictive habitat distribution models used in ecology, we examine how physico-chemical parameters (precipitation, temperature, salinity, and pH) or extreme weather events (lighting or storms) might drive the spatial distribution of forest gaps. The impact of forest gaps on mangrove ecosystem functioning has not been fully ascertained; gaps provide recruitment opportunities for seedlings to replace dead trees, thus leading to local natural regeneration that potentially has implications for the entire mangrove stand, the associated microbial and faunal communities, and the ecosystem processes that they drive.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A003
Presentation mode: Lightning Talk

Floodplain Restoration and Mangrove Rehabilitation as Site-specific Elements of Coastal Protection in the Lower Mekong Delta, Vietnam

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Development and the unsustainable use of natural resources in the coastal zone of the Lower Mekong Delta in Vietnam are threatening the protection function of the mangrove forests, resulting in erosion of the muddy coastlines. These threats will be exacerbated by the impacts of climate change. Restoration of floodplains is a precondition for mangrove rehabilitation in sites where severe erosion has destroyed the mangrove belt. Sophisticated and site-specific approaches to coastal protection become increasingly important in this context. Permeable bamboo fences, arranged in a T-shape, consisting of a long-shore part which dampens the incoming wave energy and a cross-shore part which decreases the long-shore currents, are effective for reducing erosion, stimulating sedimentation and thereby restoring floodplains and re-creating conditions for mangrove regeneration. This cost-effective approach will only be feasible within a specific set of boundary conditions. If these limiting criteria are exceeded to only a small extent, adaptations such as strengthening the fence with concrete poles must be considered. If the limiting criteria are exceeded to a large extent, use of T-fences is not feasible. Other factors to be considered are location of the fences to minimise lee erosion, as well as proximity to the shoreline and length of submergence periods to minimise damage by shipworms. The duration of submergence and exposure to waves also affect the effort required for maintenance. The general application as well as the design and layout of the T-fences must therefore be checked and adapted to each site. To support this, the Decision Support Tool for Coastal Protection for the Mekong Delta (CPMD) which provides guidance for the site-specific and appropriate planning of coastal protection measures and for the prioritisation of investments was developed.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A039
Presentation mode: Oral

Applying spatially explicit benefit transfer techniques to ecosystem service valuation of an urban ecosystem

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Urban and peri-urban mangroves are important providers of ecosystem services derived both from beyond city limits and from internal urban ecosystems. Yet, urban development often ignores the complex spatial heterogeneity of ecosystem services resulting unintended and sometime irreversible trade-offs. The lack of primary data for services in most places has forced the mapping of ecosystem services using proxies through benefit transfer mapping. We use spatially explicit benefit transfer to estimate the value of mangroves ecosystems services provided to the people of the city state of Singapore. We focus on above ground carbon sequestration, air quality regulation, recreation and shoreline protection services, and hypothesis that despite land uses trade-offs, the aggregate ecosystem service production in urban and peri-urban mangroves is comparable to natural environments. In the context of national spatial planning, we illustrate how spatially explicit benefit transfer techniques can be used to inform national spatial planning and more sustainable development.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A005
Presentation mode: Poster

Urbanising Malaysia: The Impacts and Consequences of Mangrove Habitat Loss

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As the nation progresses to become a high income economy, human development continues to grow at the expense of her natural resources and environment. Mangroves are one particular down-stream wetland habitats, especially in Malaysia as well as in the ASEAN region, to bear witness and to have suffered first-hand impacts from land-use change for socio-economic development. Due to various reasons, mangrove forest area has dwindled significantly especially in the final quarter of the past century, parallel to the period where the country's growth was most rapid. This presentation showcases significant spatio-temporal changes in some iconic mangrove habitats in Malaysia. It quantifies the extent and explains the causes of these changes, and describes how these changes actually correspond to local, national and regional development from 1966 until present day. This presentation also highlights the implications of mangrove loss on their linkages and networks with adjacent habitats, as well as on their ecosystem roles, functions and benefits.

Session: T003 - Mangrove loss and deforestation
Abstract ID: T003-A004
Presentation mode: Poster

Value Chain Analysis of Mangrove Forests in Central Mozambique: Uses, Stakeholders and Income

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This study documents the value chain derived from mangrove forests highlighting the stakeholder's engagement and benefits derived across value chain in central Mozambique. Furthermore, this work evaluates the income pathways involved with different stakeholder and related sites. Focus group discussions with different stakeholders (mangrove wood harvesters, transports, sellers and general users), and key informants (local authorities) were conducted in the Zambezi Delta, Nhangau and Chiveve areas. The services provided were divided into direct uses of extractable products and indirect unextractable. The main benefits that the community obtain where wood extraction, astatic value and honey production, and the first benefit has commercial importance in the Zambezi Delta and Nhangau. Within the Zambezi Delta, for small poles, profit occurred with the wholesale level (82.6%). For the larger poles went to harvesters, 125.0%. At Nhangau small poles get profits of 17 %, medium poles 11.5% and larger poles 24 %; for charcoal, a greater portion of profits went to retailers with 50%. Men were mostly involved in mangrove wood harvesting for commercial purpose, while women in firewood collection, mostly for domestic use. Several routes from harvester to consumer were documented. The main actors or stakeholders involved were: transporters, wholesalers, retailers and sometimes middlemen. At the Chiveve the community benefited mostly from non-extractable products such as flooding control, water purification, nursery ground for fisheries and landscape beauty. The results of this study can be used to enhance decision-making for habitat or environment management, practice of sustainable mangrove business, and land-use planning at multiple geographic scales and socio-political levels and sites in Mozambique and beyond in the WIO (Western Indian Ocean) region. We anticipated Mozambique mangrove value of 2400, 00 USD per hectare, such information can also be used to identify ways to improve the performance of a value chain and actors wellbeing.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A022
Presentation mode: Lightning Talk

An R Package for Computation of Mangrove Forest Structure Using Plot and Plotless Methods

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Mangrove structure is influenced not only by the magnitude and periodicity of favorable energy inputs (temperature, hydroperiod, tides, sunlight, and nutrients), but also by stressors (salinity, drought, storms, and frost) which may have a diminishing effect on forest structure. In worldwide characterization of mangrove forests, researchers use several structural parameters to inform, compare, classify, and evaluate mangrove communities for both research and management. However, the calculation of these structural parameters involves a multi-step series of protocols and formula applications that are error-prone and time consuming. Using standard mangrove structure methodologies found in the literature, the mangroveStructure package for R was developed to deliver a simple tool to quickly calculate mangrove forest structure based on either plot or plotless methods. Outputs of the package include density, diameter, basal area, height, as well as relative values of density, dominance, frequency, and importance value. Output also includes common structural indices (complexity index and mean stand diameter) and visual representations of relative values, diameter and height histograms, and canopy height distributions along the transect line. This package will be useful to scientists interested in mangrove field surveys and those seeking a better understanding of mangrove ecosystems structural variability. To familiarize users with its many features, the package includes example data sets collected in the mangroves of Darién, Panama and south Florida, USA.

Session: T009 - Mangrove management
Abstract ID: T009-A026
Presentation mode: Poster

The Perceptions of Stakeholders on Current Management and on Alternative Livelihoods in Support of Sustainable Mangrove Management in Sokone and Toubacouta, Senegal

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These studies were conducted on mangroves of Sokone and Toubacouta, Senegal. Despite their ecological and economic importance, these mangroves have suffered degradation mostly from anthropogenic activities. For their sustainable management, it is important to take into consideration the divergent perceptions, values, and knowledge of stakeholders. Hence, We applied Q methodology in capturing the subjective perceptions of local stakeholders on current management. Q methodology encourages people to identify issues that are of importance to them thus highlighting many subjective but distinct views. Parrellely, Nominal Group Technique (NGT) through its features of combining individual and group reflection, was used to identify alternatives to unsustainable mangrove uses as a strategy to ensure the sustainability of mangroves among others. The analysis of the Q methodology data identified three distinct discourses:(i) 'Official discourse'- 'mangrove management is fragmented, Communities need to fill the gap for the management to work uniformly in all parts', (ii) 'Happy villagers'- 'Village level co-management works but some imbalances need to be corrected' and (iii) 'Unhappy villagers'- 'mangrove management is not working, things need to change, but it's not up to us to act'. The NGT sessions identified agriculture, followed by non-destructive mangrove-based activities (apiculture, ecotourism) as the most important alternatives to unsustainable mangrove uses. The identified consensus viewpoints concerning the current management provide a common ground to implement prescriptive modifications to the present management regime at the local scale. The study highlights the need for establishing clear guidelines concerning the role of the government in participatory decentralized resource management and sets the scene for beginning policy debates in the country. In addition, the provision of alternatives by the current management will create financial revenues to local communities which will reduce the dependence and pressures on mangrove resources thus contributing to the achievement of the objectives of a sustainable management.

Session: T001 - Impacts of people on mangrove structure and function
Abstract ID: T001-A025
Presentation mode: Poster

Utilization of Fishing Resources and Mangrove Wood Products in Mamanguape River Estuary (MRE), Northeastern Brazil

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Mangrove forests and coral reefs are important interconnected ecosystems supporting tropical coastal livelihoods. However, disturbances such as overfishing can produce undesirable social-ecological outcomes such as degraded ecosystems and impoverished users. The present study aimed at assessing livelihoods and utilization of coastal resources, along with perceptions of coastal populations in Northeastern Brazil's Mamanguape River Estuary (MRE). We used a socio-ecological approach and obtained data through 120 household interviews, and field observations. The surveys with communities of Barra de Mamanguape, Lagoa de Praia and Tramataia (indigenous ethnicity) showed that they are highly dependent on artisanal fishery for subsistence and income generation. From the 76 species exploited as food resources, nearly half are highly important for maintaining the structure of the local trophic web. The fact that households perceived a significant decline in population stocks for nine of these keystone species that are highly exploited in MRE indicates the current vulnerability of the system. We reported a significant decline in the exploitation of mangrove wood after the prohibition of mangrove cutting at the end of the twentieth century. Mangrove wood products are currently used only for subsistence of the surveyed populations, in which *Rhizophora mangle* L. and *Laguncularia racemosa* (L.) Gaertn.f. are the most used species for roof construction and firewood. Regarding household perceptions on future prospects, they considered the creation of a fisheries cooperative, the development of a community-based tourism and the construction of a road as important community development projects. The conducted social-ecological assessment indicated a high vulnerability of coastal population livelihoods. The high reliance on fishery resources together with the weak institutional structures and centralized governance creates a scenario of high susceptibility. Hence, this study highlights the need for the establishment of adaptive and context-relevant resource management strategies in order to guarantee the sustainability of this estuarine social-ecological system.

Session: T001 - Impacts of people on mangrove structure and function
Abstract ID: T001-A026
Presentation mode: Poster

Spatiotemporal Dynamics of the Conversion of Tropical Mangrove Lands to Shrimp/Fish Ponds, and Their Subsequent Abandonment: a Case Study of Indonesia's Mahakam Delta

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Mangrove forests are essential for protecting coastal zones from natural disasters and supporting livelihoods of coastal inhabitants of the tropics and subtropics. Globally mangroves are also being deforested and degraded at an alarming rate. Indonesia contains 26% of global mangrove forest area, a quarter of which has been deforested in last three decades, mainly for construction of shrimp/fish ponds. And yet, accurate estimates of the rates and areas of mangrove loss are lacking. This study is the first of its kind aimed at detailed chronological analysis of four different phases of human-induced changes in mangrove land (intact mangroves → deforested mangroves → ponds → abandoned ponds) by utilizing a time series of optical and radar imagery. Rule-based classification methods were used to: (1) produce a time series of land cover maps from 1994 to 2015; and (2) quantify and map lifespans of ponds in the Mahakam Delta of Indonesia. Overall, the accuracy of the land-cover change classification was 88.74%, with a kappa coefficient of 0.82. Of the 96,300 ha of primary mangrove forests of the delta in 1994, nearly 62% had been deforested and converted to ponds by 2015, with a 4.48% annual rate of loss on average. This study also identified the abandoned ponds, and demonstrated that most of the ponds in the delta have productive lifespans of 10-13 years. This information is crucial for stakeholders because the abandoned ponds can potentially be rehabilitated for aquaculture or be targeted for mangrove restoration.

Session: T003 - Mangrove loss and deforestation
Abstract ID: T003-A009
Presentation mode: Oral

When Community-based Mangrove Conservation Fosters Integrated Coastal Management

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People of New Caledonia and Wallis demonstrate high cultural link to mangroves, engaging in significant efforts for their conservation and rehabilitation, eventually leading to wider integrated coastal management outcomes. Mangroves from these tropical island countries play an essential role in the wellbeing of their populations: they provide significant food source (especially mud crabs, oysters and some fishes…), tanning for traditional fabrics, fish nurseries, coastal protection, water purification, carbon storage and overall a unique cultural experience.The comparatively little loss of mangroves and quite large restoration efforts over the last few decades is to be found in a key enabling factor : the people of these nations have demonstrated a strong cultural attachment to mangroves and made it clear and loud to decision-makers. Facing many threats such as prawn farming, urban & road development, pollution, siltation (especially from mining)… the important local communities mobilization that occurred over the last 20 years is related to the cultural value and livelihood they provide : Prawn farms only develop in the highest parts of mangroves where no tree grows, green-grey infrastructures is widely used for coastline protection, urban development maintains natural water flows and wastewater treatment, mining tailings are safely stored and mangrove restoration involves many… It is estimated that 50 000 trees have been planted on 15 sites over the past 10 years, with some financial support, from public and private sectors, but most often from volunteers. As outlined above, conservation outcomes span much beyond the mangrove themselves, into the land, rivers and marine coastal habitats ; this suggests that mangrove conservation, with a strong cultural approach, is a strategic area for investment in conservation.

Session: T009 - Mangrove management
Abstract ID: T009-A031
Presentation mode: Poster

Mangroves in a Network of Connected Ecosystems: Sources and Sinks of Organic Matter

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Coastal ecosystems cannot be considered isolated but are embedded in a network of interacting marine and terrestrial ecosystems that exchange organisms and matter. It has been discussed for decades whether mangroves are sources or sinks of nutrients and organic matter: the direction of fluxes obviously depends on local and regional circumstances, such as hydrodynamics and coastal currents. Hence, aiming for large-scale generalizing models of matter fluxes into, and out of, mangroves warrants detailed case-studies under different environmental conditions. For a small Caribbean Island, San Andrés (Colombia), that is hit by strong North-easterly winds and currents throughout the year, we hypothesized that a coral reef in front of the East coast will dampen the oceanic inflow of water bodies and make the export of organic matter from the mangroves behind the reef, the Old Point National Park, into the coastal water possible. Using a combination of stable isotope-analysis, environmental metabolomic fingerprinting, and metabarcoding of environmental DNA, we detected biomarkers of organic matter from various sources in sediments between mangroves and reef. Together, our findings suggest that the mangroves of Old Point are fuelled by macroalgae and seagrass but export little material into the reef. Hence, managing these mangroves will require simultaneously managing the reef and seagrass beds in front of the coastline, particularly because there are no rivers on the island that could import terrigenous material into the mangrove. On the other hand, as the Old Point mangroves probably retain an essential percentage of the organic matter and nutrients that enter the mangrove, their role in maintaining the coastal waters adjacent to the reef oligotrophic should not be neglected in reef management. We believe that trans-boundary studies like this one pledge for a more integrative approach in coastal management, planning for protected area networks rather than isolated protected areas.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A012
Presentation mode: Oral

The Use of Accelerometer Technology to Improve Mangrove Rehabilitation and Understanding of Tidal Wetland Dynamics

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Mangrove rehabilitation success is often hampered by physical disturbance during tidal inundation. Wave action and tidal currents create drag forces on and scour around recently anchored mangrove propagules and seedlings. Physical disturbance by tidal currents and waves in mangrove forests or salt marshes can be stochastic in nature due to seasonal variation in wind driven wave activity and residual tides around the mean high water mark. Short-term variability of physical disturbance (such as storm events or exceptional neap tides) has previously been shown to be a main driver to mangrove establishment success on tidal flats. In order to monitor short-term variability in physical forcing (e.g. inundation, hydrodynamic energy) at ecologically meaningful temporal scales and spatial accuracy requires an in-situ approach with high frequency (seconds to minutes) but long-term (months to years) observations. We will present field and flume data to introduce a new method using low-cost accelerometer technology in order to assess in-situ physical disturbance in tidal wetlands. We will discuss how acceleration data loggers can be deployed to assess site suitability for mangrove rehabilitation or to study spatial pattern of hydrodynamic energy and flood-water levels in tidal wetlands.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A002
Presentation mode: Oral

Dynamic System for Silvofishery Financial Feasibility in Mangrove Forest

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Silvofishery is a combination of aquaculture and mangrove area with the aim of rehabilitating mangroves that sustainably consider aspects of the economy. The purpose of this study was to find the best silvofishery system based on total values and net present value (NPV) averages using dynamic model simulations and provide information about the effect of price changes or production on selected commodities on silvofishery. Commodities observed in silvofishery ponds included tiger shrimp, milkfish and mangrove crabs. Financial feasibility was simulated for 14 years. The results showed that tiger shrimp and mangrove crabs were the best combination of silvofishery and feasible to be implemented, having an average NPV of USD 867/ha/year. The influence of the increase in non-fixed costs (variable cost) indicated that silvofishery combination of tiger shrimp and mangrove crabs is still feasible to be applied. The decline in the selling price of the commodity of tiger shrimp and mangrove crab shrimp causes a silvofishery combination of tiger shrimp and mangrove crab to be feasible.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A032
Presentation mode: Poster

Characterization of Macrozoobenthos and Lipid Input Under Different Land-use of Mangrove Forest, North Sumatra, Indonesia

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Mangrove plays an important role in coastal ecosystems including ecological, social, and economic aspects. This study aimed to study the diversity and distribution of macrozoobenthos in mangrove with different habitat characteristics and to identify factors affecting diversity and distribution of macrozoobenthos with lipid input from litter mangrove in the mangrove forest area. The study was conducted in five locations spread in North Sumatra and Aceh. Each location represents different mangrove states; natural mangroves (Langsa and Jaring Halus Village), mangrove encroachment into aquaculture (Percut Sei Tuan Village) and mangrove encroachment into oil palm plantation (Pulau Kampai and Pulau Sembilan). Samples of macrozoobenthos was done in a 1 x 1 m2 sub plot located in a 10 x 10 m2 transect of three repetition times. Results showed that 21 species of macrozoobenthos were found. The highest diversity index was found in Pulau Kampai (2.93), the highest similarity index was found in Pulau Kampai (0.96), and the highest dominance index was found in Langsa (0.15). According to Principle Coordinate Aanalysis scores, lipidinput from Rhizophora mucronata, Sonneratia alba, Acrostichum aureum, Acanthus ilicifolius, Xylocarpus granatum, Exocecaria agallocha and Avicennia marina was positively correlated with several macrozoobenthos.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A028
Presentation mode: Poster

The Crucial Role of Tree-Soil-Water-Feedback for Mangrove Zonation Patterns: a Cross-System Approach Linking Continuous Hydrogeological Modelling and Individual-Based Plant Models

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Although it is commonly accepted that vegetation patterns may depend on subsurface properties, including soil water availability, the details of plant-soil water interactions are not well known. Modelling can help to resolve the potential importance of component processes. Two complementary modelling approaches may provide a means to explore plant- soil water interactions, 1) Individual-based vegetation models and 2) continuous groundwater flow models. Here we present a joint process-based simulation systems to study the feedback between vegetation and subsurface hydrodynamics. Our model is a novel, modular model that couples mangrove stands and groundwater dynamics. The model uses existing and intensively tested approaches and implements a feedback between them. Groundwater dynamics are simulated using the OpenGeoSys software (continuum finite element simulation tool), whereas the dynamics of the tree population are described by the individual-based BETTINA model. The feedback of the plant growth to the hydrodynamic processes within the aquifer is given by means of dynamic boundary conditions, whereas BETTINA receives dynamic subsurface properties, such as salinity in soil water, as input parameters. Within the model, heterogeneous salinity distributions are established by the mangrove population. The resulting plant-soil water-feedback leads to mangrove-typical zonation patterns. A dependence of the salinity distribution on aquifer structures can be shown, leading to commonly observed patches deviating from the zonation. Independent of initial plant distributions, the model automatically reaches dynamic steady state plant distributions. This suggests a crucial role of the interaction of vegetation and subsurface hydrodynamics on vegetation zonation patterning and the distribution of tree allometry. Based on this, we discuss the benefits and disadvantages of this novel modelling approach as well as its implication for future research directions.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A042
Presentation mode: Oral

The Practical Use of a Hydrological Classification Method for Ecological Mangrove Restoration in the Mangroves of Singapore

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Many ecological mangrove restoration (EMR) projects are failing because hydrological properties are not assessed properly. In this research, we tested a hydrological classification method to improve quantification of these conditions for EMR practices in the mangroves of Pulau Ubin, Singapore. We investigated how water level measurements, in different parts of the mangrove area, can be used to determine the hydrological suitability. This was done by measuring the hydrological conditions in a 'natural' mangrove forest and in a disturbed area appointed for mangrove restoration. The measured water levels were transformed into two parameters relevant for mangrove establishment and survival, minutes of inundation per day and minutes of inundation per inundation. Additionally, for each location, the mangrove forest was classified based on the occurrence of different mangrove species. Results of this study showed that the hydrological classification was able to accurately relate mangrove species distribution to hydrological conditions measured in the mangrove forest. Natural recolonization at the mangrove recovery site hasn't occurred, because the area was inundated either too often or too long. The measured water level data was also used to calculate the chances of successful establishment of mangrove seedlings at the disturbed site, based on a minimum amount of disturbance free days that seedlings need to establish (window of opportunity). This analysis gave similar results to the hydrological classification, and was also able to determine the reason of unsuccessful recovery in the disturbed site. This study showed that accurate water level measurements can be used as a preliminary assessment to determine if an EMR site is suitable for natural recovery or planting or that a modification of the hydrological conditions is necessary first.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A028
Presentation mode: Poster

Common Roots: the Role of Civil Society in Mangrove Conservation

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Nature Society (Singapore) is a civil society organization which promotes the protection and preservation of Earth's natural ecosystems. Its Marine Conservation Group supports the NGO's advocacy and outreach functions, and delivers scientific data needed for the conservation and management of our marine and coastal resources. The group's activities are focused on limiting anthropogenic threats through citizen science and ground-up governance. NSS strives to keep Singapore's natural mangroves intact. We reason that too much has been lost, that an amazing diversity of mangrove species thrive in remaining spaces, and that addressing the threats of deforestation, pollution and climate change must be with urgency. Preserving our natural mangroves and restoring degraded habitats serve as valuable offsets amidst continuing urbanization. In advocacy and outreach, two of three IBAs NSS regularly monitors (Kranji-Mandai and Ubin-Khatib Bongsu) contain mangroves. Regular kayaking and clean-ups in these areas, which include the R.U.M. sites, are effective outreach activities. Data collected over time can help answer conservation and sustainability questions. Surveys of our south islands include monitoring of mangroves on Pulau Semakau and Hantu. In citizen science and research, NSS has published five peer-reviewed papers on native horseshoe crabs and had its proposal to review the Asian horseshoe crabs' status accepted by IUCN. Research and capacity building must continue within the region to reach this end, and with it, a stronger basis for protecting key mangrove and mudflat habitats. NSS noticed the invasive Mytella strigata on Kranji mudflats in early 2016, which led to a solution-based research partnership between civil society, academia and resource managers. Collaborative research allows NGOs and academics to react quickly to emerging issues and provide evidence-based positions for decision-making. Citizen science connects volunteers to projects, widens research scope through greater participation, and mainstreams science through informing the public and influencing conservation policy and practice.

Session: T009 - Mangrove management
Abstract ID: T009-A046
Presentation mode: Poster

Networking via root grafts - just a whim of nature or a strategy of trees to be more resilient in stressful environments?

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Two of the oldest living trees known on earth, the Pando and the Old Tjikko, are clonal plants. Their longevity has been attributed to the mutual benefit of resource sharing and the accumulation of beneficial somatic mutations. Similar effects are known for mycorrhizal networks and trees connected by grafted roots. Could it be that networking is generally advantageous increasing forest integrity under harsh conditions? Using an ultrasonic Doppler probe, we mapped networks of grafted black mangroves (*Avicennia germinans*) along inundation gradients in Mexico. To analyse their potential role for mitigating drought stress, we investigated (1) the network topography and (2) the influence of tree characteristics, tree constellations, pore water salinity and redox potential, as well as the microtopography and hydroperiod on the occurrence of root grafts. We found that the number of root grafts increases with tree density. Under stressful saline conditions the number of grafted trees in a plot is larger (~ 52%) than under moderate conditions (~20%). The probability of root grafting is a sigmoid function increasing with the size of the trees, but its shape is very much influenced by pore water salinity. Under more stressful conditions, the inflection point is earlier (smaller trees graft) and steeper (the maximum number of grafted trees is achieved earlier). In stressful conditions the tree networks are small, with 4 - 5 connected trees in average, and have a more linear structure than in moderate conditions. The latter agrees with evolutionary game theory, which predicts that cooperation flourishes most if organisms are strongly pairwise-tied because the costs (for grafting) are quickly payed-off by the reciprocal benefits (sharing of water, nutrients and other resources). Our findings thus support the recent hypothesis that root grafting is an evolutionary beneficial, and thus adaptive behavior, which improves resource acquisition by trees.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A015
Presentation mode: Oral

Exploring the Molecular Diversity of Phytoplankton Communities in a Mangrove Ecosystem- the RuBisCO Story

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Phytoplankton forms the basis of aquatic primary production in mangrove environments. The phylogeny and diversity based on rbcL, the large subunit encoding the key enzyme ribulose-1, 5-bisphosphate carboxylase/oxygenase (RuBisCO) was investigated to elucidate the community structure and temporal trends of chromophytic eukaryotic phytoplankton assemblages in Sundarbans mangrove ecosystem. Members belonging to Bacillariophyceae were the most frequently detected group in rbcL clone libraries (485 out of 525 clones), highlighting their importance as a major bloom-forming group. Other major chromophytic algal groups including Cryptophyceae, Haptophyceae, Pelagophyceae, Eustigmatophyceae, and Raphidophyceae which are key component of the assemblages were also detected. Many of the rbcL sequences showed identity with key bloom forming diatom genera including Thalassiosira and Nitzschia and the presence of these genera were also confirmed by bright field microscopy. Moreover, some of the rbcL sequences detected in Sundarbans were ubiquitous in distribution showing 100% identities with uncultured rbcL sequences targeted previously from the Gulf of Mexico and California upwelling system that are geographically distant from study area. Interestingly, several novel rbcL lineages were also detected highlighting the presence of cryptic diversity and the need to establish cultures as well as undertake sequencing from this ecosystem. Principal component analysis indicated that nitrate is an important variable that is associated with observed variation in phytoplankton assemblages. To conclude molecular tools applied in this study highlighted the ecological significance of diatoms along with other chromophytic algal groups in mangrove ecosystems such as in Sundarbans.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A023
Presentation mode: Lightning Talk

Identifying Areas, Understanding Causes and Estimating Impacts of Mangrove Erosion Hotspots

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Accretion and erosion are natural phenomena taking place dynamically in the mangrove ecosystem, but anthropogenic pressures may increase these dynamics and result in increased erosion. This leads to mangrove degradation and loss of ecosystem services. The scale of global mangrove forest degradation is poorly known. This study identifies mangrove erosion hotspots around the world using available data on shoreline erosion, surface water change, and mangrove distribution. Some processes that could cause unnatural rates of mangrove erosion-like changes in drainage density and changes in land cover are studied in the hotspot areas to find possible causes of erosion. The impacts of mangrove erosion on the ecosystem of hotspot areas are estimated in terms of loss in species diversity and fragmentation. Within the hotspot areas, the impacts of mangrove erosion are used to identify areas for conservation priority. While some of these areas are protected they might not be managed with the perspective of erosion and some areas might not come under any protection. Finally, this study evaluates best management practices and makes recommendations on improving management to reduce mangrove erosion. Due to climate change induced sea level rise and upstream changes in sediment management, mangrove erosion could increase in the future. Thus, it is important to identify mangrove erosion hotspots and study mangrove erosion causes and impact to be better prepared for future scenarios and address management shortcomings.

Session: T003 - Mangrove loss and deforestation
Abstract ID: T003-A015
Presentation mode: Oral

Macroecology of Mangrove Carbon in Colombia: Biogeography, Foundation Species and Climate

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Mangroves extent over nearly 1672 km2 in both coasts (Caribbean and Pacific) in Colombia, ranking twelve place among mangrove-holding countries, and storing 2% of global total carbon. However, little is quantitatively known about drivers of mangrove storage due to the limited number of studies published in international journals and the limited coverage of recent field assessments of carbon. Moreover, there is no previous appraisal of mangrove biogeography in Colombia, despite mangroves extent between superhumid and arid climates. The aims of this paper were the following: 1) to compare above-ground carbon (AGC) storage among biogeographic basins (Caribbean and Pacific), 2) to estimate the contribution of foundation species (Red mangrove: *Rhizophora* spp.; Black mangrove: *Avicennia germinans*) to AGC, and 3) to estimate the role of climate (i.e. annual rainfall) to country-wide patterns. We used density and tree-diameter data from 106 sites (range: 1.4 and 12.2 N) measured during a national inventory conducted by the Ministry of the Environment in the mid-90's to calculate AGC based in allometric equations. Total AGC was 81.8 ± 40.5 Mg/ha (mean ± s.d.; range: 22.6-226.9), and marginal differences are observed between basins (Caribbean: 73.78 Mg/ha, Pacific: 87.26 Mg/ha). *Rhizophora* contributed the highest fraction (Caribbean: 63.0%; Pacific: 88.8), with 78.66 Mg/ha for the Pacific and 50.34 Mg/ha for the Caribbean. *Avicennia germinans* accounted for the second largest contribution (Caribbean: 14.98 Mg/ha, Pacific: 4.62 Mg/ha). By using annual rainfall obtained from the nearest climatic stations, it was found that AGC country-wide steeply increased with annual precipitation below 1500 mm/yr, leveling at 100 MgC/ha in rainy areas (>3000 mm/yr). These results improve our understanding of broad-scale geographical patterns of variation in AGC needed to implement national-level blue carbon management and policies, and to improve global models.

Session: T008 - Blue carbon
Abstract ID: T008-A013
Presentation mode: Poster

Mangroves of Colombia in the Times of Peace: Appraisal of Ecological State and Threats for Blue Carbon Projects in a Post-Conflict Era

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After 50 years of armed conflict between a major rebel guerrilla and the democratic state in Colombia, compromising some rural coastal areas, a peace agreement was signed in 2016. Opportunities for conservation and rural socio-economic development are foreseen in fishing communities using blue carbon based-projects (mostly involving mangroves) with international funding under the REDD+ and payments for ecosystem services schemes, among others. However, little is unknown about the geographic variation of mangrove carbon stocks, landscape contexts and socio-economic variables that may be used for decision-making on project location and assessment of mid- and long-term viability. Biotic data (blue carbon stocks), land cover types, deforestation rates, land scape contexts (antromes), human demographics, social and economic data, and governability were gathered from national and international repositories of open data and compiled into a GIS for both coastal basins (Pacific and Caribbean). Non-metric multidimensional scaling (nMDS) was employed to identify spatial patterns using different scales for pooling: basins, states (administrative level 2), and municipalities (administrative level 3). Using a reclassification method on rasterized data, we classified the variables with greater spatial variance into 5 categories indicating its possible contribution to project success. The arithmetic combination of scores for each variable was used to obtain an index of likelihood of success. While locations in the Pacific coast, particularly in Chocó, Cauca and Nariño, exhibit the largest above-ground carbon holdings (>100 Mg/ha), extensive mangrove areas, low deforestation rates, forested coastal landscapes, low population densities, and isolation from populated centers, they also exhibit low scores in socio-economic variables, and low governability in some cases. In the Caribbean, fewer locations exhibit large carbon holdings per area but only three are extensive enough to attract major projects. Socio-economic indicators and governability were greatly variable.

Session: T008 - Blue carbon
Abstract ID: T008-A057
Presentation mode: Poster

How Does Salinity Influence the Metabolome of *Avicennia germinans* Along Three Rivers of French Guyana?

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With only about 60 different plant species in the world, mangroves are nevertheless of great interest for the study of biodiversity. Indeed, these species are strictly subservient and thus constitute unique and very characteristic plant communities. In addition, these plants present highly specialized adaptive structures that enable them to cope with the extreme ecological constraints of the environment (in the intertidal zone with a very high amount of salt, unstable ground, anoxic soils...). Such conditions also drive the production of plant specialized metabolites (PSM). These compounds, although determined by the genetic factors of the species, may vary according to the phenological stage of the plant, its age and the influence of biotic and abiotic factors. Understanding the variations of PSM content according to the pressures of environmental parameters represents therefore a big challenge, since these compounds are largely involved in ecosystem functioning. as mediators in biotic interactions or as defense compounds against abiotic factors by maintaining the fitness of plants. In the context of climate change, changes in the salinity regime are being considered and our hypothesis is that salinity may lead to increases in resources allocation to the specialized metabolism and therefore defense compounds.Analysis with UHPLC-QToF, in both negative and positive modes, of leaves and roots of *Avicennia germinans* growing along three rivers of French Guyana under different salinity levels were conducted. Our results reveal a significant impact of salinity levels on the metabolome of this dominant species in French Guyanian mangroves. Biomarkers are to be identified to further discuss and assess the plant's metabolic response to salt level variations.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A050
Presentation mode: Poster

A Typology of Intervention Types for Indonesian Mangrove Regimes

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Mangrove forest landscapes, much as other ecosystems in the Anthropocene period can be regarded as social-ecological systems. Each landscape or system occurs as a set of system states, which tend towards a single, particular stable-state known as a regime. A wide variety of mangrove regimes currently exist in Indonesia, ranging in terms of condition (pristine to degraded) and vulnerability (low to high). Degraded mangrove landscapes may have crossed one or more social and/or ecological thresholds, and in some cases multiple cascading thresholds. Currently, a limited number of management options are prescribed for mangrove systems in Indonesia regardless of the state of their current regime. The most popular current intervention is mangrove planting, which is assumed to be beneficial and has been subsumed in ambitious political targets such as full nation-wide mangrove restoration (totalling 1.8 million hectares) by the year 2045. This paper takes a step-back to look at a variety of mangrove regimes in Indonesia focusing on significant social attributes (governance regime, community participation, economic and financial value) and ecological attributes (land-cover, autecology, community ecology, hydrology, elevation capital and disturbance) which define their system state. These regimes are then juxtaposed with regards to their value and their position in relation to known thresholds. This talk concludes by presenting a typology of management interventions based on their system state which include; a) enhancement of adaptive capacity, b) restoration or rehabilitation and c) intentional transformation which should all be considered before d) unintentional or forced transformation occurs.

Session: T009 - Mangrove management
Abstract ID: T009-A013
Presentation mode: Oral

Informing Coastal Wetland Conservation at the Global Scale: Accessible Science for Effective Action

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The global extent of coastal wetlands – mangroves, seagrass and saltmarsh – has declined considerably over the last half century. Recent efforts to protect and restore these habitats have reversed decline in some regions, while it continues in others. The Global Wetlands Project, an international scientific team, is working to inform and empower coastal wetland conservation at a global scale. The project is focussed on elevating scientific understanding of critical issues and delivering tools to help address these issues more effectively and efficiently. We have already developed models for projecting carbon emissions from mangrove deforestation and identified the importance of coastal wetlands in sustainable fisheries at a global scale. We are now making this science more accessible to conservation agencies and wetland managers through web applications. For instance, our web app for simulating carbon emissions was applied to Mexican mangrove forests to estimate the value of remnant carbon stocks in international carbon markets. Our next steps are to integrate other ecosystem services and biodiversity values into our simulation tools, like fisheries production and the risk of ecosystem collapse, and engage with more coastal wetland managers to help inform effective action.

Session: T009 - Mangrove management
Abstract ID: T009-A022
Presentation mode: Lightning Talk

Mangrove Inventory Comparisons, Findings from Multi-agency Tests in Florida

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The unique and invaluable mangrove ecosystems occur in sensitive yet adverse intertidal zones of the land/sea interface and are limited to tropical or subtropical climates. Traditional forest inventory methods of ground access to mangrove sites is often difficult and time consuming. Tides, mud flats, prop roots, and tree densities can be hazardous to travel in mangrove forests. To investigate potential mitigation of these issues and assist data capture, the Southern Research Station (SRS) of the USDA Forest Service initiated a collaborative study with the Florida Forest Service (FFS) and the National Aeronautics and Space Administration (NASA) to test alternative measurement methods on mangrove plot locations. Consultation with the Mexican Forest Service (CONAFOR) inventory of mangroves provided the diameter method studied. This presentation outlines the study parameters and provides updated findings from methods being compared. First, inventory on a single point plot design to reduce the amount of traverse involved in the current four point subplot design. Second, measure tree diameter at breast height (dbh) at 0.30 m above the highest prop root (for trees with prop roots at or above normal dbh) to alleviate the difficult measurement at 1.37 m above that point under current traditional methods. Third, synchronize NASA flyovers of mangrove plot locations using global positioning system (GPS) coordinates and Goddard LiDAR Hyperspectral Thermal (G-LiHT) airborne imaging system to test the viability of remotely sensed data as a source of data acquisition for the numerous inaccessible mangrove plot locations in south Florida.

Session: T009 - Mangrove management
Abstract ID: T009-A027
Presentation mode: Poster

Testing for a Species Effect on Mangrove Ecosystem Carbon Stocks Across Three Sites in Thailand

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Variation in mangrove ecosystem carbon stocks is largely driven by the soil organic carbon (SOC) pool, which is highly dependent upon site geomorphology. Soil characteristics that determine SOC, however, may be influenced by species composition and dominance within a particular site, leading to conflicting conclusions within the literature. This proposed talk will discuss research that tests for a species effect on mangrove ecosystem carbon stocks across three sites of differing geomorphology in southern Thailand. Ecosystem structure and carbon stocks were sampled in 138 plots across 33 transects from three sites via the standardized Kauffman and Donato (2012) protocols. We use mixed effects models to account for spatial autocorrelation within site and transect, and test for a species effect on aboveground, belowground, and SOC stocks across the comprehensive dataset. Specifically, we model bulk density, percent organic carbon, and SOC as a function of density-weighted values of plant traits at the species and genus level, for example root morphology or nutrient content, across various depth horizons. The preliminary results of the research show a significant species effect across the three sites when controlling for within-site and within-transect variation for percent organic carbon and SOC, whereas bulk density is not found to be dependent upon species composition. Finally, we report first-pass estimates of total ecosystem carbon stocks from field data within Thailand, which is notably data-poor in the mangrove carbon stock literature. The findings have important implications for mangrove restoration efforts that are motivated by CO2 offset programs, which are currently underway in Thailand.

Session: T008 - Blue carbon
Abstract ID: T008-A048
Presentation mode: Lightning Talk

The Global Mangrove Watch

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Globally mangrove forests have witnessed a considerable amount of change over the past 30 years. Mangroves are also at the forefront of climate change with changing sea levels and temperatures providing new opportunities for mangroves but also making some areas uninhabitable. The time lag between these events and the mangrove response is also short, it can be only a few months. Little information is known on the overall extent of mangroves and how this extent and condition has been changing at a global scale. This study has therefore created the first global monitoring system for mangrove forests. The system came out of the JAXA Kyoto & Carbon (K&C) initiative and has therefore focused on the application of JAXA ALOS PALSAR, ALOS-2 PALSAR-2 and JERS-1 data with the augmentation of Landsat to aid the definition of a new 2010 mangrove global mangrove baseline. Change products (from the 2010 baseline) were produced for 1996 using JERS-1, 2007, 2008 and 2009 using ALOS PALSAR, and 2015 and 2016 using ALOS-2 PALSAR-2. The baseline classification was created using an automated machine learning approach based on random forests algorithm while the change products were produced using a new innovative map-to-image change detection approach. The baseline was assessed to have an overall accuracy of 95.25% with 2.5% omission and 6% commission based on 53,800 visually accessed random points from 20 regions. Globally, mangrove change has been estimated at a rate of -0.29% per year, i.e., a loss of 5.8% in mangrove extent from 1996 to 2016. This is not equally distributed with Indonesia, having the largest area of mangroves within a single country, having lost almost 20% of mangrove extent from 1996 to 2016.

Session: T003 - Mangrove loss and deforestation
Abstract ID: T003-A019
Presentation mode: Oral

Exploring the State of Heavy Metal Pollution in Hong Kong Mangroves and Its Potential Influence on Mangrove Crabs

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Mangroves are disappearing at alarming rates in response to a variety of human activities. One of the major threats faced by Hong Kong mangroves is heavy metal pollution, which is introduced by industrial activities. Mangroves have long been suggested as natural 'sinks' for contaminants due to their capacity to accumulate pollutants, however little attention has been paid to the influence of heavy metals on mangrove fauna including crabs. Crabs are vital to the health and resilience of mangroves by performing key ecological roles such as nutrient cycling and bioturbation, negative impacts to these communities therefore have the capacity to destabilise whole mangrove ecosystems. This investigation aims to assess the extent of heavy metal contamination in Hong Kong by analysing the metal content (Al, Cu, Cd, Cr, Fe, Mg, Mn, Zn, Ni, Pb and As) of mangrove sediments and representative plant and crab species across four study sites using Induction Coupled Plasma Mass Spectrometry (ICP-MS). This investigation also attempts to explore the influence of heavy metal exposure on the metabolic performance of mangrove crabs, specifically Parasesarma bidens, via respirometric and heart rate experiments. When comparing the thermal performance of P.bidens populations from 2 polluted and 2 pristine sites, we found that populations exposed to high levels of metal pollution displayed suppressed oxygen consumption ($\mu mol\ min^{-1}\ g^{-1}$) against an increasing thermal gradient (3°C $hour^{-1}$ from 22 – 50°C) in comparison to other populations . This research aims to offer insight to investigating human impacts on organisms and ecosystems, promoting inter-disciplinary approaches to investigating such impacts in the hope to inform future conservation and environmental management strategies that reduce human impacts on ecosystems.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A005
Presentation mode: Poster

The Carbon in Above Ground Standing Biomass and Soil of Planted and Natural Mangrove Forest in Trang, Thailand

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Abstract The importance of studying carbon in restored mangrove ecosystem is significant in determining the ecosystem functions and services it provides. In this study, the organic carbon content was evaluated in both 10-25-YO (planted) and >50-YO (natural) mangrove stands. The following sources of carbon were obtained in aboveground standing biomass (CS-AGB), sediment OC (OC-S) and Organic matter (OC-POM). Related physicochemical parameters associated in the 10-25-YO and >50-YO mangrove forests were also measured. Except for aboveground biomass, samplings were done quarterly from May 2017 to February 2018. The present study obtained lower CS-AGB in 10-25-YO (131.96 +17.58 t C ha-1) than >50-YO mangrove forest (223.21 +20.20 t C ha-1). However, we found higher OC-S in 10-25-YO (272.49 +14.55 Mg C ha-1) than >50-YO (254.73 +10.93 Mg C ha-1), reflected in the higher densities found in the 10-25-YO forests. The derived OC-POM was lower in the 10-25-YO forest (52.27 +9.45 Mg C ha-1) than in >50-YO forest (74.29 +33.56 Mg C ha-1) influenced by allochthonous inputs of organic matter from rivers and creeks, and a number of species in >50-YO forests. The overall results revealed that in both 10-25-YO and 50-YO mangrove forests can be a good source and sink of OC. This information is an added value of the ecosystem function of mangroves. Further, the information of OC in restored mangrove will help the local community and policy maker to address the climate change issue in Trang, Southern Thailand.

Session: T008 - Blue carbon
Abstract ID: T008-A011
Presentation mode: Poster

Comparison On The Species Composition And Abundance Of Crabs: Assessment Of The Effectiveness Of Mangrove Rehabilitation Sites

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One of the myriad ways to restore ecological functions of mangrove ecosystems is through replanting method. Considering the vast services that mangroves could offer, replanting of mono-genus stands became trending. However, few or very limited information on the impacts of associated organisms like commercially important crabs have been reported. The present study compare the species composition and abundance of crabs in mangrove rehabilitation sites in Banacon Island. Crab traps were deployed during night time and retrieved in the daytime. A total of 1,226 crabs were collected in this study. Seven (7) species of crabs were recorded in the mangrove area and intertidal area. Results revealed that species composition were higher in intertidal area (control) than the mangrove rehabilitation sites. In terms of abundance, mangrove rehabilitated area showed higher number as compare to intertidal area, where Thalamita crenata dominated the highest number followed by Portunus pelagicus. Thus, replanting of mono-genus stand contributed possitive effect in terms of abundance of crab species.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A037
Presentation mode: Poster

Estimating the Full Greenhouse Gas Emissions Offset Potential of Mangroves: A Comparison of GHG Profiles Between Rehabilitating and Established Mangroves

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Mangrove forests are extremely productive, with rates of growth rivalling some terrestrial tropical rainforests. However, our understanding of the full suite of processes underpinning carbon exchange with the atmosphere and near shore-waters, the allocation of carbon in mangroves, and fluxes of non-CO2 GHG gases (N2O and CH4) is limited to a handful of studies. This constrains the scientific basis from which to advocate for greater support for and investment in mangrove restoration and conservation. Improving understanding is urgently needed given the on-going landuse pressures mangrove forests face, particularly throughout much of SE Asia. The current study reduces uncertainties by providing a holistic synthesis of the net potential GHG mitigation benefits resulting from rehabilitating mangroves and established forests. Rehabilitating sites from two contrasting locations representative of high (Tiwoho) and low (Tanakeke) productivity systems on the island of Sulawesi (Indonesia) were used as case studies to compare against established mangroves. A carbon budget, allocation and pathways model was developed to account for inputs (sequestration) and outputs (GHG emissions) to estimate Net Ecosystem Production and Net Ecosystem Carbon Balance. Our results indicate that while Tiwoho's rehabilitating sites and established mangroves represent a significant carbon sink (-10.6 ± 0.9 Mg CO2e ha-1 y-1 and 16.1 Mg CO2e ha-1 y-1 respectively), the low productivity of Tanakeke has resulted in minimal reductions to date (0.7 ± 0.3 Mg CO2e ha-1 y-1). Including NEP from mangrove-allied primary producer communities (e.g. benthic algae) and the portion of dissolved inorganic carbon exported from mangroves (EXDIC) that remains within the water column may drive overall removals considerably upwards in established forests to -37.2 Mg CO2e ha-1 y-1. These values are higher than terrestrial forests and strengthen the evidence base needed to underpin the use of forest carbon financing mechanisms for mangrove restoration.

Session: T008 - Blue carbon
Abstract ID: T008-A003
Presentation mode: Oral

Assessment of Potential Contribution of Mangrove Vegetation to Apiculture Along Leyte and Samar Islands, Philippines

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Mangrove ecosystems are vital environmental resources that provide extensive ecosystem services. While there has been extensive research on floristics and faunistics in mangroves, there has been limited information in community structure and total carbohydrate analysis of flower nectars, which can be explored for possible apiculture. A rapid assessment of mangrove community structure was conducted in Leyte Gulf, Maqueda, and Matarinao Bays of Leyte and Samar Islands from January to May 2018. Flower nectars were collected through washing method and total carbohydrate analysis was evaluated using phenol-sulfuric acid method A total of 15 sites were assessed using the transect line-plot method. A total of 23 mangrove species were identified from the 15 sites (2 dominant, 17 minor, and 2 associated species) belonging to 12 families, including 21 true mangroves and 2 mangrove associates. Leyte Gulf and Maqueda Bay have 17 species, while Matarinao Bay has 13 species. In general, the mangrove sites are dominated by *Rhizophora apiculata* and *Sonneratia alba*. Rehabilitated sites are dominantly planted with Rhizophora. In contrast, natural mangrove stands are composed of mixed species of *Aegiceras, Avicennia, Bruguiera, Rhizophora, Sonneratia,* and *Xylocarpus*. In Maqueda Bay, *S. alba* had a higher concentration of total carbohydrates (mg mL-1) with 62.59% than *R. apiculata* with 9.23%. In Matarinao Bay, *S. alba* had higher concentration with 38.9% than *R. apiculata* with 23.3%. In Leyte Gulf, *S. alba* had higher concentration with 26.34% than *R. apiculata* with 14.30%. Considering the carbohydrate content and optimal percentage needed by honeybees, these data suggest that sites dominated with *S. alba* have good prospects for apiculture over the popularly planted *R. apiculata*.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A010
Presentation mode: Poster

Effect of Copper and Cadmium on Osmoregulation and Oxygen Consumption in Mangrove crab (*Parasesarma Bidens*)

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Adaptation in osmoregulation marks one of the key elements in the success of mangrove crabs. Mangrove crabs inhabit brackish water and live in conditions of varying salinity, it is important for them to maintain their osmoregulatory processes. The osmoregulation strategies allow them to cope with different sets of salinity and water availability, contributing to the survival of crabs in the fluctuating environment. Yet, osmoregulation can be compromised by the presence of unusual levels of heavy metals. With the above background, I will investigate the effect of heavy metals on the osmoregulation of a mangrove crab species: *Parasesarma bidens*. Specimens of the model species will be exposed to different concentrations of essential (Cu) and non-essential (Cd) metals under a gradient of salinity, while the osmolarity of the haemolymph and respiration rate will be determined for each experimental condition. It is hypothesized that the targeted crabs will show failure in various physiological pathways under the influence of heavy metals, given that osmoregulation in crabs are directly linked to the acid base regulation, CO_2 excretion and even NH_3 excretion to different extents. It is important to understand the vulnerability of the crab species under the impact of heavy metals, especially in estuary and mangrove system where bioaccumulation of heavy metals can occur in significant terms. It is known that in Hong Kong, mangrove ecosystems are threatened with the anthropogenic input of heavy metals, mainly from industrial activities. With the mangrove crabs as one of the bioindicators, investigating the physiological responses of them subjected to high concentrations of heavy metals can provide a better understanding on the effect of anthropogenic input of heavy metals on the crabs, as well as the mangrove ecosystem itself.

Session: T001 - Impacts of people on mangrove structure and function
Abstract ID: T001-A017
Presentation mode: Poster

Can We Assess the Functionality of Mangrove Ecosystems Through Their Macrobenthic Assemblages? a Case Study from Hong Kong

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How can we determine if a particular mangrove forest provides the vital array of functions and services these ecosystems are known to offer to humankind? Is there a reliable and scientifically sound tool to assess the viability and functionality of such a forest? These are some key questions researchers, environmental managers and decision makers should ask in order to develop effective management strategies of mangroves, which are under increasing anthropogenic pressure worldwide.The present meta-analytical approach, based on the assumption that there is no viable and functional mangrove without a rich and functionally diverse macrobenthic assemblage, intends to answer the above questions, providing reliable tools to assess mangrove functionality. Analyses were performed on standardised assessments of both taxonomic and functional diversity of gastropods and decapod crustaceans carried out for 43 mangrove forests along the Hong Kong coast. We used the Taxonomic Distinctness Index (Δ*) to measure species richness on the basis of their taxonomic relatedness and two indices, Functional Richness (FRich) and Functional Redundancy (FRed), to calculate the Functional Diversity (FD) of the studied forests. To assess FD, and in order to avoid redundancy in the traits chosen, we focused on three specific categorical traits: 1) selected microhabitat within the mangrove forest, 2) diet and 3) bioturbation potential.Our results show that both biodiversity and functional redundancy of fauna are still rather high for most of the Hong Kong mangroves, although the destruction of mangroves led to a very small average area of the analysed forests. Moreover, we could identify areas strongly degraded, which are in need of immediate and effective management. We believe that the tools we propose can be of great importance both to assess target forests for conservation programs and to identify successful practices in rehabilitation.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A026
Presentation mode: Oral

A Home Away from Home: a Built Habitat Acts as a Mangrove Analogue in a Novel Ecosystem

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Changing environmental pressures can expose species to novel ecosystems. Whether through range shifts, deforestation, or other mechanisms, mangrove associated species are increasingly encountering environments with which they have little or no ecological or evolutionary experience. Within these novel ecosystems, such species are likely to experience suboptimal novel conditions which negatively impact their ecology and life history. However, built structures (telephone poles, boat docks, etc.) have the potential to act as mangrove analogues by providing structure and other resources which are more similar to mangroves than the surrounding habitat, potentially providing mangrove associated species with refuge from negative novel conditions. We present a case-study of this phenomenon through an exploration of the range-expansion of the mangrove tree crab Aratus pisonii. The northward range-expansion of this historically neotropical mangrove associated species has outpaced the coincidental range-expansion of mangroves resulting in this crab colonizing salt marshes along the southeast coast of the United States. We show that suboptimal conditions experienced by this crab in the salt marsh result in negative impacts on its ecology and life history, including reduced size and reproductive potential. However, boat docks, which provide structure superficially resembling mangroves, provide improved thermal and dietary conditions over the surrounding salt marsh. We mechanistically show that docks act as mangrove analogues and mitigate many negative impacts A. pisonii experiences in the salt marsh allowing crabs to grow larger, have higher reproductive output, and survive further north than conspecifics elsewhere in the salt marsh. Ultimately, our study highlights the potential of artificial habitats to act as mangrove analogues within non-mangrove ecosystems. If our results hold true for other mangrove associated species, artificial structures could represent an opportunity for management and mitigation in areas where mangroves cannot be restored and for species experiencing suboptimal conditions as a result of climate-mediated colonizations of non-mangrove ecosystems.

Session: T009 - Mangrove management
Abstract ID: T009-A025
Presentation mode: Poster

Promoting Regional Communication and Collaboration within the Mesoamerican Reef Ecoregion.

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The Mesoamerican reef (MAR) ecoregion is a shared resource of Mexico, Belize, Guatemala and Honduras, with an estimated 239,176 ha of mangroves, equivalent to 1.7% of the world's mangrove coverage. Despite comprehensive legislation existing in each country to protect mangroves, and approximately half of the region's mangroves located within a total of 42 protected areas, mangrove cover declined by an estimated 32% between 1990 and 2010. We conducted reviews of the governance of mangroves, protected area management plans, and peer-reviewed articles for the four countries of the MAR. Our findings suggest management efficacy is reduced by complex governance frameworks, disconnects between managers and researchers, and geopolitical differences. Management plans for mangrove protection and conservation rarely made use of scientific data, but for effective management, greater efforts are required to ensure evidence-based research within mangrove management plans. We found a distinct separation of perceived major threats to mangroves between Ramsar site managers and researchers with managers primarily focused on localized anthropogenic threats, whilst research has largely been conducted on more regional or global natural threats. To promote communication between government, non-government organizations and scientists within the region, the Mesoamerican Mangrove and Seagrass Network, an online discussion group, has been established. The network provides a conduit for people working in the region to share experiences, identify what mangrove projects are being conducted and by whom, connect with experts and foster regional collaborations.

Session: T009 - Mangrove management
Abstract ID: T009-A004
Presentation mode: Lightning Talk

A New Mobile App Based on Botanical Expertise for Identifying Asian Mangrove Species

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Preserving tropical vegetation biomes stems with an accurate identification of constituent plant species. In Asia, identifying mangrove plant species is particularly required in biodiversity assessment, restoration or preservation programs, which are pivotal components of the ecosystem's preservation from unsustainable anthropogenic activities. The necessary rigour coming from botanical expertise, however, remains both insufficiently considered and unavailable for non-botanists including scientists, local communities and stakeholders of the coastal zone management. In this work, we will present a mobile application, working on both iOS and Android, that allows for the identification of 51 Asian mangrove species at your fingertips. We have based our approach on generic drawings covering the full range of botanical characters that guarantee the identification of mangrove species at both propagule and adult growth stages. The tool has been evaluated in situ by botanist and non-botanist scientists from different Asian countries. In the first instance, we will discuss difficulties in correctly identifying Asian mangrove species, especially, those from the same family, and the technical approach we chose to finally solve them. Then, subsequently, we will demonstrate how, with this app, we will be able to map mangrove species in tropical vegetation biomes with the objective of sharing accurate survey data on existing mangrove flora all around the world, year after year.

Session: T009 - Mangrove management
Abstract ID: T009-A021
Presentation mode: Lightning Talk

Export of Metal Complexing Ligands from Singapore Mangroves to Local Coastal and Regional Waters

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Mangrove's role in mitigating pollution effect, specifically in terms of trace metal sequestration and regulation is important. Not only do metals accumulate in sulfide-rich anoxic sediments in mangroves, but the mangrove trees themselves can also be sources of metal-complexing ligands that regulate trace metals' bioavailability and biological effect. These ligands from mangroves will add to the pool of coastal waters' ligands from natural and anthropogenic organic and humic matter to produce the conditions of coastal waters. Here we extend the results of a project where selected trace metals and ligands were studied in the porewater around 2 mangrove trees (Avicennia alba and Rhizophora apiculata) as the trees relate or respond to local sources of metal from anthropogenic activity at 5 sites around Singapore along a perturbation gradient. By contrasting the mangrove ligands with ligands from a seasonal study of coastal waters around Singapore, we can infer correlations and establish links and transport of mangrove-originated metal ligands across the salinity gradient and into coastal waters. Given the impact variability in the Singapore mangroves across sites, we further compare the mangrove ligands with regional seawater ligands from another study the Malacca Straits and the South China Sea. These comparisons let us assess the connectivity of mangrove ligand sources into coastal local and regional waters in order to assess their size in comparison to other relevant regional ligand sources (peatland, rivers, phytoplankton, aquaculture, etcs). Finally, by further extrapolating this local Singapore-scale ligand data to the region, a rough estimation of the potential pollution mitigation capacity provided by regional mangroves can be estimated.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A008
Presentation mode: Oral

Understanding Social and Spatial Differences in the Sociocultural Perspectives Held by Coastal Communities About Mangrove Ecosystem Services and Benefits

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Mangroves are a vital part of many coastal socio-ecological systems, and are of particular importance to those who rely directly on the ecosystem services they provide. Change in ecosystem service provision can disproportionately affect those most reliant on associated benefits. Yet, it is not commonplace for beneficiaries' perspectives about the full range of ecosystem services to be incorporated into assessments. Furthermore, little regard has been paid to the ways in which local-level difference in the social and spatial characteristics of mangrove socio-ecological systems can influence perspectives. This is problematic because knowledge about, and concerns and priorities associated with mangroves are unlikely to be uniformly held. The purpose of this study was to disaggregate perspectives held by local-level beneficiaries about the full spectrum of mangrove ecosystem services. This enabled us to gain insights that could help to: a) improve the legitimacy of decision-making that has consequences for mangroves, and b) reduce unequal outcomes resulting from change in the services they provide. We adopted a spatially-explicit mixed-methods approach to work with two communes that formed part of Vietnam's Red River Delta mangrove socio-ecological systems during 2017/8. Thirteen ecosystem services were identified by villagers during focus groups and transect walks. Polygons representing locations perceived to provide those ecosystem services were drawn by respondents on 1:15,000 scale maps during household surveys, when data about livelihoods was also gathered. We disaggregated responses and generated ecosystem service hotspots for disaggregated groups to see whether livelihood characteristics influenced which mangrove services and benefits were prioritised, and if and why different mangrove spaces were perceived as important by different groups. Analysis of this data is currently ongoing, and emerging results will be presented during the conference.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A017
Presentation mode: Oral

The Under-appreciated Diversity of Mangrove Types in the Greater Caribbean: an Examination using Mangrove Fish Assemblages

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The Greater Caribbean (GC) biogeographic unit comprises three sub-provinces: (1) the Gulf of Mexico, (2) the Central American coast and the offshore islands and (3) the northern coast of South America south to ~7°N. Our understanding of the relationship between mangroves and fish in this large region has been largely restricted to studies performed in the central province where mangroves occur in close proximity to coral reefs and seagrasses. Here I compile information from ca. 20 studies on mangrove fish community structure performed throughout the GC from south-eastern USA to northern Guyana to elucidate the variability in mangrove fish composition in this region. Approximately 600 fish species belonging to 109 families were found in mangrove systems of the GC, representing about 38% of the total shore fish fauna of this region. Classification and ordination analyses indicated that at least three distinct mangrove fish assemblage units exist in the GC: (1) comprising assemblages in the Gulf of Mexico, (2) including areas where mangroves occur in proximity to coral reefs and contain a significant number of coral reef fish species and (3) comprising of areas in the northern coast of South America, which have affinity to mangrove fish assemblages of the Brazilian province in the Western Atlantic. These results highlight an under-appreciated variability in the type of fish assemblages that reflects the biogeographic zoning of the GC region and the different mangroves typologies in this region. Despite fringe mangroves accounting for a significant part of this ecosystem in this region, studies on mangrove systems with different typologies (deltas, estuaries and lagoons) in the GC should be encouraged to have a more comprehensive understanding of: (1) the function of mangroves as fish habitat and (2) the complex biogeographic history of this region.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A030
Presentation mode: Poster

230 Years of Climate Driven Regime Shifts in a Mangrove-saltmarsh Ecotone

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Climate change is redistributing species around the globe, and one consequence is a tropicalization of temperate ecosystems. Over the past few decades, mangroves have rapidly displaced saltmarshes near multiple poleward mangrove range limits, including in northeast Florida. However, it is uncertain whether these changes are due to anthropogenic climate change or natural decadal climate variability. Here we used satellite imagery, aerial photos, historical shoreline maps from the USGS, and other historical records to document changes in mangrove abundance along the northeast coast of Florida from the late 1700s to the present. These changes in the mangrove-salt marsh ecotone were compared to climate variability over the past 150 years. We then used modeled climate projections to estimate the contribution of ACC to observed decreases in the frequency of extreme freeze events. We also projected how the frequency of freeze events in this region will change over the next 50 years. We found that the current ecotone between mangroves and saltmarshes in northeast Florida is highly dynamic, and has shifted between mangrove and saltmarsh dominance at least six times between the late 1700s and the present. Our results indicate that recent mangrove range expansion should indeed be placed into a broader historical context of an oscillating system. However, climate projections suggest that the recent expansion may represent a more permanent regime shift due to the effects of climate change.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A030
Presentation mode: Oral

Warming Can Influence Mangroves with Implications for Resilience to Sea Level Rise: Early Findings from the Wetfeet Project

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Climatic warming alters coastal wetland ecosystems directly and indirectly by altering plant community structure. Along the Florida (USA) coast, average temperatures have increased, likely having an influence on ecosystem processes, while decreasing freeze frequency has allowed mangroves (Avicennia germinans) to expand their range into higher latitudes. Though we are beginning to understand some consequences of mangrove encroachment, the implications of climatic warming for surface elevation maintenance and resilience to sea level rise remain unknown. Across a chronosequence of mangrove encroachment into marshes, we have established passive warming experiments to investigate how warming influences mangrove growth and ecosystem processes. Warming chambers, placed over both mangrove and marsh vegetation are compared with control plots (2 temperatures x 2 vegetation types x 6 replicates x 3 sites) and have warmed the air temperature by an average of 2°C. We are measuring aboveground plant growth, belowground organic matter dynamics, and microbial communities to understand aboveground belowground linkages that may impact sediment trapping and root production. We are parameterizing a version of the Marsh Elevation Model to examine how mangrove growth and sediment trapping influence surface elevation with respect to sea level rise. We have found that warming increases mangrove stem elongation after six months. Mangroves at the highest latitude site exhibited the slowest growth but showed the largest warming effect on growth. Early model runs show that mangroves have a capacity for maintaining surface elevation with respect to sea level rise. As temperatures warm, stimulations in mangrove growth may have implications for coastal ecosystem resilience.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A042
Presentation mode: Oral

Microbial Community Structure and Its Relationship to Heavy Metals in Shenzhen and Hong Kong Mangrove Sediments

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To explore the effects of heavy metals to microbial community structures of mangrove sediment, surface and rhizosphere sediment samples were collected from Futian National Reserve, Shenzhen Bay Mangrove Park, Baguang Mangrove Reserve, and Mai Po Reserve. The contents of Cr, Ni, Cu, Zn and Pb were analyzed, with the pollution levels of which being evaluated by Pollution Load Index (PLI). Microbial assemblages were profiled using 16S rRNA high-through put sequencing and OTUs data were analyzed using cluster analysis, α-diversity analysis (Shannon Index), and spearman correlation analysis. There were significant differences in heavy metal contents among different sampling sites. Mai Po Reserve had the most severe pollution of heavy metals, with PLI of 1.51 in mud flat and 1.38 in mangrove forest. The other three sampling sites were less polluted, with PLI of 0.45 in Futian Reserve, 0.31 in Shenzhen Bay Mangrove Park, and 0.21 in Baguang Reserve. The four sites had no significant differences in microbial community structure, with predominance of Proteobackteria, Chloroflexi, Actinobacteria, Bacteroidetes, and Firmicutes at phylum level, as well as Gammaproteobacteria, Alphaproteobacteria, Deltaproteobacteria, Anaerolineae, Betaproteobacteria at class level. Multivariate analyses revealed that there were no statistically significant correlations between metal pollutions and microbial community structure across different sites. Results from Spearman correlation analyses indicated that heavy metal contents influenced the within-habitat diversity of some phylum and class such as phylum BRC1 and class Epsilonproteobacteria.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A004
Presentation mode: Poster

The Relative Role of Stochasticity Versus Determinism in Shaping the Biogeographic Patterns of Mangrove Crab in Five Subtropical Intertidal Ecosystems

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The relative importance of stochasticity versus determinism in shaping the biogeographical patterns of intertidal crab is unclear. Here, we sampled 84 sites across 480 km geographical distances and used both variation partitioning analysis (VPA) and geographic detector method (GDM) to investigate the relative role of stochasticity and determinism in affecting the spatial distribution of mangrove crab in Southeast China. Our results revealed that mangrove crab exhibited a distinct geographical pattern. We provided evidence for distance decay relationships in crab community dissimilarity and found dissimilar community gradients in response to latitude. Both canonical correlation analysis (CCA) and GDM tests showed that the spatial distribution of mangrove crab was significantly correlated with both environmental (extremely high and low atmospheric temperature, water temperature, water dissolved oxygen, salinity, and pH) and geographical factors (latitude and longitude). Further, the interaction between spatial and environmental factors bilinear enhancement with each other to influence the biogeographical pattern of crab. Together, 12.8% of the variation in the geographical pattern of mangrove crab could be explained, with spatial parameters accounting for 7.1%, environmental factors 2.9%, the joint effect of spatial and environmental factors 2.8%, respectively. Our results suggest that the biogeographical patterns of mangrove crab are more influenced by stochastic processes than by deterministic processes. Moreover, a large proportion of unexplained variation (87.2%) implies that more complex assembly mechanisms may exist to govern the biogeographical pattern of mangrove crab in these subtropical intertidal zones. Keyword: biogeography, deterministic processes, mangrove crab, stochastic processes

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A007
Presentation mode: Poster

The Population Genomics of the Mangrove Species Sonneratia Alba Cast Light on the Genome Shaping from Isolation and Migration

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How genomic composition is shaped by isolation, gene flow and selection? We sought for answers by re-sequencing 33 genomes of *Sonneratia alba*, which is a widespread mangrove species in the Indo-West Pacific (IWP) region. The results of comparative genomic analyses indicated low genetic diversity within populations and strong sequence divergence among populations from four major oceanic regions, i.e. the South China Sea, the East Indian Ocean, northwestern Australia and eastern Australia. The observed population structure was shaped by the geographic isolation due to the emergence of merged shelves (Sunda and Sahul shelves) during the Pleistocene glacial periods. However, as the admixture in the Kukup population indicated, during the interglacial periods, the rising sea level and opening of the Strait of Malacca also permitted genetic exchange between the East Indian Ocean and South China Sea. The contrasts of population structure pattern among genomic loci revealed by genome scanning may provide insight into how isolation and migration shaped the divergence patterns at the genomic level. Besides, the identified highly divergent genes between the two Hainan populations (Sanya and Wenchang) were under strong positive selection as the MK test indicated. Alleles of partial such genes in the Sanya population were further found to be introduced from Indian Ocean via gene flow through the Strait of Malacca, which may be a case of adaptive gene flow. The study provides clues that interregional genetic exchanges in mangroves facilitate re-use of standing genetic variation to establish in new habitats.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A008
Presentation mode: Oral

The Function of Aerial Root Structures on Sediment Accumulation and Surface Elevation Change in Mangrove Wetlands of China

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Sedimentation in mangrove systems is greatly influenced by biological processes. Aerial roots, typical structures in mangroves, can promote sedimentation by reducing water velocities and by trapping plant litter and detrital particles. We conducted an in situ study to discern the mechanisms of surface elevation change (SEC) related to forests with different aerial root structures. Forests with four root types were considered: knee roots of *Bruguiera*, plank roots of *Kandelia*, pneumatophores of *Sonneratia*, and prop roots of *Rhizophora*. All sites were located at Dongzhaigang Mangroves Nature Reserve, Hainan Island, China. The Rod Surface Elevation Table-Marker Horizon (SET-MH) approach was combined with shallow SET benchmarks to identify vertical accretison rates versus subsurface change, and determine the relative influence of each on SEC by forest type. After four years, root zone expansion was 0.65-4.09 mm y-1 among root types, where live fine root biomass (0-50 cm soil depth) was 804-1622 g m-2, explaining 45.3% of variation in sub-surface change through root zone expansion ($p=0.004$). Vertical accretion (22.5-37.9 mm yr-1) varied significantly by aerial root type and by season. *Kandelia, Bruguiera* and *Rhizophora* forests had similar vertical accretion rates that were higher than for *Sonneratia* forests. Aerial root biomass explained 39% of the vertical accretion rates measured, although correlations were weak, which might be due to variability within treatments in forest stand density or tidal inundation frequency. However, fine root biomass greatly promoted root zone expansion to influence increased SEC, and was important even with high rates of vertical accretion. SEC was approximately 4~8 mm yr-1 and average sea-level rise along the Chinese coast is 3 mm yr-1. This indicates that all root types contributed enough to sustain a relatively stable mangrove forest at Hainan, but certain species may be promoting greater SEC through their root characteristics.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A007
Presentation mode: Oral

Hong Kong as a Diversity Hotspot for Mangrove Snails: Results of a Recent Survey

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Together with crabs, gastropods are the most well represented taxon of marine origin in Indo-Pacific mangrove forests. Their high diversity is determined by the availability of a diverse range of microhabitats and by their broad range of food preferences. Diversity, assemblage composition and abundance of these molluscs are highly variable among different mangrove forests and different habitats within these forests, depending on various environmental factors. Despite their importance, the overall ecological role of gastropods and their impact on mangrove ecosystem functioning is far from clear.The mangroves of South China Sea, and of Hong Kong in particular, are known to be a diversity hot spot for mangrove snails, with 62 species recorded for Hong Kong mangroves alone. However, available taxonomic and ecological information on this taxon are far from being up-to-date, or reliable. The present study was thus designed to revise the diversity and assemblage composition of Hong Kong mangrove snails, in order to build a base-line dataset, inclusive of a specimen reference collection and a DNA reference collection of all the identified species. Along the last two years, qualitative surveys, performed in 25 mangrove forests distributed along the Hong Kong coast, were carried out in parallel with quantitative surveys in 11 focal mangroves, where abundance and biomass of snails was assessed. We recorded 39 species of mangrove snails, including a new record, Nerita planospira. DNA analyses were carried out on the majority of the species identified, to confirm their identities and build a gene bank. Through this comprehensive and territory-wide survey, we could confirm that Hong Kong is still a biodiversity hotspot for mangrove associated snails, despite the threats and anthropogenic stresses exerted on mangrove forests.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A018
Presentation mode: Poster

Estimation of Blue Carbon Storage in Mangrove Ecosystems of Java, Indonesia

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Mangrove ecosystems are important carbon sinks that play a key role in the mitigation of global climate change. It has been estimated that the carbon stored in Indonesia's mangrove and seagrass ecosystems account for 3.4 Pg C, or approximately 17% of the world's 'blue carbon' reservoir. While research on blue carbon continues to develop, there are still knowledge gaps and a need for scientific data on carbon sequestration and storage from a range of geographical locations. In this paper we present results from our ongoing study to estimate mangrove blue carbon storage from several field sites representing the variation found in coastal areas of Java, the most populated main island of Indonesia. Blue carbon inventory for Java is a pertinent issue because the island's mangrove ecosystems continue to be degraded and threatened by anthropogenic activity, while the ecosystem services they provide become increasingly more important. Sampling sites include Pamanukan, Sancang, Segara Anakan, Baluran, Pulau Dua, and Pulau Rambut, which represent areas located in the northern, southern, and eastern areas of Java, as well as islands off-shore. Methodology used for carbon estimation primarily followed the technical procedures outlined by the Blue Carbon Initiative. Current results indicate that total carbon stocks (live biomass and soil substrate) in the mangrove ecosystems range from 572.6 Mg C ha-1 (in Pamanukan) to 1,599.2 Mg C ha-1 (in Leuweung Sancang Nature Reserve). Although there is much variation among sites, total carbon stock data obtained in this study still fall within the range reported by other studies in Indonesia and elsewhere.

Session: T008 - Blue carbon
Abstract ID: T008-A053
Presentation mode: Poster

Ecological Functioning and Services of Mangroves: a Global Analysis

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Mangrove ecosystems are amongst the most productive and ecologically important ecosystems in the world, and yet there has been a rapid decline in cover globally in the last ~40 years (with approximately 35% being lost between 1980-2000). Ecosystem functions (the intrinsic characteristics by which an ecosystem maintains its integrity) and goods and services (the benefits people obtain from the ecosystems) associated with mangroves are also likely to have been lost. In this study, we explore whether the decline of mangrove extent corresponds to a loss of mangrove ecological functions and in turn the services they provide. We do this by considering species-specific ecological functions provided by mangrove species using biological traits analysis (BTA). The identification of species biological traits (the species' life-history, physiological, morphological, behavioural and structural attributes) as a proxy for functioning, combined with mangrove species composition data from different regions over time, could reveal areas of ecological functional loss or redundancy. Linking functional loss or redundancy to goods and services can show us how human well-being might be affected, which will help highlight risks, conservation concerns, and provide an evidence base to support mitigation measures.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A044
Presentation mode: Oral

Production of Zn complexing ligand by *Avicennia alba* and *Rhizophora apiculata* roots in response to Zn concentrations at human-impacted sites, Singapore.

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Mangroves are among the most productive terrestrial ecosystems and are sources of terrestrial metal and nutrient inputs for the oceans. Currently, mangroves are cleared faster than any other tropical rainforests and where mangroves still exist, they are heavily impacted by upstream and coastal anthropogenic chemical discharges. Mangrove ecosystems accumulate metals, because the anoxic waterlogged conditions precipitate metals as sulfides. This could potentially reduce the amount of metal discharging from inland into the coastal waters, or vice versa. Mangrove roots could however, alter these biogeochemical processes in several ways – 1. by translocating atmospheric oxygen into the mud, 2. by secreting organic molecules/ligands that could bind to the dissolved metals. We sample along a disturbance gradient in 5 sites in Singapore mangroves, which are fragmented and exposed to different human activities, including shipyards, vegetable farms, aquacultures, industries and residential estates. Since mangrove species have different root morphology and physiology, we selected two common mangrove species, *Avicennia alba* with pencil roots and *Rhizophora apiculata* with stilt roots, and investigate the extend that their roots alter the bioavailability of selected metals in the porewater and sediment, relative to upstream and downstream metal concentrations. By analyzing the porewater in mangrove sediment, our work will also identify for the first time, based on the ligands' binding properties, ligands that are important to complexing metals in mangroves. The project will elucidate some of the complex processes that determine the extent that mangroves are sink or sources for these metals.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A018
Presentation mode: Lightning talk

Singapore Holocene Relative Sea-level History Revealed from Mangrove Peats

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The early Holocene (11.6–7.0 ka BP) was a period of dramatic environmental change coincident with rapid relative sea-level (RSL) rise. Constraining this period however has remained inadequately studied, especially in far-field regions that experience minimal isostatic adjustment such as Singapore. Here we present results from a 38.5 m sediment core (MSBH01B) obtained to a depth of ~50 m below MSL from a coastal reclamation area in the Kallang River Basin, Singapore.Core MSBH01B contains a desiccated, highly oxidised pre-last glacial maximum palaeosol at the depth of ~- 19.4 m MSL that is transgressed by mangrove peats followed by marine muds. We applied a multi-proxy approach to the post-last glacial maximum (LGM) transgressive sediments comprising sediment and stable carbon isotope analyses and XRF-scanning at cm-scale within a Bayesian chronological framework of 23 14C AMS dates. We dated four wood/charcoal samples from the mangrove peat to produce 4 new sea level index points spanning ~9.5 – 9.2 ka BP, which provide the earliest record of post-LGM marine transgression in Singapore. The basal mangrove peat is overlain by ~11m of marine muds which coarsens upward into a shelly, sandy mud unit dated to ~7.2 ka BP. We present a revised early Holocene RSL curve for Singapore, which shows RSL rising from -20.5 ± 1.7 m at 9.5 ka BP to at least -3.8 ± 1.7 m at 7.2 ka BP. Furthermore, we also explore the potential of mangrove peats to derive more recent late Holocene sea-level trends with a goal of extending Singapore's recent sea level history as revealed by tide-gauge measurements as far back in time as the sediments allow.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A037
Presentation mode: Lightning Talk

Using Surface Elevation Data to Improve Projections of Wetland Vulnerability and Coastal Management

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Tidal saline wetlands are threatened globally by human alteration and environmental changes; despite our knowledge of their value and vulnerability, mangrove and saltmarsh loss continues. Wetland surface elevation relative to sea level is an important indicator of wetland health and vulnerability. The surface elevation table (SET) has been installed in a variety of wetland environments and is considered the global standard for measurements of high-precision surface elevation change. Data generated using the SET are incorporated into models that predict future wetland vulnerability to changing environmental conditions and project the outcome of planned management action. Increasingly, government agencies and other research organizations are including the installation and measurement of SETs in their wetland monitoring programs. However, it is unclear how these results are translated into management decisions that improve wetland condition and minimize vulnerability. We conducted a review of the uptake of SET data into management and policy decision making, including a consideration of the impediments to uptake, limitations of the technique and ancillary data that might be required to inform decision making. We highlight what the SET has done to improve our understanding of ecosystem processes and discuss the implications for science and management after thirty years of measurements. We then propose a conceptual model to better understand the processes or management activities most influencing the sustainability of a wetland. Using data from the SET and other variables, the model predicts the trajectory of wetland development and estimates the time to reach optimal resilience or functional equivalence to a natural or target system. We explore this conceptual model in the context of specific case-studies, focused on the application of SETs in assessing the success of wetland restoration projects in Australia and the United States and make recommendations that advance interpretation of SET data and lead to improved wetland management.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A064
Presentation mode: Oral

Processing of Mangrove Woody Detritus Viewed at Molecular, Organismal, Functional Group and Ecosystem Levels: New Perspectives for Interpreting Carbon Fluxes

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Mature mangroves are predominantly composed of woody tissues composed of a polymer complex termed lignocellulose, formed from cross-linked cellulose, hemicellulose and lignin. Some insects consume live wood, but most mangrove wood eventually becomes detritus that is resistant to all but a few specialist groups of decomposers. Mangrove wood decomposers consist of functional groups of decay microbes (fungi and bacteria), which operate at the microscopic scale of the wood cell wall, and tunnelling invertebrates that excavate macroscopic holes within bulk wood. Tunnelling beetles and termites, plus basidiomycete fungi dominate cause wood breakdown on the forest floor in the landward portion of mangrove forests, but also throughout these forests in dead wood held above the reach of high tides. Below a tidally-determined boundary, wood on the forest floor is degraded by an assemblage of marine decomposers. A guild of wood boring bivalves of the family Teredinidae consume the bulk of the available wood while vastly increasing the surface area accessible to marine ascomycete fungi and bacteria. The wood that teredinids consume is converted into body tissue, into huge numbers of microscopic larvae and into faecal matter consisting of microscopic particles of the partially digested lignocellulose complex. Cellulose and to a lesser extent hemicellulose are depleted in the faecal matter. Wood boring crustaceans of the family Limnoriidae (Isopoda) and Cheluridae (Amphipoda) perform a similar degradative function to teredinids and are locally important marine members of the tunnelling functional group. The enzymatic and oxidative processes used by these invertebrates to release sugars from lignocellulose are starting to be revealed, allowing us to integrate our perspectives of the process of carbon cycling related to mangrove wood at the molecular, organismal and ecosystem levels. A proper understanding of mangrove detrital processing is essential for a mangrove-related response to the REDD+ initiative.

Session: T008 - Blue carbon
Abstract ID: T008-A068
Presentation mode: Oral

Effects of Nutrient Loading on Diversity, Composition and Function of Soil Microbial Communities in Mangroves

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Mangrove ecosystems are important for carbon storage due to their high productivity and low decomposition rates. Our waterways have seen increased nutrient loads as a result of anthropogenic activities and it is unclear how this may affect carbon and nutrient cycles in downstream mangroves that receive these nutrient-rich waters. This study aims to assess how diversity, composition and function of soil microbial communities are affected by nitrogen and phosphorus addition in mangroves. This was achieved through nutrient addition experiments conducted both in the laboratory and in the field. The field component of this study comprised two long-term nutrient addition experiments on Florida's east coast. We also conducted a complementary nutrient addition incubation experiment in the laboratory using soil from one of the field sites. The lab study was used to assess the short-term microbial response in both aerobic and anaerobic environments. Soil microbial community diversity and composition were examined in both experiments by sequencing the 16S rRNA gene and ITS region for soil bacterial and fungal communities respectively. Soil respiration was measured as an indicator of microbial activity. We also measured litter and root decomposition at one of the field sites, plus microbial biomass and enzyme activities associated with organic matter decomposition in the laboratory experiment.We found differences in bacterial and fungal soil community composition between the treatments. Although previous studies had found that plant growth was nitrogen limited at these sites, this was not necessarily the case for the soil microbial communities. Nitrogen addition depressed some of the measured microbial responses and responses varied between aerobic and anaerobic environments. This study furthers our knowledge of soil microbial responses to nutrient loading in mangrove environments and can be used to guide future studies to see whether these responses vary across regions and soil types.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A019
Presentation mode: Oral

Reconciling nature, people and policy in the mangal social-ecological system through the adaptive cycle heuristic

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While mangroves are increasingly described as social-ecological systems (SES), performing SESresearch is so much more than merely documenting local utilisation patterns in case-studies. The aim of this synthesis is to show how building different degrees of ecological, human and institutional resilience in an era of uncertainty can be achieved through the adaptive cycle heuristic. Uncertainties come in many forms and shapes: climate change, changing social-economic dynamics, or as the ever-increasing public awareness, participation in governance, and regularisation. The adaptive cycle is used to reflect on and understand such complex dynamic systems with stakeholders having various (mutual) relationships at risk, and for interactive adaptive planning. Based on 20 years (1997-2018) of socio-ecological research in mangroves in 20 countries using systematic participatory research methods, we documented traditional knowledge and lifestyles, apparent change as perceived by local communities, and forest management practices. We used a suite of conceptual frameworks (DPSIR, 4R) in combination with systematic and verifiable participatory methods (Focus Group Discussions-FGD, Nominal Group Technique-NGT, Q-methodology, Delphi, and Participatory Rural Appraisal-PRA, including face-to-face interviews, semi-structured interviews and questionnaires), which were often cross-checked with ecological methods and remote sensing, resulting in SESstudies carried out following a comparable template.These social-ecological studies form windows of experimentation that provide insights beyond their case-specific context. In order to synthesise and sensitise the cumulative knowledge base arising from the application of the above methods in all these sites, the need for a suitable overarching interpretation framework arose. Here, the adaptive cycle heuristic represents the connectedness between variables of a mangrove versus the mangrove's accumulated capital (natural, social). We used this heuristic to interpret spatio-temporal changes (ecological, social, economic, political) in mangrove SES in Senegal, Gambia, Tanzania, Kenya, Sri Lanka, Malaysia and Singapore. We focus on coastal protection function, silviculture and restoration management and on centralised and decentralised approaches.

Session: T009 - Mangrove management
Abstract ID: T009-A002
Presentation mode: Oral

Conception of Biomimetic Artificial Mangrove Roots to Restore Degraded Mangrove Habitats and Develop Sustainable Eco-System Based Management Models

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Mangrove belts are natural buffers against storms, flooding, and erosion, providing critical coastal protection to local communities. In response to global mangrove destruction, massive reforestation programs have been gaining popularity in the past decades. However, replantation has generally become known to yield low survival rates due to inappropriate planting methods and disregard to hydrological and sediment conditions. Furthermore, these actions often exclude long-term coordination and participation of local communities for restored area management. In the wake of climate change impacts, this paper describes an innovative solution for mangrove restoration named ROOT.The ROOT model is designed to mimic the hydrodynamic function of prop roots and pneumatophores of mangrove trees. Inspired by the ability of prop roots (Rhizophora species) to facilitate sediment deposition and the ability of pneumatophores (Sonneratia alba) to facilitate sediment retention over a longer period of time and attenuate wave energy, the model aims to restore appropriate environmental conditions for mangrove recolonization in degraded areas. The model relies on the deployment of ROOT units in the intertidal zone on the forefront of degraded areas, efficiently attenuating wave energy, securing adequate sediment provision, and serving as habitats for marine and terrestrial life in the long term.The solution's design results from numerical and physical simulation that enables the identification and testing of key structural properties that generate optimal wave attenuation and sediment stabilization. The results are then combined with a biomimetic approach so as to develop a root like form. Local diagnosis, deployment and area management relies on the concept of community-based mangrove rehabilitation. A strong and sustainable local involvement model integrates the units' fabrication, deployment, maintenance and side uses. The solution therefore contributes to the development of sustainable income-generating activities in mangrove dependent communities and recognizes the importance of local multi-stakeholder cooperation to ensure proper management practices.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A019
Presentation mode: Poster

The Influence of Life Stage on the Chilling Stress Response of Indo-West Pacifc Mangrove Species

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The latitudinal limit of mangroves is largely governed by species-specific tolerance to low temperature, particularly to extreme cold events. Therefore, information on the cold tolerance of various subtropical mangrove species is valuable in guiding replantation efforts. Life-stage has been shown to influence the cold tolerance of Atlantic-East Pacific mangrove species, however, information on the influence of life stage on the cold tolerance of Indo-West Pacific (IWP) mangrove species is lacking, and thus it is unknown whether the cold tolerance of adult can be used as a proxy for seedlings of the mangroves of the IWP region. In this study, we determine the influence of life stage on the cold tolerance of IWP mangrove species by comparing the physiological response of adults and seedlings of four subtropical mangrove species—Kandelia obovata, Bruguiera gymnorhiza, Avicennia marina and Aegiceras corniculatum—to low temperature exposure. The physiological response of these species to low temperature exposure was determined by measuring the effective quantum yield of photosystem II (Fv/Fm) before (November 2018), during (January 2019) and after winter (April 2019) in the subtropical Beilun Estuary Nature Reserve located in Guangxi, China. We found that the before winter Fv/Fm values were not significantly different between the seedlings and adult trees of all four species. We predict that (1) adults will show a lower level of chilling stress (higher Fv/Fm value) during winter and faster recovery (less difference between pre- and post-winter Fv/Fm value) as compared to seedlings, and (2) that the seedlings of K. obovata, the most cold-tolerant species, will show the lowest level of chilling stress across species during and after winter. This study is the first to compare the cold tolerance of the adults and seedlings of IWP mangrove species.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A035
Presentation mode: Poster

Nitrogen Enrichment Accelerates Mangrove Range Expansion in the Temperate-Tropical Ecotone

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In coastal wetlands, mangroves in temperate-tropical ecotones are encroaching on adjacent saltmarshes, a pattern that is primarily attributed to warmer winter temperatures. Climate change is expected to increase the vulnerability of coastal wetlands to eutrophication, and increases in nutrient availability may mediate the rate of mangrove expansion. In previous studies, nutrient enrichment has been shown to favor more rapidly growing saltmarsh plants, promoting their persistence by allowing them to outcompete mangroves. In contrast, nutrient enrichment has also been shown to increase the growth and survival of mangrove seedlings when they are grown in competition with saltmarsh plants. We investigated the consequences of nutrient enrichment on coastal wetlands in the mangrove-saltmarsh ecotone near the temperate edge of mangrove distribution along the northeast coast of Florida. We tested the hypotheses that nutrient enrichment alters the ongoing, climate-driven expansion of mangroves into areas historically dominated by saltmarshes by increasing mangrove growth and cover, allowing them to outcompete and overgrow adjacent saltmarsh plants. We manipulated nutrient availability and measured the effects on growth, cover, diversity, leaf traits and nutrient dynamics of Avicennia germinans near its latitudinal limit in northern Florida. We found that A. germinans plants growing in the saltmarsh-mangrove ecotone grew taller and wider, increased their canopies, and had higher reproductive output when enriched with nitrogen compared to control plants and phosphorus-enriched plants.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A024
Presentation mode: Poster

Structuring Effect of Salinity on the Chemical Quality of *Avicennia germinans* Leaves and Litter Decomposition in French Guyanas' Mangroves

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Mangrove vegetation produces a wide variety of plant specialized metabolites (PSM), whose expression may be affected by the expected consequences of climate change (e.g. changes in temperature and salinity). These compounds are involved (i) in maintaining the survival and reproductive capacity of plants but also (ii) as mediators of biotic interactions or as factors controling ecosystem processes such as litter decomposition, which contributes to global carbon dynamics and ecosystem productivity. Litter decomposition efficiency depends on environmental conditions and on the chemical composition of leaf litter that influences the abundance and activity of decomposers. Our research project's hypothesis is that an increase of water salinity leads to an increase of resources allocation of mangrove trees to the specialized metabolism, impacting leaf and litter composition. Changes in litter quality could therefore affect the decomposer community and their possible functional specificity. In order to assess the plasticity of mangroves facing environmental changes, we chose to study in situ the effect of a salinity gradient on the production of PSM in leaves and litter of Avicennia germinans, a dominant species in French Guyana. Three rivers were assessed (Sinnamary, Kourou and Mahury), on each of them A. germinans leaves were sampled along two salinity levels and analyzed by UHPLC-QTOF. Same leaf samples were transplanted in situ for decomposition rates determination with crossed transplantations, in order to be linked with potential metabolomic profile variations. Our preliminary results suggest the establishment of a Home Field Advantage on leaf decomposition where decomposition rates decrease when leaf litter is transplanted to a different salinity level from which it originates. These results highlight the possible structuring role of salinity in the establishment of a chemical interaction specificity between A. germinans and the decomposer community, impacting decomposition efficiency and carbon dynamics in mangroves.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A049
Presentation mode: Poster

As Good as G(Old)? Comparing Biodiversity and Ecosystem Services of Restored and Natural Mangrove Forests in the Wallacea Region (CoReNat)

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Mangrove forests provide habitat to terrestrial and marine species, sustain the livelihoods of millions people, and are high priority habitats in climate change mitigation strategies due to their extraordinary carbon sink capacity. They are degraded globally, with land use change being the most serious threat at present. Successful restoration/rehabilitation of diverse, functional, resource-rich and resilient mangroves is a major development challenge in many countries. Indonesia has lost 40% of its mangroves over the last three decades, causing manifold problems for people's lives. Halting and reversing Indonesia's mangrove loss is key for improving livelihoods and reducing poverty, which is why the government now spends around $13 million a year for planting mangroves on degraded areas. Many planting projects in Indonesia and elsewhere have failed, and it is mostly understood why (e.g. due to failure to achieve hydrological restoration, use of the wrong foundation species and neglect of key social factors, such as ensuring agreed goals for the initiative). In contrast, there are numerous knowledge gaps in understanding how successful the fewer 'successful' plantation projects are in regards to recreating diverse and functional self-organising/maintaining systems. The new UK-Indonesia co-funded project CoReNat will investigate outcomes of established community-based mangrove restoration/rehabilitation (R/R) projects in North-Sulawesi to unravel whether these mangroves are 'As good as (G)Old?'. The project will assess whether/to which degree mangrove ecosystem biodiversity, functions, resilience and service provision have been restored, and provide evidence-based recommendations for maximizing the success of future R/R efforts in Sulawesi and beyond. Combining UK and Indonesian experience and expertise, CoReNat takes a novel interdisciplinary approach to deliver a comprehensive ecosystem evaluation of established restored/rehabilitated and adjacent natural (reference) mangroves, bringing together paleoecology, geoscience, botany, zoology, environmental microbiology, ecological network analysis combined with next generation sequencing, toxicology and bioexploration.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A024
Presentation mode: Poster

Blue Carbon Benefits from Revegetation by Temperate Mangrove

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Carbon accounting for Blue Carbon projects can be hampered by scarcity of field data to inform baseline and project scenarios. South Australia has the globally largest expanse of temperate mangrove (Avicennia marina), and a strong interest in Blue Carbon benefits. We present data from a decadal scale gradient of mangrove colonisation, and compare the above ground biomass (AGB) and carbon stock with data from adjacent mangrove forests along the coast of Gulf St Vincent. Following the breach of a levee bank in the early 1930s, mangroves colonised the area behind the embankment, encroaching about 1.5 km inland. A time series analysis of aerial photography allowed identification of mangrove frontiers and recolonization rate. Using the thus known age of mangrove forest sections, field measurements were undertaken along the gradient to determine mangrove density and AGB. Tree density decreased with forest age, e.g. from 7500 trees ha-1 in a 30 year old forest to 2000 trees ha-1 in the 80 year old forest. The average tree height increased to 5.7 m (80 year old), with an individual tree height growth rate of about 7 cm yr-1. The AGB was 273 t d.m. ha-1 in the 80 year old forest, with a standing stock of 128 t C ha-1, comparable to an adjacent area not impacted by the embankment. The standing stock was estimated to increase by 1.4 t C ha-1 yr-1. The standing stock in the 80 year old forest was equivalent to 470 t CO2e ha-1, and the living biomass sequestration rate estimated at 5.2 t CO2e ha-1 yr-1. Data obtained from the space-time substitution along this colonization gradient allow improved project scenario estimation of change in carbon stock and sequestration by living mangrove biomass for Blue Carbon tidal reconnection activities.

Session: T008 - Blue carbon
Abstract ID: T008-A064
Presentation mode: Oral

Warming Stimulate the Growth and Greenhouse Gas Emission of Mangroves in Their Northern Limit of China

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Global warming promoted mangrove poleward expansion and consequently altered their capacity to keep pace with sea-level rise (SLR). Kandelia obovata is the most widely distributed and cold resistant mangrove species in China, with the northern limits at 27.5°N. We conducted an in situ control experiment simulating warming and SLR in Aojiang Estuary of Zhejiang, which is 50 km north away from the mangrove north limit in China. Warming was achieved using open top chambers with a warming (+2°C) and a normal temperature group (+0°C). SLR was conducted using the natural slope of intertidal zone with three tidal levels of high (HW), medium (MW) and low (LW). Kandelia trees were planted on the mudflat two years ago and shorter than 1 m before the experiment. The results showed no significant effect of warming on tree height, while promoted the relative growth rate (RGR) in MW+2°C and HW+2°C treatments. No significant promoting on RGR was found in LW+2°C comparing to the control. The carbon dioxide (CO2) and methane emission from the warming group of all sea-level treatments were 212.8±15.2 gCm-2yr-1 and 1.3±0.6 gCm-2yr-1, which were respectively 104.9 % and 186.3% to the control (+0°C), suggesting a higher GHG emission in future warming scenarios. Methane emission in LW was significantly higher than those in MW and HW, indicating a remarkable stimulation of sediment GHG emission by SLR. We can predict that warming and SLR significantly stimulate GHG emission of mangroves, even though they promoted plant growth. For Kandelia forests in their north limit, the positive effects of plant carbon accumulating may be counteracted by the negative effects of increasing GHG emission in future warming and SLR scenarios.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A029
Presentation mode: Oral

UAVs at Mangrove Range Limits: Providing High-resolution Insights to Species Composition and Height in Dynamic Forests

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Fine-scale changes to mangrove extent, height, and species composition occurring at range limits are often difficult to detect and monitor. Drivers like temperature, storms, precipitation and nutrients play a key role in stand characteristics but can be incredibly variable over time and space at range limits. Unmanned aerial vehicles (UAVs) offer a way to obtain high-resolution insights into forest characteristics at high temporal frequencies. We tested the application of UAVs for detecting species composition and tree height in a mangrove forest in the Santispec Lagoon in Baja California Sur, Mexico. UAV data were acquired using a DJI Matrice 100 equipped with a Micasense Rededge-M sensor and were processed using the Structure from Motion (SfM) technique to create a multispectral orthomosaic (4 cm resolution) and a Digital Surface Model (DSM; 4 cm resolution) from which a Canopy Height Model (CHM) was created. The multispectral imagery and CHM were tested for their capacity in classifying species and estimating height through a comparison to forest inventory data collected for 150 trees. Preliminary findings suggest that the high-resolution UAVs data allows for the differentiation among three mangrove species, Rhizophora mangle, Avicennia germinans and Laguncularia racemosa. In addition, mangrove heights estimated from the CHM correlate well with mangrove heights measured in situ ($r2 = 0.51$). Our findings indicate the potential for UAVs in detecting species composition and height within a mangrove stand. In the future, repeated UAV surveys could help map fine-scale changes in mangrove extent, height and composition to improve our understanding of mangrove response to drivers operating at range limits.

Session: T001 - Impacts of people on mangrove structure and function
Abstract ID: T001-A030
Presentation mode: Oral

Coastal and Estuarine Mangrove Ecosystems Are Feeling the Pinch – What Do We Know About the Threats, the Processes Affected, and the Prognosis for Not Coping?

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For more than 50 million years, mangrove habitats have flourished along shifting intertidal shorelines, seemingly in deference to changes in continental margins, sea levels fluctuating tens to hundreds of metres, combined with their direct exposure to coastal waves and winds. This small group of specialised plants clearly have highly successful strategies to cope and survive in this tightly constrained, mostly tropical niche worldwide. Currently however there is an unprecedented accumulation of pressures, their increasingly rapid delivery, and wide global influence. Never before has there been such a combination of ever-expanding human development pressures coupled with extreme alterations in climates and rising sea levels. This combination of pressures along with the growing evidence of habitat deterioration worldwide has given cause for widespread concern. A common question is how will these ecosystems cope.With this presentation, we outline and review the broad environmental conditions and constraints that define the mangrove tidal wetland habitat. In so doing, our objective has been to structure and quantify the distinct and unusual mix of processes involved in their establishment, growth and development. The framework created helps explain a number of larger ecosystem responses by tidal wetlands, including one notable incident in Australia's Gulf of Carpentaria involving the mass dieback of mangroves on a regional scale. Observations and deductions made from such case studies are essential to the development and implementation of effective management policy. The framework applied supports well-advised strategies for managing recovery while minimising socio-economic and environmental impacts.

Session: T003 - Mangrove loss and deforestation
Abstract ID: T003-A023
Presentation mode: Oral

Declining Regeneration Potential of *Rhizophora stylosa* Griff. in Mangrove Plantations: An Impact of Scolytid Beetle (*Coccotrypes rhizophorae* Hopkins) Infestations

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In mangrove conservation and rehabilitation programs, propagule predation might be a more serious concern than plant biological factors associated to reproductive success and population dynamics. This claim is corroborated by a five-year study on reproductive biology and germination ecology of Rhizophora species in a 65-ha mangrove forest in Gubat, Sorsogon, Philippines. Field monitoring and assessment was done in five 100 m2 field plots and transect lines established across the intertidal zones using point-centered quarter method and quantum geographical information system. Data collected from 100 R. stylosa trees (D130 > 2.5 cm) positioned at 20-m interval revealed that 68-85% of the harvested propagules (n= 1000/sampling) were infested with scolytid beetles (Coccotrypes rhizophorae Hopkins). The beetles attack the hypocotyl during the different stages of their life cycle, which is completed in 50-75 days. The female bore onto the hypocotyl and oviposit their eggs. The developing juveniles exclusively feed on the soft tissues of the hypocotyl until their adult stage. C. rhizophorae can undergo 3-5 generations within the duration of R. stylosa propagule development—from hypocotyl emergence to propagule dispersal. Severely infested propagules may contain an average of 18 eggs, 33 larvae/pupae and 6 adults (n=100/sampling). In addition, 76-82% of the R. stylosa wildlings collected from experimental plots (n=100/sampling/plot) showed signs of beetle infestation. Wildlings that scaped due to mild beetle's damage exhibited stunted growth and low survival rate. Thus, low viability of harvested propagules and poor growth performance and high mortality rate of planted R. stylosa seedlings in rehabilitation sites can, among other things, be attributed also to C. rhizophorae infestation. With climate change, this R. stylosa-C. rhizophorae biotic interaction may have significant implications on mangrove management, research and development in the Philippines.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A014
Presentation mode: Oral

Using Community-Based Ecological Mangrove Restoration in Abandoned Shrimp Ponds, Southern Thailand: Successes, Challenges and Lessons Learned

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The post Indian Ocean tsunami period spurred great interest in planting mangroves to increase protection and provide goods and services to local communities. Millions of seedlings and propagules were planted throughout the SE Asia region with generally very poor results. There were many reasons for failure, but typically mono-culture plantations were created where mangrove never occurred. Tidal mudflats were often targeted for planting. These afforestation efforts were generally failures wasting large amounts of money and time, while disappointing local stakeholders. Lessons not learnt largely continue. Mangrove Action Project (MAP) recognized the need to change these failing efforts. As a result MAP studied the successful Ecological Mangrove Restoration (EMR) method developed and utilized by Robin Lewis of Florida, USA for over 30 years which places strong emphasis on correcting the hydrology and removing stressors so that mangroves can regenerate naturally. MAP adopted the EMR principles but recognising the critical role of local communities, as central stakeholders, Community-based Ecological Mangrove Restoration (CBEMR) evolved.MAP has been teaching this holistic approach to mangrove rehabilitation in Asia, Latin America and Africa. MAP in Thailand has been creating demonstration sites, especially using abandoned shrimp ponds, which have left communities more vulnerable to tropical storms and coastal erosion. CBEMR is a comprehensive process, emphasizing hydrological restoration, where it's been disturbed, working with nature, correcting problems causing mangrove loss in the first place, while building strong community participation and stewardship. The CBEMR goal is full ecosystem restoration, with higher biodiversity compared to planting alone and closer species composition to surrounding natural mangrove.MAP's approach to mangrove restoration offers important insights into "best practices" ensuring long-term success in restoring a more natural, fully functioning, biodiverse ecosystem. MAP has established eleven small-scale, demonstration CBEMR sites in southern Thailand. This presentation highlights successes, challenges, and lessons learned to-date.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A016
Presentation mode: Oral

Climate Change, Mangrove Forests And Fisheries In South-East Asia And The Caribbean

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Mangroves forests constitute an important type of environment in subtropical and tropical areas, providing a range of ecosystems services from coastal protection to carbon sequestration. Additionally, livelihoods of coastal communities depend on the good quality of the forest environment, and their fisheries resources. These ecosystems are exposed to extreme events and sea-level rise, which impact the mangrove forest and its associated livelihoods. However, one of the distinctive characteristics of mangrove forest is its important resilience and adaptive capacity, through the ability of trees to cope with tidal range and salinity, and, through sedimentation and accretion, track sea-level rise.Although data are already available on the adaptive capacity of mangrove forests to cope with climate change, there is less information on the adaptation of local communities, in particular fisheries communities, to both current and anticipated near-future environmental change.Through an innovative mixed methods approach, this PhD project aims at understanding the effect of climate change on mangrove socio-ecological systems and the relation between biophysical information and local communities' knowledge and perception. Biophysical measurements will be acquired from field monitoring while interviews of local communities, in particular fisheries communities, will be conducted. The approach also provides a comparative study between South-East Asia and the Caribbean, to understand the potential variability of vulnerability and adaptation in these two very contrasting ecosystems.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A048
Presentation mode: Poster

Trends and Changes in Mangrove Canopy Height, Biomass and Carbon Stocks

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Vegetated coastal ecosystems, also called Blue Carbon ecosystems, such as mangroves, salt marshes and seagrass beds, are highly efficient carbon sinks and have been shown to capture significant amounts of carbon into sediments and plant biomass. Mangrove-lined estuaries and coastal ecosystems are significant to global biogeochemical processes and regulate the structure, productivity and function of adjacent coastal ecosystems disproportionately to their land cover. Mangrove extent, structure and changes vary considerably both on local and regional scales, resulting in large differences in estimates of losses, gains, aboveground carbon stocks and fluxes. Here we will present the changes in mangrove canopy height, biomass and carbon stocks from 2000 to 2015 in Africa and South East Asia based on spaceborne and airborne remote sensing data. We will first present the recently produced baseline global mangrove canopy height map for the 2000 epoch and updated 2015 maps for Africa and South East Asia. We will then present more recent trends in mangrove growth, cover and carbon stock changes with a focus on Africa and Asia, by using a combination of timeseries analysis of Landsat and Sentinel data (from 2000 to 2016) and updated aboveground carbon stock estimates derived from Lidar and SAR data. Finally, we will discuss the implications of our work.

Session: T003 - Mangrove loss and deforestation
Abstract ID: T003-A020
Presentation mode: Oral

March of the Mangroves in Fits and Starts: Nitrogen Fertilizer Enhances Freeze Tolerance of Mangroves

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In January 2018, the overnight temperatures along parts of the Florida coast plummeted to -4°C, causing a severe frost that did widespread damage to mangrove trees growing near their latitudinal limit. The area impacted by this frost included a long-term fertilization experiment where wetland plants, including Avicennia germinans and surrounding saltmarsh vegetation, had been treated annually with nitrogen (+N) or phosphorus (+P) fertilizers, or left untreated as controls since 2013. Our results showed that +N caused a significant increase in Avicennia tree height, cover, leaf area index (LAI) and reproduction,which accelerated the encroachment of mangroves and the conversion of saltmarshes into mangrove forests. After the freeze event, the control and +P trees exhibited extensive damage in their canopies whereas the +N trees suffered little to no damage. LAI was 50% greater in +N trees after the freeze compared to control and +P trees. Air temperature, measured with Hobos temperature loggers installed in each of the experimental trees, also showed that winter minimum temperatures were warmer under the +N trees compared to control and +P trees. Our results indicated that freeze tolerance increased significantly in response to N enrichment and was related to tree height, LAI, and microclimate. This freeze event therefore provides a case study to examine how future cold temperature extremes may interact with nutrient enrichment, plant growth, freeze tolerance, reproduction, and microclimate to affect the rate of mangrove range expansion.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A058
Presentation mode: Poster

The Molecular Adaptation in the Fluctuating Intertidal Environment in the Mangrove Tree, *Sonneratia alba*

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The adaptation in the extreme environment of intertidal zone in mangroves can provide insights into evolution. Various studies have shown adaptive evolution in mangroves at physiological, ecological and genomic level. However, these studies paid little attention to transcriptional regulation due to the absence of enough transcriptomic resources. Here, we sequenced the transcriptomes of Sonneratia alba under hypotonic, normal, and hypersaline conditions and performed transcriptome analysis to investigate the underlying transcriptional regulation of salt adaptation in S. alba. With the whole genome data of S. alba as background, we conducted functional analyses for differentially expressed genes (DEGs). We inferred that the maintenance and regulation of cellular environmental homeostasis are important adaptive processes in S. alba. i) The KEGG pathways of sulfur metabolism as well as flavone and flavonol biosynthesis are significantly enriched in up-regulated genes in leaf tissues. They are both involved in scavenging ROS or synthesis and accumulation of osmosis-related metabolites in plants. ii) There is a significantly increasing percentage of transcription factors encoding genes in up-regulated genes, particularly AP2/EREBP, NAC, WRKY and bZIP families, and the expressions of salt tolerance related TF families were characterized under hypersaline condition, suggesting that TFs also play a curial role in salt adaptation of mangroves. iii) The positively selected genes with up-regulation may contribute to adaptation in the fluctuating intertidal environment. Our study also provides valuable resource for researching adaptive evolution in extreme environment.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A003
Presentation mode: Oral

A Promising Partnership: Improving Financial Investments in Mangrove Management and Conservation by Engaging the Private Sector

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Mangroves are under threat globally and the various stakeholders, including governments and NGOs, have been working on the conservation of mangrove ecosystems for years, yet with mixed results. Lack of sustainable finance, beyond an initial project implementation cycle, is often cited as a reason for long-term project failure. A new report by the Save Our Mangroves Now! (SOMN) initiative, co-led by WWF-Germany and IUCN and supported by BMZ, provides guidance on making mangrove management investments more sustainable and impactful. The presentation by SOMN will highlight key results and recommendations of the study applicable to practitioners and policy makers through a qualitative cost-benefit analysis of case studies including one from Viet Nam (Mangroves and Markets project), interviews and a literature analysis. These include the common successes and challenges linked to mangrove conservation and the business case for the private sector to engage in sustainable management efforts. Results indicate that mangrove investments can deliver a number of environmental and social benefits. This is of great interest to governments wanting to reduce coastal damage and impact investors wanting to 'do good' while earning economic returns. Many of the benefits of mangroves are in cost-avoidance, while others provide financial revenues, such as fisheries, the carbon market or tourism. For current and future projects, this means investing in the project planning stages and embracing longer timeframes to take advantage of the diverse benefits effective mangrove management provides. To sustain mangrove conservation financially, an increasingly promising and innovative option are emerging collaborations between non-profit and impact investors using approaches like blended finance. Additionally, conservation of these ecosystems has also been shown to contribute to the UN Sustainable Development Goals and other targets and commitments like the Aichi targets and the UNFCCC nationally determined contributions.

Session: T009 - Mangrove management
Abstract ID: T009-A024
Presentation mode: Lightning Talk

Interference Competition as a Key Determinant for Spatial Distribution of Mangrove Crabs

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The spatial distribution of mangrove crabs has been commonly associated with tree zonation and abiotic factors such as ground temperature and soil granulometry. Conversely, no studies were designed to investigate the role of competition for resources and predation in shaping crab distribution in mangroves, despite these biotic factors are recognised as key determinants for spatial patterns observed in the communities colonising rocky and sandy intertidal habitats. We studied floral and faunal assemblages in two zones of a Sri Lankan mangrove, a man-made upper intertidal level and a natural eulittoral, mid-shore one. Leaf choice experiments were designed to study both feeding rate and intra and inter-specific interactions for food of sesarmid crabs in the two habitats in order to better understand crab spatial distribution. The two intertidal belts differed in terms of floral composition and crab species abundance. The eulittoral zone was strongly dominated by the sesarmid Neosarmatium smithi, while within the elevated littoral fringe four sesarmids (N. smithi, N. asiaticum, N. malabaricum and Muradium tetragonum) were more abundant. At both levels, all sesarmids showed to collect significantly more Bruguiera spp. and Rhizophora apiculata leaves than Excoecaria agallocha ones. There was no temporal segregation in feeding activity among the four species, resulting in a high interference competition for leaves. Regardless of the habitat, N. smithi was always successful in winning inter-specific fights.Our results showed that the elevated littoral fringe was more crowded with crabs, but was less favourable in terms of food availability and environmental conditions. The dominance of N. smithi in gathering mangrove leaves suggests that this species may segregate the other sesarmids into less favourable habitats. The present data strongly suggest for the first time that interference competition for food can contribute to shape mangrove crab spatial distribution.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A014
Presentation mode: Oral

Impacts of Sea-level Rise on Mangrove Forests in China

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Vulnerability of mangrove forests to sea-level rise (SLR) can be evaluated by making comparison between surface elevation change and SLR. However, such efforts are hindered by a lack of site-specific data on surface elevation changes. In addition, data of surface elevation change were typically derived from some portion of the intertidal zone, leading to inconclusive predictions of mangrove response to SLR. We quantified the sediment accretion and surface elevation change of mangrove forests along the coastal area of South China. Moreover, an empirical, dynamic model was constructed in an intertidal zone of our study site to explore how tide-dominated mangrove forests respond to different rates of SLR. The RSET data showed a rather high sediment accretion (29.6 mm yr-1 on average) and surface elevation gain (18.5 mm yr-1 on average) compared to global average estimates. Human-induced high sediment availability resulted in the rapid sediment accretion and thereby high surface elevation gains. In addition, rates of sediment accretion and surface elevation change were typically higher in the lower intertidal zone due to more tidal inundation. Our model showed that current relative SLR would not lead to the loss of mangrove cover but could alter mangrove species zonation along the intertidal profile by 2100. Importantly, rapid SLR and landward barriers can pose a considerable threat to the high-intertidal community by causing increased inundation of the high-intertidal zone, subsequent shifts in species zones, and the loss of mangrove biological and structural diversity along the intertidal profile. Overall, mangrove forests in China appear to have the strong capacity in vertical soil building by way of sufficient sedimentation to mangrove forests, and have a high resistance to SLR. Rapid SLR and landward barriers can lead to the loss of the high-intertidal community in the intertidal zone, which impairs the functioning of mangrove wetlands.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A061
Presentation mode: Poster

Macroalgae Associated to the Roots of *Rhizophora mangle* in the National Park Rosario Islands, Caribbean Colombia

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The roots of Rhizophora mangle provide a nursery habitat for many species, due to the tridimensional structure they provide, which delimit an area difficult to access to large predators. Moreover, they provide a hard substrate for many benthic species, which attach to the roots and contribute to the tridimensional structure of the ecosystem. Among these organisms, there are several macroalgae, which contribute to the primary productivity of the ecosystem and provide food and shelter to herbivores. Along the Caribbean coast of Colombia, there are over 70.000 ha of mangrove forest. However, despite the importance of this phytocoenosis, there are no studies on the macroalgae associated to mangrove roots in the country.In the present study we identified the macroalgae associated to the roots of Rhizophora mangle, in Cholón beach, Rosario islands National Park, Caribbean Colombia. We report a total of 69 species: 32 Cyanophyta, 22 Rhodophyta, 4 Phaeophyceae and 11 Chlorophyta. Of these 69 species, 24 are new records for the islands, and other 24 are new records for Colombia. We observed a very high diversity of cyanobacteria, and also the numebr of macroalgae reported are very high, if compared to similar studies in other countries. This is the first study on the macroalgae associated to mangrove roots in the Colombian Caribbean, and highlights both the high diversity of the marine flora of the Southwestern Caribbean, as well as the lack of studies on the topic.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A047
Presentation mode: Poster

Mangroves on the Move: Investigating the Effects of Mangrove Invasion on Soil Processes Along the Eastern Florida Coastline

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Both mangrove wetlands and salt marshes are highly productive ecosystems that provide valuable ecosystem services like flood protection and carbon storage. These services are tightly linked to the structure and functional ecology maintained by foundational plant species. Mangrove wetlands and salt marshes support different ecological communities, and therefore inherently have different impacts on ecosystem processes. This suggests that changes in vegetation type within tidal wetlands could alter wetland structure and ecosystem services. Along the Florida coastline, mangroves are rapidly encroaching northward into territory previously inhabited by temperate salt marsh ecosystems due to decreasing frequency of freeze events. It is currently unknown how these dramatic shifts in dominant coastal vegetation will impact "on the ground" processes within these ecosystems, such as decomposition and root growth. In order to understand how soil processes will change as a result of vegetation shifts, we investigated belowground root and soil processes at Florida field sites along marsh-to-mangrove gradients, both with and without experimental warming. We also measured soil respiration rates and 13C partitioning within greenhouse mesocosms. The black mangrove Avicennia germinans and the marsh grass Spartina alterniflora utilize different photosynthetic pathways (C3 and C4 pathways, respectively). Therefore, stable carbon isotope signatures can be used to distinguish the fractions of respiration contributed by the plants or by the soils they are grown in (derived either from mangrove or marsh vegetation). Working closely with the Guana Tolomato Matanzas National Estuarine Research Reserve, we believe that our work will provide valuable information to local land managers and environmental education programs regarding the future of coastal wetland structure and response to global change factors.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A031
Presentation mode: Poster

Exploring Changes in Bacterioplankton Community Structure in Response to Tannic Acid, a Major Component of Litterfall, in a Mangrove Ecosystem: A Laboratory Mesocosm Approach

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Litterfall constitutes a major source of allochthonous matter for bacterioplankton communities in estuarine mangroves. Tannic acid (TA), an abundant component of mangrove litterfall, leaches out and contributes substantially to DOC and DOM pools of the adjacent estuaries. Estuarine conditions of Sundarbans were mimicked in a laboratory mescocosm set-up using barrels to understand the influence of TA on bacterioplankton communities. Estuarine water from Stn3 of Sundarbans Biological Observatory Time Series (SBOTS) was enriched with TA and the change in functional bacterioplankton communities were analysed on Day 0,Day7 and Day15 of the experiment. Bacterioplankton communities were elucidated by sequencing the V3-V4 region of 16S rRNA on an Illumina MiSeq platform. Concentrations of TA, gallic acid, trace metals, nitrate,ortho-phosphate and hydrological parameters were determined on a daily basis.TA significantly affected the concentration of nitrate and trace metals in the barrels. Proteobacteria was dominant in Control and TA enriched barrels on Day 0. Their abundance then decreased significantly in the Control indicating dependence on steady flux of nutrients. Proteobacterial abundance in the TA barrels remained high indicating the use of TA as carbon and nitrogen source. TA appeared to inhibit bacterioplankton phyla including Actinobacteria, Acidobacteria and Verrucomicrobia that existed in large abundance in the Control on Day 15 but were absent in TA enriched barrels. At class level, Bacteroides was found to be present in highest abundance in the TA enriched barrels. Bacteroides can break down TA using tannase as an enzyme. This experiment indicated that bacterioplankton communities of Sundarbans could harbour genes necessary for breakdown of complex components of litterfall and recycle them into the marine microbial loop. An understanding of the components of mangrove litterfall and its influence on the resident biological communities of estuarine mangroves could be essential for our understanding of functioning of coastal ecosystems.

Session: T008 - Blue carbon
Abstract ID: T008-A042
Presentation mode: Poster

Would Wood Make the Difference? Inter- and Intraspecific Variation in Mangrove Carbon Fraction and Wood Specific Gravity in Gazi Bay, Kenya

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The tropical mangrove ecosystem harbors great potential for carbon offsetting schemes because of their exceptionally high carbon sequestration potential. As stored carbon can be directly monetized through carbon offsetting schemes, as is the case for the studied system, accurate species-specific estimation of carbon content in trees is essential. However, estimations suffer from uncertainties at various measuring scales, from the wood to the stand level, and these errors are propagated and accumulate. This study emphasizes that substantial variation even exists at the wood level, with both the carbon fraction and wood specific gravity varying inter- and intraspecifically. Ten mangrove species were sampled in Gazi Bay, Kenya, which showed carbon fraction values ranging from 45.8% (Avicennia marina) to 49.8% (Ceriops tagal) and wood specific gravity values from 0.58 (Sonneratia alba) to 0.93 (Pemphis acidula). Environmental factors (soil salinity, stand density, and elevation a.s.l.) had no to moderate influences and generated species-specific patterns. At the tree level, significant differences were found among stem, aerial roots, and branches of Rhizophora mucronata, but not among different stem tissues of A. marina, C. tagal and R. mucronata. Although repositories compiled species-specific values of both carbon fraction and wood density, they are highly incomplete for eastern African mangrove species and do not account for intraspecific and inter-site variability. Our results thus provide insight in carbon content variation and underscore the need to include these sources of variation to render future carbon accounting more accurate.

Session: T008 - Blue carbon
Abstract ID: T008-A027
Presentation mode: Poster

Mapping and Monitoring of South Asian Mangroves (1970 - 2014)

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Mangrove forests of south Asia provide critical ecological as well as societal services to the coastal community including protection from storms and tidal waves, controlling soil erosion, trapping nutrients, regulating micro-climate and groundwater dynamics as well as commercial activities such as hunting, fishing and recreation. However, both natural drivers along with developmental activities has resulted in steady loss of critical mangrove habitats. Conservation and sustainable use of mangroves require detailed information on the current and historical extents of these habitats. However, information on temporal changes in the mangrove habitats of south Asia have been very limited. This study attempts to highlight the temporal changes in the mangrove habitats of south Asia, over a period of ~40 years. Landsat images archived in Google Earth Engine was utilized to map mangrove extents over time (1970, 1990, 2000, 2005, 2014). Images were classified using Random Forest supervised classification technique in Google Earth Engine. Temporary and permanent changes in mangrove habitats are identified and major causes of mangrove change are studied at site specific level. Finally, quantitative estimates of mangrove habitat gain/loss as well as consequences of mangrove change to biodiversity and carbon stock were presented. The study develops a novel methodology to monitor and analyze changes in mangrove habitats, using an open sourced cloud platform such as Google Earth Engine. The information generated through this study will be crucial to understand the efficacy of previous conservation efforts as well as for understanding two major global ecosystem goods and services of mangroves viz. carbon sequestration and biodiversity conservation.

Session: T003 - Mangrove loss and deforestation
Abstract ID: T003-A001
Presentation mode: Poster

Darwin City's Greatest Asset: Mangroves Facing a Rising Tide in Northern Australia

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Darwin Harbour has over 20, 000 ha of mangroves in near pristine condition providing valuable ecosystem services to the community of Darwin city. Yet these mangroves are subject to variable, but high rates of relative sea level rise of 6.4mm yr^{-1}. Mangroves have the capacity to adapt by keeping pace with SLR and avoiding inundation via above (sedimentation) and below ground (root growth) vertical elevation gains. If elevation is not maintained relative to SLR the mangrove and accommodation space is limited, the ecosystem benefits they provide to the Darwin community will be compromised. Macro-tidal mangrove estates, such as Darwin Harbour are considered to be more resilient to SLR than meso- and micro-tidal counterparts, although this assertion has rarely been tested. The effect of SLR is made more complex by interacting environmental changes such as alteration in hydrology and sediment availability due to climate change (impacts from altered rainfall, wind and wave action from variations in monsoon strength), catchment land use change, industrialisation and urbanisation. Darwin Harbour has been a site for several SLR modelling exercises, yet there is a scarcity of field based observations of in situ sedimentation rate and surface elevation change. Therefore it is important to establish a spatially distributed and long-term monitoring program to determine the impacts of SLR and anthropogenic pressures that informs the management of Darwin Harbour's mangroves. A network of 39 rod surface elevation tables and marker horizon (RSET-MH) stations have been installed in Darwin Harbour's mangroves to determine the contemporary surface elevation change. We report on 2 – 4 years of spatially variable elevation changes, across a tidal and floristic composition gradient, and compare these contemporary changes to historic sedimentation rates from radioisotope (^{210}Pb) dating.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A013
Presentation mode: Poster

Mapping the Global Drivers of Mangrove Loss and Vulnerability

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An understanding of the local factors contributing to past mangrove loss is critical to the planning of restoration and policy initiatives that seek to address future mangrove vulnerability. Here we present global, 30 meter resolution maps of mangrove loss drivers from 2000 to 2016, and resultant forest vulnerability in each mangrove-holding nation. Aggregated changes in NDVI over three epochs of time are used to identify regions of mangrove loss extent, and Google Earth Engine-based random forest machine learning algorithms then classify land cover changes from mangrove to wet soil, dry soil, or water within loss regions. A series of decision trees uses several global-scale, 30 meter resolution datasets to identify the ultimate driver of mangrove loss as agriculture, aquaculture, human-settlement, erosion, or dieback. Past trends in the prevalence of each driver are projected toward future scenarios that seek to estimate the risk of further expansion of mangrove loss. Continental, national, and sub-national trends in the prevalence of each driver reveal the most critical risk factors to address through localized restoration frameworks, identifying potential stressors as well as regions of low vulnerability. All global loss driver maps are compiled in an interactive application known as the Electronic Coastal Monitoring and Assessment Program (EcoMap), enabling users to understand the extent and drivers of both past and potential future losses. EcoMap provides the information necessary to inform coastal resource planning measures and sustainable development mechanisms on the local to the global scale.

Session: T003 - Mangrove loss and deforestation
Abstract ID: T003-A016
Presentation mode: Oral

Linking International Trade with Mangrove Conservation Outcomes: a Random Forest Supervised Classification Analysis in Sebilang National Park, Indonesia from 2000 to 2017

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Although conservation efforts are always implemented locally, the forces that shape the decision-making process and conservation policy are increasingly global. To simultaneously promote human prosperity while protecting biodiversity requires an understanding of how interactions between local and global forces shape conservation management. Focusing on the mangrove ecosystem, this study takes Sebilang National Park in Indonesia as a pilot site to investigate how global material exchanges may influence ecosystem conservation efforts. By applying Random Forest supervised classification to identify land use and land cover change (LULCC) in the park between 2000 and 2017, the study aims to evaluate conservation effectiveness under increasingly global demands as mangrove loss threat. The results testified a 10% increase of mangrove forest from fish ponds and agriculture lands, owing to local mangrove restoration projects. However, a booming expansion of palm oil is identified in the park as well with a 390% increase during the period. Our study approves the effectiveness of mangrove conservation efforts in this national park but highlights the potential mangrove deforestation due to palm oil plantation expansion. Although for the moment, palm oil plantation has not replaced mangrove forests, this booming area increase of the land use type for the past thirty years even in the national park indicates its current popularity in Indonesia for large-scale commodity production under prosperous global demands. This study brings us an alert to more closely monitor and understand spatial and temporal variation in the mangrove forest landscape under this global palm oil demands in Indonesia. Future research and policies should address more on monitoring deforestation driven by land use and land cover change (LULCC) and conserve mangrove forest ecosystem in the area.

Session: T001 - Impacts of people on mangrove structure and function
Abstract ID: T001-A018
Presentation mode: Lightning Talk

Patchiness of Distribution of Mangrove Insects Suggests the Need to Protect Multiple Sites

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Mangroves might be poor in tree species, but the insect fauna is unexpectedly rich. Mangroves in Singapore are here used as a model for an in-depth study of insect diversity. Thirty-two insect groups were surveyed during a two-year project involving 4 sites (13 stations). Phenology seems to depend on the monsoons with e.g. beetles, hover flies, robber flies and horse flies having their highest abundance/adult activity during the dryer periods while other groups such as dolichopodid flies are most active during the rainy seasons. Dolichopodidae flies proved to be good bio-indicators for site quality assessment, being one of the most abundant and diverse groups, specific for microhabitats as shown in DCA analysis. More than 37,000 specimens belonging to 159 dolichopodid morpho-species were collected. The total species number of dolichopodids for Singapore's mangroves is estimated to exceed 220 based on species richness estimation. Hence, only 72% of the expected species richness was found during the project. In each of the 4 sites, around 60 species were found which may be the carrying capacity. Only 24 species were common to all 4 sites, 73 species were unique for a site, thus indicating high patchiness. Haplotype networks confirm low interconnectivity. Similar trends of patchiness were found for most other insect groups which implies that several mangrove sites have to be protected in order to protect the community.

Session: T001 - Impacts of people on mangrove structure and function
Abstract ID: T001-A028
Presentation mode: Oral

Species Turnover in the Mangroves of the South-china Sea: a Comparison of the Predatory Fly Communities of Tropical Singapore with Subtropical Hong Kong

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Mangroves contain a specialized insect fauna that is restricted to mangroves. Here, we studied the beta diversity of Dolichopodidae (Diptera) between one tropical and one subtropical site in the South-China Sea. The mangrove Dolichopodidae of Singapore is fairly well known with about 220 species that are exclusive to mangrove compared to 38 species in Hong Kong. All species have been NGS barcoded and the haplotypes seem to be congruent with the morpho-species. One species in the genus Diaphorus has identical haplotypes. This species is only found in back mangroves. Seven species from Singapore (3% of known fauna) are also known from Hong Kong (barcode distances <3%). Most of these species are rare in Singapore while they can be common in Hong Kong. The remaining species differ with regard to morphology and DNA barcodes (>3%); i.e. the beta diversity is high. Similar patterns are observed for the hybotid genus Elaphropeza represented by a species-group of small, yellow predatory flies that are also exclusive to mangroves. Six morphologically very similar species were found in Hong Kong and Singapore. They differed mainly with regard to small differences in male terminalia while the barcodes differed by > 12%. Based on these analyses, we conclude that the predatory fly communities in Singapore and Hong Kong are closely related but the species turnover is very high.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A014
Presentation mode: Poster

Internal Mesophyll Structures Contribute to Carbon Accumulation in Mangrove Leaves

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Bifacial and isobilateral leaves in dicotyledon plants have different arrangements of their palisade and spongy mesophyll tissue. Since different anatomic leaf structures tend to affect carbon accumulation rates (A), we hypothesize that an isobilateral leaf with palisade tissue structures on both sides of the leaf would result in a two-fold increase in A, due to photosynthesis on both sides of the leaf is possible versus the bifacial leaf with palisade cells on a single side. We examined the leaf anatomical structure in 29 mangrove species. Isobilateral leaves were present in 11 of the 29 species (38%), which is a higher percentage than typically found in terrestrial plants. Two species, Sonneratia apetala (isobilateral leaf) and Avicennia marina (bifacial leaf), were selected as representatives of these two leaf types for further study. We monitored stem sap flow, daily A, and leaf angles over one year. Leaf angles of isobilateral leaves were about 1.7 times more tilted than the bifacial leaf. Both leaf sides of Sonneratia exhibited higher diurnal A and photosynthetic capacity than both sides of Avicennia, resulting in potentially faster growth for the stands. The leaf angle of Sonneratia was 70.5° to the earth surface, while that of Avicennia was 7.3°. Vertical leaf angle can minimize the photoinhibition risk and increase light transmittance of leaves under strong light, especially at midday. By monitoring annual water use versus A at the stand level, net primary productivity (NPP) of individual Sonneratia stands was 317 g C·m-2·yr-1, which was about twice as much as Avicennia, 160 g C·m-2·yr-1. The current results indicate a significant potential contribution of leaf anatomical structure to higher leaf carbon accumulation. This may implicate an anatomic reason behind high carbon assimilation of mangroves with high proportions of isobilateral leaves.

Session: T008 - Blue carbon
Abstract ID: T008-A023
Presentation mode: Poster

Modeling Mangrove Response to Changing Sea Level

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Accelerations in the apparent rate of sea-level rise (SLR) pose a major threat to mangrove ecosystems. However, mangrove response to SLR has varied depending on local topography, terrigenous sediment availability, tidal range, and geomorphic setting. Low island mangroves in the Caribbean have been shown to compensate to increases in SLR by biogenic processes and peat accumulation. We hypothesize that low elevation Pacific atolls in carbonate settings that lack rivers may be more sensitive to SLR than Caribbean examples may suggest, owing to the higher relative rates of SLR in the lower Pacific basin, sediment-poor environments, and hence poor rates of vertical accretion. Our goal is to determine if these atolls can keep up with SLR via the production of biogenic sediments by mangroves or redistribution and accumulation of carbonates, and suggest threshold rates of SLR. We propose a general conceptual model for mangrove persistence on a low-lying atoll in the southwest Pacific. Our study site is on the low elevation atoll of Ouvea, a part of the Loyalty Islands, New Caledonia. The forest is dominated by two mangrove species - Bruguiera gymnorrhiza and Rhizophora stylosa. We have initiated a series of studies to provide new insights into key processes associated with mangrove-tree growth, organic-sediment production and how resulting surface-elevations in the mangrove forest are tracking with SLR. A key question we address within our modeling framework is the relative contributions of carbonate sediment trapped within the mangrove forest and biogenic peat production. We demonstrate how these processes influence mangrove-forest response to SLR.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A011
Presentation mode: Oral

Scenario-based Projection of the Impacts of Sea Level Rise on Mangroves

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Mangrove forests inhabiting the intertidal zone of tropical coasts are ecosystems of high biodiversity and productivity which makes them worthy of protection. In the context of climate change induced sea level rise (28 - 98 cm by the end of the 21st century) and increasing coastal development it is essential to understand the fate of this ecosystem. Taking the example of Buffalo Creek (Northern Territory, Australia) I investigated how the potential habitat of mangroves could change until 2100 under the four RCP climate scenarios of the IPCC. The methodology builds a bridge between a relatively old ecological concept, complex projections of sea level rise and modern GIS tools. The notion of different inundation classes in mangrove forests – postulated by J. G. Watson in 1928 – serves as basis. Five different zones differing in inundation depth and frequency (and therefore in species) were determined by using tidal data. The shift of these zones (i.e. inundation classes) with rising sea level was simulated in a GIS by means of a high-resolution digital elevation model (5 m) coupled with information on mangrove species zonation. The findings from this show that overall the intertidal zone and therefore the potential habitat of mangroves will grow in each scenario. Benefits will arise for the mangrove zones dominated by Sonneratia alba, Rhizophora stylosa and Bruguiera exaristata since their respective inundation classes will grow in size the most. In contrast, Ceriops australis – inhabiting landward zones of the forest – will increasingly suffer from habitat loss. Despite some limitations the methods together with an elaborated description of selection criteria for further study areas and the data quality requirements provide a good starting point for a standardized assessment of sea level rise impacts in mangrove forests all across the tropics. (Please note: this is an extended abstract of my bachelor thesis.)

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A016
Presentation mode: Poster

Sediment Accretion and Carbon Accumulation Rates in Disturbed Mangrove Forests of North Sumatra, Indonesia

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Mangrove ecosystem stands in the middle of complex systems with various elements that mutually affect one and another. Management and development regulation in the surrounding area have impacts not only forest structure but also sedimentation regimes in many ways. Moreover, accretion rates are driven by several processes that dissimilar for one and another region. In this study, 210Pb natural radionuclide was used in order to measure the accretion and carbon accumulation rates following the hydro-geomorphic settings as the response of the disturbed condition of natural mangrove in the North Sumatran area. As a comparison, restored mangrove area after 20 yr old acquired higher tree density and aboveground biomass (AGB) (1332.38 ± 67.19 trees ha-1; 155.66 ± 12.74 Mg ha-1) compared with natural but disturbed mangrove (686.05 ± 59.31 trees ha-1; 81.29 ± 12.53 Mg ha-1) ($F_{1,3} = 9.68$, $p = 0.004$). This pattern also notices in belowground biomass (BGB), basal area, species richness, and diversity as well as soil carbon. This is indicate restored mangrove are capable to exceed the natural mangrove which manages in precise ways. In disturbed mangrove, average value of accretion and carbon accumulation rates, the highest was in fringe area with (8.56 ± 0.46 mm yr-1; 81.71± 85.36 g C m-2yr-1), followed by mudflat (5.28 ± 0.29 mm yr-1; 49.65 ± 14.9 g C m-2yr-1), and interior (4.28 ± 0.24 mm yr-1; 55.32 ± 22.67 g C m-2yr-1). Furthermore, very low compared with the global average of carbon accumulation rate for mangrove and saltmarsh (163 - 226 g C m-2yr-1), also not significantly different in hydro-geomorphic settings. Regional aspect is still playing an important role in sedimentation. However, increase accretion rates not necessarily increase the value of soil carbon accumulation rates.

Session: T008 - Blue carbon
Abstract ID: T008-A004
Presentation mode: Poster

Adaptive Roots of Mangrove Plant *Avicennia marina:* Structure and Transcriptome Analyses

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Avicennia marina is a common mangrove species and a pioneer in community succession. A. marinaroot system is highly specialized to the tidal wetland environment where they suffer from hypoxia conditions. Adapting to such environment, A. marinahas evolved a sophisticated root system to better secure itself on the muddy soil (anchor root) as well as breathing root (the pneumatophore) growing geotropically and anti-geotropically, respectively. However, how this specialized root system is developed from the same cable root is not understood. By paraffin sections of the pneumatophore specific developmental stages, it was revealed that the pneumatophore formation was a complex dynamic process including pneumatophore initiation and emergent stages. Anatomical differences amongst the negative geotropic shoot, geotropic anchor roots, and gas exchanging pneumatophore, clearly reflect their functional diversion. In particular, pneumatophore tip contents abundant aerenchyma tissues and a thin cap structure. To elucidate the gene expression regulation of these root formations, transcriptomes of the tips of shoot, the initials of the anchor root and pneumatophore were performed. Through transcriptome analysis, we identified that the actions of plant hormones brassinosteroid and auxin regulate different root initiations. For examples, in anchor root initiation, auxin responsive gene ARF3was downregulated, but in pneumatophore initiation, ARF3was up-regulated, indicative thatARF3is important for different root development. Another auxin related gene IAA19may play a key role in pneumatophore development because it was down-regulated in pneumatophore initiation, consistent with former studies where IAA19/mgs2mutant in Arabidopsis showed negative geotropism in root and shoot. Moreover, the potential molecular mechanism of pneumatophore negative geotropismwas co-regulated by the interactions of statoliths, calcium signaling pathway and auxin pathway.These results offer potential ground for mechanistic understanding of the formation of these adaptive features of mangrove plants.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A019
Presentation mode: Poster

Food Selection by Detritivorous Crabs Among Detritus from Different Sources

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Detritus-feeding mangrove crabs of the Sesarmidae family are key drivers of ecosystem processes, such as sediment turbation and organic matter turnover. As ecosystem engineers, they shape the environmental conditions of the substratum by building burrows in the sediment. As mangroves receive detrital matter from both terrestrial and marine adjacent ecosystems, the potential of these detritivores to process detritus from different sources is relevant for our understanding of organic matter turnover and dynamics, and budgets of in- and outflows of detritus between mangroves and neighbouring ecosystems such as seagrass beds. Laboratory experiments will be set up to assess food preferences and ingestion rates of various detrital food sources of marine or terrestrial origin (e.g. macroalgae, seagrass, mangrove, saltmarshes and coastal forests) by mangrove crab. Comparing the chemical composition of food sources and egested fecal pellets with high resolution through (pyrolysis-)gas chromatography/mass spectrometry will not only provide insight into differential digestion of different food sources but also on the chemical stability of different detrital sources against microbial decay upon being deposited in the sediment by detritivorous crabs. Of particular interest in this context is the storage of different food sources inside crab burrows. This project will answer questions on the reasons and advantages of this behaviour for the crab and whether male and female crabs behave differently in this respect. The latter aspect will prove relevant in the context of crab-fisheries that –be it by legal constraints or because of larger sizes of male crabs– preferentially remove male crabs from the mangrove system

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A021
Presentation mode: Poster

The Role of Glycine Betaine in Range Expansions; Protecting Mangroves Against Extreme Freeze Events.

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Due to a warming climate, mangroves are expanding their range poleward. As mangroves expand their range limit poleward, leading edge individuals are likely to experience an increased incidence of freeze events. However, the mechanism used by mangroves to survive freezing conditions, is unknown. Here, we coupled common garden experiments at different locations experiencing variable winter freeze conditions to show glycine betaine, an organic osmolyte, increases significantly with cold treatment, playing an important role in the freeze tolerance of Avicennia germinans, a neotropical mangrove. We found glycine betaine accumulation was similar across all freeze treatment locations and source populations, suggesting glycine betaine is not a range-limit adaptation and is used for freeze tolerance by A. germinans irrespective of source population. However, plants sourced from populations that do not experience freezing conditions exhibited greater rates of mortality, indicating range-edge populations of A. germinans have other heritable adaptations in addition to glycine betaine for freeze tolerance.Extreme weather anomalies, which are predicted to increase with climate change, are expected to be a major force shaping coastal habitat diversity, while also driving mass mortality at the range limit. As mangroves continue to expand poleward, leading edge individuals are likely to experience an increased incidence of freeze events. Our findings suggest freeze tolerance in this species may be genetically based and that leading edge A. germinans have the potential to survive extreme freeze events and recover post freeze, allowing for their continued expansion poleward and may act to promote adaptation of freeze tolerance in range-edge populations.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A002
Presentation mode: Poster

Foliar Water Uptake by Coastal Wetland Plants from an Atmosphere of High Humidity: a Novel Water Acquisition Mechanism for Arid Zone Mangroves.

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An increasing number of studies have linked climate change to species range shifts, changes in community structure and productivity in mangroves. Many of these range shifts are associated with shifts to higher latitude, with species expanding their range poleward with increasing temperatures. Temperature, however, does not explain range limitation along arid coastlines where mangroves are often limited in range and structure at lower latitudes than proposed by thermal limits alone. Here, mangroves are likely limited by arid conditions, in particular low annual rainfall, which has been shown to limit plant growth and productivity. Rainfall in arid regions is often too low to meet the physiological demands for growth and reproduction of many plant species living in these habitats. Plants living in arid zones often have water saving adaptations and also access available water sources such as dew and mist through foliar water uptake. Here, through the use of controlled growth chamber and field experiments in Baja, Mexico, we investigate the potential for foliar water uptake in mangroves living in arid zone environments. We propose that mangroves living in arid zones access foliar water under high atmospheric humidity through mist, dew and limited rainfall when available. We suggest foliar water uptake as an important water acquisition mechanism for arid zone mangroves to improve plant water status and enhance physiological processes.The results of this study will increase our understanding of how coastal wetland systems respond to changes in fresh water availability, and how these changes impact on coastal systems and effect mangrove range expansion. By understanding how coastal wetland communities respond and potentially change as a response to changes in non-saline water availability we can better plan for future scenarios such as expansion of arid regions, increased extreme weather events, loss of habitat and rising sea levels.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A028
Presentation mode: Oral

Speciation with Gene Flow via Cycles of Isolation and Migration: Insights from Multiple Mangrove Taxa

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Allopatric speciation requiring an unbroken period of geographical isolation has been the standard model of neo-Darwinism. While doubts have been repeatedly raised, strict allopatry without any gene flow remains a plausible mechanism in most cases. To rigorously reject strict allopatry, genomic sequences superimposed on the geological records of a well-delineated geographical barrier are necessary. The Strait of Malacca, narrowly connecting the Pacific and Indian Ocean coasts, serves at different times either as a geographical barrier or a conduit of gene flow for coastal/marine species. We surveyed 1700 plants from 29 populations of 5 common mangrove species by large-scale DNA sequencing and added several whole-genome assemblies. Speciation between the two oceans is driven by cycles of isolation and gene flow due to the fluctuations in sea level leading to the opening/closing of the Strait to ocean currents. Because the time required for speciation in mangroves is longer than the isolation phases, speciation in these mangroves has proceeded through many cycles of mixing-isolation-mixing, or MIM, cycles. The MIM mechanism, by relaxing the condition of no gene flow, can promote speciation in many more geographical features than strict allopatry can. Finally, the MIM mechanism of speciation is also efficient, potentially yielding m^n (m>1) species after n cycles.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A004
Presentation mode: Lightning Talk

Temporal Dynamics of Microbial Communities in Mangrove Sediments: On the Effects of Tidal and Diel Cycles

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Sediment microbial communities play an essential role in organic matter dynamics in mangrove ecosystems which are subject to temporal variation at different scales, such as tidal and diel variation. While these sources of variation are expected to have a strong influence on sediment microbial activity, this has scarcely been investigated. Here, we studied the effects of tidal and diel cycles on sediment microbial activity in mangrove forests on San Andrés Island (Colombia). Temporal trends were assessed at three intertidal sites exhibiting different mangrove species composition and tidal regimes due to elevation. We jointly assessed temporal variation in sediment environmental conditions and sediment microbial activity (via deep sequencing of the bacterial 16s rRNA, and selected microbial enzyme activities). This approach will provide valuable insights into how microbial communities respond to temporal changes in their environment, and how changes in microbial activity may, in turn, influence biogeochemical processes that might be involved in organic matter dynamics and, thus, be of high interest in the context of Blue Carbon. Preliminary results show that inorganic nutrient concentrations, oxygen penetration depth, and total carbon and nitrogen contents varied by 90-340%, 160-280%, and 20-80% of their respective mean values over the course of two weeks. Given the influence of such factors on microbial communities, we expect to also observe a strong temporal signal in the microbial activity (ongoing analyses). Based on our results, we will propose guidelines for a better standardization of microbial research in mangrove ecosystems. Moreover, we will discuss the validity of the comparison of microbial communities in mangrove ecosystems at a large scale and across divergent sampling times, and our ability to conduct meta-analyses of existing data sets.

Session: T008 - Blue carbon
Abstract ID: T008-A052
Presentation mode: Lightning Talk

Changes in Mangrove Forest Cover and Their Effect on Community Composition, Ecosystem Processes and Spatial Subsidies

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Mangrove trees shape their physical, chemical and biological environment: their roots trap sediments, take up and release chemical compounds from and into the sediments and the surrounding water; their canopy produces shade; and their leaf litter is a source of nutrients for detritivores and microbes. All this affects the composition of associated microbiota (bacteria, archaea, fungi, protists) and fauna, as well as the processes that are driven by these organisms, such as organic matter (OM) turnover and carbon cycling. Moreover, because mangroves both produce organic matter and trap organic matter from other sources (marsh plants, seagrasses, algae), mangrove trees also shape the nature and abundance of organic matter subsidies. We took advantage of a large-scale experiment manipulating the cover of mangroves versus marsh plants to assess how changes in mangrove forest cover affected 1) associated microbial and faunal communities, assessed via metabarcoding of environmental DNA in the sediment, and 2) the content, structure (assessed via pyrolysis-gas chromatography-mass spectrometry) and origin of OM in the sediments. From this, we infer how changes in mangrove forest structure affect ecosystem processes, particularly OM dynamics.

Session: T003 - Mangrove loss and deforestation
Abstract ID: T003-A013
Presentation mode: Poster

The World Is Getting Stormier. How Will Coastal Mangrove Forests Hold Up?

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Mangroves are disturbance-driven ecosystems, but predicted increases in frequency and intensity of storms could result in disturbance regimes that are too extreme for forests to outpace. Loss of forest biomass means loss of ecosystem services such as coastal protection. How is the storm surge impact on mangrove forests linked to forest protective capacity? The trees that compose the mangrove forest show a wide range of characteristics. Different species have different mechanisms for dealing with wind and wave loading. This results in different forest population dynamics under disturbance impact. Furthermore, salinity and mechanical stress impact a tree's growth, so that trees in highly saline areas may be weaker, and trees in highly exposed areas may be stronger. We will measure tree branch and petiole strength for seven mangrove species in sites with various salinities and wave exposures in the southern Guangdong province of China in early 2019. Our observations may be used to predict changes in forest biomass, which can help to identify if additional restoration works are needed to maintain the forest as a flood barrier.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A039
Presentation mode: Poster

The Effect of Soil Warming on Avicennia Germinans and Spartina Alterniflora Species Interactions and Belowground Processes: A Mesocosm Approach

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Although multiple studies have investigated the effects of atmospheric warming on mangrove range expansion into salt marsh, data gaps exist in our understanding of how belowground processes are affected by soil warming and what implications this may have for coastal plant communities. At the marsh-mangrove ecotone we suggest that the effects of soil warming may be particularly important in modulating key plant and soil responses and species interactions. To investigate this, we established a tidal mesocosm experiment consisting of four vegetation treatments and three estuarine water temperature regimes in a completely cross-classified manner. The four vegetation treatments are Avicennia germinans and Spartina alterniflora planted in monoculture and in mixture, plus unvegetated soil. Marsh soil and transplants of A. germinans and S. alterniflora were collected at the Guana Tolomato Matanzas National Estuarine Research Reserve (GTM NERR), St. Augustine, Florida, USA, from areas adjacent to a companion warming chamber experiment. Semidiurnal tides have been established to simulate the tidal frequency and flooding depth at GTM NERR (semi-diurnal tide with 1.4 m range and high tide flooding depth of 25 cm above marsh surface). The three estuarine water temperature regime treatments represent the current ambient seasonal water temperature fluctuations at GTM NERR plus two elevated water temperature regimes of 2.5 and 5 C above ambient temperatures in the summer and 5 and 10 C above ambient temperatures in the winter. Data collection is currently underway and includes plant above- and belowground architecture and productivity, soil biogeochemistry, decomposition, and carbon dynamics. An initial six month harvest is planned for May 2019. This type of controlled mesocosm approach in conjunction with companion field experiments can provide novel information to advance our understanding of pivotal environmental drivers of shifts in plant community composition and provision of ecosystem services under future warming scenarios.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A033
Presentation mode: Poster

Effects of Tree Thinning on Benthic Macroinvertebrate Community in Mangroves

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Benthic macroinvertebrates play an important role in energy transfer in the mangrove ecosystem. However, their habitat and foraging space may be affected by the density of mangrove tree. This study was aimed to determine the correlation between mangrove tree density and the abundance and community structure of benthic macroinvertebrates. Two species of mangroves (Kandelia obovata and Avicennia marina) were investigated on the coast of Fangyuan, Changhua, central western Taiwan. Three sampling sites were set: seaward site of A. marina (SA), landward site of A. marina (LA), and site of K. obovata (K). The succession of species composition of the benthic macroinvertebrates was examined under different mangrove thinning strategy. The results showed that both abundance and species richness of benthic macroinvertebrates of SA were higher than LA. This indicates that the seaward site has the higher biodiversity than the landward site. By comparing two sites K and LA, those distances were similar from the coast, K has the higher biodiversity than LA. After thinning, irradiance and soil temperature increased and thus resulted in higher biomass of benthic algae. However, different thinning effects occurred between seaward site and landward site. The community of macroinvertebrates were only affected in the first half year of SA, while the thinning effects were still apparent after more than one year at the landward sites. It is likely that periodic tidal flushing reduced the thinning effect. In conclusion, mangrove tree density did affect the abundance and community structure of macroinvertebrates, but the tidal flushing may regulate the effects.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A011
Presentation mode: Oral

Predicting the Dispersal Patterns of a Non-native Mangrove Species in an Estuary of Southern China Under Sea-level Rising Scenarios

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A non-native mangrove species, Sonneratia apetala, was planted near mangroves in Zhangjiang Estuary of China in 2007, which invaded mudflats of the whole estuary in early 2014. Four years after being cleaned in 2014, trees and saplings of S. apetala can still be found. We carried out two surveys for species distribution in 2014 and 2018, and tested the effects of salinity and elevation on its survival and early growth by simulated experiments. Using the database of salinity, elevation, and area boundary of Zhangjiang Estuary, we built a marine topographic model of the estuary by applying the ordinary kriging spatial interpolation function with Arcgis 10.4. We predicted the potential dispersal patterns of this non-native mangrove species under two sea-level rising scenarios from IPCC. The field surveys showed that the surface soil salinity of Zhangjiang Estuary was mesohaline between 0~12 PSU. Most of the trees and saplings of S. apetala grew on the mudflats with soil salinity of 2~12 PSU in the estuary. The salinity simulated experiment also showed significant depress in seedling biomass if salinity higher than 20 PSU. All seedlings in elevation simulated experiment survived in current elevation and in the two sea-level rising treatments (RCP 4.5 and RCP 8.5 scenarios projection to 2100), although biomass in RCP 8.5 treatments was significantly decreased. The marine topographic models showed that S. apetala would occupy the mudflats with mesohaline in current elevation if without management. However, the potential dispersal patterns would be changed by rising sea-level. According to well performance of seedlings in low elevation treatments of simulated experiments, the potential dispersed region of S. apetala under RCP 4.5 would be the mudflats in whole estuary. While under RCP 8.5, the elevation of currently mudflats would greatly decline, which would sharply reduce its potential dispersed regions.

Session: T001 - Impacts of people on mangrove structure and function
Abstract ID: T001-A008
Presentation mode: Poster

The Relevance of Particulate Matter Interchange Between Mangrove Forests, Seagrass Beds and Tidal Flats for Singapore Blue Carbon

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Mangrove forests and seagrass beds in South East Asia are reported as being important "Blue carbon" sinks with high amounts of carbon stored. Connectivity between adjacent ecosystems has been shown to influence processes such as production within ecosystems, due to the interchange of particulate organic matter and nutrients that can enhance primary production. We estimated the carbon stored in the living biomass of mangroves and seagrasses, using species-specific allometric equations, and quantified the sediment carbon content. During ebb tide, particulate organic matter, dissolved organic carbon, particulate organic carbon and chlorophyll-a contents were measured. The exchange of particulate organic matter among ecosystems (mangrove forests, seagrass beds and tidal flats) was quantified based on stable isotope signatures, using a MixSIAR model approach. Aboveground carbon stores in the biomass ranged from 25 to 202 MgC ha-1, belowground biomass stored 12 - 69 MgC ha-1, and the sediment carbon stock was between 4 and 50 MgC ha-1). Dissolved:particulate ratio vary between 0.8 and 4.2 being dissolved organic carbon higher in most of the locations. Contents of dissolved organic carbon and chlorophyll-a were significantly correlated ($p<0.01$ and $R2=0.3$). Locations where mangrove forests had higher sediment carbon also exhibited higher carbon contents in the adjacent tidal flats. Mangrove trees and oceanic sources were the greatest contributors to particulate organic matter in all locations except in Sungei Buloh where terrestrial plants contribute more than mangrove forests. Macroalgae contributed more to the particulate organic carbon than seagrasses. Our results suggest that depending on the location mangrove forests act as donors or recipients of carbon for adjacent ecosystems such as seagrass beds and tidal flats. Connectivity of adjacent ecosystems should be taken into account in ecosystem management in order to enhance the ecosystem services of carbon storage provided by mangrove forest and adjacent coastal ecosystems.

Session: T008 - Blue carbon
Abstract ID: T008-A037
Presentation mode: Poster

Factors Affecting Seascape Carbon Dynamics: a Perspective from Zanzibar Mangrove Forests and Seagrass Beds

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Mangrove and seagrass plants take up and store carbon from the atmosphere in their biomass. Additionally, the architecture of mangrove tree roots and the shape of seagrass leaves could enhance the retention of suspended particulate matter within the ecosystems and support carbon accumulation. Most studies in mangrove forests and seagrass beds Blue carbon have been done with the focus in one ecosystem without taking into account adjacent ecosystems. Evaluating mangrove forests and seagrass beds along with adjacent ecosystems will contribute to a better knowledge of carbon dynamic at the seascape level. We selected six locations in Unguja Island of the Zanzibar archipelago, three mangrove forests adjacent to seagrass beds, one isolated mangrove forest, and two isolated seagrass beds. We quantified carbon in mangrove and seagrass biomass and the quantity of organic and inorganic carbon in the sediment across the seascape, including adjacent mud flats and terrestrial soils. We evaluated factors that could affect the sediment carbon content in the sediment, using linear and generalized linear mixed effects models with the factors biomass, species composition and functional richness (traits), sediment characteristics and area of the ecosystem as predictors. The tree community composition differed among locations, as well as the carbon content of the mangrove biomass. Seagrass species composition also varied across locations. The sediment carbon within mangrove forests exhibited a higher proportion of organic carbon, while in the sediments of seagrass beds the inorganic carbon presented a higher proportion. In mangroves forests, factors like forest area and functional richness explained the differences in sediment carbon content among sites. In seagrass beds, functional richness explained the differences in sediment carbon content among sites. The separation of organic and inorganic carbon in tropical blue carbon stock studies will help to improve our understanding of dynamics in the different carbon components.

Session: T008 - Blue carbon
Abstract ID: T008-A030
Presentation mode: Poster

Integrated Assessment of the Mangrove Ecosystem Services in the Bangladesh Sundarbans Complex

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The Sundarbans, the world's largest mangrove forest, provides multiple ecosystem services (ES) to human societies. However, studies on ES assessment and utilisation patterns of various goods and services are relatively scant. Despite the Sundarbans' complex Social-Ecological Systems (SES) providing a range of ES, studies pinpointing various ES following any internationally recognized frameworks are scarce. By fussing primary and secondary data, this study aims at assessing ESs and highlights the importance of the Sundarbans mangrove for well-being of human societies. To compile qualitative and quantitative data, we surveyed 240 households with a social-ecological questionnaire and 60 expert interviews in the South-West Bangladesh. In accordance with the Common International Classification of Ecosystem Services (CICES) framework, 17 sub-categories of ES in the Sundarbans including 7 provisioning, 7 regulation and maintenance, and 3 cultural services were recorded. In the Sundarbans SES, traditionally, fishermen communities "use" 34 mangrove floral component (e.g. firewood, construction, furniture, thatching materials, medicinal and chemical, fodder, culinary) and 202 fishery species (e.g. fin-fishes, shrimps, crabs, mollusks) for their livelihood and income. Fisheries (food), followed by coastal protection, ecotourism and recreation, artificial fisheries (aquaculture - shrimp farming) and natural fisheries (nursery or habitat function) were ranked as the top five ES in this study. The production and revenue generation from various ES indicates a decreasing trend since 1995 onwards mostly due to policy and management intervention for conservation to combat mangrove degradation. Since past 17 years, the sources of revenue sharply shifted from wood and timber (which is very important and usual worldwide) to fisheries resources, tourism, cultural heritage and non-timber forest products (NTFPs). Nevertheless, incorporating the values of ES, the local utilisation pattern of mangroves, necessities of adequate alternative options are vital in decision-making to ensure conservation and better management options in the Bangladesh Sundarbans SES.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A009
Presentation mode: Poster

Developing a Blue Carbon Mangrove Conservation Project in Cispata, Colombia

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Conservation International, the national marine research institute, regional environmental authorities and local stakeholders are working with Apple, in Cispatá, Colombia, to establish the first mangrove blue carbon conservation project. The project will produce the first Verified Emissions Reductions through the new Wetlands Conservation and Restoration methodologies under the Verified Carbon Standard. Approximately 12,000 people live in the area, but there are high levels of poverty, with communities depending on the mangroves for wood, agriculture, forestry, fisheries and tourism activities. Recently, the mangrove ecosystems and the carbon stores in Cispata, are experiencing pressure from agricultural lands, destructive tourism infrastructure, and increased logging. Our project will result in the avoided degradation and deforestation of 9,600 ha of natural mangrove forests and the restoration of mangrove forest cover by 1,800 ha, which together will generate an estimated 1 million tCO2eq of VCUs over the life of the project. This generated carbon value will provide a significant component of the long-term sustainable financing strategy for enhanced ecosystem conservation and restoration, sustainable ecotourism and aquaculture programs, and improved sustainable fishing practices in the region. The Cispatá Blue Carbon project will also provide a key demonstration of how mangrove protection and conservation can support the broader goals of the Paris Agreement and provide sustainable finance options for maintaining healthy coastal ecosystems.

Session: T008 - Blue carbon
Abstract ID: T008-A002
Presentation mode: Oral

Murky Mangroves and Catchy Corals – Does Ecosystem Attractiveness Influence Conservation Action?

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The perception of ecosystems is usually translated into a discourse that highlights specific features by framing those ecosystems in a particular manner. When these features take over the discourse, the multidimensional and varied depiction of an ecosystem becomes oversimplified, and is reduced to a cliché or a caricature. As discourses enable or constrain actions and define acceptable and desirable management, they have a direct relevance for biodiversity and nature conservation. Using qualitative coding, we compare descriptions and representations of mangrove forests and coral reefs, and explore the potential influence of differences in ecosystem-attractiveness on conservation action. We show that mangroves are predominantly used to set a scene of threatening, impenetrable and dark forests. They are pictured as hostile to human settlement, harbouring disease (vectors), or as a home to indigenous people and runaways who seem the only ones capable of finding their way through the mud and maze. However, some picture mangroves as a refuge where one can hide against the outside world. We find that attractiveness is less frequently highlighted for mangroves than for coral reefs. Coral reefs are admittedly dangerous for those navigating nearby, yet they protect the coastline against storm surges and potential intruders. Apart from the numerous pictures of climate-change affected coral reefs, corals are typically depicted as shining, characterized by clear water and brightly colored fauna. Besides investigating perception-differences between these two coastal ecosystems, we extend our study with a mangrove-focused analysis to compare samples of world literature, popular literature and media with the current perception as exposed on social networks. We aim at bridging the gap between the global attention for conservation framings, and the discourses shaping how the public saw and sees mangroves. We discuss whether perception and discourse could play a role in conservation prioritization and in willingness to protect.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A014
Presentation mode: Lightning Talk

Impact of Mangrove Forest Management on Birds: Field Assessment and Reflections on Ecological Functionality

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Matang Mangrove Forest Reserve (MMFR) in Malaysia is often – speculatively – presented as the 'most sustainably managed mangrove forest in the world'. Yet the impact of extractive silvicultural practices on biodiversity and ecological functionality is vastly under-researched.In 2015 we conducted a forest structure characterization in undisturbed protective areas and in managed mangrove stands of varying ages following logging. Furthermore, we assessed the diversity and composition of bird assemblages and compared the response of dietary guilds to the forest management scheme.Analysis of forest structure in protective mangrove stands shows structural development which cannot be found in managed stands. At MMFR unexploited forests are floristically and structurally complex and diverse, and more functional as they support more diverse and specialised bird communities. The managed forests, consisting of even-aged monospecific stands, support bird assemblages with pronounced decreased diversity.Based on these results, we conclude that exploited mangrove plantations exhibit a lower ecological functionality for resident forest bird communities due to habitat degradation. However, although response to disturbance varied between species and within and between feeding guilds, adverse effects are mostly affecting functionally specialised species This has important implications for the functioning of managed forest fragments. Although reduced abundance and richness do not necessarily result in an immediate decline in ecosystem processes, the changes in community composition are likely to disrupt biotic processes, and therefore ecosystem resilience in the long-term. Our findings indicate that bird communities are useful ecological indicators of habitat quality. Furthermore, our findings emphasise the crucial role of habitat and landscape heterogeneity (which is at least partly maintained by the differential logging structure which creates a patchwork of forest stands of different age categories) for supporting diverse avian communities and maintaining ecological functionality, especially in intensively managed mangrove forests where faunal populations are under strong anthropogenic pressure.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A017
Presentation mode: Poster

Distribution of Invertebrate Organisms on Rhizophora and Avicennia

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Distribution patterns of invertebrate organisms within mangrove forests are proxies to the ecological status and health of such areas. Yet, information on distribution of many non-economically important invertebrates within mangrove ecosystems are anecdotal and non-specific. We elucidate the vertical distribution patterns of two keystone guilds –grazing gastropods and invertebrate filter feeders – on Avicennia alba and Rhizophora apiculata within three mangrove areas (Pandan Mangroves, Khatib Bongsu Mangroves, and Sungei Buloh Wetland Reserve) in Singapore. Both groups are ecologically important; grazing gastropods are primary consumers and an important food source, while filter feeders are bio-fouling organisms. We test the specificity of these invertebrate organisms to host tree species. The two tree species in this study possess distinct root structures with varying complexity; Avicennia alba with pencil roots and Rhizophora apiculata with prop roots. Distribution of these organisms on the trunks as well as roots structures are analysed, and correlated with environmental parameters such as temperature, relative humidity, canopy cover and tree dimensions. The trunks and roots of these two species support rich diversity of twenty species; influenced, to a degree, by their root structure. This study provides a baseline for mangrove areas in Singapore, but more importantly, informs the management and rehabilitation efforts of imperiled mangrove areas.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A033
Presentation mode: Lightning Talk

Patterns of Mangrove Seedling Herbivory Across a Salinity Gradient

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Global climate change is anticipated to affect salinity regimes via sea level rise and increased storm frequency and intensity. As sea level rises, salt water will move further into intertidal systems, while stronger, more frequent storms can either push salt water inland through storm surge, or increase freshwater inputs with heavy rain events. Salinity is an important factor for plants and animals in both terrestrial and aquatic ecosystems. As such, shifts in salinity are expected to affect patterns of plant/arthropod interactions. Pacific islands have long been considered model systems for exploring ecological phenomena, and they are biodiversity hotspots at imminent risk of the effects of climate change. This study explores patterns of herbivore damage on seedlings of two mangrove species along a spatially compact salinity gradient (8-29 ppt) in mangrove forests on Kosrae, Federated States of Micronesia. Leaves from Bruguiera gymnorrhiza and Rhizophora apiculata were collected, photographed, and analyzed to quantify leaf area damaged by three types of herbivores: crabs, marine snails, and insects. Preliminary analysis showed that the ratio of the number of leaves damaged to number of leaves sampled weakly but significantly decreased with increasing salinity ($p < 0.01$, $r2 = 0.3$), but this pattern was lost when individual herbivore type was examined. Additional analyses of leaf area damage, per herbivore type and total herbivory, will be quantified using ImageJ. Comparisons of these patterns with presented and discussed.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A032
Presentation mode: Poster

Changes in Mangrove Surface Area and Morphodynamic Implications in Mayotte Island, Indian Ocean

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The Island of Mayotte, in the Indian Ocean, is characterized by a vast reef-lagoon complex comprising significant mangrove development nested between volcanic headlands. Since 2005, field experiments involving topographic surveys, observations and hydrodynamic measurements have been coupled with the analysis of aerial photographs (1950-2016) in order to improve understanding of the mangrove dynamics. Many of these mangroves show a clear regression (up to 50%) essentially located on the west and south coasts of the island, where the entire lagoonal mangrove fringe is receding with significant geomorphological implications. Observations of cross-shore profiles show that progressive mangrove retreat promotes erosion of the muddy substrate over which waves rework and concentrate sand into well-defined bars whereas the mud is dispersed towards the lagoon. These sand bars progressively migrate shoreward as swash bars that are built up into beach ridges behind the subsisting mangrove fringe. Continuous beach ridge accretion leads to burial and asphyxia of mangrove root systems, generating mangrove mortality. At the same time, the decrease in the width of the mangrove fringe enhances wave energy transmission across this fringe. The ridges are built up by swash processes but are also subject to active overwash processes that lead to landward ridge migration. In some cases, the extermination of mangrove stands can lead to an active erosional cliff and the retreat of the adjacent coastal plain. Mangrove degradation and the ensuing coastal reworking will ultimately render vulnerable adjacent coastal socio-ecosystems.

Session: T003 - Mangrove loss and deforestation
Abstract ID: T003-A014
Presentation mode: Poster

The Magnitude of 'Blue Carbon' Storage in Mangrove Ecosystems: Carbon Accumulation Rates vs. Stocks, Sources vs. Sinks

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Mangrove ecosystems store large amounts of organic carbon, in particular in the sediment. In the light of climate change debates and the need for identifying and quantifying natural carbon sinks, research in the past decade has emphasized the quantitative significance of mangrove forests and the economic implications mainly by determining carbon stocks and calculating potential CO2 emissions caused by mangrove degradation. However, this approach does not help in terms of quantifying the present carbon sinks that take up and balance the currently emitted CO2. While sediments are undoubtedly the most relevant part, there are uncertainties about the magnitude of the carbon storage potential of mangrove forests for four reasons: (i) stocks do not provide current carbon accumulation rates (CAR), (ii) deposits below mangrove forests can be much thicker than the often considered 1-3 m, (iii) a significant part of the deposited carbon can be allochthonous and old, and (iv) large amounts of mangrove carbon can be exported and deposited in nearby coastal sediments. To properly assess the carbon storage of mangrove ecosystems and related economic implications, therefore requires addressing these issues. We present examples of age-dated sediment archives from mangrove forests and adjacent coastal lagoons in Indonesia and India with different environmental settings and conditions. Variations in carbon storage and composition can be high even within one system. For example, mangrove deposits from the eastern and the central Segara Anakan Lagoon in Java, Indonesia, differ markedly in carbon stocks and CAR and display opposing patterns. Adjacent lagoon sediments have a lower CAR, but contain 20-50 % mangrove carbon over a 5 m-long sediment record spanning the past 400 years. Considering these aspects may have important implications for assessing the relevance and magnitude of mangrove carbon storage with respect to balancing current fossil fuel emissions and related economic implications.

Session: T008 - Blue carbon
Abstract ID: T008-A035
Presentation mode: Oral

Thermal Physiology of Mangrove Crabs with Different Degrees of Terrestrialization

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Crabs have important functions on mangroves and associated ecosystems, acting as ecosystem engineers. Mangrove crabs are marine animals in evolutionary transition to occupy the terrestrial environments and, therefore, they are adapting to the new conditions and stresses they face inland. One stress crabs face in the terrestrial environment is the intense temperature, predicted to increase in the globe with the anthropogenic climate changes. Studying the physiological responses to temperature of different semiterrestrial crab species can help understanding the vulnerability of brachyuran crabs to global warming, as well as the process of terrestrialization occurring in this group. Here, the physiological responses to thermal stress of phylogenetically related crabs with different degrees of terrestrialization was investigated. The maximum thermal limits (± 0.1°C) and aerial oxygen consumption in different temperature conditions (± 0.01 μgO2 L-1 g-1) were compared between two species of intertidal mangrove associated crabs, both from the superfamily Ocypodoidea: Macrophtahlmus tomentosus, in lower shores, and Tubuca arcuata, in higher shores, associated with mangroves. Our preliminary data show that T. arcuata have a higher maximum thermal limit (mean ± SD = 42.2 ± 0.4°C) compared to M. tomentosus (40.8 ± 1.5°C) (Mann-Whitney, $U=6$, $p<0.05$). Both species have similar oxygen consumption response to different temperature conditions (PERMANOVA, pseudo-$F(3,31) = 1.158$, $p = 0.313$), consumption that increases at higher temperatures (PERMANOVA, pseudo-$F(3,31) = 30.707$, $p = 0.001$). Both model species can deal with intense thermal stress that they experience in their intertidal environments. However, the higher thermal limits of T. arcuata indicates that this species is better adapted to support a more intense heat stress. This physiological response represents both an advantageous adaptation to survive a microhabitat that is exposed to air for long time and a powerful response to cope with global change.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A035
Presentation mode: Poster

Understanding Mangrove Through DNA Metabarcoding: a Case Study from Iriomote Island

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The revolutionary development of the DNA Metabarcoding using the environmental DNA (eDNA) has been changing our ways of understanding ecosystems. DNA Metabarcoding by using aquatic samples, in particular, provides us with rapid, effective, precise and massive data to assess the environment where the water samples were collected. Mangrove ecosystem is in the aquatic environment and can be an ideal target to be studied by the DNA Metabarcoding techniques. In this study, we present our recent works on the mangrove ecosystem by using MiFish and its related methodologies. MiFish (Miya et al. 2015. R. Soc. Open sci.2) is originally a set of primers for DNA Metabarcoding to identify fish species from water samples. Because of the usefulness of the primers and its related methodologies developed in Japan, the method using the primer set is now called MiFish method and became one of the standard methods of DNA Metabarcoding for fish in Japan. We employed the MiFish methods to some mangrove river systems in Iriomote Islands that was recently recommended to World Heritage site by the Japanese government. In a study site of Nakara River, by performing fieldwork for just one day, we obtained water samples that contain eDNA. Metabarcoding analyses of these samples identified more than 120 fish species and gave us information on the fish fauna of the river system and insights on conservation. We are expanding our study not only for fish but also for crustaceans, insects, amphibians, birds and mammals, to understand the mangrove ecosystem as a whole through the DNA Metabarcoding data.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A024
Presentation mode: Oral

Patterns of Macrobenthos Community in Different Types of Pond-to-mangrove Reversion Wetlands in Dongzhaigang Bay, China

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Pond-to-mangrove reversion has a vast potentiality for mangrove rehabilitation in China and brought increasingly awareness in recent years. Our research focuses on the effects of different ways of pond-to-mangrove reversion on the spatial distribution of infauna and environmental indicators.Based on whether the pond involves with elevation lifting and planting, four types of ponds (naturally restored, semi-naturally restored, semi-artificially restored, artificially restored) and control mangrove and mudflat at Dongzhai Bay, Hainan, China were investigated. Two sites with different restored period were sampled for macrobenthos separately, DaoXue(DX) and WenLin(WL).16 mollusks, 13 crustaceans and 7 polychaetes are collected. Spatial difference is significant ($p<0.05$) among different types of ponds in both the density of crustacean (DX: naturally restored>semi-naturally restored>control, WL: control>naturally restored>semi-artificially restored>artificially restored) and mollusk (DX: control>naturally restored>semi-naturally restored, WL: semi-artificially restored>naturally restored> artificially restored> control). Mollusk mainly distributed in mudflat, which is significantly ($p<0.05$) related with C:N ratio, elevation, tree height and pH of soil, while crustacean is mainly found inside mangroves and correlated with soil particle size, total nitrogen and carbon percentage. Planted ponds in both sites distribute more crustacean than mollusk, which might refer to their significantly ($p<0.05$) lower soil pH and higher soil particle size, C:N ratio and tree height. They also have a lower tree density but greater crown breadth and diameter at breast height than unplanted ponds, indicating that replanting can accelerate the succession process. Higher soil pH and soil particle size presented in elevated ponds which is related to the higher density and biomass of mollusks but lower in terms of crustacean. Therefore, pond-to-mangrove reversion without elevation-lifting is recommended, for its effectively mangrove ecosystem rehabilitating. Although replanting can stimulate secondary succession, it might reduce habitat heterogeneity and the macrobenthos, which should be seriously considered. Further investigation is still needed for a solid conclusion.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A003
Presentation mode: Poster

Mangrove restoration in India: What for and what to do?

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Mangrove forests are ecologically significant and economically valuable. In the present study, restored Avicennia marina of different age groups is experimentally proved to be an ideal sink for C, N, S, Fe and Mg in relation to ecological factors of the Vellar-Coleroon Estuarine system, southeast coast of India. The present work has also identified the main factor that is responsible for mangrove degradation is non-flushing of the canals in the estuarine system. Therefore, this work has emphasized a proper monitoring of the mangrove restored sites for ensuring the free flow of tidal water through desiltation and hydrological manipulations at least in the early stages of restoration. However, 40% of mangroves are degrading in India. Despite increasing pressures, the mangrove forest cover in India has increased by 181 sq. km during 2015-2017. This increase is estimated for ecological services based on the IUCN global map report of 2018. The increased forest cover has likely resulted in additional carbon storage of 389 tonnes in soil and above-ground biomass, which is equivalent to international market value of about 12,000 USD in India. Also the increased forest cover has possibly added over 8.4 million individuals of commercial fishes to coastal waters with excess annual catch of 10,351 kg and additional economic gain of 7,000 USD. The increased forest cover is further estimated to safeguard 440 additional people from flood damages. The work has emphasized the need to double the mangrove eco-restoration efforts in India at the annual rate of 100 sq. km, so as to achieve the target of 6,000 sq. km within a 10-year period to sustainably restore the ecosystem services.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A013
Presentation mode: Lightning Talk

Evidence for the Central-Marginal Hypothesis Along Some, But Not All, Distributions of an Expanding Mangrove Species, *Avicennia germinans* (L.) L.

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The central-marginal hypothesis (CMH) posits that range margins exhibit less genetic diversity and greater inter-population genetic differentiation compared to range cores. CMH is based upon long-held assumptions that species exist along ecological gradients with optimal conditions and highest abundances within range cores, while marginal conditions toward range limits impede growth and survival. Empirical research has confirmed CMH, but exceptions remain common. One obvious factor that could explain this inconsistency is the intrinsic difficulty of defining range core and margin for many species. We argue that mangroves provide a model system to test CMH that alleviates many common difficulties. Mangrove distributions are easily defined because of their restriction to narrow intertidal zones, and because their range limits are controlled by climatic factors. An absence of freeze events has been linked to contemporary mangrove range expansion along three coastlines in the United States, with range margins dominated by Avicennia germinans. Here, we test CMH by documenting changes in A. germinans population genetics along these three coastlines, two of which conform to the underlying assumptions of CMH whereas the third does not. We also test an implicit prediction of CMH, that limited range margin genetic diversity may reduce evolutionary potential and inhibit adaptation, by measuring cold-stress associated functional traits of leaves to assess differences in freeze tolerance. As predicted, the two coastlines that conform to CMH assumptions also confirm the theory's predictions, whereas the third, non-confirming coastline does not. In contrast to theory, range margin A. germinans exhibit functional traits consistent with greater freeze tolerance compared to the range core. These findings may help clarify the lack of consensus regarding CMH. We demonstrate that when underlying assumptions are met, CMH is validated. However, functional traits suggest that limited genetic diversity at range margins does not necessarily inhibit adaptation.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A015
Presentation mode: Lightning Talk

Matang Mangrove Forest Reserve (MMFR) Productivity and N Loading

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Matang mangrove forest reserve (MMFR) is considered as a most productive mangrove forest. In the last decades, it is discussed in different studies that the productivity of MMFR is declining. To investigate this decline in productivity Isotopic productivity model was used in six (18,31,42,71,74 and 55) compartments of MMFR. Compartments selection was based on locality and plantation age. In this isotopic model, N and P were used as limiting nutrients. Resulted, the productivity of 15 years old aged compartment was higher than 25 years old aged compartment. The compartment which was close to the populated area showed higher productivity than all. In last, the productivity of 15 years old age compartment was equal to 80 years old aged compartment. N and d15N showed the peculiar pattern. Compartment with high values of N and d15N showed less productivity than the compartment with the moderate value of N and d15N. This study aims to investigate nitrogen loading and its effect on productivity.Keywords: MMFR, Productivity, Compartment, decline, Isotopic model

Session: T009 - Mangrove management
Abstract ID: T009-A038
Presentation mode: Poster

Trace Metal Contamination In Hong Kong Mangroves: Where Are We Now? 2000-2018

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Mangrove forests are under siege from a number of direct and indirect anthropogenic stressors. One of the major causes of mangrove loss over the last 50 years has been the increasing volume of chemical-runoff from urban, industrial and agricultural areas. Mangroves act as physical and biochemical barriers to contaminant transport, and their fine-grained sediments sequester trace metals. Therefore, high levels of heavy metals, such as Cu, Zn, Pb, Fe, Mn and Cd, have been reported from mangrove sediments all over the world, especially in Southern China and Hong Kong. To understand the trends of trace metal pollution for Hong Kong mangroves, the present study compares heavy metal contamination in mangrove sediment recorded in 2000, during the most recent survey, to the ones collected by our team in 2018. Furthermore, this study characterizes mangrove sediments at 8 mangrove sites around Hong Kong not surveyed in 2000. The sediment samples were collected between August and October of 2018 at 11 different mangrove sites throughout the Northeast, Deep bay, Lantau Island, and Sai Kung regions of Hong Kong. These sites all have various levels of industrial and domestic waste inputs and hydrological influences. Six samples were taken at each site, 3 from the seaward side of the mangrove forest and 3 from the landward side. Sediment particle size was determined for each sample using laser diffraction and heavy metal analyses (Al, Cu, Cd, Cr, Fe, Mg, Mn, Zn, NI, Pb, and As) were carried out using an ICP-MS machine. The results of this study helps illuminate the changes occurring in these mangrove stands in the nearly twenty-year gap between surveys and it is of critical importance for future management of water quality and mangrove conservation in Hong Kong.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A011
Presentation mode: Poster

Evaluating the Current Issues and Challenges on Blue Carbon Ecosystems from Social Science and Policy Perspectives

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The blue carbon ecosystems (mangroves, seagrass meadows and salt marshes) are gaining salience mainly due to their roles in climate change mitigation. Policy frameworks and other managing initiatives are now in the works at an international standpoint especially for countries in the so called "coral triangle". There is an on-going JICA – JST joint project focuses on the comprehensive assessment and conservation of blue carbon ecosystems and their services (BlueCARES Project) in Indonesia and Philippines. Using a multi-layered approach, this study presents current issues and challenges in blue carbon ecosystems of select provinces in Indonesia and Philippines from social science and policy perspectives. This study identifies the ecosystem services to local communities and how they utilized these resources. Local knowledge on ecosystem functions and destructive activities and potential threats (terrestrial activities) is highlighted in this study as well. Present concern on blue carbon ecosystems is how they are being managed and utilized. To identify the focus of the spatial policy and management plans of the study sites in the two countries, literature review and content analysis was conducted. In Indonesia, current managing efforts on mangrove ecosystems are towards conservation and potential tourism sites. In the Philippines, managing efforts are focused on rehabilitation and reforestation for disaster prevention. There is limited data for blue carbon ecosystems and even less for efforts of translating such evaluation into practices. Overall aim of this study is to contribute to the blue carbon strategy of the BlueCARES project and provide a framework for policy and decision-makers.

Session: T009 - Mangrove management
Abstract ID: T009-A053
Presentation mode: Poster

Wetland Plant Composition Affects Ecosystem Connectivity During a Catastrophic Hurricane

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Plant composition (density and identity) in coastal wetlands are changing worldwide. Subtropical salt marshes dominated by low-stature herbaceous species are transitioning to woody mangroves, but how changes in identity and density of dominant plant species will affect ecosystem connectivity (retention and erosion) is uncertain. We experimentally manipulated patch-scale (3 x 3 m) cover of mangrove (Avicennia germinans) and saltmarsh plants (e.g., Batis maritima) in plots (24 x 42 m) along a density gradient in coastal Texas, USA. Hurricane Harvey made direct landfall in August 2017, providing a unique opportunity to test how plant composition mitigates hurricane effects on above- and belowground biomass, erosion and accretion, and surface and subsurface soil chemistry (C, N, P, S). Erosion and accretion were more variable in marshes than mangroves, and both declined with increasing mangrove cover. Concentrations of surface soil C, N, P, S decreased and were spatially homogeneous after the storm. Increased sulfide was correlated with up to 5x reduction in root biomass. Mangrove cover decreased 25-40%, but marsh plant cover was unaffected. Mangrove damage was greatest for trees > 1.5 m tall; these trees exceeded storm surge height and were exposed and more vulnerable to wind and debris. Mangrove regrowth began within two months of landfall. Aboveground damage to mangroves was somewhat reduced by the presence of neighboring mangroves and with increasing distance from the shoreline. Plant composition filtered physical not chemical characteristics associated with the storm.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A004
Presentation mode: Oral

Water Conservsation Value of Mangroves

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Mangrove ecosystems facilitate numerous unique ecological interactions and provide value to humans living in and around them. Many studies have focused appropriately on understanding their role in transforming and storing atmospheric carbon from CO2, with most studies identifying an elevated capacity for carbon storage and flux in mangroves versus virtually any other ecosystem assessed globally. Here, we suggest that what makes mangrove ecosystems even more valuable is that they not only have a capacity to assimilate and store large amounts of carbon, but also use water very efficiently in the process. Mangroves are routinely immersed in saline water through tides. Uptake of desalinized fresh water is energetically expensive such that mangroves make use of alternate freshwater sources whenever possible (e.g., rainfall atop exposed soils at low tide), and when such water is unavailable, they use what they can extract from seawater very efficiently, making them among the most water-use-efficient C3 plants on the planet. In this talk, we will provide experimental evidence for elevated efficiencies in water use among mangroves by describing the studies on leaf-leaf, tree-level, and stand-level water use, and suggest a water conservation value for mangroves. For example, having mangroves on the landscape could prevent the loss of as much as 300-500 mm H2O/year versus regional evapotranspiration in environments with high amounts of rainfall. While this would be lower in arid environments, the importance of water conservation there may be proportionally higher. This analysis is a mix of experimental and theoretical evidence, but our hope is to stimulate thought about what well-described leaf-level water use efficiency among an entire community type might mean when scaled, and potentially begin the assignment of water conservation value to this already valuable wetland type. Future studies will need to focus on testing this idea on multiple mangrove landscapes.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A002
Presentation mode: Oral

Delayed Mangrove Morality from Hurricanes in the Caribbean.

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Mangrove forests are among the first ecosystems to feel the full force of hurricanes. These ecosystems provide a buffer for inland ecosystem against both storm surge and strong winds.Considering expanding city hardscapes, sea level rise, and regular natural disturbances from tropical storms, mangrove forests are constrained by development on one side and ocean on the other. Where flooding and wind damage are severe, mangrove mortality may continue in the months to years after the hurricane. Under these circumstances, the frequency and intensity of future hurricanes can push the resilience of coastal wetlands beyond their environmental thresholds. One specific challenge for determining the resiliency and vulnerability of coastal wetlands after hurricanes is to identify the changes in ecosystem structure following catastrophic storm events. These changes in canopy cover and vertical canopy structure will ultimately influence the stability of the forest and the effectiveness of storm surge reduction. Through Earth observations from optical and radar satellites we have estimated the structure, extent, and change of mangrove forests across the hurricane-prone region of the Caribbean over the past 30 years. Through this spatio-temporal analysis, we have identified hot spots of loss associated with hurricane-related dieback as well as areas that are highly resilient to tropical storms. Tall forests and forests with access to regular tidal flooding were among the most resilient, with a majority of the damaged area showing signs of rapid recovery within a year after the storm. Mangroves of all heights that were disconnected from tidal flushing experienced dieback with little evidence of recovery. These findings highlight the differential impacts of hurricanes on mangrove communities where storm surge and ponding lead to longer recovery periods.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A051
Presentation mode: Oral

Conserving Mangrove Habitat In A Biophilic City – Berlayer Creek As A Case Study In Singapore

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In striving to be a biophilic city, Singapore has put greenery and nature first in its design, planning and management. The area of mangrove forests in Singapore has dwindled to about 660 ha since its founding, which is slightly less than 1% of the total land area. Despite the on-going urban development, the planning authorities have made a conscious effort to integrate natural vegetation into areas opened for public recreation through its "blue and green" plans. One excellent example is Berlayer Creek, a 5.6-ha riverine mangrove forest that is next to Labrador Nature Reserve and forms part of a 2.1 km park connector. This paper gives an overview of the development history of the creek, its management challenges and the biodiversity studies that have been conducted there. It also recognises the immense educational and recreational values of such a remnant mangrove habitat, and provides recommendations on its long-term management to safeguard its ecosystem services.

Session: T009 - Mangrove management
Abstract ID: T009-A044
Presentation mode: Poster

A World Without Functional Mangroves?

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Mangrove ecosystems worldwide have been under various threats for decades. Recent renewed interests in the services of mangrove ecosystems in coastal protection and carbon storage have increased awareness in their conservation. However, this paradigm shift may already be too late to preserve the capacity of mangrove ecosystems for key services. This pessimistic prognosis is based on (1) widespread coastal squeeze casts a death sentence on even healthy mangroves in the face of predicted sea level rise; (2) rampant pollution and lack of proactive management results in extensive degradation; (3) an obsession with forest area increase and simplistic planting results in low long-term success of restoration of functional forests and erosion of mangrove functional diversity; and (4) a lack of reliable and practical indicators for assessing mangrove ecosystem health. While some of these situations (e.g. issues 1 and 2) are difficult to reverse, researchers and managers of mangrove ecosystems may contribute to the amelioration of, or provide solutions to, the other issues. Not only do different mangrove forests provide different services, the ecology of different zones of the same forest may also be widely divergent, e.g. proportion of root/litter production accumulated or exported. The role of mangrove forests in functions such as storing C or dampening wave energy can only be realistically assessed through a spatially-explicit (e.g. variability in function along the tidal gradient) and context-sensitive (e.g. species composition) treatment of ecological processes. This approach is understandably tedious and therefore potentially impractical. Building a unified model of ecosystem function by incorporating the known gradients and drivers in different geomorphologic and urban contexts may not only enable the formulation of health indices for mangrove ecosystems but also their capacity for services. This information will in turn benefit future rehabilitation and restoration efforts to facilitate the survival of functional mangrove ecosystems.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A037
Presentation mode: Keynote

Expansion and Adaptive Evolution of Wrky Transcription Factor Family in Avicennia Marina

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Transcription factors play an important role when plants response to extreme environment. WRKY family is one of the most abundant groups of transcription factors in higher plants, which has been found expanding in many species and its members regulate important biological processes and responses to biotic and abiotic stress. Although the genome of Avicennia Marina, a representative mangrove species, has been sequenced, functional studies on its genome, especially on transcription factors, still lag behind those of others. Here we identified a total of 122 WRKY genes in Avicennia Marina genome and confirmed the result by refining domain structure, followed by structural, phylogenetic and expression pattern analysis. Results show the AmWRKY family could be classified into three groups and seven subgroups. Compared to non-mangrove land relatives of Avicennia Marina such as Sesamum indicum, AmWRKY family has gone through a remarkable expansion mainly via segmental duplication throughout its evolution history, and such expansion is especially obvious in IIc、 IIe and III subgroups. AmWRKY genes have notably different expression pattern both in root and leaf tissue when exposed to osmotic stress, and 246 genes that co-express with AmWRKY genes and have WRKY binding element in upstream sequence were identified. Furthermore, some critical amino acids leading to functional divergence among AmaWRKY subgroups were detected using DIVERGE v3.0. In addition, positive selection analysis shows that several specific regimes may have been under positive selection drive in the adaptive evolution process of Avicennia Marina. Together, these results will not only further our understanding of the molecular evolution of WRKY family in Avicennia Marina, but also provide more insights on the adaptive evolution mechanisms of mangrove species from a functional genomics aspect.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A006
Presentation mode: Poster

De Novo Assembly of An Important Mangrove Species Bruguiera gymnorhiza Genome and The Evolution of Genes After Whole Genome Duplication

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Mangrove forests are one of the most productive and diverse ecosystems. The adaptation of the salinity and tidal stress of mangrove species are of scientific significance to study the response to global change. Whole genome duplication can add to genomic novelty, which is related to the adaptation process. In this study, we use a combination of single-molecule long reads, Illumina short reads and Hi-C technology for the assembly of Bruguiera gymnorhiza. The longest scaffold and N50 for the B. gymnorhiza genome, are 20.8Mb and 14.8Mb, respectively, which shows the assembly of its genome is near the choromosome level. We find that the ancestor of Bruguiera gymnorhiza experienced a whole-genome duplication at ~70 myrs ago, which if before the species diversification with its related species, Rhizophora apeculata. By comparing gene loss and retention after whole-genome duplication event, we find the function retention genes are mostly related to the stress response. Our research provide a possible mechanism for the adaptation of mangrove species.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A010
Presentation mode: Lightning Talk

Transcriptome Analysis of *Kandelia obovata* and *Avicennia marina* Leaves in Response to Short-term and Long-term Submerging Stress

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To sustain tropical and subtropical intertidal shores, mangroves have adapted to harsh conditions including periodical hypoxia submerged under seawater. Although physiology and morphology of mangroves adaptation to hypoxia were widely studied, the molecular mechanisms are still poorly understood. We applied transcriptome-wide RNA-seq to tackle molecular mechanisms of hypoxia in Kandelia obovata and Avicennia marina. For transcriptome analysis, leaves were collected in three different stages, short-term (0, 4 and 12 h) and long-term (7 days) seawater immersion treatment, where simulating semidiurnal tides were performed with the inundation periods of 12 and 4 h, respectively. Total RNA were extracted from leaves of treated plants and RNA-seq libraries were constructed and sequenced. Transcriptome analysis showed that >1000 differentially expressed genes (DEGs) were dramatically induced in K. obovata after submerged treatment. However, in A. marina, <200 DEGs were found in long-term 4h inundation period, indicative that the response to submerging in K. obovata is more complicated than that in A. marina. Assignments of the annotated genes based on Gene Ontology Molecular Function revealed that there were more genes induced under the submerging condition in the categories of "oxidoreductase activity", "ATP binding", and "NADP binding", suggesting that these energy metabolism pathways are enhanced. In addition, "carbohydrate phosphatase activity", "fructose 1,6-bisphosphate 1-phosphatase activity", were only enhance in K. obovata. Upon analysis of the transcription factors among DEGs, it was identified that most them were clustered into the ethylene response factor (ERF) family, suggestive that ethylene plays a major role in these two species when responding to flooding stress. KEGG pathway analysis showed that many genes induced after long-term treatment were found in the "starch and sucrose metabolism" pathway, implying that energy problem might be severe in late-stage of flooding. Our results provide new insight of mangrove plants adaptation to coastal conditions.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A020
Presentation mode: Lightning Talk

Molecular Mechanisms of Mangrove Viviparity

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Vivipary in plants refers to the phenomenon that sexually produced offspring germinate on the maternal plants with short or no dormancy. This distinct way of reproduction is most apparent in some mangrove species in which it is a genetically programed process. In true-viviparous species in Rhizophoraceae (Rhizophora, Kandelia, Ceriops, andBruguiera), embryos penetrate out of both testa and pericarp. Thus, their propagules are germinated seedlings instead of seeds. The ecological significance of viviparity has long been recognized, and morphological / physiological studies have been started a century ago, yet its genetic and molecular mechanisms remain to be a mystery. We performed comparative transcriptome analysis of targeted viviparous tissues in Kandelia obovata, a widespread true viviparous mangrove in China. A total of 75 RNA-seq libraries made from 25 tissues (3 repeats each) were sequenced including pericarp, testa, cotyledon, axis in stages before and after fertilization, and before and after hypocotyl breaking through the testa and pericarp. Thousands of differentially expressed genes were obtained when making pairwise-comparing genome wide. Functional analysis showed that genes involved in hormone biosynthesis and signal transductions, cell cycle/division, and energy metabolic pathways were enriched, suggesting their vital roles in viviparous process. Plant hormones including abscisic acid (ABA) and Gibberellic acid (GA) have been previously considered critical in vivipary. Therefore, we further interrogated a set of genes involved in ABA and GA synthesis, response and degradation pathways. Many of the target genes exhibited temporal-spatial expression patterns. Among these, the high level expression of ABA degradation genes is particularly of interests because it may directly results in low amount of ABA, an important signature of viviparous seeds. Further analysis of these transcriptome data will enable us to understand the molecular process related to this unique feature of mangrove plants, and their adaptation mechanisms to harsh coastal tidal zones.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A028
Presentation mode: Lightning Talk

Comparisons in Responses of Plant-soil Systems to Nitrogen Addition and Air Warming Between Two Mangrove Species

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Mangrove forests are very sensitive to global climate change such as air warming, but also experience excessive nitrogen loading in China and other developing countries with extensive mangrove coverage. However, there are limited studies on how these two factors jointly affect mangrove plant growth, soil biochemical processes and other ecological properties of mangrove forests. In this study, we measured plant morphology and biomass plus soil respiration, N2O emission, enzyme activities and microbial community structure of two mangrove species–Avicennia marina, a pioneer species, and Bruguiera gymnorrhiza, a late successional species–in a controlled experiment under treatments of 30 mg·L-1N addition and 3°C air warming. To our surprise, there were no significant effects of the air warming treatment on these parameters in most cases, although the nitrogen addition treatments significantly increased plant growth and soil biochemical processes. In addition, the responses of A. marina were significantly higher than those of B. gymnorrhiza. Interactive effects between the air warming and nitrogen addition were observed only in some parameters such as plant growth, soil respiration and some of microbial community structure in the mesocosm A. marina. These findings will be discussed with the future dynamics of mangrove forests under both global and regional changes.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A063
Presentation mode: Poster

Remote Sensing of Mangrove Health and Degradation in Singapore

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Mangroves carry a host of ecosystem services including habitat support, coastal protection and carbon storage. In Singapore, mangroves have been cleared to make way for urban development and land reclamation, leaving behind small fragments of mangroves along the mainland coast and offshore islands. The remaining mangroves are exposed to long-term natural and anthropogenic stressors such as sea level rise, pests, diseases, pollution and changes in sediment supply and hydrodynamics. As these stressors could take years, if not decades, before they cause apparent losses, it is crucial to monitor mangrove communities over time, identify degrading sites early and take necessary actions before the damage becomes irreversible. Considering the risk of losing the small but diverse mangrove communities left in Singapore to such stressors, this study has assessed the current spatial distribution of mangrove health and degradation in the various patches dotted around Singapore using multi-spectral remote sensing and vegetation indices such as Normalised Difference Vegetation Index (NDVI) and Ratio Vegetation Index (RVI). Overall, mangroves on Pulau Tekong had the highest average NDVI of 0.754 while Pulau Salu had the lowest at 0.375. Among the sites of the field surveys, Pulau Ubin had the highest average NDVI of 0.703, followed by Pasir Ris Park at 0.671 and lastly, Sungei Buloh Wetland Reserve at 0.603. These indices have been compared with ground measurements of 554 trees from 17 species collected from field surveys at three study sites. This was done to evaluate the suitability of this methodology for studying diverse mangrove fragments scattered around an urban landscape and to identify aspects of the condition of mangroves which could be associated with spectral data from satellite imagery. The findings provide a snapshot of mangrove degradation in Singapore, which could inform park managers and policy makers in the effective protection of the remaining mangrove areas.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A015
Presentation mode: Lightning Talk

Carbon Cycles and Blue Carbon Potentials of Chinese Mangrove Forests

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Coastal wetlands ecosystems, especially mangroves, seagrass beds and salt marshes, have a high carbon sequestration capacity and several Chinese governmental agencies are actively promoting their protection, restoration and blue carbon sink potentials at all levels. Since 2008, we have established field stations for the mangrove forests in the Zhangjiangkou Estuary of Fujian, The Leizhou Peninsula of Guangdong and the Qinglangang of Hainan, respectively, for monitoring changes in carbon stocks in both biomass and sediments as well as CO2 exchange between mangrove forests and atmosphere. We also applied stale isotope techniques to quantify possible sources of the carbon in mangrove sediments and lateral carbon exchange between mangrove wetland and nearshore oceans. This presentation will summarize some key progresses of our studies on carbon cycle Processes and blue carbon sink Potentials of selected mangrove forests in China Our results indicated that the mangrove forests in China contained significantly lower carbon density than tropical mangrove forests, but had significantly higher carbon exchange rate than both nearby terrestrial forests and inland wetlands. The carbon in the sediments of mangrove forests could originate from mangrove, river and algae input, and new carbon from the invasion of C4 grass Spartina alterniflora at least at the Zhangjiangkou Estuary site. We estimated that lateral carbon exchange between mangrove forests and nearshore ocean through tidal system could be as high as 20% of GPP at the Zhangjiangkou Estuary and Leizhou Peninsula site. The national blue carbon sink potential for China was also estimated according to our survey data. Our results have significant implications for mangrove conservation, restoration and blue carbon managements in China and other developing countries.

Session: T008 - Blue carbon
Abstract ID: T008-A014
Presentation mode: Oral

Mangroves Structure and Thickness to Mitigation Coastal Erosion Due to Impacting of Wave Energy: a Case Study in Soc Trang, Vietnam

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Mangrove forests have important roles for protecting the coastal zones due to its ability to attenuation the wave energy as a natural measure by dissipating the wave energy, which abilities would change according to mangrove structure and thickness. The objective of the study was to evaluate the wave energy attenuation passing through the different type of mangrove structures to propose the appropriate mangrove forests thickness. The 3 transects with 250m long from the seaside edge to inland was carried out, on each transect designed 3 standard plots with unit distances of 50m. The manual measurement method was used to measure the forest structure and the diver WH-Infinity was used to measure the wave energy. The mangrove structures have changed considerably, including an increase of the density, height, and diameter of trees from the seaside edge towards the inland. However, at the same site, there was a decline in the quantity and height of mangrove roots leads to the ability to reduce wave energy also varies with the difference of the structure and thickness of the forests. The ability of wave energy reducing was increased from 40.41% at 50m distances to 95.45% at 250m from the sea edge. The thickness of mangroves was positively correlated with the wave reduction coefficient with $r = 0.94$. The results of the analysis of the modeling on correlations between mangrove thickness and the wave reduction coefficient (R %) determined that the mangroves thickness was greater than 230 m to ensure that the wave energy would not be affected to the coastal zone. However, in the case of strong waves and surges, more thickness of mangroves would be needed to guarantee the protection coastal zone function. This is also necessary to verify the accuracy of the model result in near future in all wave energy conditions.

Session: T009 - Mangrove management
Abstract ID: T009-A052
Presentation mode: Poster

Comparison of Stakeholder's Knowledge on Mangroves with Scientific Results in Mayotte Island (indian Ocean)

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Mayotte Island in the Mozambique Channel holds 735 hectares of mangroves, occupying 29% of the coastline. In 2011, the island became a French overseas department meaning adopting the same legal and social system used in France. This change in status has consequences for the management of the mangrove ecosystems there. The National Forestry Authority has established itself in Mayotte and is drafting a management plan of the island's mangroves for the next 10 years.In this context, we conducted a campaign of interviews with stakeholders influencing the preservation and management of the island's mangroves in order to better understand their knowledge, representations and opinions. We carried out 25 semi-structured interviews with 12 from the central and local government, 5 from associations, 5 from the tourist sector and 3 from experts. Here, we focus on the knowledge of stakeholders and analyse it by two experts in the geomorphology and the ecology of the mangroves of Mayotte. The knowledge assessed from open-ended questions relates to the biodiversity and the specificity of Mayotte's mangroves relative to mangroves in other territories; the nature and relative importance of impacts was evaluated from classifying and commenting a set of photographs; knowledge of the health status was assessed with a cognitive map exercise.Results show disparity in stakeholder's knowledge depending on the topic. For instance, regarding the biodiversity, only some stakeholders think this ecosystem is particularly rich. Regarding the impacts on mangroves, all stakeholders agree that embankments, roads across mangroves and rubbish are very impacting but few are aware of the consequences of other impacts mentioned. This is the case with paths crossing the mangrove seaward: the majority of stakeholders didn't know that this has been shown to contribute to the erosion of mangroves. These results are useful to know what kind of knowledge should be transmitted to stakeholders.

Session: T009 - Mangrove management
Abstract ID: T009-A017
Presentation mode: Poster

Testing Hydrological Suitability for Mangrove Restoration in Vietnam and Indonesia

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Mangrove restoration projects, aimed at restoring important values of mangrove forests after degradation, often fail because hydrological conditions are not properly restored. We present a simple, but robust methodology to determine hydrological suitability for mangrove species, which can guide restoration practice. In 15 natural and 8 disturbed sites (i.e. disused shrimp ponds) in three case study regions in south-east Asia, water levels were measured and vegetation species composition was determined. Using a hydrological classification for mangroves, sites were classified into hydrological classes, based on duration of inundation, and vegetation classes, based on occurrence of mangrove species. In the natural sites, hydrological and vegetation classes were similar, showing a clear differentiation of mangrove species between wet and dry sites. Application of the classification to disturbed sites showed that in some locations hydrological conditions had been restored enough for mangrove vegetation to establish, in some locations hydrological conditions were suitable for various mangrove species but vegetation had not established naturally, and in some locations hydrological conditions were too wet for any mangrove species (natural or planted) to grow. We quantified the effect that removal of obstructions such as dams would have on the hydrology and found that failure of a restoration project at one site could have been prevented. In this presentation we will discuss the use of a hydrological classification in mangrove restoration projects compared to using elevation only. We conclude that the hydrological classification gives important information about how to restore the hydrology to suitable conditions to improve natural regeneration or to plant mangrove species, which could not have been obtained by estimating elevation only. Based on this research a number of recommendations are given to improve the effectiveness of mangrove restoration projects.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A025
Presentation mode: Poster

Sensitivity of Mangrove and Fisheries Production to Extreme Climatic Events in the Exmouth Gulf, Australia

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Extreme climatic events strongly influence the function and composition of ecosystems. The Exmouth Gulf, a large (2,600 km2) mangrove fringed embayment in the northwest of Western Australia has 161 km2 of mangrove and supports a productive prawn fishery (~900 tonnes/year worth approximately AUD$12 million/year). This region has a high frequency of cyclones and more recently, marine heatwaves have occurred. Using a long term record of mangrove growth and fisheries production (2004-2017) we analysed the effects of cyclones on mangrove productivity and catch per unit effort for the prawn fishery. Overall, mangrove and prawn fishery productivity were enhanced in years with high levels of cyclonic activity which was positively linked to levels of summer rainfall and high wind speeds. For mangrove productivity, exceptions to this pattern occurred when cyclones passed close to the field site and exceeded wind speeds of 100 km/hour. For the fishery, exceptions to the pattern of increasing catch associated with cyclones occurred in the year with a marine heatwave (2012). Although these data are correlative, increasing nutrient availability associated with disturbance of shallow sediments and mixing within the water column during cyclones and delivery of freshwater are likely to be important processes that stimulate both mangrove and fisheries production in the region. The predicted decline in the frequency of cyclones with climate change for this region is likely to have negative consequences for the productivity of both mangroves and fisheries.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A010
Presentation mode: Oral

Monitoring the Matang Mangrove Forest Reserve Using Landsat Dense Time Series

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Matang Mangrove Forest Reserve (MMFR) in Peninsular Malaysia has been under a silvicultural management since 1902 for the production of charcoal (from 30-year old trees) and poles (from 15- and 20-year old trees) from Rhizophora apiculata Blume and R. mucronataLamk species. In this study, we have used time series of Landsat derived Normalized Difference Moisture Index (NDMI) as a tool for assessing the ongoing mangrove management of this reserve. A yearly NDMI analysis from 1988 to 2015 was considered to track the vegetation status. We were able to identify the clear-felling events, track the regeneration of the forest and estimate the vegetation cover. Three different types of maps were created: (i) a map describing the forest patches that were clear felled between 1988 and 2015, (ii) a map describing the recovery time after a clear felling event of different mangrove forest patches, (iii) and a series of maps that describe the vegetation cover per year. These maps provide a new source of information to the local management authorities, especially to validate their mangrove replantation policy with the natural/afforested recovery rates observed.

Session: T003 - Mangrove loss and deforestation
Abstract ID: T003-A024
Presentation mode: Oral

Local Policies and Activities for Mangrove Conservation in Indonesia: Suggestion for Sustainable Aquaculture

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Mangrove conservation is an urgent task in Indonesia which has rich mangrove forests and faces deforestation. Aquaculture has been reported as main driver for the deforestation and land-use change for mangrove which is a main part of blue carbon ecosystems. Indonesia has declared a policy which aims to be the highest producer for aquaculture product, which might be a threat for various ecosystems, including the mangrove. The concern is not only for the land-use change activities, but as well as the unsustainable practices for these aquaculture, specifically brackish water aquaculture, which is only lasts for a couple years before getting abandoned. Existing regulation and guidelines regarding sustainable aquaculture practices was established, but it still faces obstacle and challenges before it is really implemented widely, even so, reviewing the policy might also prove critical to understand the cause of willingness for the people to implement the sustainable aquaculture practices. In this study, local policies and activities for mangrove conservation and sustainable aquaculture were analyzed to identify the policy process and regional characteristics. The results show the regional contexts which influence its policy process and need to be considered in policy making and implementation.

Session: T009 - Mangrove management
Abstract ID: T009-A032
Presentation mode: Poster

Of Mangroves and Men: Understanding Anthropogenic Marine Debris in Hong Kong Mangroves

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In the era of single-use plastic, the issue of the prevalence of anthropogenic marine debris (AMD) in the marine environment is becoming increasingly apparent. Numerous studies have shown that plastic can represent over 90% of debris found on beaches, but there are few studies investigating it in other coastal habitats, for example - the mangroves. This research project investigates the occurrence of anthropogenic marine debris in Hong Kong mangroves. Little research has been performed on mangrove rubbish in general, and understanding the distribution and type of rubbish in the mangroves is vital to continuing research in the area. The mangroves are often lauded as a natural buffer against damaging weather events such as storms and typhoons, but the features of the mangroves that make them such good buffers (such as complex root systems and high density) may also mean that they potentially are great "catchers" of marine rubbish. We designed and performed standardised surveys to collect and compare data about quantity, diversity, and possible sources of marine litter in different zones of the mangrove. Our results indicate that the sources and types of rubbish vary between the seaward zone and the landward zone of a mangrove. This information is vital for understanding the source of anthropogenic marine debris in mangroves, and how we can work to reduce its occurrence. In general, anthropogenic marine debris impact is measured by abundance and weight, here we will also discuss the importance of considering the "area covered" by marine litter. The presence of marine litter in mangroves has implications not only for the mangrove plants themselves, but also for the animals (e.g. crabs) that inhabit them.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A017
Presentation mode: Oral

The Effects of Water Temperature on the Cold Tolerance of Widespread Mangrove Species *Bruguiera gymnorhiza*

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Air temperature has been show to be the main environmental factor influencing the distribution of mangrove species. However, as mangroves are coastal plants that experience frequent inundation, water temperature likely plays a role in their chilling tolerance. In this study, we examine the potential effects of water temperature on the response of mangroves to chilling, by comparing the chilling response of Bruguiera gymnorhiza seedlings maintained under warm water temperature to those maintained under ambient water temperature. To assess the influence of local adaptation on the chilling response of mangroves under warm and ambient water temperatures, we compared the chilling response of seedlings from higher and lower latitudinal locations. To determine the influence of water temperature on the response to and recovery from chilling we compared the condition of these seedlings before, during and after exposure to chilling temperatures. The condition of these seedlings during each of these treatment conditions, was determined by (1) measuring the effective quantum yield of photosystem II (Fv/Fm), (2) assaying the amount of antioxidant enzymes and reactive oxygen species and (3) analysing the total expression of cold responsive genes. We found that seedlings maintained under a higher water temperature had significantly higher Fv/Fm values than those maintained under ambient water temperatures, but only during the initial stages of recovery. This suggests that water temperature plays a role in the recovery of mangrove species from chilling stress and thus may influence the distribution of mangrove species in areas where annual minimum temperatures reach chilling conditions. Furthermore, we found that seedlings from higher latitudinal locations had significantly higher Fv/Fm values than those from lower latitudinal locations during the initial stages of recovery. This suggests that local adaptation may play a role in the influence of water temperature on the response of mangrove species to chilling.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A034
Presentation mode: Poster

An App Based Approach for Mangrove Monitoring and C Stock Assessments

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High carbon (C) stocks in mangroves has elevated their overall importance in climate change mitigation and adaptation strategies and national reports. This has also significantly increased the number of national C stock assessments and mangrove inventories that collect plot level data in the field on data sheets following the Sustainable Wetland and Adaptation Method Program (SWAMP) method. Data is then laboriously entered and analyzed in programs such as Excel or Access that is often a time-consuming endeavor. We modified a forest inventory application called Silva Metricus to collect plot level data on Android systems in the field for mangrove assessments and inventories. The desktop version of Silva Metricus is then used to manage and analyze mangrove forest inventory data sets using regionally specific allometric equations and wood densities. This results in a significant reduction in time spent entering and analyzing data sets and an overall reduction in project cost. Silva Metricus also allows for QA/QC of data and for generating uncertainties required in national reports. We will present results from a project that quantified C stock across an age gradient of naturally regenerated mangroves in SE Sulawesi using Silva Metricus.

Session: T008 - Blue carbon
Abstract ID: T008-A063
Presentation mode: Poster

Sea Level Rise Smack Down: 210pb Vs Set/rset Methodology

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Sea level rise is one of the greatest threats that mangroves will face in the coming decades. As a result, several studies have examined changes in mangrove surface elevation relative to sea level rise using either surface elevation tables (SET/rSET) or the naturally occurring radionuclide, 210Pb. This July, see these two methods come face to face in the octagon of MMM5 to finally determine their pros and cons. Two methods enter, one leaves! It's an all-out sediment methodology war as surface elevation data collected side by side from mangrove on Pohnpei, FSM, will be compared using SETs and 210Pb cores. Preliminary data revealed that 210Pb data does not effectively capture subsidence events. While both methods were able to detect positive surface elevation gain, this rate was significantly greater for SETs than 210Pb ($p < 0.05$), suggesting the latter method is the more conservative of the two. Additional data will be presented for other sites on Pohnpei and will also include a special appearance by rSETasaurus rex, who will attempt to use 80 million laser beam points to quantify surface elevation! You'll pay for your whole seat, but you'll only need the edge!

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A060
Presentation mode: Poster

Application of an Individual Based Restoration Model for Three Mangrove Species in a Coastal Lagoon-estuarine System in the Colombian Caribbean

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To simulate the restoration trajectories of the Ciénaga Grande de Santa Marta mangrove swamp (CGSM), a neotropical lagoon-estuary system that experienced a massive death due to high levels of soil salinity, we used the FORMAN model. This model based on individuals, allows to simulate the tendencies of the basal area (BA). To validate, calibrate and adjust the model, we used data from 16 years of monitoring of Rhizophora mangle, Avicennia germinans and Laguncularia racemosa, in three CGSM sites. We simulated two scenarios: (1) Assuming stability in the variation of salinity and, (2) increase in salinity according to the average increase in recent years. The adjustments in the rates of recruitment and calculated salinity allowed to calibrate the model and reproduce the pattern and magnitude observed in the three CGSM sites. In two sites, only the data pattern is played. The general trends of BA of each species were adequately reproduced. In the scenario in which salinity is maintained in a stable interval, the system would achieve long-term stability (> 100 years). A constant average increase in interstitial salinity would result in a severe reduction of BA in the short term (less than 20 years), showing the vulnerability of CGSM to increases in salinity and the need to implement sustainable management measures. The study contributes to the understanding of the dynamics of tropical coastal lagoons in the long term and highlights the importance of modeling as a basic tool for rehabilitation and management projects.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A006
Presentation mode: Oral

Conversions and Restoration of Mangroves in Tanzania: Bridges and Barriers for Sustainability

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Competing conversions of mangrove forests into agricultural land, aquaculture ponds, and salt evaporation pans result in loss of biodiversity and simplification of structural complexity given by naturally variable age-structure of mangrove trees. Contrary, restoring and retaining mangroves in a functional state is likely to enhance ecosystem resilience to emerging climate change threats, and offer some degree of sustainability of ecosystem services critical to the livelihoods of coastal communities. While mangrove restoration efforts and avoided deforestation are increasingly in place as "bridges", there are still socio-ecological "barriers" tied on little knowledge of how the bridges affect human livelihoods. The fact that mangrove ecosystem services are rarely considered during environmental decision-making, principally because they are not well identified, quantified, or considered in ways applicable to livelihoods is pertinent. This is common where mangroves have been considered waste wetlands albeit they are legislatively declared state forest reserves. They have remained without strong legal enforcement and communities have inherently considered these forests as "no mans" resource. As such, mangrove ecosystem services have been taken for granted. However, mangroves have a better chance of survival if other stress factors related to human activity and environmental change are minimised. In addition to showing how human choices relinquish the bridges and propel barriers on mangrove ecosystems, and their services, by describing risks associated with mangrove loss, this paper reviews the consequences of conversions and restoration of mangrove ecosystems in the face of global change factors at local scales and tries to clarify on the links between underlying mangrove ecology and ecosystem services for human well being and sustainable livelihoods of coastal communities in Tanzania. The paper concludes by highlighting pertinent interdisciplinary interventions that will demonstrate how rational management strategies on restoration and avoided deforestation can enhance sustainability.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A011
Presentation mode: Poster

Accumulation of Heavy Metals in Mollusks as Bioindicator of Contamination in Mangroves Disturbed by Mining in Lake Uacon, Zambales, Philippines

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Mining effluents discharged in mangrove environment may cause damages to the vegetation, sediments and faunal communities. The accumulated heavy metals (HM) may lead to toxicity and bioaccumulation in faunal communities. HM accumulation in mollusks reflects direct impacts of mining in the mangrove environment. The presence (or absence) and dominance of some mollusk species in a mining-contaminated sediments may provide information on its adaptation mechanism to survive a polluted environment. This study assessed the HM in mollusks in Lake Uacon in Candelaria, Zambales (NW Luzon) that is known to be affected by mining. Molluscs were collected and tissue samples were obtained to determine the HM content. The mean concentrations in mollusc tissues were 55.81 ppm, 21.53 ppm and 36.25 ppm for nickel, copper, and chromium, respectively. Nickel and copper concentrations were within threshold values, but chromium was two to three times higher than the threshold value. The recorded mollusc species were Cassidula nucleus, Ellobium aurisjudae, Littorina scabra, Neritina turrita, and Pirenella cingulata. Among species, N. turrita had the highest nickel and copper concentrations and can be considered as a potential bioindicator of HM contamination in mangroves. HM accumulation in mollusk is linked to metal fractions bound in sediments. The HM contamination is related to the presence or absence of molluscs as shown in the apparent discoloration and highest value of HM in sediments. Molluscs distribution is also dependent on the sediment characteristics including pore water quality like pH, availability of food, and organic matter. These factors are crucial to the adaptation and survival of molluscs. Thus, mining impact can be assessed using molluscs as bioindicator not only on the magnitude of HM but on the quality and condition of the mangrove ecosystem.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A023
Presentation mode: Poster

Trace Metals Dynamics in a Mangrove Developing Downstream a Densely Populated Mega-city (Can Gio, Ho Chi Minh City, Vietnam)

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Mangroves are considered as efficient filters between land and sea, possibly acting as sinks for trace metals, protecting coastal waters from pollutions. However, this ability depends notably on sediment characteristics and hydrology. Because of their toxicity to mangrove biodiversity and to human health, trace metal cycling is a serious question addressed during the last few decades and nowadays. In contrast to the rest of the world, trace metal distribution in Viet Nam's mangrove forests has received little attention. In this talk, we will present trace metals dynamics in the Can Gio mangrove, which is located in Southern Viet Nam, being situated at the edge of a densely populated megacity (Ho Chi Minh City, ~10 million inhabitants) and the South China Sea. Along the Can Gio estuary, trace metals, which mainly originated from upstream lateritic soils, were transported mostly associated with suspended solids, notably with oxihydroxides. After being deposited in the mangrove, oxihydroxides were dissolved during organic matter (OM) decay processes under suboxic conditions, releasing trace metals in pore-waters. The enrichment of mangrove-derived OM from the mudflat to the Rhizophora stand played a key role in controlling diagenetic processes and metals' cycling. Dissolved metals were then re-precipitated with new bearing phases such as organometallic complexes, suphides, or carbonates depending on the redox condition and on metal characteristics. Furthermore, part of these dissolved metals were available for biota uptake (we notably studied plant and snails) or exported to tidal creek through pore-water seepage, the latter being enhanced during the rainy season. Consequently, Can Gio mangrove sediments can act as sources of trace metals for adjacent ecosystems. Plants uptake and pore-water seepage induced the decrease of trace metals stocks in the sediment along the intertidal gradient, especially in the Rhizophora stand, the most reactive one because of its richness in OM.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A006
Presentation mode: Oral

Opportunities for the Improvement of Mangrove Forest Management: an Assessment of Local Population Perceptions in Matang Mangrove Forest Reserve, Malaysia

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Effective management of a socio-ecological system (SES) requires a good understanding of: (i) ecosystem functionality, (ii) interactions between social and ecological units, and (iii) the decision-making system. Matang Mangrove Forest Reserve (MMFR) represents the largest patch of mangrove (40 288 ha) in peninsular Malaysia, and it has been under silvicultural management (with a 30-year forest rotation cycle) for charcoal and timber production since 1902.The aim of this study is to assess the perception of the local population in the biggest administrative range of Matang (i.e. Kuala Sepetang) towards the current mangrove management regime of MMFR. In order to identify if there is a correlation between professional activities and perception among the local people, participants were clustered in three main working categories: (i) charcoal and timber workers, (ii) fishermen and (iii) service providers. This study focuses on the degree of popular support of three main management discourses resulting from a previous investigation using Q methodology: (1) Optimization- 'keep up the good work, but keep improving', (2) Change for the better- 'ecotourism & participatory management for sustainability', and (3) Continuity – 'business as usual is the way to go'.This study indicates that discourse (2) was the most popular (supported by 72% of the participants). This discourse voices the willingness of the local people on increasingly participatory management, and they perceive service providing (i.e. ecotourism) as an opportunity to improve their livelihoods. Moreover, the working category with most disagreement towards some aspects of the 'official discourse' (Discourse 3), was 'charcoal and timber workers'. The present findings indicate opportunities for further improvement and fine-tuning of the ongoing management regime at the MMFR.

Session: T009 - Mangrove management
Abstract ID: T009-A029
Presentation mode: Poster

The Quantification of Blue Carbon in a South African Warm Temperate Estuary

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Coastal habitats provide a variety of ecosystem services and have been termed blue carbon forests due to their ability to store larger amounts of carbon compared to terrestrial habitats. In South Africa, blue carbon habitats occur in sheltered estuarine environments where very little is known about their carbon storage. This study was the first to quantify and compare carbon storage in the sediment and biomass of salt marsh, seagrass and mangrove ecosystems at a warm temperate estuary in the Eastern Cape, which is the southern distributional limit for mangroves along the east coast of South Africa. As expected, total sediment organic carbon (up to 1 m depth) was significantly higher in mangroves (151.67 ± 18.64 Mg C ha-1) compared to salt marsh (2.61 ± 0.19 Mg C ha-1) and seagrass (1.67 ± 0.81 Mg C ha-1). These values were lower than the means for salt marsh and mangroves globally likely due to drier climate, coarse grained sediment and low productivity associated with slower growth at latitudinal limits which decrease the preservation of carbon. Seagrass carbon storage was limited by the patchiness, low structural complexity and dynamism of seagrass beds in South Africa which fluctuate in area over time. While carbon storage was limited, this study provided baseline data for South Africa's estuaries to partake in potential carbon credit trading schemes. This will aid with management and protection of mangrove habitats in future.

Session: T008 - Blue carbon
Abstract ID: T008-A029
Presentation mode: Poster

Recolonization of Mangroves and Epifaunal Mollusc Assemblages in Abandoned Aquaculture Ponds

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When aquaculture ponds are abandoned, a natural colonization process will take place to recover mangrove forest. Sediment compaction along with the remnants of feed in the sediment from past aquaculture activities may either facilitate or constrain the growth of mangroves along with mangrove-associated mollusc species. In this study, we determined and assessed the recolonization of mangroves in abandoned aquaculture ponds and the viability of mangrove-associated molluscs as restoration indicator. Vegetation, organic matter (in the sediments) and mollusc assemblage were assessed and compared in mangrove-colonized ponds (4- and 20-yr stands) and natural mangrove stands traversing seaward to landward transect. A total of 8 and 13 species of mangrove and molluscs respectively were recorded. In terms of vegetation, the 20-yr old colonized stands and natural mangroves have the highest number of taxa (S = 5) while the 20-yr colonized stands have the highest number of mangrove stems. In terms of relative abundance (RA), the species Cerithidea quoyii (43 %) was the most dominant followed by Terebralia sulcata (23 %). The 20-yr old mangrove-colonized stands have the highest OM (36 %). The presence and dominance of mangrove-associated species can be a useful restoration indicator in rehabilitating abandoned aquaculture ponds.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A030
Presentation mode: Lightning Talk

Carbon Stocks in the Pacific and Caribbean Colombian Mangroves

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Mangroves are well known for their carbon accumulation high rate. However, they are threatened by deforestation and degradation which, in turn, generate high greenhouse gas emissions. Since mangroves are ecologically diverse within the same climatic zone, coastal geomorphology and hydrological processes influence the chemical and physical conditions of their soils, as well as the structural development of their vegetation and, consequently, on the carbon storage capacity of their different compartments. Therefore, it is essential to quantify the ecosystems carbon stocks. This study estimated the carbon stocks of Cispatá and Málaga bays (Colombian Caribbean and Pacific, respectively). Carbon stocks in above ground biomass, roots, necromass (standing dead trees and debris) and soil (first 45 cm deep) were calculated, as well as their relationship with the soil chemical characteristics. The carbon stocks varied between 226.4±126.9 for the Pacific coast, and 521.2±80.1 Mg C ha-1 for the Caribbean. The soil was the main compartment, representing more than 60% of the carbon stock in both littorals. It was also the one with the greatest variability, with means of 142.2 and 417.4 Mg C ha-1 for the Pacific and the Caribbean, respectively. The highest carbon stock in soil was associated with higher values in the C/N ratio. Nevertheless, higher root carbon stocks were associated to high N, Ca and Mg concentrations. We also found greater allocation to the root biomass at the expense of the aboveground compartment when soil nutrients were less available. These results reaffirm that the protection of mangroves is one of the key in climate change mitigation strategies, however, carbon stock estimates should take into account the great variability of these forests.

Session: T008 - Blue carbon
Abstract ID: T008-A020
Presentation mode: Poster

Delimiting Species In The Red Mangrove *Rhizophora mangle* Species Complex

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Delimiting species is not a trivial task because speciation is a dynamic and gradual process. Additionally, interspecific hybridization, which is commonly observed in plants, may blur species boundaries making the separation of species even more challenging. In species-poor communities as mangrove forests, identifying and counting species within a certain geographic scale is particularly relevant. Along the Atlantic-Caribbean- Eastern-Pacific (ACEP) biogeographic region and South Pacific islands (SPI), Rhizophora genus is presumably represented by two species, R. mangle and R. racemosa, and a putative hybrid species R. X harrisonii. However, chloroplast DNA and microsatellite data suggest that R. mangle, R. racemosa and R. X harrisonii individuals from the Atlantic coast are more genetically related among each other compared to those from the Pacific basin. To clarify species boundaries within ACEP and SPI R. mangle species complex, we used genome-wide single nucleotide polymorphisms (SNP) and Approximate Bayesian Computation. We genotyped 62 SNPs for 331 individuals from 35 sampling localities and tested more than 100 evolutionary models, which differentially considered species morphological identification, the role of the American continent as a barrier to interspecific gene flow and R. X harrisonii topological positioning. We observed that, although the low number of SNPs may preclude a precise model selection, three evolutionary scenarios were supported. Despite their differences in lineages divergence topology and time of divergence, they all consider the role of the American continent as a barrier to Pacific-Atlantic gene flow and that R. X harrisonii is independently maintained in both coasts of the American continent. Therefore, we challenge the existence of only three morphospecies within the R. mangle species complex. Our findings are not only interesting for biogeographers or evolutionary biologists, but they may be also relevant for mangrove forests conservation and management as species are the basic units of biology.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A018
Presentation mode: Lightning Talk

Success of Mangrove Colonization and Persistence at the Northern Boundary in Eastern Florida (USA) Based on a Revised Elevation Model: Location, Location, Location

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An adaptation of the Marsh Equilibrium Model (MEM) for simulations of mangrove (Avicennia germinans) colonization of marsh habitat at their northern boundary indicates that the success of colonists depends on the relative elevation of the site and the future acceleration of sea-level rise (SLR). On low elevation sites it is a race against time for young mangroves. Their success depends on their ability to 'out-grow' the rise in sea level through biogenic accretion associated with growth. Counterintuitively, mature mangroves at a similar elevation may not survive as long as young mangroves, because mature mangroves do not possess the same growth advantage – a model assumption. Based on model simulations of sea level rising to 100 cm in a century, mangroves appear to be superior to salt marshes in their ability to keep up with sea level. Mangroves also produce tissue with higher lignin concentrations than Spartina alternifora and have higher biomass production. Consequently, mangroves are superior contributors to the biogenic component of marsh surface accretion. In terms of coastal resilience, the climate-driven, northward migration of mangroves may be beneficial for Florida wetlands.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A065
Presentation mode: Poster

How Can North Sumatran Mangroves Cope with Sea Level Rise?

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Being in the brink of the busy Malacca Strait, North Sumatran mangroves have significant roles to play concerning the resilience of fishing community and their livelihoods. We assessed the carbon stocks across various level of mangrove stands, sedimentation rates, and livelihood of fishing community. Aquaculture has been the backbone of the fishing community but unsustainable with the declining yield over the years. When restored, the aboveground carbon showed a significant increase although the belowground carbon still far below the protected mangroves. The area has slightly higher sedimentation rates (3.7-5.6 mm yr-1) than the average global sea level rise of the worst IPCC scenarios of 2.6 - 3.2 mm yr-1. Coastland subsidence is observed and taken into account but the mudflat geomorphic setting cannot cope with regional sea level rise of 4.2 ± 0.4 mm yr-1 observed along the Strait.Conservation of the existing intact mangroves in North Sumatra is facing tremendous development pressure. Coastal spatial planning will have to be oriented towards watershed approach rather than administrative boundary, which is less conservative. The approach may offer the way of restoring degraded mangroves as information of water and nutrient cycling as well as sediment transport may be generated and factor in.

Session: T008 - Blue carbon
Abstract ID: T008-A067
Presentation mode: Oral

How to Convey a Complex Message to a Wide Audience: Avoiding the Ocean Divide Between Science and Public Understanding? Insights from a Coastal Awareness Project in Sri Lanka

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Scientists are known to be weak at communicating their findings beyond their peers. The causes are multiple: communication to a wide audience is not felt as a primary assignment, the messages are increasingly complex and cannot be reduced easily to simple statements. Yet, society has a right to call upon scientists. The scientific process is borne mostly by public funding and society, the latter of which so righteously expect justification and feedback on the utilisation and output of funds. Inversely, scientists, whether covering fundamental or applied fields, cannot shy away from communicating their findings to the public.Tropical coastal conservation is complex, because it combines ecological borderlines and transition zones, with local and global processes (through ocean connectivity and the spatial scale of coastal problems) and intense human pressure. Coastal systems further confront private interests and 'commons', as the property and interests of all, and hence also the responsibility of all. Often pressure and conflicts are strongest towards the narrow coastal fringe.In the framework of the VLIR-UOS funded project 'Green Dyke' in Sri Lanka (2008-2014), we developed a Coastal Resources Awareness Centre (CORAC), which essentially is a fixed and a mobile version of a targeted exhibition and associated communication activities to a wide and complex audience. In this centre we highlighted the 'green dykes' or natural land barriers being coastal and marine ecosystems (with a main focus on mangroves) protecting the coastline against sea-borne hazards and providing goods and services for the livelihood of the local population. Drawing on this experience, the authors present their approach in Sri Lanka and combine this with a reflection on the multiplicity of roles that can be taken on by scientists, from advocacy to honest broker-ship. The experience in Sri Lanka can serve as a source of inspiration for coastal ecosystems' public awareness campaigns elsewhere.

Session: T009 - Mangrove management
Abstract ID: T009-A043
Presentation mode: Poster

Investigation of Metal Detoxification Mechanisms in the Roots of the Seedlings of a Common Mangrove, *Rhizophora mucronata* with an Emphasis on the Expressions of Phytochelatin Synthase (pcs).

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Mangroves are highly exposed to chemical contamination due to their proximity to the shores. Exposure to excessive heavy metals can alter their photosynthetic activity, induce oxidative stress and eventually lead to their death. Rhizophora mucronata is a common mangrove species found throughout the coast of Thailand. Our previous study shows that R. mucronata seedlings are tolerant to heavy metal and that they concentrate metal content in their roots. However, the knowledge on the mechanisms underlying their tolerance and on the possibility of using them as biomarker for heavy metal pollution is still lacking. In this study, we investigated the level of the transcripts encoding phytochelatin synthase (PCs), an enzyme responsible for the production of phytochelatin, which is a group of peptides involved in metal detoxification and sequestration in the roots of R. mucronata seedlings upon exposure to copper and zinc excess (200 mg Cu or Zn /L in 1/10x Hoagland solution, salinity 8) on day 1 and 5. The physiological responses i.e. photosynthesis and oxidative stress were concomitantly assessed. We found that copper decreased the photosynthetic electron transport from photosystem II and the maximum quantum yield of photosystem II of R. mucronata seedlings whereas zinc exerted no effect. No evidence of oxidative stress induced by metal accumulation was detected despite observed toxicity symptoms in Cu-treated seedlings (i.e. slight wilting of leaves and bent stems). Semi-quantitative PCR showed a down-regulation of pcs in Cu-treated roots whereas a down-regulation was observed on day 1 followed by a recovery in day 5 in Zn-treated roots. Our results suggested that PCs plays an important role in Cu and Zn tolerance. A down-regulation of pcs in Cu-exposed plants led to a failure of detoxification and sequestration, hence the phytotoxic effects, whereas a recovery of pcs expression in Zn-exposed plants allowed the plants maintain their function.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A016
Presentation mode: Poster

Molecular cloning and characterization of a phytochelatin synthase gene, RmPCS from Rhizophora mucronata

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Phytochelatin synthase (PCS) is the enzyme-catalyzed synthesis of phytochelatins (PCs), the heavy metal-detoxifying peptides in higher plants. The present study describes for first time the cloning and characterization of RmPCS gene of Rhizophora mucronata. Full-length cloning of RmPCS genes by polymerase chain reaction (PCR) yielded 1,491 base pair (bp)-long. The open reading frame was coded for 498 amino acids with a molecular weight of 54.9 kDa. The molecular phylogenetic analysis suggested that the RmPCS gene was closely related to Kandelia candel phytochelatin synthase mRNA. In addition, the amino acid sequence of the RmPCS contains the Phytochelatin synthase (PCS) domain in the N-terminal. The positions of the Cys-56 residues and the conserved His-162 and Asp-180 residues are the three residues that are conserved in all known PC synthases. The recombinant RmPCS was cloned in pET28a vector and expressed recombinant protein in Escherichia coli strain BL21 to determine the heavy metal detoxification function.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A025
Presentation mode: Poster

The Relative Role of Mangroves on Wave Erosion Mitigation and Sediment Properties

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Fringe mangroves reduce erosive processes by wave energy dissipation, sediment retention and soil development. We aim to better understand the effects of fringe mangroves on erosion patterns and sediment dynamics and of wave exposure on seedling densities in three sites with increasing wave power: a coastal lagoon, a sandy coast and a deltaic bar. During two dry and wet seasons mean grain size, sorting and bulk density was assessed using standard procedures within each setting in vegetated and unvegetated shores. Regression analysis was carried out to explain sediment properties variance as a response of the vegetation volume that oppose to wave energy. In addition, we estimated seasonal erosion/accretion rates for 2.4 years and seedling densities at, and prior to wave exposure. Mangrove-vegetated shores experienced 15- and 3- times lower erosion rates than unvegetated shores in the sandy coast and the deltaic bar, while in the coastal lagoon experienced accretion compared to a slight erosion of the unvegetated shore. Increased vegetation volume favored the deposition of particles with low settling rates, of different sediment classes and induced binding of coarse sediments in the deltaic bar and the sandy coast. Exposition to waves reduced mangrove seedling densities 3-, 4- and 15- times in agreement with increasing wave power of the study sites. Erosion mitigation occurred even under high wave power, expanding the view that mangroves mitigate erosion just in low energy environments. Such results suggest models of wave, sediment and mangrove dynamics and coastline change may consider mangrove structure variability to better understand and predict coastline evolution. On the other hand, although mangrove mitigated erosion in all settings, mangrove vulnerability was high in the deltaic bar and absent in the protected coastal lagoon. Thus, ecological models must consider the effects of wave power on ecological processes and mangrove vulnerability.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A015
Presentation mode: Poster

Effect of Human Driven Disturbances on Mangrove Wave Dissipation in the Sinú River Delta, Colombian Caribbean

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Wave dissipation by mangroves foster sediment settling and erosion control. While disturbances such as small-scale logging, typical along the tropics, may affect wave dissipation by diminishing vegetation density, mangrove loss generate vertical erosion and changes in the nearshore profile that can affect wave breaking. We aim to assess the effect of small-scale logging and of nearshore profile modifications by mangrove loss in wave dissipation. In a deltaic bar, mangrove wave dissipation was measured between 1 m and 3.5 m cross-shore distance along a control transect and a transect with a small-scale logging treatment. Pressure sensors and a sampling frequency of 1Hz were used to estimate wave height during 34 h. On the other hand, we estimate the breaking point and breaking wave height associated with two mangrove nearshore profiles located in a deltaic bar and a protected coastal lagoon, respectively and associated with 0.6%, 1.2% and 1.8% slope increments of such profiles. Wave evolution across such profiles and relative to wave boundary conditions measured seashore was estimated with the PETRA program. Slope increments are based on a 0.6% slope difference found between unvegetated and vegetated shores in the study area. The proportion of the tidal prism volume occupied by mangrove structures was of 0.06 in the treatment transect compared to 0.10 in the control transect. Under the same incident significant wave heights, wave reduction was on average 9% m-1 higher in the control transect. The breaking point increased 5.7 m and 0.04 m on average, while the breaking wave height increased 0.00 m and 0.01 m in the protected coastal lagoon and the deltaic bar, respectively with 0.6% higher slopes. Results suggest that small scale logging affect capability of mangroves to dissipate waves, while mangrove loss would move the wave breaking point landward favoring erosion.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A016
Presentation mode: Oral

SEDIMENT CARBON STOCK OF WEST KALIMANTAN MANGROVE FOREST

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The present study aims to investigate the influence of oceanographic factor and riverine input on mangrove ecosystem and their ability in absorbing carbon. The location of study was conducted in two different locations in west kalimantan, which are (1) Mempawah with three sampling stations and (2) Bakau Besar with four sampling stations. The sediment sampling was carried out using Polyvinyl Chloride (PVC) pipes in the middle of the transect point and taken within ± 20 cm depth. After laboratory pre-treatment, we analyzed the carbon content using Carbon Hydrogen Nitrogen (CHN) Analyzer. The results showed that station 3 of Mempawah and station 2 of Bakau Besar have high organic carbon content, i.e., 0.1003 gram C/m3 and 0.2324 gram C/m3, respectively. We also found that, input organic carbon in the river (location 2) and canal (location 1) were higher at high tide than low tide. The high and low tide load of organic carbon in the river is 7056.64 gram/second and 5673.30 gram/second and load in canal is 294.57 gram/second and 164.10 gram/second, respectively. Besides that, we also found that the sediment type at station 3 of Mempawah is categorized as silt (75%) and fine sand (± 0.24%). Whereas at station 2 of Bakau Besar, the sediment contains silt (68%) and fine sand (± 2%). The difference in type of sediment depends on wave height. In addtion, those two stations have a total mangrove density up to 2388 individuals/ha and 2749 individuals/ha, respectively. According to this findings, we suggest that high organic carbon is influenced not only by high biomass density but also by the oceanographic factor that affects load of organic carbon in river and canal, and the difference of sediment types that are influenced by wave height at the study site.

Session: T008 - Blue carbon
Abstract ID: T008-A010
Presentation mode: Poster

Estimating Mangrove Forest Area and Biomass Change Over a Decade in the Niger Delta, Nigeria

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Mangrove forests are beneficial ecosystems to coastal settlements due to the ecosystem services they provide. The exploitation of mangrove forests in the Niger Delta has led to their loss and the encroachment of nipa palm. There is no knowledge regionally of the current trend in mangrove degradation in the delta. Here, we estimate mangrove and nipa area' and generate a mangrove aboveground biomass map in the Niger Delta over a decade. We established 25 0.25 ha plots and 200 observations points. AGB was estimated from established allometric equations from stem surveys of mangrove trees > 5cm. ALOS PALSAR, Landsat and SRTM DEM were used to classify mangrove area while the relationship between field estimates of AGB and radar backscatter was established to generate a biomass map of the region. A total of 6.25ha of mangrove area was sampled with mean AGB of 80 t ha^{-1}. We estimated a mangrove area of 794 561 ha and nipa area of 11 419 ha in 2017. Analysis of change detection we discovered a 30% decrease in the mangrove area between 2007 and 2017. The relationship between radar backscatter and field estimates of AGB showed the highest R square value of 56% (p-value < 0.001) from a combination of the ratio of HV: HH and HV ALOS PALSAR data. We estimated mean AGB over the Niger Delta as 83.4 t ha^{-1} in 2017 and 90.5 t ha^{-1} in 2007. Our research identifies opportunities using remote sensing to estimate biomass based on the radar-AGB relationship we found. Land cover change is drastically reducing mangrove forests over the Niger Delta region with Nipa invasion playing a significant role. This is the first step for a regional scale mangrove forest monitoring system and creates opportunities for carbon credit generation under REDD+ in Nigeria.

Session: T003 - Mangrove loss and deforestation
Abstract ID: T003-A021
Presentation mode: Oral

Stand, Biomass and Canopy Patterns across Disturbance Gradients in Mangrove Forests of the Niger Delta.

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Mangroves forests in the Niger Delta are poorly quantified and at risk due to oil pollution, deforestation, and invasive species. Here we report the most extensive survey of mangrove plots for stand, biomass and canopy characteristics in the Niger Delta yet recorded across tidal and disturbance gradient. We established twenty-five geo-referenced 0.25-ha plots across three regions. We estimated aboveground biomass (AGB) from established allometric equations based on stem surveys. Leaf area index (LAI) was recorded using hemispherical photos. We estimated mean AGB of 83.7 t ha-1 with an order of magnitude range, from 11-241 t ha-1. We found significantly higher plots biomass in close proximity to the protected site and tidal influence, and the lowest in the sites where urbanization was actively taking place. The mean LAI was 1.45 and ranged five-fold from 0.46 to 2.41. There was a significant positive correlation between AGB and LAI (R2= 28%), supporting a hypothesized link between production and biomass. Satellite observations of NDVI for the growing season correlated positively with in-situ LAI (R2= 63%) and AGB (R2= 80%). We divided the plots into three disturbance regimes and three nipa palm invasion levels. Lower stem sizes (5-15cm) accounted for 70% contribution to the total biomass in disturbed plots, however, the undisturbed regime had a more even contribution of different size classes to AGB. Nipa palm invasion also showed a significant link to larger variations in LAI and proportion of basal removed within plots. We conclude that forest degradation is removing larger stems (> 15 cm DBH) preferentially from these mangroves and creates an avenue for nipa palm colonization. Our research identifies opportunities to use remote sensing to estimate biomass, based on LAI-AGB-NDVI relationship we found, and can also serve as a calibration dataset for other remote sensing data, such as radar.

Session: T001 - Impacts of people on mangrove structure and function
Abstract ID: T001-A023
Presentation mode: Poster

Variation in Carbon Accumulation Rates and Contaminant Sequestration in Mangrove Soils of Puerto Rico

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Mangrove ecosystems provide vital services for human society, including carbon storage and sequestration of excess nutrients and contaminants. Yet, given accelerated sea level rise and land use changes that alter forest productivity, the ability of mangrove ecosystems to continue accumulating sediments and sequestering contaminants is uncertain. We quantified differences in soil nutrients, contaminants, and accumulation rates across a gradient of physiography, climate, and land use in three mangrove forests on the island of Puerto Rico: Piñones on the northern coast, Jobos Bay in the southeast, and Punta Tocon in the southwest. Two 40-cm deep cores were collected at each location, and total nitrogen, total phosphorus (TP), organic and inorganic carbon, soil bulk density, and percent organic matter (OM) were determined at 2-cm intervals in the top 10 cm and 1-cm intervals thereafter. Trace metal analysis was conducted every third interval. Sediment accumulation rates were determined by radiometric dating with 210Pb isotopes. Mean OM content was much lower in cores from the northern coast compared to the southern coast (12-28 % vs. 65-69%), in part due to the large fraction of siliciclastic sediments imported to the northern coast. TP increased over the time period represented, from 100 to 300 ug/g at depth to over 600 ug/g at the surface. Average metal concentrations were generally observed as Zn>Ni>Cu>Pb>Cr>As>Co>Hg>Cd>Ag, with the largest concentrations in Punta Tocon soils, except Pb which was highest at Piñones. 100-year accretion rates ranged from 2 to 3 mm y-1 for all sites, whereas 10-yr accretion rates varied by location from 2 mm y-1 at Jobos Bay to 8 mm y-1 at Punta Tocon. Increased rates of sedimentation in the past decade could be tracking rates of sea level rise, which would prove invaluable for continued carbon and metal sequestration.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A045
Presentation mode: Lightning Talk

Microclimate Regulation as an Under-recognised Ecosystem Service of Mangrove Forests

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Intertidal mangrove forests are known to provide a range of provisioning, regulating and cultural ecosystem services to coastal populations. The regulation of urban microclimates is a key ecosystem service promoted in terrestrial forested ecosystems, but is rarely discussed in mangroves. This study quantified the potential role of mangroves in modifying the microclimate of an urban area in northwest Singapore. Fixed climate stations measuring surface ambient temperature and relative humidity were employed to study the spatio-temporal variation of microclimate of different land use and land cover types over eight months in two years. The mangrove forest was found to be about 1.5 degC cooler than the surrounding urban area and slightly cooler than other non-urban areas such as the neighbouring mudflat and grassland. Vegetation canopy cover is an important feature to promote cooler microclimates beneath the canopy, preventing solar radiation from warming the ground surface and consequently resulting in lower surface ambient air temperature. This study demonstrates that mangroves have great potential in significantly reducing urban temperatures, with the mangroves providing more day-time than night-time cooling potential. A greater awareness of this important ecosystem service will aid urban planning and provide stronger incentives for the conservation of threatened mangrove forests in rapidly urbanising landscapes throughout the tropics.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A012
Presentation mode: Lightning Talk

Correcting the Bias in Estimating Organic Carbon Content from Loss-on-ignition in Mangroves and Saltmarshes

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Loss-on-ignition (LOI) is widely used to estimate organic carbon (OC) content, and thus carbon stocks, due to easy operation and low costs. The wide use of a conversion factor of 1.724 (LOI:OC) oversimplifies the relationship between LOI and OC, and may lead to significant biases in estimating global sediment carbon stocks in 'blue carbon' ecosystems. We estimated sediment OC using LOI at different mangrove and saltmarsh sites in Hong Kong. OC of matched samples from the same sites was independently measured using an elemental analyzer. The sites are mostly typical mineral sediments with LOI less than 8%. The conversion factors of LOI:OC are 5.376 and 4.673 for mangroves and saltmarshes, respectively. This means the use of the common conversion factor will overestimate mangrove and saltmarsh sediment carbon stocks by 212% and 171%, respectively, in our studied sites. We also found that LOI can be used to estimate leaf and root OC (organic nitrogen) by conversion factors of 2.978 (12.837) and 1.737 (27.027), respectively. Our results highlight the urgency to correct the bias in estimating OC and carbon stocks from LOI in 'blue carbon' ecosystems, and the potential of using LOI for estimating leaf and root OC and organic nitrogen. The difference in the conversion factors between mangroves and saltmarshes, and between mineral and organic sediments should be taken into account when estimating OC from LOI for these wetlands.

Session: T008 - Blue carbon
Abstract ID: T008-A061
Presentation mode: Poster

Spatial Variations in Macrofaunal Community in Mangroves

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Macrobenthos are ecological indicators of mangroves and play an important role in the nutrient cycling of mangrove ecosystems. Four study sites with two mangroves species were selected in the west coast of Taiwan. Xinfeng (XF) and Zhunan (ZN) in the northern coast were dominant with Kandelia obovata, while Budai (BD) and Beimen (BM) (BD) in the southern coast were dominant with Avicennia marina. Our results showed that macrofaunal communities were different between K. obovata (XF, ZN) and A. marina (BD, BM). However, the abundance of Sipuncula was high in ZN, while it was almost absent in XF. This distinctness can be attributed to the high silt/clay content in ZN, which is the preferred habitat for Sipuncula. The dominant macrofauna of BM and BD were polychaetes and gastropods, respectively, which can be linked to the regional environmental conditions. Combined with the results of previous studies, it appears that the macrofaunal communities in mangroves are dependent upon local environmental conditions rather than mangrove tree species.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A025
Presentation mode: Poster

Building Coastal Resilience for Disaster Risk Reduction and Climate Change Adaptation Through Community Engaged Green-gray Infrastructure and Supplemental Livelihood Development

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The Philippines is the third most at-risk nation to the effects of climate change, according to the United Nations. This extreme vulnerability was demonstrated by the scale of the devastation caused by Typhoon Haiyan in 2013, when more than 6,000 lives and 900,000 homes were lost. With 50% or more of the 1,500 cities and municipalities in the Philippines lying along the coast and 62% of the country's population living in coastal zones, there is a critical need to find preemptive, innovative, and scalable solutions to mitigate these natural disasters. Green-gray infrastructure has the potential to be one such solution, especially for the most isolated and vulnerable of the coastal communities in the Philippines. Conservation International and our partners are implementing a green-gray infrastructure program in the Central Philippines to increase the coastal resilience of highly vulnerable communities by accelerating the local, regional, and international implementation of green-gray infrastructure projects. Green-gray infrastructure combines conservation and restoration of critical ecosystems with selective use of traditional "gray" engineering approaches to provide climate change resilience and adaptation. By blending "green" conservation with "gray" engineering techniques, communities can incorporate the benefits of both solutions while, though a hybrid approach, minimizing the limitations of using either green or gray infrastructure individually. The concept designs, planned for implementation in 2019, use civil engineering techniques to establish and support the rehabilitation of mangrove communities. The long-term benefits of rehabilitating coastal mangrove forests in the region will support community adaptation strategies. Partner communities have established mangrove nurseries and will construct, monitor, and maintain the projects with oversight from the local municipal engineer. Partner communities are also engaged in organizational strengthening and development, including value chain analysis of possible supplemental livelihood options, for example from the manufacturing of coconut products, establishing eco-tourism venues, raising organic livestock, and making salt.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A015
Presentation mode: Oral

Sediment Physiochemical Properties in Different Level of Mangrove Disturbances Areas at Matang Mangrove Forest, Perak

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Mangrove sediment is a rich resource of elements. The productivity of mangrove is completely depended on the enrichment of sediment. Anthropogenic activities also affect and contaminate the sediments. This study aims to assess the physicochemical properties of Matang mangrove forest sediments in three different areas. These areas were selected based on different level of mangrove disturbances areas (Sungai Sepetang: highly disturbed, Sungai Tinggi: moderately disturbed and Sungai Tiram Laut; least disturbed) at Matang Mangrove Forest, Perak. At 1.5 meter depth, sediments were sampled into five segments (0-15, 15-30, 30-50, 50-100 and 100-150 cm). Total 21 elements (Sand, Silt, Clay, EC, pH Water, pH KCl, N, P, K, Ca, Mg, Mn, Fe, Pb, Zn, Cu, Cd, Cr, Ni, Al and Na) were analysed to determine the sediment physiochemical properties. In term of sediment texture, the percentage of sand was the highest, followed by silt, clay and it is classified under class sandy loam. The chemical properties are shown that nutrients and heavy metals elements status is still under a lower range. Nutrients and heavy metal elements were found at various areas and it is not focused on the specific areas.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A012
Presentation mode: Poster

Latitudinal Gradients and Poleward Expansion of Mangrove Ecosystems in South Africa

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In 1963, William Macnae published the first comprehensive assessment of mangrove swamps in South Africa and made firsthand observations of these mangrove ecosystems. Our work reassesses South African mangrove habitats, highlighting changes since Macnae's assessment, through a literature review of research done in the past 50 years and using the results of a dedicated mangrove survey spanning 2012–2017. Until now, changes have been recorded mostly for mangrove vegetation, including a change in mangrove cover and a poleward shift of mangrove species. While some mangrove-associated fauna have disappeared from most sites (e.g. the gastropod Terebralia palustris), others, such as fiddler crabs, have spread farther south. The effects of decreasing diversity with an increase in latitude were not observed along the South African coast. Instead, habitat quality and estuarine mouth state seem to exert greater influence on species diversity in the mangroves, and a poleward shift in species distribution is now evident, not just for the mangrove flora but for the fauna as well. South African mangrove research needs to include a continuous monitoring plan, especially if we are to contribute to global knowledge on blue carbon, the effects of sea-level rise, and the resilience of the mangrove ecosystems.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A004
Presentation mode: Poster

Merging of Scientific Exploration and Traditional Knowledge in the Inhambane Bay Mangroves, Mozambique

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The Inhambane Bay mangroves cover an area of approximately 5800 ha. Because local communities depend on this habitat, they have sought to establish, manage and enforce nine no-take zones to protect mangrove flora and fauna, including fish that use the bay as a nursery. Each community governs its own area and has developed no-take zones based on traditional ecological knowledge. As a result, harvesting and other land use is prohibited, either permanently or for certain established periods. Rules are enforced by the local fishing council with support from the government, the police and a local NGO.Ecologically, very little is known about Inhambane Bay. Although conservation measures are in place and monitoring is rigorous, the effectiveness of these zones has not yet been studied. Furthermore, community members who manage the area have had minimal training.Local and scientific knowledge is being collected and communicated to all stakeholders in a project initiated by Ocean Revolution (NGO).We aim to assess the biodiversity of the Inhambane Bay mangroves using scientific methods and traditional knowledge and to examine the effects of community-based no-take zones and human influence on mangrove ecosystems and diversity. More importantly, the Inhambane Bay Mangrove Study provides a unique opportunity to understand: 1) what makes a community-supported conservation initiative successful; 2) how this system works with little to no conflict between stakeholders each with a unique understanding and set of knowledge; and 3) how to involve communities in scientific study of their environment. Using multiple approaches (including community bioblitzes, workshops, participatory systems, models and good old storytelling), we reveal not just the biology and ecology of the Inhambane Bay mangroves, but also the stories of the communities that have protected this habitat for centuries and the lessons we have learnt from them.

Session: T009 - Mangrove management
Abstract ID: T009-A049
Presentation mode: Oral

The Mangrove Forest Carbon Flow and Storage Subjected to Anthropogenic Stress Levels

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Mangroves are an important forestry resource throughout the intertropical belt. Anthropogenic activities have significantly altered the biodiversity of strategic ecosystems, especially the mangroves of Buenaventura, on the Colombian Pacific coast. Activities such as deforestation, extraction of minerals and wood, and inappropriate land use are, among others, the main impacts on these mangrove forests. The present study evaluated the flow and storage of carbon in mangrove forests subjected to different anthropogenic stress levels in the Bay of Buenaventura Bay, Colombian Pacific coast. Four sampling stations were located: Agua Dulce, Islalba, Piangüita and Punta Soldado. The dominant species of the forest correspond to Rhizophora spp, Laguncularia racemosa, Avicennia germinans and Pelliciera rhizophorae. At each station, six plots were established, in a 150 m transect, where three sediment samples were taken: lower, middle and upper (1 m depth) per plot, to determine the carbon reserves, measuring the depth, the density and organic carbon concentration of the sediment. The highest values of organic carbon were found in the Agua Dulce station, 175.97 mg / ha-1, followed by Punta Soldado 147.74 mg / ha-1 and Pianguita 88.87 mg / ha-1. The lowest values were registered at the Islalba station with 82.37 mg / ha-1. These results suggest a correlation between levels of stress on the ecosystem and carbon storage capacity, which demonstrates the importance of conserving mangrove forest cover as carbon capture areas for the mitigation of greenhouse gas emissions in the coastal area.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A001
Presentation mode: Oral

Mangrove Monitoring and Carbon Assessment in J. N. "ding" Darling National Wildlife Refuge, Sanibel Island, Florida.

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While the ability of mangrove ecosystems to sequester carbon is well understood, the lack of long term in-situ observations precludes spatially explicit and precise mapping of carbon stocks and potential sequestration. Here we present research that integrates extensive above ground biomass field data with 194 permanent biomass plots and Landsat imagery over a period of thirty-two years (1985 – 2018) over Ding Darling National Wildlife Refuge (DDNWR), Sanibel Island, Florida. The goal of the study is to monitor mangrove distribution, estimate the amount of carbon stored and create a baseline for future carbon sequestration estimates and forecasting. The current mangrove distribution was estimated as 1,250 hectares using National Agriculture Imagery Program (NAIP) aerial photographs. The continuous change detection and classification (CCDC) technique was applied to all available Landsat observations for annual mangrove monitoring and depicted a loss of 45 hectares in 2004 as a result of hurricane Charley. For estimating above ground carbon content in Avicennia germinans, Laguncularia racemosa and Rhizophora mangle, we tested three methods. The first uses allometric equations specific to Florida but derived from trees with a smaller maximum diameter at breast height (DBH) than those measured in this study. Because of this shortcoming, our second method uses general allometric equations developed for the Americas, which were derived from mangroves with a DBH range similar to those measured in the field. The third method, uses a combination of both references depending on diameter. Our preliminary carbon stock estimates are 56.77, 60.52, and 64.54 MgC/ha and total of 70,963, 75,650, and 80,675 MgC for the refuge using the three methods, respectively. The loss of 45 hectares in 2004 translates into an estimated loss of 2,554.7, 2,723.4, and 2,904.3 MgC. Our results provide a baseline for estimating potential future mangrove loss and how such change would affect carbon storage.

Session: T003 - Mangrove loss and deforestation
Abstract ID: T003-A008
Presentation mode: Poster

Expansion of an introduced mangrove species in mangrove-*Spartina* ecotone in southern China

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Biological invasion are changing the species composition and structure of native mangrove community in southern coast of China. Invasive saltmarsh plant of Spartina alterniflora, introduced from USA, gradually dominated intertidal mudflats and open gaps in mangrove forests, suppressed growth and recruitment of native mangrove seedlings. Exotic mangrove species of Sonneratia apetala, introduced from Bangladesh, can successful encroachment in various habitats with a high spreading and fast growth ability. To a better understand of the pattern and mechanism of S. apetala regeneration in mangrove-Spartina ecotone, we investigated the dynamics of intertidal vegetation in Leizhou Bay, Guangdong Province, which was the southern distribution limit of S. alterniflora and has the vast plantation of S. apetala. The result showed that seeds of S. apetala dispersed to all intertidal habitats, with a fast expansion of S. apetala into native Avicennia marina shrubs and invasive S. alterniflora meadow, and grew taller than other species within two years after establishment. To compare the response of exotic S. apetala and native A. marina at different habitats during the early stage of recruitment, we transplanted seedlings of these two mangrove species into four habitats of unvegetated mudflat, invasive Spartina meadow, native A. marina stand, and exotic S. apetala plantation in the field, with a decrease of light availability. Survival was nil in S. apetala plantation where shading by dense vegetation killed all transplanted seedlings, while seedling can survive in Spartina meadow and A. marina stand, but grow slower than those in unvegetated mudflat. S. apetala has lower survival but higher growth rate than A. marina in all four habitats. These indicated that S. apetala plantation and rapidly natural regeneration have transformed the native mangroves and monospecific intertidal Spartina grasslands or even converting to near complete dominance by the exotic mangrove S. apetala in southern coast of China.

Session: T009 - Mangrove management
Abstract ID: T009-A019
Presentation mode: Poster

Modelling the Effect of a Partial Dieback of *Avicennia* Trees as a Strategy to Survive Temporary Increases in Salinity

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Trees of Avicennia species have the capability to partially die-back when exposed to adverse environmental conditions, including increases in porewater salinity. The BETTINA individual based modelling approach enables the quantification of the tree's water use depending on it's allometric characteristics and thus provides a tool to model the equilibrium between porewater salinity and plant size and density in a mangrove stand. Coupling the model with a hydrodynamic ground water model, the water use of trees corresponds to the water extraction from the soil and, in combination with the water fluxes, leads to a change of salinity in the root zone. Annual variations of the sea level, the tidal regime, ground water inflow and / or precipitation may have an impact on the equilibrium of the combined system. Lower salinities improve the plant water uptake and cause an accelerated tree growth. Higher salinities lead to lower potential gradients and reduced water uptakes of the plant. Consecutive partial die-back decreases water demand and uptake and thus may reduce the tree's effect on the soil water salinity and enable the survival of the individual. Individual based models can enhance our understanding of the regulating effect of the partial die-back on the water balance in the combined plant-soil system.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A020
Presentation mode: Oral

Experimental Flooding Affects Physicochemical Conditions, Induces Some Physiological Responses and Alters Proteomic Profile of the Seedlings of a Common Mangrove, *Rhizophora mucronata*

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Mangrove seedlings are subjected to natural tidal flooding which may occasionally lead to complete submergence. With the projection of sea level rise and an increase in extreme weather events predicted by climate change scenarios, waterlogging and submergence may become one of the main stressors for mangroves. Flooding limits gas exchange, resulting in hypoxia and the floodwater, when it covers the leaves, reduces light availability. These changes in physicochemical conditions may affect plant metabolic processes. Rhizophora mucronata is a common mangrove and is the dominant species in various mangrove forests in Thailand. This study coupled a physiological investigation with a proteomics analysis of R. mucronata seedlings exposed to flooding in a greenhouse experiment. Twenty days of flooding resulted in a significant decrease in dissolved oxygen, oxidation-reduction potential and pH of the sediment porewater; in addition, light intensity was significantly lower in complete submergence treatments. Seedlings under complete submergence showed the photosynthetic characteristics of a shade plant as well as displayed lowered stomatal conductance. In addition, we observed a vertical reorientation of the leaves under complete submergence. Label-free proteomics analysis of both the leaf and root total proteins showed that proteins involved in key metabolic processes such as photosynthesis, nucleic acid metabolism, plant development, defense responses and carbohydrates metabolisms differentially expressed in response to submergence. Nevertheless, other physiological features such as the maximum quantum yield of photosystem II, oxidative stress-related parameters and tissue carbon nitrogen and phosphorus as well as sodium and potassium contents exhibited no significant change. Overall, our study shows that R. mucronata seedlings acclimate to complete submergence conditions by making adjustments both at the morphological, physiological and cellular levels.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A025
Presentation mode: Oral

Influence of Salt Marsh Canopy on Black Mangrove (Avicennia germinans) at its Northern Latitudinal Limit.

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Avicennia germinans (black mangrove) is the most freeze-tolerant mangrove species in North America. As annual minimum temperatures increase globally, freeze-intolerant *A. germinans* has expanded poleward into grass-dominated salt marsh communities. Understanding species interactions and colonization dynamics of *A. germinans* at its northernmost extent is crucial for understanding climate related changes in coastal habitats. In this study, we transplanted *A. germinans*, at seedling and propagule life history stages, into *Spartina alterniflora* dominated salt marsh plots along a latitudinal gradient spanning beyond the species' current range limits. Half of the experimental plots had the salt marsh grass canopy removed to observe interactions between species and effects of canopy on microclimate. Plots were monitored for 2 years. Removal of the marsh canopy resulted in lower minimum temperatures and longer freeze duration. Seeding survival was greatest at the southernmost site; however, at the northernmost site seedling survival was limited to plots where *S. alterniflora* canopy remained intact. There was no effect of *S. alterniflora* canopy on propagule survival. This study elucidates competitive and facilitative interactions between herbaceous marsh canopy and early life-history stages of *A. germinans* showing the value of manipulative field experiments in testing ecological theory and providing important information for predicting shifts in species in a changing climate.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A007
Presentation mode: Lightning Talk

Investigating Mangrove Productivity in Relation to Socio-economically Important U.S Fisheries

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Two thirds of the human population live in or near coastal areas which have caused extensive damage to coastal ecosystems. In particular, mangrove ecosystems have undergone extensive damage due to overpopulation. Mangrove forests play an integral role for the sustenance of commercial fisheries and fuel such economies. Previous research have focussed mainly on the effects of abiotic fluctuations such as salinity and temperature on mangrove forests. However, relatively little is known about the nuanced interactions between mangrove ecosystems and organisms that depend on it. This project aims to map out trophic interactions of heterogeneous subtropical mangrove ecosystems and identify sources of energy exchange, and the consequent impact on coastal fisheries. The aims of this project will be achieved firstly through meta-barcoding of gut contents from key species using a variety of markers such as COI, 12S, rbcL, Trn-L-intron and 18S. Secondly, carbon and nitrogen isotope ratios will be analysed to determine trophic positioning and reveal habitat usage to identify the main carbon resource pool. Stable isotope data will also be used to monitor changes in the food web along a salinity gradient. This research will be conducted in Estero Bay, adjacent to the Gulf of Mexico, in collaboration with Florida Gulf State University at the Vester Marine and Environmental Science Research Field Station. Estero Bay is surrounded by mangrove forests which are fed by different rivers offering an ideal juxtaposition of contrasting habitats. The results obtained will unravel vital information about how food webs are influenced by mangrove ecosystems and its consequent impact on fisheries recruitment.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A031
Presentation mode: Poster

Mangrove Community Resilience and Succession After Subsidence Inflicted Sea Level Rise in Car Nicobar Islands, India: Implications for Mangrove Conservation

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The inter-specific resilience among mangrove species to sea level rise (SLR) is key to design conservation strategies for this economically and ecologically important ecosystem that is among the most vulnerable to SLR. In addition to the eustatic sea level rise, tectonic processes can also cause increase or drop in sea level, which can provide insights for the mangrove community responses to sea level change. We observed the mangrove species responses and succession after the acute SLR of c. 1 m caused by land subsidence during 2004 Sumatra-Andaman earthquake at Car Nicobar Island, India. The seaward mangrove community comprised of Rhizophora spp. have survived after the subsidence, whereas mass tree mortality was observed in the landward mangrove community comprised of Bruguiera spp., Lumnitzera spp., and Xylocarpus spp. Subsequently, the Rhizophora spp. (mainly R. mucronata) have successfully colonized the earlier landward mangrove habitats, whereas the landward mangroves are found seldom in the new inter tidal habitats that were coconut plantation before the subsidence. Seed source availability may be the major influencing factor for the varying rates of landward and seaward mangrove colonization in the new habitats. The observed resilience of Rhizophora spp. can be explained by the local specific geological legacy and species specific ecological processes. It is noteworthy that these island landscape have experienced four large frequency earthquakes (>7 Mw) and land subsidence & uplift during the past two centuries, which might have had an positive influence in the species specific resilience for sea level change. The observed resilience of Rhizophora spp. indicates their potentiality for the mangrove restoration activities targeted towards mitigating sea level rise and provides opportunities for further scientific enquiries on multiple aspects of mangrove response to subsidence.

Session: T003 - Mangrove loss and deforestation
Abstract ID: T003-A012
Presentation mode: Lightning Talk

Silvicultural Transformation of Even-aged *Rhizophora* Plantations in Thailand

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Abandoned shrimp ponds in Thailand have been restored through the establishment of even-aged Rhizophora apiculata plantations with an initial spacing of 1.5 m x 1.5 m. These restoration efforts aimed at quickly re-establishing a forest canopy, and consequently providing previously lost ecosystem services. However, there are concerns whether these even-aged pure stands are inferior to more structurally diverse forests and cannot provide ecosystem services effectively. We assessed the effects of silvicultural interventions, specifically the creation of canopy openings, on the structural characteristics of R. apiculata plantations. We compared the structural development of stands under strict conservation with thinned stands using the individual-based growth model KiWi. In each treatment, 16 regularly spaced gaps were created in a stand of 1 ha size. Thinning treatments differed in the size of these gaps (25, 56, or 110 m2) and the age of the forest stand (6, 15, 25, or 35 years). Additionally, seedlings of the non-planted species Avicennia marina colonized the plantation. The results suggest that the creation of large forest gaps (110 m2) effectively accelerated the structural transformation of even-aged stands to more diversely-structured forests, while maintaining a forest cover. Even in older forest stands, this silvicultural intervention increased the structural diversity by increasing tree size differentiation and species mixture. In contrast, smaller gaps did not provide sufficient space for the long-term establishment of non-planted tree species or younger R. apiculata trees. These findings were linked to the concepts of service- and sustainability-oriented conversion of forest stands into other forest types, and its implication for the provision of ecosystem services were discussed.

Session: T009 - Mangrove management
Abstract ID: T009-A030
Presentation mode: Oral

Neglect of Coastal Bamboo Fences Triggered Mangrove Decline in Thailand

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Along the Upper Gulf of Thailand, coastal fences and breakwaters have been constructed using bamboo since 2005. Despite their potential benefits, bamboo structures disintegrate within seven years releasing floating debris, which severely damages mangrove tree stems. It was investigated whether these stem damages resulted in the decline of Avicennia stands along the Upper Gulf of Thailand. Tree health assessments were conducted to assess the probability of crown dieback in damaged and undamaged trees. Satellite-derived NDVI time-series were used to detect long-term forest decline. The majority of assessed trees showed signs of moderate to severe crown dieback, which was significantly more likely to affect damaged trees. The health of seaward mangroves was declining as trees were unable to recover from insect defoliations after the collapse of a nearby fence, whereas more landward mangroves remained unaffected. It is recommended to secure bamboo fences by replacing stems before their detachment.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A009
Presentation mode: Poster

Lessons In Mangrove Rehabilitation In The Philippines Over The Decades

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Much money and resources have been invested in mangrove rehabilitation in the Philippines (and elsewhere) going back to the 1960s. From the many mangrove initiatives over more than half a century, the following lessons are distilled:

a) Prioritize reversion of abandoned ponds to mangroves which gives higher success rates (over seafront planting) as these ponds were once mangrove forests.
b) Where seafront planting is feasible or cannot be avoided, apply the following protocols:
    1. Select planting sites during Neap Tide (vs Spring Tide) to allow 70% mangrove emergence.
    2. Plant at middle to upper intertidal elevation (vs lower intertidal to subtidal levels) to avoid:
        i. seagrass beds (the default mode in most of the present National Greening Program sites of the Philippine government)
        ii. mudflats and coral reefs
    3. Corollary to the above, plant mangroves in gradual rows in a seaside direction from the beach (rather than landward from a delineated low tide point).
    4. Plant the right species, generally Avicennia marina and Sonneratia alba (which require nurseries) instead of the conveniently sourced but ecologically incorrect Rhizophora.
    5. Plant during the season of least wave action, e.g., the northwest monsoon along most of the Philippine coastline.
c) Apply Green-Gray Engineering (or Building with Nature) to mitigate wave action and erosion along some seafronts.
d) Apply science-based protocols such as in items A-C above, and also the following:
    1. Restore a 100-m wide greenbelt of mangroves (and/or beach forest) to reduce up to 60% of energy from wind and swell waves (MacIvor et al, 2012).
    2. Follow a 4:1 mangrove-pond ratio for sustainability of brackishwater pond aquaculture (Saenger et al., 1983).
    3. Apply Assisted Natural Regeneration to restore abandoned ponds in ~3 years rather than the 15-20 years required for Natural Regeneration (Primavera et al., 2012).
    4. Corollary to 3 above, use excess wildings (representing interest) for nursery rearing based on the concept that mangrove stands are "sapling banks" (Ellison, 2000).
e) Apply Community-based Mangrove Rehabilitation whose essence is volunteer community labor for planting, maintenance and protection together with the granting to these communities the rights to sustainable mangrove use (e.g., shellfish gleaning, seedling harvest for nurseries).
f) For international and national development agencies to undergo a paradigm shift in defining success of mangrove rehabilitation in terms of survival rates and new forest area at the end, away from the quotas in the beginning of number of hectares/propagules planted.

Presentation mode: Keynote

Breakwaters: a Green-gray Strategy for Mangrove Rehabilitation in Highly Eroded Coastline of Pedada, Ajuy, Iloilo, Philippines

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Mangroves are natural buffers that protect coastal communities from wave surges and tsunamis. In the Philippines, mangrove cover has drastically declined and its loss has been associated with conversion to other uses, particularly aquaculture ponds in the 1980s. Various management and rehabilitation efforts were implemented in the country to reverse the trend. However, physical factors such as waves, currents and wind affect survival rates of newly planted seedlings along the seafront. The Zoological Society of London – Philippines explored different strategies to increase survival rates of mangroves in high energy coaival. The breakwaters are temporary piles of rocks 0.9 m high and 1.5 m wide designed to last until the mangroves are at least 5 years old and can withstand wave action. Results show an increasing trend in elevation with a maximum sedimentation rate of 50 cm/year behind the breakwaters. Accretion in one of the breakwaters increased from 210 m2 in 2010 to 3,822 m2 in 2016. Identifying the edge of soil accretion has been difficult in the recent years as it already started to converge with landward sediments and natural recruits have already established. None survived among the Avicennia marina, Sonneratia alba and Rhizophora mucronata planted in 2010. Planting continued in 2012 when sediment was already firm and stable. S. alba was recorded to have the highest survival rate at 73.6% among the species planted. Natural recruitment of S. alba and A. marina was also recorded in 2013, but it was difficult to distinguish between planted seedlings in succeeding surveys. The Pedada, Ajuy breakwater highlights science-based approaches backed up by properly designed engineering structures enhancing mangrove survival in highly eroded areas.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A012
Presentation mode: Poster

Training of Trainers on Mangrove and Beach Forest Rehabilitation and Conservation

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The role of mangroves in coastal protection was highlighted when Typhoon Haiyan devastated central Philippines in November 2013. The overwhelming response to rehabilitate natural buffers of the coast included the government's US$22 million Mangrove and Beach Forest Development Project and a greater demand for the Mangrove and Beach Forest Training Course of the Zoological Society of London - Philippines (ZSL-Philippines) which features lectures and practical sessions on Mangrove Biology (Taxonomy), Nursery, Outplanting, Pond Reversion, Ecoparks and Community Organizing. Since its inception in 2009, the Mangrove Training Course has graduated more than 1,500 individuals from government agencies, local government units, non-government organisations, communities, academe, and the private sector. With the growing demand for training and the limited resources of ZSL-Philippines, the Training of Trainers (ToT) on Mangrove and Beach Forest Rehabilitation and Conservation was developed in 2015. In addition to the standard mangrove and beach forest topics, the curriculum covers the mechanics of a training course – from planning to the sessions and pre-/post-training evaluation. The ToT has now produced 190 graduates from 9 sessions. Monitoring through online surveys and on-site visits reveal that ToT graduates have conducted more than 45 trainings and undertaken rehabilitation of 923.33 ha of degraded mangrove forest and abandoned fishponds. A paradigm shift to the use of science-based protocols was evident in site visits e.g. some nurseries and seafront planting sites were growing the mangroves Avicennia marina and Sonneratia alba, other than the easy-to-plant but ecologically incorrect Rhizophora species.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A020
Presentation mode: Poster

Fine-scale Assessment of Changes in Zonations of Species for the Management of Imperiled Mangroves, Pichavaram, India

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Each mangrove region has a specific history which needs to be understood as it is a central component for adapting current conservation plans to changing coastal conditions induced by increasing natural or human pressures. As these latter impact the functioning, physiognomy and extent of mangroves, it is urgent to design and implement monitoring programs able to monitor changes in zonations of mangrove species (ZMS). Recent studies highlighted the combined potential of very high spatial resolution (VHSR) satellite images and robust field data to map such mangrove areas dominated by a few species. Here we examined the Pichavaram mangroves, southeast coast of India. The 1100-ha mangrove wetland area was, in 1987, declared to be a Forest Reserve by the Forest Department, Government of Tamil Nadu. Disturbances generated by the 2004-tsunami, decreasing freshwater, and increasing pollutants inflow, combine to modify the geochemistry of the whole region with a potential influence on the zonation of mangrove species. Afforestation programmes have been carried out since the 1980s using the fishbone canal-bank technique. We inventoried species and measured trunk diameters (DBH), tree heights within forest plots representative of a large range of planted and natural ZMS. Based on this ground expertise, we performed a spectral and textural analysis of five VHSR multispectral images acquired between 2003 and 2018 to generate ZMS maps on a scale of 1:2000. Our results indicate that mangrove cover is increasing while species richness decreases in favour of salt-tolerant species. Our analysis also highlights a shrunk in average tree crown size, suggesting alterations in species succession and plant growth capability. We thank the Tamil Nadu Forest Department for allowing us to undertake this study.

Session: T001 - Impacts of people on mangrove structure and function
Abstract ID: T001-A007
Presentation mode: Oral

Terrestrial Glomalin-related Soil Protein Sequestration Contributes Carbon Storage in Coastal Mangrove Wetlands

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Mangrove wetlands serve as an important carbon storage ecosystem in tropical and subtropical coastal area. Mangroves are buffering terrestrial carbon sequestration including massive arbuscular mycorrhizal fungi derived glomalin-related soil protein (GRSP). As a stable fungal protein, GRSP is distributed widely in terrestrial ecosystems such as forests, grasslands, desert and agricultural ecosystems.This particular terrigenous-derived carbon is transported to the coastal zones, where it accumulates in sediments. However, mechanism of sequestration of this stable terrestrial derived carbon in mangrove wetlands is not well explored. Here, we reveal this stable glomalin-related soil protein distribution in Chinese mangrove wetland which contributed 3-15% to soil organic carbon. Compared with terrestrial ecosystems, coastal wetlands even contain higher GRSP contents. Mangrove plants increased GRSP deposition in wetland. Significant higher content of GRSP was found in mangrove rhizosphere than bear beach. As a glue-like soil protein, it suggested that GRSP accumulation in the sediment profiles increased water-stable aggregates formation thus increasing potential stabilization and burial of carbon in wetlands. Iron, an important factor contributing to the sequestration of organic carbon, whose total- and GRSP-bound- concentration were also found to be significantly higher in mangroves than bear beach. Furthermore, we found that the rhizosphere aerobic environment promoted the oxidation of Fe(II) to Fe(III) in mangrove sediments, which caused the terrigenous-derived GRSP bound with Fe(III) to form a stable iron oxide/GRSP complex via adsorption and coprecipitation. Assessment of GRSP contributes to mangrove wetland carbon storage provides knowledge for distinguishing terrestrial arbuscular mycorrhizal fungi derived carbon burial of mangrove wetland. Moreover, the combined GRSP with soil organic matter facilitated carbon storage in mangrove wetlands, this provides a new mechanism for carbon sequestration in mangrove wetlands.

Session: T008 - Blue carbon
Abstract ID: T008-A031
Presentation mode: Poster

Blue Carbon Local Governance in the Philippines: Analysis of the Mangrove Management Plans in Municipal Level

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The role of mangrove forest ecosystem in mitigating climate change has received an increasing attention in the recent years. The mangrove ecosystem together with salt marshes and seagrass meadows comprise the blue carbon ecosystems. Several studies have already documented how these ecosystems can sequester carbon and how much carbon stocks are stored in their biomass. Increase on the initiatives on the protection and management of these ecosystems have been propagated in different platforms both internationally and nationally. However, studies that focus on the content of coastal management plans (CMPs) and how they affect the use of blue carbon ecosystems services are very limited. In the Philippines, frameworks on management of blue carbon ecosystems are on the exploration phase. This study will utilize content analysis to determine the current focus of the mangrove management plans in the country, focusing on the plans in municipal level. To address this, the municipalities in the three geographically distinct provinces were selected; Palawan (western side), Panay (central part) and Eastern Samar (eastern side), Philippines. Though this study only focuses on the mangrove forest ecosystem management at a local (municipal) level, it can give an overview of the country's collective effort on climate change mitigation through blue carbon ecosystem managements. Furthermore, this study can highlight the different activities and its potential to blue carbon local governance. The results of this study can contribute to the developing global pool of knowledge on climate change mitigation as well as addressing the lack of management-related studies on these ecosystems.

Session: T008 - Blue carbon
Abstract ID: T008-A026
Presentation mode: Poster

Uncertainties in Estimation of Spatial Carbon Dynamics in the Sundarbans Mangrove Forest, Bangladesh

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Mangroves are arguably the most carbon-rich ecosystem in the world despite of having very limited spatial coverage. Systematic study of mangrove carbon estimation has increased in the last decade owing to its mounting importance to climate change mitigation strategies and the need for accurate carbon accounting at a national level. The large uncertainty in carbon accounting in mangroves is a consequence of many factors, including choice of allometric model, which is often non-site and non-species-specific. Another imperative factor driving uncertainty is using the global wood density that usually doesn't reflect the variation of local or regional environmental condition. Belowground root carbon possesses the largest uncertainty when it is measured with allometric equation rather than direct harvesting. To address these issues, we collected both above and belowground data from 160 plots from the Sundarbans mangrove forest, Bangladesh. By using local species-specific model and measured wood density, we estimated and compared total ecosystem carbon with the outputs from regional and world's generic allometric model along with published wood density. We used direct coring and canal photography in order to assess accurate carbon in the belowground roots. By using and comparing different methods we tend to validate and improve methodological approaches of blue carbon estimation in mangroves. We believe that the estimated uncertainties are inevitable while quantifying carbon budget at national level and understanding the capacity of this unique ecosystem to withstand climate change.

Session: T008 - Blue carbon
Abstract ID: T008-A038
Presentation mode: Poster

Assessing Alternative Approaches in Measuring Surface Elevation Changes Following Mangrove Clearance in Tsimipaika Bay, North West Madagascar.

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Madagascar contains 2% of the world's mangroves, many of which are exhibiting signs of widespread degradation and a country-wide net loss of over 20% between 1990 and 2010. Substantial losses of mangroves through harvesting can increase vulnerability to erosion, subsidence and lead to rapid sediment carbon losses. Assessing changes in sediment dynamics and quantifying soil carbon losses following mangrove deforestation is vital to the development of baseline scenarios in fulfilling climate mitigation project requirements. While a loss of sediment elevation is visually noticeable throughout the cleared mangrove areas of Tsimipaika Bay in Northwest Madagascar, its quantification is challenging and the impact on carbon storage is unknown. Traditional methods to track surface elevation changes over time are costly, survey design is often difficult, due to patterns in degradation limiting areas available as control sites, and use of manipulative experimentation is generally infeasible. Therefore, a rapid, inexpensive assessment of sediment elevation change, in relation to individual trees, was deployed alongside routine carbon stock surveys. Targeting areas cleared during different time periods, a measurement was made of the distance between the sediment surface and the point at which the top of the highest buttress root became even with the main stem for two species, Bruguiera gymnorrizha and Ceriops tagal. Between 2016 and 2018, a total of 458 of plots were surveyed. This included 4180 individual trees and covered 'intact' sites, exhibiting varying levels of degradation, and areas that were cleared of mangroves within time frames ranging from 1997 - 2003 to 2013 - 2016. Results were analysed across deforestation time periods and factors taken into account included the intensity of degradation, individual tree size and environmental settings. Here, we present the initial results of our rapid assessment of sediment elevation change and compare them to the results gathered through 210Pb profile analysis and rSET monitoring.

Session: T003 - Mangrove loss and deforestation
Abstract ID: T003-A017
Presentation mode: Poster

Restrictions on the Latitudinal Expansion of Mangroves at the African Southern Distribution Limit and Implications for Ecosystem Service Delivery.

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Globally, mangroves are predicted to expand their distribution ranges towards higher latitudes as temperatures continue to rise and the climate in these regions becomes more suitable for their persistence. Mangrove expansion generally occurs at the expense of salt marsh habitats and changes in ecosystem service delivery following this shift have already been recorded. A structural equation model (SEM) approach was first used to identify factors driving the current distribution of mangroves. We found that current mangrove distribution at the southern African range limit is not determined by temperature, but rather by geomorphological characteristics of the coastline. Instead, mangroves are restricted to occurring in sheltered estuaries that have relatively large floodplains, a permanent connection to the Indian Ocean, and a relatively low daily flushing rate. A species distribution model was then developed using Maxent software to identify suitable estuaries for mangrove expansion under climate change scenarios of increasing temperature while accounting for the geomorphological restrictions. An existing index for estimating changes in ecosystem services over time for this region was then applied to determine shifts in ecosystem service delivery following mangrove expansion. We found that only a few of the estuaries at higher latitudes along this coastline would successfully support mangrove habitats. Following mangrove establishment, a shift in ecosystem services was predicted using the index. However, we do not expect that salt marsh habitats will be completely lost to mangroves at this range limit, as many temporarily-closed systems currently support salt marsh but will restrict future mangrove expansion. Understanding current distribution patterns is therefore essential to inform on predicted range expansions. This study shows that predicted climate change responses are not uniform across different regions and that local factors need to be incorporated into predictive models.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A009
Presentation mode: Oral

Elimination of Reproductive Hindrances in Mangrove Propagation, an Emergent Criterion for Successful Mangrove Rehabilitation- a Study from Indian Sundarbans

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Present degradation of mangroves due to anthropogenic, environmental and climate change factors is not only closely linked with its loss of adaptability and ecosystem resilience, degraded habitat condition also greatly affects the reproductive mechanisms of mangroves. As the mangroves mainly propagate through sexual reproduction, elimination of any barrier coming in the way of sexual reproduction in mangroves is a prerequisite of immense importance that mainly contributes to its sustenance and development. Our studies unequivocally establishes that xenogamous mode of outcrossing is the most successful mode of pollination for fruit set in mangroves of Indian Sundarbans. Open pollination is also found to be equally successful here but self pollination in autogamous and geitonogamous mode is found to be a miserable failure in this study. The three species of Avicennia, like A. alba, A. marina and A. officinalis show the highest percentage of xenogamy and these are the most reproductively successful species in Indian Sundarbans. Hence most of the mangrove species in Sundarbans are found to be obligate outcrossers and are predominantly pollinator dependent in fruit setting with viable embryos. Xenogamous mode of pollination prevents inbreeding depression which is prone to extinction and needs copious pollen and nectar formation, effective vast spectrum of pollinator resources, favourable environment for flowering and pollinator movement etc. In case of mangroves having separate sexes (separate female and male flowers), like Heritiera fomes, availability of both male and female flowers in adequate proportion is another basic constraint to cause successful xenogamy. Effective rehabilitation programme must look after rebuilding of ecological niche favourable for outcrossing, for example, single species plantings may have negative effects in attracting diverse pollinators. Site-specific features hindering pollination success of species variably should be repaired and eliminated for facilitating cross-pollination as principal system of sexual reproduction in restored mangroves that maintains its genetic variability.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A005
Presentation mode: Lightning Talk

Mangroves Management for Resilience: Countering the Risks of Coastal Floodings in Freetown, Sierra Leone

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Sierra Leone is one of the LDC (Least Developed Countries block at the UNFCCC) which are more affected by climate change but have contributed less to it.A review of the management of the formerly biodiverse and extensive mangroves of Sierra Leone reveals that they are under significant anthropogenic pressure due to limited management and poor coordination with urban planners. Extractive pressure from rapidly increasing local populations, encroachment for rice growing and a lack of local livelihoods have resulted in serious and extensive over-harvesting of mangrove wood. Furthermore, large quantities of mangrove resources have been extracted for building materials, fuelwood for cooking and fish smoking, and salt production. These unsustainable activities around the capital Freetown should be seen in the wider context of a lack of urban planning, contradictory urban development and tourism initiatives, minimal enforcement of mangrove protective legislation, limited dialog with coastal communities and squatters within the mangrove areas and a poor understanding of their socio-economic pressures and opportunities. As a result, mangrove degradation and clearance around the capital have greatly reduced the ability of these wetlands to protect sections of the city from seasonal flooding, which regularly inundate parts of Freetown, causing a loss of livelihoods and destruction of property. This is part of an ongoing research project happening in collaboration between University College London's Development Planning Unit (DPU) and SLURC (Sierra Leone Urban Research Centre), and also the theme of a personal dissertation to obtain the title of Master of Science in Environment and Sustainable Development.

Session: T009 - Mangrove management
Abstract ID: T009-A047
Presentation mode: Poster

Mangroves and the Whole Picture: the Importance of the Historical Ecology Approach in a Changing World

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Mangrove-human interactions have always tended to human wellbeing, recently through the lenses of ecosystem services. The study of mangroves under the Historical Ecology framework aims to provide insights in how economic and historical cycles and events interfere in landscape configuration. In cultural landscapes, anthropogenic cycles may not always be in sync with mangrove ecosystems' natural capacity of recovering from short-term and long-term impacts and changes. The Brazilian municipality of São Sebastião has its history entangled with economic cycles since colonial times. After more than 500 years of intensive crops (sugarcane and coffee) and dense infrastructure construction (port, submarine outfall, and petroleum terminal), a sandy beach turned into an embayment, the Araçá Bay. The mangroves there confined continued to represent a source of subsistence, culture, and sacred representativeness to the local folk. Besides relying on formal scientific literature, the bay's historical and ecological relevance were assessed through oral history, books, reports and other documents (e.g. ancient explorers, municipal land authority), nautical charts, maps, photographs, post cards and even paintings. We expose the historical ecology of Araçá Bay in a narrative of four symbolical periods: 1) Early occupation; 2) Changes in coastal geomorphology; 3) Population growth and land use intensification; and 4) Port establishment and its subsequent expansion. Landscape analysis relied on geoprocessing tools, relating land use and mangrove responses across scales. This approach seeks to generate insights to creative thinking towards the mitigation of contemporary issues. This urban mangrove has turned into a beacon of environmental protection, evidencing the importance of protecting such mangrove relics and their capacity to provide ecosystem services. We propose that this bay should be protected under the category of 'area of environmental relevance', and, in a larger scale, to be granted the status of 'cultural landscape'.

Session: T001 - Impacts of people on mangrove structure and function
Abstract ID: T001-A005
Presentation mode: Poster

Do Not Forget Phosphorus! a Critical Driver Controlling Mangrove Carbon Storage in the Everglades Mangrove Ecotone Region, Florida USA

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Carbon storage in mangrove wetlands are regulated by phosphorus (TP) availability in neotropical latitudes, particularly in karstic settings. P availability is controlled by storm surge in these regions and reflected on the spatial distribution of organic carbon above and belowground. However, it is not clear how P availability interacts with storm surge to control carbon allocation and productivity. We evaluated the CNP stoichiometry of mangrove forest aboveground and litterfall along the Shark River estuary (SRE) to assess differences in carbon storage before and after the impact of Hurricane Wilma. This storm occur in October 2005 triggering significant TP deposition. Deposition was higher close to SRE mouth (SRS-6) in comparison to the middle (SRS-5) and upper regions (SRS4). We determined the species-specific foliar CNP ratio from 2008 to 2014. We hypothesized that litter TP concentration will be significantly higher at the SRS-6 site as result of higher soil TP concentrations after storm impact. Results reveled the highest TP concentrations in the leaves (average range: 600-1790 μg/gdw) of all mangrove species in the SRS-6 site in comparison to the same species at SRS4 and SRS-5. Species-specific C: N ratios were distinct with higher ratios observed in L. racemosa (80-110) followed by R. mangle (70-85) and A. germinans (40-60). Our findings indicate that ~10 years after hurricane impact, there is still a TP legacy that controls forest growth and productivity by the rapid recovery (~4 years) of the forest canopy regardless of the significant defoliation (>90%) at the SRS-6 site. This legacy was extended by the impact of Hurricane Irma in September 2017. We propose a mechanism that considers both the positive and negative feedbacks of storm surge and TP delivery in maintaining the patchy distribution of mangrove carbon storage and net primary productivity.

Session: T008 - Blue carbon
Abstract ID: T008-A065
Presentation mode: Oral

Mangrove, people and sea level rise: the past as a guide to the future

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Mangroves occur at the coast and will be central to any discussion regarding the implications of sea-level rise for coastal communities, not least because of parallels between the distribution of people and mangroves, and their response to sea-level rise. Mangrove forests can respond to sea-level rise by maintaining their position within a tidal frame that is transitioning upwards, and this response is dependent upon a range of hydrological, sedimentological and biological factors. The availability of lateral and vertical accommodation space is increasingly proposed as a means of conceptualising the response of shorelines to sea-level rise and recent analyses demonstrated the significance accommodation space has on global carbon storage in coastal wetlands over the past few millennia, and likely influence on future carbon sequestration.As mangrove forests provide crucial ecosystem services for people in coastal communities, there is an immediate and critical need to understand and project the capacity of mangrove forests to adapt to anticipated accelerating sea-level rise. Improved access to spatial data has facilitated the application of spatial models that project changes to mangrove accommodation space with sea-level rise. However, many attempts to address this urgent need are founded upon inadequate knowledge of coastal morphodynamics and mangrove physiological adaptations, apply simple heuristics (e.g. bath-fill or bruun rule type approaches), or complex open access models (e.g. SLAMM) without scrutiny, and extrapolate data well beyond appropriate timescales. Mangrove scientists presently have relatively good understanding of the behaviour of mangrove forests at millennial timescales, and processes operating at contemporary timescales. However, there is less certainty about the response of mangrove forests at decadal to century timescales, and it is these timescales that are particularly important for managers and policy makers. It is now time for mangrove scientists to integrate data across spatial scales and prioritise accuracy over precision when undertaking projections. These challenges are discussed in the context of lessons learnt whilst researching mangrove forests in Australia and elsewhere. This research emphasises the need for cross-disciplinary research projects and international collaboration between physical and social scientists. These challenges provide a focus for research that will have relevance for society and will play an important role in future debate about the response of mangrove forests to sea-level rise and the implications for humans.

Presentation mode: Keynote

Inorganic and Organic Carbon Exports from Mangrove Floodplains to the Coastal Ocean

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Mangrove forests are highly productive and one of the most carbon-rich ecosystems in the world. Of the total mangrove net primary production, most of the carbon is lost via carbon dioxide (CO2) or methane (CH4) to the atmosphere, buried in mangrove sediments, or exported as particulate organic (POC), dissolved organic (DOC) or inorganic carbon (DIC) to the ocean. Here, we present a comprehensive study on mangrove inorganic and organic carbon exports to the adjacent coastal ocean. The contribution of alkalinity, DIC, DOC and POC tidal exports from floodplain mangroves to total estuary loads to the Great Barrier Reef lagoon in Queensland, Australia, were calculated for different low and high flow years. Quantitatively, mangrove carbon export accounted for ~10% of the total carbon loads to the Great Barrier Reef, which shows that outwelling of organic and inorganic carbon from floodplain mangroves is an important carbon source to estuaries and nearshore coastal waters. Despite high seasonal and inter-site variability, overall mangrove alkalinity exports were higher than DIC exports with potential impacts on the carbonate chemistry of the coastal zone. This may be particularly important for near shore inner coral reefs that are significantly affected by coastal runoff.

Session: T008 - Blue carbon
Abstract ID: T008-A007
Presentation mode: Oral

Carbon Sequestration by Deltas Worldwide

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Deltaic coastlines provide a wealth of ecosystem services, however, are one of the most threatened habitats on Earth due to reduced sediment load, high subsidence rates and ramping sea level rise. The disappearance of coastal landscapes leads to a rapid decline in ecosystems services such as carbon (C) sequestration in deltaic deposits where it remains immobile for millennia. Here, we examine trends in soil organic carbon (SOC) stocks and carbon accretion rates (CAR) in deltas worldwide, spanning across mangrove, tidal freshwater, and saltmarsh wetlands. Deltaic mangroves store slightly less C (24.9 MgC ha^{-1}) in the soil top meter than deltaic marshes (28.3 MgC ha^{-1}). However, mangroves in deltaic settings sequester two times more C (308.3 gC $m^{-2}yr^{-1}$) than marshes (148.3 gC $m^{-2}yr^{-1}$). Mean SOC stocks differed between tropical (251.5 MgC ha^{-1}) and artic (274.9 MgC ha^{-1}) deltas, but not between subtropical and temperate deltas (322.1, and 235.1 MgC ha^{-1}, respectively). Mean CAR was significantly lower for artic deltas (33.1 gC $m^{-2}yr^{-1}$) but consistently higher among tropical, subtropical and temperate deltas (273.6, 277.8, and 242.8 gC $m^{-2}yr^{-1}$, respectively). Globally, deltas store 22 PgC in the soil top meter and sequester 0.2 PgC yr^{-1}. These estimates of CAR in deltas are 15% higher than CAR for tropical, temperate and boreal forests combined, and equivalent to 2% of all fossil fuels emissions in 2017. Our findings place deltas as significant atmospheric carbon sinks despite occupying only 0.6% of the global land mass, and advance our understanding about the role of blue carbon ecosystems in balancing the planet's climate.

Session: T008 - Blue carbon
Abstract ID: T008-A034
Presentation mode: Oral

From Plastid to Nuclear Dna: Patterns of Genetic Structure and Phylogenetic Inconsistencies in Avicennia Marina in the Western Indian Ocean

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Avicennia marina is a major constituent of the mangrove forests in the Indo-West Pacific mangrove region. We therefore aimed to interpret patterns of genetic diversity and structure by collecting a total of 1128 A. marina samples in 31 sites in Kenya, Tanzania, Mozambique, South Africa, Madagascar, Mayotte Island, Europa Island and the Seychelles (main islands and Aldabra atoll). Nuclear DNA was genotyped using 8 microsatellites alongside matK, rbcL and trnH-psbA chloroplast markers for phylogenetic analysis and different haplotypes were sequenced for their whole chloroplast genome. Analysis included determination of population genetic diversity and differentiation parameters, individual-based Bayesian clustering and phylogenetic analyses. A high level of genetic diversity and northward directed gene flow in the central East African region (Kenya and Tanzania) gradually lowered towards the Mozambican Channel, though genetic exchange between Mozambique and West Madagascar has taken place. We found indirect evidence of long-distance dispersal over more than 500 km. The southern range edge populations had a low genetic diversity and several genetic breaks. The largest genetic break was found between the easternmost populations (Seychelles main islands, Aldabra atoll, Foulpointe in East Madagascar) and all other 26 populations. With the chloroplast markers and sequences, not such differentiation was observed. Five regions could be considered from the microsatellite based FST and Dest values. Overall, we observed a lower genetic diversity in A. marina in the Western Indian Ocean (WIO) as compared to other regions of the Indo-West Pacific. This, together with a matK based phylogeny, indicates a more recent origin of the WIO populations. Additionally, we found two distinct copies of chloroplast per sample which can be attributed to either heteroplasmy or the occurrence of nuclear copies of plastid DNA. This occurrence of multiple cpDNA copies in A. marina could cause misinterpretation of phylogenetic output, as shown in our phylogenetic analysis.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A011
Presentation mode: Oral

Potential Blue Carbon Losses from Aquacultural Transformations of India's Mangrove Swamps

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Most of India's shrimp production occurs on the southeast coast, in the states of Andhra Pradesh, West Bengal, Tamil Nadu, and Orissa. These states also contain the majority of India's mangrove area. The estimated area of active shrimp ponds in 1990 was ~50,000 ha and increased to a maximum of 300,000 ha in 2001. This likely corresponds to an equivalent area of displaced mangroves and decreased soil carbon stocks. Mangrove soils are one of the world's most efficient sinks for atmospheric carbon dioxide, and the organic carbon in its soil has been designated as blue carbon. The removal of mangroves trees and drainage of soils around ponds results in a considerable loss of soil carbon. Globally, there has been limited study of how much carbon has been lost to such aquaculture transformations, but in one area in India, measurements comparing soils of abandoned shrimp ponds to those of nearby mangroves suggests that ~80% of soil carbon was lost. Although it has been recognized that the aquaculture methods (i.e., extensive, semi-intensive, intensive) and the age of the ponds can affect the carbon footprint of shrimp aquaculture, these are not regularly taken into account when estimating blue carbon losses. We are compiling data on types of aquaculture methods and age of aquaculture sites on the southeast coast of India and will present estimates of the overall loss of blue carbon from India's mangrove soils.

Session: T003 - Mangrove loss and deforestation
Abstract ID: T003-A026
Presentation mode: Poster

Thirty Years of Carbon Sequestration in an Expanding Mangrove Forest

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We report on 'blue carbon' stock change in an expanding mangrove forest through the first comparative study of radiometric analysis and repeat field measures over a multi-decadal period. Examining one tall gallery forest of Avicennia marina, expanding seaward, and an adjacent interior scrub mangrove of mixed Avicennia marina and Aegiceras corniculatum, expanding landward, radiometric analysis estimated a soil organic carbon accumulation rate of 4.3 ± 0.6 Mg C $ha^{-1}y^{-1}$in the tall gallery forest and 2.2 ± 0.5 Mg C $ha^{-1}y^{-1}$in a stunted mangrove. However, repeat measures of root carbon separated by 30 years estimated an increase of 5.06 Mg C $ha^{-1}y^{-1}$ in the tall forest and 6.63 Mg C $ha^{-1}y^{-1}$ in the stunted forest – suggesting an underestimate of carbon accumulation by radiometric dating of 15% and 67% in the tall and stunted forest respectively. A higher carbon stock in the interior forest was attributed to root mass increase, associated with landward mangrove encroachment. Extrapolated to the entire region of NSW we estimate that mangrove encroachment has contributed at least ~1,777,000 Mg C sequestration over the 70 years for which this has been observed in NSW.

Session: T008 - Blue carbon
Abstract ID: T008-A022
Presentation mode: Oral

Effects of Diesel on Growth Response of Rhizophora Mucronata Seedlings Using Microcosm Experiment

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A short-term microcosm experiment (30 days) was made to investigate the effects of diesel on the growth response of Rhizophora mucronata seedlings. The study used the Silica Gel Treated n-Hexane Extractable Material (SGT-HEM) in different parts of mangrove seedlings (roots, stem, and leaves) as well as in sediments and water. Diesel oil was introduced to different tank system at 5.2%, 10.5%, and 15.7% (Wdiesel/Wsediment). A 12-hour tidal cycle period was made to simulate high tide and low tide scenarios. Sediments and plant samples were extracted using sonication method, while water samples were extracted using liquid-liquid extraction method. Extract were concentrated and dried to constant weight. The total SGT-HEM was determined gravimetrically. Results showed that the level of SGT-HEM was in the order sediment > water > root > stem > leaves indicating Total Petroleum Hydrocarbon uptake. The mean concentration for all the mangrove parts were 2989.7 mg/kg for 5.2 % concentration, 5654.8 mg/kg for 10.5 % concentration, and 7607.8 mg/kg for 15.7 % concentration. The SGT-HEM in roots has 60% higher concentration than the stem and leaves. Diesel treatment decreased the shoot and root growth of the seedlings. Around 91 % of Rhizophora mucronata seedlings can withstand a concentration below 15.7 % (Wdiesel/Wsediment) over 30-days of exposure to diesel.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A013
Presentation mode: Poster

The Forester, the Pilot and the Geometer: An Accuracy Analysis of Mangrove Tree Heights Measured Using Forestry Techniques, UAVs and Hypsometers

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Tree height is a fundamental measurement in forest inventory studies and a critical variable for the assessment of vegetation biomass, carbon stock and site productivity that authorities use in decision-making. However, measuring tree height is often a challenging task and may generate significant errors. In the present study, an accuracy analysis of tree height estimation was conducted through different methods ranging from traditional (thumb rule and pole) to geometric and trigonometric equipment (SUUNTO clinometer, Nikon 550 rangefinder, Blume-Leiss BL 60 altimeter), and advanced technologies (Unmanned Aerial Vehicle or UAV – DJI Phantom 3 professional, Leica distometer). These measurements were carried out in natural and urban vegetation settings (mangrove vegetation at Matang as closed canopy and on UMT campus as open canopy). In total, 173 mangrove trees (open canopy-146; close canopy-54) were measured from the both sites and grouped into different stem diameter size classes (0-20 cm, 20-40 cm and 40-60 cm). Height measurements obtained from the Leica distometer were considered as control. This was achieved by shooting the Leica distometer at a UAV flying at the tree's canopy level. Using percentage errors, our results show that height measurements obtained from the DJI drone (3.5%), rangefinder (7.1%), pole (7.4%), altimeter (7.5%), clinometer (7.7%), stick method (14.8%) and thumb rule (15%) were from most to least accurate in that order. This trend was consistent regardless of the sites and size class being considered. Our next step of analysis is aimed at investigating how the angle of inclination affects the accuracy of tree height.

Session: T009 - Mangrove management
Abstract ID: T009-A039
Presentation mode: Poster

How do logging and regeneration affect mangrove ecosystem carbon stocks and sediment GHG effluxes? New data from West Papua, Indonesia

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Mangrove forests are known for their efficiency in capturing and storing atmospheric carbon into their biomass and anoxic soils. However, many mangroves face substantial anthropogenic disturbances such as land-use and land-cover change (LULCC), including timber harvesting. While timber forest products can generate valuable economic income, the impacts of above-ground mangrove removal and regeneration to total ecosystem carbon stocks and sediment greenhouse gasses (GHGs) efflux are not yet fully understood. This study investigates the impact of mangrove timber harvest and regeneration on biomass and soil carbon stocks, and sediment CO2 and CH4 effluxes, respectively. The field sampling was conducted across a logging chronosequence of 0, 5, 10, 15 and 25 years after logging, as well as an undisturbed forest control site. We applied field-based carbon stocks difference and flux chamber measurement approaches. Our results show a significant loss (88%) of biomass carbon due to tree removal, followed by consistent increases of 9 Mg C ha-1 yr-1 over 25 years of stand regeneration. Despite persistent soil carbon stocks between control and harvested sites, we find substantial increases (146%) in dead downed wood biomass carbon which are attributed to the biomass logging residue. We found that sediment CO2 and CH4 effluxes increased in response to belowground biomass mortality. In addition, other variables such as soil physicochemical properties, forest structure, hydroperiod and bioturbation were also recorded and compared with carbon stocks and fluxes data across sites. Our findings suggest that mangrove timber harvest generates substantial carbon losses, while mangrove regeneration over 25 years can potentially regain those emitted carbon at a similar level as an undisturbed forest. These field data are essential to update current IPCC emissions factors, particularly the carbon emissions from LULCC activities affecting mangroves.

Session: T008 - Blue carbon
Abstract ID: T008-A005
Presentation mode: Oral

Investigating the Relationship Between Mangrove Extent and Fishing at the Global Scale

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Mangrove-fisheries are highly variable in character and functioning but this complexity is rarely demonstrated in the current literature. Most studies are divided between a focus on direct mangrove gathering versus fishing that occurs offshore. Further, the location and extent of areas we include in investigation of mangrove-fishing productivity are rarely based on any known ecological parameters. As such, knowledge surrounding the variety of locations where mangrove-fishing takes place is particularly lacking and consequently where mangrove-fishery resources are distributed is largely unknown. This spatial information is vitally important if mangroves and mangrove-fishery resources are to be successfully protected through marine protected areas, fisheries management and conservation planning. This project investigates whether the relationship between mangroves and fishing that can be detected on a global scale. The Sea Around Us global fisheries catch database, along with high resolution mangrove extent maps from the Global Database of Continuous Mangrove Forest Cover for the 21st Century (CGMFC-21), is used to explore the relationship between subsistence and artisanal fisheries catches and mangrove forests for the 2000-2012 period. Spatial trends in mangrove extent and fish catches are then further explored via a number of potential explanatory environmental variables, using high resolution data sets available through Google Earth Engine. Finally, the project explores whether trends emerging in global data are representative of mangrove-fishing information collected at local scales.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A034
Presentation mode: Poster

Transcriptome Analysis of Flooding Stress Tolerance in the Roots of *Kandelia obovata*

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Flooding is one the most challenging abiotic stresses influencing plants growth and development. Mangroves experience the exceptional flooding tolerance and their roots exhibit specific adaptations to flooding stress. However, sea-level rise has become the greatest threat to mangrove survival and development seriously due to global climate warming. Therefore, studying the medium-term effects of flooding on mangrove roots provides us better understanding of the molecular mechanism responding to sea-level rise. In this study, we characterized the gene expression changes of K. obovata roots with direct exposure to flooding by RNA-sequencing analysis on an Illumina Hiseq platform. A total of 147,169 unigenes were yielded with an average read length of 616 bp. Of 2659 unigenes that were differentially expressed in response to flooding stress, 1203 and 1456 unigenes were significantly up- and down-regulated, respectively. Most these differentially expressed genes (DEGs) were mainly associated with flooding stress, including the genes related to hormonal signaling, starch and sucrose metabolism, antioxidant activities and transcriptional regulations. The detection results of transcript expression level of nine selected DEGs on real-time quantitative PCR were consistent with those of transcriptome analysis. The results provide a better understanding of the complex molecular mechanisms involved in response and adaption of K. obovate to flooding stress.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A012
Presentation mode: Poster

Convergent Evolution of Genome Size of Mangrove

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Mangroves are woody plants growing in the extreme environment of intertidal zone on tropical and subtropical coasts. Intertidal habitats have many abiotic factors such as high salinity, strong UV light, hypoxia and periodically fluctuating tides. When mangroves invade intertidal zone, the habitats may impose intense selective pressure on genome of these plants. Mangroves have convergently evolved similar phenotypic traits and the underlying genic convergence (Xu et al. 2017). Since the high salinity of the intertidal zone may directly affect the cellular environment, mangroves also extensively modified their amino acid compositions and reduced gene family size. Such genome-wide changes indicate that mangroves may have unique genome features such as genome size. In this study, we collected and measured the genome sizes of 21 true mangroves from independent clades, and 8 mangrove associates. Comparing with non-mangrove, mangroves have significantly downsized genomes ($P < 10\text{-}9$). In particular, we found that the true mangroves from Rhizophoraceae contained significantly smaller genomes than did the non-mangrove relatives from Malpighiales ($P < 10\text{-}5$). Whereas mangrove associates do not show this difference ($P = 0.26$). Comparisons based on phylogenetic relationships show that the genome size reduction occurred independently in the true mangrove clades. As the reduction in genome size has evolved independently at least 7 times, it appears to be an adaptive strategy of these woody plants to live in the intertidal zone. Since the environment of intertidal zone are with high salinity and low nutrient availability, the small genome size may increase genome stability and reduce energy consuming.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A007
Presentation mode: Poster

Effects of Multiple Rounds of Cold Treatment on Physiological States of *Kandelia obovata* Reveals Possible Mechanisms of Cold Acclimation

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Kandelia obovata is considered as one of the most cold tolerant mangrove species and has been planted to temperate regions to protect the coastline there. However, the cold resistance mechanism and low temperature adaptation mechanism of K. obovata remain unclear. In this research, the medium temperature acclimation experiment was designed to simulate the natural conditions in the seedling of K. obovate to explore the mechanism of low temperature acclimation of K. obovate. A total of six groups of low temperature acclimation experiments with different cycles number and treatment times were set up and physiological indexes and expression profile of cold stress related genes of K. obovata seedlings were measure at each stage. We found that in the several rounds of acclimation processes, the plants were able to rebuilt the physiological dynamic balance, indicating that K. obovata has the ability to resist the low temperature environment and form low temperature acclimatization. The results of this study were compared with the field investigation results which found that the seedlings of K. obovata could also increase the content of photosynthetic pigments and improve the photosynthesis efficiency in the field environment. The trend of acclimatization of K. obovata is different from common woody low temperature plants, but more similar to the acclimatization mode of annual herbaceous plants. We speculate that K. obovata's unique and active coping with low temperature acclimatization may be an important reason for explaining the cold resistance of K. obovata. Therefore, we suggest that in the process of the northward migration of K. obovate, transplanted seedlings should be given several rounds low temperature treatments, which can help to produce low temperature memory and improve survival rate.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A017
Presentation mode: Poster

Convergent Adaptation at Multiple Genomic Levels among Plants Colonizing the Land-sea Interface

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Convergence among phenotypically-similar species will be a new frontier for genomic studies. However, previous searches have not been successful (Foote et al., 2015; Parker et al., 2013; Thomas and Hahn, 2015; Xu et al., 2017; Zou and Zhang, 2015) mainly because the chosen species usually inhabit rather different habitats and, hence, may not necessarily evolve by convergence. In this backdrop, multiple plant species that colonized the shared environment on global tropical coasts (collectively referred to as mangroves) may permit an ideal test for genome convergence. Here, we sequenced the genomes and transcriptomes of 16 species of mangroves, sufficiently extensive for convergence analysis. Using the new CCS method (Xu et al., 2017), we detect evolutionary convergence in 140 genes. They show that the saline habitats drive genomic convergence via the inter-cellular and cytoplasmic environments. The cellular-level effect is further supported by the genome-wide AA compositions with nine strongly over- or under-used AAs, in particular, among genes showing extra-nuclear localizations. Interestingly, the unusual AA usages are still evolving within these mangrove genera. Genome sizes, repetitive elements and gene families also evolve by convergence. In conclusion, genomic convergence depends on the conditions of species, environment and cellular state, all of which fulfilled by the mangrove guild.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A005
Presentation mode: Oral

Evaluating the Relationship Between the Sun-induced Chlorophyll Fluorescence and Photosynthesis in a Mangrove Forest

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Recently, remote sensing of sun-induced chlorophyll fluorescence (SIF) as a novel optical tool for assessment of vegetation photosynthesis has been proved to have a strong link with gross primary production (GPP) at broad scales. However, the mechanistic understanding of the relationship is still limited. Moreover, the results of these relationships in different ecosystems are inconsistent. For a better understanding of the photosynthesis mechanism of the mangrove ecosystem, we evaluated the relationships among light use efficiency (LUE) and fluorescence yield (SIFy) and absorbed photosynthetically active radiation (APAR) in different light conditions by using ground-based continuous measurements and UAV-based instantaneous measurements. We found that, whether in high-light or low-light conditions, the LUE-APAR relationships are negatively correlated. However, the SIFy-APAR and LUE-SIFy relationships produce different results under different light conditions. Our study exhibited a weak positive SIFy-APAR relationship and a weak negative LUE-SIFy relationship in low-light condition. In contrast, a clear negative SIFy-APAR relationship and a positive LUE-SIFy relationship were exhibited in high-light condition. Our study presents the first measured SIF by using ground-based and UAV-based sensors for photosynthesis research in a mangrove forest. This issue will help to better understand the photosynthesis mechanism of the mangrove ecosystem, so as to further improve the accuracy of global GPP mapping by using the SIF.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A043
Presentation mode: Oral

Extracting Mangrove Forest Phenology with Landsat and Modis Data Fusion

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Vegetation phenology indicates the timing of periodic events in the life cycle of the plant. Its change affects carbon, water and energy exchanges between vegetation and atmosphere. Recent studies have shown that phenology can be affected by mixed pixels. Mangroves, with high productivity, are evergreen forests which grow in heterogeneous areas. In this paper, we used high spatiotemporal resolution data acquired from an enhanced spatial and temporal adaptive reflectance Fusion model (ESTARFM) by fusing Landsat and MODIS to monitor mangrove forest phenology and evaluated the effect of mixed pixels. We used gNDVI, an index related to canopy chlorophyll, to estimate phenological parameters, including start of season (SOS), time of maximum greenness (Max Green), end of season (EOS) and length of season (LOS). The results showed that the greenness of mangrove exhibited seasonal variation, with high value in dry season and low value in rainy season. SOS estimated from fused images occurred between day of the year (DOY) 210 and 220 days, EOS occurred between 85 and 100 days. Compared to fused images, the median of SOS estimated from MODIS was one month earlier, while EOS was delayed and the Standard Deviation of phenology metrics was bigger. With the increase of mangrove abundance, the difference of SOS estimated from both resolution data becomes smaller. This research suggests that the fused images can get more detail information than MODIS and the high spatiotemporal resolution data may be the best choice when monitoring phenology, especially in heterogeneous areas.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A045
Presentation mode: Poster

Salt Marsh Influences Resilience of *Avicennia germinans* to Freezing Temperature and Hurricane Damage

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The range limit of Avicennia germinans, a neotropical black mangrove, is moving poleward and currently includes locations that freeze periodically. The northward march of the range has also increased vulnerability to hurricane damage as new coast line becomes established with A. germinans. Glycine betaine is an organic osmolyte significant to osmoregulation and enables various plant species to tolerate environmental stressors including salinity and extreme temperatures. We have previously demonstrated accumulation of glycine betaine in response to increased salinity and freezing temperatures in controlled A. germinans seedling studies. However, the mechanism of glycine betaine in allowing mangroves to survive environmental stressors in field conditions has yet to be elucidated. Here, the use of common garden experiments at an exposed tidal flat and less-exposed, salt marsh locations in Saint Joseph Bay, Florida USA were used to consider the impact of environmental stressors in the field. Significantly more seedlings in the salt marsh survived the first year. A freeze event in which temperatures dropped below 0ºC (-5 to 0ºC) for 16 hours occurred one year after establishing the garden. Glycine betaine accumulation occurred in seedlings from both locations following the freeze event, with seedlings of the salt marsh site accumulating significantly more. Incidently, the common garden was in the direct path of Hurricane Michael in October 2018. Significantly more salt marsh seedlings survived the hurricane damage. The poleward expansion of mangroves will likely increase exposure to freeze and hurricane events. Our findings suggest that extreme weather resilience in this species may be influenced by protective ecosystem interactions.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A057
Presentation mode: Poster

The Cold Stress Response of Indo-West Pacific Mangrove Species with Varying Latitudinal Limits

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Mangroves are found throughout the world in tropical and subtropical regions, but have recently displayed global northward range expansion resulting in the displacement of coastal salt march ecosystems. Rising annual minimum temperatures have been identified as the primary factor facilitating the poleward range expansion of mangroves. This suggests that by determining the minimum temperature a mangrove species can tolerate the current and future latitudinal limit of that species can be predicted. In this study, we test whether chilling tolerance best predicts differences in the latitudinal limit of Indo-West Pacific (IWP) mangrove species by comparing the chilling stress response of three commonly co-occurring IWP mangrove species that display differing latitudinal range limits, Kandelia obovata, Bruguiera gymnorhiza, and Avicennia marina. To determine the chilling tolerance of these species we compared their physiological and molecular condition before, during and after exposure to chilling temperatures to assess how these species respond to and recover from chilling stress. The physiological condition of these species during each of these treatment conditions, was determined by measuring the effective quantum yield of photosystem II, night respiration and light energy utilization. To identify differences in the expression of cold responsive genes, leaves were collected 24 hours after the onset of each of the treatment conditions and then sent for transcriptomic sequencing. We found that K. obovata, the species with the northernmost latitudinal limit recovered quickly from chilling stress exposure, while the other two species with lower latitudinal limits, B. gymnorhiza and A. marina showed high mortality and those that survived showed very slow recovery. This suggests, that the higher chilling tolerance of K. obovata has facilitated it's ability to inhabit areas at higher northern latitudinal limits than any other IWP mangrove species and may facilitate further latitudinal range expansion by this species as annual minimum temperatures continue to rise.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A001
Presentation mode: Oral

Biodiversity and Forest Structure of Natural Mangrove Systems of Bali and North Sulawesi, Indonesia

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This study established a detailed baseline inventory of mangrove species in natural forests of Nusa Lembongan, Bali, and Bangka Island, North Sulawesi, Indonesia. Conducted between 2015 and 2016, lack of previous description of mangrove forests within this highly diverse region prompted this study of diversity and forest structure. Mangroves are intertidal, salt-tolerant marine trees and shrubs that live along low energy coastlines throughout the tropics and subtropics. Indonesia sustains 43 species and the largest mangrove forest area of any country, distinguishing it as the foremost location to study mangrove diversity. In the natural forests of Bangka Island and Nusa Lembongan eleven species of trees were identified, distributed across three diameter breast height (DBH) size categories: sapling, pole, and adult. There was high variability in species composition between islands, evident through Shannon diversity index (H') and Simpson's diversity index (1/Ds). Both indicated higher diversity at Bangka Island, apparently due to the presence and abundance of underrepresented species. Furthermore, mean adult tree DBH across all species combined was significantly greater at Bangka Island than at Nusa Lembongan, and the DBH of R. mucronata was significantly greater than that of R. apiculata, the most abundant species on Bangka Island and Nusa Lembongan, respectively. Bangka Island was categorized by a high density of adults, while saplings on Nusa Lembongan had the highest density. These patterns give insight into the complex nature of these systems involving both the dominant Rhizophoraceae species and the rarer species in the forests. This research offers a valuable foundation for better understanding the composition of mangrove ecosystems both in Indonesia and globally and creates the potential to return to these forests in the future for continued long-term research and for management of these important ecosystems in the face of climate change and sea level rise.

Session: T001 - Impacts of people on mangrove structure and function
Abstract ID: T001-A032
Presentation mode: Poster

Incorporating Coastal Blue Carbon Ecosystems Into National Greenhouse Gas Inventories

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Blue carbon ecosystems, mangroves, tidal marshes, and seagrass beds, are critically important coastal wetlands that support fisheries, improve water quality, protect coastlines, and provide capacity for climate change mitigation. Efforts to conserve and restore these ecosystems can lead to avoided greenhouse gas (GHG) emissions and increased carbon sequestration. The International Partnership for Blue Carbon unites governments, scientists, and non-governmental organizations (NGOs) with the common goal of building awareness and exchanging knowledge, to implement practical action for the conservation of coastal wetlands. For coastal wetlands the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands outlines the underpinning science to aid this process. This document provides guidance to countries on reporting GHG emissions associated with land-use changes associated with wetlands, and offers technical advice for measuring, reporting, and verifying GHG emissions. A workshop was held in July 2018 to bring together scientists, NGOs, and government representatives from Australia, Cambodia, Fiji, Malaysia, Mexico, Papua New Guinea, Thailand, the United Arab Emirates, and the United States. Few countries have implemented this IPCC guidance, so this exchange aimed to document the progress of incorporating coastal wetlands into national GHG inventories, discover challenges, and share knowledge. This workshop focused on four case studies, the United States, the United Arab Emirates, Australia, and Indonesia, demonstrating the current progress and approach each country has taken to adopt this guidance into their inventories. Key lessons learned addressed issues in reporting, technology and activity data, modelling, and policy. The exchange demonstrated the value of international communication and collaboration to identify common challenges, discuss solutions, and establish connections as the process of developing inventories progresses.

Session: T008 - Blue carbon
Abstract ID: T008-A025
Presentation mode: Poster

The Importance of Mangroves for the Conservation of Marine Megafauna

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Marine megafauna are a threatened taxonomic group and emerging research is highlighting important, previously-unknown associations between these animals and mangroves. These habitats are also in global decline and are largely marginalised on conservation agendas. Conservation and protection, and the policy that enables these, relies on knowledge of how and which species utilise specific habitats, with erroneous information capable of affecting management. We review the literature and highlight the diverse ways in which marine megafauna utilise mangrove and other coastal wetlands. Based on IUCN species lists, our review increases the number of species with known habitat associations by 37%, representing over 12% of all marine megafauna species. However, half of these species' assessments do not include habitat change as a threat, which is concerning given current rates of loss and degradation in these habitats. We also identify and map conservation hotspots where high rates of global mangrove decline intersect with high megafauna biodiversity, with Indonesia and Malaysia areas of concern. Ultimately, preventing biodiversity loss is one of the greatest challenges facing ecologists and conservation biologists, and we need greater recognition of habitat change as a key driver of marine biodiversity loss so that coastal wetland habitats are better valued in legislation and policy, helping to protect these habitats and the charismatic and ecologically important megafauna.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A002
Presentation mode: Oral

Mangrove Forest Growth Dynamics Across Different Aged Stands in West Papua, Indonesia

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Bintuni Bay, located in the south of the Bird's Head Peninsula of West Papua, Indonesia, has one of the largest mangrove forest concessions in the world. The Bintuni Bay concession has over 82 000 hectares of forest under a selective logging regime, with a primary focus on sustainable forest management. The current 30-year harvest rotation is based on previous surveys conducted on different aged forest stands in the region. Post-harvest forest regeneration was evaluated to be successful in 2015 but detailed changes in forest dynamics during the rotation period are yet to be observed. The objective of the study is to estimate individual tree and species-level growth in Bintuni Bay mangroves and the effects of stand age and forest structure on growth. In March 2018, over 370 dendrometers were installed on individual trees from different canopy layers in forest plots of different age (5,10, 15, 20, 25-year, unharvested forests), where forest structure (species, diameters, heights, densities) has been initially surveyed. The growth increment of each tree dendrometer band is measured every 3-4 months since 2018, and this will continue for 5 years (2022) in order to track small-scale differences in individual tree diameter growth patterns over time and by canopy condition and forest age. Preliminary observations show a difference in tree growth among canopy layers and forest stand ages. Through this study, the effects of forest structure, soil condition and climate on individual tree growth, and the overall secondary mangrove forest growth at different stages of the rotation can be modelled with more accuracy. The observations will help future forest management of the concession, facilitating estimates of sustainable production that maintains ecological integrity of the forest.

Session: T009 - Mangrove management
Abstract ID: T009-A007
Presentation mode: Lightning Talk

Relative Contribution Of Environmental And Spatial Variables To The Genetic Diversity Of Avicennia Germinans And A. Schaueriana

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Mangroves are one of the most threatened ecosystems by ongoing climate changes, due to their coastal distribution, where they act as sentinels of sea level rise and increased frequency of extreme events, as storms, heat waves and droughts. Yet, their protection and restoration is urgent for fighting climate change, as they can store more atmospheric carbon dioxide per hectare than any other tropical forest in the world. In this scenario, the identification of the abiotic factors that determine the distribution of genetic diversity in mangrove tree species is crucial for the definition of conservation plans and for predicting the consequences of future changes to these species. Therefore, we aim to identify the contribution of environmental and spatial variables to the structure of genetic diversity of two widespread mangrove species of the genus Avicennia (L.) along the Atlantic coast of South America. Seventy-seven individuals of Avicennia schaueriana and 57 individuals of A. germinans were genotyped for a total of 6170 and 2297 biallelic SNP loci, respectively. Pairwise FST between sampling sites was calculated and interpreted as genetic distances. Similarly, we determined pairwise geographic distances between localities. Twenty-nine oceanographic and climatic variables from global public databases were used for extracting environmental values for all occurrence points of the species, downloaded from GBIF. Then, this matrix was transformed through a principal components analysis (PCA), which was used to obtain pairwise euclidean distances between sampling points, which were interpreted as environmental distances. In a landscape genetics approach, we will use distinct statistical approaches to investigate relationships between genetic and environmental distances and between genetic and geographical distances. Our results will likely contribute to the prediction of species potential to respond to climate change and to the definition of strategies for management, conservation and recovery of degraded mangroves in the Atlantic coast of South America.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A029
Presentation mode: Oral

Global Gradients in Mangrove Forest Structure and Relationship to Climate Variables and Local Geophysical Variables

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We generated global maps of mangrove canopy height and biomass based on remote sensing measurements. The maps show that maximum attainable mangrove canopy height is driven by regional precipitation rate and temperature and can be limited by hurricane frequency. These conclusions are supported by large scale patterns of mangrove structure observed along the coast of the various continents. The tallest mangroves in the world were found along the Atlantic coast of Central Africa, more specifically Gabon, and the Pacific Coast of Colombia. Forest canopies taller than 60 meters have been measured. The global maps were based on surface elevation data from SRTM (Shuttle Radar Topography Mission) and TanDEM-X (TerraSAR-X Add-oN Digital Elevation Mission), providing fine spatial resolution of the 30 and 90 meters respectively at two different epochs: 2000 and ~2015 respectively. Overall, our estimates of abovegroudn biomass agree with other studies, however, the new spatially explicit estimates of mangrove canopy height increase accuracy. In fact, the complex spatial patterns at regional and local scales underscore the role of environmental and geophysical factors driving mangrove productivity. Globally, we find that sparse field-allometry limits the accuracy of large-scale carbon stock estimates, suggesting the use of local environmental and geophysical factors as explicit allometric variables. To perform an in-depth analysis of mangrove structural patterns where we found the tallest mangrove forests (i.e. Gabon and Colombia), we collected in situ data with airborne radar and Lidar data. The airborne maps of canopy height validate the global observations at these sites, and provide fine scale details reveling local geophysical gradients. We find the structure of mangrove forests follows, as expected, dominant geophysical features such as micro-topography, tidal channels and distance to channels. The Lidar data provides explicit vertical profiles highlighting the extraordinary variety of canopy structure found even at local-scales.

Session: T008 - Blue carbon
Abstract ID: T008-A060
Presentation mode: Oral

Mangroves Dramatically Increase Carbon Storage After Three Years of Encroachment

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In North America, the dynamic ecotonal boundary between mangrove and salt marsh is currently fluctuating in response to freeze – free winters, which can cause rapid alterations in a number of wetland processes and attributes. Permanent plots were established in pure salt marsh habitat along the Atlantic coast of Florida in 2015 and by 2018 mangrove saplings had moved in. In this study, above- and belowground biomass measurements and soil C in the top 10 cm soil profile were quantified in 2018 and compared to 2015 data to better understand the effects of mangrove transgression on C storage in salt marsh habitat. Plant and soil fractions were tested for δ13C stable isotopic signatures to elucidate soil C sources. In three years, mangrove biomass increased dramatically and soil C doubled in pure salt marsh plots, consequently increasing total C in the system. There were increases in bulk density and soil organic matter, however soil C:N did not change. δ13C values suggest that soil C was derived mainly from salt marsh soil organic matter, especially that of belowground, not aboveground biomass. These results provide real – time, quantitative data on the transgression of mangroves into salt marshes over a relatively short period of time.

Session: T008 - Blue carbon
Abstract ID: T008-A001
Presentation mode: Lightning Talk

Can Maintenance of Mangrove Plantation Enhance Diversity and Abundance of Macrofauna in Mangrove Planted in Abandoned Shrimp Ponds?

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Mangrove plantation has been used to establish the plant community in abandoned shrimp ponds along many coastal areas, but how the maintenance of plantation help to restore macrobenthic community remains largely unknown. Here, we investigated the effect of maintenance activities on diversity and abundance of macrofauna in 11-years Rhizophora apiculata planted in abandoned shrimp ponds. Four plots (30x30 m) of the plantation were assigned for control and three maintenance activities, including enrichment (replanting six species of mangrove in open space of degraded mangrove), pruning, and thinning. Three replicates of macrofauna were collected in each plot before applying the maintenance activities and the collections were repeated after 8- and 16-months of the maintenance. Shannon's diversity index (H') of macrofauna shows an increasing trend in every plot, especially the enrichment which has significantly higher diversity after 16 months of replanting. Higher species number of crustacean and polychaetes were observed at pruning and thinning plots. The abundance of macrofauna in pruning and thinning significantly increased after 8-months of the maintenance, while there is no significant difference among three times of sampling in other plots. Replanting mangroves in open space creates new microhabitats, whereas pruning and thinning allow sunlight to reach the surface of sediment and may improve sediment quality. These processes may enhance diversity and abundance of macrofauna in mangrove plantation.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A023
Presentation mode: Poster

Tangled Roots and Changing Tides: Understanding the Complicated, Interconnected and Evolving Legal and Institutional Regimes Governing Mangrove Conservation and Sustainable Use

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Mangrove ecosystems are complex – equally complex are the legal and institutional structures that can create tools for their protection as well as conditions enabling their harm. Mangroves cut across a range of sectors (marine, forest, freshwater, etc.) and jurisdictions (international, regional, national, district/province, municipal, community, etc.) and can be addressed through myriad legal tools (protected areas, land use planning, payments for ecosystem services, environmental impact assessments, etc.). Save our Mangroves Now! (SOMN) has undertaken an ambitious global study to understand not just what legal tools and frameworks affect mangrove ecosystems but also how they are implemented, who is involved, and whether they contribute to, or impede, mangrove conservation and sustainable use. A team of researchers from around the world have undertaken a global legal and literature review and seven case studies in Africa, Asia and Latin America using a four stage methodology that looks at the text of legal instruments, the functioning of institutions, the behaviour of regulated entities and stakeholders, and the resulting outcome for mangrove coverage and health.This presentation will feature stories from Madagascar, Costa Rica, Vietnam and other countries that illustrate how legal tools are being used respond to the drivers of mangrove degradation and what makes these tools effective. For example, in Madagascar, transfer of governance responsibility to local communities and customary authorities is a promising mechanism for mangrove conservation, but requires significant capacity on the part of local communities. In Vietnam, legal requirements for replanting of harvested forest could support mangrove restoration, but the effectiveness of these requirements can be undermined by significant use of monoculture plantations. These and other examples will serve to highlight options and factors of success for design and implementation of legislation, regulations, contracts and institutions that contribute to real protection of one of the world's most valuable ecosystems.

Session: T009 - Mangrove management
Abstract ID: T009-A036
Presentation mode: Oral

Examining Coastal Litter in Mangroves from an Ecosystem Service and Disservice Framework

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Singapore's coastline is heavily exploited by a wide and varied number of coastal visitors for leisure, recreation, fisheries, and commercial uses. This use produces large amounts of terrestrial litter which often overlaps with washed up marine litter and together, creates expansive distributions of coastal litter throughout the coastline. While coastal habitats may vary, mangroves have been recognized for the valuable coastal ecosystem services they provide and more recently, the negatively perceived disservices they can be associated with. In Singapore, mangroves have been described as a place of beauty to some and a place of fear to others. It is imperative to evaluate an ecosystem holistically when assessing the level of ecosystem service and disservice provision. It is also equally important to understand the role that societal perceptions play in these valuations. For example, the accumulation of coastal litter in mangroves is perceived to be a disservice for its aesthetics and hazards to wildlife. But can the same accumulation of coastal litter also be valued as an ecosystem service? We propose a coastal ecosystem service and disservice framework; through which we examine coastal litter in Singapore mangroves. Specifically, our objective examined the drivers of ecosystem service and disservice provision relating to coastal litter. We observed social perceptions of different amounts and types of litter in mangroves, and how they were labelled and valued within our proposed framework. Our work utilized litter surveys, social interviews, and analyzed economic data to quantify the tradeoffs associated with coastal litter such as aesthetic value and cleanup costs. The data we collected was used to review, test, and report results and limitations of our study. We challenged societal perceptions using a novel ecosystem service and disservice framework of coastal litter.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A023
Presentation mode: Poster

Global-scale Dispersal and Connectivity in Mangroves

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Dispersal provides a key mechanism for geographical range shifts in response to changing environmental conditions. For mangroves, which are highly susceptible to climate change, the spatial scale of dispersal remains largely unknown. Here we use a high-resolution, eddy- and tide-resolving numerical ocean model to simulate mangrove propagule dispersal across the global ocean and generate connectivity matrices between mangrove habitats using a range of floating periods. We find high rates of along-coast transport, and transoceanic dispersal routes across the Atlantic, Pacific, and Indian Ocean. The American and African continents present important dispersal barriers. Archipelagos, such as the Galapagos and those found in Polynesia, Micronesia, and Melanesia, act as critical stepping-stones for dispersal across the Pacific Ocean. Direct and reciprocal dispersal routes across the Indian Ocean via the South Equatorial and seasonally-reversing monsoon currents, respectively, allow connectivity between Western Indian Ocean and Indo-West Pacific sites. We demonstrate the isolation of the Hawaii Islands and help explain the presence of mangroves on the latitudinal outlier Bermuda. Finally, we find that dispersal distance and connectivity are highly sensitive to the minimum and maximum floating period. We anticipate that our findings will guide future research agendas to quantify biophysical factors that determine mangrove dispersal and connectivity, including aspects such as the influence of ocean surface water properties on metabolic processes and buoyancy behaviour, which may determine the potential of viably reaching a suitable habitat. This will help to better understand global mangrove species distributions and their response to changing climate conditions.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A002
Presentation mode: Oral

Biomass Estimation Based on Canopy Height Measurement for Mangroves in Panay Island, Philippines

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Currently, establishment of accurate monitoring system of carbon stocks in coastal regions has been one of the important issues to manage coastal ecosystems in tropical regions since the coastal ecosystems, such as coral, seagrass beds and mangroves, have been rapidly and widely lost or degraded, which can result in significant release of CO2 to atmosphere. In particular, mangrove preserves a tremendous amount of carbon stocks, and precise and accurate methods to assess mangrove carbon stocks are essential to evaluate the carbon dynamics in tropical coastal regions. In the present study, we constructed a biomass estimation model focusing on canopy height – aboveground biomass relationship on the basis of plot-based data. We also applied that model to scale-up the plot-based data with remote sensing method such as airborne LiDAR and SRTM. The field researches were conducted in mangroves in Panay Island, Philippines, where stem diameter at breast height DBH and stem height H were measured with circular plots whose radius is 7 m according to a standard protocol. The aboveground biomass AGB was estimated with allometric equation. The D – H relationship analysis showed H specific to DBH decreased at higher salinity site, i.e. potential canopy height decreased from ca. 27 m at a low salinity site to ca. 13 m at a high salinity site. We modeled the relationship between canopy height and AGB and compared with that reported for terrestrial forests, and found that the AGB specific to canopy height was apparently higher in mangroves than in terrestrial forests. Although both of airborne LiDAR and SRTM detected the canopy height gradient along tidal gradient, AGB estimation based on canopy height tended to be underestimation for some high salinity sites where tree architecture were characterized with short H with thick DBH.

Session: T008 - Blue carbon
Abstract ID: T008-A012
Presentation mode: Oral

Biogeomorphic Evolution of a Modern Tidal-Creek Mangrove Forest Reconstructed Using n-alkane Biomarkers Preserved in Sediment Archives

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Contrary to the global trend of mangrove-habitat decline due to human activities, rapid habitat expansion has occurred in New Zealand estuaries over the last century. This expansion has coincided with accelerated estuary infilling due to increased soil erosion from deforested catchments since the mid-1800s. Quantifying patterns and rates of mangrove-habitat expansion has largely been based on aerial-photographic surveys conducted since the 1930s. Understanding of mangrove-forest evolution during the modern era prior to systematic monitoring is poor. Mangroves produce a range of organic compounds that may enable reliable biogeomorphic reconstructions. Long-chain n-alkanes (C25–C35) produced by terrestrial plants represent a major fraction of the epicuticular waxes of mangrove leaves. They are resistant to microbial decay when preserved in anoxic estuarine mud. Here, we reconstruct the biogeomorphic evolution of an Avicennia marina forest that has colonized a tidal-creek since the mid-1800s using radioisotope dating, stable-isotope analysis and abundance of n-alkanes preserved in sediments. Historical records constrain the major phase of mangrove-forest development (1863–1939). The contributions of n-alkanes produced in situ by mangroves, as well as from catchment soils eroded from historical and contemporary plant communities, to the estuarine-sediment pool were evaluated using an isotopic-mixing model. Our results show that mangrove leaves produce mainly odd-chain length n-alkanes (C29–C35) that have significantly enriched d13C values, which can be discriminated from catchment soils. Carbon content and n-alkane concentrations increase with forest maturity over decadal time scales and modelling indicates 3–6-fold increases in n-alkane contributions from mangroves as tidal-flat sites are colonized. Spatial-temporal resolution was reduced by n-alkane export to unvegetated-tidal flats (halo effect) and gradual increase in the contribution of mangrove leaves to the n-alkane pool (lag effect) in estuarine sediments. Our study shows that n-alkane biomarkers can inform biogeomorphic reconstructions when supported by reliable geochronology and complimentary data.

Session: T001 - Impacts of people on mangrove structure and function
Abstract ID: T001-A002
Presentation mode: Oral

Stakeholder Perspectives and Ecosystem Services in Mangrove Ecosystems. Results from Singapore, Brazil, and South Africa

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An improved management of mangrove areas to preserve biodiversity and ecosystem services requires a sound knowledge of land-use impacts and the drivers of ecosystem development. This presentation will identify and characterize the main ecosystem services, based on empirical work with stakeholders of mangrove areas conducted in the frame of the DiSeMiNation project. Detailed analyses of sediments from corresponding mangrove ecosystems will link stakeholder perspectives with those ecosystem processes that underlie the above services. This will translate into recommendations for sustainable use by local communities, and contribute to the spatial planning of protected areas.Mangrove forest services in three countries, namely Singapore, Brazil and South Africa, have been examined through stakeholder surveys and workshops with scientists, conservationists, government officials, community leaders, educators, resource users, and coastal managers. The most appreciated services of mangrove ecosystems are their nursery function and cultural, (e.g. recreational, educational) values. These are followed by regulating services like erosion control and carbon storage. Only in the Brazil location, where the extraction of food and other life-supporting goods is explicitly included in mangrove protection status, the provision of crab, fish, and wood are also highly valued.The stakeholders' opinions differ considerably. While conservationists and fish companies would like to forbid the extraction, neighboring inhabitants require permission to use crabs, fish, timber and other mangrove goods; but some of them also ask for a fair control to prevent unsustainable use and commercial extraction in large amounts. The legal situation and governmental action have been scrutinized, with outcomes ranging from clear and adaptive management to weak conservation status and risky uses, mainly due to bad implementation of (basically sound) government instruments and lacking trust by local people. The project team works on approaches to 'transfer' scientific findings into actual management and identified knowledge gaps that should be addressed during this course.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A021
Presentation mode: Poster

Revisiting Mangrove Allometry for the Purpose of Sustainable Forest Management in West Papua, Indonesia

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Allometric equation has been of interest to many researchers worldwide primarily as a practical way to estimate the biomass and carbon content of forests. This study further develops the equation in the context of sustainable mangrove forest management, focusing on the ability to accurately estimate the merchantable weight with only diameter at breast height (DBH) as variable. The objective is to have a model that can covers DBH range from 15 cm to 70 cm without the need to determine tree height (H). The data used for modelling was collected during forest surveys from 2015-2018 in the PT. Bintuni Utama Murni Wood Industries mangrove logging concession in West Papua. During the 2018 survey, additional measurements of log diameter and length were collected. Wood density was then estimated by cutting samples from the bottom, middle and the top portion of harvested trees. Focusing on three major commercial species, the resulting database consists of 1333 Rhizophora apiculata trees (DBH: 5 cm - 76 cm, height: 4.3 m - 46.1 m), 205 Bruguiera gymnorrhiza (DBH: 5 cm - 82 cm, height: 5.5 m - 38.8 m), and 240 Bruguiera parviflora (DBH: 5 cm-71 cm, Theight: 4.3 m - 38.8 m). For density, samples were collected from more than 110 trees. A new and more robust allometric equation was established to predict overall merchantable dry weight (Wd) with the following structure: Wd = C1ρD2Hc/(1+ae^(-rD)),where C1, a and r are constants, r is dry wood density, Hc is maximum height of the species at particular site, and D is DBH.Comparisons were made between this equation and several existing model for mangrove to the actual iharvested log measured. The new allometric equation correlates slightly better even when compared with existing allometric equation with both DBH and Height as variable.

Session: T009 - Mangrove management
Abstract ID: T009-A003
Presentation mode: Poster

Estimating Tree Volume of Bintuni Bay Mangroves with Sentinel-2 Images and Principal Component Analysis

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Maximising the harvest volume per area is vital to reduce the impact of logging within a forestry concession. However, estimation of harvesting potential by ground surveys is time consuming, labour-intensive, and is limited to sampling a small percentage of a large concession area. Thus, remote sensing could provide a less costly yet more comprehensive result. The mangrove concession of interest is managed by PT Bintuni Utama Murni Wood Industries, Bintuni bay, West Papua, Indonesia, with an area of over 82,000 hectares. Prior studies worldwide have used remote sensing to estimate biomass for carbon accounting purposes. While those studies may tolerate a higher degree of error, this study requires a higher level of precision as the results will be implemented in the company's ten-year management plan. Simple spectral indices are not reliable as individual spectrum could be influenced by various environmental factors across diverse locations. Preliminary studies done with spectral bands and forest structure data from 80 datapoints of 20-m resolution pixels confirmed this limitation. Principal Component Analysis, which combines multiple spectrums into a limited number of "Principal Components" was deployed and found to enable a more significant and consistent agreement within the same dataset.This study plans to use the Principal Component Analysis with Sentinel-2 images to estimate the mangrove tree volumes across the concession area. It will use ground survey data from more than 300 plots with 5 20-m sequential subplots collected from 2018 to early 2019. A model will subsequently be developed to estimate the volume per hectare gradient for the entire concession. The result will be applied to the year 2021 to 2030 harvest plans with the objective to minimize the amount of area touched.

Session: T009 - Mangrove management
Abstract ID: T009-A006
Presentation mode: Poster

Ecological Resilience of Mangroves: a Comparison of Two Mangrove Ecosystems

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This study compared two social-ecological systems of mangroves, Sathurukondan (urban mangroves) and Nasivanthivu (rural mangroves), in Batticaloa district, Sri Lanka. Both ecosystems are varied with mangrove dependency, disturbances and conservation approaches. Species diversity, forest characteristics and structure were derived from transect method. The social data was collected from semi-structured interviews. A total number of 31 species in Sathurukondan and 27 in Nasivanthivu recorded, which include 5 and 8 true mangroves respectively. Species richness, diversity, evenness and mean DBH of trees were higher in Nasivanthivu whereas density of mangroves and mean height of trees are higher in Sathurukondan. Density of dead stumps, regenerating stumps and saplings were higher in Sathurukondan whereas the percentage of juvenile is higher in Nasivanthivu.Both sites are exposed to encroachment, waste accumulation, destruction and erosion, which detracting from resilience at both sites. At present, direct mangrove resources were used to a much smaller extent and cutting of mangroves became banned at both sites. Participatory and true local concerns on mangrove conservation may not be properly integrated. Sathurukondan mangrove ecosystem, today, experienced regenerating patches with higher biodiversity with mangroves and its associates indicating r-phase (exploitation) of adaptive cycle with high resilience contributing to maintaining it a mixed vegetated area. Nasivanthivu mangrove ecosystems are experiencing a mosaic of phases (r and K phases) of the adaptive cycle without causing degrading revolt to impact the forest functions of providing ecological systems. Continued erosion and other development activities may shift the spatial distribution of mangroves within the lagoon. The mangrove ecosystem as a whole may be determined by smaller scale cycles pushing the system to either ends of the spectrum, growth and degradations. The study indicates that the urban mangrove system likely to move towards r phase and rural mangroves likely to move towards K phase of the adaptive cycle.

Session: T009 - Mangrove management
Abstract ID: T009-A050
Presentation mode: Oral

Socio-ecological Dimensions of Mangrove Ecosystem Services in the Rapidly Urbanized Klang Islands – Implications for Mangrove Management in Southeast Asia

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Southeast Asia accounts for approximately one-third of the global mangrove extent, but this highly biodiverse region has seen the greatest proportion of mangrove loss globally in the last two decades. While the multiple ecosystem services of this coastal habitat are widely recognized, especially for provisioning of fishery resources and coastal livelihoods, they are often under-valued especially in the face of urbanization. This trend of loss is reflected at a local scale in the Klang Islands, a group of islands located 35 miles from the capital city of Kuala Lumpur in Peninsula Malaysia. These islands have experienced rapid mangrove destruction arising from urban development, reclamation, selective logging, aquaculture, and agriculture (particularly palm oil). A series of participatory workshops and interview surveys over two years have been conducted to bring together local stakeholders from three inhabited islands with varying interests to share their knowledge and vision for mangroves, with particular attention to fisheries and community well-being. First-hand accounts from local villagers who were traditionally reliant on mangroves for livelihood and cultural importance reported significant impacts to their lives as a result of mangrove clearing; these include loss of valuable fishery resources, reduced access to mangrove-based harvests, increased coastal erosion and subsequent widening of channels, and increased storm frequencies. An unexpected finding was the bleak consensus of disappearing fishery as an important livelihood among the three islands. Generally, local villagers acknowledged the importance of mangroves but accepted the state of loss and hardships given the necessity of infrastructure development as a priority. Ideas for integrating the two competing forces include creating new forest growth as well as introducing (eco) tourism activities. These findings support the need for improved recognition of the socio-ecological aspects of the mangrove ecosystem services and the urgent need to practically shape sustainable mangrove management through more inclusive practices.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A038
Presentation mode: Poster

Crabs and Gastropods as Indicators of Faunal Recovery in Replanted Tropical Mangroves Using a Triple Isotopic Approach

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To date, measurements of success for mangrove replanting from a faunal perspective had been primarily limited to assessment of changes in diversity, abundance and biomass over time. Stable isotopes have conventionally been used to elucidate sources of primary producers in diet of faunal consumers with general success. In this study we used a triple isotopic (C, N, H) technique to assess native benthic macrobenthic diet changes in a chronosequence of replanted mangrove stands in the tropical Matang forest of Malaysia. Distinct isotopic signature shift was seen, especially for C and H, in diet of crabs and gastropods, between younger (ages 0 and 5 post-replanting) and older stands (15 years onwards post-replanting, including a virgin forest as reference site). Prawns and barnacles on the other hand did not show significant food web changes. A top-down approach for mixing model provided conservative estimates of mangrove contribution of 65 to 70% to diets of crabs and gastropods in the older stands while microalgae contribution ranged from 45 to 65% in the younger stands. The triple isotopic approach revealed that while work remains to be done in terms of improved characterization of 'primary producer sources' especially the bacterial component, the novel use of this approach is promising to track success of mangrove faunal food web recovery.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A036
Presentation mode: Oral

A Comprehensive Review of Global Mangrove Extent, Biomass and Carbon Estimates

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Within the last decade, advances in computing have enabled the generation of multiple global scale mangrove maps of extent (Giri et al, 2000; Bunting et al, 2018), change (Hamilton et al, 2016) and aboveground and belowground biomass and carbon (e.g., Hutchinson et al, 2014; Attwood et al, 2017; Sanderman et al, 2018). These multiple datasets have often had overlapping goals and outputs with updated maps regularly including the work of their predecessors. These have enabled detailed results at a variety of resolutions, at the global scale, that have helped the community understand changes in mangrove extent and subsequent ecosystem biomass and carbon. However, there has been little comparrison between these datasets and limitied assessment of the propagation of error throughout the linked products. As mangroves are increasingly threatened, a comprehensive understanding of their extent and carbon content can only be achieved through a synthesis of all global mangrove maps, accounting for each of their strengths, caveats and sources of error. In this review, we quantify and map the differences between similar global mangrove products and attribute these to the variation in the datasets and methods used. We attempt to combine these isolated products into a definitive assessment of global mangrove forest extent and ecosystem carbon and suggest the movement towards a definitive single hybrid geospatial dataset.

Session: T008 - Blue carbon
Abstract ID: T008-A041
Presentation mode: Poster

Investigating Spatial Patterns of Variability in Bacterial Communities Inhabiting Arid Avicennia Marina Forests

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Mangrove forests provide a suite of critical ecosystem services from local to global scales. Soil conditions and associated micro-organisms play a fundamental role in some of these services, such as nutrient cycling and carbon sequestration. Despite their importance, microbial abundance and function in mangrove soils has received little effort in current ecological and molecular research. High spatial variability in a temporally dynamic system facilitates the diversification of microbial assemblages and functions. Such variability may be of great importance for carbon cycling and nutrient dynamics of the ecosystem. This study compares bacterial communities of mangrove soils in arid Avicennia marina forests across different spatial scales. Soil characteristics and the structure of bacterial communities analyzed via 16S rRNA gene sequencing were compared across: (i) Two distinct zones (seaward/landward) within a given forest; (ii) From forests with varying local hydrodynamic conditions (exposed/sheltered); and (iii) From forests in different geographic regions (Saudi Arabia vs Australia). Results from this study are expected to help identify the factors that drive microbial community composition in mangrove soils and how potential environmental changes will affect these assemblages. A better understanding of the dynamics of bacterial activities in mangrove soils is vital for management efforts, as well as future studies, especially those focusing on blue carbon research.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A022
Presentation mode: Lightning Talk

Proposing Livelihood Strategies Ecosystem-based Adaptation by AlivE planning tool in the Coastal Mangrove Forest: a Case Study in Cu Lao Dung Island, Vietnam

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Ecosystem-based adaptation is particularly important for people whose livelihoods depend on climate-vulnerable ecosystems. Healthy mangroves ecosystems are more resilient and can better resist the negative impacts of climate change, thus supporting for secure livelihoods of coastal communities. The objective of the study was to proposing livelihood strategies for farmer livelihoods in the coastal area in Soc Trang province. AlivE tool was use to promotes a bottom-up, community-centered approach to ensure the needs of vulnerable people are addressed and to foster local ownership and sustainability livelihood. Individual interviews with local farmers and management staffs and participatory rural appraisal were done to collect data according to the the sustainable livelihoods framework of the UK Department for International Development (DFID). The results show that mangroves in the coastal zone are full of values of ecosystem services including: Provisioning services, Regulating services, Cultural services and Supporting services. However, under the pressure of increasing exploitation and climate change, these values are seriously degrading in terms of quality of service, especially provided services. In contrast to those effects, survey results about the awareness and preparedness of coastal communities to the potential for conservation, restoration, and sustainable use of coastal mangroves which is increasing over time. The AlivE planning tool has assessed the effectiveness of ecosystem-based adaptation measures and propose the optimal ecosystem-based adaptation strategy for coastal community livelihoods.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A040
Presentation mode: Poster

Nature's Headlamps: a Unique Light-focusing Structure in Perisesarma (de Man, 1895) Mangrove Crabs

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Visual signalling plays a key role in animal communication. In low-light environments, such as within mangrove forests, animals should benefit from being able to enhance the intensity of the signal they transmit. Here, we examine the facial bands of two mangrove crab species, Perisesarma eumolpe (de Man, 1895) and Perisesarma indiarum (Tweedie, 1940), and show that these bands reflect incoming light in a manner that produces the strongest light intensities at angles of between 0˚ to 10˚above the horizontal–the optimum range for maximising signal intensity between two Perisesarma crabs. Furthermore, we demonstrate through a series of choice experiments that the brightness and colour of these bands are used in sexual signalling. These facial bands are, to our knowledge, the first example of light-focusing, external, macro signalling structures in nature.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A019
Presentation mode: Oral

Investigation of Physiological Responses of Rhizophora mucronata Lam. Seedlings to Copper and Zinc Excess

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Mangrove forest is a sink of heavy metals because it is directly exposed to contamination via urban water, industrial and agricultural runoff. Rhizophora mucronata, a dominant mangrove species found in coastal areas and estuaries of Thailand. Copper (Cu) and zinc (Zn) are common contaminants introduced to aquatic systems via various channels. Investigation of physiological responses of R. mucronata under excessive Cu and Zn is therefore a basis for evaluation of the impacts of heavy metals pollution on mangrove health. Seedlings were supplied with Cu or Zn (0, 50 or 100 mg per plant). The plant tissues (both roots and leaves) were analyzed for superoxide dismutase and peroxidase activity, non-protein thiols content, total reactive oxygen species, lipid peroxidation, and Cu and Zn accumulation. In addition, the root tissues were fractionated into cell wall and cytoplasmic fractions and were analyzed for Cu and Zn content. The R. mucronata limited Cu and Zn translocation to the leaves as the HM were accumulated largely in the roots. Consequently, no physiological change was observed in the leaves. An increase in oxidative stress or antioxidant defense were not detected in the roots, suggesting that heavy metal sequestration in cell wall evidenced in this study was able to prevent heavy metal toxicity in the roots of R. mucronata seedlings.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A003
Presentation mode: Poster

Carbon, Nitrogen and Phosphorus Stocks in Neotropical Mangroves Along a Restoration and Degradation Path

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Mangroves, in addition to having an important role in the storage of carbon, contribute greatly to the health of the ecosystem and the adjacent waters, also by store nitrogen and phosphorus from inland. It has been found that up to 88 and 99% of the C and N of the ecosystem can be stored in the sediments of the mangroves, respectively. The objective of this study was to evaluate the stock of organic carbon (OC), total nitrogen (TN) and total phosphorus (TP) in the sediments of the mangroves (up to 1 m deep) in a highly intervened site, the Cienaga Grande de Santa Marta (Colombia), where a rehabilitation project was implemented between 1995 and 1998. The OC in the sediments was around 266.5 ± 46.6, Mg C ha-1, the highest values being found at sites where massive mangrove mortality occurred in comparison with a conserved site. In these places, the highest percentage of OC was found to be deeper than 30 cm, showing that the organic material of the dead trees is being buried under new layers of sediment. The TN stock did not show significant differences between natural and restored sites and was around 17.1 ± 1.1 Mg N ha-1. On the other hand, TP was significantly higher in the natural site than in those that suffered mangrove mortality. The average for all sites was 0.18 ± 0.06 Mg P ha-1. The results of this study can be used to make management decisions of mangrove ecosystems subject to continuous changes and strong pressures.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A041
Presentation mode: Poster

Multi-species Genetic Structure, Demography and Adaptation of the Mangrove Genus *Rhizophora*, Revealed by Re-sequencing Data: Implications for Conservation Genomics Under Climate Change

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Mangrove forests have been under severe threat due to human activities, such as coastal development, exploitation for fuel wood, forest products and fishpond operations since the 1980s (Tomlinson 1986). Moreover, mangrove ecosystems are threatened by recent climate change and sea-level rise could be their greatest threat (Gilman et al., 2008). To maintain the high value of ecosystem services of mangroves across several dimensions (ecological, socio-cultural and economic, Mukherjee et al. 2014), conservation genomics is a high research priority for many mangrove species. In this study, we focused on the genus Rhizophora, including widely distributed and important species in the Atlantic - East Pacific (AEP) and South Pacific regions. We studied 4 species (R. mangle, R. racemose and R. samoensis, with samples covering each species distributional range) by conducting a resequencing approach based on the draft genome of R. apiculata and R. stylosa (Xu et al. 2017). A large number of single nucleotide polymorphisms (SNPs) were obtained and the deepest genetic divergence was detected between the Atlantic and Pacific Oceans across the American continent, regardless of species. Although more detailed genetic structure was detected in the Atlantic populations of R. mangle than a previous study (Takayama et al. 2013), genetic differentiation was not clear among species in the Pacific populations, probably due to ancestral polymorphism. Historical transbarrier (transoceanic and transisthmian) gene flow, past demographic history and adaptation of these species will be discussed together with conservation implications under climate change.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A026
Presentation mode: Poster

Conservation International Fiji's Pathway Towards a Collaborative Mangrove Management and Restoration Strategy in Fiji

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In Fiji, mangrove forest entails slightly more than 40,000 ha of land area primarily located on the two largest islands, namely Viti Levu and Vanua Levu. Mangrove forests are important ecosystem for Fijian coastal communities due to their provision of ecosystem services, such as timber and fuelwood, fisheries, sediment trapping, coastal protection and carbon sequestration and storage. However, mangrove forests in Fiji face many threats, among them is the expansion of coastal development, pollution, illegal harvesting, and increased pressure from sea level rise. Conservation International - Fiji (CI-Fiji) has expanded its strategy to include additional efforts for conservation, restoration, and monitoring of mangroves by partnering with multiple stakeholders in Fiji to effectively manage Fiji's valuable coastal ecosystems. Between 2012 and 2018, CI-Fiji was involved in the development and implementation of two critical mangrove projects. CI contributed by providing assistance with the rapid baseline biodiversity and scientific, archaeological and socioeconomic survey of the Mangrove Ecosystems for Climate Change Adaptation & Livelihoods (MESCAL) project funded by International Union for Conservation of Nature. MESCAL efforts aided to promote an adaptive co-management approach as well as the restoration of mangrove ecosystems in five Pacific Island Countries. Second, CI was co-partner in developing a three-year mangrove rehabilitation project funded by the International Tropical Timber Organization (ITTO). The project addressed concerns in mangrove forest areas that have been heavily impacted by human development along the mangrove and coastlines. These collaborative mangrove conservation and restoration efforts have motivated CI-Fiji to spearhead the Fiji Blue Carbon Roadmap to stimulate the investment in accelerating blue carbon projects in coastal ecosystems with multiple stakeholders in Fiji. Through this collaborative roadmap, CI-Fiji efforts include continue raising technical and policy awareness on the blue carbon ecosystems (seagrasses and mangroves), their multiple co-benefits while complementing existing community activities and policy interests.

Session: T009 - Mangrove management
Abstract ID: T009-A020
Presentation mode: Poster

So Many Choices, So Little Time – Can Social Science Facilitate Choosing a Mangrove Management Approach?

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Viewing mangrove forests within the Social-Ecological System (SES) framework, broadens possibilities for mangrove management and conservation. The international community has complemented mere 'fortress conservation' with approaches that consider the crucial human elements alongside the ecological elements. Presented with more options, choosing becomes increasingly difficult for management bodies. With mangrove forests being affected by competing land uses and climate change, the 'Paradox of Choice' must not result in indecision and inaction. Over the past few years, we have worked towards an adaptable decision-analysis (DA) framework that allows decision-makers to select a management approach which meets social and ecological objectives. The DA framework is based on fieldwork in rural and (semi-)urban settings across Malaysia and Singapore. Similar contexts -including ecological, social, economic and political aspects- occur across Southeast Asia. To obtain an adaptable DA framework, we identified and prioritised management objectives relevant to mangrove SES's within different contexts. We also identified direct and indirect drivers of mangrove deforestation and conservation, clarifying the possibilities for impact on mangrove management. We found that local mangrove dependent activities do not guarantee broad social support for prioritising mangrove conservation objectives. High development pressures further emphasise the need for a framework guiding decision-making towards socially and ecologically sustainable mangrove management options. We want to illustrate the complementary use of semi-quantitative Q methodology, qualitative coding, quantitative Likert scoring surveys and the Delphi method. These social science methods enable us to involve ecology experts as well as people living adjacent to mangroves. The combination of quantitative and qualitative methodologies facilitates identifying perspectives on social and ecological management objectives as well as understanding the values and (empirical) reasoning underlying these perspectives. The systematic nature of the methods allows the mapping of change over time as well as further improvement of the adaptability of the framework to even more contexts.

Session: T009 - Mangrove management
Abstract ID: T009-A028
Presentation mode: Oral

Assessment the Effectiveness of Mangrove Rehabilitation in Ca Mau Province from 2004-2013 Using Remote Sensing Data

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Mangroves play a very important role in providing ecosystem services for local communities. Mangrove forests not only offer timber products, but they also play a role in shoreline stabilization and biodiversity conservation. In Vietnam, mangrove forests have been severely reduced over the last seven decades, especially in Ca Mau province, due to the expansion of shrimp farming, economic development, and, population growth. With the support from non-government organizations (NGOs), many state-run mangrove restoration programs have successfully restored and conserved mangrove forests across various communes in Ca Mau. The objective of this study is to assess the effectiveness of mangrove restoration efforts in Ca Mau province from 2004 to 2013. Applying an object-based classification approach, this study quantified and analyzed changes in mangrove coverage and local people's awareness regarding mangrove protection from 2004 and in 2013 in 4 communes of Ngoc Hien and Nam Can districts (Dat Mui, Vien An, Vien An Dong and Lam Hai), using SPOT 5 and household survey data. The results showed that mangrove forest areas increased by 93.25%, from12,031.40 hectares in 2004 to 23,251.00 hectares in 2013. of The analysis of household interview data illustrated that local people's awareness on mangrove protection increased from 80.37% (interviewed in 2010) to 95.89% (interviewed in 2015). Local communities also had optimistic views about sustainable management of mangrove forests in the future, with 72.60% of participants believed that mangrove forest areas would get larger. Only 6.85% of interviewees said mangrove coverage would get smaller and 20.55% said it would remain the same as present. By incorporating remote sensing and household survey, this study concluded that mangrove restoration programs in Ca Mau from 2004 to 2013 were overall effective in terms of restoring forest areas as well as raising local awareness regarding the importance of mangroves.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A026
Presentation mode: Oral

Assemblages and Metabolic Responses of Invertebrate Larvae Associated to the Ting Kok, Hong Kong Mangrove Habitats

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Mangrove forests increase the degree of habitat complexity within bays, estuaries and creeks. Many studies suggest that the complexity of mangrove forests provide a valuable habitat for resident and transient juvenile fish, shrimp and crab larvae that utilise these ecosystems. This research examined the spatial differences in larval communities among three different habitats within a mangrove forest. The respirometric response of sesarmid and pinnixid larvae occurring within the tidal creek were also measured at average and increased temperatures that are experienced during the summer. Furthermore it was hypothesised that sesarmid larvae will have a lower respiration rate to pinnixid larvae with increased temperature due to their smaller size and close association to the mangrove as adults. Light traps were used to sample larval assemblages in tidal creeks, the pencil roots of Avicennia marina, and the buttress roots of Kandelia obovata in the Ting Kok mangrove forest, Hong Kong. A fluorescence based microplate respirometer was used to quantify the oxygen consumption rate of sesarmid and pinnixid zoeae with increasing temperature. Preliminary results indicate: assemblages of invertebrate larvae vary spatially among habitats, as well as with maximum tidal height. The metabolic rates of sesarmid and pinnixid larvae increased with increasing temperature, with pinnixid larvae having a higher respiration rate than sesarmid larvae at 28°C and 33°C. These results suggest that habitats within these mangroves present different larval assemblages. Furthermore, the metabolic responses of zoeae indicate that pinnixid larvae may be more susceptible than sesarmid ones to increased temperatures. Mangrove habitats, defined by the different tree species, indeed host distinct larval communities, with some taxa more vulnerable than others to the extreme summer temperature in this region, highlighting the key conservation role of these systems for the early establishment of macrobenthos.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A016
Presentation mode: Oral

Plastic Morphological Responses of Mangroves to Environmental Change

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Plant morphological plasticity plays a critical role in determining survival, community dynamics and ecosystem function. Rapid morphological adjustments of bellow and above ground biomass as a response to environmental variations can lead to changes in plant architecture, their interactions and potentially in ecosystem function. For seedlings colonizing mudflats, environmental disturbances like flooding frequency and duration can affect biomass allocation into roots and stems, determining seedling survival and establishment success, while adult trees must compete for resources and sustain wind disturbances that can cause crown asymmetry and compromise mechanical stability. Under climate change scenarios, mangrove ecosystems will face sea level rise, potential increase in soil salinity and in frequency and intensity of extreme weather events. Understanding plastic responses to environment at individual and community level can provide accurate tools for management, restoration and adaptation to environmental change. In this work, we evaluated plastic responses determining colonization success on tidal flats by measuring seedling resource allocation into stem and root biomass along elevation gradients in the field. In a laboratory experiment we further quantified the importance of root length for wave resistance by tracking mimic propagule dislodgement in real time using an acceleration data logger. For mature trees, we quantified tree crown displacement from stem positions in response to neighbourhood and wind direction of pressure along an increasing salinity gradient. This clearly showed a shift from neighbourhood-driven to wind-driven crown asymmetry suggesting increased susceptibility to wind forces as salinity increases. As crowns become asymmetric, anchoring root systems respond in different ways to compensate for mechanical imbalance. Focusing on bio-physical interactions our results further elucidate understudied links between mangrove plant architecture and ecosystem functioning.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A003
Presentation mode: Lightning Talk

Preliminary Assessment of Mangrove Damages Caused by Hurricane Irma (2017) in the Saint Martin Island (West Indies)

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Strong winds and storm surges from hurricane Irma in the Saint Martin Island on 5-6 September 2017 damaged 95% built structures, displaced about 7000 people and caused 11 deaths, 7 missing and 111 injured. Damages caused on natural resources by the most powerful hurricane that struck the island this century are so far unassessed. Here, we quantified mangrove forest damages resulting from hurricane Irma using a remote sensing approach coupled with ground observations. Mangrove areas were mapped prior to Irma using photointerpretation on very high resolution images and validated by a field survey in 2011. Very high resolution Pleiades images and forest inventories were used to monitor mangrove structure and health prior to, and following, Irma event. Based on differences in satellite observations coupled with stand health characteristics, we classified mangrove into 5 damage level categories: undamaged, weakly damaged, strongly damaged and died. We show that about 1/4 of mangrove areas were undamaged, and that almost 1/2 of damaged mangroves died. The Atlantic, windward coast of the island has been the most impacted by the hurricane. Mangroves were also differentially affected depending on tree species. In the coming decades, hurricane activity will likely to substantially increase – roughly a 300% increase by 2100. Our work, raises the question of the future characteristics of Caribbean mangrove forests in the face of climate change consequences.

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A022
Presentation mode: Poster

Responses of Mangrove Seedlings to Invasive Cordgrass-induced Aboveground and Belowground Competition

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The competitive interactions from above- and below-ground between woody seedlings and herbaceous vegetation have influenced the encroachment of woody plant into grasslands. Moreover, the strength of biotic interactions varied with different woody species. The invasive Spartina alterniflora (cordgrass) inhibited growth and regeneration of mangrove seedlings in mangrove-salt marsh ecotones. Although the relative importance of aboveground competition has long been studied, we know little about how the cordgrass-induced belowground competition in mediating the establishment of mangrove plant varies with species.By using the target technique, we conducted a field experiment to assess the responses of one exotic (Sonneratia apetala) and two native (Avicennia marina and Aegiceras corniculatum) mangrove seedlings to different combinations of above- and below-ground competition treatments (full, shoot only, root only, and no competition) imposed by cordgrass in Zhangjiang Estuary in southern China, where invasive cordgrass, exotic and native mangroves co-occurred.After one growing season, the survival and growth of mangrove seedlings were significantly reduced in full competition, with compare to other treatments. In shoot and root competition treatments, growth of both mangrove seedlings were suppressed to the similar magnitude, compared with no competition treatment. This highlighted the importance of belowground competition in inhibiting seedling growth. Competitive response indices based on growth responses confirmed belowground competition was as important as aboveground competition. Exotic S. apetala typically showed reduced survivorship but faster growth in every treatment, differed from the native A. marina and A. corniculatum, which demonstrated that different mangrove species existed different strength of biotic interactions. Furthermore, our study suggested that the method of removing aboveground of invasive cordgrass and then transplanting native mangrove seedlings may be constrained by the belowground competition except to the exotic fast growth mangrove species of S. apetala, which will shed light on mangrove rehabilitation under biological invasions.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A014
Presentation mode: Lightning Talk

Genome-wide Insights into Low Temperature and Drought Stress Regulated Genes in *Bruguiera gymnorhiza*

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Understanding the response to temperature and drought stresses has never been more relevant to mangrove ecology today, as climate warming allows for the expansion of mangrove distribution range poleward, and increased salinity resulted from changing precipitation pattern is predicted to lead to mangrove forest decline, especially along arid coasts. The extent of poleward distribution range expansion depends on species tolerance towards chilling stress; on the other hand, the effect of changing precipitation pattern depends on species tolerance towards salinity (physiological drought) stress. As non-model tropical trees, the molecular network regulating the response to chilling and drought stress in mangroves is poorly understood. Addressing this critical knowledge gap could help elucidate on the biological limitation and evolutionary potential of mangroves growing at the edge of their tolerances, and improve predictive modelling of future mangrove distribution. This presentation summarizes the findings from three studies on the chilling and drought stress-regulated genes in Bruguiera gymnorhiza, a widespread mangroves species from the Indo-West Pacific region. First, a growth chamber experiment revealed that cold tolerance of B. gymnorhiza can be attributed to prolonged expression of cold-induced genes. Second, preliminary data from a cold experiment on seedlings from different latitudes that were grown in a common garden showed that cold tolerance is (genetically) adaptive, as seedlings originating from a higher latitude displayed a higher level of cold tolerance. Third, findings from a drought experiment revealed that abscisic acid played a central role in regulating response to osmotic stress, including the synthesis of osmoprotectant glycine betaine. Collectively, these studies bridge the gap between ecophysiology and genomic research. They provide a systematic understanding of abiotic stress response in mangroves, from the plant level (e.g. stress signaling, stress-responsive gene expression) to the population level (e.g. adaptation in different populations).

Session: T002 - Impacts of climate change on mangrove distribution, structure and function
Abstract ID: T002-A046
Presentation mode: Oral

The Delineation of Marine Protected Areas: Perspectives from Comparative Phylogeography of Mangrove Trees and Crabs

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The establishment of marine protected areas (MPAs) is a common policy tool to conserve fisheries species and their habitat at a global scale. However, challenges associated with estimating the dispersal of pelagic fishes and their larvae reduce our ability to provide biological justification for the delineation of MPAs. Here, the phylogeography of mangrove trees and crabs were used to facilitate the detection of barriers to connectivity in coastal fauna that are strongly associated with the mangrove habitat. Since mangrove trees have propagules that are passively-dispersed by sea, phylogeographic data provides important insights on the biogeographic barriers and dispersal patterns under the influence of prevailing ocean currents. Similarly, mangrove crabs also have larvae that are dispersed by sea. Phylogeography data from more than 20 studies on mangrove trees and crabs in both the Atlantic-East Pacific and the Indo-West Pacific regions revealed genetic breaks across several well-known biogeographic barriers, suggesting the universality of physical factors in dictating the dispersal and population structure of coastal and marine species. However, the detection of several cryptic oceanic barriers indicated that ocean circulation patterns could play a crucial role in restricting habitat connectivity. Ultimately, this demonstrates the practicality of using comparative phylogeography across taxa to achieve an ecologically meaningful delimitation of reserve networks.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A027
Presentation mode: Poster

Knowledge Gaps Negatively Affects Village-level Mangrove Planting Outcomes

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Our previous paper (Wodehouse & Rayment 2019) highlighted the low success rate of mangrove rehabilitation efforts since 2007 (a mean survival of 20% with a median of 10%), across a sample of eight villages across Thailand and the Philippines. Here we explore some of the thinking that underpinned the rehabilitation decisions made. 150 semi-structured interviews were conducted with villagers, village leaders and conservation group leaders describing their most recent mangrove planting events. This was supplemented by 257 formal rehabilitation science tests and direct observation of mangrove planting activity. Mudflats were the most frequently reported planting zone (33% of interviews, including 80% of Philippine interviewees) and 64% of all villagers and 77% of government mangrove agency officers believed that mudflats were appropriate places for mangrove planting. Interviewees believed that particular sites were chosen either because they were perceived as degraded (34%) or because it was an uncontested space available space for planting (34%). Despite planting at all elevations including mudflats, 94% of interviewees claimed to have planted mid-mangrove species, particularly Rhizophora spp. In part this was because only 21% of villagers and 35% of government officers could name species appropriate for low zone planting. No villager or government officer claimed to have planted low-zone pioneer species (eg Sonneratia spp.). Planting timing was determined by a desire to celebrate national days in Thailand (41% of Thai interviewees) or due to logistical constraints (56% of Philippine respondents, including 22% of interviewees who timed planting to coincide with low tides to enable access to mudflats), rather than by silvicultural factors. Villagers were consistently over-optimistic about the success of their planting projects with more than half claiming a >70% survival rate, cf. 20% actual survival). These results highlight the importance of better connecting mangrove rehabilitation efforts with the scientific and silvicultural literature.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A010
Presentation mode: Oral

Villager Participation in Mangrove Management Is Not a Panacea and Needs Additional Capacity Building Intervention

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Government agencies responsible for mangroves often have limited resources to tackle over-exploitation or unsustainable management. Thus, despite widespread awareness of the link between mangrove health and fisheries productivity, over-harvesting of mangrove wood persists. This study examined villager participation in mangrove governance via 118 semi-structured interviews with villagers and village leaders from eight mangrove villages across Thailand and the Philippines. Although attitudes to mangrove rules were generally positive in both countries (85%), active involvement in rule-making was significantly lower in the Philippines (7% cf ca. 50% in Thailand). Typically, government agencies set meeting agendas, and provided sample sets of rules. Village participants often struggled to adapt these and felt decisions were steered in the governments' favour, and only 12% of villagers (all in Thailand) believed discussion to be in good faith. At the end of the rules development process, around 15% of all villagers felt that they had the final say. Village meetings were less participative than they appeared because some participants joined meetings primarily to collect incentives offered. Villagers who disagreed with proposed rules or activities rarely spoke in public fora due to a lack of confidence, not wanting to identify as mangrove cutters and not wanting to publicly contradict social 'betters'. Activity plans were generally not aided by participation. Three-quarters of all villagers simply agreed with the species choice made for them, resulting in 94% of interviewees reporting that they planted mid-zone mangrove species, even though at most half of all planting attempts were actually conducted in the mid-zone. Village leaders and project managers are therefore recommended to guage public opinion through smaller or one-to-one meetings, and to employ training to strengthen the capacity of village conservation groups (and their leadership) to produce locally appropriate mangrove management and governance rules, activities and sanctions.

Session: T009 - Mangrove management
Abstract ID: T009-A023
Presentation mode: Poster

Does Logging-induced Regrowth Change Leaf Chemistry in White Mangroves? - New Insights Using Pyrolysis-GC/MS

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With human populations rapidly increasing, especially in coastal regions of the tropics, the number of people depending on mangrove resources is rising. General 'No-take' policies are not a sustainable solution for mangrove conservation and securing livelihoods at the same time. Therefore, spatial planning of mangrove management and protection are much needed. Communities along the coastline of North Brazil practice a traditional form of selective mangrove-logging strongly focusing on the White Mangrove (Laguncularia racemosa). As stumps of felled Laguncularia trees resprout, wood extraction is often considered sustainable resource use and remains therefore unrestricted. However, subsequent ecological impacts of felling and regrowth have yet to be investigated. With our study, conducted in a North-Brazilian Extractivist Reserve (RESEX), we assessed how cutting and regrowth influences the leaf chemistry of the White Mangrove. We analysed leaf samples from trees at different stages of regrowth for carbon, nitrogen and phenolic content. Early regrowth, shortly after cutting the stem, was characterised by a significant increase in in leaf nitrogen content. Subsequently, nitrogen content declined quickly in the leafs. None of the other parameters exhibited any changes. Further analyses using pyrolysis-gas chromatography/mass spectrometry (Pyrolysis-GC/MS) will yield more detailed insights into the chemical composition of the leaf organic matter. In the light of our preliminary results, that support the assumption that selective logging has an impact on the leaf chemistry of White Mangrove trees, we will discuss the ecological sustainability of this resource use.

Session: T009 - Mangrove management
Abstract ID: T009-A015
Presentation mode: Poster

Mercury Pollution in Matang Mangrove Forest Reserve, Malaysia: Is Charcoal Production a Threat ?

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Mangroves act as important sinks for heavy metals, including mercury (Hg), by sequestering them in sediment and plant tissues. The charcoal production activities at the Matang Mangrove Forest Reserve (MMFR) in Peninsular Malaysia not only release carbon, but also emit Hg back to the ambient environment, raising concerns on the environmental risk. There is very limited information available on Hg levels at the MMFR, and hence the present study aimed at analyzing Hg from different plant/animal tissues and sediment samples provide a clear picture on the local pollution status. Leaves, bark and roots were sampled from Rhizophora apiculata (Blume) and R. mucronata (Lamk.), whereas surface sediments were collected from the river bank and 10-15 m inside the forest. Animal tissues of the mangrove gastropod Cassidula aurisfelis (Bruguiere) and the cockle Tegillarca granosa (Linn.) were also tested. Among the plant tissues, only leaves showed elevated Hg values compared to roots and bark, with an increasing trend of Hg concentration from young leaves (mean concentration, 3.17 μg Kg-1) to mature (19.31 μg Kg-1), senescent (33.88 μg Kg-1) and decomposing leaves (36.05 μg Kg-1). There was no clear gradient of Hg concentrations from the point source(s) of charcoal production, except that leaves and gastropods collected from the downstream locations had rather higher Hg levels. Geo-accumulation index was found to be less than one and signifies unpolluted nature of the mangrove sediment. Also, cockles had a lower Hg concentration than the permissible limit (500 μg Kg-1) implying no health hazards for consumption. Overall, the MMFR is still safe in terms of the hazardous Hg contamination through the decadal charcoal production and other human intervention activities in the vicinity. Perhaps future scientific investigation might provide more insights on the environmental impact(s) of charcoal production at the MMFR.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A007
Presentation mode: Poster

Mangrove Restoration Potential: a Global Map Highlighting a Critical Opportunity

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Rapid losses of mangroves over the past 50 years have had negative consequences on the environment, climate, and humanity, through diminished benefits such as carbon storage, coastal protection and fish production. Restoration of mangrove forests is possible, and has already been undertaken in many settings, but such efforts have been piecemeal, and many have failed. The current work describes the findings from a new effort to locate and map, on a global scale, the places where mangroves can be restored, and to calculate the potential benefits from such restoration. As a framework for the study, based on the new Global Mangrove Watch timeseries a typology of mangroves has been developed with mangrove areas classified into deltaic, estuarine, lagoonal and fringing systems, and subsequent analyses based on the resulting 6000 individual units. An expert-derived model for restorability has been developed based on the key environmental components that influence the ease of restoration: tidal range; recent sea level rise; projected future sea level rise; recent change in sediments; time since loss; average size of loss patches; and the proximity of loss areas to remaining mangroves. Using this model, some 8120 km^2, or 6%, of former mangrove areas are considered restorable, 6665 km^2 of which are considered highly restorable. The work overlays current and potential mangroves areas with models of ecosystem services to assess potential benefits from restoration, including carbon sequestration in aboveground biomass amounting to 69 million tonnes of carbon, the saving of 296 million tonnes of soil carbon stocks through a combination of sequestration and avoided emissions and the addition of commercial fisheries species in mangrove waters totalling 27.6 trillion young-of-year finfish and 62 trillion invertebrates. The output of the work the 'Mangrove Restoration Potential Map', provides a critical tool for encouraging restoration and enabling robust, data-driven policy changes and investments.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A013
Presentation mode: Oral

Sunlight and Microorganism Mediated Dissolved Organic Matter Dynamic Along the Mangrove Creek Continuum

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Mangroves fringe most of the tropical coasts and contribute a major source of dissolved organic carbon to the oceans. It has been well documented that sunlight or microbes have a great impact on DOM in aquatic ecosystems, however, little is known about the fate of DOM delivered from mangroves to coastal oceans coupled the photo-bio interaction. Here, we aimed to understand mechanisms and interactions between the photo-bio induced transformation of DOM to creek water across the Zhangjiang estuary in China. Creek water samples from mangrove which placed in UV-transparent Whirlpak bags were exposed to natural sunlight in August 2018 for 0, 30, 70, 140, 200 hours. In addition, photo-altered subsamples impacted by biodegradation were also collected. We found that four DOM components based on fluorescence coupled parallel factor (PARAFAC) analysis. Component 1 (C1) (Ex = 300 nm, Em = 340 nm） and C3(Ex = 295nm， Em = 304nm were ascribed to protein-like substance, otherwise, C2(Ex = 230nm, Em = 454nm) and C4 (Ex = 290nm, Em = 390nm) were ascribed to humic-like substances. Four fluorescent components exhibited dynamic DOM variation patterns similarly. Higher molecular weight compounds such as fulvic acid and humic acid were produced during both photo- and biodegradation. Photo-products of DOM may result in self-assembly, not only preferentially in promoting biodegradation. DOM chemistry is altered by light, therefore mediate microbial DOM degradation. This finding provides new insights into predicting the face of DOM transportation from mangrove ecosystem to the adjacent ocean.

Session: T008 - Blue carbon
Abstract ID: T008-A032
Presentation mode: Poster

Effects of Tree Species and Density on Carbon Sequestration in Mangrove

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Mangroves provide many ecosystem services, and the carbon sequestration is one of the important function of carbon cycle and climate regulation because of the high productivity. This study was aimed to construct the basic carbon sequestration data of Taiwanese mangroves and tried to contribute to effective management. Two mangrove species from four forests of the west coast of Taiwan were selected, ie. Xinfeng (XF), Zhunan (ZN) (dominated by Kandelia obovata) and Budai (BD), Beimen (BM) (dominated by Avicennia marina). Three plots with an area of 25 m2 of each site were investigated from autumn 2017 to summer 2018. The results showed that carbon sequestration rate per unit area of K. obovata was higher than A. marina. The correlation of tree density and carbon sequestration was conformed to the relationship of a previous study. These four sites haven't reached the optimal tree density from the perspective of carbon sequestration.

Session: T008 - Blue carbon
Abstract ID: T008-A051
Presentation mode: Poster

Natural Hybridization Between Introduced *Sonneratia apetala* and Native Species Raises Concern in Mangrove Restoration

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Natural hybridization is prevalent in plants and plays an important role in the invasive success of exotic species. The mangrove species Sonneratia apetala, which is native in Indian Peninsula from India and Sri Lanka to Burma, has been frequently introduced to coasts of South China for mangrove ecological restoration during the past three decades. It has been concerned that So. apetala possesses high-competitive advantages, which may threaten the ecological diversity of native mangroves. In this study, by molecular examination of two suspected individuals, we demonstrated that So. apetala could hybridize with So. alba which is native in China. We also proved So. alba to be maternal parent in this hybridization and no polyploidization occurred in the process. This hybridization may exacerbate the competitive capability of So. apetala. Moreover, the invasive potential of the hybrids also needs to be evaluated. Particular caution should be taken to use So. apetala for mangrove restoration in the future.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A003
Presentation mode: Poster

Microbial Remediation of Heavy Metals in Polluted Mangrove Soils

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With the rapid development of economy and industry, the exploitation and utilization of heavy metals are increasing day by day. The pollution of heavy metals is becoming more and more serious, which poses a serious threat to human living environment and health. For the treatment of heavy metal pollution, the traditional methods are troublesome, energy-consuming, high-cost and easy to cause secondary pollution. Microbial remediation using native microorganisms from contaminated areas is a potential alternative to solve this problem. Firstly, through selective cultivation of soil samples collected from Futian mangrove in Shenzhen, a number of strains resistant to copper and zinc as well as a highly resistant fungus strain were screened out. Three primers were used for preliminary identification of the fungus and the low similarity from the blasting result suggested that the fungus might be a new strain. Secondly, their growth resistance to copper and zinc was explored. The results showed that they were resistant to copper and zinc. The fungus strain could tolerate zinc up to a concentration of 2000ppm, which is of great significance for the future study of microbial remediation of heavy metal contamination.

Session: T004 - Mangrove degradation (e.g., pollution, overharvesting)
Abstract ID: T004-A010
Presentation mode: Poster

Ecosystem Services of Mangroves and Other Coastal Systems from Natural to Urban: A Review from the Tropics

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Mangroves and other coastal ecosystems form a dynamic boundary between land and sea and are often lauded for providing a multitude of valuable ecosystem services. While a wide variety of research has been completed on ecosystem services in temperate coastal environments far less research has been done in the tropics. The tropics already contain some 40% of the world's population and this percentage is expected to grow, thus a greater understanding of tropical coastal ecosystem services and their demand is needed. Urban centers are expected to see the greatest rates of population growth and concomitantly, there will be increased modification of coastal ecosystems and accelerated demand for the services that these ecosystems provide. Furthermore, current research rarely compares and investigates differences between natural, peri-urban, and urban coastal ecosystem services. We undertook a systematic review to evaluate the current state of knowledge for ecosystem services in mangrove and adjacent seagrass, coral, beach, and novel artificial habitats in tropical coastal locations where urban, peri-urban, rural, or natural settings exist. Our findings highlight established research areas and existing data gaps, while drawing comparisons and describing similarities between different tropical coastal settings. Through understanding both nuances and generalities, we highlight the need for more focused research on comparing ecosystems services along a development gradient to better inform mangrove and coastal conservation, policy, and planning.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A019
Presentation mode: Oral

Mandai Mangrove and Mudflat – a Conservation Management Approach in Singapore

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Mandai mangrove forest, is one of the few remaining largest mangrove habitats in Singapore with an extensive mudflat exposed at low tide. It has more than 2/3 of the mangrove plant species found in Singapore, many of which are threatened or rare. The site is also known to house threatened species of seagrasses, horseshoe crabs breeding sites and myriad of other mangrove-related fauna. NParks' studies have shown that due to the diversity and abundance of benthic animals such as mollusc, crustaceans and worms, etc., the mudflat of Mandai mangrove provide migratory shorebirds with a rich feeding ground. Results from surveys and radio-tracking of flagged shorebirds in recent years confirmed that majority of the shorebirds that roost in the Wetland Reserve at high tide will fly to forage at the extensive mudflat exposed at low tide. This establishes both sites as ecologically inter-dependent habitats for shorebirds, and are important for their conservation in Singapore.The National Parks Board (NParks) announced that Mandai Mangrove and Mudflat will be conserved as a Nature Park as recently as October 2018. Collectively, the Wetland Reserve, Kranji Marshes and the new Nature Park safeguard a variety of complementary wetland habitats, including mangroves, mudflats and freshwater marshes, strengthening the conservation of wetland biodiversity in the northwestern part of Singapore. One of the most well-known mangrove and mudflat habitats in Singapore, to nature lovers and scientists alike, this presentation aims to share the journey it took to conserve this habitat as a Nature Park, from research strategies to aid science-based decision-making to close collaboration with community partners to co-create stewardship and ownership.

Session: T009 - Mangrove management
Abstract ID: T009-A048
Presentation mode: Poster

Modeling Coupled Dynamics of Mangrove Photosynthesis, Transpiration, and Species Composition Under Soil Salinity Gradient

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Mangrove forests are an important component of blue carbon ecosystem and plays a major role in climate change mitigation. Though mangroves provide many key ecosystem services, they are disappearing with an alarming rate due to deforestation and degradation. Therefore, to understand and assess mangrove blue carbon dynamics, a robust model is needed for examining possible conservation and management strategies. Mangroves grow in intertidal zones and their species zonation from seaward to landward side depends on soil salinity gradient. Mangrove species have their own soil salinity tolerance values. Osmotic effects of soils salinity may also significantly affect plant transpiration. Consequently, their blue carbon stocks and sequestration may display spatial patterns within the forests. This study aimed to develop a dynamic model to simulate mangrove growth, transpiration, and species composition under soil salinity gradient as a first step in blue carbon dynamics modeling in mangroves. The model was developed based on a spatially-explicit individual based model by Sato et al. (2007) (SEIB-DGVM), which simulates light competition with surrounding trees and was originally developed for terrestrial vegetation ecosystem, by adding the effects of soil salinity on photosynthesis. And the scheme of the soil-plant-atmosphere continuum was implemented to the model to take into account the role of soil salinity on coupled dynamics of plant water fluxes and photosynthesis. Species composition and growth data were collected at Fukido mangrove forest in Ishigaki Island, Japan, where R.stylosa and B.gymnorrhiza are dominant species. The model so developed was applied at the study site and validated with the field data. The model showed good performance to reproduce the species composition, above-ground biomass for each species along the soil salinity gradient. Thus, it was revealed that mangrove growth pattern and species composition can be well reproduced when soil salinity is precisely given as the environmental factor in the model.

Session: T008 - Blue carbon
Abstract ID: T008-A043
Presentation mode: Poster

Mangrove Biodiversity and Fauna Composition During the First 30 Years Rotation (1988 - 2018) on a Sustainably Managed Mangrove Forest in Bintuni Bay, West Papua, Indonesia

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Since its inception in 1988, PT. Bintuni Utama Murni Wood Industries (BUMWI) has sustainably managed and developed the value of the mangrove ecosystem in Bintuni Bay, which is one of the largest stretch of mangrove forests in the world covering more than 260,000 ha. The economic activities have benefited local people, regional and national government, as well as the employees and shareholders of the company while preserving the environmental services and natural resources provided by the ecosystem. Approximately 82,120 ha of mangrove ecosystem in the area are being systematically harvested by BUMWI to produce wood chips using 30 years rotation cycle with strict compliance to sustainable forest management standards. For these efforts, BUMWI became the first company in West Papua to receive the forest management certificate from Forest Stewardship Council® (FSC®). One of the pillars in sustainable mangrove management is the implementation of environmental management and monitoring program. Dataset from the monitoring of mangrove biodiversity and fauna composition has been established for the last 10 years (2009 - 2018). 4,219 quadrat plot sampling (20 x 20 m) were installed to collect mangrove vegetation data and 516 km line transects were established to identify fauna composition during last decade. 27 mangrove species (10 families) were recorded along with 186 birds (39 families), 42 macrobenthos (20 families), 6 mammals (5 families), 5 reptiles (4 families) and 4 marine keystone species (3 families). Species diversity (using Shannon-Wiener Index), species similarity (using Sorensen Index), species dominance, classification of protected species (by Indonesian Law, IUCN Red List and CITES), distribution pattern, structure of vegetation and difference between area (tested by ANOVA) were analysed to evaluate the effectiveness of the environmental management during the first 30 years rotation.

Session: T009 - Mangrove management
Abstract ID: T009-A018
Presentation mode: Poster

Herbivory Mediates the Invasion of *Spartina alterniflora* Into Mangrove Forest in China

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Cordgrass (Spartina alterniflora) was introduced to China from the USA. It grows vigorously in China and has spread over much of the Chinese coast, mixed with mangroves in the south. Although exotic cordgrass numerically dominates intertidal mudflats and open gaps in mangrove forests, intact forests appear to be highly resistant to cordgrass invasion. The biotic resistance hypothesis proposes that biotic interactions, such as competition and herbivory, resist the establishment and spread of non-native species. The relative and interactive role of competition and herbivory in resisting plant invasions, however, remains poorly understood. We investigated the roles of competition and herbivory in resisting cordgrass invasions into mangrove forests. Seed predation or herbivory on seedlings by native crabs was intense in habitats of dense mangrove, mangrove forest edge, or the open mudflat. Survival was nil in habitats where seed predation, herbivory, and shading by dense vegetation killed all seeds and germinated seedlings, except on the mudflat. As to the clones of cordgrass, field transplant and herbivory exclusion experiments showed that while the impact of native rodent grazing on cordgrass was weak on mangrove forest edges and open mudflats, rodent grazing strongly suppressed cordgrass in dense mangrove. A greenhouse experiment confirmed a synergistic interaction between grazing and light availability in suppressing cordgrass establishment, with the strongest impacts of grazing in low light conditions that likely weakened cordgrass to survive and resprout. When both were present, as in mangrove understory habitats, grazing and low light acted in concert to eliminate cordgrass establishment, resulting in resistance of mangrove forests to cordgrass invasion. Our results reveal that grazing by native herbivores can enhance the resistance of mangrove forests to cordgrass invasion in southern China, and suggest that investigating multifactor interactions may be critical to understanding community resistance to exotic invasions.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A001
Presentation mode: Oral

Pond-to-mangrove Reversion in China

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Mangrove forests are one of the most threatened ecosystems, owing to exploitation for resources. In China, mangroves have dropped from 40,000-50,000 hectares in 1950s to 15,122 in 1990s, up to a 67% loss of natural forests. Aquaculture expansion is considered as a major factor causing mangrove decline in China and many other countries.Actions have been taken in China to restore mangrove forest since 2001, as a result, mangrove had been continuously recovering from 22,300ha in 2001 to 34,100ha in 2017. Yet, these efforts generally ended up with failure of high mortality rate of mangrove seedlings, taking up mudflat for foraging birds and undiversified planting species and habitats. It may be attributed to replantation in lower-to-mid intertidal site with high inundation time and the lack of management.On the other hand, since the aquaculture shrimp ponds converted from mangrove were soon abandoned due to disease or unsuitable environment, it is put forward that these disused ponds located in mid-to-upper intertidal zones could be ideal for mangrove ecosystem rehabilitation. Mangroves are thought to be capable of self-regenerating with normal tidal pattern and propagules coming in. Hence, hydrological restoration by simply breaking the dikes of the ponds is the key to the success of mangrove rehabilitation, which can bring back tidal flow, flush out chemical remnant and carry seedlings of mangroves. While artificially replanting is only needed if the pond is not undergoing a normal secondary succession. Emerging quantitative evidences also support the hypothesis.In China, pond-to-mangrove reversion has great potentiality of mangrove rehabilitation, for the vast area of disused ponds located near mangroves. Currently, restoration actions in China often involved with elevation lifting and seedlings planting. Thus, it is intriguing to find out which way is proved to be most effective both ecologically and economically.

Session: T010 - Mangrove rehabilitation
Abstract ID: T010-A001
Presentation mode: Poster

Genetic Diversity Among Natural Populations of *Aegiceras Corniculatum*

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Aegiceras corniculatum is a crypto-viviparous mangrove tree widely distributed in the Indo-West Pacific (IWP) region. Eleven populations of Aegiceras corniculatum from the IWP region were collected and sequenced on the Illumina GA platform using high-throughput sequencing technology. In total, 93 genomic regions (95046 bp, sequencing depth> 3000x) were scanned to identify single nucleotide polymorphisms (SNPs). Our results showed a high level of genetic variation at the species level, but relatively low genetic diversity within region and within population. When populations were grouped according to geographic regions, revealed three major clades: South China, Eastern Thailand and Western Thailand, high differentiation was observed between populations, but interrupted gene flow existed between the structured populations， this pattern may be attributed to the repeatedly cycles of isolation and migration under sea level fluctuation.

Session: T005 - Mangrove genetics and connectivity
Abstract ID: T005-A009
Presentation mode: Poster

Tidal Changes in the Fish Assemblage of a Tropical Estuarine Mangrove Wetland, China

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Tropical coasts mangroves provide important nursery grounds for fish communities; however, their spatial dynamics among microhabitats during a tidal cycle remains largely unknown. In our study, the utilization of a tropical estuarine mangrove wetland by fish assemblage was investigated over a complete tidal cycle in March, June, September and December 2009. Fish were sampled using centipede net at three sites (located in the North Bay, middle part of the Bay and the Southeast Bay, respectively) with different microhabitats (creek, vegetated area and mudflat) at Dongzhaigang Bay, Hainan, China. The daily tidal levels during the sampling period were also recorded. 2,580 individuals, belonging to 40 fish species, 21 families were identified. Spatial variations of fish assemblages among creek, vegetated area and mudflat over a tidal cycle were found ($p<0.05$), with creeks had the highest species richness, number of individuals and biomass. However, the utilization of different microhabitats by fish did not have obviously changes over the tidal cycle at all the three sites separately ($p>0.05$). Nonetheless, all the fish variables showed a synchronized tendency over the tidal cycles, which also depended on seasons (e.g. In December, the biomass and height of tide showed an opposite trend). Statistically, only fish assemblages captured at creeks and vegetated areas had positively correlation with height of tide and water depth ($p<0.05$). Besides, even though dynamics of fish abundance were found among creeks, vegetated areas and mudflats, similarities of fish assemblages recorded at the three microhabitats within the same sites were higher than at the microhabitats between different sites. Based on the results, we may conclude that tidal changes in fish assemblages did exist at Dongzhaigang Bay. However, characteristics of sites like elevation and location may have stronger effects on their spatial variations than height of tide.

Session: T006 - Importance of macrobenthos and other fauna
Abstract ID: T006-A010
Presentation mode: Lightning Talk

Carbon Storage in a Small Mangrove-dominated Estuary (Kipumbwi-Sange) in Coastal Tanzania

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Geomorphology and climate determine mangrove wetlands functional and structural properties where the interaction between fresh water availability, as river discharge, or the dominance of evapotranspiration associated to low soil nutrients can trigger major differences in forest stature and productivity reflected on complex spatial arrangements of mangrove ecotypes. The coastal environmental settings along northeastern coastal Tanzania dominated by semidiurnal tides is classified as small spatial scale estuaries and lagoons, providing an opportunity to assess how environmental drivers (e.g.local hydroperiod, soil nutrient concentrations) associated with coastal settings, control mangrove spatial distribution and carbon storage and sequestration capacities. In this study, we surveyed forest structure and soil carbon storage in a small estuarine mangrove of Kipumbwi-Sange (KISA) in 2016 and 2017. Total aboveground biomass (AGB) for an "undisturbed" forest (i.e., no apparent deforestation) is 91±22 Mg ha^{-1} while belowground biomass (BGB) is 40±7 Mg ha^{-1}. Total organic carbon is estimated at 700 ± 58 Mg ha^{-1}, including AGB, BGB and soil organic carbon (SOC), which is similar to other coastal areas in Eastern Africa. Our AGB and BGB estimated for this small-estuarine-setting mangrove are close to those measured in carbonate-setting along the Shark river estuary (SRE) in Florida Coastal Everglades USA, which are influenced by a semidiurnal-tide regime, and where AGB and BGB are ~100–162.2 Mg ha^{-1} and ~25–44 Mg ha^{-1} respectively. Yet, total soil organic matter (top 45 cm) measured by loss-on-ignition along KISA ranges from 7.9-18% contrasting with 55.2-87.8% along SRE. This finding suggests a higher SOC storage in carbonate-setting mangrove as forecasted by other studies. These results are used to evaluate the interaction of soil nutrients availability and hydroperiod, explaining magnitude and spatial distribution of carbons stocks in a range of mangrove ecotypes present within a variety of geomorphic settings.

Session: T008 - Blue carbon
Abstract ID: T008-A054
Presentation mode: Poster

High-resolution Monitoring of Bed-level Dynamics in Intertidal Environments Using Laser Ranging Technology

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Climate change-related temperature increases and sea-level rises have a significant impact on coastal environment. The morphodynamic processes on tidal flats under this global change have been studied by many numerical and analytical models. But a further theoretical research of morphodynamic processes requires a large amount of bed-level measurement data to reflect the complex reality of tidal flats. The newly-developed SED sensor has avoid problems like discontinuous deployment, high cost and labor request, coarse resolution. However, the instrument is inserted directly to the ground while is working, inducing scour pits around measuring point. Thus, we introduce a new instrument which make use of laser ranging called Laser-SED (surface elevation dynamics) sensor. It could avoid instrument self-disturb by not touching the ground surface and obtain data from four measuring points at the same time with millimeter vertical resolution. The developed sensors can be installed at both bare and vegetated tidal flats to monitoring short-term bed level changes under different settings. In light of this, we set up a group of Laser-SED sensors in National Mangroves Park in Hailing island, Yangjiang. Firstly, these new instruments were tested using data obtained from SED sensors and traditional sediment erosion bars. The results have showed an excellent agreement among these measurement methods indicating that Laser-SED sensors are reliable in bed-level measurements. Secondly, we use the L-SED sensor to reveal the difference in short-term bed dynamics between the mangrove areas and bare tidal flat. The result shows that, under the same wave exposed, mangrove areas tend to accumulate sediment whereas bare flats are generally eroded, which is in agreement with previous studies. We expect that Laser-SED sensor could be applied in other environments such as sandy beaches, dunes and flood plains to acquire valuable data sets for (bio)geomorphological studies, but the applicability remains to be tested.

Session: T009 - Mangrove management
Abstract ID: T009-A051
Presentation mode: Lightning Talk

Ecosystem Service Modeling as a General Approach for Studying Mangrove Carbon Sequestration: Challenges and Benefits

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Land managers responsible for restoring and managing coastal tidal wetlands such as mangroves are faced with myriad of challenges including sea level rise, extreme climate events, land use change, input of agricultural waste water, and maintaining key ecological properties and functions such as carbon stock and sequestration. U.S. Geological Survey (USGS) works with coastal land managers and communities to provide science support for their management concerns. In doing so, the USGS scientists have adopted a general approach of modeling ecosystem services to quantify and monetize location-specific ecosystem services to incentivize land managers to consider climate mitigation functions of the tidal wetlands together with other key services provided. This presentation will introduce this general approach, discuss different modeling frameworks available for such applications, highlight challenges and benefits of using this approach, and present results from case studies.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A028
Presentation mode: Poster

Digging Into Sediments and Microbes for Nature Conservation: a Multi-disciplinary Approach to Mangrove Management, Sustainable Use and Spatial Conservation Planning

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The establishment of protected areas to preserve ecosystems services, while allowing for sustainable use by local communities, requires a sound knowledge of abiotic and biotic drivers of spatial species assemblages and how these translate into ecosystem processes that underlie services. Numerous ecosystem services of tropical mangrove forests, both for local communities and globally, depend on sediment processes that are mainly driven by the sediment microbiota. In a multi-disciplinary global study that covers species-rich and -poor mangrove forests along latitudinal gradients in the AEP and the IWP, we aim at unravelling how the floral and faunal communities, environmental conditions and human resource-use govern service-relevant microbial processes in mangrove ecosystems, and how related services spatially contribute to the benefit of users. The innovative combination of cutting-edge technologies and methods in biology, chemistry and socio-ecological sciences into a "conservation-omics" framework, will provide a sound basis for knowledge-driven spatial conservation planning not solely in mangroves, but also easily transferrable to other coastal ecosystems. Here we present first results on microbial and faunal sediment communities and sediment processes from a selected site. In a subsequent presentation (Syrbe et al.), we will shed light on stakeholder perspective towards our findings.

Session: T007 - Ecosystem services of mangroves
Abstract ID: T007-A027
Presentation mode: Poster