Mangrove & Macrobenthos Meeting

MMM4

ABSTRACT BOOK

An international discussion on the causes and consequences of mangrove ecosystem responses to an ever-changing climate.

July 18 -22, 2016 | St. Augustine, FL

UF | IFAS
UNIVERSITY *of* FLORIDA

ABSTRACT BOOK

July 18-22, 2016

St. Augustine, FL

www.conference.ifas.ufl.edu/mmm4

@mmm4conference
#MMM4

Network: FC-Campus
Username: MMM4@guest.com
Password: 16827774

TABLE OF CONTENTS

WELCOME MANGROVE ENTHUSIASTS!

On behalf of the Organizing Committee, the Scientific Program Committee, and our partners, welcome to the 4th International Mangrove & Macrobenthos Meeting (MMM4). We are pleased you could join us for the first MMM in the United States at Flagler College here in historic downtown St. Augustine, the "Ancient City", the oldest continuously occupied European-established city in the continental U.S.

MMM conferences are a series of international meetings that commenced in 2000 and recur at 4-6 year intervals. They are focused on understanding, conservation, and sustainable use of mangrove ecosystems worldwide. These conferences were initiated to create a greater awareness of the plight of mangroves, which remains one of the most threatened ecosystems on Earth.

Since its inception, MMM has provided a forum for mangrove scientists, students, resource managers, engineers, and policy-makers from around the world to gather and learn from each other. The first MMM conference, the Meeting on Mangrove Macrobenthos, was initiated in 2000 by the Museum of Zoology of the University of Florence, Italy, and the Macrobenthos of Eastern African Mangroves (MEAM) Group held in Mombasa, Kenya, convened by Marco Vaninni and Stefano Cannici. It focused on the biology, ecology, and exploitation of macrofauna and macrobenthic species in mangrove ecosystems worldwide. Since then, MMM has become recognized as the event to attend if you are involved in mangrove research. In 2006, MMM2 was held in Coolangatta, Australia, hosted by Norm Duke and Joe Lee with the goal to bring mangrove scientists together to address topical issues and to promote mangrove research. The third MMM conference was convened in 2012 by Farid Dahdouh-Guebas in Galle, Sri Lanka. MMM3 expanded on the original MMM scope to include mangrove management as well as mangrove research.

Previous conferences in the series have been successful in the pursuit to push the field of mangrove ecology forward on an international level. This year, the momentum continues with a jam-packed program of oral presentations, posters and keynotes addressing today's hot topics and issues. The Conference Planning and Program Committees worked hard to develop a diverse program that includes a stellar line-up of mangrove scientists, visionaries, and restoration professionals, yielding a full variety of excellent presentations and opportunities to exchange ideas and discuss strategies to address common problems that we all face.

St. Augustine provides a perfect location for us to focus on mangrove ecosystems and how they are being affected by climate change. This venue along the Atlantic Coast of Florida was chosen for MMM4 because it represents the transition between temperate and tropical zones, where the pressures of climate change are especially visible. As a result of decreasingly cold winters and sea level rise, the distribution of mangroves is expanding northward and landward along this part of the Florida peninsula into coastal wetlands that have historically been dominated by salt marsh plants. This location, which currently contains the northernmost Atlantic exemplars of all three mangrove species found in North America, provides numerous opportunities to witness the consequences of climate change at this dynamic ecotone.

We would like to thank our generous Sponsors listed on page 8, whose financial support is critical to making MMM4 a reality. So please make time to stop by and visit with each of our sponsor representatives at their displays in the Gymnasium. We are also grateful to those who gave of their time and expertise to organize and moderate sessions, and to share their expertise with us. Further, we would be remiss without thanking all of the many individuals recognized on page 6, who volunteered their personal time and energy to organize and plan this conference. Of course, the success of every conference is dependent on those who attend—so thank you for participating in MMM4!

Have a great week, enjoy yourself, and when you leave, we trust you will take with you new information, new connections, and new tools and knowledge you can use to advance Mangrove Research in your neck of the woods.

Best regards,

Candy Feller

CONFERENCE COMMITTEES

Planning Committee

Candy Feller, ***Chair***, *Senior Scientist*, Smithsonian Environmental Research Center, Edgewater, MD

Nikki Dix, *Research Coordinator*, GTM Research Reserve, St. Augustine, FL

Ken W. Krauss, *Research Ecologist*, U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA

Roy R. "Robin" Lewis III, *Wetland Scientist*, *President*, Lewis Environmental Services, Inc. and Coastal Resources Group, Inc., Keys Restoration Fund, Salt Springs, FL

Todd Osborne, *Assistant Professor*, Whitney Laboratory for Marine Bioscience, University of Florida, Gainesville, FL

Gary Raulerson, *Assistant Manager*, GTM Research Reserve, St. Augustine, FL

Jessica Veenstra, *Assistant Professor*, Flagler College, St. Augustine, FL

Science Program Committee

AUSTRALIA

Norman C. Duke, James Cook University, Townsville, QLD

Joe S.Y. Lee, Griffith University, Gold Coast Southport, QLD

Catherine E. Lovelock, University of Queensland, Brisbane, QLD

Todd Minchinton, University of Wollongong, Wollongong, NSW

BELGIUM

Farid Dahdouh-Guebas, Université Libre de Bruxelles & Vrije Universiteit Brussel, Brussels

---

BRAZIL

Yara Schaeffer-Novelli, Oceanographic Institute, University of São Paulo, São Paulo

---

CHINA

Luzhen Chen, Xiamen University, Xiamen, Fujian Province

COLOMBIA

Jose Ernesto Mañcera Pineda, Universidad Nacional de Colombia, Bogata

---

GERMANY

Uta Berger, Technische Universität Dresden, Dresden

INDONESIA

Ben Brown, Mangrove Action Project Indonesia, Indonesia

JAMAICA

Mona Webber, University of the West Indies, Kingston

KENYA

Jared O. Bosire, World Wildlife Fund, Kenya Country Office, Mombasa

SINGAPORE

Daniel A. Friess, National University of Singapore, Singapor**e**

SOUTH AFRICA

Gonasagren Naidoo, University of KwaZulu-Natal, Durban

UNITED KINGDOM

Mark Huxham, Edinburgh Napier University, Edinburgh, Scotland

UNITED STATES

Candy Feller, ***Chair***, Smithsonian Environmental Research Center, Edgewater, MD

Samantha Chapman, Villanova University, Villanova, PA

Donna Devlin, Florida Atlantic University, Fort Pierce, FL

Ken W. Krauss, U.S. Geological Survey, Lafayette, LA

Roy R. "Robin" Lewis III, Lewis Environmental Services, Inc., Salt Springs, FL

Karen McKee, U.S. Geological Survey, Lafayette, LA

Todd Osborne, University of Florida, Gainesville, FL

Michael J. Osland, U.S. Geological Survey, Lafayette, LA

Edward Proffitt, Florida Atlantic University, Fort Pierce, FL

Victor H. Rivera-Monroy, Louisiana State University, Baton Rouge, LA

Thomas J. Smith III, U.S. Geological Survey, St. Petersburg, FL

Wayne P. Sousa, Department of Integrative Biology, UC Berkeley, Berkeley, CA

A SPECIAL THANK YOU TO OUR SPONSORS

Without their generous support, this conference would not be possible.

Mangrove Tree Crab *(Aratus pisonii)*

CHINA GREEN

UNIVERSITY of LOUISIANA LAFAYETTE

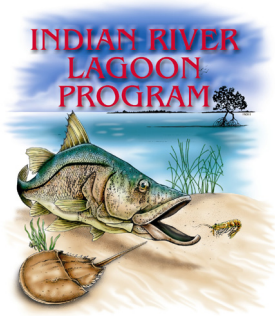
Institute for Coastal and Water Research

USGS science for a changing world

Smithsonian Environmental Research Center

Eastern Oyster *(Crassostrea virginica)*

Smithsonian TMON - MarineGEO



Coffee Bean Snail *(Melampus coffeus)*

UNISENSE

SCHEDA ECOLOGICAL ASSOCIATES

General Contributions

NASA

FLAGLER COLLEGE COASTAL ENVIRONMENTAL SCIENCE

TAMPA Estuary Program

eco environment coastal & offshore

Partnering Organizations

Smithsonian Environmental Research Center

GTM RESEARCH RESERVE

UF IFAS UNIVERSITY of FLORIDA

USGS science for a changing world

THE WHITNEY LABORATORY UNIVERSITY OF FLORIDA

FLAGLER COLLEGE COASTAL ENVIRONMENTAL SCIENCE

WEDNESDAY FIELD TRIPS

Field Trip #1: Mangrove and Marsh Restoration Tour

7:00 - 7:45 AM	**Coffee Available - Lewis Auditorium (Flagler College)**
7:45 AM	**Board Bus**
8:00 AM	**Bus Departs**

Over 12,000 ha of mangrove forest and tidal marsh along the central Florida east coast have been successfully restored over the last 40 years. This includes physical removal of dredged material deposits (spoil areas) down to wetland elevations in excavated and filled areas of wetlands for mostly natural recolonization, the reconnection and management of diked mosquito control wetland areas to continue to control mosquitoes while allowing seasonal hydrologic restoration, return of fish use of to these areas, and again natural recolonization by mangroves and marsh plants (see Figures 1 and 2). These programs have emphasized the ability of mangroves and marsh species to undergo natural secondary succession with limited or no planting, a key principal in the Ecological Mangrove Rehabilitation (EMR) program developed over recent decades and summarized in the recently released Ecological Mangrove Rehabilitation Manual (Lewis and Brown 2014). This bus trip will highlight these successfully restored areas, featuring visits to the North Peninsula State Park in Volusia County, Florida and the Merritt Island National Wildlife Refuge in Titusville.

Please Note:

Participants could potentially get wet and muddy during site visits and should wear appropriate clothing and footwear, bring sunscreen and bug spray. Lunch and water will be provided.

LOCATION:	North Peninsula State Park (NPSP) and Merritt Island National Wildlife Refuge (MINWR)
ROUTE:	Travel by bus to North Peninsula State Park, view restoration sites, travel to Merritt Island NWR to view other restoration sites and have lunch, bus back to hotel.
ROUTE LENGTH:	220 miles round trip
DEPART/RETURN:	Depart at 8:00 a.m. – Arrive back at hotel at approximately 5:30 p.m.
TRAVEL TIME TO SITES:	1.5 hour to NPSP, 2 hours to MINWR, 2.5 hour return trip
TIME AT SITES:	3 hours plus lunch (30 minutes)
TOTAL TRIP TIME:	9 hours, 30 minutes
FIELD TRIP CAPTAINS:	Robin Lewis, Laura Flynn and Cynthia Sapp, Coastal Resources Group
SITE GUIDES:	Ron Brockmeyer, Jorge Rey and Melinda Donnelly

Field Trip #2: Whitney Marine Lab with Boat or Kayak Tour

6:45 - 7:15 AM	**Coffee Available - Lewis Auditorium (Flagler College)**
7:15 AM	**Board Bus**
7:30 AM	**Bus Departs**

The Whitney Laboratory for Marine Bioscience and the Whitney Sea Turtle Hospital are located on a narrow stretch of land between the Atlantic Ocean to the east and the Matanzas River Estuary to the west. The Whitney lab, established in 1973, has a long history of neuroscience and marine biology research. New and exciting areas of research include estuarine biogeochemistry, ecology, and climate change sciences. Participants will tour the Whitney lab, the Whitney Sea Turtle Hospital, and travel along one of Florida's most protected and undeveloped estuaries. A limited number of participants may choose to kayak with master naturalists (http://rippleeffectecotours.com) on this part of the tour for an additional $35. Or, for those who choose not to kayak, a boat ride will be available. This estuary is of exceptional interest to mangrove scientists as it is a zone of transition with Avicennia germinans and Rhizophora mangle encroaching on historically Spartina alterniflora dominated salt marsh.

Please Note:

Summertime in Florida will be HOT. Please wear light clothing that offers sun protection. Being on the water will amplify the exposure to sun so we recommend sunglasses, hats, plenty of sunscreen and lightweight clothing that provides protection from the sun. Hydration is also important so please take advantage of opportunities to hydrate (bring your water bottle to refill). If you have any known health conditions or allergies that may impact your enjoyment of this trip, please make these known to the tour guides in advance.

Lunch and water will be provided. Bottled water will also be available before and after the field trip. All participants should bring sunscreen and bug spray.

LOCATION:	Whitney Marine Lab - 9505 Ocean Shore Blvd, St. Augustine FL 32080
ROUTE:	Travel by bus to Whitney Lab and disembark for kayak or boat tour, lab and turtle hospital walking tour, and lunch.
ROUTE LENGTH:	20 miles round trip
DEPART/RETURN:	Depart at 7:30am – Arrive back at hotel at approximately 1:30pm
TRAVEL TIME TO SITES:	20 minutes
TIME AT SITES:	4 hours
TOTAL TRIP TIME:	5.5 hours
FIELD TRIP CAPTAIN:	Todd Osborne
SITE GUIDES:	Todd Osborne, Catherine Eastman, Danny Lippi, and others
OTHER:	Participants who choose the kayak option could potentially get wet and should wear appropriate clothing and footwear. This kayak trip is approximately 4 miles long, so participants should be prepared for some exercise!

Field Trip #3: March of the Mangroves Boat Tour

Meet at St. Augustine Marina (111 Avenida Menendez, St Augustine, FL 32084)

TRIP A | **Participants gather at 8:30 AM. Boat departs at 9:00 AM**

TRIP B | **Participants gather at 12:30 PM. Boat departs at 1:00 PM**

The World Meteorological Organization declared 2001-2010 the warmest decade on record; subsequent years since then have been recorded as the warmest years on record. St. Johns County has long been the ecotone for the mangrove–salt marsh interface. Historically, the most northern line of mangroves has waned as cold snaps hold them to their southern boundaries. The recent warming trend and the lack of hard freezes in the region have allowed mangroves to march north. This 3-hour boat trip will take you on the river to see firsthand just how far the Mangroves have marched from their historical locations.

Please Note:

Participants MUST attend the Trip (A or B) for which they registered.

You may get wet on the boat and should wear appropriate clothing and footwear.

Sunscreen, beverages, and Personal Floatation Devices will be provided by Field Trip Captain.

DESTINATION:	Guana Tolomato Matanzas National Estuarine Research Reserve
ROUTE:	Travel by boat from St. Augustine Marina to local sights along the Tolomato River, then back to the Marina.
ROUTE LENGTH:	36 miles round trip
DEPART/RETURN:	Trip A: Depart Marina at 9:00am – Arrive back at Marina at 12noon Trip B: Depart Marina at 1:00pm – Arrive back at Marina at 4:00pm
TOTAL TRIP TIME:	3 hours
FIELD TRIP CAPTAIN:	Matthew Monroe
SITE GUIDE:	Matthew Monroe

KEYNOTE SPEAKERS

Catherine Lovelock

Monday, July 18th, 12:45pm

Dr. Lovelock is Professor in the School of Biological Sciences at The University of Queensland, Australia. Prior to joining The University of Queensland in 2004 she was Research Scientist at the Smithsonian Environmental Research Center, Maryland, USA and Post Doctoral Fellow at the Smithsonian Tropical Research Institute in Panama. She obtained her PhD in 1992 from James Cook University, Queensland, Australia. Her research focuses on the effects of, and adaptations to, climate change in coastal plant communities, fundamental metabolic and physiological processes of coastal and marine plant communities and the impacts of nutrient enrichment on tropical and subtropical coastal and marine plant communities. She leads the Climate Change Adaptation for Natural Resource Management project for the east coast of Australia, and she is a member of the International Scientific Blue Carbon Working Group, the CSIRO Coastal Carbon Biogeochemistry Cluster, the EU network for Climate Change Research in the Tropical Coastal Zone and a past member of the advisory committee for coasts of the Great Barrier Reef Marine Park Authority.

Robert Twilley

Friday, July 22nd, 1:30pm

Dr. Twilley is Executive Director of Louisiana Sea Grant College Program and professor in the Department of Oceanography and Coastal Science at LSU. Presently, Dr. Twilley serves as President-Elect of Coastal Estuarine Research Federation. He has been a Distinguished Professor at both LSU and UL Lafayette. In the last several years, Dr. Twilley has served in administrative capacities in higher education including Vice President for Research, Associate Vice Chancellor of Research and Economic Development, and Director of the Wetland Biogeochemistry Institute. He is founder of the LSU Coastal Sustainability Studio and developed the UL Lafayette Center for Ecology and Environmental Technology. Most of Dr. Twilley's research has focused on coastal wetlands in the Gulf of Mexico, throughout Latin America, and in the Pacific Islands. Dr. Twilley has published extensively on wetland ecology, global climate change, and he has been involved in developing ecosystem models coupled with engineering designs to forecast the rehabilitation of coastal and wetland ecosystems.

2016 PROGRAM AGENDA

Sunday, July 17, 2016		
1:00PM - 6:00PM	**Flagler Dorm Check-in** *(Latecomers must check in with Flagler Security in Ponce de Leon Hall Rotunda, accessible from Kenan Parking Lot)*	
3:00PM - 6:00PM	**Registration Open (Lewis Auditorium Lobby)**	
3:00PM - 6:00PM	**Poster and Sponsor/Exhibitor Move-In (Gymnasium)**	
Monday, July 18, 2016		
9:00AM - 6:00PM	**Registration Open (Lewis Auditorium Lobby)**	
9:00AM - 12NOON	**Poster and Sponsor/Exhibitor Move-In (Gymnasium)**	
12:30PM - 12:45PM	**Welcome Remarks by Organizers**	
12:45PM - 1:40PM	**Catherine Lovelock | Keynote Presentation** ***Deserving of a Better Fate: Mangroves and Sea Level Rise***	
1:40PM - 3:30PM	**Session 1: Biodiversity and Biocomplexity** **Moderator: Karen L. McKee**	
1:45PM	Shing Yip Lee	SEEING THE TREES AS WELL AS THE FOREST: QUANTIFYING THE RELATIONSHIP BETWEEN HABITAT SPATIAL COMPLEXITY AND MANGROVE ECOSYSTEM SERVICES
2:00PM	Janine Adams	DYNAMICS OF MANGROVES ALONG THE SOUTH AFRICAN COASTLINE
2:15PM	Susan Bell	RECRUITMENT OF *AVICENNIA GERMINANS* IN A MOSAIC SALTMARSH: A FIELD STUDY OF PATCH-SCALE PLANT INTERACTIONS
2:30PM	Takashi Yamamoto	GENETIC STRUCTURE AND POPULATION DEMOGRAPHY OF WIDESPREAD SEA-DISPERSAL PLANTS *VIGNA MARINA* IN THE PACIFIC
2:45PM	Hanyu Meng	DO NATIVE INTERTIDAL BURROWING CRABS BENEFIT FROM NON-NATIVE *SPARTINA ALTERNIFLORA*?
3:00PM	Anusha Rajkaran	WILL THE EXPANSION OF MANGROVE FORESTS ALTER THE NURSERY FUNCTION OF ESTUARIES IN SOUTH AFRICA?
3:15PM	Wayne Sousa	RATES OF MANGROVE FOLIVORY HIGHER THAN ASSUMED
3:30PM	**PM REFRESHMENT BREAK (Gymnasium)**	
3:55PM - 6:00PM	**Session 2: Historical Ecology and Climate Change** **Moderator: Samantha Chapman**	
4:00PM	Michael Osland	CLIMATE CHANGE AND THE GLOBAL DISTRIBUTION OF MANGROVE FORESTS
4:15PM	Donna Devlin	BIODIVERSITY IS INTEGRAL TO THE ABILITY OF FOUNDATION SPECIES TO ADAPT TO CHANGING CLIMATE CONDITIONS
4:30PM	Zachary Cannizzo	AN EXPLORATION OF CHANGING DIET AND BEHAVIOR IN THE RANGE-SHIFTING MANGROVE TREE CRAB (*ARATUS PISONII*) BETWEEN ITS HISTORIC AND NOVEL HABITATS
4:45PM	Armando Reis Neto	MANGROVES AT THE ARAÇÁ BAY, SÃO PAULO, BRAZIL: A HISTORICAL ECOLOGY APPROACH
5:00PM	Glenn Coldren	ARTIFICIAL WARMING INCREASES ADULT MANGROVE AND SALT MARSH GROWTH RATES AND MAY ENHANCE TRANSITION TO MANGROVE DOMINANCE
5:15PM	Daniel Murdiyarso	MANAGING TERRESTRIAL CARBON STOCKS THROUGH A LONG-TERM LOGGING ROTATION IN MANGROVE FORESTS IN BINTUNI BAY, WEST PAPUA
5:30PM	John Parker	WHAT CONTROLS POLEWARD RANGE LIMITS OF MANGROVES?
5:45PM	Nico Koedam	MANGROVES–CAPTURED BY THE KEEN EYE OF A 17TH CENTURY LANDSCAPE PAINTER
6:00PM - 7:00PM	**WELCOME RECEPTION (Gymnasium)**	

Tuesday, July 19, 2016		
7:30AM - 6:30PM	**Registration Open (Lewis Auditorium Lobby)**	
7:30AM - 8:30AM	**LIGHT MORNING REFRESHMENTS (Gymnasium)**	
8:30AM - 10:15AM	**MANGROVE RESTORATION FORUM** **Moderator: Roy R. "Robin" Lewis III** ***Introduction and Review of Past, and Present Opportunities*** **Jorge Rey, Ron Brockmeyer and Melinda Donnelly** ***The Rehabilitation of Impacted Wetlands in the Indian River Lagoon, Florida*** **Nicole Cormier** ***Using Surface Elevation as a Tool to Assess Functional Equivalency after Mangrove Forest Restoration*** **Roy R. "Robin" Lewis III and Laura L. Flynn** ***Future? We Have to Learn From Our Mistakes and Implement Early Detection and Preemptive Rehabilitation***	
10:15AM	**AM REFRESHMENT BREAK (Gymnasium)**	
10:40AM - 12:30PM	**Session 3: Macrobenthos and Marine Communities, Part I** **Moderator: Wayne P. Sousa**	
10:45AM	Mark Huxham	KROPOTKIN'S GARDEN: PLANT-PLANT AND ANIMAL-PLANT FACILITATION IN MANGROVE ECOSYSTEMS
11:00AM	Rachel Smith	ENGINEERING COMMUNITY CHANGE FROM THE BOTTOM-UP: MANGROVE EXPANSION ALTERS DETRITAL INVERTEBRATE COMMUNITY COMPOSITION
11:15AM	Nasreen Peer	INVESTIGATING THE RESILIENCE OF MANGROVE ECOSYSTEMS AND FIDDLER CRABS IN SOUTH AFRICA
11:30AM	Inga Nordhaus	EFFECTS OF ENVIRONMENTAL CHANGE ON MANGROVE BIODIVERSITY, COMMUNITY DYNAMICS AND ECOSYSTEM FUNCTIONS IN JAVA, INDONESIA
11:45AM	Jenny Booth	MANGROVE MICROBIOME DYNAMICS IN CRAB BIOTURBATED SEDIMENT
12:00PM	Gustavo Adolfo Castellanos-Galindo	MODELING TROPHIC FLOWS IN THE WETTEST MANGROVES OF THE TROPICAL EASTERN PACIFIC REGION
12:15PM	Karen Diele	FROM SCIENCE TO POLICY: UNDERSTANDING REPRODUCTIVE RHYTHMICITY OF BRAZILIAN MANGROVE CRABS TO IMPROVE THEIR CONSERVATION AND FISHERIES MANAGEMENT
12:30PM - 1:50PM	**GROUP LUNCHEON BUFFET (Dining Hall)**	
1:55PM - 3:45PM	**Session 4: Macrobenthos and Marine Communities, Part II** **Moderator: Norman C. Duke**	
2:00PM	Eric Milbrandt	THE BENEFITS OF A MULTIPLE HABITAT RESTORATION STRATEGY BY COMBINING HYDROLOGIC RESTORATION, MANGROVE PROPAGULE PLANTINGS AND OYSTER SUBSTRATE ADDITIONS IN A SEMI-ENCLOSED FLORIDA EMBAYMENT
2:15PM	Marco Fusi	GILL-BACTERIA SYMBIOTIC ASSOCIATIONS IN DUAL-BREATHING ANIMALS LIVING IN MANGROVE ECOSYSTEMS
2:30PM	Jessene Aquino-Thomas	LATITUDE AFFECTS DOMINANCE BY SECONDARY FOUNDATION SPECIES ON RED MANGROVE (*RHIZOPHORA MANGLE*) PROP ROOTS
2:45PM	Richard MacKenzie	UNDERESTIMATING THE ROLE OF LEAF LITTER IN SESARMID CRAB DIETS: THE IMPORTANCE OF ISOTOPE FRACTIONATION VALUES
3:00PM	Yara Schaeffer-Novelli	RELATIONSHIP BETWEEN THE BIOMASS OF MANGROVE ROOTS AND THE DENSITY OF THE POLYCHAETE SPECIES *CAPITELLA SP*
3:15PM	Ronald Baker	MARSHES TO MANGROVES: WHAT DO WE REALLY KNOW ABOUT THE FUNCTIONAL VALUES OF TIDAL WETLANDS FOR FISHERY SPECIES?
3:30PM	Carole McIver	STABLE ISOTOPES OF MACROBENTHOS AND FISH IN MANGROVE-FOREST FOOD WEBS OF SHARK RIVER, USA
3:45PM	**PM REFRESHMENT BREAK (Gymnasium)**	

Tuesday, July 19, 2016 (continued)		
4:10PM - 6:00PM	**Session 5: Habitat, Distribution and Connectivity** **Moderator: Norman C. Duke**	
4:15PM	Steven Pennings	VEGETATION REGIME SHIFT IN COASTAL WETLANDS AFFECTS TRAPPING OF WRACK SUBSIDIES FROM SUBTIDAL HABITATS
4:30PM	Matthew Hayes	THE ROLE OF GROUNDWATER ON GROWTH, BIOMASS ALLOCATION AND DECOMPOSITION IN MANGROVE FORESTS
4:45PM	Erin Kiskaddon	TROPHIC FOOD WEB DYNAMICS ACROSS A MANGROVE/UPLAND ECOTONE
5:00PM	Lucy Gillis	MIND THE TRAP: IMPLICATIONS OF THE TRAPPING EFFICIENCY OF *AVICENNIA* AND *RHIZOPHORA* ROOTS
5:15PM	Jock Mackenzie	EFFECTS OF SEVERE FLOODING ON ESTUARINE MANGROVES–DISTURBANCE, RESILIENCE AND RESTORATION
5:30PM	Tom Van der Stocken	A MODELING STUDY ON THE ROLE OF DISPERSAL VECTOR INTERACTIONS IN THE POTENTIAL FOR LONG DISTANCE DISPERSAL IN MANGROVES
5:45PM	Kyle Cavanaugh	REGIONAL VARIABILITY IN THE DYNAMICS OF GLOBAL MANGROVE RANGE LIMITS
6:00PM - 6:40PM	**Lightning Round #1: Biodiversity, Habitat and Climate Change** **Moderator: Farid Dahdouh-Guebas**	
6:00PM	MODERATOR'S INTRODUCTION & TRANSITION	
6:04PM	Shazia Farzana	EFFECTS OF POLYBROMINATED DIPHENYL ETHERS (BDE-99 AND BDE-209) ON GERMINATION AND GROWTH OF A MANGROVE PLANT, *KANDELIA OBOVATA*
6:08PM	Amy Langston	INVESTIGATING TOP-DOWN AND BOTTOM-UP INFLUENCES ON BLACK MANGROVE (*AVICENNIA GERMINANS*) ENCROACHMENT IN FORESTED FRESHWATER ISLANDS ALONG THE BIG BEND COAST OF FLORIDA
6:12PM	Ed Proffitt	MARSH-MANGROVE INTERACTIONS: SHORT TERM EXPERIMENTAL RESULTS AND LONGER TERM CONSEQUENCES FOR PLOT DOMINANCE
6:16PM	Jacqueline Raw	IMPORTANCE OF AUTOCHTHONOUS SOURCES FOR GASTROPOD CONSUMERS IN SUBTROPICAL ESTUARINE MANGROVES: A CASE STUDY FROM SOUTH AFRICA
6:20PM	Judith Klein	TROPHIC INTERACTIONS IN BENTHIC FOOD WEBS OF MANGROVES SUBJECT TO MULTIPLE HUMAN ACTIVITIES
6:24PM	Nelson Miranda	*LITTORARIA (GASTROPODA: LITTORINIDAE)* AS BIOINDICATORS OF MANGROVE HEALTH
6:28PM	Devi Choesin	MANGROVE DISTRIBUTION AND CONDITION IN JAVA, INDONESIA, WITH SPECIAL REFERENCE TO LEUWEUNG SANCANG NATURE RESERVE, WEST JAVA
6:32PM	Marguerite Toscano	SEA LEVEL RECONSTRUCTIONS FROM THICK MANGROVE PEAT DEPOSITS IN FLORIDA, BELIZE AND PANAMA – AGE AND PALEO ELEVATIONS OF BASAL PEATS VS. CONTINUOUS SAMPLING, AND RELATIONSHIP TO GEOPHYSICAL SEA LEVEL MODELS
6:40PM - 8:00PM	**POSTER SESSION 1 & NETWORKING RECEPTION (Gymnasium)**	
Wednesday, July 20, 2016		
7:00AM - 5:00PM	**FIELD TRIP DAY (OPTIONAL)**	

Thursday, July 21, 2016		
7:30AM - 6:30PM	**Registration Open (Lewis Auditorium Lobby)**	
7:30AM - 8:30AM	**LIGHT MORNING REFRESHMENTS (Gymnasium)**	
8:25AM - 10:00AM	**Session 6: Ecophysiology, Biogeochemistry and Sea-Level Rise, Part I** **Moderator: Yara Schaeffer-Novelli**	
8:30AM	Samantha Chapman	MANGROVE ENCROACHMENT INTO MARSHES ALTERS BELOWGROUND ORGANIC MATTER DYNAMICS WITH IMPLICATIONS FOR SURFACE ELEVATION
8:45AM	Andre Rovai	ECOGEOMORPHOLOGY: TOWARDS A UNIFIED FRAMEWORK TO EXPLAIN STRUCTURAL AND FUNCTIONAL PROPERTIES OF MANGROVE ECOSYSTEMS
9:00AM	Krishna Ray	OSMOTIC ADAPTATION IN MANGROVES AND ASSOCIATES—A CHALLENGE FOR DEGRADED MANGROVE ECOSYSTEM
9:15AM	Gordon Anderson	TEN YEARS AFTER: WILMA STORM DEPOSITS' EFFECT ON VERTICAL SOIL ACCRETION IN A COASTAL MANGROVE FOREST (2005-2015), EVERGLADES NATIONAL PARK, FL, USA
9:30AM	Cyril Marchand	MAIN FACTORS DRIVING GHG EMISSIONS FROM MANGROVE SEDIMENTS
9:45AM	Joshua Breithaupt	ASSESSING THE APPLICABILITY OF DIFFERENT TIMESCALES FOR QUANTIFYING COASTAL WETLAND VULNERABILITY TO SEA LEVEL RISE
10:00AM	**AM REFRESHMENT BREAK (Gymnasium)**	
10:25AM - 12NOON	**Session 7: Ecophysiology, Biogeochemistry and Sea-Level Rise, Part II** **Moderator: Donna J. Devlin**	
10:30AM	John Kominoski	BIOTIC AND ABIOTIC DRIVERS OF CARBON STORAGE DURING MANGROVE ESTABLISHMENT IN SALT AND FRESHWATER MARSH ECOSYSTEMS: A MECHANISTIC FRAMEWORK
10:45AM	Todd Osborne	CARBON BIOGEOCHEMICAL PROCESSES ALONG A MANGROVE-SALTMARSH ECOTONE
11:00AM	Thorsten Balke	WHAT DETERMINES THE SEAWARD LIMIT OF MANGROVE AND SALT-MARSH VEGETATION?
11:15AM	Pierre Taillardat	LATERAL CARBON AND NUTRIENT EXCHANGES IN A LOW LATITUDE MANGROVE TIDAL CREEK: A MULTI-STABLE ISOTOPE APPROACH
11:30AM	Martin Zimmer	ORIGIN OF SEDIMENTARY ORGANIC MATTER AND ITS FATE UPON DECOMPOSITION
11:45AM	Kerrylee Rogers	MANGROVE DISTRIBUTION CHANGES IN AUSTRALIA AND THE VULNERABILITY OF MANGROVE TO SEA-LEVEL RISE
12NOON - 1:20PM	**GROUP LUNCHEON BUFFET (Dining Hall)**	
1:25PM - 3:15PM	**Session 8: Socio-Ecology and Ecosystem Services** **Moderator: Mark Huxham**	
1:30PM	Benjamin Brown	RAPID FEASIBILITY ASSESSMENTS FOR DETERMINING APPROPRIATE MANGROVE RECOVERY INTERVENTIONS AT THE LANDSCAPE SCALE IN INDONESIA
1:45PM	Cheryl Doughty	HOW WILL MANGROVE ENCROACHMENT AND ERODING IMPOUNDMENTS IMPACT COASTAL PROTECTION OF INTERTIDAL WETLANDS IN THE MERRITT ISLAND NATIONAL WILDLIFE REFUGE?
2:00PM	Clare Duncan	BIODIVERSITY INFLUENCES ON MANGROVE FOREST ECOSYSTEM SERVICES DELIVERY
2:15PM	Dan Friess	OIL PALM–A RAPIDLY INCREASING CAUSE OF MANGROVE DEFORESTATION IN SOUTHEAST ASIA
2:30PM	Mohammad Mahmudul Islam	DRIVERS OF CHANGES IN ECOSYSTEM SERVICES OF THE SUNDARBANS MANGROVE ECOSYSTEM IN BANGLADESH
2:45PM	Nguyen Thi Huynh Phuong	AN INVESTIGATION INTO SOCIAL LEARNING DYNAMICS AND CONVERSION TO SUSTAINABLE INTEGRATED MANGROVE SHRIMP FARMING IN BINH DAI DISTRICT, BEN TRE PROVINCE, VIETNAM
3:00PM	Philine zu Ermgassen	MODELLING THE VALUE OF MANGROVE FISHERIES
3:15PM	**PM REFRESHMENT BREAK (Gymnasium)**	

Thursday July 21, 2016 (continued)		
3:40PM - 5:30PM	**Session 9: Blue Carbon** **Moderator: Joe Lee**	
3:45PM	Lola Fatoyinbo	HIGH-RESOLUTION 3-D MAPPING OF FOREST STRUCTURE AND ABOVEGROUND BIOMASS STOCKS IN BLUE CARBON ECOSYSTEMS IN THE AMERICAS, AFRICA AND SOUTH ASIA
4:00PM	Sean Charles	INCREASING MANGROVE DENSITY INCREASES CARBON STORAGE BUT DECREASES SEDIMENT ACCRETION IN COASTAL WETLANDS: EVIDENCE FROM LARGE-SCALE EXPERIMENTAL MANIPULATIONS
4:15PM	Sahadev Sharma	RESTORATION MAY INCREASE CARBON STOCK OF DEGRADED MANGROVE FORESTS ACROSS CAMBODIA
4:30PM	Edward Castaneda	CARBON STORAGE AND SOIL BURIAL RATES IN RIVERINE AND SCRUB MANGROVE FORESTS OF THE FLORIDA COASTAL EVERGLADES, USA
4:45PM	Audrey Leopold	NET ECOSYSTEM CO_2 EXCHANGES BETWEEN A DWARF *AVICENNIA MARINA VAR. AUSTRALASICA* MANGROVE AND THE ATMOSPHERE: APPLICATION OF THE EDDY-COVARIANCE FLUX TOWER TO "LE COEUR DE VOH" MANGROVE (NEW CALEDONIA)
5:00PM	Sarah Mack	STATUS AND CHALLENGES OF MANGROVES IN CARBON MARKETS
5:15PM	Tim Jennerjahn	BLUE CARBON–RELEVANCE OF THE MANGROVE STOREHOUSE
5:30PM - 6:15PM	**Lightning Round #2: Ecosystem Services, Community Structure and Restoration** **Moderator: Daniel A. Friess**	
5:30PM	MODERATOR'S INTRODUCTION & TRANSITION	
5:35PM	Chelsea Barreto	WARMING AND MANGROVE ENCROACHMENT INFLUENCE MARSH MICROBIAL COMMUNITY COMPOSITION
5:39PM	Alfredo Quarto	GLOBAL PERSPECTIVE ON MANGROVE LOSS, THREATS AND SOLUTIONS
5:43PM	Katherine Vande Velde	BIODIVERSITY CONSERVATION IN SOCIAL-ECOLOGICAL SYSTEMS: THE LAST(ING) MANGROVES OF SINGAPORE
5:47PM	Jhoanata Bolivar	ESTIMATION OF CARBON STOCKS IN COLOMBIAN MANGROVES AND ASSOCIATED UNCERTAINTIES
5:51PM	Derrick Y.F. Lai	EFFECTS OF LAND COVER CHANGE ON SOIL ORGANIC CARBON FRACTIONS IN A SUBTROPICAL MANGROVE WETLAND
5:55PM	Sandip Kumar Basak	MANGROVE COMMUNITY STRUCTURE ANALYSIS IN WESTERN SUNDARBANS IN INDIA - A GUIDE FOR DESIGNING MANGROVE RESTORATION
5:59PM	John Paul Kennedy	GENETIC AND MORPHOLOGICAL VARIATION OF EAST FLORIDA BLACK MANGROVE *(AVICENNIA GERMINANS)*
6:03PM	Kayla Marie Castro	A MULTIDISCIPLINARY APPROACH IN ASSESSING TYPHOON-DAMAGED MANGROVE FORESTS IN THE PHILIPPINES
6:07PM	Emma Asbridge	MANGROVE RESPONSE TO ENVIRONMENTAL CHANGE IN NORTHERN AUSTRALIA
6:15PM - 7:30PM	**POSTER SESSION 2 & NETWORKING RECEPTION (Gymnasium)**	

Friday, July 22, 2016		
7:30AM - 3:00PM	**Registration Open (Lewis Auditorium Lobby)**	
7:30AM - 8:30AM	**LIGHT MORNING REFRESHMENTS (Gymnasium)**	
8:25AM - 10:00AM	**Session 10: Forest and Community Structure, Part I** **Moderator: Victor Rivera-Monroy**	
8:30AM	Neil Saintilan	TROPHIC STRUCTURE OF MANGROVE ECOSYSTEMS IN EASTERN AUSTRALIA AND THE INPUT OF ANTHROPOGENIC N: INSIGHTS FROM STABLE ISOTOPE ANALYSIS
8:45AM	Koji Takayama	GENETIC AND EVOLUTIONARY CONSEQUENCES OF EXTREME LONG-DISTANCE SEED DISPERSAL OF THE MANGROVE GENERA, RHIZOPHORA AND HIBISCUS
9:00AM	Michael Ross	DISTURBANCE, SITE AND VEGETATION FEEDBACKS CREATE LANDSCAPE STRUCTURE IN SOUTH FLORIDA COASTAL WETLANDS
9:15AM	Marilia Cunha-Lignon	INVASIVE SPECIES OF AQUATIC MACROPHYTES AFFECTING MANGROVE FORESTS STRUCTURE AND CONSERVATION IN PROTECTED AREAS
9:30AM	Alison Kim Shan Wee	MANGROVES IN A CHANGING WORLD: FROM POPULATION GENETICS TO ECOLOGICAL GENOMICS
9:45AM	Victor Rivera-Monroy	CANOPY GAP-SIZE NICHE DIFFERENTIATION AND GAP-PHASE REGENERATION AS CRITICAL MECHANISMS TO EXPLAIN FOREST STRUCTURAL AND FUNCTIONAL ATTRIBUTES IN THE EVERGLADES MANGROVE ECOTONE REGION
10:00AM	**AM REFRESHMENT BREAK (Gymnasium)**	
10:25AM - 12NOON	**Session 11: Forest and Community Structure, Part II** **Moderator: Uta Berger**	
10:30AM	Gustavo Maruyama Mori	WESTERN MANGROVE SPECIES IN FACE OF PAST AND CURRENT CLIMATE CHANGES: A MULTI-DISCIPLINARY APPROACH
10:45AM	Mark Hester	SPATIAL VARIATION IN MANGROVE COMMUNITY ZONATION IN THE LOWER FLORIDA KEYS, USA
11:00AM	Tadashi Kajita	TOWARD THE CONSERVATION GENETICS OF MANGROVES ON A GLOBAL SCALE
11:15AM	Mériadec Sillanpää	MANGROVE REGENERATION IN CONTEXT OF SUSTAINABLE FOREST MANAGEMENT: A WEST PAPUA CASE STUDY
11:30AM	Juliana Vantellingen	DEVELOPING TOOLS FOR SUSTAINABLE MANGROVE FOREST MANAGEMENT IN WEST PAPUA, INDONESIA: ASSESSING SUSTAINABLE HARVEST YIELDS AND REGENERATION STRATEGIES
11:45AM	Marc Simard	GLOBAL TRENDS IN MANGROVE FOREST STRUCTURE
12NOON - 1:20PM	**GROUP LUNCHEON BUFFET (Dining Hall)**	

Friday, July 22, 2016 (continued)		
1:30PM - 2:25PM	**Robert Twilley** **Keynote Presentation** ***Using Ecogeomorphology Models to Scale Global Estimates of Biomass, Productivity and Carbon Dynamics in Mangrove Ecosystems***	
2:25PM - 3:45PM	**Session 12: Restoration, Rehabilitation and Remote Sensing, Part I** **Moderator: Michael J. Osland**	
2:30PM	Norm Duke	MANAGING OIL SPILL IMPACTS ON MANGROVES: SHOULD WE BE CONCERNED?
2:45PM	Uta Berger	FACILITATION AND MANGROVE RESTORATION: CONCEPT, EVIDENCE AND PRACTICES
3:00PM	Mathiventhan Thavanayagam	PRESENT STATUS OF MANGROVE RESTORATION IN BATTICALOA DISTRICT, SRI LANKA: IS IT SUCCESS?
3:15PM	Duncan Hill	EXPLORING THE FULLY-POLARIMETRIC CAPABILITIES OF RADARSAT-2 FOR MONITORING A DEGRADED WHITE MANGROVE (*LAGUNCULARIA RACEMOSA*) FOREST OF THE MEXICAN PACIFIC
3:30PM	Severino III Salmo	A COMPARATIVE ASSESSMENT OF DAMAGES AND REGENERATION PATTERNS BETWEEN PLANTED AND NATURAL MANGROVE STANDS AFTER CATASTROPHIC TYPHOONS IN THE PHILIPPINES
3:45PM	**PM REFRESHMENT BREAK (Gymnasium)**	
3:30PM - 5:00PM	**Poster & Sponsor Displays Move Out**	
4:10PM - 5:30PM	**Session 13: Restoration, Rehabilitation and Remote Sensing, Part II** **Moderator: C. Edward Proffitt**	
4:15PM	Dan Peng	RESPONSES OF GROWTH, INTERACTIONS BETWEEN MANGROVES AND *SPARTINA ALTERNIFLORA* ACROSS TIDAL ELEVATION GRADIENT
4:30PM	Clint Cameron	TOWARDS AN IMPROVED UNDERSTANDING OF CARBON STORAGE, SEQUESTRATION AND GREENHOUSE GAS MITIGATION BENEFITS RESULTING FROM REHABILITATING MANGROVE ECOSYSTEMS IN INDONESIA
4:45PM	Danielle Ogurcak	THE DETECTION OF DISTURBANCE IN THE SOUTHEAST SALINE EVERGLADES AND ITS RELATIONSHIP TO MANGROVE FOREST TRANSGRESSION
5:00PM	Damien Burrows	APPLICATION OF MANGROVEWATCH FOR BROAD-SCALE ASSESSMENT OF MANGROVE CONDITION AND DYNAMICS IN THE TORRES STRAIT–THE NORTHERN-MOST AUSTRALIAN ISLANDS
5:15PM	Farid Dahdouh-Guebas	ISLAND-WIDE COASTAL VULNERABILITY ASSESSMENT OF SRI LANKA REVEALS SAND DUNES, PLANTED TREES AND NATURAL VEGETATION AS POTENTIAL BARRIERS AGAINST OCEAN SURGES
5:30PM	**Closing Remarks**	
6:00PM	**Conference Concludes**	

POSTER DISPLAY INFORMATION

Poster presentations play a key role in the success of a conference. We are dedicating two (2) evenings to poster presentations and networking, as well as featuring certain poster presentations with lightning talks (see the Detailed Agenda). Poster presentations are an integral part of this meeting, and we hope these poster events will generate as much buzz about the excellent work on display as the abstracts deserve.

All posters will be up for the entire duration of the conference for maximum visibility. Early morning, mid-day and afternoon refreshments will be served in the poster session room (the Gymnasium) each day. Our Welcome Reception and Poster Sessions will also take place there, allowing plenty of time to view all the research on display.

Poster Set-up

Sunday, July 17 | 3:00pm – 6:00pm
(If you arrive after this time, you can set it up on Monday, July 18, 9:00am – noon.)

Poster Removal

Friday, July 22 | 3:30pm – 5:00pm

Poster Session Receptions

POSTER SESSION ONE: Tuesday, July 19 | 6:40pm – 8:00pm*

*Session One Poster Presenters, please stand at your poster during the Session One Reception as follows:

- Presenters at ODD NUMBERED BOARDS: 7:00pm – 7:30pm.
- Presenters at EVEN NUMBERED BOARDS: 7:30pm – 8:00pm.

POSTER SESSION TWO: Thursday, July 21 | 6:15pm – 7:35pm*

*Session Two Poster Presenters, please stand at your poster during the Session Two Reception as follows:

- Presenters at ODD NUMBERED BOARDS: 6:35pm – 7:05pm.
- Presenters at EVEN NUMBERED BOARDS: 7:05pm – 7:35pm.

This is the primary opportunity for attendees to meet with presenters personally and ask questions, so please be courteous to your neighbors and be available at your poster during the appointed time and date.

Poster display boards will be dismantled and removed by the vendor on Friday evening at 5:00pm.
Please remove your poster promptly during the assigned removal time. Conference organizers are not responsible for lost or damaged posters removed by the display board vendor. Posters left behind will be discarded.

DIRECTORY OF POSTER PRESENTATIONS

Poster presentations are an integral part of this meeting, and we hope these poster events will generate as much buzz about the excellent work on display as the abstracts deserve. Two evenings are dedicated to poster presentations and networking, and some posters will be featured in lightning talks. Lightning talks are highlighted in orange below. Consult the program agenda for detailed presentation times.

Poster #	Assigned Session	First Name	Last Name	Organization	City	State / Province	Country	Format	Abstract Title
90	Session One	Guilherme	Abuchahla	University of São Paulo - USP	São Paulo		Brazil	Poster	ARE MANGROVE PANARCHIES?
103	Session Two	Fahad	Al Jamali	University of Qatar	Doha		Qatar	Poster	INTRODUCTION OF MANGROVE RESTORATION PRACTICES TO INCREASE THE MANGROVE FOREST COVER IN AL WAKRA REGION OF STATE OF QATAR
52	Session Two	Hanan	Almahasheer	King Abdullah University of Science and Technology (KAUST)	Thuwal		Saudi Arabia	Poster	CARBON SINK CAPACITY OF RED SEA MANGROVES
43	Session One	Kangkuso	Analuddin	Halu Oleo University, Kendari, Indonesia	Kendari	Sulawesi Tengah	Indonesia	Poster	MANGROVE FOREST PRODUCTIVITY IN CENTER PART OF CORAL TRIANGLE ECO-REGION AT THE SOUTH SULAWESI, INDONESIA
22	Session Two	Rafael	Araujo	Rosenstiel School of Marine & Atmospheric Science, University of Miami	Miami	FL	United States	Poster	FRIENDS OR FOES? THE PROBLEM OF SOUTH FLORIDA'S INVASIVE MANGROVES
123	Session Two	Anna	Armitage	Texas A&M University at Galveston	Galveston	TX	United States	Poster	CITIZEN SCIENCE DATA REVEAL THE IMPACT OF A CHANGING TEXAS MARSH-MANGROVE ECOTONE ON COASTAL BIRD COMMUNITIES
124	Session Two	Anna	Armitage	Texas A&M University at Galveston	Galveston	TX	United States	Poster	BOTTOM-UP EFFECTS OF MANGROVE STAND EXPANSION ON SALT MARSH PLANT AND ANIMAL ASSEMBLAGES: IMPLICATIONS FOR MANGROVE RESTORATION IN TEXAS
122	Session Two	Anna	Armitage	Texas A&M University at Galveston	Galveston	TX	United States	Poster	NUTRIENT ENRICHMENT SHIFTS MANGROVE SIZE DISTRIBUTION WITHIN THE MANGROVE-MARSH ECOTONE
69	Session Two	Emma	Asbridge	University of New South Wales (UNSW)	Sydney	NSW	Australia	Poster & Lightning Talk Thursday	MANGROVE RESPONSE TO ENVIRONMENTAL CHANGE IN NORTHERN AUSTRALIA
77	Session One	Irfan	Aziz	University of Karachi	Karachi		Pakistan	Poster	CONTRIBUTION OF PREVALENT SOLUTES CONSTITUITIVELY INVOLVED IN OSMOTIC ADJUSTMENT IN MANGROVES FROM PAKISTAN

33	Session One	Remi	Bardou	University of California ,Los Angeles	Los Angeles	CA	United States	Poster	MODELING MANGROVE RANGE LIMIT SHIFTS IN THE NORTH PACIFIC COAST IN RESPONSE TO CLIMATE CHANGE
81	Session Two	Chelsea	Barreto	Villanova University	Villanova	PA	United States	Poster & Lightning Talk Thursday	WARMING AND MANGROVE ENCROACHMENT INFLUENCE MARSH MICROBIAL COMMUNITY COMPOSITION
117	Session Two	Sandip Kumar	Basak	Kandi Raj College	Murshidabad	West Bengal	India	Poster & Lightning Talk Thursday	MANGROVE COMMUNITY STRUCTURE ANALYSIS IN WESTERN SUNDARBANS IN INDIA-A GUIDE FOR DESIGNING MANGROVE RESTORATION
97	Session Two	Satyanarayana	Behara	Universiti Malaysia Terengganu	Kuala Terengganu	Terengganu	Malaysia	Poster	ASSESSMENT OF MANGROVE VEGETATION BASED ON GROUND-TRUTH AND REMOTE SENSING APPLICATIONS AT BRUNEI BAY, EAST MALAYSIA
26	Session Two	Rayna	Benzeev	National University of Singapore	Singapore		Singapore	Poster	QUANTIFYING THE FISHERIES ECOSYSTEM SERVICES OF SINGAPORE'S MANGROVES
29	Session One	Sara	Betancur	Universidad Nacional de Colombia	Medellín		Colombia	Poster	GALLS ON *RHIZOPHORA MANGLE*: RELATIONSHIP WITH ENVIRONMENTAL VARIABLES AND EFFECTS ON VEGETATION
61	Session One	Rupesh	Bhomia	University of Florida	Gainesville	FL	United States	Poster	MACRONUTRIENT PROCESSING AND RETENTION IN MANGROVE ENVIRONMENTS OF WESTERN AFRICA: A CASE STUDY FROM LIBERIA, SENEGAL AND GABON
62	Session One	Md Khurshid Alam	Bhuiyan	University of Cadiz	Puerto Real	Cadiz	Spain	Poster	PRODUCTIVITY OF TIDAL BORNE ACCUMULATED SEDIMENTS IN A TROPICAL MANGROVE OF SARAWAK, MALAYSIA
53	Session Two	Jhoanata	Bolivar	Max Planck Institute for Biogeochemistry	Jena		Germany	Poster & Lightning Talk Thursday	ESTIMATION OF CARBON STOCKS IN COLOMBIAN MANGROVES AND ASSOCIATED UNCERTAINTIES
113	Session Two	Mark	Brown	U.S. Forest Service	Knoxville	TN	United States	Poster	FLORIDA MANGROVE FOREST LAND: CHALLENGES, EXTENT, AND CHARACTERISTICS
34	Session One	Jordan	Byrum	Harbor Branch Oceanographic Institute, Florida Atlantic University	Fort Pierce	FL	United States	Poster	COMPETITION, FACILITATION, AND GROWTH AMONG MANGROVES ACROSS A LATITUDINAL GRADIENT IN FLORIDA
118	Session Two	Susan	Carstenn	Hawaii Pacific University	Kaneohe	HI	United States	Poster	NON-NATIVE MANGROVE FORESTS IN STREAM MOUTH ESTUARIES ON OAHU, HAWAII
102	Session Two	Kayla Marie	Castro	Ateneo de Manila University	Quezon City		Philippines	Poster & Lightning Talk Thursday	A MULTIDISCIPLINARY APPROACH IN ASSESSING TYPHOON-DAMAGED MANGROVE FORESTS IN THE PHILIPPINES

5	Session One	Dinorah	Chacin	University of South Florida	St Petersburg	FL	United States	Poster	DEMOGRAPHIC RATES COMPARISON OF JUVENILE OYSTER, *CRASSOSTREA VIRGINICA*, AMONG REEFS LOCATED ON BLACK MANGROVES, OYSTER BARS, AND MARSHGRASS HABITATS
37	Session One	Devi	Choesin	Institut Teknologi Bandung	Bandung		Indonesia	Poster & Lightning Talk Tuesday	MANGROVE DISTRIBUTION AND CONDITION IN JAVA, INDONESIA, WITH SPECIAL REFERENCE TO LEUWEUNG SANCANG NATURE RESERVE, WEST JAVA
70	Session One	Jeremy	Conrad	USFWS	Sanibel	FL	United States	Poster	IDENTIFING DRIVERS OF ELEVATION CHANGE IN FLORIDA'S MANGROVES
88	Session One	Leticia	Contreras	University of Texas Rio Grande Valley	Brownsville	TX	United States	Poster	ARE MANGROVE PANARCHIES?
82	Session One	Hayley	Craig	University of Manchester	Manchester		United Kingdom	Poster	EXPLORING RELATIONSHIPS BETWEEN PLANT AND SOIL MICROBIAL DIVERSITY IN MANGROVES
96	Session Two	Farid	Dahdouh-Guebas	University Libre Brussels	ULB	Bruxelles / Brussels	Belgium	Poster	MANGROVES AT THEIR LIMITS: DETECTION AND AREA ESTIMATION OF THE CAP TIMIRIS MANGROVES, IN MAURITANIA, USING REMOTE SENSING
95	Session Two	Farid	Dahdouh-Guebas	University Libre Brussels	ULB	Bruxelles / Brussels	Belgium	Poster	WHOSE MANGROVE IS IT AND WHAT IS IT FOR? MAPPING MANGROVE MANAGEMENT DISCOURSES USING Q METHODOLOGY
54	Session One	Zhaohua	Dai	USDA Forest Service	Cordesville	SC	United States	Poster	A NEW PROCESS-BASED MANGROVE CARBON ASSESSMENT TOOL: MCAT-DNDC
7	Session One	Zhaohua	Dai	USDA Forest Service	Cordesville	SC	United States	Poster	A REGIONAL FRAMEWORK FOR MANGROVE RESEARCH AND TRAINING FORESTS IN EAST AFRICA
55	Session Two	Pedram	Daneshgar	Monmouth University	West Long Branch	NJ	United States	Poster	IMPACTS OF INCREASED SALINITY ON MANGROVE CARBON CYCLING PROCESSSES
30	Session One	Tess	Danielson	Louisiana State University	Baton Rouge	LA	United States	Poster	MANGROVE LONG-TERM ABOVEGROUND NET PRIMARY PRODUCTIVITY IN THE FLORIDA COASTAL EVERGLADES: RESPONSE TO HURRICANE DISTURBANCE AND RESILIENCE MAGNITUDE
105	Session Two	Amanda	Demopoulos	US Geological Survey	Gainesville	FL	United States	Poster	ASSESSMENT OF RECOVERY OF MANGROVE HABITATS USING STABLE ISOTOPES

25	Session Two	Esther	Edu	UNIVERSITY OF CALABAR, NIGERIA, WEST AFRICA	Calabar	WV	Nigeria	Poster	EVALUATION OF CARBON BIOSEQUESTRATION IN THE MANGROVE SWAMPS OF THE GREAT KWA RIVER, CALABAR, NIGERIA
10	Session One	Ryohei	Egawa	Tokyo Institute of Technology, Tokyo, Japan	Meguro-ku	Tokyo	Japan	Poster	RELATIONSHIP BETWEEN BIOTURBATION AND ENVIRONMENTAL CHARACTERISTICS OF MANGROVE FORESTS IN FUKIDO ESTUARY, JAPAN
87	Session One	Amy Anne	Erickson	Louisiana State University Shreveport	Shreveport	LA	United States	Poster	MANGROVE EXTRACTS INFLUENCE FEEDING ACTIVITY BY MANGROVE TREE CRABS IN FLORIDA AND BELIZE
91	Session One	Shazia	Farzana	City University of Hong Kong	Kowloon Tong	Hong Kong	Hong Kong	Poster & Lightning Talk Tuesday	EFFECTS OF POLYBROMINATED DIPHENYL ETHERS (BDE-99 AND BDE-209) ON GERMINATION AND GROWTH OF A MANGROVE PLANT, KANDELIA OBOVATA
94	Session Two	Emanuelle	Feliciano	NASA Goddard Space Flight Center	Greenbelt	MD	United States	Poster	ESTIMATING MANGROVE CANOPY HEIGHT AND ABOVE-GROUND BIOMASS IN EVERGLADES NATIONAL PARK WITH TERRESTRIAL LASER SCANNING, AIRBORNE LIDAR AND TANDEM-X DATA
13	Session One	Jianxiang	Feng	Graduate school at shenzhen Tsinghua University	Shenzhen		China	Poster	RESTORATION OF NATIVE MANGROVES TOOK A LONG TIME TO REVERSE THE RAPID DIET SHIFT OF BENTHIC MACROFAUNA CAUSED BY THE INVASION OF EXOTIC SPARTINA ALTERNIFLORA
27	Session Two	Stela	Fernando	Instituto Nacional de Investigação Pesqueira	Maputo		Mozambique	Poster	CURRENT STATE OF EXPLOITATION OF BIVALVES WITH ECONOMIC IMPORTANCE ON INTERTIDAL ZONE IN NORTHEN MOZAMBIQUE
93	Session Two	Leon Yan-Feng	Gaw	National University of Singapore	Singapore	Singapore	Singapore	Poster	MANGROVE FOREST DYNAMICS IN TANINTHARYI, MYANMAR 1989-2014, AND THE IMPLICATIONS OF FUTURE ECONOMIC REFORMS
35	Session One	Nisse	Goldberg	Jacksonville University	Jacksonville	FL	United States	Poster	POPULATION STRUCTURE OF THE RED MANGROVE *RHIZOPHORA MANGLE* IN GUANA TOLOMATO MATANZAS NATIONAL ESTUARINE RESEARCH RESERVE
63	Session One	Carla Roberta	Gonçalves Reis	Universidade de Brasília	Brasília	Distrito Federal	Brazil	Poster	NITROGEN DYNAMICS IN MANGROVES
83	Session One	Patrick	Grootaert	Royal Belgian Institute of Natural Sciences	Brussels		Belgium	Poster	ASSESSMENT OF INSECT BIODIVERSITY IN MANGROVE HABITATS IN SOUTHEAST ASIA USING MEGADIVERSE FLIES

71	Session One	Xudong	Guo	Xiamen University	Xiamen	Fujian	China	Poster	IMPACTS OF SEA LEVEL RISE ON THE GROWTH OF A DOMINANT AND A NON-NATIVE MANGROVE SPECIES IN CHINA
109	Session Two	Zixiao	Guo	Sun Yat-sen University	Guangzhou	Guang-dong	China	Poster	GENETIC DISCONTINUITIES IN A DOMINANT MANGROVE *RHIZOPHORA APICULATA* (RHIZOPHORACEAE) IN THE INDO-MALESIAN REGION
89	Session One	Ian	Hendy	The University of Portsmouth	Portsmouth	Hampshire	United Kingdom	Poster	TERRESTRIAL AND MARINE CONSORTIA OF WOOD DEGRADERS IN MANGROVE FORESTS ARE DIVIDED BY A SHARP TIDALLY-DEFINED BOUNDARY
56	Session Two	Sharyn	Hickey	The University of Western Australia	Crawley	WA	Australia	Poster	CHANGING COASTAL LANDSCAPES: WHERE ARE MANGROVES GOING AND WHAT DOES IT MEAN FOR CARBON DYNAMICS?
36	Session One	Richard	Hodel	University of Florida	Gainesville	FL	United States	Poster	PROJECTING THE POTENTIAL FUTURE DISTRIBUTIONS OF THREE MANGROVE SPECIES IN FLORIDA AND BEYOND USING ECOLOGICAL NICHE MODELING
4	Session One	Derrick	Hudson	University of South Florida	Tampa	FL	United States	Poster	ZONATION PATTERN AND SPATIAL ARRANGEMENT OF A *GEUKENSIA GRANOSISSIMA* POPULATION IN A MIXED MANGROVE FOREST OF TAMPA BAY
45	Session One	Laura	Hundy	U.S. Geological Survey	Lafayette	LA	United States	Poster	CLIMATIC CONTROLS OF BIOMASS AND SOIL CARBON IN MANGROVES AND OTHER TIDAL SALINE WETLANDS
46	Session One	Adrien	Jacotot	Institut de Recherche pour le Développement (IRD)	Noumea		New Caledonia	Poster	INFLUENCE OF INCREASED CO_2 CONCENTRATIONS AND SEA-LEVEL RISE ON LEAF GAS EXCHANGE PARAMETERS - GREENHOUSE EXPERIMENTS
2	Session One	Dean	Janiak	Smithsonian Marine Station	Ft. Pierce	FL	United States	Poster	SPATIAL AND TEMPORAL TRENDS IN EPIBENTHIC COMMUNITIES INHABITING ARTIFICIAL AND NATURAL SUBSTRATES WITHIN THE INDIAN RIVER LAGOON
3	Session One	Cora Ann	Johnston	University of Maryland	College Park	MD	United States	Poster	MARINE COMMUNITY STRUCTURE EMERGES ACROSS SCALES IN A PATCHY MANGROVE-MARSH LANDSCAPE
38	Session One	Daniel Solomon	Kahsay	University of Bremen, Germany	Bremen	Bremen	Germany	Poster	EFFECT OF NUTRIENT ENRICHMENT ON GROWTH OF THE MANGROVE *AVICENNIA MARINA* SEEDLINGS IN THE MASSAWA COASTLINE, ERITREA

64	Session One	Abu Hena Mustafa	Kamal	University Putra, Malaysia	Bintulu	Sarawak	Malaysia	Poster	DECOMPOSITION OF *RHIZOPHORA APICULATA* (BLUME) AND *XYLOCARPUS GRANATUM* (KOENIG) LITTER COMPONENTS IN A TROPICAL MANGROVE
11	Session One	Md.	Kamruzzaman	Khulna University, Bangladesh	Kyoto		Japan	Poster	COMPARATIVE REPRODUCTIVE PHENOLOGICAL STUDIES OF THREE SUBTROPICAL MANGROVE SPECIES
23	Session Two	Martin	Keeley	Mangrove Action Project	Cayman Brac		Cayman Islands	Poster & Lightning Talk Thursday	MANGROVES AND NATURE DEFICIT DISORDER
108	Session Two	John Paul	Kennedy	Smithsonian Marine Station	Ft. Pierce	FL	United States	Poster & Lightning Talk Thursday	GENETIC AND MORPHOLOGICAL VARIATION OF EAST FLORIDA BLACK MANGROVE (*AVICENNIA GERMINANS*)
16	Session One	Judith	Klein	Institute for Research for Development	Montpellier	Herault	France	Poster & Lightning Talk Tuesday	TROPHIC INTERACTIONS IN BENTHIC FOOD WEBS OF MANGROVES SUBJECT TO MULTIPLE HUMAN ACTIVITIES
18	Session Two	Nico	Koedam	Vrije Universiteit Brussel	Brussels		Belgium	Poster	SPIRITUAL VALUE OF COASTAL NATURAL FEATURES AND MANGROVES – WHAT MUST WE PROTECT AND FOR WHOM ?
92	Session Two	John	Kovacs	Nipissing University	North Bay	ON	Canada	Poster	ASSESSING THE USE OF SPACE-BORNE SYNTHETIC APERTURE RADAR FOR MONITORING MANGROVE FOREST IMPACTS FOLLOWING MAJOR OIL SPILL EVENTS
84	Session One	Natividad	Lacdan	University of the Philippines Manila	Manila		Philippines	Poster	FLORISTIC SURVEY OF THE MANGROVES OF KITAY, TAGKAWAYAN QUEZON PROVINCE, PHILIPPINES
114	Session Two	David	Lagomasino	Universities Space Research Association	Greenbelt	MD	United States	Poster	MANGROVE DEVELOPMENT PATTERNS: CANOPY GAINS AND LAND EXPANSION IN DELTAS
57	Session Two	Derrick Y.F.	Lai	The Chinese University of Hong Kong	Hong Kong		Hong Kong	Poster & Lightning Talk Thursday	EFFECTS OF LAND COVER CHANGE ON SOIL ORGANIC CARBON FRACTIONS IN A SUBTROPICAL MANGROVE WETLAND
47	Session One	Amy	Langston	University of Florida	Gainesville	FL	United States	Poster & Lightning Talk Tuesday	INVESTIGATING TOP-DOWN AND BOTTOM-UP INFLUENCES ON BLACK MANGROVE (*AVICENNIA GERMINANS*) ENCROACHMENT IN FORESTED FRESHWATER ISLANDS ALONG THE BIG BEND COAST OF FLORIDA

115	Session Two	Celia	Macamo	Universidade Eduardo Mondlane	Maputo		Mozambique	Poster	STRUCTURAL PARAMETERS, CHANGE DETECTION AND CONDITION OF MANGROVE FORESTS IN TWO CONTRASTING UTILIZATION PATTERNS IN THE NORTHERN MOZAMBIQUE
65	Session One	Aaron	Macy	Dauphin Island Sea Lab	Dauphin Island	AL	United States	Poster	SHIFTS IN NUTRIENT ALLOCATION DURING BLACK MANGROVE (*AVICENNIA GERMINANS*) ENCROACHMENT INTO SALT MARSH (*SPARTINA ALTERNIFLORA*)
78	Session One	Cyril	Marchand	IRD - Institut de Recherche pour le Développement	Noumea		New Caledonia	Poster	RELATIVE AND SYNERGISTIC IMPACTS OF CLIMATE AND DIRECT ANTHROPOGENIC PRESSURES ON THE PERFORMANCE OF *AVICENNIA MARINA SUBSP AUSTRALASICA*: AN IN-SITU LATITUDINAL APPROACH
28	Session Two	Carilyn	Martin	Environmental Conservation and Protection Center	Alabel		Philippines	Poster	ECONOMIC VALUATION OF MANGROVES IN GLAN, SARANGANI PROVINCE, PHILIPPINES
72	Session One	John	Meeder	Florida International University	Miami	FL	United States	Poster	SALTWATER ENCROACHMENT AND PREDICTION OF ECOSYSTEM RESPONSE TO THE ANTHROPOCENE MARINE TRANSGRESSION, SOUTHEAST SALINE EVERGLADES, FLORIDA
85	Session One	Nelson	Miranda	NMMU	Port Elizabeth	Eastern Cape	South Africa	Poster & Lightning Talk Tuesday	LITTORARIA (GASTROPODA: LITTORINIDAE) AS BIOINDICATORS OF MANGROVE HEALTH
39	Session One	Althea	Moore	Northeastern University	Nahant	MA	United States	Poster	INTERACTIVE EFFECTS OF ENVIRONMENTAL SETTING AND SEEDLING ORIGIN ON MANGROVE ESTABLISHMENT
66	Session One	Chandan	Mukherjee	West Bengal State University	Kolkata	West Bengal	India	Poster	IN SEARCH OF SOIL INDICATORS TO EVALUATE THE IMPACT OF SEA LEVEL RISE -A STUDY FROM SUNDARBAN, INDIA
40	Session One	Mayda	Nathan	University of Maryland	College Park	MD	United States	Poster	RANGE-EDGE FECUNDITY OF A RANGE-EXPANDING SPECIES, THE BLACK MANGROVE (*AVICENNIA GERMINANS*)
31	Session One	Magdalene	Ngeve	Vrije Universiteit Brussel	Brussels		Belgium	Poster	CONTRASTING EFFECTS OF HISTORICAL SEA LEVEL RISE AND CONTEMPORARY OCEAN CURRENTS ON REGIONAL GENE FLOW OF *RHIZOPHORA RACEMOSA* IN EASTERN ATLANTIC MANGROVES
1	Session One	Richard	Osman	Smithsonian Env. Res. Center	Edgewater	MD	United States	Poster	MODELING THE LINKED DISTRIBUTION OF MANGROVES AND ASSOCIATED EPIFAUNAL POPULATIONS IN A COASTAL LAGOON

21	Session Two	Martha	Palacios	Universidad Autonoma de Occidente	Cali		Colombia	Poster	THE USE OF MANGROVE WOOD PRODUCTS AROUND THE COLOMBIAN PACIFIC AMONGST SUBSISTENCE AND COMMERCIAL USERS
79	Session One	Enrique	Peña	Universidad del Valle	Cali	Valle del Cauca	Colombia	Poster	PHOTOSYNTHETIC PERFORMANCE OF MANGROVE SPECIES IN RESPONSE TO VARYING SALINITY
12	Session One	Yisheng	Peng	Sun Yat-Sen University	Guangzhou		China	Poster	REDUCED PREDATION RISK DRIVES THE DISTRIBUTION PATTERNS OF TWO PULMONATE GASTROPODS IN A MANGROVE-SALTMARSH TRANSITIONAL HABITAT
9	Session One	Alejandro	Pleites	Universidad Autónoma de Baja California Sur	La Paz	Baja California Sur	Mexico	Poster	MANGROVE CRABS (*ARATUS SP.*) HERBIVORY ON RED MANGROVE TREES (*RHIZOPHORA MANGLE L.*), IN MAGDALENA BAY AND CORE ZONE OF BALANDRA, BAJA CALIFORNIA SUR, MÉXICO
48	Session One	Ed	Proffitt	Dept. of Biological Sciences, Fla Atlantic Univ	Ft. Pierce	FL	United States	Poster & Lightning Talk Tuesday	MARSH-MANGROVE INTERACTIONS: SHORT TERM EXPERIMENTAL RESULTS AND LONGER TERM CONSEQUENCES FOR PLOT DOMINANCE
19	Session Two	Melissa Roxana	Quispe Zúñiga	University of Bonn	Bonn		Germany	Poster	STAKEHOLDER ANALYSIS ON THE MANGROVE CHARCOAL PRODUCTION SYSTEM AT MATANG MANGROVE FOREST RESERVE, PENINSULAR MALAYSIA
98	Session Two	Kara	Radabaugh	Florida Fish and Wildlife Research Institute	St, Petersburg	FL	USA	Poster	THE COASTAL HABITAT INTEGRATED MAPPING AND MONITORING PROGRAM (CHIMMP): STATUS AND EXTENT OF FLORIDA'S MANGROVES AND SALT MARSHES
58	Session Two	Md Mizanur	Rahman	Kyoto University	Kyoto		Japan	Poster	ECOSYSTEM CARBON STOCK AND STAND STRUCTURE ACROSS THE INTERTIDAL ZONE IN SUNDARBANS RESERVED FOREST, BANGLADESH
49	Session One	Gary	Raulerson	Tampa Bay Estuary Program	St. Petersburg	FL	United States	Poster	HABITAT RESTORATION INITIATIVES TO BUFFER POTENTIAL IMPACTS OF CLIMATE CHANGE IN THE TAMPA BAY ESTUARY
14	Session One	Jacqueline	Raw	Nelson Mandela Metropolitan University	Port Elizabeth		South Africa	Poster & Lightning Talk Tuesday	IMPORTANCE OF AUTOCHTHONOUS SOURCES FOR GASTROPOD CONSUMERS IN SUBTROPICAL ESTUARINE MANGROVES: A CASE STUDY FROM SOUTH AFRICA

44	Session One	Armando	Reis Neto	University of São Paulo - USP	São Paulo		Brazil	Poster & Oral	MANGROVES AT THE ARAÇÁ BAY, SÃO PAULO, BRAZIL: A HISTORICAL ECOLOGY APPROACH
116	Session Two	Victor	Rivera-Monroy	Louisiana State University	Baton Rouge	LA	United States	Poster	ESTIMATING SPECIES-SPECIFIC ABOVE-GROUND MANGROVE BIOMASS IN A CARIBBEAN OCEANIC ISLAND (SAN ANDRES, COLOMBIA)
67	Session One	Christian	Sanders	Southern Cross University	Coffs Harbour	NSW	Australia	Poster	CARBON BURIAL FROM SALTPANS TO MANGROVES IN TROPICAL REGIONS OF BRAZIL AND AUSTRALIA
76	Session One	Sigit	Sasmito	CIFOR	Bogor		Indonesia	Poster	THE IMPACT OF MANGROVE CUTTING AND REGENERATION ON SURFACE ELEVATION DYNAMICS IN BINTUNI MANGROVE, WEST PAPUA, INDONESIA
68	Session One	Tracey	Schafer	University of Florida, Whitney Laboratory	St. Augustine	FL	United States	Poster	EVALUATION OF AN ORGANIC CARBON TRAJECTORY ON A MANGROVE SPOIL ISLAND
119	Session Two	Whitney	Scheffel	University of South Alabama/ Dauphin Island Sea Lab	Dauphin Island	AL	United States	Poster	IMPACTS OF BLACK MANGROVE EXPANSION ON FAUNAL COMMUNITIES IN THE NORTHERN GULF OF MEXICO
59	Session Two	Lisa	Schile	Smithsonian Environmental Research Center	Edgewater	MD	United States	Poster	VARIATIONS IN MANGROVE SOIL CARBON STORAGE ACROSS CLIMATE GRADIENTS
15	Session One	Ashvin	Sewsahai	Anton de Kom University of Suriname	Paramaribo		Suriname	Poster	ASSESSING THE VERTICAL GRADIENT OF *DISCAPSEUDES SURINAMENSIS* AND *HALMYRABSEUDES SPAANSI* AT THE POMONA MUD BANK (SURINAME) IN RELATION TO THEIR BIOMETRICS
121	Session Two	Michelle	Shaffer	University of Central Florida	Orlando	FL	United States	Poster	EVALUATING THE EFFECTS OF THE RANGE EXPANSION OF *AVICENNIA GERMINANS* ON EASTERN SHORELINE BIRD COMMUNITIES ALONG THE EAST COAST OF FLORIDA
24	Session Two	Y. Peter	Sheng	University of Florida	Gainesville	FL	United States	Poster	SIMULATING THE EFFECT OF MANGROVES IN REDUCING COASTAL INUNDATION DUE TO STORMS AND SEA LEVEL RISE
110	Session Two	Suhua	Shi	Sun Yat-sen University	Guangzhou		China	Poster	MANGROVE BIODIVERSITY AND A NOVEL SPECIATION MECHANISM -THE MIXING-ISOLATION-MIXING (MIM) CYCLES ON THE INDO-MALAYAN COASTS
6	Session One	Geoffrey	Shideler	University of Miami - RSMAS	Miami	FL	United States	Poster	FISH ABUNDANCE AND SIZE ALONG THE FLORIDA REEF TRACT: THE INFLUENCE OF ADJACENT MANGROVE AND SEAGRASS HABITAT ON A REGIONAL SCALE

60	Session Two	Lorae	Simpson	Smithsonian Marine Station	Fort Pierce	FL	United States	Poster	CARBON STOCKS IN A SHIFTING ECOSYSTEM; CLIMATE INDUCED MIGRATION OF MANGROVES INTO SALT MARSH
86	Session One	Lee	Smee	Texas A&M - Corpus Christi	Corpus Christi	TX	United States	Poster	GETTING TO THE ROOT OF THE PROBLEM: BLACK MANGROVE EXPANSION INTO SOUTHEAST TEXAS SALTMARSHES
17	Session One	Elise	Snavely	Leibniz Center for Tropical Marine Ecology	Bremen		Germany	Poster	EFFECTS OF THE INTERACTIONS OF CERIOPS TAGAL AND BURROWING CRABS ON MANGROVE SEDIMENT CHARACTERISTICS
120	Session Two	Matthew	St. Clair	University of Miami, RSMAS	Key Biscayne	FL	United States	Poster	A COMPARATIVE ANALYSIS OF MANGROVE FORESTS AND STRUCTURAL CHARACTERISTICS USING THE PCQM AND PLOT METHODS
50	Session One	Hilary	Standish	Harbor Branch Oceanographic Institute	Fort Pierce	FL	United States	Poster	MANGROVE GROWTH FORM AND SALT MARSH INTERACTION ALONG ENVIRONMENTAL GRADIENTS
41	Session One	Suyadi	Suyadi	The University of Auckland	Auckland		New Zealand	Poster	SPATIAL PATTERNS OF MANGROVE FOREST EXPANSION IN THE AUCKLAND REGION, NEW ZEALAND
101	Session Two	Ramanathan	Thirugnana Sambandam	Annamalai University	Parangipettai, Cuddalore District		India	Poster	MANGROVE RESTORATION IN THE SOUTH PICHAVARAM MANGROVE FORESTS, SOUTH EAST COAST OF TAMIL NADU, INDIA
112	Session Two	Michael	Timm	Rosenstiel School of Marine & Atmospheric Science, University of Miami	Miami	FL	United States	Poster	STRUCTURAL COMPARISONS OF NATURAL VERSUS SEA WALL SHORELINE MANGROVE FORESTS
73	Session One	Marguerite	Toscano	Smithsonian Environmental Research Center	Silver Spring	MD	United States	Poster & Lightning Talk Tuesday	SEA LEVEL RECONSTRUCTIONS FROM THICK MANGROVE PEAT DEPOSITS IN FLORIDA, BELIZE AND PANAMA – AGE AND PALEO ELEVATIONS OF BASAL PEATS VS. CONTINUOUS SAMPLING, AND RELATIONSHIP TO GEOPHYSICAL SEA LEVEL MODELS
100	Session Two	Camilo	Trench	The University of the West Indies	Kingston 7		Jamaica	Poster	A CASE STUDY OF ECOLOGICAL MANGROVE RESTORATION IN PORTLAND COTTAGE, JAMAICA
99	Session Two	Camilo	Trench	The University of the West Indies	Kingston 7		Jamaica	Poster	MANGROVE RESTORATION ON THE PALISADOES IN JAMAICA
8	Session One	Natasha	Valencia-Martínez	Universidad del Valle	Cali	Valle del Cauca	Colombia	Poster	ECOLOGICAL ROLE OF MANGROVE CRABS IN THE PACIFIC COAST OF COLOMBIA

32	Session One	Craig	van der Heiden	Institute for Regional Conservation	Delray Beach	FL	United States	Poster	LONG TERM VEGETATION CHANGES IN ROOKERY BAY NATIONAL ESTUARINE RESEARCH RESERVE 1940-2012
20	Session Two	Katherine	Vande Velde	Université Libre de Bruxelles	Brussels	Bruxelles / Brussel	Belgium	Poster & Lightning Talk Thursday	BIODIVERSITY CONSERVATION IN SOCIAL-ECOLOGICAL SYSTEMS: THE LAST(ING) MANGROVES OF SINGAPORE
106	Session Two	Linda	Walters	University of Central Florida	Orlando	FL	United States	Poster	MANGROVE-BASED LIVING SHORELINES ALONG SHORELINES DOMINATED BY SHELL MIDDENS
74	Session One	Kevin R. T.	Whelan	National Park Service, SFCN	Miami	FL	United States	Poster	CALIBRATED DENSITY PROFILES OF THICK MANGROVE PEAT SEQUENCES FROM COMPUTED TOMOGRAPHY: APPLICATIONS FOR ASSESSMENT OF MANGROVE PALEOECOLOGY, PEAT COMPACTION AND SEA LEVEL RECONSTRUCTIONS
104	Session Two	Kathy	Worley	Conservancy of Southwest Florida	Naples	FL	United States	Poster	A TALE OF TWO BLACK MANGROVE (*AVICENNIA GERMINANS*) DIE-OFFS & EFFORTS AT RESTORATION
42	Session One	Arimatéa	Ximenes	Université Libre de Bruxelles	Bruxelles		Belgium	Poster	SPATIAL ASSESSMENT OF THE BIOCLIMATIC FACTORS DRIVING MANGROVE FOREST DISTRIBUTION ALONG THE BRAZILIAN COASTLINE
51	Session One	Jiaxing	Xu	The Chinese University of Hong Kong	Hong Kong		China	Poster	THE EFFECTS OF TEMPERATURE AND SALINITY ON ANAEROBIC CH_4 AND CO_2 PRODUCTION POTENTIAL FROM SUBTROPICAL WETLAND SOILS
111	Session Two	Shaohua	Xu	Sun Yat-Sen University	Guangzhou		China	Poster	THE GENOME OF *RHIZOPHORA APICULATA* PROVIDES INSIGHT INTO ADAPTIVE EVOLUTION OF MANGROVE SPECIES TO THE INTERTIDAL ZONE
107	Session Two	Erik	Yando	University of Louisiana at Lafayette	Lafayette	LA	United States	Poster	MANGROVE PROPGULE DISPERSAL AND ESTABLISHMENT AT THE SALT MARSH-MANGROVE ECOTONE: LINKING HYDROLOGY, DISPERSAL DISTANCE, AND PROPAGULE RETENTION
75	Session One	Lu	Zhai	University of Miami	Coral Gables	FL	United States	Poster	PREDICTION OF PLANT VULNERABILITY TO SALINITY INCREASE IN A COASTAL ECOSYSTEM BY STABLE ISOTOPIC COMPOSITION OF PLANT STEM WATER: A MODEL STUDY
80	Session One	Hewei	Zhao	Xiamen University	Xiamen		China	Poster	SAP FLOW CHARACTERISTICS OF TWO MANGROVE SPECIES, SONNERATIA CASEOLARIS AND S. APETALA, IN CHINA

ABSTRACTS

(Listed alphabetically in order of presenting author)

ARE MANGROVES PANARCHIES?

Guilherme Moraes de Oliveira Abuchahla[1]*, and Yara Schaeffer-Novelli*[2]
[1]Institute of Energy and Environment, University of São Paulo, SP, Brazil
[2]Oceanographic Institute, University of São Paulo, SP, Brazil

Mangrove ecosystems have proven to be highly resilient and adaptive when facing severe environmental conditions such as high salinity, anoxic sediment, and siltation. On the other hand, these ecosystems have proven to be highly sensitive towards many of the common human practices, which include deforestation, changes in hydrodynamics, and direct as well as indirect effects of climate change.

As complex adaptive systems, mangroves adapt continuously through self-organization and creation of novelty. In order to better understand the thresholds of mangrove resilience, discontinuities in key patterns and processes can be an effective tool. The analysis of discontinuities indicates gaps between ecosystem panarchy regimes, in which each adaptive cycle is usually marked by four phases: exploitation (r), conservation (K), release (α), and reorganization (Ω).

The present study has identified discontinuities in mangrove basal area within a specific site at Bertioga, in the Brazilian southeastern coast. The site offers a wide range of data throughout three decades of monitoring, since the disruptive event of an oil spill, in the year of 1983. Discontinuities in mangrove basal area and species composition have been analyzed together with other acquired data, both quantitative and qualitative. The analysis demonstrated significant decrease in basal area, as well as the change in species composition (from highly dominant *Rhizophora mangle* L. to the exclusive *Laguncularia racemosa* Gaertn.f.), fitting the studied mangrove into the panarchical phases along with its evolution and responses since the referred oil spill.

In a rapidly changing world, where mangroves might not build up resilience at such pace, the understanding of mangrove ecosystems as cyclic adaptive systems is the key tool for adaptive environmental management. This might be of great importance for mangrove's endurance, as well as its importance to other systems and forms of life.

Contact Information: Guilherme M. O. Abuchahla, Instituto BiomaBrasil, R. Laboriosa, 74A/80, 05434-060 São Paulo, SP, Brazil, Phone: +55 11 97689 9416, Email: abuchahla@me.com

DYNAMICS OF MANGROVES ALONG THE SOUTH AFRICAN COASTLINE

***Janine Adams*[1]** *and Anusha Rajkaran*[2]

[1]Department of Botany, Nelson Mandela Metropolitan University, South Africa
[2]Department of Biodiversity and Conservation Biology, University of Western Cape, South Africa

Mangroves in South Africa exist at one of the most southerly limits in the world providing a unique opportunity to study their dynamic responses. Indeed, the distribution of mangroves in South Africa is influenced by a complex set of interacting factors. As a result of the exposed coastline all mangroves are restricted to the more sheltered environment provided by estuaries. Climate warming and an increase in CO_2 will enable mangroves to expand their present distribution to higher latitudes but this will depend on propagule dispersal between estuaries and the availability of suitable habitats. Many of the small east coast estuaries are temporarily open systems and remain closed to the sea for different periods. Globally mangroves are expanding into salt marsh habitats but the patterns are not that clear in South African estuaries. At the Kobonqaba Estuary there was complete die-back of *Avicennia marina* due to inundation as a result of closure of the estuary mouth to the sea and an increase in water level. Drought, low freshwater inflow as well as sediment deposition from a large sea storm resulted in the mouth closing to the sea for the first time ever recorded. Salt marsh replaced the mangrove habitat over four years. Population structure in other small east coast estuaries indicates historical single successful recruitment events and persistence linked to initial flooding and connectivity with the sea. However, an increase in the intensity of freshwater floods is predicted for the east coast which will scour banks and completely remove mangroves. It is important that these dynamic responses are understood as estuaries with mangrove habitats in South Africa are prioritized for conservation.

Contact Information: Janine Adams, Department of Botany, Nelson Mandela Metropolitan Univerisity, PO Box 77000, Port Elizabeth, 6031, South Africa, Phone: +27 41 5042429, Email: Janine.adams@nmmu.ac.za

INTRODUCTION OF MANGROVE RESTORATION PRACTICES TO INCREASE THE MANGROVE FOREST COVER IN AL WAKRA REGION OF STATE OF QATAR

Fahad Al Jamali
University of Qatar, Al Tarfa, Doha, Qatar

Colonization of bare tidal flats by pioneering species of mangrove undergo several critical and complex physical processes, processes which are not well documented in the Arabian Gulf. The lack of such preliminary threshold processes for an early seedling establishment of Gray Mangrove *Avecennia marina* is mainly attributed to the hydrodynamic forces and sediment properties, resulting in a failure to acquire and colonize adjacent available tidal flats. Identifying the need of mangrove reforestation and potentiality of available bare tidal flats in the study area, Al Wakrah, Qatar; we developed the mangrove seedlings of *A. marina* in the nursery, allowing us to bypass an early natural critical seedling establishment process. The results of replanting the nursery raised seedlings have shown signs of significant success in the bare flats next to previously occupied natural mangrove forest. However due to natural inabilities, as well as anthropogenic deforestation of *A. marina*, an in depth study is required to develop appropriate conservation and management practices to protect economically and environmentally important mangrove forests.

Contact Information: Fahad Al Jamali, University of Qatar, Al Tarfa, Doha P.O Box 2712, Qatar, Phone: 974-5559-8891, Email: f.aljamali@qu.edu.qa

CARBON SINK CAPACITY OF RED SEA MANGROVES

Hanan Almahasheer[1, 2], *Oscar Serrano Gras[3, 4], Carlos M. Duarte[1], Pere Masque[3, 4,5] and Xabier Irigoien[1]*

[1]King Abdullah University of Science and Technology (KAUST), Red Sea Research Center, Thuwal, Kingdom of Saudi Arabia
[2]Biology Department, University of Dammam (UOD), Dammam, Kingdom of Saudi Arabia
[3]School of Natural Sciences & Centre for Marine Ecosystems Research, Faculty of Health, Engineering and Science, Edith Cowan University, Joondalup, Australia
[4]The UWA Oceans Institute, University of Western Australia, Crawley, Australia
[5]Universitat Autònoma de Barcelona, Departament de Física -Institut de Ciència i Tecnologia Ambientals, Spain

Mangroves, A*vicennia marina*, occupy about 135 Km^2 in the Red Sea and represent one of the most important vegetated communities in this otherwise arid and oligotrophic region. We assessed carbon sequestration in 10 sites within four locations in the Saudi coast of the Central Red Sea. We combined estimates of carbon density down to about 1 m in depth along the profile of the sediment with date estimates derived from ^{210}Pb and ^{14}C isotopes to estimate (a) the burial rate of organic carbon over time and (b) the stock of organic carbon contained within the top meter of the sediment. These results inform the potential of blue carbon strategies, adopted as one of the mitigation strategies of the Kingdom of Saudi Arabia, in mitigating CO2 emissions through the restoration and conservation of mangroves, which remain healthy and stable ecosystems in the Red Sea.

Contact Information: Hanan Almahasheer, King Abdullah University of Science and Technology (KAUST), Red Sea Research Center, Building 2, level2, 2207-WS14 Thuwal, Western Province, Thuwal 23955-6900; Saudi Arabia; Phone: 966551504339; Email: Hanan.almahasheer@kaust.edu.sa

MANGROVE FOREST PRODUCTIVITY IN CENTER PART OF CORAL TRIANGLE ECO-REGION AT THE SOUTH SULAWESI, INDONESIA

***Kangkuso Analuddin*[1]**, *Jamili*[1], *Andi Septiana*[1], *Idin Sahidin*[2], *Usman Rianse*[3], *Sahadev Sharma*[4&5], *Kazuo Nadaoka*[5]

[1]Faculty of Mathematics and Natural Sciences, Halu Oleo University, Kendari, Indonesia
[2]Faculty of Pharmacy, Halu Oleo University, Kendari, Indonesia
[3]Faculty of Agriculture, Halu Oleo University, Kendari, Indonesia
[4]Department of Natural Resources and Environmental Management, University of Hawaii at Manoa, Honolulu, HI, USA
[5]Department of Mechanical and Environmental Informatics, Tokyo Institute of Technology, Tokyo, Japan

Mangroves can capture high amount of organic carbon in soil and possess high productivity therefore their management and conservation is important to mitigate climate change. Mangroves also play an important role in material cycle for the coastal zone at the coral triangle eco-region, which is the huge biodiversity spot in the world. This study aimed to elucidate the mangroves productivity status at the Southeast Sulawesi, Indonesia as center part of coral triangle area. Five dominant mangroves were analysed including biomass stock and their net productivity. Total 75 net traps were placed on mangroves stands of *Rhizophora apiculata*, *R. mucronata*, *R. stylosa*, *Ceriops tagal* and *Lumnitzera racemosa*. The litters were collected from June 2014 to May 2015. In addition, the tree censuse were done in the same years inside the permanent plots of these mangroves. Allometric models of these species were established for estimation of aboveground biomass. Average aboveground biomass stock on mangroves (ton ha^{-1}) was estimated as 615.60 for *Rhizophora apiculata*, 452.25 for *R. mucronata*, 109.77 for *Lumnitzera racemosa*, 162.61 for *Ceriops tagal* and 326.61 for *R. stylosa* stands. The *R. apiculata* had the highest biomass due to mature stands because no standing dead biomass, which means self-thinning, stopped and it is old growth forest. Biomass increment of mangroves (ton ha^{-1} yr^{-1}) was estimated respective 10.96 for *Rhizophora apiculata*, 12.70 for *R. mucronata*, 22.63 for *Lumnitzera racemosa*, 31.25 for *Ceriops tagal* and 36.83 for *R. stylosa*. Biomass increment is higher for *R stylosa* because of young forest and young forest can grow faster. On the other hand, standing death biomass (ton ha^{-1} yr^{-1}) was estimated respective 0 for *R. apiculata*, 7.60 for *R. mucronata*, 1.14 for *L. racemosa*, 23.87 for *C. tagal* and 6.54 for *R. stylosa*. However, yearly litter production (ton ha^{-1} yr^{-1}) was estimated respective 14.412 for *R. apiculata*, 13.161 for *R. mucronata*, 10.811 for *L. racemosa*, 13.678 for *C. tagal* and 12.62 for *R. stylosa* stands. Meanwhile, net primary production (ton ha^{-1} yr^{-1}) were estimated respective 25.372 for *R. apiculata*, 18.261 for *R. mucronata*, 32.301 for *L. racemosa*, 21.508 for *C. tagal* and 42.914 for *R. stylosa* stands. High net primary productivity for *R stylosa* is because of higher biomass increment and litterfall production. Higher mangroves productivity is supporting the coastal ecosystem productivity at the coral triangle eco-region. However, still unprotected mangroves areas are converted into aquaculture ponds. These results can be used for the management and conservation to make policy. Therefore, these results can support to maintain high biodiversity and productivity in the coral triangle area.

Contact Information: Kangkuso Analuddin, Faculty of Mathematics and Natural Sciences, Halu Oleo University, Kendari, Indonesia, Phone: +6282196100071, Email: zanzarafli@gmail.com

TEN YEARS AFTER: WILMA STORM DEPOSITS EFFECT ON VERTICAL SOIL ACCRETION IN A COASTAL MANGROVE FOREST (2005-2015), EVERGLADES NATIONAL PARK, FL, USA

***Gordon H. Anderson[1]**, Karen M. Balentine[2], Ginger Tilling-Range[3], Joshua L. Breithaupt[4], Joseph M. Smoak[5], Kevin R.T. Whelan[6], and Ken W. Krauss[7]*

[1]U.S. Geological Survey-Wetland and Aquatic Research Center, Gainesville, FL, USA
[2]U.S. Fish and Wildlife Service-Great Dismal Swamp NWR, Suffolk, VA, USA
[2]Cherokee Nation Technology Solutions contracted to the U.S. Geological Survey–Coastal and Marine Science Center, St. Petersburg, FL, USA
[4]University of South Florida-College of Marine Science, St. Petersburg, FL., USA
[5]University of South Florida-Department of Environmental Science, Policy and Geography, St. Petersburg, FL., USA
[6]National Park Service-South Florida Caribbean Network, Palmetto Bay, FL., USA
[7]U.S. Geological Survey-Wetland and Aquatic Research Center, Lafayette, LA, USA

In October 2005, Hurricane Wilma storm surge flooded the southwest coast of Florida, depositing an estimated 27, 000 m3 of marine sediment into the Shark River estuary mangrove forest. Since 1999, project scientists have monitored sediment accretion and soil elevation change on the Shark River with Surface Elevation Tables (SET) and feldspar plots. Our ongoing study has provided us the opportunity to have a precise pre-storm baseline to compare Wilma storm deposit accretion and mangrove peat surface elevation changes for the last 10 years.

Immediately after Wilma, storm deposit core samples averaged 38 mm in depth and SET measurements of soil elevation increase was 43 mm. We observed that storm deposits are persistent since 2005 at the SET site. There is evidence of spatial storm deposition variability, including storm sediment loss from rainfall erosion and tidal flushing of sediment back to the estuary, as well as storm sediment stabilization from crab bioturbation and fine mangrove root growth into storm deposits from underlying peat sediment.

For ten years, periodic surface elevation and sediment measurements were taken, including in September 2015. Recent Surface elevation (SET) measurements showed an increase of 41 mm from pre-Wilma, a slight loss in total sediment elevation from the post-Wilma 2005 peak elevation increase of 43 mm; and sediment core samples averaged 61 mm in depth with the 27 mm of grey storm deposits buried below a 34 mm layer of brown organic sediment.

The take-away message is clear: Wilma storm deposits were persistent and did provide increased sediment to the mangrove peat and an increase in mangrove sediment elevation from pre-Wilma levels. However, increased surface sediment accretion, yet lower total sediment elevation, suggests sub-surface processes such as compaction, peat degradation and groundwater levels may affect the overall peat sediment profile elevation and are not clearly understood.

Furthermore, only three major western landfall hurricanes were strong enough to transport large volumes of sediment occurred during the last 100 years, the ability of storms to enhance sediment buildup on the southwest Everglades mangrove coast is probably insufficient to ameliorate the estimated average of 2 mm per year increase in sea level change.

Contact Information: Gordon H. Anderson, USGS-WARC, 7920 NW 71st St., Gainesville, FL., USA 32653,
Phone: 352-264-3487, Email: gordon_anderson@usgs.gov

LATITUDE AFFECTS DOMINANCE BY SECONDARY FOUNDATION SPECIES ON RED MANGROVE (*RHIZOPHORA MANGLE*) PROP ROOTS

***Jessene Aquino-Thomas*[1]** *and C. Edward Proffitt*[12]*,*

[1]Dept. of Biological Sciences, Florida Atlantic University, Boca Raton, FL, USA

[2] Stationed at Harbor Branch Oceanographic Institute, Fort Pierce, FL, USA

Red mangroves (*Rhizophora mangle*) are a dominant primary foundation species in tropical and subtropical areas of Florida. The prop roots of R. mangle support secondary foundation species such as barnacles throughout their overlapping range, sponges in the tropics, and eastern oysters (*Crassostrea virginica*) in subtropical/south temperate estuaries. Foundation species and ecological engineers such as these provide habitat for many other species and can affect ecological functions, such as acting as a predation refuge, a barrier to damage, and ameliorating abiotic effects. The relationship between primary foundation species and a secondary foundation species has largely been ignored, but may be integral for understanding ecological functions and community processes. Interactions between foundation species may be broad and cascading. Changing climate will affect the occurrence of both primary and secondary foundation species in Florida estuaries by causing shifts in environmental gradients. Mangroves are 'invading' salt marsh settings in the north and providing additional habitat for oysters and associated species. The focus of this study is on the changing in secondary foundation species occurrence and dominance along the latitudinal gradient on Florida's Atlantic coast.

The research is investigating the connections between mangroves, the dominant secondary foundation species, and the resulting biodiversity to understand the temporal and spatial variability of the ecosystems. The hypotheses tested by structural equation modeling analysis of observational data are: A) there is a latitudinal gradient for secondary foundation species on red mangrove prop roots, B) the identity of the secondary foundation species influences the occurrence of other species on the prop roots along the latitudinal gradient, C) water quality will influence both the dominate secondary foundation species and overall prop root biodiversity, D) marine geography factors will influence both the dominate secondary foundation species and overall prop root biodiversity. The sites being studied range over 493 km from Key West in the south to Vero Beach in the north. Water quality variables include chlorophyll a, temperate, salinity, and dissolved oxygen. Marine geography factors include tidal range, fetch, flooding, the length of the mangrove forest adjacent to water, and the connectivity of the mangrove forest to other mangrove forests.

The study is on-going and preliminary data indicate a general trend that biodiviersity on prop roots increased the further south along the latitudinal gradient. In the southern zone of the study the average prop root had over twenty different tropical species present. Dominance on the prop root was often shared between several species of Porifera, several species of Ascidiacea, and *Isognomon alatus (the flat tree oyster)*. In the northern region of the study prop roots were dominated by *C. virginica* and prop roots averaged five species per root. Sometimes *C. virginica* was the sole organism present on prop roots in the northern region. The transition zone is located in Miami-Dade County, where both tropical and temperate species are present are on prop roots. In the transition zone the mean number of species on prop roots was fourteen, but there was substantially more varability in number of prop root residing species.

Contact Information: Jessene Aquino-Thomas, Florida Atlantic University, Biology, 872 Sw 9 Ave, Boca Raton, FL 33486; United States, PH 561-297-3700; FX 954-850-9616; Email: Jaquino3@fau.edu

FRIENDS OR FOES? THE PROBLEM OF SOUTH FLORIDA'S INVASIVE MANGROVES

Kelly J. Cox[1] *and* ***Rafael J. Araújo***[2]

[1]University of Miami School of Law, Coral Gables, Florida, USA

[2]Rosenstiel School of Marine & Atmospheric Science, University of Miami, Miami, Florida, USA.

Florida is home to three native "true" (sensu Tomlinson 1986) species of mangroves (Rhizophora, mangle, Avicennia germinans, and Laguncularia racemosa), two "minor" species (Acrostichum aureum and A. danaeifolium), and one ubiquitous mangrove associate (Conocarpus erectus and its northern Caribbean variety C. e. var. sericeus). These mangroves are common along both the Atlantic and gulf coasts of Florida as far north as the Ponce de Leon Inlet and Cedar Key, respectively. During the 1940s, renowned American botanist David Fairchild traveled to Indonesia and brought back with him specimens of the Burmese mangrove Bruguiera gymnorrhiza which he proceeded to plant at his Miami home but later converted into a botanical garden, the Kampong. Approximately 30 years later, Fairchild Tropical Botanical Garden horticulturists planted a second non-native species, the Tonga mangrove Lumnitzera racemosa. For decades the two species of mangroves remained contained to their respective botanical gardens. However, they eventually "escaped" and have since naturalized and spread. In spite of local effort to eradicate both species, seeds, propagules, and plants are still being found in the area, likely a result of the capacity of both species to adapt and acclimate to the south Florida region. Mangroves in Florida are protected under the 1996 Mangrove Trimming and Preservation Act (MTPA), which defines a "mangrove" as any specimen of the three true Florida native mangroves. The act, however, has not been altered to reference the existence, let alone the impact, of invasive mangrove species in Florida. From a textual statutory interpretation standpoint, the Plain Meaning Rule and the canon of expression unius suggest that because the statute specifically defines which mangrove species are under the jurisdiction of the act, all other species of mangroves are not included for the purposes of protection and preservation. That is, invasive mangrove species are in no way protected under the MTPA. In this sense, protection of invasive mangrove species would be contrary to the statutory intent and the substantive purpose of the act. However, within the context of invasive species control and eradication, the MTPA only implies that that invasive mangroves are not protected. It in no way mandates or requires their removal through explicit language. Pursuant to Florida Administrative Code Chapter 5B-57, the Florida Department of Agriculture and Consumer Services administers the Florida Noxious Weed List. The last update to the Noxious Weed List was in 2014 and at that time included 87 parasitic and terrestrial weeds. Among these noxious weeds were species, which are known coastal invasive plants that are regularly found imposing upon mangrove ecosystems, suggests that it would be appropriate for B. gymnorrhiza and L. racemosa to also be included on this list. Listing would make illegal the sale, cultivation, introduction, collection, or transport of the invasive mangrove species without a permit which would surely aid in preventing further intentional distribution. However, obtaining a noxious weed listing is more difficult than it may appear at first glance. This is because Florida boasts a very strong, and notorious, aquarium trade and at least one of the invasive species (B. gymnorrhiza) is touted as an easy aquarium plant to establish. An essential part of an effective precautionary approach to management of invasive mangrove species requires integration of such an approach into the legal framework. As such, we propose that Lumnitzera racemosa and Bruguiera gymnorrhiza should be listed on the Florida Noxious Weed List. MTPA should be referenced as the authority by which state and local agencies can engage in eradication and management strategies for these species. Finally, a Florida Invasive Species Council should be established in order to promote horizontal and vertical integration between different levels and areas of government. This council should facilitate invasive species policy in the state by commissioning scientific studies, adopting risk assessment techniques to prioritize eradication, overseeing thoughtful and impactful use of funding, and assisting with planning strategies and management techniques.

Contact Information: Rafael Araujo, Rosenstiel School of Marine & Atmospheric Science, University of Miami, Marine Biology and Ecology, 4600 Rickenbacker Causeway, Miami, FL 33149; United States, PH 305-421-4681; Email: raraujo@rsmas.miami.edu

CITIZEN SCIENCE DATA REVEAL THE IMPACT OF A CHANGING TEXAS MARSH-MANGROVE ECOTONE ON COASTAL BIRD COMMUNITIES

Ashley A. Whitt[1], Wesley E. Highfield[2], Steven C. Pennings[3],* ***Anna R. Armitage***[1]

[1]Department of Marine Biology, Texas A&M University at Galveston, Galveston, TX, USA
[2]Department of Marine Sciences, Texas A&M University at Galveston, Galveston TX, USA
[3]Department of Biology and Biochemistry, University of Houston, Houston, TX, USA

Climate change is causing poleward shifts in species distributions. Along the Texas coast, this shift manifests as the woody encroachment of black mangroves (*Avicennia germinans*) into salt marshes historically dominated by graminoid species. Alterations to ecosystem functions in response to this shift are poorly understood. Citizen science, the public's involvement in data collection, can allow ecologists to feasibly investigate larger spatial and temporal patterns than otherwise possible. We used crowdsourced birdwatcher observations from Cornell Lab of Ornithology's eBird database to test the hypothesis that coastal bird communities differ between marsh and mangrove habitats in Texas. We overlaid observations of passerines, wading birds, and shorebirds onto vegetation distribution maps of lower and central Texas in geographic information system (GIS) software. Using spatial analysis tools, we calculated the amount of marsh or mangrove area within a 100 m radius of reported observation GPS coordinates. To control for variation in birdwatcher data, we only used observations that were stationary or traveled within the 100m radius bounds. Furthermore, we limited total observation time to no more than three hours.

Areas where mangrove stands were present had significantly lower species richness but higher relative bird abundance. Mangrove areas had higher relative abundances of shorebirds, which tend to flock in large numbers. We hypothesize that these shorebirds are utilizing edge habitat around these mangrove stands. Marshes had higher abundances and species richness of passerine species than mangroves. Cosmopolitan blackbird species (Family Icteridae, especially grackles) comprised most of the passerines seen in mangroves. Marshes had higher abundances of probing wading birds, such as white ibis (*Eudocium albus*), but a similar number of stalking hunters, such as herons and egrets, as mangroves. The overlap in bird community composition between habitat types suggests that some bird species may utilize both vegetation types, but potentially for different purposes (e.g., foraging vs. roosting). Overall, our results suggest that shifts in vegetation structure within the marsh-mangrove ecotone will affect higher trophic levels.

Contact Information: Ashley A. Whitt, Department of Marine Biology, Texas A&M University at Galveston, 200 Seawolf Parkway, Galveston, TX 77551 USA, Phone: 612-708-2093, Email: whitta@tamug.edu

BOTTOM-UP EFFECTS OF MANGROVE STAND EXPANSION ON SALT MARSH PLANT AND ANIMAL ASSEMBLAGES: IMPLICATIONS FOR MANGROVE RESTORATION IN TEXAS

Anna R. Armitage[1]*, Hongyu Guo*[2]*, Sayatani Dastidar*[2]*, Zoe Hughes*[2]*, Carolyn A. Weaver*[1]*, Ashley Whitt*[1]*, Sean P. Charles*[3]*, John S. Kominoski,*[3] *and Steven C. Pennings*[2]

[1]Texas A&M University at Galveston, Galveston, TX, USA
[2]University of Houston, Houston, TX, USA
[3]Florida International University, Miami, FL, USA

Management of coastal wetland loss commonly includes restoration projects that will augment wetland ecological functions and economic values. Many restoration projects on the Gulf Coast of the United States focus on the re-establishment of grass and forb species that dominate low elevation marshes, which can substantially improve the production of some fisheries. However, as in many subtropical coastal environments, warming winter temperatures are contributing to a regime shift from marshes to woody mangrove swamps. Therefore, some coastal managers in this region have recently increased the use of black mangroves (Avicennia germinans) in restoration projects. Currently, however, there is little quantitative information comparing the ecological functions of marsh and mangrove systems within the Texas marsh-mangrove ecotone to inform the use of mangroves in Gulf Coast restoration.

Our goal was to quantify the bottom-up effects of this foundation species shift on coastal wetland plant and animal assemblages using a novel combination of surveys and a large experiment. In 2012, we thinned black mangroves in ten 24 x 42 m experimental plots on Harbor Island (Port Aransas, TX) to create a gradient (0-100%) of mangrove cover; cleared areas were colonized by marsh vegetation. In addition, we established several large survey plots at sites with either marsh or mangrove vegetation. Within all plots, we periodically recorded vascular plant density and diversity, counted epifaunal density, used pit traps to sample nekton, and recorded bird abundance. We also used the citizen science database eBird to compare bird use between the marsh and mangrove survey sites.

In plots with more than 50 % mangrove cover, marsh plant assemblages comprised < 25 % cover and were less diverse. Within marsh or mangrove stands, benthic epifauna and nekton densities were generally similar. These data suggested that tidal transients and resident fauna were not selective in terms of aboveground vegetation structure. However, mangroves were associated with lower soil organic content and caused more heterogeneous wrack accumulation patterns, suggesting that there may be differences in the trophic movement of carbon in marsh and mangrove habitats. Citizen science data indicated that avian species richness was higher in marsh than in mangrove areas, and there were differences in composition. For example, wintering shorebirds tended to be more diverse in marsh than in mangrove habitats. It is likely that birds selected habitat based on vegetation features, and a heterogeneous marsh-mangrove mosaic may facilitate a range of behaviors, including foraging and sheltering.

Overall, our results revealed that salt marsh and mangrove areas support different plant and animal assemblages. Therefore, the introduction of mangroves into salt marshes is likely to change a number of ecosystem characteristics. The ecosystem benefits of mangrove restoration likely will be maximized in areas where mangroves are already established.

Contact Information: Anna R. Armitage, Department of Marine Biology, Texas A&M University at Galveston, 200 Seawolf Parkway, Galveston, TX 77553 USA, Phone: 409-740-4842, Fax: 409-740-5001, Email: armitaga@tamug.edu

NUTRIENT ENRICHMENT SHIFTS MANGROVE SIZE DISTRIBUTION WITHIN THE MANGROVE-MARSH ECOTONE

Carolyn A. Weaver[1] *and* ***Anna R. Armitage***[1,2]
[1]Texas A&M University, College Station, TX, USA
[2]Texas A&M University at Galveston, Galveston, TX, USA

Global changes are driving shifts in plant species distribution and dominance, particularly within ecotones. In many coastal mangrove-marsh ecotones, factors such as increased temperatures and elevated CO_2 are facilitating mangrove expansion. In the Northern Gulf of Mexico, reduced frequency, duration, and severity of freezing events have contributed to mangrove stand expansion, often encroaching into salt marsh habitat. Shifts in dominant vegetation can also be influenced by local factors, such as anthropogenic nutrient enrichment. In this study, we investigated how nutrient addition would impact mangrove encroachment and salt marsh displacement over time, within *in situ* co-occurring stands. We fertilized mixed *Avicennia germinans* (black mangrove) and *Spartina alterniflora* (smooth cordgrass) stands in Port Aransas, TX. After four growing seasons (2010-2013) of continuous fertilization, *Avicennia* metrics were consistently more positively influenced by nutrient enrichment than *Spartina*. Enrichment promoted *Avicennia* growth; for example, fertilized mangrove maximum height was 46% taller than in control plots. Additionally, the densities of mangroves in larger size classes significantly increased in fertilized plots over the course of the experiment. Fertilization promoted increased growth in *Avicennia* and shifted mangrove size distribution, potentially improving the competitive advantage over marsh grass. We propose that excess nutrient input may act as a positive feedback for temperature-driven mangrove encroachment, thereby accelerating marsh displacement. Coastal areas within the mangrove-marsh ecotone with higher nutrient runoff may be more susceptible to this vegetation shift, which could have large implications for coastal ecosystem functions.

Contact Information: Carolyn Weaver, Texas A&M University at Galveston, P.O. Box 1675, Galveston, TX, USA 77553-1675, Phone: 409-741-4070, Email: caweaver@tamu.edu

MANGROVE RESPONSE TO ENVIRONMENTAL CHANGE IN NORTHERN AUSTRALIA

Emma Asbridge[1], *Richard Lucas[1], Catherine Ticehurst[2] and Neil Flood[3]*

[1] The University of New South Wales (UNSW), Kensington, NSW, Australia
[2] CSIRO Land and Water, Black Mountain, ACT, Australia
[3] Remote Sensing Centre, Brisbane, QLD, Australia

Globally, mangroves are responding to coastal environmental change but separating human-induced from natural events and processes is often difficult due to the prevalence of human disturbance. For this reason, focus needs to be on protected sites (e.g., national parks) or land that is far away from settlement and infrastructure. This study therefore considered the response of mangroves in Kakadu National Park (KNP) and the Gulf of Carpentaria, northern Australia, as these have remained largely undisturbed from anthropogenic activities, at least since European settlement. Hence, changes observed here can be attributed largely to a natural cause.

This study sought to establish and quantify mangrove change over the period of Landsat Thematic Mapper (TM), Enhanced TM (ETM+) and Operational Land Imager (OLI) observations (1987-2014) and explain natural processes that may have occurred. By comparing classifications generated from a time-series of Landsat-derived Foliage Projective Cover (FPC) data, mangroves in the Gulf of Carpentaria were observed to have extended seawards along the coastline, with inland intrusion occurring along many of the tidal rivers and rivulets. Landward expansion was concentrated within the Mornington Inlet catchment and was attributed to sea level rise linked to the Madden-Julian Oscillation (MJO). Persistent inundation on the landward margins during the wet season made conditions (e.g., salinity) more suitable for mangroves, allowing the forests to compete with saltmarshes and expand landwards.

At the mouth of the Leichhardt River, the main periods of seaward extension were attributed to discharge of sediments in the near shore, through peak flood events, as determined from river gauge data, open water maps generated using Landsat and the MODIS Open Water Likelihood (OWL) algorithm. Colonization of sediments occurred approximately 2 years after the flood event. Light Detection and Ranging data (LiDAR) identified that seaward movement of mangroves occurred in phases, with distinct structural zones developing following each large rainfall and discharge event. Movement of species (primarily *R. stylosa*, *C. tagal* and *A. marina*) within the mangrove zone was evident, reflecting their physiological adaption to more or less favourable conditions. By contrast, seaward expansion along the Mornington Inlet was gradual and was attributed to prolonged inundation due to the low-lying nature of the region. This inundation continually pulses sediments into the near shore, thereby allowing for regular seaward extension.

Similar trends of seaward and landward expansion were observed in KNP. For four catchments within the Alligator Rivers Region of KNP, annual maps of mangrove extent were generated between 1987 and 2014 using a rule based classification of Landsat-derived FPC data and a Canopy Height Model (CHM) generated from Shuttle Radar Topographic Mission (SRTM) data. The classifications were validated against maps generated from true colour aerial photography (1991), Compact Airborne Spectrographic Imager (2002) and LiDAR (2014) data, producing an average overall accuracy > 80 %. The changes in extent observed using the 25 m Landsat data corresponded to those detected through time-series comparison of the three airborne datasets. Over the time-series, fluctuations in mangrove extent and also the FPC of communities dominated by different species was observed with these corresponding to changes in both sea level and river discharge (both of which relate to rainfall). The study concluded that mangroves in this region are responding to a combination of related factors (primarily sea level and river discharge).

This research has demonstrated the dynamic nature of mangroves and their use as key indicators of change in response to climate-related phenomena (primarily rises in sea level and increases in rainfall). Furthermore, the study has indicated that early recognitions of the impact of a changing climate on globally important ecosystems is fundamental for conserving and managing environments of international, national and local importance.

Contact Information: Emma Asbridge, Centre for Ecosystem Sciences, Biological, Earth and Environmental Sciences, the University of New South Wales, High Street, Kensington, NSW 2052, Australia, Phone: 0435714228, Email: e.asbridge@unsw.edu.au

CONTRIBUTION OF PREVALENT SOLUTES CONSTITUITIVELY INVOLVED IN OSMOTIC ADJUSTMNET IN MANGROVES FROM PAKISTAN

Farzeen Khan[1] *and* ***Irfan Aziz***[2]

[1]Govt. College

[2]Institute of Sustainable Halophyte Utilization, University of Karachi, Karachi-75270, Pakistan

Mangroves are known to possess high levels of salinity tolerance, yet accumulation of salts may induce subcellular changes both in physiological and biochemical parameters. Salt induced solute accumulation is a well known feature for osmotic adjustment in plants under salt stress. Concomitantly, synthesis of compatible osmolytes involves energy cost thereby reducing plant growth. This study highlights the contribution of different solutes to leaf osmolality in mangroves and possible metabolic shifts under saline conditions. Seedlings of three mangroves viz., *Avicennia marina*, *Ceriops tagal* and *Rhizophora mucronata* were exposed to different sea salt concentrations [0% seawater(O.P = 0.02 MPa), 50% seawater (O.P =1.4), 125% seawater for *C. tagal* only (O.P =3.5 MPa) and 150% seawater for *A. marina* and *R. mucronata* (4.2 MPa)]. Plants were raised in a netted green house under ambient environmental conditions to determine growth, leaf osmolality and relative solute (organic/inorganic) contribution. Fresh and dry biomass in all mangroves increased under optimal salinity (1.4 MPa) with tallest individuals as well as higher RGR (relative growth rates) in *A. marina*. Higher RGR could be attributed to low bulk elasticity (ε) in *A. marina* and lower RGR to increased sclerophylly in *C.tagal*. A 50% growth reduction was observed in supra-optimal salinities (3.5 / 4.2 MPa) with lowest RGR and biomass in *C. tagal*. Leaf osmolality ($\Psi\pi$) progressively increased with increases in salinity in *C. tagal* & *R. mucronata*. On the contrary, a rapid increase with the introduction of salinity was found in A marina. Higher osmolalities could be accounted for an increase in the amount of sodium (Na^+) which contributed the most among all tested solutes. HPLC/GC-MS profiles indicate that contribution of Glycinebetaine (GB) in *A. marina* and total soluble sugars in *C. tagal* and *R. mucronata* followed by sugar alcohols had an important role in osmotic adjustment. Increasing organic:inorganic ratio under saline conditions and Na^+ partitioning indicates a possible metabolic shift in plants at the cost of growth.

Contact Information: Irfan Azziz, Institute of Sustainable Halophyte Utilization, University of Karachi, Karachi-75270, Pakistan, Phone: +923218962445, Email: irfanaziz@uok.edu.pk

MARSHES TO MANGROVES: WHAT DO WE REALLY KNOW ABOUT THE FUNCTIONAL VALUES OF TIDAL WETLANDS FOR FISHERY SPECIES?

Ronald Baker
James Cook University, Townsville, QLD, Australia

Mangroves, salt marshes, and other vegetated tidal wetlands are broadly considered to confer equivalent values to mobile aquatic fauna; they are believed to provide rich foraging grounds and refuge from predation. Around the globe, tidal wetlands are considered particularly important in supporting many fishery species whose life-cycles bring them into coastal ecosystems for part of their lives. Despite their apparent immense value providing food security and supporting fisheries, the ways that mangroves and other wetlands actually support fishery species remains unclear. Findings in recent years suggest that the paradigms of food and refuge are overly simplistic. In order to effectively manage and maintain the values of these ecosystems in the face of ongoing development and an ever-changing climate, it is critical we understand the mechanisms and processes that underpin their values.

Using published literature and insights gained from 15 years of research into the functioning of coastal wetland nurseries, this talk will examine what we really know about the functional values of tidal wetlands in general, and mangroves in particular, in supporting fishery species. It will explore the evidence for direct occupation of vegetated wetlands, their role as foraging grounds through direct access, trophic relays, and outwelling, and their value in providing refuge from predation.

Rather than being densely occupied habitats, the evidence suggests a much more limited direct role of mangroves in providing feeding grounds and refuges for fishery species. Instead, mangroves appear to be an important component of an inter-connected coastal seascape that must be understood and managed at a broader scale to ensure the ongoing support of fisheries.

Contact Information: Ronald Baker, College of Marine and Environmental Sciences, Bld. 145, James Cook University, Townsville, QLD, Australia 4811, Phone: +61 7 4753 8538, Email: ronald.baker@jcu.edu.au

WHAT DETERMINES THE SEAWARD LIMIT OF MANGROVE AND SALT-MARSH VEGETATION?

***Thorsten Balke*[1]*, Michael Kleyer*[2] *and Tjeerd J. Bouma*[3]**

1University of Glasgow, Glasgow, UK
2University of Oldenburg, Oldenburg, Germany
3NIOZ Royal Netherlands Institute for Sea Research, Yerseke, The Netherlands

Intertidal wetlands such as mangroves and salt marshes are increasingly valued for their ecosystem services, yet we lack sufficient understanding of their lateral dynamics to predict future development. Knowledge gaps are also evident from poor success of restoration efforts at the transition zone towards the open tidal flat.

We present the results of lab and field experiments to determine bottlenecks to vegetation establishment of mangrove and salt marsh vegetation. By means of GIS and meta-analysis, a global relationship between tidal range and the elevation of the seaward wetland border is established. Short and long term variability in flooding regime at this critical elevation are determined from global tide gauge data.

Our study highlights that flooding frequency and not duration is the main bottleneck to seaward expansion of mangroves and salt marshes whereas differences between meso- to macrotidal coasts and microtidal wetlands exist. Tidal range is locally changing due to global sea-level rise and sometimes more importantly coastal engineering. We propose that understanding the effects of locally changing tidal range is crucial if we want to predict future mangrove development in times of climate change.

Contact Information: Thorsten Balke, School of Geographical and Earth Sciences, University of Glasgow, Glasgow G12 8QQ, United Kingdom, Email: balke.thorsten@gmail.com

MODELING MANGROVE RANGE LIMIT SHIFTS IN THE NORTH PACIFIC COAST IN RESPONSE TO CLIMATE CHANGE

Kyle C. Cavanaugh, and ***Remi Bardou***
University California, Los Angeles, CA, USA

This study examines the dynamics of mangroves on the Pacific coast of North America near their poleward range limit in Baja California, Mexico. A number of studies have documented expansion of mangroves near their range limits in other parts of the world, and our objective was to determine whether such expansion is currently occurring in Baja California. We also examined how mangrove range limits may have shifted under past climatic fluctuations. We used remote sensing in order to map the current extent of mangroves and salt marshes, from the south end of Baja California to Southern California. We then used species distribution modeling to reconstruct past mangroves habitats and predict their future distribution. Our results suggest that historic mangroves distributions along the Pacific coast have been highly dynamic. However, by comparing current mangroves distribution data with modeling results, we conclude that mangrove distribution in this region are not only driven by climate factors, but seem to also be limited by dispersal constraints. By using high resolution oceanic currents modeling, we have been able to simulate mangroves propagules dispersal potential, and our preliminary results show that mangroves habitat seems to be dictated more by dispersal barrier than by climatic factors.

Contact Information: Remi Bardou, University of California, Los Angeles, 1255 Bunche Hall, Los Angeles, CA 90095, Email: remi.bardou@ucla.edu

WARMING AND MANGROVE ENCROACHMENT INFLUENCE MARSH MICROBIAL COMMUNITY COMPOSITION

Chelsea Barreto[1], *Dennis Wykoff[1], Glenn Coldren[1], Ember Morrissey, and Samantha Chapman[1]*
[1]Villanova University, Villanova, PA, USA
[2]Northern Arizona University, Flagstaff, AZ, USA

Mangroves are encroaching into saltmarsh ecosystems globally due to climate change. It is unknown how mangrove expansion will affect the belowground processes important for coastal wetland viability such as root growth and microbial organic matter decomposition. Wetland soil microbial communities, which partially regulate organic matter decomposition may respond to this dominant plant range shift and to climate warming directly. We examined how wetland soil microbial communities are being affected by 1) mangrove encroachment and 2) chronic air temperature warming. Using a two-year passive warming experiment and plots positioned across a mangrove-marsh ecotone, we assessed microbial community composition with 16S-based DNA sequencing and qPCR. Both warming and mangrove invasion significantly impacted microbial community structure. For instance, abundance of the bacterial group *Rhodospirillales,* which are commonly found in marine or freshwater environments and are mainly anoxic, decreased in warming plots. This decrease could indicate that warming increases the amount of oxygen entering the soils via plant roots. Similarly, the abundance of *Anaerolineales,* another group of anaerobic bacteria*,* decreased in mangrove-encroached plots, perhaps due to increased root biomass. Finally, the abundance of *Acidobacteriales* increased in mangrove-encroached plots, perhaps due to increased root exudates or carbon inputs driven by mangrove encroachment. In support of these explanations, we found that root biomass correlates with abundance of key bacterial groups, indicating that root processes could be a driver of community composition. Our findings on soil bacterial shifts due to global change may provide early indications of how soil processes important for maintaining surface elevation will change with global change.

Contact Information: Chelsea Barreto, Villanova University, 800 Lancaster Ave, Villanova, PA 19085,
Phone: 908-839-5596, Email: cbarreto@villanova.edu

MANGROVE COMMUNITY STRUCTURE ANALYSIS IN WESTERN SUNDARBANS IN INDIA-A GUIDE FOR DESIGNING MANGROVE RESTORATION

Sandip Kumar Basak[1*], *Tapan Sutradhar[2], Momtaj Begam[2], Krishna Ray[2]*

[1]Department of Botany, Kandi Raj College, Kandi, Murshidabad, West Bengal, India

[2]Environmental Biotechnology Group, Department of Botany, West Bengal State University, Barasat, West Bengal, India

Mangroves are responsible for sediment accretion and augment the geo-morphological process of land building. These morphological developments are continuous, causing habitat modification and hence mangrove distributional pattern is a dynamic phenomenon across the coastal mudflats. The earlier theory of fixed zonation of mangroves reflecting successional pattern is no longer valid. For example, as per our observation, *Excoecaria agallocha*, once considered to be a back mangrove, is now found to be a frequent frontliner in the mudflats of western part of Indian Sundarbans. The ecological restoration program of mangroves should be based on the study of this dynamic successional pattern. Therefore careful study of the neighboring mangrove community structure before designing an ecological mangrove restoration program is indispensable. To carry out successfully, our mangrove restoration program in western part of Indian Sundarbans, plantations of mangrove saplings follow the existing community pattern we observed along the neighboring mangrove forests. We studied in detail the community structure of mangrove forests in several neighboring islands in western Sundarban. Our study not only included the pristine vegetation, we also analyzed mangroves and its associate communities from the adjoining degraded mangrove pockets. A distinct difference in the trend of mangrove succession and distribution is evident among degraded and non-degraded mangrove stands. The community structure, species diversity, composition of homogeneous and heterogenous community with dominant species, classification of distinct community types and association of species are extensively studied from our 10 m X 10 m quadrat data spanning a number of islands of western Sundarbans. Two-Way Indicator Species Analysis (TWINSPAN) was used as the classification method and the species diversity and dominance indices were calculated in PAST software. Percentage similarity in species composition between each pair of stands was calculated using Sørensen's similarity index (S). The distributional pattern observed proved to be unique in many aspects and deviated from the conventional succession trend of mangroves, establishing the dynamic nature of mangrove habitat due to erosion/ accretion controlling the mudflat stability in Indian Sundarbans.

Contact Information: Sandip Kumar Basak, Associate Professor, Kandi Raj College, Department of Botany, Kandi, Murshidabad, West Bengal 742137, India; PH 919434353556 ; FX 919434353556; Email: sandipbasak9592@gmail.com

ASSESSMENT OF MANGROVE VEGETATION BASED ON GROUND-TRUTH AND REMOTE SENSING APPLICATIONS AT BRUNEI BAY, EAST MALAYSIA

***Behara Satyanarayana*[1,2,3]*, Aidy M. Muslim*[1]*, Mohd-Lokman Husain*[1]*, Nurul Amira Izzaty Binti Horsali*[1]*, Nurul Ashikin Binti Mat Zauki*[1] *and Farid Dahdouh-Guebas*[2,3]**

[1]Mangrove Research Unit (MARU), INOS, UMT, Kuala Terengganu, Malaysia
[2]Laboratory of Systems Ecology and Resource Management, ULB, Brussels, Belgium
[3]Laboratory of Plant Biology and Nature Management, VUB, Brussels, Belgium

Out of 709,700 ha mangrove cover in Malaysia, East Malaysia (i.e. Sabah and Sarawak) supports as high as 596,867.90 ha while West (Peninsular) Malaysia host only 112,832.10 ha. The mangrove vegetation at Brunei Bay is jointly shared and administered by both East Malaysia as well as Brunei Darussalam. There are four major estuaries namely, Limbang, Sundar, Weston and Menumbok that support the entire stretch of bay-mangrove complexes. The present study, based on ground-truth (Point Centred Quarter Method - PCQM) and remote sensing (Advanced Land Observation Satellite – ALOS) data, revealed, for the first time in peer-reviewed scientific literature several interesting observations on mangrove species composition/distribution in the area under the jurisdiction of East Malaysia, probably one of the pristine mangrove sites in the country. Among the four estuaries, Limbang and Menumbok showed higher tree density and basal area (density, 101-125 stems 0.1 ha^{-1} and basal area, 93.3-99.5 m^2 0.1 ha^{-1}) which indicates a more mature nature of vegetation than to Sundar and Weston (density, 77-106 stems 0.1 ha^{-1} and basal area, 15.7-28.3 m^2 0.1 ha^{-1}) (One-way ANOVA, $P = 0.2$ for density and $P = 0.03$ for basal area). Also, the Complexity Index was high in the order of Menumbok > Limbang > Weston > Sundar and evident for less/undisturbed nature of mangroves at the both former locations. From the supervised classification of ALOS data (ArcMap *v*.10), it was possible to map the distribution of five dominant species, notably *Nypa fruticans*, *Rhizophora apiculata*, *Sonneratia caseolaris*, *S. alba* and *Xylocarpus granatum* (accuracy: 81%). The area statistics show that the extent of Malaysian mangrove cover at Brunei Bay is 35,183.74 ha where Limbang occupied 5,011.42 ha, Sundar (up to Sipitang village) 9,606. 46 ha, and Weston + Menumbok together 20,565.86 ha. Both ground-truth and remote sensing based observations stand complementary to each other and represented the distribution of *Sonneratia* spp. as pioneer group of vegetation at shallow river mouths (depth, 1.8-2.5 m), *N. fruticans* in the areas with a perennial input of freshwater (salinity, 0.6-21.3‰), *R. apiculata* in the places of strong neritic incursion (22.8-27.9‰), and *X. granatum* in presumably interior/elevated grounds. The present results would be able to assist not only for local monitoring and management, but also as base-line study for future mangrove investigations at Brunei Bay.

Contact Information: Behara Satyanarayana, Institute of Oceanography and Environment, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Malaysia, Phone: +60 179525529, Email: satyam2149@gmail.com

RECRUITMENT OF *AVICENNIA GERMINANS* IN A MOSAIC SALTMARSH: A FIELD STUDY OF PATCH-SCALE PLANT INTERACTIONS

Susan S. Bell
University of South Florida, Tampa, FL, USA

Interactions among plants at ecotones that affect recruitment either by influencing seed dispersal or seedling establishment may shape patterns of range expansion, such as mangrove encroachment into saltmarsh habitats as sea-level rises. Saltmarsh plants have been demonstrated to influence dispersal, entrapment, and establishment of mangrove propagules. Various field and greenhouse studies have shown that saltmarsh plants can either facilitate or suppress mangrove seedling growth depending upon environmental context (i.e., latitude and intertidal position) and abiotic conditions (i.e., inundation and salinity). However, it is not yet known whether saltmarsh taxa also influence mangrove recruitment via associational resistance or susceptibility to herbivory. An experimental field study was conducted within a mosaic saltmarsh habitat at the landward edge of a mangrove forest to investigate whether the species composition of saltmarsh vegetation patches into which mangrove propagules disperse differentially influences the fate of mangrove seedlings. The relative susceptibility of propagules to herbivory within patches containing different saltmarsh taxa was examined as a potential mechanism operating on mangrove recruitment. Experimental plots were weeded to establish 3 saltmarsh treatments: 1) the grass *Monanthochloe littoralis* in monoculture 2) the grass *Sporobolus virginicus* in monoculture, and 3) polycultures containing both grasses (*M. littoralis* and *S. virginicus*) and 1 to 4 other plant taxa. Propagules of *A. germinans* were emplaced into plots and were monitored for 38 weeks. Seedling establishment was significantly reduced in *S. virginicus* monocultures relative to *M. littoralis* monocultures. Mangrove mortality due to herbivory was less frequent in *M. littoralis* monocultures relative to treatments containing *S. virginicus*. Patch-scale heterogeneity in saltmarsh groundcover at landward margins of fringing mangrove forests may influence spatial patterns of mangrove recruitment into higher tidal elevation areas.

Contact Information: Susan S. Bell, Department of Integrative Biology , University of South Florida, 4202 E. Fowler Ave, Tampa, FL, USA 33620-5200, Phone: 813-974-2542, Email: sbell@usf.edu

QUANTIFYING THE FISHERIES ECOSYSTEM SERVICES OF SINGAPORE'S MANGROVES

***Rayna Benzeev*[1]*, Neil Hutchinson*[2]*, and Dan Friess*[3]**

[1]Fulbright US Student Program, National University of Singapore, Singapore
[2]James Cook University, Singapore Campus, Singapore, Singapore
[3]Department of Geography, National University of Singapore, Singapore, Singapore

Rapid development has segmented Singapore's mangrove habitat into few separated patches, with potential implications for organisms that rely on connectivity within the ecosystem. Fish populations, for example, may be impacted by this fragmentation and development, as many species rely on mangroves as nursery habitat for juveniles. In our study, we examine several sites along Singapore's mangrove-urban interface to determine the extent to which urbanization of mangrove habitats influences Singapore's fisheries resources. By catching fish with traps and nets as well as deploying underwater video cameras, we aim to quantify fish stocks through an ecosystems services perspective. In this way, we not only consider the value of the fisheries provisioning services provided by mangroves, but also the nursery regulating services. By quantifying these services at each mangrove site, we hope to assess the extent to which mangrove habitat contributes to Singapore's fisheries resources and how this changes over an increasingly urbanized landscape.

Contact Information: Rayna Benzeev, National University of Singapore, Geography 1, Arts Link, Singapore 117570; PH 6584253588; Email: rayna.benzeev@gmail.com

FACILITATION AND MANGROVE RESTORATION: CONCEPT, EVIDENCE AND PRACTICES

Uta Berger[1], *Aor Pranchai, Juliane Vogt, and Uwe Grüters*
[1]Institute of Forest Growth and Computer Science, TU Dresden, Germany
[2]Department of Silviculture, Faculty of Forestry, Kasetsart University, Thailand

In the face of an increased mangrove loss and degradation worldwide, there is an urgent need for the development of novel, effective, and low cost measures for restoration and the rehabilitation of ecosystem functioning. Because facilitation has been recognized as driving force in terrestrial plant populations, it is a promising ecological mechanism for the development of efficient restoration measures. Nevertheless, the role of positive interactions among neighbouring plants is almost overlooked in mangrove restoration so far. Moreover, traditional practices seem to contradict the empirical evidence that mangroves switch from tree to shrub architecture under harsh conditions and are then able to nurse seedlings and saplings initiating the subsequent the regeneration of mangrove stands. Instead, planting is typically done in a row securing a minimum distance of the saplings considering expecting neighbourhood competition and subsequent self-thinning of the cohort.

Based on a case study from north Brazil, we discussed the role of positive plant interaction for the restoration of degraded mangrove areas. We analysed a quasi time-series of a dwarf forest recovering from a stand-replacing event caused by a road construction in 1974. Infrequent inundation and high pore water salinity limited tree growth and canopy closure for more than thirty years.

Shrubs and seedlings were stem-mapped together with herbaceous ground vegetation and wood debris along vegetation gradients. The spatial distribution of plants and covariates was studied using point pattern analysis, point process models, and the individual-based mangrove simulator mesoFON in order to infer underlying ecological processes, such as seed dispersal, seedling establishment, tree recruitment and tree interaction.

Our results confirm that salt-marsh vegetation acts as the starting point for mangrove re-colonization and indicate that positive interactions among trees accelerate forest regeneration. However, positive associations between tree height, internode length and basal stem diameter decreased with tree density indicating a shift from facilitation to a balance between facilitation and competition during the regeneration process, which is in agreement with the current theoretical concepts discussed in terrestrial plant ecology.

Based on our findings, we present attempts to intergrade facilitation into mainstream plant ecology, discuss their relevance for the development of efficient restoration measures and for improving our understanding of the response of mangrove systems to changes in environmental driving factors.

Contact Information: Uta Berger, Institute of Forest Growth and Computer Sciences, Technische Universität Dresden, Pienner Straße 8, D-01737 Tharandt, Germany, Phone: +49-351-463-31613,
Email: uta.berger@tu-dresden.de

ALLS ON RHIZOPHORA MANGLE: RELATIONSHIP WITH ENVIRONMENTAL VARIABLES AND EFFECTS ON VEGETATION

***Sara Betancur**, Juan D. Mira and Ligia E. Urrego*

Universidad Nacional de Colombia, Sede Medellín, Departamento de Ciencias Forestales, AA569 Medellín, Colombia.

Beaches and estuaries of the gulf of Urabá at the Colombian Caribbean, are mainly cover by extensive mangrove forests and encloses about 4000 ha. However, most trees of these mangrove forests show structures like tumors, named galls, on stems and aerial roots of *Rhizophora mangle.* Although galls phenomenon has occurred in different zones of the world, the role of the environmental conditions on the incidence of the illness, the effect of the galls in the vegetation structure and thus in the ecological equilibrium and the environmental services that the ecosystem offers, are unknown. In order to identify the environmental conditions that enable the infection and the effect of this illness over the vegetation, 27 circular 500m^2 plots were established in both forests with presence and lack of galls. In these plots height, DBH and number of galls of each tree and natural regeneration dynamics (survival mortality and recruitment) were measured. In addition, in each plot, the flooding or water table level, sedimentation rate, pore-water pH, salinity and dissolved solids were recorded, as well as trace metals and metalloids present in soil samples. We found that the presence of galls is concentrated in mangroves along the Atrato river delta with an average infection of 49% (19 - 96%) of the red mangrove trees. The statistical analysis showed an increasing probability of infection with the diameter of the trees. The infection symptoms appeared on young trees (from 2.5 cm with DBH). The diameter-height ratio showed differences between healthy and infected trees. Significant differences were found in the environmental conditions between sites. Mangroves at the Atrato river delta, highly infected, were characterized by low salinity, high alluvial sedimentation rate, high soil organic matter percentages and concentrations of Cu, Mn and As, but low B concentration. Instead, mangroves at the Rionegro bay, that lack the infection, were characterized by the predominance of marine conditions, especially higher concentrations of Ca and Mg, and higher pore-water salinity. The principal component analysis showed a strong relationship between these environmental variables and the gall presence. Besides, variables as Organic Carbon, Organic matter; Cu and Fe had quadratic correlation with the galls. Furthermore growth and mortality of seedlings and trees do not increase with the presence of galls, we did not find significant differences between places with and without galls.

Contact Information: Sara Betancur, Universidad Nacional de Colombia, Medellín, Colombia,
Email: sbetancv@unal.edu.co

MACRONUTRIENT PROCESSING AND RETENTION IN MANGROVE ENVIRONMENTS OF WESTERN AFRICA: A CASE STUDY FROM LIBERIA, SENEGAL AND GABON

***Rupesh K Bhomia*[1]** *and J. Boone Kauffman*[2]

[1]Soil and Water Science Dept., University of Florida, Gainesville, FL, USA

[2]Fisheries and Wildlife Dept., Oregon State University, Corvallis, OR, USA

Macronutrient cycling in the environment play an important role in maintaining our planet habitable. Cycling and storage of organic carbon (C) in the mangrove ecosystems is responsible for variety of ecosystem functions and services. Although mangroves are considered as high priorities in climate change adaptation and mitigation strategies due to their C sequestration potential, mangroves are among the least studied ecosystems.

We measured total ecosystem carbon stocks including above and below-ground biomass, dead and downed woody debris and total soil carbon in three West African countries- Liberia, Senegal and Gabon (north and south). These sites represented a gradient of annual rainfall, varying soil pH and salinity conditions, and different vegetation composition and structure. Ecosystem C stocks ranged from 450 to 850 Mg C ha^{-1} across these sites. Mean ecosystem C stocks in Liberia and Senegal were 864.9 ± 100 Mg C ha^{-1} and 654.0 ± 101Mg C ha^{-1}, respectively. Mean ecosystem C stocks in South and North Gabon were 447.9 ± 39.8 Mg C ha^{-1} and 984.8 ± 32.6 Mg C ha^{-1}, respectively.

Comparison of C stocks between these sites will enable to discern differences in blue carbon storages across rainfall, salinity and latitudinal gradients. If mangroves areas are converted into different land use type, estimates of subsequent losses in carbon in the form of CO^2 emissions will be presented.

Contact Information: Wetland Biogeochemistry Lab, Soil and Water Science Dept., University of Florida, Gainesville, 32611; Tel: Cell - 352-870-2461, Email: rbhomia@ufl.edu

PRODUCTIVITY OF TIDAL BORNE ACCUMULATED SEDIMENTS IN A TROPICAL MANGROVE OF SARAWAK, MALAYSIA

*M M Hoque[1], M K Abu Hena[1], M H Idris[1], H A Osumanu[2], M M Billah[1], M N Nesarul[1], **M K A Bhuiyan**[3]*

[1]Department of Animal Science and Fishery, Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Sarawak Campus, Sarawak, Malaysia

[2]Department of Crop Science, Faculty of Agriculture and Food Sciences Universiti Putra Malaysia Campus Bintulu, Sarawak, Malaysia

[3]Faculty of Marine and Environmental Sciences, University of Cadiz, Puerto Real Campus, Cadiz, Spain

Mangroves are frequently inundated by tidal action during which enormous amount of sediments are trapped and the productive roles of these sediments are less studied for tropical mangroves. This study was carried out to explore the productive and nutritive roles of tidal borne sediments in a pristine mangrove area of Sarawak, Malaysia. Sediment traps were used to trap the tidal borne sediments for one year. The tidal sediments were found to be rich in terms of cation exchange capacity (17.05 ± 1.28 cmol/kg sediments), organic matter (15.39 ± 1.68%), organic carbon (13.17 ± 2.98%), nutrients (Carbon 14.52 ± 3.29%, Nitrogen 11.61 ± 2.24 mg/g, Sulphur 9.58 ± 0.79 mg/g, Phosphorous 1.76 ± 0.35mg/g, Potassium 3.45 ± 0.19 mg/g, Calcium 34.31 ± 3.47 mg/g, Magnesium 18.48 ± 2.49 mg/g and Sodium 16.21±1.08 mg/g). Significant positive correlation ($p < 0.01$) of organic matter and organic carbon with nitrogen, sulphur, phosphorus and calcium are the indication of potential sources of these nutrients from the organic matter. Besides, significant correlation ($p < 0.05$) of sediment nutrients with the nutrient concentrations of leaf, stipules, flower, propagules, stem, bark, roots of *Rhizophora apiculata* and *Xylocapus granatum* trees, saplings and seedlings are the clear indication of nutritive roles of tidal borne sediments in the growth, health and productivity in the mangrove ecosystem. This result will provide baseline information in regards to productive roles of a pristine mangrove of Sarawak, Malaysia. Continued and long term research including various influencing parameters will help develop a model of sedimentation process for the coastal area of the tropical region.

Contact Information: Md. Khurshid Alam Bhuiyan, Joint Doctorate Fellow: Erasmus Mundus PhD in Marine and Coastal Management, Faculty of Marine and Environmental Sciences, University of Cadiz, Puerto Real Campus, 11519, Spain, Phone: +34 631-683-856, Email: mohammed.bhuiyan@alum.uca.es

ESTIMATION OF CARBON STOCKS IN COLOMBIAN MANGROVES AND ASSOCIATED UNCERTAINTIES

***Jhoanata M. Bolivar**, and Carlos A. Sierra*
Max Planck Institute for Biogeochemistry

We estimated carbon stocks in aboveground biomass (AGB) for mangroves in the Caribbeanand Pacific coasts of Colombia using existing information on carbon density and area. We estimated a national carbon stock in AGB for Colombian mangroves as 14.95 ± 2.72 TgC (mean ± SE), from which 2.20 ± 0.86 TgC were in the Caribbean and 9.61 ± 2.78 TgC were in the Pacific coast. Uncertainty for total AGB in Colombian mangroves, reported as SE/mean in percentage, was around 18% at the national level, around 32% in the Caribbean coast, and between 25% and 34% in the Pacific coast. This uncertainty was more influenced by uncertainties associated with the estimation of mangrove area for the Caribbean coast, while for the Pacific coast it was more influenced by the uncertainties associated with AGB density. This difference is the result of a contrasting availability of AGB data for both coasts. For the Caribbean coast we found a higher number of AGB data for locations with contrasting environmental conditions; in the case of the Pacific coast, despite a larger mangrove area in comparison to the Caribbean coast and higher variability in terms of structure and species composition, there are only reported data of AGB for one location. Comparison between observed AGB data and estimations from global models showed that they underestimate AGB for Colombian mangroves. We reparameterized these models with our data, but found poor goodness- of-fit statistics for these model structures. We propose therefore five models new potential statistical models to predict AGB in Colombian mangroves based on climatic data. In all cases, models including enhanced vegetation index (EVI) and mean temperature of driest quarter (BIO9) were the best.

Contact Information: Jhoanata Bolivar, Max Planck Institute for Biogeochemistry, Hans-Kno¨ll-Str. 10, 07745 Jena, Germany, Phone: + 49 3641 576152, E-mail: tbolivar@bgc-jena.mpg.de

MANGROVE MICROBIOME DYNAMICS IN CRAB BIOTURBATED SEDIMENT

***Jenny Marie Booth**, Marco Fusi, Ramona Marasco and Daniele Daffonchio*

Biological and Environmental Sciences and Engineering Division, King Abdullah University of Science and Technology, Thuwal, Kingdom of Saudi Arabia

Plant, animal and microbial community interactions form the basis of mangrove forest resilience to environmental changes, such as anthropogenic pollution, global warming, sea-level rise and ocean acidification. Despite its importance in overall ecosystem functioning, the sediment microbial component and its interactions has been overlooked. Notably absent are studies of Red Sea mangroves, which are of particular interest due to their presence at the northern limit of mangrove distribution and the severe conditions imposed by this region, foreseen to become sharply exacerbated under climate change.

In this study we investigate the mangrove sediment bacterial microbiome at three depth levels (1, 2 and 5 cm, defined here as surface, subsurface and deep sediment, respectively) in a natural *Avicennia marina* stand in the Farasan Archipelago along the south coast of Saudi Arabia (16°45'8.07"N; 42° 2'17.39"E), with two distinct types of macrobenthonic bioturbation by ocypodid and sesarmid crabs. We then examined ocypodid burrow sediment bacterial communities on a fine-scale using a radial profiling method, employing molecular analysis of the 16S rRNA gene with the high-throughput Illumina platform to resolve the bacterial community diversity and using O_2, H_2S, pH and redox microsensors to characterize the sediment environment.

The mangrove environment selects for a unique and diverse microbiome. Sediment communities in bulk sediment immediately adjacent to the mangrove had a different bacterial composition and a comparatively lower species richness and evenness than mangrove sediment. Inside the forest we detected a strong influence of crab family-specific bioturbation on the microbiome composition. Notably, we found that sesarmid crab bioturbation enriches deep sediment, considered to be anaerobic, with bacteria belonging to the Piscirickettsiaceae family. The large contribution of this aerobic group to deep sediment communities supports the infiltration of oxygen below the sediment surface facilitated by crab bioturbation, also corroborated by oxygen microsensor profiles. On a finer-scale, ocypodid burrows strongly shape the sediment communities with stratification in terms of depth (surface, subsurface and deep sediment) and distance from the burrow wall along a vertical gradient from the burrow wall to 4.5 cm horizontal distance. Certain families known to respire aerobically were better represented below the surface.

In this study we highlight the strong relationship between crab bioturbation and sediment bacteria diversity, providing a comprehensive description of how the bacterial microbiome is influenced by sediment engineering. The influence of macrofauna on the sediment microbiome may become increasingly important in the face of climate change, affecting microbe-driven ecosystem processes and the overall system functioning.

Contact Information: Jenny Booth, KAUST, P.O. Box 4700, Thuwal, Kingdom of Saudi Arabia 23955-6900,
Phone: +966(0)545654267, Email: jenny.booth@kaust.edu.sa

ASSESSING THE APPLICABILITY OF DIFFERENT TIMESCALES FOR QUANTIFYING COASTAL WETLAND VULNERABILITY TO SEA LEVEL RISE

Joshua L. Breithaupt[1], *Joseph M. Smoak[1], Christian J. Sanders[2], and Matthew N. Waters[3]*

[1]University of South Florida, St. Petersburg, FL, USA
[2]Southern Cross University, Lismore, Australia
[3]Valdosta State University, Valdosta, GA, USA

In its simplest form, assessing the vulnerability of coastal wetlands to sea level rise is a matter of comparing the rate of sediment addition and elevation change with the rate of sea level rise. Complications arise because these rates change and are not monotonic over the course of numerous timescales. Historically, sediment accumulation rates have been derived from soil core observations of depth or mass combined with a dating method for identifying a start date in the record ranging from decades to millennia prior to sample collection. In the last few decades the coupled Surface Elevation Table – Marker Horizon (SET-MH) methodology has offered a time-series approach with regular, repeated measurements as an alternative perspective to the soil core record. Each approach and its respective timescale offer valuable insights about the rates and processes of addition and loss to the soil body. However, what appears to be missing from the literature is an explicit consideration about the applicability of the rates derived from each timescale.

Several recent high profile publications have used data collected over ~5-15 years to model outcomes that are likely to play out over 50-100 years or more in coastal wetlands. This quandary is similar to the conversation presently taking place within the sea level rise community regarding the length of an observable record required for detecting acceleration in regional and global sea level rise. The uncertainty in this question is largely due to the need for identifying and removing annual and multi-decadal variability from long-term trends in tide gauge records. If these questions persist regarding sea level, then we suggest that the same question pertains to assessments of soil accretion and elevation change – two processes that are highly dependent on sea level.

In this study we examine the role of timescale on the interpretation of accretion rates and elevation change data for several locations around the globe where multiple timescales are represented within a regional geographic footprint. Our findings present two primary conclusions. First, accretion rates are inversely correlated with time; the greater the timescale of observation the smaller the total measured rate of accretion. Surprisingly this holds true even when data from all regions are combined, indicating the presence of a global signal in accretion rates at each timescale. Second, the elevation change data show very few regions with an elevation change trend that is different than zero, and no correlation with the length of record. Two possible explanations are that variation between individual SET trends (i.e. one site falling and one site rising) or variation between different temporal scales (i.e. one timescale increasing and another timescale decreasing) cancel each other out and produce no overall trend. We conclude that extrapolation of short-term data to longer timescales should be resisted unless it can be demonstrated that trends in the time-series of elevation change (or MH-derived accretion rates) have accounted for any seasonal or multi-decadal variability. The focus here is on accretion and elevation change, but the principles of concern would also apply to assessments of carbon burial potential.

Contact Information: Joshua L Breithaupt, University of South Florida, College of Marine Science, 140 7th Ave S, St. Petersburg, FL 33701, Email: jlbreith@mail.usf.edu

THE REHABILITATION OF IMPACTED WETLANDS IN THE INDIAN RIVER LAGOON, FLORIDA

Jorge R. Rey[1], ***Ronald E. Brockmeyer***[2], *and Melinda J. Donnelly*[3]
[1]University of Florida, IFAS, Vero Beach, FL, USA
[2]St. Johns River Water Management District, Bureau of Water Resources, Palatka, FL, USA
[3]University of Central Florida, Dept. of Biology, Orlando, FL, USA

Coastal wetland management efforts in Florida, which date back to the 1920s, have included ditching, dredging and filling, and impounding, all having mosquito control and environmental benefits and liabilities. Along the Indian River Lagoon, in east-central Florida, impounding was a popular technique for mosquito control, as the area's low tidal amplitude and the structural complexity of the mangals bordering the lagoon precluded the use of other source reduction techniques used elsewhere. Early impoundment efforts resulted in considerable vegetation damage and isolation of these areas from the adjoining estuary, partially due to poor water management capabilities. Significant research on the ecology of the impoundments and the estuarine habitat that they border resulted in important improvements to management protocols and greatly enhanced our ability to restore the structure and function of these important habitats.

With this *a priori* research and inter-agency endorsement, an aggressive campaign to reconnect impounded wetlands to the adjacent estuary via culverts began in 1980s. With federal, state, regional, and local agency support, impoundment reconnections quickly accelerated in the early 1990s. This campaign expanded to include full restoration of impounded wetlands, where practical, beginning in the late 1990s. This work was accomplished by mechanically leveling dikes to wetland elevations, followed by natural regeneration of plants from neighboring sources. By the mid 2000s, sufficient progress had been made with this expanded restoration work to warrant an ecological evaluation of the effort.

Plant and fiddler crab monitoring began in 2005 and included three restored impoundments in different stages of recovery and two reference marshes. Two additional impoundments were added in 2007 and the monitoring protocol was revised to add fishes, mobile invertebrates, and birds. Post-restoration monitoring identified important factors in habitat recovery and provided management recommendations, including: 1) target elevations for promoting natural hydrological properties, 2) effectiveness of natural regeneration following dike leveling, 3) benefits of leaving shoreline wetland vegetation intact to enhance the rate of plant recovery on leveled portion of dike, and 4) importance of abiotic conditions to prevent non-native plant recruitment. Lessons learned were used to guide impoundment restoration beginning in 2009 and monitoring data are now regularly evaluated to set restoration objectives and targets for success. Today, over 12,850 ha of the 16,150 ha of impoundments in the Indian River Lagoon have been reconnected, breached, or fully restored.

Contact Information: Ron Brockmeyer, St. Johns River Water Management District, PO Box 1429, Palatka, FL 32178, United States; Phone: 386-329-4495; Email: rbrockmeyer@sjrwmd.com

RAPID FEASIBILITY ASSESSMENTS FOR DETERMINING APPROPRIATE MANGROVE RECOVERY INTERVENTIONS AT THE LANDSCAPE SCALE IN INDONESIA

Ben Brown[1]*, Yusran Nurdin*[1]*, Ratna Fadillah*[2]*, Jajang Sonjaya*[2]*, Woro Yuniati*[2]*, and Rio Ahmad*[2]
[1]Charles Darwin University – Research Institute for Environment and Livelihoods - Australia
[2]Blue Forests - Indonesia

In 2015, a set of feasibility assessments were commissioned by several international aid agencies, and NGO's interested in supporting landscape-scale mangrove rehabilitation. Feasibility assessments were required to understand the social and ecological risks and opportunities to work in critical and degraded landscapes at such a scale. Research was carried out by a multi-disciplinary team over the course of four months in seven landscapes occurring on the islands of Sumatra, Java, Kalimantan and Sulawesi. The findings were categorized based on a) status and condition of the mangrove forest, b) social and cultural condition of local communities, c) utilization of the mangroves and adjacent resources for livelihoods and economic values, and d) governance and the role of key stakeholders. Findings were analyzed individually and in group settings (amongst the research team and with stakeholders from government, NGO's and aid agencies) through the development of problem and objective trees as well as an options analysis of actions recommended in the objective tree. The options analysis uncovered four social-ecological conditions in the seven landscapes;

1) high degree of degradation - low feasibility of rehabilitation/transformation - strong social support, [i.e. Demak, Central Java]
2) high degree of degradation - moderate to high feasibility of rehabilitation/transformation - mixed degree of social support, [i.e. Mahakam Delta, East Kalimantan and Tanjung Panjang, Gorontalo]
3) high degree of degradation - moderate to high feasibility of rehabilitation/transformation - low degree of social support [Rawa Aopa, SE Sulawesi and Mamuju, West Sulawesi]
4) moderate degree of degradation, high feasibility of rehabilitation and mixed degree of social support [Indragiri Hilir, Riau and Kubu Raya, West Kalimantan].

Implications for developing and supporting management interventions for each of the above categorizations are discussed. Site prioritization was carried out, but was not always found to be useful by the various international stakeholders who have different motivations for supporting interventions. These included; proof of concept of soft-engineering techniques, establishment of a sustainable mangrove-aquaculture agroecosystem, resolution of social-conflict, and preference for working in a public-private partnership, which in some cases contradicted the degree of social [economic] or ecological feasibility determined for a given landscape. National government agencies found prioritization useful for considering landscape scale interventions, with the caveat that the capture of discrete project opportunities could not replace normative, annual mangrove management interventions in each coastasl province and district. Both Indonesian government agencies as well as international aid agencies and NGO's felt that the rapid feasibility assessments and categorization of management challenges were useful tools to help project planners understand their options and begin the process of project intervention planning.

Contact Information: Benjamin Brown, Charles Darwin University, Research Institute for Environment and Livelihoods, Charles Darwin University, Darwin NT 0820, Australia; PH 61889466574; FX 61413183355;
Email: seagrassroots@gmail.com

FLORIDA MANGROVE FOREST LAND: CHALLENGES, EXTENT, AND CHARACTERISTICS

***Mark Brown*[1]*, Karen Cummins*[2] *and Jarek Nowak*[2]**
[1]USDA Forest Service, Knoxville, TN, USA
[2]Florida Forest Service, Tallahassee, FL, USA

Despite mangrove forests vital importance to marine and estuarine environments in the land-sea interface, their mapping and characterization in Florida and elsewhere has been challenging.

The U.S. Forest Service, in cooperation with the Florida Forest Service, examined some of the challenges of capturing the geographic extent and characteristics of mangrove forests within the state of Florida. Determining the geographic extent of mangrove forest land and correlating that to forest inventory characteristics can lay the groundwork in forecasting the future of mangrove ecosystems. Mangroves are predicted to expand both northward and landward as a result of global climate change and associated sea level rise. Mangroves are expected to invade areas previously occupied by salt marshes in parts of Florida and elsewhere in the southeastern United States. Given the dynamic nature of mangrove expansion/contraction in response to climate change and urban development, mapping this rare ecosystem is a challenge.

Mangroves occur from southern most parts of Florida Keys to northern Florida, both on the Gulf of Mexico and the Atlantic coasts; however, not in continuous fashion. Recent estimates of mangrove forest area in Florida range from 571,055 to 765,465 acres. Mangrove forest land mapping is traditionally done via remote sensing and land cover/land use classification methods. Small patches of mangrove forest such as those extending into northern Florida are often difficult to capture with these methods due to image resolution and interpretation limitations. Whereas various remote sensing techniques are used to estimate mangrove forest geographic extent, forest inventory methods are employed in the United States and other parts of the world to measure mangrove tree heights and diameters, and therefore volumes, biomass and carbon sequestered in mangrove wood. Challenges to getting reliable and comparable estimates range from differing definitions of forest land, accuracy and precision of techniques used, inventory design, to accessibility of plot locations for on-the-ground measurements.

Ground based sample plot data from a cooperative State-wide forest inventory were used to further describe and characterize mangrove forests and the population of mangrove trees. The inventory found mangrove forests in three of the State's four survey units. The South unit contained 82 percent of the mangrove forests, the Central unit 13 percent, and the Northeast unit 5 percent. The major owners of Florida's mangrove forests were State, Private, and the National Park Service with 35 percent, 23 percent, and 22 percent, respectively. A reserved status, prohibiting human disturbance, covered 60 percent of the mangrove forests. Most mangrove forests, 68 percent, were less than 30 years old. Weather was the leading disturbance, affecting 21 percent of mangrove forest land, while human caused disturbance affected 5 percent. The population of mangrove trees revealed 88 percent ranged from 1 to 3 inches in diameter. Mangrove seedlings/saplings less than 1 inch in diameter averaged >10,000 per acre. Most mangrove trees, 69 percent, were between 10 and 20 feet in height. The basal area stocking of mangrove trees showed 82 percent averaged less than 80 square feet per acre. Biomass of mangrove averaged 8.2 tons dry weight per acre. More detailed findings regarding Florida's mangrove resource are delineated throughout the paper.

Contact Information: Mark Brown, USDA Forest Service, Southern Research Station, 4700 Old Kingston Pike, Knoxville, TN 37919. Phone: (865) 862-2033, Email: mbrown03@fs.fed.us

APPLICATION OF MANGROVEWATCH FOR BROAD-SCALE ASSESSMENT OF MANGROVE CONDITION AND DYNAMICS IN THE TORRES STRAIT – THE NORTHERN MOST AUSTRALIAN ISLANDS

***Damien W.Burrows**, Norman Duke and Jock Mackenzie*
TropWATER, James Cook University, Townsville, QLD, Australia

The Torres Strait islands lay between northern Australia and southern New Guinea. These islands are of particular interest because of their position between Australia and SE Asia, their predominantly indigenous population and management, and their low elevation which makes them especially vulnerable to sea-level rise and increased storm surge. The Torres Strait islanders have a unique seafaring culture and they identify strongly with their marine and coastal resources.

Despite being part of Australia, the coastal habitats of these islands are poorly known and this, combined with the threat of rising sea levels and seawater intrusion, resulted in local communities and regional natural resource managers expressing a desire for further information on the state of these ecosystems in order to improve management. We used the MangroveWatch methodology (www.mangrovewatch.org) to survey the diversity, extent and condition of mangrove and shoreline habitats on these islands. This involved boat and helicopter-based video recording of shoreline habitats using GPS-linked still and video cameras, where the footage is analysed using various metrics back in the lab. This work was supplemented by ground-truthing and analysis of historical imagery. Local indigenous land and rangers were trained in the use of MangroveWatch field protocols, and participated in all aspects of fieldwork. This involvement is critical given their prime role as traditional owners and current managers of the resource.

A total of 35 mangrove species were recorded, with 2 of these being new records for Australia. A total of 26,054 ha of mangrove forests are mapped throughout the islands. We assessed mangrove condition along 300km of shoreline across 14 islands. Mean extent of mangrove cover along shorelines was 67%, demonstrating how important mangroves are as coastal habitats on these islands. Approx 59% of shorelines were assessed as being in a healthy state and 18% in poor condition – this being indicative of the dynamic coastal environment in Torres Strait where even natural stands undergo significant change.

Shoreline processes affecting mangroves varied considerably between individual islands, reflecting that management options will also vary. Overall the dominant shoreline process is erosion (21% greater than expansion). Several islands are undergoing significant expansion and loss at different locations. Mangrove cutting is common on the inhabited islands. Sea level rise appears to be directly threatening 13% of Torres Strait mangrove habitat. Evidence of historical mangrove dieback along shorelines appears to coincide with changes in sea level. Historical change was assessed across 11 islands. One island has had a net increase in mangrove area of 13% since 1974 with half of that being regrowth in historically cleared areas.

The MangroveWatch methodology allows for a broad-scale, yet rapid, assessment of mangrove condition, especially in remote locations. In particular, it is suitable for meaningful involvement of indigenous participants in the gathering of field data.

Contact Information: Damien Burrows, TropWATER-Centre for Tropical Water and Aquatic Ecosystem Research, James Cook University, Townsville, QLD 4811 Australia, Phone: 61-7-47814262,
Email: damien.burrows@jcu.edu.au

COMPETITION, FACILITATION, AND GROWTH AMONG MANGROVES ACROSS A LATITUDINAL GRADIENT IN FLORIDA

Jordan Byrum *and C. Edward Proffitt*

Department of Biological and Biological Sciences and Environmental Sciences Program, Florida Atlantic University, Harbor Branch Oceanographic Institute, Fort Pierce, Florida, USA

With rising temperatures due to global climate change, mangrove species are expanding worldwide. Because of this, mangroves are invading salt marshes along the northeast coast of Florida. Since mangroves have limited, but species specific, cold tolerances, there should be different temperature stresses at different latitudes. Growth and spacing of mangroves is often governed by competition for space and nutrients, however, plant facilitation can occur in high stress environments during drought, flooding, and extreme cold or heat.

Propagules of each species (*Rhizophora mangle, Avicennia germinans,* and *Laguncularia racemosa*) collected from the northern and southern populations are being planted in close proximity to larger, mature mangroves, in a field experiment. The propagules are planted at areas of significance in relation to the mature tree (near the trunk, at the edge of the prop roots, at the edge of the canopy, in the pneumatophores, and a control outside the zone of influence). Temperature, light, soil conditions, flooding depth and frequency data are collected in addition to periodic measurements of the seedlings.

The southern site is a spoil island in the Indian River Lagoon near Fort Pierce, FL which was restored in 2005 and is located at 27° 28.7 N, 80° 19.4 W. The northern site is located in Mosquito Lagoon at 28°55.9 N, 80° 49.9 W and is a series of restored dragline ditches.

We predict that at the northern colonization front, presence of adult trees will facilitate seedling recruitment by ameliorating environmental conditions, while those at the southern site will experience competition from adult trees, resulting in lower growth rates. We anticipate mangroves will outcompete salt marsh plants for light once they become large enough to form a canopy.

Contact Information: Jordan Byrum, FAU Harbor Branch, 5600 US-1, Fort Pierce, FL 34946,
Email: jbyrum2014@fau.edu; or cproffit@fau.edu

TOWARDS AN IMPROVED UNDERSTANDING OF CARBON STORAGE, SEQUESTRATION AND GREENHOUSE GAS MITIGATION BENEFITS RESULTING FROM REHABILITATING MANGROVE ECOSYSTEMS IN INDONESIA

Clint Cameron[1], *Lindsay B. Hutley*[1], *Keith A. McGuiness*[1], *Daniel A. Fries*[2], *Benjamin Brown*[1,3], *Yusran N. Massa*[3], *Surwardi*[3]

[1]Research Institute for the Environment and Livelihoods, Charles Darwin University, NT, Australia
[2]Department of Geography, National University of Singapore, Singapore
[3]Yayasan Hutan Biru (Blue Forests), South Sulawesi, Indonesia

To date, discourse associated with 'blue carbon's' potential application within real world carbon markets has focused on blue carbon as a mitigation strategy in the context of avoided deforestation (e.g. REDD+). Here we summarise results from field surveys of carbon storage and sequestration gains from mangrove sites that have undergone ecological rehabilitation as well as a comprehensive quantification of GHG emissions from undisturbed mangroves, converted aquaculture ponds and rehabilitated sites. Replicated sites at two contrasting locations in Sulawesi have been selected. These locations are representative of high and low productivity mangrove stands and have a similar management history (clearing and conversion aquaculture). The locations have also been subjected to similar rehabilitation practices (Ecological Mangrove Restoration, EMR) and they provide a framework to quantify the rate of carbon gain with restoration of high (deep muds, silty substrates) and low (shallow, coralline sands) productivity mangrove ecosystems.

At each location in Sulawesi, protocols as developed by CIFOR Bogor for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forests has been implemented. Historic and newly established plots have been used to quantify the magnitude of the above- and below-ground carbon pools at intact (reference) and degraded (abandoned fish ponds) sites. The major carbon pools assessed to date include biomass (above and below ground), dead / downed wood, leaf litter and the largest pool, soil organic carbon content.

At these same locations and sites both CO_2 and non-CO_2 (methane CH_4, and nitrous oxide N_2O) fluxes from substrate has been measured using a static chambers interfaced to a photoacoustic gas analyzer. These fluxes will be scaled to provide annual estimates of GHG as a function of land use (intact mangrove versus abandoned aquaculture pond vs site undergoing restoration) at high and low productivity systems.

As sites are rehabilitated, carbon sequestration and GHG emissions capping occur and the magnitude of these changes will be estimated based on stock and fluxes measures taken from reference and rehabilitated sites. These data are critical to provide comprehensive and transparent estimates of the rate of carbon accumulation over time following restoration. This knowledge is essential for the assessments of long-term viability of REDD+ schemes that could be implemented by coastal communities in developing countries such as Indonesia.

Contact Information: Clint Cameron, Research Institute for the Environment and Livelihoods, Charles Darwin University, NT, Australia, 0909, clint.cameron@cdu.edu.au, ph +618 8946 6413

THE COLONISATION OF LAND BY MANGROVE CRABS LOWERS THEIR SENSITIVITY TO GLOBAL WARMING

Stefano Cannicci[1,,2], *Marco Fusi*[2,3] *and Francesca Porri*[4,5]

[1]The University of Hong Kong, Hong Kong, Hong Kong SAR
[2]University of Florence, Sesto Fiorentino, Italy
[3]King Abdullah University of Science and Technology, Thuwal, Saudi Arabia
[4]Rhodes University, Grahamstown, South Africa
[5]South African Institute for Aquatic Biodiversity, Grahamstown, South Africa

Intertidal animals, including mangrove crabs, are central for the understanding of the biological consequences of global warming. They live at the interface of marine and terrestrial systems; rely on different sources of oxygen (i.e. aerial or dissolved) and must cope with a daily and abrupt extreme heat stress. Mangrove crabs are also an exceptionally important topic for studies on evolutionary biology. Several species inhabiting mangrove forests are in transition between a marine and a terrestrial life, an evolutionary pathway often associated with and induced by abrupt temperature changes, such as the ones we are witnessing.

Due to the critical role played by crabs in mangrove ecosystem functioning, there is an urgent need to determine their sensitivity to global warming in order to understand the vulnerability of the entire ecosystem. Here we present a series of studies in which we could relate the terrestrial adaptations to the thermal vulnerability of three pivotal mangrove crab species distributed along the Western Indian Ocean, comparing their equatorial (Kenya) and subtropical populations (South Africa).

The thermal responses differed largely among species and regions. *Neosarmatium africanum*, the species dominating the landward belt of mangroves, showed a limited capability of extracting oxygen from air and a low physiological performance to changes in temperature along its distribution, suggesting high sensitivity to rapid environmental warming. The fiddler crab *Uca urvillei*, which dominates the seaward areas, proved to be a highly efficient air-breather, as well as an efficient thermal generalist, with higher tolerance than the sympatric sesarmid *Perisesarma guttatum*. Noticeably, *U. urvillei* revealed little difference in thermal tolerance between equatorial and sub-tropical populations, while *P. guttatum* showed adaptation to local conditions. In particular, the equatorial population showed to be highly vulnerable to global warming, living closer to the upper limit of its thermal niche than the subtropical one. The Kenyan population of *P. guttatum*, however, presented behavioral mechanisms of partial thermoregulation, possibly enlarging its thermal niche.

Our results show that the sea-to-land transition of mangrove crabs has important implications for their adaptations to climate changes. The air-breathing species seem capable of extending their thermal tolerance, acting therefore as possible winners in the current projections of a warmer climate. Moreover, we recently showed that temperature might be the evolutionary driver of sea-land transition in crabs, further suggesting a climate-dependent evolution of animals and, ultimately, the role of climatic changes in evolutionary processes and speciation.

Contact Information: The Swire Institute of Marine Science and the School of Biological Sciences, The University of Hong Kong, Pokfulam Road, Hong Kong, Hong Kong SAR; Phone +852 28092179, Email: cannicci@hku.hk

NON-NATIVE MANGROVE FORESTS IN STREAM MOUTH ESTUARIES ON OAHU, HAWAII

***Susan Carstenn[1]**, Kelly Ratana[2], Stacia GOECKE[1] Natalie Dunn[1,3] and Toby Matthews[4]*

[1]Hawaii Pacific University, Honolulu, HI, USA
[2]NIWA, Wellington, New Zealand
[3]Malama Maunalua, Honolulu, HI, USA
[4]NOAA, Honolulu, HI USA

O'ahu's stream-mouth estuaries (SMEs) serve as nursery grounds and habitat for native Hawaiian, as well as, introduced biota. Their location at the confluence of streams and coastlines means they also serve as an important corridor for native amphidromous species. Oahu's SMEs may be permanently open (PO) or intermittently open (IO) to the ocean, and some are artificially breached (AB) during times of closure as a precaution against upstream flooding. Few studies have investigated fundamental characteristics of these communities, the influence of upstream land use, the effect of non-native *Rhizophora mangle* on water quality or stream management practices e.g. concrete lining and artificial breaching on community structure and water quality.

Landscape Development Intensity index (LDI) was used to characterize watershed land use upstream from SMEs. LDI is a weighted average of Non-renewable Areal Empower Intensity reflecting the magnitude of human disturbance as a function of non-renewable energy use; LDI coefficients range from 0 sej*ha^{-1}*yr^{-1} (solar emjoules per hectare per year) for an undisturbed ecosystems) to 29401.3 E15 sej*ha^{-1}*yr^{-1}(central business district). LDIs of watersheds draining into SMEs on Oahu ranged from 0.97 E15 sej*ha^{-1}*yr^{-1} (Kahana) to 20.8 E15 sej*ha^{-1}*yr^{-1} (Keaahala).

Rhizophora mangle was introduced to Hawaii in 1907 and subsequently inhabits many of Hawaii's SME. *R. mangle* canopy cover in perennial SMEs ranged from 0 – 35.4 %; in intermittently open SMEs mangrove cover ranged from 0 – 16.4 %. *R. mangle* cover was negatively correlated with LDI i.e. *R. mangle* canopy cover was lower with greater human disturbance. This may be explained by greater stream management (e.g concrete liners) in more urbanized watersheds reducing area for mangroves to establish.

Though several physico-chemical variables drove differences in water quality across all SMEs, no clear differences were detected in physico-chemical metrics among SME classes. Fish and macroinvertebrate in faunal communities, however, differed among the three SME classes. PO SMEs were occupied by marine-associated fish species and closed IO or AB SMEs tended to be dominated by non-native *Poeciliidae spp.* and *Cichlidae spp*. The latter species were most common in SMEs that experience long periods of closure, indicating that time since closure may be a dominant factor influencing SMEs and helping to inform future artificial breaching management. Intermittent SMEs, dominated by benthic macroinvertebrate species with high tolerances, had poor water quality regardless of mangrove cover, while mangrove forests of perennial SMEs had considerably reduced habitat quality, defined by lower dissolved oxygen saturation, higher temperature, organic matter enrichment, and the presence of indicator species

Contact Information: Susan Carstenn, Hawaii Pacific University, 45-045 Kamehameha Highway, Kaneohe, HI, USA 97645, Phone: 808-292-4447, Email: scarstenn@hpu.edu

CARBON STORAGE AND SOIL BURIAL RATES IN RIVERINE AND SCRUB MANGROVE FORESTS OF THE FLORIDA COASTAL EVERGLADES, USA

Edward Castañeda-Moya*, Robert R. Twilley,* and *Victor H. Rivera-Monroy*

College of the Coast and Environment, Department of Oceanography and Coastal Sciences, Louisiana State University, Baton Rouge, Louisiana, USA

Mangrove forests are large reservoirs of blue carbon (C) along tropical and subtropical coastlines and play a critical functional role in the global C cycle. In the Florida Coastal Everglades (FCE), mangrove vegetation patterns result from the interaction of environmental gradients and natural disturbances (i.e., hurricanes), creating a spatial array of distinct riverine and scrub mangrove ecotypes across the coastal landscape. Here, we evaluated long-term (2001-2004) vegetation patterns (above-and belowground), soil C storage, and soil C burial rates in mangrove sites along two distinct FCE hydrologic basins (Shark River – SR and Taylor River – TR). We tested the hypothesis that spatial patterns of carbon storage and sequestration in vegetation and soil components are regulated by the interaction of environmental gradients with significant lower storage in scrub mangroves along the TR basin compared to riverine mangroves in the SR basin. Mean vegetation C storage was 3.9 times higher in SR (72.9 $\pm$ 7.3 Mg C ha^{-1}) than in TR (18.7 $\pm$ 2.5 Mg C ha^{-1}), with greater C allocation to belowground in scrub mangroves (75%) relative to riverine mangroves (20%). Mean total (vegetation plus soil) ecosystem C storage ranged from 142.2 $\pm$ 47.4 Mg C ha^{-1} (TR) to 254.8 $\pm$ 13.9 Mg C ha^{-1} (SR). The vegetation C pool accounted for 16% (TR) and 29% (SR) of the total C storage; whereas soil C pools represented the larger fraction of C storage in each basin (SR: 84%; TR: 71%). Long-term (^{137}Cs) soil annual accretion rates were twice higher in SR (0.29 $\pm$ 0.03 cm yr^{-1}) relative to TR basin (0.16 $\pm$ 0.05 cm yr^{-1}), thus controlling a wide range of soil C burial rates ranging from 1.31 $\pm$ 0.06 Mg ha yr^{-1} (SR) to 0.62 $\pm$ 0.24 Mg ha yr^{-1} (TR). Our results show that riverine mangroves in the FCE store and sequester more C relative to scrub mangrove forests, which are P limited and influenced by long flooded hydroperiods. Further, regardless of forest ecotype, a large proportion of mangrove carbon production is stored in the soil. Our findings underscore the relative contribution of structurally distinct neotropical forested wetlands to mangrove carbon budgets. This finding is relevant given the need to quantitatively differentiate the actual regional and latitudinal contribution of each mangrove ecotype when assessing the economic value of C storage and sequestration (i.e., ecosystem services) for the establishment of global carbon markets to offset rising greenhouse gas emissions.

Contact Information: Edward Castañeda-Moya, College of the Coast and Environment Bldg., Room 3251, Louisiana State University, Baton Rouge, Louisiana, USA 70803, Phone: 337-322-5158, Email: ecasta1@lsu.edu

MODELING TROPHIC FLOWS IN THE WETTEST MANGROVES OF THE TROPICAL EASTERN PACIFIC REGION

Gustavo A. Castellanos-Galindo[1,2]*, Jaime Cantera*[1]*, Natasha Valencia* [1]*, Sebastian Giraldo* [1]*, Enrique Peña*[1]*, Lotta C. Kluger*[2] *and Matthias Wolff*[2]

[1]Ecomanglares, Universidad del Valle, Cali, Colombia

[2]Resource Management group, Leibniz Center for Tropical Marine Ecology (ZMT), Bremen, Germany

The most structurally developed mangroves of the Neotropics can be found along the southern and central part of the Colombian Pacific coast, an area of macrotides (~4 m tidal amplitude) and extremely high precipitation (> 6000 mm $year^{-1}$). These ecosystems provide valuable services, such as food provision and coastal protection from storms to the coastal inhabitants of this area (< 10 inhabitants km^{-2}). Fishing and harvesting of mangrove-associated resources is strictly artisanal and concentrated on mangrove cockles and estuarine fishes. Here, we present a preliminary trophic model of a mangrove system in the vicinity of Buenaventura, the largest urban center of the Colombian Pacific coast. Mangroves in the studied area have an extension of ca. 44 km^2, and are located in the inner part of a bay (Bahía Málaga). Integrating all available information on biomass, catches, diet composition and dynamics of the main functional groups within the system, a preliminary trophic steady state model of 16 compartments was constructed using Ecopath with Ecosim (EwE). Similar to other mangrove ecosystem models, mangrove trees contribute most (~99 %) to total system biomass, providing the primary food source for other important mangrove-associated compartments such as mangrove crabs (e.g. *Ucides occidentalis*, and other crabs). However, most of the food energy contained in the mangrove litter is constantly washed out by the daily tidal currents, possibly one of the reasons for the very low biomass of epifauna found in Bahía Málaga when compared to other Neotropical mangrove systems (i.e. Gulf of Nicoya in Costa Rica, Caeté estuary in north Brazil). Fish biomass in the system is dominated by zoobenthivores (0.42 g m^{-2}) feeding predominantly on mangrove decapod crustaceans. These fish biomass values are also considerably lower than reported for similar systems in the Neotropics. Low salinities (< 25) throughout the year may contribute to an impoverishment of the mangrove epifauna and fish communities that may be able to withstand but not to flourish under these conditions. The fact that this well developed mangrove forest contains very low biomass of secondary and third order consumers suggest its high vulnerability to over-exploitation and the need to regulate the fishery of the few species harvested within this system. The results of this study are expected to help in the holistic understanding of mangrove ecosystem functioning and the design of science-based management measures in this area.

Contact Information: Gustavo A. Castellanos-Galindo, Leibniz Center for Tropical Marine Ecology, Farenheitstr. 8, Bremen, Germany, Phone: +49 (421) 23800 - 42, Email: gustavoa80@yahoo.com

A MULTIDISCIPLINARY APPROACH IN ASSESSING TYPHOON-DAMAGED MANGROVE FORESTS IN THE PHILIPPINES

***Kayla Marie I. Castro**, Severino G. Salmo III, Maria Carmela A. Garcia and Anne Brigitte U. Lim*
Ateneo de Manila University, Loyola Heights, Katipunan Avenue, Quezon City, Philippines

The Philippines is visited by an average of twenty typhoons every year. The most devastating yet is Super Typhoon Haiyan. This became an impetus of a nationwide mangrove planting project aiming to increase forest cover, and protect the coast against typhoons. However, these planting projects fail to take in a multidisciplinary approach. In this study, we looked at different biological, physico-chemical and geographical factors in assessing the health and recovery of typhoon-damaged mangrove forests. The study sites were along the path of Typhoon Haiyan. Species count, tree diameter and height, and patterns of recovery were assessed within representative 5-m radius plots from six sites (from eastern, central and northwestern Philippines). Most of the species found were from the genera *Sonneratia*, *Avicennia*, and *Rhizophora*. Sediment cores (1.2 m) were obtained for carbon stock calculation, and ^{210}Pb dating for sedimentation rate calculation. Carbon-nitrogen-phosphorus ratios were also obtained from mangrove sediments and leaves to determine nutrient retention efficiencies. Elevation changes were measured using rod surface elevation– marker horizon (rSET-MH). Carbon stocks were observed to be 1.5 to 3 times higher in the natural stands than in the planted stands. Elevation and sedimentation rates show small increments that vary per site (2.4 – 12.5 mm/year). Based on our observations, natural recovery is possible in the study sites, and reforestation is not needed. Vegetation patterns and environmental factors help to know whether there is a need for reforestation programs, and if a site is fit for mangroves survival. Biological, physicochemical, and geophysical factors can be used separately to assess typhoon-damaged mangroves. However biological factors give insights on the intrinsic ability of the mangroves to survive in their environment, as reflected by physicochemical and geophysical factors. A multidisciplinary approach takes advantage of the relationship of these different factors in assessing whether typhoon-damaged mangrove environment can be left to recover naturally or assisted through reforestation programs.

Contact Information: Kayla Marie I. Castro, Ateneo de Manila University, Loyola Heights, Katipunan Avenue, Quezon City 1101 Philippines Phone: (02) 426-6001 local 5652, +639177792493, Email: mkay.castro@gmail.com

REGIONAL VARIABILITY IN THE DYNAMICS OF GLOBAL MANGROVE RANGE LIMITS

Kyle C. Cavanaugh
University of California, Los Angeles, CA, USA

Understanding the processes that limit the geographic ranges of species is one of the central goals of ecology and biogeography. This issue is particularly relevant for coastal wetlands given that climate change is expected to lead to a 'tropicalization' of temperate coastal and marine ecosystems. In coastal wetlands around the world, there have already been observations of mangroves expanding into salt marshes near the current poleward range limits of mangroves. However, there is still uncertainty regarding regional variability in the factors that control mangrove range limits.

Here we used satellite imagery time series to characterize patterns of mangrove abundance near their poleward range limits around the world. We tested commonly held assumptions that abundance and fitness should decrease while temporal variation in abundance should increase towards the edge of the range. Collectively, our analyses provide insight into the factors that limit the distribution of mangroves and how the relative importance of those factors varies regionally.

Contact information: Kyle Cavanaugh, Department of Geography, University of California, Los Angeles, CA, USA 90095, Phone: 703-489-4671, Email: kcavanaugh@geog.ucla.edu

DEMOGRAPHIC RATES COMPARISON OF JUVENILE OYSTER, *CRASSOSTREA VIRGINICA*, AMONG REEFS LOCATED ON BLACK MANGROVES, OYSTER BARS, AND MARSHGRASS HABITATS

***Dinorah H. Chacin**, Timothy Pusack, Matthew Farnum, Owen Stokes-Cawley, and Chris Stallings*
College of Marine Science, University of South Florida, St. Petersburg, FL, USA

In eastern North America the historical northern limit of mangroves is located near 30° N and is restricted by mangrove's sensitivity to cold temperatures, while saltmarshes dominate most of the coastal habitats in temperate climates. Due to global climate change, increased temperature in coastal habitats and fluctuations in the frequency of cold events are becoming more common and can have ecological consequences. For example, the increase in global average surface temperature has already caused shifts in the distribution of biological communities. Similarly, expansions of mangrove habitat range have been documented in Florida, Lousiana, and Australia. *Avicennia* is the most cold-tolerant genus of mangroves and the *germinans* species' range has extended northward along the USA Atlantic coast colonizing saltmarshes. As this colonization begins, a shift can occur where one foundation species can be replaced by another with potential effects in ecosystem function due to the numerous roles foundation species play in the seascape.

In this study we examined demographic rates of juvenile oysters, *Crassostrea virginica*, growing in reefs with both marshgrass and mangroves as neighboring habitats. The goal was to elucidate the effects the expansion of mangrove habitat range may cause on ecological processes in oyster reefs. In a field experimental setting we deployed juvenile oysters in three levels of caging experiments (cage, control, and cage control) in four major locations in St. Augustine, Florida. In two of the study sites we measured growth and survival in reefs located among black mangroves, and oyster bars. Similarly, in the remaining study sites we measured growth and survival in reefs located among marshgrass and on oyster bars. We monitored their demographic rates monthly for four months and observed no difference in growth or survival of juvenile oyster among the three different habitat types. Oyster growth ranged from 0.03 mm/day to 0.14mm/day and showed significant difference among individual sites, but not among habitat types. The results indicated local environmental factors in each study site might have been more important than habitat type in influencing ecological processes in oyster reefs.

Contact Information: Dinorah Chacin, University of South Florida, 830 1st St SE, St Petersburg, FL 33701; United States, Phone: 727-553-1130; Email: dchacin@mail.usf.edu

MANGROVE ENCROACHMENT INTO MARSHES ALTERS BELOWGROUND ORGANIC MATTER DYNAMICS WITH IMPLICATIONS FOR SURFACE ELEVATION

***Samantha K. Chapman**, Heather Tran, Glenn Coldren, Cheryl Doughty, Chelsea Barreto, James Morris, J. Adam Langley, Ilka C. Feller*

Villanova University, Villanova, PA, USA

Mangroves are encroaching into salt marshes around the world, representing one of the most dramatic plant range shifts occurring today. While we are starting to capture the scope of mangrove encroachment in wetlands, we lack “in the ground” information required to understand its consequences for carbon storage and wetland sustainability in the face of sea level rise. Despite the importance of wetland plant root production and organic matter decomposition in regulating surface elevation, no one knows how woody mangrove invasion into herbaceous salt marshes will affect the soil-accumulating processes that sustain these ecosystems. Mangroves, which have larger and more porous roots, may increase oxygen delivery to anoxic soils, potentially increasing decomposition rates while at the same time building more soil volume. In a mangrove-salt marsh ecotone in Florida, we found that mangrove abundance increased by 69% in 7 years and thus increased C storage at a rate of 2.7 Mg C ha-1 yr-1, double the C sequestration rate of many temperate wetlands. Wetland root biomass, which partially determines soil elevation, is three times higher in mangrove-dominated as compared to marsh-dominated plots and root ingrowth rates are four times higher in mangrove-dominated plots. Despite these increases in organic matter inputs due to this range shift, mangrove roots decompose twice as quickly than marsh roots, losing about 30% of their mass after only four months. Taken together these results suggest that mangrove encroachment into marshes speeds up belowground carbon cycling. We predict that mangrove encroachment will result in increased surface elevation gain driven by the balance of increased root productivity and increased OM decomposition, and we are testing this hypothesis with the Marsh Equilibrium Model and with terrestrial laser scanning data. As mangroves continue to encroach into higher latitudes, in the absence of deep freezes, mangrove-driven increases in organic matter accumulation will likely tend to increase soil elevation. However, as temperatures and sea levels continue to rise, understanding the balance of root biomass accumulation and organic matter decomposition will be even more important in order to maintain wetland resilience to inundation.

Contact Information: Samantha Chapman, Villanova University, 800 Lancaster Ave., Villanova, PA 19085, United States, Phone: 610-519-5343; Email: samantha.chapman@villanova.edu

INCREASING MANGROVE DENSITY INCREASES CARBON PRESERVATION BUT DECREASES SEDIMENT ACCRETION IN COASTAL WETLANDS: EVIDENCE FROM LARGE-SCALE EXPERIMENTAL MANIPULATIONS

Sean P. Charles[1], *John S. Kominoski,[1] Anna R. Armitage[2], Hongyu Guo[3], Sayatani Dastida[3], Zoe Hughes[3], Carolyn A. Weaver[2], Ashley Whitt[2], and Steven C. Pennings[3]*

[1]Florida International University, Miami, FL, USA
[2]Texas A&M University at Galveston, Galveston, TX, USA
[3]University of Houston, Houston, TX, USA

Mangroves are expanding poleward due to increases in temperature, and in the Gulf of Mexico, black mangroves (*Avicennia germinans*) are expanding into once grass- and forb-dominated salt marshes. Coastal wetlands are globally important sinks of "blue carbon" (C), storing the majority of C belowground. Soil C storage is important for maintaining elevation of wetland soils relative to sea level and influences coastal vulnerability to sea level rise and storms. Vegetation type can alter C inputs (providing autochthonous organic inputs and mediating the trapping of allochthonous organic matter and sediment) and C breakdown rates (changing the quality of organic matter, altering microclimate, and priming and oxidizing soil C). Thus, understanding how vegetation changes alter C storage is essential given large-scale changes in mangrove and marsh cover in coastal wetlands. We manipulated vegetation identity and density in 10 experimental plots (24 $\times$ 42m) to represent an ecotonal gradient from herbaceous- to mangrove-dominated (0-100% mangrove cover) in Port Aransas, Texas, USA. We measured differences in C standing stocks (above and belowground plant biomass and soil %C) and changes in inputs of organic C (root productivity and surface accretion). We further assessed how changing biotic (species identity, density) and abiotic (temperature, light) characteristics influence litter breakdown (*k*). We found that increasing mangrove cover increased above and belowground biomass and %C in surface soil, had no effect on belowground productivity, and decreased sediment accretion (potentially due to coastward relative to interior entrainment of coastal subsidies). Mangroves reduced litter *k* by producing more recalcitrant litter than herbaceous wetland plants and reducing soil surface temperature and light. Our findings indicate that changes in the identity and density of functional vegetation types in wetland ecosystems (marsh vs. mangroves) alters the mechanisms of ecosystem C storage and sediment accretion.

Contact information: Sean P. Charles, Florida International University, 11200 SW 8th Street, Miami, FL, USA, Schar056@FIU.edu

MANGROVE DISTRIBUTION AND CONDITION IN JAVA, INDONESIA, WITH SPECIAL REFERENCE TO LEUWEUNG SANCANG NATURE RESERVE, WEST JAVA

Devi N. Choesin[1]*, Hafiz N. Arditama*[1]*, and Dimas T.A. Panjaitan*[2]
[1]Institut Teknologi Bandung, Bandung, Indonesia
[2]Golder Associates, Jakarta, Indonesia

Indonesia is an archipelagic country which consists of more than 17,000 islands and has a coastline length of 95,000 km. About 3 million hectares of mangrove forest grow along this coastline, making up 23 percent of all mangrove ecosystems in the world. However, extensive areas of mangrove forests in Indonesia continue to decline and are in critical condition due to anthropogenic effects. The highest rate of decline has been recorded on Java island, including West Java province. Coastal areas in West Java have developed into industrial, cultivated/fishpond, or tourism areas. Amidst these generally populated areas, Leuweung Sancang Nature Reserve (LSNR) in the southern coast of Garut district represents one of the last coastal conservation sites in West Java. Despite the ecological importance of this site, however, little scientific information is available.

This paper reviews and discusses in general mangrove distribution and condition on the island of Java, then focuses on a study in LSNR as an example of a remnant mangrove area which has suffered from poor management and is currently under threat. The specific objectives of the study were to describe mangrove community structure; determine mangrove distribution pattern along salinity and substrate gradients; and assess mangrove health in LSNR. Field data collection was conducted at three sites located in the western (Cipalawah), mid (Cipunaga) and eastern (Cibako) parts of the LSNR coast. Vegetation analysis data were collected using line-transects divided into at least three nested-plots within 90 meters from the outer boundaries of the mangrove community, perpendicular to the shoreline. Three replications were performed at each location randomly. Substrate sampling and salinity measurements were conducted at each plot.

Seven mangrove species were recorded, *i.e*., *Aegiceras corniculatum*, *Sonneratia alba*, *Avicennia alba*, *Avicennia marina*, *Rhizophora apiculata*, *Bruguiera gymnorrhiza*, and *Xylocarpus granatum*; with varying species richness and diversity among sites. *Aegiceras corniculatum* was clearly dominant in Cipunaga; while importance values of species in Cibako and Cipalawah tend to be more even. Shannon-Wiener diversity indices ranged from 0.62 in Cipunaga to 1.43 in Cipalawah. Communities at Cipunaga and Cibako showed high similarity (Morisita-Horn index 0.86). Mangroves in general did not exhibit any clear pattern of zonation; distribution seems to be more affected by coastal geomorphology and inundation. Using standard criteria outlined by the Ministry of Environment based on percent cover and density, mangroves at LSNR fall into the category of good, with medium density. However, in terms of regeneration potential (criteria of Rawat *et al*., 2014), the regeneration of *Sonneratia alba*, *Avicennia marina*, and *Xylocarpus granatum* is considered poor, while *Avicennia alba* shows no regeneration.

This study has provided updated information on the condition of mangroves in LSNR which is representative of the southern coast of West Java. These findings, along with other important issues we have identified, should be considered in formulating a strategy for the sustainable management of LSNR.

Contact Information: Devi N. Choesin, School of Life Sciences and Technology, Institut Teknologi Bandung (SITH-ITB). Jalan Ganesha 10, Bandung 40132, Indonesia. Phone: +62-22-251-1575, Email: devi@sith.itb.ac.id / devichoesin@yahoo.com

ARTIFICIAL WARMING INCREASES ADULT MANGROVE AND SALT MARSH GROWTH RATES AND MAY ENHANCE TRANSITION TO MANGROVE DOMINANCE

Glenn A Coldren[1]*, Samantha Chapman*[1]*, Adam Langley*[1] *and llka. C. Feller*[2]

[1]Villanova University, Villanova, PA, USA.

[2]Smithsonian Environmental Research Center, Edgewater, MA, USA.

Increasing temperatures and a reduction in the frequency and severity of freezing events has been linked to shifts in species distributions, growth patterns and interactions. Differences in responses to both minimum and mean temperatures may alter species interactions leading to enhancements or reductions in predicted range shifts of plant communities. The distributional ranges of mangrove species are primarily limited by freezing events which limit growth and survival. In recent years, a northern range expansion of mangrove species has been observed, likely due to the diminishing occurrences of fatal freezing events associated with climate change. As these mangrove communities move to higher latitudes they are interacting with salt marsh communities that inhabit the same intertidal area in temperate zones.

In this study we conducted an *in situ* warming experiment to test the effects of air temperature increases (mean +2°C) on co-occurring mangrove and salt marsh species. Warming was achieved using passive warming enclosure chambers (8x2.5x2.5m) with two treatment levels (ambient, warmed). The chambers were installed at a mixed salt marsh-mangrove site, located at Merritt Island, Florida, which is a transitional zone for the two communities. Each plot enclosed multiple adult mangroves and had both a mangrove and salt marsh dominated area within the chamber. The design allows us to examine changes in dominance between the two species groups under warmed conditions. A shallow sediment elevation table (SET) was installed into each plot to examine changes in elevation due to warming. Experimental plots consisted of the salt marsh species *Distichlis spicata* and *Juncus roemerianus* and adult mangroves of *Laguncularia racemosa*.

Results indicated that adult mangroves (*Laguncularia racemosa*) showed a strong positive response in above ground growth as a result of warming. Under warming, increased growth of *Laguncularia racemosa* led to a shift towards greater mangrove area cover and reduced salt marsh cover within the chambers. Leaf area of mangroves also increased under warming. Salt marsh species (*Distichlis spicata* and *Juncus roemerianus*) showed significant increases in above ground growth but only during the growing season. Sediment elevation was slightly positive throughout the experiment but greater in warmed treatments. It is important to note that no freezing temperatures occurred at the site during the study likely reducing the effect of minimum temperature differences on mangroves.

Contact Information: Glenn Coldren, Villanova University, 800 E. Lancaster Ave., Villanova PA, USA 19085.
Email:glenn.coldren@villanova.edu

IDENTIFYING DRIVERS OF ELEVATION CHANGE IN FLORIDA'S MANGROVES

Jeremy Conrad[1,2]*, and C. Edward Proffitt*[2]

[1]U.S. Fish and Wildlife Service, J.N. "Ding" Darling National Wildlife Refuge, Sanibel, FL, USA

[2]Florida Atlantic University, Dept. of Biological Sciences, c/o Harbor Branch Oceanographic Institution, Fort Pierce, FL, USA

Mangrove forests around the globe are in danger of being submerged and eroded by sea level rise (SLR). In some Caribbean locations, mangroves have been found to completely or partially offset submergence through the production of below ground root structure and or accumulation of new sediments. Recent literature suggests that in riverine settings, sedimentation is the primary process of elevation change. However, most of Florida's mangroves are not riverine and may not receive the necessary sedimentation to keep pace with SLR. Currently, the primary processes and rates of change that are important to offsetting the effects of SLR are poorly understood in Florida mangrove forests.

To better understand the primary processes and rates of change in Florida mangroves, we are applying a novel three step approach. First, with the aid of colleagues, we are establishing and monitoring a network of forty-five surface elevation tables (SET) and marker horizons (MH) on National Wildlife Refuges throughout Florida. Surface elevation tables and marker horizons have been demonstrated to accurately measure minuscule changes in mangrove elevation and capture rates of sedimentation. The network will span along both coasts of Florida from Central Florida to Big Pine Key and provide for both a localized and regional analysis of mangrove elevation change in response to SLR. Second, at each SET/MH location we are monitoring biannually a suite of variables that have been demonstrated or suspected to affect belowground production. These variables include: above and belowground productivity, vegetation structure, hydrology, salinity, nutrient loads, and soil density and composition. Third, since coastal wetlands are at constant risk of eutrophication from terrestrial sources, we will conduct a nutrient manipulation experiment to assess the effects of different nutrient levels on above and belowground productivity, decomposition, and elevation change. Our treatments will include: control sites and the addition of nitrogen (N), phosphorus (P), and a mix of N and P to experimental sites.

A conceptual meta-model will be developed and function as a multivariate hypothesis for the selected variables. Data will be analyzed by a structural equation model that will identify the path coefficient linking each variable to the main response variable of elevation change for each SET site. This multivariate approach will provide land management organizations, such as USFWS, an understanding of what drives elevation change in Florida's mangroves, how that change is keeping pace with SLR, and aid in prioritizing management decisions that address the threat of SLR on Florida's coastal resources.

Contact information: Jeremy Conrad, 1 Wildlife Dr, Sanibel, FL, USA, 33957, Email: Jeremy_Conrad@fws.gov

EARLY DRIVERS OF BLACK MANGROVE (*AVICENNIA GERMINANS*) LEAF LITTER DECOMPOSITION IN THE WATER COLUMN

***Leticia Contreras**, Alejandro Fierro-Cabo and Carlos Cintra-Buenrostro*
University of Texas Rio Grande Valley, Brownsville, TX, USA

In most estuaries, major energy and matter flows to higher trophic levels originate in detrital pathways. These transitional systems provide valuable ecosystem services, some of which are a function of organic turnover such as the duration of carbon and nutrient sequestration, and the sustained productivity fueled by nutrient remineralization. Decomposition of abundant plant material produced by mangroves, seagrasses and other macrophytes, is a major process in the organic turnover of many estuarine systems, and occurs in both the sediments and the water column. Many decomposition studies have documented this process with plant litter on or within the sediments, but the most intense part of it frequently occurs in the water column. Understanding how early mangrove leaf litter decomposition is affected by driving environmental variables is essential to predict changes in nutrient cycling and carbon sequestration potential.

In a recent study, measurements of in situ decomposition of black mangrove (*Avicennia germinans*) leaf litter suspended in the water column, showed important differences among four estuaries in south Texas with moderate differences in salinity, water temperature, nitrogen availability and tidal flow. Thus, a series of experiments under controlled conditions were conducted to determine the influence, within observed ranges in the estuaries, of these water conditions on mass loss of mangrove leaf litter. Preliminary results indicate greatest mass loss in the treatment with higher temperature (31^{o}C) and lower salinity (20 ‰) after 60 days (48.3%), whereas lower temperature (20^{o}C) and higher salinity (66‰) had the least mass loss (23.6%). Treatment with water turbulence presented the greatest mass loss after 60 days (54.9%) compared to the control (38.5%). N availability experiments indicate greater mass loss in the treatment with 3.0 mg/L $(NH_4)_2SO_4$ (34.5%) compared to both, the control and 1.5 mg/L $(NH_4)_2SO_4$ treatments (29.5%). All four water column variables tested appear to have a marked effect on mangrove litter decomposition rates.

Contact Information: Leticia Contreras, University of Texas Rio Grande Valley, One West University Blvd., Brownsville, TX., USA 78520, Email: leticia.contreras01@utrgv.edu

USING SURFACE ELEVATION AS A TOOL TO ASSESS FUNCTIONAL EQUIVALENCY AFTER MANGROVE FOREST RESTORATION

***Nicole Cormier*[1]**, *Ken W. Krauss*[1], *Kerrylee Rogers*[2], *Debra J. Stokes*[3], *Michael J. Osland*[1], *Amanda W. J. Demopoulos*[4], *and Roy R. Lewis III*[5]

[1]U.S. Geological Survey, Wetland and Aquatic Research Center, Lafayette, LA, USA
[2]University of Wollongong, Wollongong, NSW, Australia
[3]School of Environmental Science & Engineering, NSW, Australia
[4]U.S. Geological Survey, Wetland and Aquatic Research Center, Gainesville, FL, USA
[5]Coastal Resources Group, Inc., Salt Springs, FL, USA

Mangrove forests are highly productive tidal forested wetlands that provide fisheries and wading bird habitat, carbon storage, erosion protection, and water quality improvement. However, these forests are threatened globally by aquaculture, harvesting, human infrastructure, and natural disturbance. Mangrove loss means a loss of the goods and services they provide. Mangrove restoration and creation efforts are often used to off-set the goods and services lost by mangrove destruction and degradation, commonly carbon sequestration, shoreline armoring, and wave buffering. However, there is concern that created wetlands are not functionally equivalent to their natural counterparts. While mangrove restoration projects are implemented the world over, few studies are conducted post-restoration to determine the long-term growth and development of these forests to substantiate restoration success. Furthermore, recent strong interest in payment for ecosystem services or compensation for losses (particularly for carbon sequestration) will require greater certainty in investment return; there is now even greater need to verify the functional equivalency of mangrove restoration.

Mangrove substrate elevation relative to sea level is a key component in restoration success; recolonization, germination, and survival are all controlled in part by soil surface elevation. Soils also provide a substrate for biotic communities and biogeochemical processes (e.g., carbon storage, nitrogen cycling), but the rate at which mangrove soil properties develop after creation or restoration is not well known. Using examples from the United States, Australia, and New Zealand, we compared the structural and functional attributes of restored mangrove forests with their natural counterparts. Some of the metrics we consider include soil surface elevation change, vertical accretion, soil structure and composition, forest structure, hydrology, and nutrient cycling.

Although the time and resources available for post-restoration assessment are typically insufficient or lacking, we can learn from mangrove restoration successes and failures. The studies that do exist suggest that long-term measurements of the structure and function of restored and created mangrove forests are necessary to determine the time and effort required to compensate for the total losses in structure, function, and ecosystem services of a natural mangrove forest. Such information is essential for developing appropriate mangrove restoration practices and mitigation strategies.

Mangrove restoration will continue to be a large part of future climate change adaptation and mitigation; therefore, it is critical to understand the time required to reach functional equivalency through successful restoration of ecosystem properties and processes.

Contact Information: Nicole Cormier, US Geological Survey, 700 Cajundome Blvd, Lafayette, LA, USA 70506,
Phone: 337-266-8838, Email: cormiern@usgs.gov

EXPLORING RELATIONSHIPS BETWEEN PLANT AND SOIL MICROBIAL DIVERSITY IN MANGROVES

***Hayley Craig*[1]*, Ilka C. Feller*[2] *and Jennifer K. Rowntree*[1]**

[1]The University of Manchester, Manchester, United Kingdom

[2]Smithsonian Environmental Research Center, Edgewater, MD, USA

Mangrove soils contain a diverse community of microorganisms that perform a vast array of ecological functions. As mangroves are naturally subject to frequent changes in environmental conditions, it is thought that the high bacterial diversity in mangrove soils could ameliorate detrimental impacts associated with environmental disturbance. Few studies have used molecular methods to assess microorganism diversity in mangrove soils and none that we know of have looked at whether this is linked to plant genetic diversity.This study aims to assess the relationship between genetic diversity of plants and species diversity of soil microorganisms in Florida mangrove ecosystems. Leaf samples were collected from *Rhizophora mangle*, *Avicennia germinans* and *Laguncularia racemosa* within different vegetation zones for microsatellite analysis and soil samples were collected from the rhizosphere of each of these plants. DNA was extracted from the soil and the 16S rRNA genes and the internal transcribed spacer regions were amplified to look at bacteria and fungi communities respectively. These amplicons were assessed using denaturing gradient gel electrophoresis (DGGE). Plant and soil communities were compared between and within vegetation zones and different sites. Additional soil variables including pH, temperature, moisture and nutrient content were also assessed. This study provides much needed information on the importance of diversity in Florida mangrove plant and soil communities and the relationships between them.

Contact Information: Hayley Craig, Faculty of Life Sciences, The University of Manchester, Michael Smith Building, Dover Street, Manchester M13 9PT, Phone: +44 161 275 1484 , Email: hayley.craig@postgrad.manchester.ac.uk

INVASIVE SPECIES OF AQUATIC MACROPHYTES AFFECTING MANGROVE FORESTS STRUCTURE AND CONSERVATION IN PROTECTED AREAS

***Marília Cunha-Lignon*[1]** *and Ricardo Palamar Menghini*[1,2]

[1]Instituto BiomaBrasil, São Paulo, Brazil

[2]Master Program in Environmental Health, Faculdades Metropolitanas Unidas, São Paulo, Brazil

Invasive species represent strong threats to biodiversity and ecosystem services. The Cananéia-Iguape Coastal System (São Paulo state, Brazil) is considered the most conserved and wide mangrove area along the São Paulo coast. The Cananéia-Iguape Coastal System (CICS), consists of a complex of lagoon channels, and is part of a World Heritage site by UNESCO, since 1999. About 16 Protected Areas are distributed on this coastal system. The CICS can be divided in two sectors, the northern and the southern, based on geomorphology and environmental conditions. Despite this, in the northern sector important environmental changes occurred due to an artificial canal producing modifications in salinity and transforming the estuarine conditions.

The current study examines the transformation of mangrove forest structure over time, submitted to invasive species of aquatic macrophytes and low salinity affecting the conservation of mangrove forests. To demonstrate this alteration, 36 permanent plots were delimitated along the northern and southern sectors in the Cananéia-Iguape Coastal System (Brazil), from 2011 to 2015.

In permanent plots, the characterization of structure forest development followed the methodology suggested by Cintrón and Schaeffer-Novelli (1984). All plants were identified and tree diameter, height, incidence of associated species, and condition (live or dead) were recorded. Mean height, basal area dominance, and stem density were also assessed.

In one hand, the conserved mangrove forests, located in the southern sector, reached less than 20% of dominance of basal area (BA) of dead trunks, between 2011 and 2015. In the other hand, the altered mangrove forests, located on sites under the influence of the waters of the artificial canal, reached 60% of dominance of BA of dead trunks, between 2011 and 2015. The interstitial salinity varied between 0 and 4, on sites under the influence of the waters of the artificial canal, from 2011 to 2015. This attribute varied from 24 to 30, on conserved mangroves, over time.

Aquatic macrophytes species showed different behavior and ecosystem services in relation to mangrove vegetation. These aquatic macrophytes don't fix sediment and consequently don't control erosion. In the CICS species of aquatic macrophytes like *Urochloa arrecta, Paspalum repens and Eichhornia crassipes* dominated the landscape on sites under the influence of the waters of the artificial canal. Over time, they are forming large populations in the northern sector of the coastal system.

The increase of mangrove forests areas showed by the increase of the dominance of BA of dead trunks and other structural vegetation characteristics, over time, alert to serious transformation of mangrove forest structure submitted to invasive species of aquatic macrophytes and low salinity.

These data are available to decision makers to use on protected area planning. The mangrove forests monitoring, using permanent plots, is an important tool which data can be very useful to coastal management and mangrove conservation.

Contact Information: Marília Cunha Lignon, Instituto BiomaBrasil, São Paulo, Brazil, Phone: (+55 12) 98168-1102, Emails: marilia.cunha@biomabrasil.org; cunha.lignon@gmail.com;

Financial Supports

National Council for Scientific and Technological Development (CNPq – Brazil) and Boticário Group Foundation

ISLAND-WIDE COASTAL VULNERABILITY ASSESSMENT OF SRI LANKA REVEALS SAND DUNES, PLANTED TREES AND NATURAL VEGETATION AS POTENTIAL BARRIERS AGAINST OCEAN SURGES

Farid Dahdouh-Guebas[1,2,*], *Behara Satyanarayana*[1,2,3], *Tom Van der Stocken*[2], *Guillaume Rans*[2], *Kodikara Arachchi Sunanda Kodikara*[1,4], *Gaétane Ronsmans*[2], *Loku Pulukkuttige Jayatissa*[4], *Mohd-Lokman Husain*[3] *and Nico Koedam*[2]

[1]Laboratory of Systems Ecology and Resource Management, ULB, Brussels, Belgium
[2]Laboratory of Plant Biology and Nature Management, VUB, Brussels, Belgium
[3]Mangrove Research Unit, INOS, UMT, Kuala Terengganu, Malaysia
[4]Department of Botany, UOR, Matara, Sri Lanka

Since then the incident of the Indian Ocean tsunami on 26 December 2004, there have been continuous efforts for upgrading the (tsunami) early warning systems as well as their availability to local/regional places in South and Southeast Asia. Meanwhile, the protection offered by coastal forests (greenbelts) to the people, property and land was also recognized and prioritized by both public and private authorities at various governance levels. Considering the fact that more than 90% of the coastline of Sri Lanka is vulnerable to water-related impacts and the existing mature/pristine mangroves able to protect less than one-third of it, an attempt was made to build knowledge on the other potential natural barriers along the coast. In this context, a 2 km belt of the entire coast was digitized, classified and assessed for vulnerability in relation to the existing land-use/cover (using GRASS v.6.4.1 in ArcView GIS). At first, a visually interpreted land-use/cover map comprising sixteen classes was developed from the Google Earth imagery (Landsat-5, 2003). Second, based on Global Digital Elevation Model (GDEM) data from the ASTER satellite, the land-use/cover map was further re-classified for altitude demarcation into waterless, run-up and flooded areas. And finally, both vulnerable and less vulnerable areas were identified by taking into account the average wave heights of the 2004 tsunami reached into the country (north: 5.5 m, south: 7 m, east: 5 m and west: 3.75 m). Among the places observed, Jaffna and Kaluvanchikudy-Komari are found to be the vulnerable and, Trincomalee, Yala and Puttalam are the less vulnerable areas. While vulnerability was largely associated with the conditions devoid of natural barriers, the less vulnerable areas contained mangroves, Casuarina, dense vegetation and/or sand dunes that worked against the waves effectively. As the present study provides only base-line information on the island-wide vulnerable and less vulnerable areas, further research in similar lines is needed to aid for future preparedness (e.g. evacuation of people) at the time of water-related impacts, if any, in the country.

Contact information: Farid Dahdouh-Guebas, Laboratory of Systems Ecology and Resource Management, Université Libre de Bruxelles - ULB, CPI 264/1, Avenue Franklin Roosevelt 50, B-1050 Brussels, Belgium & Laboratory of Plant Biology and Nature Management, Vrije Universiteit Brussel - VUB, Pleinlaan 2, B-1050 Brussels, Belgium. Phone: +32 27210203, Email: fdahdouh@ulb.ac.be

MANGROVES AT THEIR LIMITS: DETECTION AND AREA ESTIMATION OF THE CAP TIMIRIS MANGROVES, IN MAURITANIA, USING REMOTE SENSING

Viviana Otero[1,2], Katrien Quisthoudt[1], Nico Koedam[2] and **Farid Dahdouh-Guebas**[1,2*]*

[1]Laboratory of Systems Ecology and Resource Management, Université Libre de Bruxelles, Brussels, Belgium

[2]Laboratory of Plant Biology and Nature Management, Vrije Universiteit Brussel, Brussels, Belgium

The northernmost and most arid mangrove ecosystem in West Africa is found in the Parc National du Banc d'Arguin (PNBA), Mauritania, and it is only composed of *Avicennia germinans* (L.) L (Dahdouh-Guebas & Koedam, 2001). Global and regional maps show the location of these latitudinal mangroves (*e.g.* Spalding *et al*., 2010) and detailed maps made by hand are available (Dahdouh-Guebas & Koedam, 2001; Lamarche, 2008). Nevertheless, estimates of the mangrove area in Mauritania differ among studies (*e.g.* Spalding *et al.,* 2010; Lamarche, 2008; Fatoyinbo and Simard, 2013). We assessed the use of automated Remote Sensing classification techniques in order to calculate the extent and map the distribution of these latitudinal mangroves using QuickBird and GeoEye sensors. We tested unsupervised and supervised classification techniques and we developed a customized accuracy assessment procedure. This accuracy assessment takes into account the recommendations from Pontius and Santacruz (2014) and incorporates the cross-validation technique (Kohavi, 1995). As a preliminary result, it was possible to detect the northernmost mangroves of West-Africa with an accuracy of 87% ± 2% using the Maximum Likelihood algorithm. The main source of error is the low spectral difference between mangroves and other types of soil cover vegetation (11% ± 2% of exchange difference) which resulted in an erroneous classification of mangrove and non-mangrove vegetation in some areas. A first estimate of the mangrove area in Cap Timiris is 19,5 ± 5,5 ha in 2011. Apart from generating an accurate assessment of mangrove areal extent in a latitudinal range limit setting, we discuss the general approach and features related to the methodology applied.

Contact Information: Viviana Otero, Laboratory of Systems Ecology and Resource Management, Faculté des Sciences, Université Libre de Bruxelles (ULB), Avenue F.D. Roosevelt 50, CP 264/1, B-1050 Brussels, Belgium, E-Mail: voterofa@ulb.ac.be

WHOSE MANGROVE IS IT AND WHAT IS IT FOR? MAPPING DISCOURSES USING Q METHODOLOGY IN MATANG, MALAYSIA

Jean Hugé[1], Katherine Vande Velde[1,2], Francisco Benitez-Capistros[1,2], Behara Satyanarayana[3], ***Farid Dahdouh-Guebas[1,2,4]*** *& Nico Koeda[2,4]*

[1]Systems Ecology & Resource Management Unit, Biology Department, *Université Libre de Bruxelles* (ULB). 50, Av. Franklin Roosevelt, 1050 Brussels, Belgium

[2]Plant Biology & Nature Management, Biology Department, *Vrije Universiteit Brussel* (VUB). Pleinlaan 2, 1050 Brussels, Belgium

[3]Mangrove Research Unit (MARU), Institute of Oceanography & Environment (INOS), *Universiti Malaysia Terengganu* (UMT), 21030 Kuala Terengganu, Malaysia

[4]Co-last-authors

The sustainable management of natural resources requires the consideration of multiple stakeholders' perspectives and knowledge claims, in order to inform complex and possibly contentious decision-making dilemmas. Hence, a better understanding of why people in particular contexts do manage natural resources in a particular way is needed. Focusing on mangroves, highly productive tropical intertidal forests, this study's first aim is to map the diversity of subjective viewpoints among a range of stakeholders on the management of Matang Mangrove Forest in peninsular Malaysia. Secondly, this study aims to feed the reflection on the possible consequences of the diversity of perspectives for the future management of mangroves in Malaysia and beyond. The use of the semi-quantitative Q methodology allowed us to identify three main discourses on mangrove management: i. the 'optimization' discourse, stressing the need to improve the current overall satisfactory management regime; ii. the 'change for the better' discourse, which focuses on increasingly participatory management and on ecotourism; and iii. the conservative 'business as usual' discourse. The existence of common points of connection between the discourses and their respective supporters provides opportunities for modifications of mangrove management regimes. Acknowledging this diversity of viewpoints, reflecting how different stakeholders see and talk about mangrove management, highlights the need to develop pro-active and resilient natural resource management approaches.

Contact Information: Farid Dahdouh-Guebas, Professor, University Libre Brussels, Laboratory of Systems Ecology and Resource Management, ULB, Bruxelles / Brussels, B1050, Belgium, PH 3226502137; FX 3227210203,
Email: fdahdouh@ulb.ac.be

A NEW PROCESS-BASED MANGROVE CARBON ASSESSMENT TOOL: MCAT-DNDC

Zhaohua Dai[1,3], *Carl Trettin[1], Steve Frolking[2], and Richard Birdsey[3]*

[1]Center for Forested Wetlands Research, USDA Forest Service, Cordesville, SC USA
[2]ESRC, University of New Hampshire, Durham, NH USA
[3]Strategic Foresight Group, USDA Forest Service, Newtown Square, PA USA

The ability to estimate carbon (C) dynamics in mangroves is necessary for developing strategies to sustain ecosystem functions from intact forests and to restore degraded areas to provide valued ecosystem services under changing climatic conditions. A process-based model was developed by integrating new features into Forest DNDC, a freshwater forest biogeochemical model, that describe marine sediment biogeochemistry and mangrove physiology. This new model, MCAT-DNDC, can be used to estimate C dynamics in mangrove ecosystems, including above- and below-ground biomass, burial C and fluxes of aquatic C (dissolved inorganic and organic C, particulate organic C) and methane, and impacts of changing ecological drivers on C sequestration in mangroves, including temperature, precipitation, soil phosphorous, salinity and combined impacts of multiple factors. The sensitivity analysis showed that C sequestration in mangrove ecosystems was highly sensitive to multiple factors, including soil phosphorus concentration, salinity, air temperature and geographical locations. The physiological responses were distinctly different. The response of gross and net primary productivity to changes in mean daily temperature (MDT) were cubic polynomial, but leaf production was linear, and aboveground biomass was quadratic; yet their response to other ecological drivers were similar. Other components of the forest C cycle, such as burial C, dissolved inorganic and organic C, and particulate organic C respond differently to variations of the ecological drivers. For example, while mangrove productivity is sensitive to available phosphorous, it cannot mitigate the stress imposed by high salinity. The combined effects of the driving factors are complex due to their intricate interactions highlighting the value of tool to assess C dynamics in mangroves.

Contact Information: Zhaohua Dai, USDA Forest Service, Email: zdai@fs.fed.us or mcatdndc2015@gmail.com

A REGIONAL FRAMEWORK FOR MANGROVE RESEARCH AND TRAINING FORESTS IN EAST AFRICA

C.C. Trettin[1], M. Mangora[2], S. Bandeira[3], and *C. Stringer[1]* ***Presented by Zhaohua Dai***

[1]Southern Research Station, US Forest Service
[2]Inst. Marine Science, Univ. Dar es Salaam
[3]Dept. Biological Sciences, Univ. Eduardo Mondlane

Mangroves are widely recognized for their ecosystem services; however, there is insufficient information available for developing sustainable use strategies or for considering adaptation strategies to the threats from climate change, sea level rise, and land use conversion. There is also insufficient technical information to support effective mangrove restoration in the region. Accordingly, an active research, education and technology transfer program is warranted to provide needed information and enhance local capacity in the science and management of mangroves. Recognizing that a research and demonstration site is needed to provide the basis for long-term monitoring, experimentation, training and education, the USAID Africa Bureau is supporting the establishment of two research and teachings forests in Mozambique and Tanzania. The purpose is to establish a facility that can sanction research, demonstration, and education activities in such a way as to realize long-term studies, interdisciplinary and participatory monitoring, and a field laboratory for demonstrating good management practices and effective restoration techniques. Local communities will be involved to ensure their socio-economic considerations in both the operation of the forest and in the studies and demonstration trials. The mangrove research forest being established in Tanzania will be located in the Rufiji River Delta, and the one in Mozambique located in Maputo Bay. Each of these forests is being developed by an inter-agency team within the respective countries, and they will have the responsibility for the operation and coordination of the facility. Establishing monitoring capabilities and baseline studies are part of the start-up activities, which are intended to provide a foundation for collaborators working on the site. The activities among the mangrove research forest will be coordinated through the West Indian Ocean Mangrove Network.

IMPACTS OF INCREASED SALINITY ON MANGROVE CARBON CYCLING PROCESSSES

***Pedram P. Daneshgar**, Kristina M. Guarino, Kristen E. Jezycki, and John A. Tiedemann*
Marine and Environmental Biology and Policy Program, Monmouth University, West Long Branch, NJ, USA

Salinity is expected to rise in marine ecosystems of the tropics, particularly in the Caribbean, due to increased evaporative loss in surface waters related to warming. Changes in salinity are expected to have significant impacts on coastal ecosystems and the services they provide. Mangrove ecosystems, which have been demonstrated to have great value for carbon sequestration, are likely susceptible to these impacts, as their productivity is tightly related to salinity. This is clearly demonstrated by the dwarfed mangroves in regions like The Bahamas where there are no freshwater inputs to these systems. An understanding of how mangroves will respond to salinities rising above current ambient ocean levels is needed in order to assess the impacts of climate change on these valuable ecosystems.

We explored the impacts of elevated salinity on red mangrove (*Rhizophora mangle*) carbon cycling processes, primarily focusing on mangrove photosynthesis rates and mangrove sediment respiration rates. Sampling was done of mangrove tidal creeks in Eleuthera, The Bahamas where salinity ranges from ambient ocean levels to hypersaline along natural naturally occurring salinity gradients. Utilizing these gradients, predictions can be made on how red mangroves will respond to rising salinities both in the Caribbean and in estuaries that are experiencing changes in salinity due to sea level rise.

Contact Information: Pedram Daneshgar, Assistant Professor, Monmouth University, Marine and Environmental Biology and Policy Program, 400 Cedar Ave, West Long Branch, NJ 07764; United States; Phone 732-923-4784,
Email: pdaneshg@monmouth.edu

MANGROVE LONG-TERM ABOVEGROUND NET PRIMARY PRODUCTIVTY IN THE FLORIDA COASTAL EVERGLADES: RESPONSE TO HURRICANE DISTURBANCE AND RESILIENCE MAGNITUDE

***Tess Danielson[1]**, Victor H. Rivera-Monroy[1], Edward Castañeda-Moya[1], Henry Briceño[2], Rafael Travieso[2], Evelyn Gaiser[2]*

[1]College of Coast and Environment, Dept. of Oceanography & Coastal Sciences, Louisiana State University, Baton Rouge, LA, USA

[2]Florida International University, Miami, LA, USA

The mangrove ecotone region (EMER) in the Florida Coastal Everglades (FCE) has been historically subjected to a wide range of disturbances varying in intensity and frequency. Yet, discrete pulsing events are capable of significantly altering ecosystem structure (e.g. species dominance) and function (e.g. litterfall net primary productivity: NPP_L, and stem net primary productivity: NPP_S). Hurricane Wilma, a category 3 storm, crossed South Florida in October 2005, causing significant defoliation (>90%) and tree mortality in riverine and basin mangrove forests along the Shark River Slough (SRS). This event represented an opportunity to evaluate long-term trends in species-specific net productivity (stem and litterfall) before (2001-04) and after (2006-14) Wilma's impact. We investigated the response of both NPP_L and NPP_S to differential hurricane impacts at three long-term study sites (SRS-4, SRS-5, and SRS-6) to evaluate forest resiliency as related to carbon storage, sequestration, and export and spatiotemporal legacies. We hypothesized that (1) the mangrove recovery trajectory (i.e. recovery duration and rate) is dependent on the disturbance impact magnitude and initial forest structure, and (2) the stem growth will be arrested during the first three years while the tree canopy recovered from hurricane-induced defoliation. Our long-term data (2001-2014) indicates that hurricane disturbance significantly reduced productivity annual rates (by at least 65%) and carbon allocation within each site, especially in SRS-6. Hurricane Wilma's stronger wind fields (30-40 m s^{-1}) that impacted sites SRS-5 and SRS-6 caused a canopy litter export of approximately 2X the annual pre-storm average litterfall carbon (3.5 and 4.7 Mg C ha^{-1} yr^{-1}, respectively). We observed differential recovery times among sites and among species; SRS-5 and SRS-6 returned to pre-Wilma NPP_L rates by 2010, however SRS-4 has not yet reached recovery. Total forest basal area in SRS-6 was reduced from 42 m^2 ha^{-1} (SD±7) in 2004 to 30 m^2 ha^{-1} (SD±1) in 2015. This reduction reflects the cumulative mortality over a 10-year period as a result of tree defoliation induced by wind impact. Yet, relative species basal area contribution to total basal area did not change significantly from 2004 to 2015 at each site. The mangrove species *Rhizophora mangle* was the dominant species in both SRS-4 and SRS-5 sites, while *Laguncularia racemosa* remained the dominant species in SRS6 before and after the storm. Total stem production measured in 2003-2004 was relatively lower following the storm (2004-2006) at all sites, with a net reduction gradient of 11 (SRS-4), 3 (SRS-5), and 8 (SRS-6) g C m-2 yr-1 although significant differences were only registered in SRS-6. Our results underscore the EMER resilience capacity to natural disturbance showing distinct but different productivity patterns depending on species dominance.

Contact Information: Tess Danielson, LSU Dept. of Oceanography and Coastal Sciences, 3179 Energy Coast and Environment Bldg. Baton Rouge, LA 70803, Phone: 301-642-0993, Email: tdani17@lsu.edu

ASSESSMENT OF RECOVERY OF MANGROVE HABITATS USING STABLE ISOTOPES

***Amanda W. J. Demopoulos[1]**, Jill R. Bourque[1], Jennifer McClain-Counts[1], Nicole Cormier[2], Ken Krauss[2]*

[1]U.S. Geological Survey, Wetland and Aquatic Research Center, Gainesville, FL, USA

[2]U.S. Geological Survey, Wetland and Aquatic Research Center, Lafayette, LA, USA

Mangrove habitats provide important ecosystem services, including coastal storm protection, carbon sequestration, water quality improvement, and support of fish and wildlife communities. Over the past two decades, mangrove habitats have decreased drastically worldwide, highlighting the need for mangrove ecosystem restoration. While most restoration efforts focus on planting seedlings, they often ignore the underlying physical parameters causing mangrove loss, such as disruption to the hydrological regime. Mangrove restoration via a hydrology-only approach has the potential to save millions of dollars globally; but their success is yet untested. Assessments of restoration success can employ a functional equivalency approach, comparing restoration areas over time with natural, reference forests. Here we employ the use of stable isotopes, ^{13}C and ^{15}N, to assess the food web ecology of mangrove habitats. Stable isotopes are a useful tool for assessing restoration success because they help identify food sources, estimate food pathways, and elucidate trophic interactions, ultimately linking primary producers to higher trophic levels. Stable isotopes provide a metric to track changes in the trophic structure following restoration, and enable time estimates for establishing functional equivalency and restoration success.

The study was conducted at the Fruit Farm Creek hydrological restoration site within the Rookery Bay National Estuarine Research Reserve, FL. The study site includes a reference area outside the restoration area, 50 and 100-acre plots that have not been restored, and a small 4 acre plot that has been hydrologically restored. Within each plot, samples were collected along a gradient of deforestation, from a heavily degraded zone, characterized by mud flats with 0% plant cover and dead standing trees, to a transition zone, characterized by a high number of saplings, and finally into a reference zone, containing dense mangrove trees with >90% tree cover. Flora and fauna were collected from each area, and their trophic structure was determined using stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopes.

Within mangrove habitats (transition and reference zones), common epifaunal and infaunal taxa encountered included annelids, gastropods (*Cerithidea sp.*, Littorinidae, *Melampus coffea*), isopods, and fiddler crabs (*Uca sp.*). Fewer species of epifauna were observed in the degraded zone, and taxa were generally dominated by gastropods (*Cerithidia* sp. and *Melampus coffea*) and insect larvae. Fauna collected from degraded zones were enriched in ^{13}C relative to those found in reference zones, indicating a shift in the dominant carbon source from mangrove detritus (reference zone) to algae (degraded zone). In the 4 acre restored plot, the degraded, transition, and reference zones were less isotopically distinct than measurements from corresponding zones in the non-restored 10 and 50 acre plots. Our initial results suggest that the restored hydrological regime may be facilitating the maturing of the mangrove ecosystem, including the development of mangrove detritus, allowing for the trophic pathways in degraded and transition zones to be more similar to reference areas. These data serve as a baseline for assessing mangrove restoration success over time and provide critical information on the ecosystem functioning in mangrove habitats.

Contact Information: Amanda W.J. Demopoulos, U.S. Geological Survey Wetland and Aquatic Research Center, 7920 NW 71st St, Gainesville, FL, USA 32653, Phone: 352-364-3490, Email: ademopoulos@usgs.gov

BIODIVERSITY IS INTEGRAL TO THE ABILITY OF FOUNDATION SPECIES TO ADAPT TO CHANGING CLIMATE CONDITIONS

Donna J Devlin *and C Edward Proffitt*
Dept of Biological Sciences, Florida Atlantic University

Large scale disturbances associated with hurricanes, anthropogenic disturbances, and migrations are co-occurring and are predicted to continue to escalate in frequency and intensity in response to climate change. Accordingly, understanding disturbance driven mangrove foundation species' distributions and their associated communities is key to helping us to predict future distributions of these communities and their associated ecological services.

Genetic diversity is a primary component of biodiversity and is integral to the ability of populations to adapt to changing conditions. Gap-recruiting foundation tree species such as *Rhizophora mangle* characteristically form forests composed of geographic mosaics that vary in diversity at both the genetic (intra-species) level of the foundation species as well as at the inter-species level of the community. Recent work demonstrates that newly recruited *R. mangle* populations migrating northward with climate change also form patches that vary in genetic diversity dependent on local and regional oceanic current flow that disperses propagules and promotes gene flow.

To test both intra-species (genotypic maternal family) diversity and inter-species interactions, of *R. mangle* we designed a large scale (83 plots X 12 individuals/plot) common garden experiment. Plots have three levels of diversity low (monotypic plots with 1 maternal family) medium (4 individuals from 3 maternal families) and high (2 individuals from 6 maternal families). Eight maternal families were assigned stratified randomly so that each diversity treatment had an equivalent number of individuals from each maternal family. Early analyses of these data concentrated on genotypic differences, and later evaluation (4 years) concentrated on characteristics at the level of the experimental plot.

We found that the ecological functions, productivity ($p<0.001$) and infestation by parasites ($p<0.008$) varied with maternal genotype. At the plot level tree architecture varied with the level of genotypic diversity, canopy area ($p<0.0126$, R2=.66), number of surviving trees ($p<0.0486$, $R^2=.53$) and average height ($p< 0.0049$, $R^2=.73$) increased with diversity and reached a threshold at the level of medium diversity and then levelled off. Maximum tree height followed the same pattern and was marginally significant ($p>0.0620$, R2=.50). Herbivory varied with diversity ($p<0.0455$, $R^2=.42$). Arachnid community diversity increased with diversity ($p>0.003$), with greater diversity at the high diversity treatment. Within the common garden, plots with varying levels of genetic diversity influenced plant architecture, herbivory, infestation by parasites, associated communities and ecological functions. The experimental common garden establishes a small scale geographic mosaic that is shaped by the diversity of the plots.

We show that genetic diversity of *R. mangle* can influence ecological functions and associated community diversity which may have key ecological and evolutionary implications for mangroves and other foundation species as they expand their ranges with climate change. These results support the argument that genetic variation within foundation tree species has the potential to be a significant driver of the geographical mosaics of variation in foundation species communities.

Contact Information: Donna Devlin, Research Associate Professor, Florida Atlantic University, Biological Sciences, 5600 US 1 N, Ft. Pierce, FL 34946; United States; Phone: 772-242-2206; Email: ddevlin@fau.edu

FROM SCIENCE TO POLICY: UNDERSTANDING REPRODUCTIVE RHYTHMICITY OF BRAZILIAN MANGROVE CRABS TO IMPROVE THEIR CONSERVATION AND FISHERIES MANAGEMENT

Karen Diele[1,2], and *Anders Jensen Schmidt*[3]
[1]Edinburgh Napier University, Edinburgh, UK; [2]St Abbs Marine Station, St Abbs, UK
[3]Universidade Federal do Sul da Bahia, Brazil

Crabs are key players in mangrove ecosystems and therefore important to conserve. In Brazilian mangrove forests, the largest species, *Ucides cordatus*, sustains essential ecosystem functions and services such as acceleration of nutrient cycling (it is the only significant leaf litter feeder in this bioregion) and provision of food and income through fisheries yields of up to 7 tons per annum per km^2. Many populations are suffering from habitat degradation, disease and increasing fishing pressure and capture bans are in place aiming to prevent unsustainable fishery. During the last decade however, regulatory agencies have lost credibility due to a frequent mismatch between a precautionary temporal capture ban during the reproductive season and days of actual mass mating events (called andada), which has promoted law incompliance by fishermen. We aim to generate the necessary scientific knowledge to allow a robust nation-wide prediction of the occurrence of mating *en masse* in *U. cordatus*, to improve the current fisheries management for this vulnerable species.

The conspicuous andada mass mating events of *U. cordatus* occur over 3 to 5 days during the 3-4 months lasting reproductive season. Mate-searching specimens are unusually active outside their burrows and particularly easy to catch. It is common knowledge that andada occurs at syzygies, but the particular moon phase, at full, at new or more rarely at both full and new moon, varies between and within years. To prevent unsustainable exploitation, crab capture is therefore banned at *both* new and full moon, as a precautionary measure, even though andada mostly only takes place during *one* of the two moon phases, resulting in the above-mentioned conflict between fishermen and managers.

We hypothesize that the rhythm of andada is linked to geophysical cycles and therefore predictable in time. If true, this would allow a precisely tailored placement of reproductive capture bans. We tested this hypothesis in Caravelas, NE-Brazil, by assessing presence/intensity of andada with respect to the light-dark- and tidal cycle between 2006-2015 at this site. Our results show that the rhythm of andada is linked to the rarely noticed *Syzygy Tide Inequality Cycle* (STIC): we observed a shift of andada between new and full moon, depending upon which moon phase had the higher amplitude tides [1]. The likely ultimate cause of the linkage between STIC and andada is increased larval survival by synchronous release at highest amplitude spring tides one month later.

In the upcoming reproductive season, managers of the Extractive Reserve of Cassuruba at Caravelas have agreed to test the applicability of the STIC knowledge by monitoring law compliance at predicted andada moonphases only. To scale up we are also testing our predictability hypothesis over the species' distributional range. In 2013 we founded the researcher network REMAR (Rede de Monitoramento de Andadas Reprodutivas dos Caranguejos) to allow a simultaneous multiannual study at currently nine macrotidal, meso- and microtidal sites along the Brazilian coastline. We invite collaborators from other countries to join our ongoing REMAR network project, which will last until at least 2019.

Contact Information: Karen Diele, SLSSS, Edinburgh Napier University, Sighthill Campus, Edinburgh EH11 4BN, UK, Phone: +44 131 4553353, Email: kdiele@napier.ac.uk

HOW WILL MANGROVE ENCROACHMENT AND ERODING IMPOUNDMENTS IMPACT COASTAL PROTECTION OF INTERTIDAL WETLANDS IN THE MERRITT ISLAND NATIONAL WILDLIFE REFUGE?

***Cheryl Doughty*[1]*, Kyle Cavanaugh*[1]*, Ilka C. Feller*[2]*, Carlton Hall*[3] *and Samantha Chapman*[3]

[1]University of California, Los Angeles, CA, USA
[2]Smithsonian Environmental Research Center, Edgewater, MD, USA
[3]Inomedic Health Applications
[4]Villanova University, Villanova, PA, USA

As coastal wetlands across the globe face increasing pressures from climate change and anthropogenic stressors, natural ecosystem infrastructure and services are being recognized as valuable components of adaptive planning and decision-making. In the Merritt Island National Wildlife Refuge (FL, USA), salt marshes are converting to mangroves and impoundment structures are eroding. The impacts of these changes on ecosystem function, infrastructure and services remain largely uncertain. Because this area contains highly valuable human assets surrounded by low-elevation coastal wetlands (e.g., NASA's Kennedy Space Center), ecosystems services such as coastal protection (e.g. flooding and erosion mitigation) are highly important. To provide insights into coastal protection, we evaluated how wave attenuation and erosion prevention may differ by vegetation type and structure, and how these services are impacted by impoundment erosion. We used the Natural Capital Project's Integrated Valuation of Environmental Services and Tradeoffs (InVEST) model for Coastal Protection, which was parameterized using field-based vegetation measurements of height, stem diameter and stem density. Additional model inputs, such as sediment characteristics, and model assumptions of nearshore wave evolution and erosion were held constant in order to provide a baseline comparison of coastal protection between vegetation types and differing impoundment elevation profiles.

Preliminary results suggest that mangroves offer 5% more erosion prevention, a 13% reduction in wave height, and a 6% reduction in wave energy as compared to salt marsh. Furthermore, the buffering capacity, or the width of habitat needed to attenuate 90% of wave height, is 133 m for mangroves and 250 m for salt marsh. We used the estimated value of the infrastructure in MINWR (5.6 billion USD) to determine a monetary estimate of coastal protection value based on the results described above. Our estimates indicate that mangroves may contain twice as much economic value on a per area basis relative to salt marshes. In addition to vegetation type, the management of impoundments may also impact coastal protection by creating divergent topographies which border wetland habitats. As impoundment berms are left to erode and are replaced by the gradual slopes characteristic of natural coastal wetlands, we hypothesize that the coastal protection provided by these habitats will increase. As mangrove encroachment is likely facilitated by impoundment erosion and low elevation grades, we expect that an increase in mangrove extent in MINWR could result in substantial increases to coastal protection and may improve the overall resilience of these coastal ecosystems to continued global change.

Contact Information: Cheryl Doughty, University of California Los Angeles, Geography, 315 Portola Plaza, Los Angeles, CA 90095, United States; Phone: 267-614-8115; Email: cdoughty@ucla.edu

MANAGING OIL SPILL IMPACTS ON MANGROVES: SHOULD WE BE CONCERNED?

Norman C Duke
James Cook University, TropWATER Centre, Townsville QLD, Australia

Mangroves are widely acknowledged as highly vulnerable to oil spills, but this is measured mostly in terms of severity of impacts on vegetation rather than their longer term recovery and the consequences for associated trophic processes. Little is known about key linkages and functional relationships between the plants and animals making up mangrove habitat. This includes not knowing how long it takes for oil-damaged mangrove habitat to recover. While recovery of forest structure appears to occur within three decades, full habitat recovery may take much longer. From the limited data available, it seems that prevention would be the better option, rather than restoring oil-damaged habitat. But, when mangrove habitat is oiled then an effective strategy is needed.

When petroleum oil deposits on sensitive plant surfaces, it also affects soils and dependant animal life, causing a range of lethal and sublethal impacts that extend widely throughout associated coastal and estuarine ecosystems. Such disruptions also affect ecosystem services, like fisheries production and shoreline protection. And, all such impacts may persist for decades, as well as occurring at any time and at any place. So, for as long as oil is extracted and transported, there will be an ever-present risk to the health and survival of mangrove habitats worldwide. Therefore, it is essential where possible to be prepared.

Preparedness includes evaluation of risks and vulnerability, developed from baseline shoreline surveys, records of earlier impacts and recovery, and using effective longer-term monitoring. For instance, impact severity on mangroves might easily be quantified by the area of tree death along with other pragmatic descriptors, like the estimated volume of oil lost, the types of oil, the area of oiled habitat, and the area of likely sublethal impacts. The situation would also be much improved by an agreed global assessment strategy using standard criteria for the longer term, better management and monitoring of mangrove habitat affected by large oil spills. Only in applying such a strategy will it be possible to adequately understand, evaluate and assist longer term recovery of oil-impacted mangrove ecosystems.

Contact Information: Norm Duke, Mangrove Ecologist, James Cook University, TropWATER, ATSIP Building, University Drive, Townsville QLD, 4811, Australia, Phone: 61419673366; Email: norman.duke@jcu.edu.au

BIODIVERSITY INFLUENCES ON MANGROVE FOREST ECOSYSTEM SERVICES DELIVERY

Clare Duncan[1,2], *Jurgenne H Primavera*[3,4], *Julian R Thompson*[2], *Heather J Koldewey*[3,5], *Nathalie Pettorelli*[1]

[1]Institute of Zoology, Zoological Society of London, London, UK
[2]UCL Department of Geography, London, UK
[3]Conservation Programmes, Zoological Society of London, London, UK
4Zoological Society of London-Philippines, Iloilo City, Philippines
[5]Centre for Ecology and Conservation, University of Exeter, Cornwall, UK

A recent shift away from traditional 'fortress conservation' toward ecosystem approaches to land management has seen an increase in focus in the dual goals of conserving biodiversity and the goods and services (ES) derived from the world's ecosystems. The potential success of such approaches demands a mechanistic understanding of how biodiversity and ecosystem functioning and ES provision are related. Currently, however, this understanding is hindered by a lack of research into multiple mechanisms (e.g. niche complementarity, mass ratio) by which biodiversity may influence ES provision in real systems at scales at which the multiple ecosystem processes driving ES occur. Our study explores ES provision in six mangrove forests in Panay Island, Philippines. We examine how species richness, and functional diversity and trait dominance (multiple mangrove species traits: growth form, maximum height, rooting system type, specific leaf area and wood density) of mangrove species influences multiple ES provision (harvestable timber/charcoal production, downed wood kindling abundance, soil and vegetation carbon storage and storm attenuation potential [effective vegetation length; Le]). We assess the biodiversity drivers of mangrove ES provision within and between mangrove forests, utilising a linear mixed effects modelling framework controlling for the site and distance from the shoreline for each plot. Our results suggest variation in the mechanisms driving different mangrove ES, with a dominance of mangrove species with traits for high vertical structure and aboveground biomass best explaining plot-level carbon storage and timber/charcoal production, and high functional diversity in these traits as well as high multi-trait functional diversity explaining storm attenuation potential. These findings may have important implications for mangrove forest rehabilitation and restoration efforts for the maintenance of their crucial ES tropics-wide in the face of mangrove ES trade-offs.

Contact Information: Clare Duncan, Institute of Zoology (ZSL) and University College London, Nuffield Building, IoZ London NW1 4RY United Kingdom, Phone: 447887840557; Email: clare.duncan@ioz.ac.uk

EVALUATION OF CARBON BIOSEQUESTRATION IN THE MANGROVE SWAMPS OF THE GREAT KWA RIVER, CALABAR, NIGERIA.

***E.A. Edu**, A.E. Nkang, T. Okoh, and M.O. Ononyume*
University of Calabar, P.M.B. 1115, Calabar, Cross River State, Nigeria

The Carbon sequestration potential of the mangrove swamps of the Great Kwa River, Calabar, Nigeria was investigated along tidal gradients (low, mid and high) using litter production and decomposition. The mangrove species identified were *Nypa fruticans, Rhizophora racemosa* and *Avicennia africana*. Litter production and composition were measured over 12 months using litter traps (1m x 1m) while litter decomposition was monitored using litter bags (30cm x 30 cm). Litter fall and litter standing stock varied significantly ($p < 0.001$) temporally and spatially. Total litter comprised 64 % leaves, 18 % wood and 23 % miscellaneous propagules (flowers, fruits etc). Average monthly litter fall was 37.43 g dwt m^{-2} (≈ 449.2 g m^{-2} y^{-1}) while average monthly litter standing stock on forest floor was 13.38 g dwt m^{-2} (≈ 160.56 g m^{-2} y^{-1}). The time (days) for half of the initial dry mass (T_{50}) of leaves to decompose at low, mid and high tide levels were *A. africana* 46, 57 & 77; *R. racemosa* 69, 86 & 115 and *N. fruticans* 86, 99 & 115 respectively. The estimated residence time was less than one day while the projected residence time was between 83 and 142 days across tidal gradients, suggesting that other ecological processes might be involved in transporting litter away from the Great Kwa River into the Cross River estuary. Nitrogen and nutrient content in decomposing leaves increased significantly among species temporally ($p < 0.001$) and spatially ($p < 0.05$). Average C: N ratio decreased from 27.7 to 22.1 in *A. africana,* 26.4 to 23.9 in *R. racemosa* & 32.8 to 23.6 in *N. fruticans,* indicating wet mineralization. Results are considered useful in predicting patterns of accumulation and distribution of mangrove litter and sustainability of the mangrove ecosystem.

Contact Information: Edu, E.A., University of Calabar, P.M.B. 1115, Calabar, Cross River State, Nigeria,
Phone: +2348037238078, Email: esiedu@yahoo.com

RELATIONSHIP BETWEEN BIOTURBATION AND ENVIRONMENTAL CHARACTERISTICS OF MANGROVE FOREST IN FUKIDO ESTUARY, JAPAN

Ryohei Egawa[1], *Sahadev Sharma[2], Ratino Sith[1], Yusuke Tanokura[1], Kazuo Nadaoka[1]*

[1]Department of Mechanical and Environmental Informatics, Tokyo Institute of Technology, Tokyo, Japan

[2]Department of Natural Resources and Environmental Management, University of Hawaii at Manoa, Honolulu, HI, USA

Mangrove ecosystem blue carbon stock is receiving heightened attention because of storing high amount of carbon in soil due to anoxic nature. However soil carbon dynamics is influenced by factors especially like bioturbation due to benthic fauna such as dominant crab diversity. Crab burrowing activities are thought to affect the soil carbon dynamics by vertically transporting sediments and materials and establishing carbon mineralization pathways. Therefore it is necessary to understand bioturbation effects on carbon dynamics. This study aims to clarify what kind of environmental parameters govern bioturbation in mangrove soils. We measured burrow density, collapse proportion per day, depth of burrow and burrow diameter which can be the most important parameters to quantify the bioturbation effects on the material cycle in soil. It is important to understand the effect of vegetation, hydrology and soil properties on bioturbation parameters, which can be further used to develop bioturbation governed soil carbon dynamics model. Model development can be used to understand future scenario or change by seal level rise or climate change.

Field surveys were conducted in the estuarine mangrove of Fukido River (24.20 ºS, 124.15ºE) in the northern part of Ishigaki Island, Japan. We recorded seven species of fiddler crabs and five species of sesarmid crabs during our survey. Soil properties, vegetation parameters and bioturbation related data were collected from 12 plots of 7 m diameter along two transects during four seasons from August 2014 to June 2015. In each plot 5 subplots of 50 cm x 50 cm were established to understand the bioturbation effect.

Regression analysis showed that root biomass had a negative correlation with burrow collapse proportion (r =-0.738, p <0.01) and the longest burrow depth in plots (r =-0.732, p <0.05). It is suggested that root structure reduces vertical mixing of sediments and materials by making burrows hard and also being an obstacle to burrow. Hydroperiod had a negative correlation with the mean burrow depth (r =-0.750, p <0.05). Inundation may decrease crab activity to produce deeper burrow. In conclusion, our results show bioturbation parameters can be affected by soil, vegetation and hydrological parameters and these results will be useful to predict future changes of bioturbation degree that come with the change of mangrove conditions.

Contact Information: Ryohei Egawa, Department of Mechanical and Environmental Informatics, Tokyo Institute of Technology, Ookayama 2-12-1 W8-13, Meguro-ku, Tokyo, Japan Phone: +81-03-5734-2949,
Email: egawa.r.ab@m.titech.ac.jp

MANGROVE EXTRACTS INFLUENCE FEEDING ACTIVITY BY MANGROVE TREE CRABS IN FLORIDA AND BELIZE

***Amy A. Erickson*[1,2]*,Valerie J. Paul* [2]*, Ilka C. Feller*[3]*, Woody Lee*[2]*, Lisa M. Kwiatkowski*[2]*, Lorin West*[1]*, Pablo Trejo*[1]

[1]Louisiana State University Shreveport, Shreveport, LA, USA
[2]Smithsonian Marine Station at Fort Pierce, Fort Pierce, FL, USA
[3]Smithsonian Environmental Research Center, Edgewater, MD, USA

Secondary metabolites play a key role in their environment by influencing interactions among species. In doing so, they structure communities and affect ecosystem function. Extensive research has been conducted on ecological function of secondary metabolites produced by terrestrial plants and marine algae, as well as their potential application to medicine and agriculture. In contrast, researchers have just recently started to publish information on the chemical ecology of coastal plants such as mangroves. Examining the ecological function of extracts and secondary metabolites in mangroves is warranted given the considerable ecological and economic value of these systems. This study assessed the ecological activity of mangrove extracts, through the use of bioassay-guided fractionation, on feeding activity by the mangrove tree crab *Aratus pisonii*. *Aratus pisonii* is one of the most abundant crab species in mangroves in FL, Central, and South America. It is the primary herbivore of the red mangrove *Rhizophora mangle* but also is found living sympatrically with the black and white mangroves, *Avicennia germinans* and *Laguncularia racemosa*, respectively. Preliminary studies have shown that *R. mangle* and *L. racemosa* leaves are more palatable than those of *A. germinans*; thus, it was hypothesized that crabs from both locations would be deterred by *A. germinans* extracts.

Mature mangrove leaves in FL and Belize were collected and extractions were performed using a series of solvents, producing non-polar and polar extracts. The extracts were fractionated using column chromatography. Extracts and fractions were tested against crabs from both locations in feeding assays with agar-based artificial food. When both non-polar and polar extracts were combined, crabs from each location were deterred by *A. germinans* extracts from each location compared to extracts from the other species. Non-polar extracts from FL deterred feeding by FL and Belize crabs compared to other extracts from other mangrove species. Unexpectedly, non-polar extracts from Belize stimulated feeding in crabs from Belize when compared to extracts from other mangrove species. Polar extracts largely had no effect on feeding. All but one fraction of *A. germinans* deterred feeding by the crabs when compared to controls without extracts. The results suggest that mangrove extracts play an important role in influencing feeding activity by *A. pisonii* and that several different types of compounds may be responsible, especially those derived from non-polar extracts and fractions. It appears that mangrove extracts from the two locations vary in their activity and/or that the crabs vary in their sensitivity to the extracts. Further studies need to be conducted to identify specific secondary metabolites that influence feeding activity in *A. pisonii* and how such metabolites influence feeding by other mangrove herbivores.

Contact Information: Amy Erickson, Department of Biological Sciences, Louisiana State University Shreveport, Shreveport, LA USA 71115, PH: 318-797-5105, Email: amy.erickson@lsus.edu

EFFECTS OF POLYBROMINATED DIPHENYL ETHERS (BDE-99 AND BDE-209) ON GERMINATION AND GROWTH OF A MANGROVE PLANT, *KANDELIA OBOVATA*

***Shazia Farzana**, Juan Chan and Nora Fung Yee Tam*
City University of Hong Kong, Department of Biology and Chemistry, Tat Chee Avenue, Kowloon, Hong Kong

Polybrominated diphenyl ethers (PBDEs) commonly used as flame retardants worldwide are ubiquitous environmental contaminants. Coastal sediments, particularly those close to human activities, are sinks for PBDEs but their effects on coastal plants such as mangroves in tropical and subtropical regions have seldom been reported. The present study aims to investigate the germination and growth of *Kandelia obovata* Sheue Liu & Yong, a dominant mangrove plant, in PBDE-contaminated sediments. A soil microcosm experiment made up by pots with mature droppers of *K. obovata* planted in mangrove sediments contaminated with one of the two PBDE congeners, that is, BDE-99 at 336.98±13.75 μg kg^{-1} freeze dry sediment and BDE-209 at 52.68±6.1 mg kg^{-1} freeze dry sediment, was conducted. The pots receiving daily tidal flushing of artificial seawater at a salinity of 15 ‰ were placed in a greenhouse for three months. Results showed that germination of droppers was not affected by PBDEs. All droppers in both PBDE-treated and control pots were successfully germinated with the 2nd pair of leaves fully expanded in 42 days. However, the concentrations of chlorophyll a, b and carotenoid of seedlings grown in BDE-99 and BDE-209 contaminated sediments were significantly higher than that in the control (without any PBDE). Higher dry biomass of leaves and roots were found in seedlings grown in BDE-209 contaminated sediments. At the end of 3-month's exposure, concentrations of BDE-99 in leaf, stem, propagule and root tissues in the treated seedlings were 2.62±0.74, 1.35±0.17, 49.1±3.76, 751.53±99.12 μg kg^{-1}, respectively, while the respective BDE-209 concentrations in BDE-209 treated seedlings were 461.25±34.19, 567.4±67.14, 388.47±35.8 and 19531.54±2524.23 μg kg^{-1}, indicating that PBDEs in contaminated mangrove sediment were taken up by *K. obovata*, especially roots. The present study revealed that *K. obovata* was tolerant to high contamination of BDE-99 (337 μg kg^{-1}) and BDE-209 (53 mg kg^{-1}) in sediments. Because of the tolerance and uptake abilities of *K. obovata*, this species may be used in phytoremediation process.

Contact Information: Nora Fung Yee Tam, Department of Biology and Chemistry, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong, Phone: 852-3442-7793, Email: bhntam@cityu.edu.hk

HIGH-RESOLUTION 3-DIMENSIONAL MAPPING OF FOREST STRUCTURE AND ABOVEGROUND BIOMASS STOCKS IN BLUE CARBON ECOSYSTEMS IN THE AMERICAS, AFRICA AND SOUTH ASIA

Lola Fatoyinbo[1], *David Lagomasino*[1,2], , *Seung Kuk Lee* [1,2] , *Marc Simard* [3], *Emanuelle Feliciano*[2], *Carl Trettin*[3]

[1] NASA Goddard Space Flight Center, Greenbelt, MD
[2] Universities Space Research Association, Columbia, MD
[3]United States Forest Service, Cordesville, SC

Measuring and monitoring forest aboveground biomass (AGB) and carbon stocks (C) has become increasingly important because of its relevance to international climate negotiations, national climate change adaptation and mitigation programs in developing nations as well as the importance of forest Carbon stocks in global C cycle studies. Vegetated coastal ecosystems, also called *Blue Carbon* ecosystems are highly efficient carbon sinks and have been shown to play a significant role in ameliorating the effect of increasing global climate change by capturing significant amounts of carbon into sediments and plant biomass. In fact, current studies suggest that mangroves and coastal wetlands annually sequester carbon at a rate two to four times greater than mature tropical forests and store three to five times more carbon per equivalent area than tropical forests. Mangrove-lined estuaries and coastal ecosystems are significant to global biogeochemical processes and disproportionately to their land cover regulate the structure, productivity and function of adjacent coastal ecosystems.

In this talk, we will give an overview of recent efforts to quantify mangrove forest 3-D structure, composition and change at high resolution globally in the context of estimating forest biomass and blue carbon stocks. Our presentation covers field and remotely sensed investigations and describes unique remotely sensed datasets produced and collected at NASA, with an emphasis on recently collected airborne Lidar and Radar data from the Americas and Africa. In addition, we will highlight new remote sensing methods, which have permitted high-resolution 3-dimensional mapping of forest structure and aboveground biomass stocks in blue carbon ecosystems.

Contact Information: Lola Fatoyinbo, NASA Goddard Space Flight Center, Biospheric Sciences, 8800 Greenbelt Rd, Greenbelt, MD 20771, United States, Phone: 301-614-6660; Email: lola.fatoyinbo@nasa.gov

ESTIMATING MANGROVE CANOPY HEIGHT AND ABOVE-GROUND BIOMASS IN EVERGLADES NATIONAL PARK WITH TERRESTRIAL LASER SCANNING, AIRBORNE LIDAR AND TANDEM-X DATA

Emanuelle A. Feliciano[1,2], *Shimon Wdowinski[3], Matthew D. Potts[4], Seung-Kuk Lee[1,2] and Temilola E. Fatoyinbo[1]*

[1] NASA Goddard Space Flight Center, Greenbelt, MD, USA
[2] Oak Ridge Associated Universities, USA
[3] University of Miami - Rosenstiel School of Marine and Atmospheric Science, Miami, FL, USA
[4] University of California, Berkeley, CA, USA

The coastal mangroves forests of Everglades National Park (ENP) are well protected from development. Nevertheless, climate change, hurricanes and other anthropogenic disturbances have affected these intertidal ecosystems. Monitoring forest structural parameters (canopy height and above-ground biomass (AGB)) is important for the establishment of an historical database for past, present and future ecosystem comparison. It is possible to study the vertical structure of forests (canopy height) using remote sensing sensors from air- or spaceborne LiDAR/Laser Scanning or spaceborne Synthetic Aperture Radar (SAR) systems such as Shuttle Radar Topography Mission (SRTM) and TanDEM-X (TDX). Forest canopy height has a well-understood and directly proportional correlation with AGB.

In this study, we estimated mangrove canopy height in the ENP using an Airborne LiDAR (ALS) dataset and TDX datasets acquired during the years 2011-2014.The ALS dataset was acquired along a 16.5 x 1.5 km swath of mangrove forest with variable canopy height in Shark River Slough. The sampled areas were representative of mangrove stature and structure throughout the whole ENP. Analysis of the ALS dataset showed that mangrove canopy height can reach up to ~25 m close to the coastal ENP waters, where Shark River Slough connects with the Gulf of Mexico. The mean canopy height in the whole mangrove forest is located around ~9.7 m. The comparison of the Airborne LiDAR and the TDX data yielded an R^2 = 0.85 and RMSE = 1.96 m. To estimate AGB at the plot-scale we used ground-based LiDAR a.k.a Terrestrial Laser Scanning (TLS). The AGB TLS-based results indicated values ranging from 197.5 ± 22 Mg/ha for short mangroves up to 460 ± 60 Mg/ha for tall mangroves. The TLS-based results suggest that there might be higher AGB/carbon content in the ENP than previously estimated.

Contact Information: Emanuelle A. Feliciano, NASA Goddard Space Flight Center, 8800 Greenbelt Rd, Greenbelt, MD 20771, Phone: 301-614-6639, Email: emanuelle.a.feliciano@nasa.gov

RESTORATION OF NATIVE MANGROVES TOOK LONG TIME TO REVERSE THE RAPID DIET SHIFT OF BENTHIC MACROFAUNA CAUSED BY THE INVASION OF EXOTIC SPARTINA ALTERNIFLORA

Jianxiang Feng [1], *Qian Huang* [1, 2], *Jiemin Guo*[1], *and Guanghui Lin* [1, 3 *]

[1]Division of Ocean Science and Technology, Graduate School at Shenzhen, Tsinghua University, Shenzhen, China
[2]Biology Department, Marine Biology Section, Ghent University, Ghent, Belgium
[3]Ministry of Education Key Laboratory for Earth System Modeling, Center for Earth System Science, Tsinghua University, Beijing, China

To evaluate how long it will take to restore trophic relationship using native mangroves for controlling invasive *Spartina alterniflora,* we examined the trophic relationship of selected benthic macrofauna in the restored coastal wetlands following the removal of an invasive salt marsh species *S. alterniflora* in three different locations of Fujian province, China. Stable isotope analysis using Bayesian mixing model (MixSIR) showed that *Spartina*-derived material contributed at least 80.7% of the carbon sources for dominant gastropods and crabs in the *S. alterniflora* community and no significant differences were observed among the three locations. The drastic physical disturbances *during S. alterniflora* eradiction and planting of native K. *obovata* seedlings did not change the diets of selected benthic macro invertebrates during the first year of the mangrove restoration project. However, the reestablishment and development of mangroves gradually changed the food sources of these macrofauna species from homogeneous *Spartina*-dominated to heterogeneous algae material based, typical for local mangrove forests. In addition, the herbivorous crabs and arboreal gastropods responded to the change of vegetation much earlier than the detritus feeding species, but the complete shift in the trophic relationship of these benthic fauna in the mangrove wetlands invased by*S. alterniflora* required at least 3-4 decades after the restoration of native vegetation at all three locations. Therefore, the restoration of native mangroves can reverse the diets of benthic macrofauna caused by the invasion of of exotic S. alterniflora, but it will take at least severald decades, in contrast to the quick shift during plant invasion. Our results have significant implications for ecological projects and ecosystem managements in the coastal regions.

Contact Information: Jianxiang Feng, Graduate school at Shenzhen, Tsinghua University, Division of Ocean Science and Technology, L504, Tsinghua Park, Xili University Town, Nanshan District, Shenzhen, Guangdong 518055 China, Phone: 8618676374651; Email: feng.jianxiang@sz.tsinghua.edu.cn

CURRENT STATE OF EXPLOITATION OF BIVALVES WITH ECONOMIC IMPORTANCE ON INTERTIDAL ZONE IN NORTHEN MOZAMBIQUE

S. Fernando[1] *and J. Marcelino*[2]

[1]Instituto Nacional de Investigação Pesqueira, Maputo, Mozambique

[2]Departmento de Ciências Biológicas, Universidade Eduardo Mondlane, Maputo, Mozambique

To access the current state of exploitation, diversity and abundance for the main bivalve species with socio-economic importance, seagrass beds in Olumbi, Quissanga and Pemba were studied for 2 months (December 2013 – January 2014) by daily observation of catches, number of collectors and fishing frequency. 25 quadrats (0.25 m^2) was placed randomly for each area in beginning and the end of sampling. *Pinctada imbricata*, *Modiolus philippinarum* and *Choromytilus meridionalis* were the most harvested species for daily consumption and home trade. Olumbi attained the highest diversity (0.325 Simpson index) followed by Quissanga (0.248) and Pemba (0.105). Mean biomass and density were significantly different ($p < 0.01$) for all sampled areas. *M. philippinarum* was the most abundant specie in Olumbi (10ind/m^2) and Pemba (22ind/m^2) and *P. imbricata* was the most abundant specie at Quissanga (22ind/m^2). The CPUE was 39kg/collector/day for Olumbi, 28kg/colector/day for Quissanga and 7kg/colector/day for Pemba. Based on the harvesting area of 58ha-Olumbe, 389ha-Quissanga, 9ha-Pemba and mean effort of 22 collectors/day-Olumbe, 10 collectores/day-Quissanga, 5 collectores/day-Pemba, annual catch was estimated at 270ton, 88ton and 6ton respectively. The catches show the prevalence of *P. imbricata* in 99% for Olumbi and Quissanga, what reflects the preference of collectors for invertebrates with high commercial value. Pemba area is the only one with signs of over exploitation and less lengths due to the proximity to province capital city and high demand. Thus, is recommended to maintain the fishing effort in Olumbe and Quissanga and the fishery must be monitored to avoid over-exploitation.

Contact Information: Stela Fernando, Researcher, Instituto Nacional de Investigação Pesqueira, Invertebrate department, Av. Mao Tse Tung, 389 Maputo, Maputo 4603, Mozambique; PH 258827594960 ; FX: 27594960; Email: stelamcfernando@gmail.com

OIL PALM – A RAPIDLY INCREASING CAUSE OF MANGROVE DEFORESTATION IN SOUTHEAST ASIA

Daniel A. Friess[1] *and Daniel R. Richards[2]*

[1]Department of Geography, National University of Singapore, Singapore

[2]Future Cities Laboratory, Singapore-ETH Centre for Global Environmental Sustainability, Singapore

Mangrove forests continue to decline throughout the tropics due to a range of anthropogenic stressors. Southeast Asia has been a particular deforestation hotspot, with historic losses driven primarily by commercial aquaculture. A remote sensing study published in early 2016 showed that while aquaculture was still the dominant proximate driver of mangrove deforestation over the last decade, the production of other agricultural commodities – especially rice and oil palm - were also becoming increasingly important drivers of forest loss. While oil palm is a leading cause of terrestrial and peat swamp deforestation in Southeast Asia, its impact on mangroves is surprising, as few articles from researchers, governments or non-governmental organizations have previously identified oil palm expansion as an important regional threat. This presentation highlights the importance of oil palm to regional mangrove deforestation over the last decade, projects the future impacts of oil palm on mangrove deforestation rates, and identifies potential conservation solutions to reduce the impacts of oil palm on mangroves.

Our remote sensing results show that 1144 km^2 of mangrove were deforested in Southeast Asia between 2000 and 2012. Oil palm expansion accounted for 187 km^2, or 16.3% of total mangrove loss in the region, with most oil palm expansion occurring in Malaysia and Indonesia. These countries account for 85% of global palm oil production, with government policies promoting the industry as an important contributor to food security and the economy. We expect oil palm-linked deforestation to increase much more rapidly over the next decade, as the first cropping cycle for many oil palm plantations comes to an end, and governments throughout the region markedly increase production targets. For example, national legislation in Indonesia requires oil palm production to increase by 30% above 2012 levels by the end of this decade. The West Papua Region of Indonesia accounts for approximately 9% of the world's mangrove extent, and has largely escaped the large-scale deforestation experienced in the rest of the country. However, the West Papua region may become the next oil palm frontier, with government plans for huge agricultural developments covering 1.5 million hectares to boost the region's economy.

We must address the threat of oil palm now, before it reaches the scale of destruction caused by aquaculture. Previously, the focus has been on the conversion of freshwater peat swamps to oil palm plantations, and we can learn from conservation experiences in this ecosystem. Several forums exist, such as the Roundtable on Sustainable Palm Oil, and conservation mechanisms such as Payments for Ecosystem Services may show potential. While these approaches have their own flaws, we must seriously incorporate mangrove forests into conservation planning that addresses oil palm. It is crucial that we learn the lessons from previous efforts in other ecosystems, if we are to effectively conserve Southeast Asia's threatened mangroves.

Contact Information: Dan Friess, Department of Geography, National University of Singapore, 1 Arts Link, Singapore 117570, Phone: +65-6516-1419, Email: dan.friess@nus.edu.sg

GILL-BACTERIA SYMBIOTIC ASSOCIATIONS IN DUAL-BREATHING ANIMALS LIVING IN MANGROVE ECOSYSTEMS

Marco Fusi[1], *Ramona Marasco*[1], *Jenny Marie Booth*[1], *Francesca Mapelli*[2], *Massimiliano Cardinale*[3], *Sara Borin*[2], *Elena Crotti*[2] *and Daniele Daffonchio*[1]

[1]Biological and Environmental Sciences and Engineering Division, King Abdullah University of Science and Technology, Thuwal, Kingdom of Saudi Arabia.

[2]Department of Food, Environmental and Nutritional Sciences (DeFENS), University of Milan, Milan, Italy

[3]Institute of Applied Microbiology Research Center for BioSystems, Land Use, and Nutrition (IFZ) Justus-Liebig-University Giessen, Germany

In mangrove forests, Ocypodid and Sesarmid crabs are among the most important taxa that have evolved the capability to breath in air and in water. This adaptation is determined by major functional evolution of the gill system toward a lung-based function supporting bimodal breathing and catabolite excretion. Recent findings have shown how bimodal respiration could play a crucial role in enhancing the thermal tolerance of animals, allowing them to colonize new ecological niches. We hypothesize that bacterial symbiosis is a major force shaping the unique adaptation of crab gills to cope with the challenges dictated by the mangrove ecosystem and, in addition, to driving these species toward a process of terrestrialisation.

To test our hypothesis, we focused on two key stone mangrove crab species along the latitudinal distribution of West Indian Ocean mangroves: the ocypodid *Uca urvillei* and the sesarmid *Perisesarma guttatum*. These mangrove crabs were sampled across a large latitudinal range at their southernmost, equatorial and northernmost distribution sites, on the South African and Kenyan Indian Ocean coasts and the Red Sea Saudi Arabian coast, respectively. To explore the bacteria-gill association we used scanning and transmission electron microscopy techniques and analysis of the phylogenetic marker gene 16S rRNA, specifically PCR-denaturing gradient gel electrophoresis and next generation sequencing through the Illumina platform. Moreover, we used fluorescence *in-situ* hybridization (FISH) to visualize the topological association of the bacterial classes identified by molecular analysis and the gill surface of the two crab species investigated.

We detected the constant presence along the latitudinal transect of unique core microbiomes specific to each of the two species. At all three latitudes, the two communities were dominated by uncultured actinobacteria distantly related to the genus *Ilumatobacter*, while another relevant group, the Rhodobacteraceae, was represented by different operational taxonomic unit (OTUs) along the transect. These bacteria are firmly attached to the gill surfaces with dense filaments and show a uniform colonization pattern on the surfaces of the gill lamellae. The possible function of these bacteria is discussed in the light of their phylogenetic affiliation, localization on the gill surfaces and the biogeographical pattern observed along the latitudinal gradient.

Contact Information: Marco Fusi, KAUST, P.O. Box 4700, Thuwal, Kingdom of Saudi Arabia 23955-6900,
Phone: +966(0)568983358, Email: marco.fusi@kaust.edu.sa

MANGROVE FOREST DYNAMICS IN TANINTHARYI, MYANMAR 1989-2014, AND THE IMPLICATIONS OF FUTURE ECONOMIC REFORMS.

***Leon Y.F. Gaw*[1]*, Matthew Linkie*[2]*, Daniel A. Friess*[1]**

[1]Department of Geography, National University of Singapore, Singapore

[2]Fauna & Flora International, Singapore

Since its watershed election in 2015, Myanmar stands at an economic and environmental crossroads. Myanmar is a global biodiversity hotspot and contains large tracts of forest, though much of it is experiencing rapid deforestation that may increase further under expected future political and economic reforms. Mangrove forests in Myanmar exemplify this situation where large tracts of mangroves have already been lost in Rakhine and Ayeyarwady. The lack of accessibility to Tanintharyi, Myanmar's southernmost state, has, however, spared it from the same rapid development that has decimated forest covers in the other two mangrove regions.

In this study, we quantified land cover dynamics in the coastal zone of Tanintharyi, southern Myanmar between 1989 and 2014. We took a remote sensing approach, classifying six Landsat scenes over five time periods and ran a change detection of its mangrove forests. In terms of coarse areal extent, Tanintharyi seems to have experienced very little loss in mangrove cover compared to other regions of Myanmar, losing only 3.17% over 25 years. However, this view hides large loss and gains, which vary across the study site. Myeik district experienced the greatest area of deforestation (210 km^2 over 25 years), but also gained 132 km^2. Mangroves were generally deforested for Dawei and Kawthoung but its gains are comparable to losses such that the net loss is minimal. Most of the losses are to rice agriculture expansion, especially in the districts of Dawei and Myeik. New aquacultural farms built in mangroves are also driving losses near the towns of Myeik and Kawthoung.

Thus, even politically isolated regions of Myanmar such as Tanintharyi have experienced complex land cover transitions. While the loss of mangroves within our study period has been low, it and other land cover change is expected to increase rapidly in the near future as the political situation in Tanintharyi stabilizes, and international investors implement plans for large-scale agricultural commodity production and industrial and port development. Understanding historical baseline land cover change is essential for designing evidence-based conservation interventions that can protect southern Myanmar's mangrove forests in the face of these new threats.

Contact Information: Leon Gaw, Department of Geography, National University of Singapore, 1 Arts Link, Singapore 117570, Email: leongaw@nus.edu.sg

MIND THE TRAP: IMPLICATIONS OF THE TRAPPING EFFICIENCY OF *AVICENNIA* AND *RHIZOPHORA* ROOTS.

***Lucy G Gillis*[1]**, *Martin Zimmer*[1], and *Tjeerd Bouma*[2]
[1]Leibniz Center for Tropical Marine Ecology (ZMT), Bremen, Germany
[2]The Royal Netherlands Institute for Sea Research (NIOZ), Yerseke, Netherlands

Mangrove forests are located in the catchment areas of the terrestrial zone and can be adjacent to oceanic ecosystems (seagrass beds and coral reefs). These forests are thought to provide an ecosystem service retaining particulate organic material (POM) to facilitate nutrient sensitive seagrass beds and coral reefs. However they is a scarcity of knowledge of the processes, which control retention of POM. In this study using a flume and mimic mangrove roots we hope to identify physical (presence or absence of waves, fragmentation of leaves, root type) and chemical (degradation of leaves) processes, which control the retention of POM. Our study found that the majority of degraded leaves were retained within *Rhizophora* and *Avicennia* mimic roots. Only *Rhizophora* mimic roots trapped fresh fragmented leaves. Other physical drivers such as size of fragments, root type and presence of waves showed a significant difference in trapping POM. Our results firstly indicate the importance of organisms within the mangrove forest that alter the physical and chemical structure of the leaf, thus the biodiversity of the forest is vital in retaining POM. Secondly, the zonation of the tree species and the hydrodynamics acting on the roots will be important in the trapping capacity of the forest. When restoring or conserving mangrove forest to facilitate seagrass beds or coral reefs then it is vital that managers and scientists consider these parameters, which we have identified to ensure this major ecosystem service i.e. buffering of nutrient sensitive adjacent ecosystems, is functioning.

Contact Information: Lucy Gillis, Zentrum für Marine Tropenökologie (ZMT), Mangrove Ecology, Fahrenheitstraße 6 Bremen 28359 Germany, Phone: 4942123800162; Email: lucy.gillis@zmt-bremen.de

POPULATION STRUCTURE OF THE RED MANGROVE RHIZOPHORA MANGLE IN GUANA TOLOMATO MATANZAS NATIONAL ESTUARINE RESEARCH RESERVE

***Nisse A. Goldberg**, and John N. Heine*
Jacksonville University, Jacksonville, FL, USA

The phenology of the red mangrove *Rhizophora mangle* has not been studied for this population at the northern limit of its range. We measured reproductive effort of *Rhizophora mangle* from a population located in the Guana Tolomato Matanzas National Estuarine Research Reserve (GTM NERR) and compared this to patterns observed in southern Florida.

The numbers of buds, flowers, fruits, and propagules were recorded for eight of the most consistently reproductive adults per month from June 2013 to November 2015. Fallen propagules were tagged with numbered zip ties. Survivorship of fallen propagules, recruits (individuals with leaves), and juveniles (individuals with leaves and branches) was quantified.

The average (±SE) number of flower buds from these 8 adults was highest in August 2015 (355.4 ±64.1 buds per adult) and lowest in spring months. The average number of flowers was highest in September of 2014 and 2015 (134.3 ±26.8 and 148.3 ±24.4 flowers per adult, respectively) and lowest in winter and spring months. Fruits were present all year-round, and were highest in October of 2014 and 2015 (68.6 ±45.0 and 77.8 ±21.8 fruits per mangrove), with an average maximum fruit length of 3.2 ±0.2 cm. The number of propagules on the trees was highest in September of 2014 and 2015 (53.0 ±15.5 and 28.6 ±8.7 propagules per mangrove) with very few in winter months, with an average maximum propagule length of 27.4 ±1.3 cm. During the study period, 30% of the tagged propagules, 65% of tagged recruits, and 88% percent of tagged juveniles remained and persisted within a few meters of the parent adult. Of the propagules that did not survive or were missing, 46% showed evidence of being scraped or partially consumed and another 12% were completely dried. Of the recruits that did not survive or were missing, 29% were partially consumed and 10% were completely dried.

Rhizophora mangle in south Florida had more discrete and earlier periods of flowering and fruiting as compared to the population studied at GTMN NERR. For example, flowers buds were greatest in spring months in south Florida as compared to autumn months in the northern population. Flowering has been correlated to hotter and drier months. Flowers were greatest in June through September in south Florida as compared to September through November in the GTM NERR. Propagules were present during the wet season (July-October) for both populations. Propagules dropped during the periods of higher tides in winter months. However, less than half the tagged propagules were unaccounted for and likely dispersed from the parent and those that survived to a juvenile stage were likely to persist. Given the reproductive effort and survivorship of *R. mangle* and other mangrove species present, the GTM NERR salt marsh community is likely to continue to transition to a mangrove-dominated intertidal community with concomitant changes in trophic web structure and energy flow dynamics.

Contact Information: Nisse Goldberg, Jacksonville University, 2800 University Blvd, N, Jacksonville, FL, USA 32211,
Phone: 904-256-7322, Email: ngoldbe@ju.edu

NITROGEN DYNAMICS IN MANGROVES

*Gabriela B. Nardoto[1], **Carla R. G. Reis[1]** and Rafael S. Oliveira[2]*
[1]Universidade de Brasília, Brasília, DF, BRA
[2]Universidade Estadual de Campinas, Campinas, SP, BRA

Mangroves provide several ecosystem goods and services to society. However, mangrove areas are frequently subjected to land conversion, overharvesting, pollution, and are also threatened by global increases in reactive nitrogen (Nr) creation. Aiming to provide useful information to predict impacts of Nr enrichment on mangroves, we provide an updated overview on the general patterns of N dynamics in mangrove forests from previous synthesis and advance on the understanding of N dynamics in mangroves by evaluating differences in N dynamics between mangrove physiographic types in the Americas and alterations of N dynamics following N enrichment, identified with an extensive review of the literature and evaluation of a global database.

We collected and evaluated literature data on nitrogen (N) transformation rates in sediment (biological nitrogen fixation, mineralization, ammonification, nitrification, denitrification, and volatilization), dissolved N (DN) fluxes across the sediment-water interface, and natural abundance of N stable isotopes (δ15N) in the soil-plant system in conserved mangroves and those subjected to anthropogenic N enrichment. Data were obtained from 61 studies, totaling 137 mangrove sites comprising areas in the Atlantic Ocean, Caribbean Sea, Gulf of Mexico, and Indo-Pacific coasts.

Compared to terrestrial tropical forests, mangroves can sustain similar or even higher rates of biological N fixation (BNF) and higher denitrification and nitrous oxide flux rates. Mangroves can also be highly efficient users of DN forms from tidal waters, related to rapid plant uptake and an efficient conservation of DN in sediment by microbial activity. The main factors limiting N transformation rates in mangrove sediment are DIN availability and microbial immobilization in sediment. The δ15N data indicated that fringe forests exhibit higher N transformation rates in sediment and higher N losses to atmosphere, compared to other mangrove forest types. Except for BNF, all other N transformation rates in mangrove sediment seem to be intensified by increasing N availability.

Contact Information: Carla Roberta Gonçalves Reis, Universidade de Brasília, Instituto de Ciências Biológicas, Asa Norte, Distrito Federal, BRA 70910-900, Phone: +55 61 31072988, Email: carlargreis@gmail.com

ASSESSMENT OF INSECT BIODIVERSITY IN MANGROVE HABITATS IN SOUTHEAST ASIA USING MEGADIVERSE FLIES

***Patrick Grootaert[1], Jayanthi Puniamoorthy[2]**, Maosheng Foo[3], and Meier, Rudolf[4]*

[1]Entomology, Royal Belgian Institute of Natural Sciences, Brussels, Belgium
[2]Department of Biological Sciences, National University of Singapore, Singapore
[3]Lee Kong Chian Natural History Museum, National University of Singapore, Singapore
[4]Lee Kong Chian Natural History Museum and Department of Biological Sciences, National University of Singapore, Singapore

Rationale: The temporal factor for assessment of biodiversity in tropical ecosystems is a neglected and unknown factor. Mangroves in Singapore are used as model for insect phenology and for an in-depth study of insect diversity in a simple tropical marine forest ecosystem.

Methods: Insects were collected during a month-long sampling campaign with Malaise traps in 2009 in 11 mangroves in Singapore (26 sampling stations) in order better understand the relationship between fragment size, species abundance and diversity. In addition, a non-stop two-year sampling (2012-2014) in 4 sites (13 sampling stations in 4 mangroves, and 2 terrestrial reference stations) provided information on population dynamics and diversity.

Results: 32 insect groups were surveyed and insect phenology generally seems to depend on the monsoons with e.g. beetles, hover flies, robber flies and horse flies having their highest activity during the dryer periods while other groups such as dolichopodid flies are most active during the rainy seasons. Dolichopodidae of which the predacious larvae live in the mudflats and the adults hunt for small invertebrates on the mudflats, 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. During both sampling campaigns 37,302 specimens belonging to 159 dolichopodid species were collected. The total species number of dolichopodids for Singapore's mangroves is estimated (EstimateS) to be at least 215. Hence, 74% of the expected species richness was found during the project. In each of the 4 sites about 60 species were found, apparently being the functional threshold. Only 24 species were common to all 4 sites.

Conclusion: Each species has its own cyclic activity independent of the monsoons thus rendering short-time sampling rather insignificant for a sound statistical site quality assessment or diversity estimation. The results implement also that several sites have to be protected if one wants to protect a complete mangrove fauna.

Contact Information: Patrick Grootaert, Royal Belgian Institute of Natural Sciences, Entomology, Vautierstraat, 29 Brussels, B-1000, Belgium; Phone: 3226274302; Email: patrick.grootaert@naturalsciences.be

IMPACTS OF SEA LEVEL RISE ON THE GROWTH OF A DOMINANT AND A NON-NATIVE MANGROVE SPECIES IN CHINA

***Xudong Guo**, Hewei Zhao, Congjiao Peng, Naxu Hu, Luzhen Chen*

Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems and College of the Environment and Ecology, Xiamen University, Xiamen 361005, Fujian, China

Mangroves are facing the challenges about sea level rise accompanying with global change. Different mangrove species have diverse adaptability to water inundation among changing sea level according to different reactions of individual plants. In China, *Sonneratia apetala* Buch.-Ham., a non-native mangrove species from Bangladesh, has been widely used in mangrove afforestation for 30 years. A native *Kandelia obovata* Sheue, Liu and Yong, is another mangrove afforestation species in China because of its strong cold tolerance and high survival rate. Whether there is a competition between these two mangrove species in future sea level scenarios is still unknown.

In the present study, we carried out a long-term field manipulated experiment that assessing morphological and individual growth response of these two mangrove species to the inundation of rising sea level expected to occur in 80-100 years. We grew seedlings of *S. apetala* with 30cm tall and hypocotyls of *K. obovata* in a marsh organ with four elevation of sea level in Zhangjiangkou Nature Reserve in Fujian Province of China. There were four elevation treatments simulated four sea levels had been set up, including high water (HW), mean water(MW), low water(LW) and lowest low water(LLW) treatments, corresponding to the elevation of the edge of natural mangrove distribution (MW treatment), a 40-cm rise that approximated current conditions (HW treatment), a 40-cm increase in sea level (LW treatment), and a lower lowest 80-cm increase in sea level (LLW treatment), respectively. Environmental factors, such as air temperature, water temperature, water level, ect. were monitored on the spot. After half year's culture, HW plants of *S. apetala* were shorter, narrower, and produced fewer branches than LW and LLW treatments of *S. apetala*. Meanwhile, LW and LLW plants of *S. apetala*, grew more rapidly than HW and MW plants respectively. While for *K. obovata*, compare to lower plants, HW plants were shorter but wider, and produced more branches and leaves. Similar to *S. apetala*, LW and LLW plants of *K. obovata* grew more rapidly than HW and MW plants, but had little branches and leaves. However, *S. apetala* planted in each elevation treatments grew higher and wider than *K. obobata*. These short-term monitoring data suggested that inundation would promote both *S. apetala* and *K. obovata* seedlings to grow taller, while LW and LLW treatments depressed the biomass of both species. More measurements will be carried out in next two years to mimic the long-term effects of sea level rise.

This study was supported by a Chinese National Natural Science Foundation grants under contract No: 31270581 and No. 41476071, and by the Fundamental Research Funds for the Central Universities in Xiamen University under contract No. 20720140509.

Contact Information: Xudong Guo, College of the Environment and Ecology, Xiamen University, Xiamen, Fujian, China, Email: 562517431@qq.com

GENETIC DISCONTINUITIES IN A DOMINANT MANGROVE *RHIZOPHORA APICULATA* (RHIZOPHORACEAE) IN THE INDO-MALESIAN REGION E

Zixiao Guo
Sun Yat-sen University, School of Life Science

Aim
Population genomics data was used to determine the genetic diversity, genetic divergence and genetic structure of the mangrove, Rhizophora apiculata, across its distributional range and to re-assess the evolutionary processes that shaped its current distribution.

Location
The Indo-Malesian region section of the Indo-West Pacific region.

Methods
Next-generation sequencing (NGS) technology was used to sequence 81 nuclear loci from a pooled DNA sample of 31 to 44 individuals of Rhizophora apiculata from 11 populations. Five nuclear loci from six to eight individuals from 18 populations were sequenced using conventional Sanger sequencing technology to validate the results.

Results
Genetic diversity at the population level was low (π and θ were less than 1.0x10-3 in most of the populations), but relatively high at the species level (π=2.419x10-3 and θ=1.362x10-3). The populations of R. apiculata in the Indo-Malesian region were genetically differentiated and grouped into three clusters: East Indian Ocean (EIO), South China Sea (SCS) and Australasia (AUA). Based on the genetic distance matrices, two genetic discontinuities were observed, and they correspond to the Malay Peninsula land barrier and the Wallacea zone. The admixture observed in populations from the Malacca Strait were attributed to asymmetric gene flow through the strait, which was simulated by the isolation-with-migration (IM) model.

Main conclusion
Both the Sunda shelf barrier and ocean currents in Wallacea contributed to the observed genetic discontinuity, which separated R. apiculata into three clusters (SCS, EIO and AUA). The cycle between extinction and recolonization in the SCS in response to Pleistocene sea level fluctuations reduced the genetic diversity within populations. The repeated opening and closing of the gene flow corridors, such as the Malacca Strait, may have blurred the genetic discontinuities to an extent and introduced an admixture into populations in boundary areas.

Contact Information: Zixiao Guo, Sun Yat-sen University, School of Life Science, No. 135, Xingang Xi Road, Guangzhou, 510275, P. R. China, Guangzhou, Guang-dong 510275, China; Phone: 862084113677; Email: guozix@mail2.sysu.edu.cn

THE ROLE OF GROUNDWATER ON GROWTH, BIOMASS ALLOCATION AND DECOMPOSITION IN MANGROVE FORESTS

Matthew Hayes[1a], *Amber Jesse[1], Nina Welti[1], Basam Tabet[1], Tomasz Wyczesany[2], David Lockington[1], Catherine E. Lovelock[1]*

[1]The University of Queensland, St. Lucia, QLD, Australia
[2]University of Technology, Sydney, Australia

The roots of mangrove trees are periodically submerged by seawater, yet evidence for tree use of groundwater and fresh atmospheric water sources, which results in benefits for growth, is strong. Groundwater that is fresher than seawater and enriched in nitrogen often emerges on the coasts at sea level providing a resource to support the metabolic function and growth of mangrove forests. We assessed the effect of groundwater on biomass allocation and decomposition of a common and widespread mangrove, Avicennia marina, through changes in seasonal water use, nutrient availability and salinity across an intertidal gradient. Using analysis of $\delta^{18}O$ and δD isotopes in tree stem water we also assessed use of differing water sources. We found groundwater use by trees changed by season and the proportion of groundwater use or use of seawater varied over the intertidal zone. We found the proportional use of groundwater increased aboveground growth but had no effect on belowground growth. Belowground growth was influenced by nutrient availability across the intertidal zone, increasing with decreasing nutrient availability. Our research shows that groundwater can influence nutrient availability and salinity in intertidal sediments and that biomass allocation to roots will be higher in the low intertidal zone where root growth is high and rates of root decomposition low. The strong dependence of mangrove trees on groundwater gives insight into their vulnerability to local disturbances of hydrological flows and indicates that changes in groundwater availability as result of climate change or groundwater extraction will have a large effect on the functioning of mangrove forests.

Contact Information: Matthew Hayes, The University of Queensland, School of Biological Sciences, The University of Queensland, St Lucia, Brisbane, QLD, 4072, Australia, Phone: 61401672707; Email: h.matthew@uq.edu.au

TERRESTRIAL AND MARINE CONSORTIA OF WOOD DEGRADERS IN MANGROVE FORESTS ARE DIVIDED BY A SHARP TIDALLY-DEFINED BOUNDARY

Ian W. Hendy[1]*, Amaia G. Etxabe*[1]*, Jason A.Williams*[2] *& Simon M. Cragg*[1]

[1]Institute of Marine Sciences, University of Portsmouth, Ferry Road, UK

2Harte Institute for Gulf of Mexico Studies, Texas A&M University, Corpus Christi, TX, USA

Of the total marine biome, less than 2% is covered by vegetated marine habitats, yet they contribute close to half of the carbon burial in ocean habitats. Of those vegetated habitats, mangroves account for 0.5% of that area, but contain 15% of the total carbon accumulating in their sediments. Mangrove forests then are extremely productive, and mangrove productivity is often higher than that of neighbouring inland tropical forests. The breakdown, recycling and flux of nutrients from large woody detritus (LWD) in mangrove forests are caused by a consortia of biodegrading organisms that range in habitat from terrestrial to marine environments. We reveal the role of biodegrading organisms in fallen wood and also the environmental factors that influence the distribution of biodegrading consortia within the mangrove forests of East Sulawesi, Indonesia. Within the high intertidal, saprophytic decay upon LWD was dominant. Beetle larvae and termites were also abundant in decaying wood in the high intertidal, and also in the mid intertidal. In the low intertidal marine wood-borers, shipworms were the dominant biodegraders of LWD, and their activity greatly reduced the volume of LWD. In the mangrove forests, immersion time was the greatest environmental factor that influenced the distribution of the biodegrading consortia spanning from the high intertidal down to the low intertidal. The consortia of biodegrading organisms share the same LWD environment but they occupy a different niche: areas of different height above sea level. The change of biodegrading consortia in LWD between the terrestrial and the marine organisms was distinct, creating a biodegradation boundary in a distance as narrow as one meter on the mangrove forest floor – highlighting issues with climate change for both mangrove flora and fauna.

Contact Information: Ian Hendy, The University of Portsmouth, Biology, The Institute of Marine Sciences, Ferry Road, Portsmouth, Hampshire, PO4 9LY,United Kingdom, Phone: 4402392845807; Email: ian.hendy@port.ac.uk

SPATIAL VARIATION IN MANGROVE COMMUNITY ZONATION IN THE LOWER FLORIDA KEYS, USA

***Mark W. Hester**, and Jonathan M. Willis*
University of Louisiana at Lafayette, Lafayette, LA, USA

The Florida Keys are a low elevation island chain representing the southernmost extent of the continental United States. Red mangrove (*Rhizophora mangle*), white mangrove (*Languncularia racemosa*), and black mangrove (*Avicennia germinans*) are the primary intertidal coastal plant species in this area. Red mangrove typically dominates the lower intertidal zone, whereas black and white mangroves generally occur landward at higher, less frequently flooded elevations. The Lower Florida Keys have a unique geologic history, with many of the mid and upper intertidal areas exhibiting exposed surface layers of limestone. Importantly, significant soil development is frequently limited to lower intertidal areas and the higher elevation supratidal forests. As a result, black and white mangroves are often stunted in the mid and upper intertidal areas. We addressed the following primary questions: 1) Does the low elevation of the Lower Florida Keys, in combination with limited soil development for upslope migration, increase the susceptibility of these mangrove habitats to sea-level rise? 2) What are the key environmental factors that are currently controlling mangrove species occurrence and zonation? To address these questions we initiated a long-term study in which transects were established in different hydrogeomorphic settings on two of the Lower Florida Keys (Big Pine Key and Sugarloaf Key). Transects began at the lower intertidal, red mangrove interface, and extended upslope to the furthest landward extent of mangrove habitat. Plant community composition, edaphic factors, and elevation gradients were determined along each transect. Sediment elevation tables (RSETs) were installed at critical points along each transect (four per transect) to monitor accretion and net elevation change through time. In addition to the transect data, in 2014 we conducted a much broader RTK (Real Time Kinematic) elevation survey consisting of more than 1700 survey points to determine the elevational ranges that delineate the lower and upper limits of red mangrove, and the upper limits of black and white mangrove in the greater transect areas.

Transect soil depth was consistently shallow, generally not exceeding 20 cm. Results from Principal Components Analysis indicated that red mangrove cover was positively associated with soil depth and soil organic matter, white mangrove cover was positively associated with elevation, and black mangrove cover was positively associated with extractable soil salinity. Patterns of mangrove species zonation displayed considerable overlap of the upper elevation limits of their occurrence. To date, RSET data indicate that sediment accretion is variable and often transient, but that pulsed disturbance events, such as tropical storms and hurricanes, play an important role in redistributing sediment, particularly to upslope areas. Without these pulsed sediment deposition events, we suggest that accelerated rates of rising sea levels may exceed the rate of soil development, thereby limiting the ability of these mangrove communities to successfully move upslope.

Contact Information: Mark W. Hester, Institute for Coastal and Water Research, University of Louisiana at Lafayette, Lafayette, LA, USA 70504, Phone: 504 237-1151, Email: mhester@louisiana.edu

CHANGING COASTAL LANDSCAPES: WHERE ARE MANGROVES GOING AND WHAT DOES IT MEAN FOR CARBON DYNAMICS?

Sharyn M. Hickey[1,2]*, Stuart R. Phinn*[3]*, Catherine E. Lovelock*[4,5]*, Nik J. Callow*[1] *and Jeff Hansen*[1,2]*, Carlos M. Duarte*[2,6]

[1]The School of Earth and Environmental Sciences, University of Western Australia, Crawley, WA, Australia
[2]The UWA Oceans Institute, University of Western Australia, Crawley, WA, Australia.
[3]School of Geography, Planning and Environmental Management, The University of Queensland, Brisbane, Queensland, Australia
[4]School of Biological Sciences, The University of Queensland, Brisbane, Australia.
[5]Global Change Institute, The University of Queensland, Brisbane 4072, Australia
[6]Red Sea Research Center (RSRC), King Abdullah University of Science and Technology, Thuwal, Kingdom of Saudi Arabia

Mangroves and saltmarsh provide many valuable ecosystem services; in additional to their essential habitat and coastal buffer roles, they have significant capacity to sequester carbon dioxide and mitigate some climate change effects. Yet they have been subjected to large global declines and degradation, which in turn can contribute to increasing CO_2 emissions due to the loss, and subsequent erosion or exposure of soil carbon deposits. Globally and within Australia losses of mangroves and saltmarsh have been large. Loss and degradation of mangroves and saltmarsh have occurred due to both direct anthropogenic effects and due to changes in environment, but disentangling environmental and anthropogenic changes is difficult in many locations.

This study utilised remote sensing to quantify the areal change of mangroves and saltmarsh over a 23 year period across land categories at Mangrove Bay, north-west Australia, a site with minimal anthropogenic influence. In doing so, this study assessed the changing estuarine environment and determined the land categories that are expanding onto former mangrove and saltmarsh areas. This approach enabled the drivers of change in habitat area of mangroves and saltmarsh to be determined. Extrapolating from mapped habitat, a blue carbon (C) inventory for the site was developed in order to assess potential temporal changes in C inventory. Understanding the effect of climate change at this site is vital for continued conservation of coastal wetlands with growing human populations and with the severe climate change impacts predicted for this zone.

Contact Information: Sharyn Hickey, The School of Earth and Environmental Sciences, University of Western Australia, 6009 Crawley, WA, Australia, Email: sharyn.hickey@research.uwa.edu.au

EXPLORING THE FULLY-POLARIMETRIC CAPABILITIES OF RADARSAT-2 FOR MONITORING A DEGRADED WHITE MANGROVE *(LAGUNCULARIA RACEMOSA)* FOREST OF THE MEXICAN PACIFIC

Duncan J. E. Hill[1]*, John M. Kovacs*[1, 2] *and Francisco Flores-de-Santiago*[3]

[1] Department of Geography, Nipissing University, North Bay, ON, Canada

[2]James Cook University, TropWATER Centre, Townsville QLD, Australia

[3]Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, Coyoacán D.F., México

Given the ability to collect imagery independent of cloud cover, space-borne Synthetic Aperture Radar (SAR) is becoming a more popular option for monitoring mangrove forests. SAR also offers the advantage of being able to record information regarding the geometric properties of a target. This is important given that the latest generation of SAR sensors now offer fully-polarimetric imaging modes that can provide even greater detail about the geometric target interactions of the radar signal. In this study we assess the use of fully-polarimetric C-band RADARSAT-2 imagery for monitoring white mangrove *(Laguncularia racemosa)* stands of various conditions (healthy, poor condition, dead) within a degraded mangrove forest of the Mexican Pacific. Various polarization parameters were extracted from the RADARSAT-2 data and compared with field data collected from sample plots representing the various mangrove stand conditions. Specifically, we examined backscatter intensities, the co-polarized phase difference, polarimetric response plots and multiple polarimetric decompositions to identify which parameters are best suited for mangrove monitoring applications. Additionally, we assessed whether slight changes in the incidence angle greatly influenced the ability of the aforementioned parameters for monitoring mangroves.

Contact Information: Duncan Hill, Nipissing University, Geography, 100 College Drive, North Bay, ON, P1B8L7, Canada, Phone: 705-474-3450 ext.4347, Email: dhill269@community.nipissingu.ca

PROJECTING THE POTENTIAL FUTURE DISTRIBUTIONS OF THREE MANGROVE SPECIES IN FLORIDA AND BEYOND USING ECOLOGICAL NICHE MODELING

Richard Hodel
University of Florida, Gainesville, FL, USA

Mangroves are coastal trees occurring throughout the tropics and in portions of the subtropics. The coastal habitats they occupy are harsh; high salinity, frequent disturbances, and anoxic conditions surrounding roots are typical of the mangrove environment. Mangroves are characterized by a suite of traits that enable them to survive in these extreme conditions, including salt avoidance, tolerance, and/or sequestration, root adaptations to increase stability and allow access to oxygen, and some type of vivipary that promotes propagule dispersal. There are three species of mangroves native to the Neotropics: red mangroves (*Rhizophora mangle*, Rhizophoraceae), black mangroves (*Avicennia germinans*, Acanthaceae), and white mangroves (*Laguncularia racemosa*, Combretaceae). Each species has a different ability to tolerate salinity and flooding.

Mangroves have been negatively impacted by human activities, including increased shipping, coastal development, and sea level changes associated with anthropogenic climate change. In the last century, significant portions of mangrove forest have been lost worldwide, which can have far-reaching impacts. Mangroves provide a variety of ecosystem services, including water filtration, shoreline stabilization, and habitat for fish, birds, and marine invertebrates. It is important to use all available data and resources to protect mangrove forests.

Several modeling approaches have been used to predict the impact of climate change on mangroves, ranging from ecological models to land cover analyses. Previous studies have reported that mangroves are projected to move poleward in certain areas of Florida, possibly invading grass-dominated salt marshes. However, these older modeling approaches could only make relatively coarse predictions, due to low spatial resolution, not being able to distinguish between the three species of mangroves, or being applied to a small geographical area. The recent increase in availability of digitized herbarium specimens and the development of ecological niche modeling techniques have improved our ability to project the potential future distributions of species. In this study, we project the potential future distributions of red, black, and white mangroves in Florida and beyond using ecological niche modeling. These fine-scale, high-resolution projections will be valuable for prioritizing conservation measures and for quantifying key differences between the three species' habitats. Additionally, the ecological niche modeling results can be used to generate phylogeographic hypotheses that can be tested using genetic data—which we are currently collecting from samples obtained from locations across the Caribbean.

Contact Information: Richard Hodel, University of Florida, Department of Biology and Florida Museum of Natural History, Dickinson Hall (1659 Museum Rd), Gainesville, FL 32611, United States, Phone: 919-943-8076; Email: hodel@ufl.edu

ZONATION PATTERN AND SPATIAL ARRANGEMENT OF A *GEUKENSIA GRANOSISSIMA* POPULATION IN A MIXED MANGROVE FOREST OF TAMPA BAY

***Derrick S. Hudson**, and Susan S. Bell*
University of South Florida, Tampa, FL, USA

The southern ribbed mussel, *Guekensia granosissima,* is a filter-feeding bivalve commonly found associated with salt marsh grasses, oyster reefs, and man-made structures throughout the Gulf of Mexico, Caribbean Sea, and Lesser Antilles. The southern ribbed mussel is considered primarily to be a saltmarsh inhabitant with no documentation describing this species within the mangrove system. However, a population of *G. granosissima* has been discovered within the root system of a mixed mangrove forest of *Rhizophora mangle* (red mangroves), and *Avicennia germinans* (black mangroves) in Tampa Bay FL, USA. Given the lack of information on *G. granosissima* and its distribution within the mangrove system we examined select population characteristics of a *G. granosissima* population in a mixed mangrove assemblage in Tampa Bay, FL.

Using descriptive surveys, the following questions were explored: How does the relationship between *G. granosissima* size, density, and patch size vary with mangrove root type, root density, and tidal elevation? Experiments to be conducted in Spring 2016 will further examine the following question: Are the lower zonation patterns displayed by *G. granosissima* strongly shaped by predation? This work will provide the first report of features controlling populations of the southern ribbed mussel in subtropical mangrove habitat

Descriptive surveys were conducted every 2 months over a 9-month period within a study area of 500m in length. The survey utilized 0.25m^2 quadrats placed on mussel patches associated with red and black mangroves at two different tidal heights: 0.5m above MLW and 0.8m above MLW within each of 10, 50m plots. Within each quadrat, all visually apparent mangrove roots were counted and the length and width of each mussel patch was measured. From each quadrat, 25cm^2 of the mussel patch was excavated, enumerated, and each mussel's shell length measured.

Initial findings establish the following: 1) Patch size, mussel density, and root density decreased with increased tidal height; 2) The greatest densities of mussels and largest patches were found within soft sediments surrounding pneumatophores of black mangroves; 3) The mussels are predominately attached to the absorptive roots, not the above ground structure of either mangrove type; 4) A clear pattern of lower limit zonation apparent at ~0.5m above MLW; and 5) Size class distribution skews larger as tidal height increases.

This study provides a baseline of *G. granosissima* population characteristics in mangrove systems. Future work will increase our understanding of how this species utilizes the mangrove habitat and may be an important component for developing future conservation efforts of *Geukensia spp.* in tropical regions, especially for South American mangrove habitats where *Geukensia spp.* is an invader.

Contact Information: Derrick S. Hudson, Master's Student, Department of Integrative Biology, University of South Florida, 4202 E. Fowler Avenue, SCA 110 Tampa, Florida 33620-5200. Phone: 813-352-5034, Email: derrickshudson@gmail.com

CLIMATIC CONTROLS OF BIOMASS AND SOIL CARBON IN MANGROVES AND OTHER TIDAL SALINE WETLANDS

***Laura C. Hundy*[1], *Michael J. Osland*[2], *Kereen Griffith*[3], *Richard H. Day*[2], *Ken W. Krauss*[2], *Camille L. Stagg*[2], *James B. Grace*[2], *Rebecca J. Howard*[2]**

[1]Hundy Consulting Services at U.S. Geological Survey, Lafayette, LA, USA
[2]U.S. Geological Survey, Lafayette, LA, USA
[3]Griffith Consulting Services at U.S. Geological Survey, Lafayette, LA, USA

Within the context of climate change, there is a need to better understand the influence of macro-climatic drivers, such as temperature and rainfall regimes, on tidal saline wetland ecosystem structure and function. The term tidal saline wetland includes mangrove forests, salt marshes, and salt flats, which are all habitats that occupy similar geomorphic settings but different climatic regimes. Although climatic factors greatly influence aboveground biomass and soil carbon processes in tidal saline wetlands, most evaluations of the global variation in these ecosystem attributes have treated mangroves, marshes, and salt flats as different systems that operate independently. Moreover, most of these previous analyses have utilized climatic proxies (for example, latitude) rather than relevant climatic variables. The direct use of climatic variables, which have recently become available, along with a holistic treatment of mangroves, salt marshes, and salt flats as one group (tidal saline wetlands) will be necessary to understand the potential structural and functional consequences of climate-driven ecological transitions between these habitats. In this study, we developed a literature-derived dataset of biomass and soil carbon density in mangroves, salt marshes, and salt flats. We used these data to examine the influence of rainfall and temperature regimes on aboveground biomass and soil carbon density. As mangroves are highly sensitive to freezing temperatures, we hypothesized that temperature minimum would be strongly related to aboveground biomass, and that the highest biomass would be found in tropical locations with high temperatures and abundant precipitation. Since mangroves and salt marshes are both highly productive ecosystems in areas with high rainfall, we postulated that soil carbon density would be similar in both ecosystems. Our findings supported both of these hypotheses. There was no difference in soil carbon density between these two systems, and aboveground biomass displayed a non-linear threshold response to winter air temperature extremes as mangrove forests were replaced by salt marshes. Collectively, our analyses quantify important climate-coastal wetlands linkages that can be used to better understand and prepare for the ecological implications of climate change.

Contact Information: Laura C. Hundy, U.S. Geological Survey, Wetland & Aquatic Research Center, 700 Cajundome Blvd., Lafayette, LA, USA 70506, Phone: 337-266-8582, Email: lhundy@usgs.gov

KROPOTKIN'S GARDEN: PLANT-PLANT AND ANIMAL-PLANT FACILITATION IN MANGROVE ECOSYSTEMS

Mark Huxham[1] *Martin Skov*[2]*, and Richard Hartnoll*[3]
[1]Edinburgh Napier University, UK
[2]Bangor University, UK
[3]Liverpool University, UK

Ecological theory suggests facilitation is most likely to occur in physically stressed, low productivity environments. Where abiotic conditions are benign and productivity is high competition is typically the dominant determinant of community structure. Mangroves present a theoretically interesting case study for facilitation since they need to cope with a range of physiological stresses – including wave impact, low oxygen and high salinity – and yet often achieve very high rates of productivity. The types of facilitation found in these ecosystems, and the degree to which facilitatory effects outweigh those of competition, will therefore vary depending on local settings and could provide useful insights to facilitation theory in general. Understanding facilitation in mangroves also offers practical benefits. For example, removal of mangroves can result in a range of undesirable changes including sediment erosion, acid-sulphate soils and hyper-salinisation. Natural regeneration of such areas may be impossible and restoration is often difficult, but understanding how to facilitate new mangrove growth can help in achieving this.

Facilitation between individuals may occur through a number of mechanisms. These include: a) amelioration of physical stress, such as desiccation b) improved access to nutrients c) provision of refuges from competition and predation, or provision of suitable habitat. All these mechanisms operate within mangroves and will be considered in this paper; examples include the role of nurse plants in early establishment (physical stress), the positive effects of plant density on nutrient supply through sedimentation and the reduction of anoxic stress through crab burrowing (nutrients and physical stress). Whilst such effects have been shown in single-site studies it is unclear how ubiquitous they are; we will examine the evidence for how these interactions vary between sites and along stress gradients. Whole-system facilitatory effects, in which key members of the flora and fauna generate the conditions necessary for ecosystem persistence and expansion, can emerge from these individual-based mechanisms but may also arise as the aggregated effects of other biological and physical mechanisms represented at larger scales. Sedimentation and the control of surface elevation in mangrove ecosystems represents an example. Such effects may show sharp thresholds, determined for example by the density or size of forests, beyond which the system may change rapidly; understanding and predicting such threshold effects remains an important research objective for mangrove ecology.

In this paper we review the current evidence for facilitation in mangroves and present some of our own work in this area, on plant-plant and plant-animal interactions. We discuss how evidence for facilitation in mangrove ecosystems aligns with current ecological theory and whether this theory allows predictions of where facilitatory interactions should predominate. We also consider how practical and theoretical understandings of facilitation might help with mangrove conservation and restoration.

Contact Information: Mark Huxham, Edinburgh Napier University, School of Life Sport and Social Sciences, Sighthill Campus, Edinburgh, EH11, 4BN, United Kingdom, Phone: 4401314552514; Email: m.huxham@napier.ac.uk

DRIVERS OF CHANGES IN ECOSYSTEM SERVICES OF THE SUNDARBANS MANGROVE ECOSYSTEM IN BANGLADESH

Mohammad Mahmudul Islam *and Atikur Rahman Sunny*
Department of Coastal and Marine Fisheries, Sylhet Agricultural University, Sylhet-3100, Bangladesh

The Sundarbans is the world's largest mangrove ecosystem that stretches across Bangladesh and India. The populations living in the impact zone and in wider landscape context of Bangladesh depend on the forest for crucial materials and non-materials supports. This study aims at identifying the drivers, stemming from both natural and anthropogenic sources that affect ecosystem services of the Sundarbans mangrove forest. To collect empirical data, secondary data analysis was conducted and a household survey was carried out in three districts in the Sundarbans region. Using a number of analytical tools, time series data for a range of ecosystem services and biophysical, socio-economic variables were analyzed to identify the range of trends and the significant drivers of change. In addition, community perceptions were consulted to elicit how these changes are felt and affected the services on which they depend.

The forest statistics shows that most of the ecosystem services of the Sundarbans experienced negative changes since the last decade. The Interviewed households also reported decreased production of food and non-food products on which they depend for sustaining livelihoods. Time series analysis and community perceptions held a number of drivers responsible for such crises. Changes in climate variable (e.g. variation in temperature and rainfall) and rapid environmental change (e.g. reduction of fresh water supply, saline water intrusion), population explosion and poverty, demand of mangrove produce in global market (e.g. live crab), major infrastructure development (e.g. barrage in upstream), shift in state policy (e.g. blue revolution and commercial shrimp farming), governance failure (e.g. corruption) are identified as major drivers involving in degradation of ecosystem services of the Sundarbans. The finding calls for a transformation in the stewardship of ecosystem services of the Sundarbans to escape the situation where its effect might be difficult to reverse.

Contact information: Mohammad Mahmudul Islam, Department of Coastal and Marine Fisheries, Sylhet Agricultural University, Sylhet-3100, Bangladesh, Phone: +880821761952, Email: mahmud.cmf@sau.ac.bd

INFLUENCE OF INCREASED CO_2 CONCENTRATIONS AND SEA-LEVEL RISE ON LEAF GAS EXCHANGE PARAMETERS – GREENHOUSE EXPERIMENTS

*Cyril Marchand[1], **Adrien Jacotot[1,2]**, Michel Allenbach[2,3]*

[1]Insitut de Recherche pour le Développement, Nouméa, Nouvelle-Calédonie
[2]Université de la Nouvelle-Calédonie, Nouméa, Nouvelle-Calédonie
[3] Labex Corail

Mangroves are hyper productive habitats located on intertidal areas and therefore may be impacted by future climate change. Among the different scenarii, the more likely is that we can expect an atmospheric CO2 concentration of more than 500 ppm in 2050, and over 800 at the end of the century. We can anticipate a direct positive effect of increased CO2 levels on the productivity of the mangrove trees, which would stimulate the photosynthetic activity and possibly the carbon storage capacity of the ecosystem. The main issue should come from the increase in sea level (estimated to be between 0.18 to 0.59 m for 2100), which would enforce the ecosystem to colonize other opened spaces behind the foreshore. However, coastal urban expansion restricts this settlement by occupying the available space. In addition, mangroves would use a lot of energy to palliate the increasing salinity in order to survive and to continue their expansion and it is thinkable that there will have a reorganization of the species composition of the mangrove stands.

The lack of studies on the effects of climate change on mangroves currently does not allow to conclude on ecosystem development abilities. Within this context, we are developing a multi-variable approach to simultaneously evaluate the effects of increased atmospheric CO2 and sea-level rise on two common species Avicennia marina and Rhizophora stylosa. This study is conducted in New Caledonia where three elevated CO2 greenhouses, in which the length of tidal immersion can also be controlled, were built to simulate the conditions in which mangroves will growth at the end of the 21st century. More than 1000 seedlings of each species are followed. To study the effects of these two environmental parameters, a split-plot design with CO2 enrichment as primary treatment, and an increase in length of tidal immersion as secondary treatment was chosen.

For this study, we investigate in particular the gas exchange parameters (as for example the CO2 exchange rate, the transpiration rate, the total conductance for CO2, or even water use efficiency) which are direct witnesses of effects of the increased CO2 concentration. We also follow the evolution of the trees growth and biomass, as well as their physiological changes. This work would provide important data that will help to understand the future evolution of mangroves.

Contact Information: Adrien Jacotot, Institut de Recherche pour le Développement, Nouméa, Nouvelle-Calédonie, Phone: 00687-518709, Email: adrien.jacotot@ird.fr

SPATIAL AND TEMPORAL TRENDS IN EPIBENTHIC COMMUNITIES INHABITING ARTIFICIAL AND NATURAL SUBSTRATES WITHIN THE INDIAN RIVER LAGOON

***Dean S. Janiak*[1]*, Richard W. Osman*[2]*, Valerie Paul*[1]**

[1]Smithsonian Marine Station, Ft. Pierce, FL, USA

[2]Smithsonian Environmental Research Center, Edgewater, MD, USA

Coastal ecosystems worldwide are changing rapidly and will continue to do so for the foreseeable future. The majority of the world's human population is found along the coast and as the population grows, so will the rise in shoreline alteration including increases in construction of artificial structures. Depending on substrate-type and location, artificial habitats can either be more or less diverse, though typically they are comprised of more non-native species. The Indian River Lagoon (IRL) is located on the eastern shore of central Florida and is one of the most diverse estuaries in North America. Mangroves line a large portion of the shoreline within the IRL and provide essential habitat for fish and a variety of invertebrates. In comparison, a relatively small portion of the IRL is comprised of artificial structures including docks, marinas, and seawalls. Both artificial structures and the prop roots of mangroves provide a similar function as substrate for epibenthic species. To examine the relationship between artificial and natural habitat, we have been monitoring 30 sites quarterly within a large portion of the northern IRL. At each site, either samples of mangrove prop roots or video transects taken in artificial habitat were used to assess the abundance and diversity of epibenthic species over time. At each site, standardized recruitment panels were also deployed to monitor and compare colonization of species in space and time. Results suggest that both epibenthic communities and individual taxa follow strong spatial patterns throughout the lagoon and that these patterns remain somewhat consistent through time particularly for the dominant species. Overall, there are significant differences in communities inhabiting the different substrate types, although in most cases, the apparent differences are due to relative abundances rather than species composition.

Contact Information: Dean Janiak, Smithsonian Marine Station, 701 Seaway Dr, Ft. Pierce, FL 34949, United States, Phone: 772-462-0991; Email: janiakd@si.edu

BLUE CARBON – RELEVANCE OF THE MANGROVE STOREHOUSE

Tim C. Jennerjahn[1], *C.E.V. Carvalho[2], A. Kumar[3,4], A.L. Ramanathan[3], C.E. Rezende[2], and S.M. Sappal[1,3]*

[1]Leibniz Center for Tropical Marine Ecology, Bremen, Germany
[2]Universidade Estadual do Norte Fluminense, Campos, Brazil
[3]Jawaharlal Nehru University, New Delhi, India
[4]Central University of Rajasthan, Kishangarh, India

In times of still increasing greenhouse gas emissions the search for and quantification of carbon sinks is gaining more attention. In this context "blue carbon", the organic carbon stored in the marine realm, comes into focus. Vegetated coastal habitats, such as mangrove forests, saltmarshes and seagrass meadows are identified as the most efficient "blue carbon" sinks, but are also declining at alarming rates due to human interventions and climate change.

The intertidal mangrove forests are among the most productive ecosystems on earth and recent studies highlighted that major part of their carbon is stored in sediments. However, the variability in carbon accumulation rates is very high and accordingly the uncertainty in total carbon storage in mangroves. The average annual global mangrove carbon storage is on the order of 22±6 Tg yr^{-1}.

What complicates the quantification of carbon storage is the fact that mangroves are in continuous exchange with adjacent terrestrial and marine ecosystems, meaning that part of the deposited carbon is imported. In particular, during the Anthropocene mangroves receive high amounts of terrestrial inputs from heavily modified landscapes. As a consequence, part of the stored carbon is derived from eroded hinterland soils and partly very old, i.e. it is not necessarily newly fixed from the atmosphere. In order to determine mangrove and, hence, global carbon budgets accurately, it is therefore necessary (i) to distinguish between and to quantify both the autochthonous and allochthonous portions and (ii) to determine the age of carbon stored in mangrove sediments.

We provide examples from mangrove settings displaying the high variability in (i) carbon accumulation and (ii) contribution of allochthonous carbon. Concentration, accumulation rate and allochthonous input can vary by an order of magnitude on a meter to kilometer scale within one mangrove setting as observed, for example, in the Pitchavaram complex, India, and the mangrove-fringed Segara Anakan Lagoon, Java, Indonesia.

We discuss our data in the global context with emphasis on (i) the variability of sedimentary carbon storage in mangroves across the tropical belt, (ii) the relevance of mangrove carbon storage with respect to balancing fossil fuel emissions and (iii) the relevance of carbon release from mangrove destruction.

Contact Information: Tim C. Jennerjahn, Leibniz Center for Tropical Marine Ecology, Fahrenheitstrasse 6, 28359 Bremen, Germany, Phone: +49-421-23800-44, Email: tim.jennerjahn@leibniz-zmt.de

MARINE COMMUNITY STRUCTURE EMERGES ACROSS SCALES IN A PATCHY MANGROVE-MARSH LANDSCAPE

***Cora Ann Johnston**, and Daniel S Gruner*
University of Maryland, College Park, MD, USA

Where mangroves encroach into temperate salt marshes, the change in foundation species and accompanying structure and production likely alters the habitat landscape for marine communities. Where mangroves and marshes co-occur on Florida's Atlantic coast, we monitored nekton to determine whether habitat associations are distinctive in the ecotone landscape. We isolated physical structure from production to investigate their independent influences on community formation and persistence. Communities were most distinctive by site but also emerged at patch and sub-patch levels, indicating detectable structuring from the scales of kilometers to less than a meter. This suggests that community formation is influenced by dominant landscape vegetation/geographic location, vegetation patches, and physical habitat structure. Differences were driven by a small subset of the ~25 species sampled. Penaeid shrimp, Caridean shrimp, swimming crabs, gobies, mangrove crabs, amphipods, and isopods were the most responsive. Strongly associated species were often present even where mangrove patches are small and emergent. The distinct community structure indicates predominant influences of environmental filtering and/or niche-based sorting, helping to explain fast and accurate habitat tracking along the expanding mangrove edge. The differences in nekton associations also indicate that species population dynamics and community composition are likely to change as mangroves displace marshes.

Contact Information: Cora Ann Johnston, University of Maryland, 4112 Plant Sciences Building, College Park, MD 20742; Phone: 757-710-2795, Email: cora@umd.edu

EFFECT OF NUTRIENT ENRICHMENT ON GROWTH OF THE MANGROVE *AVICENNIA MARINA* SEEDLINGS IN THE MASSAWA COASTLINE, ERITREA

Daniel Solomon Kahsay[1], *Matthias Wolff* [2], *Zekeria Abdulkerim*[3]

[1]University of Bremen, Bremen Germany

[2]Center for Marine Tropical Ecology (ZMT), Bremen, Germany

[3]College of Marine Science and Technology, Massawa, Eritrea

The effect of enrichment on the seedlings of the mangrove *Avicennia marina* was studied in a field study in a mudflat intertidal in Hirgigo village coastline, near the town of Massawa, Eritrea. Seedlings were fertilized with either N, P, NPK fertilizers or without fertilizer as a control group in a blocked design plot. Branching pattern, leaf numbers and stem-length measurements were taken during 16 week of growth. Only 17 seedlings branched. No significant difference was detected in the stem-length analysis, but there was evidence of enhanced growth in the seedlings imposed with fertilizers. The average growth rate at the seventh week was more than 2 cm/3 weeks for the N group, 2.25cm/3 weeks for the P group, 2.06cm/3 weeks for the NPK group and 1.7cm/3 weeks for the control group. Although the control group did have a lower rate of growth from any of the three other treatments, the difference was not statistically significant ($p= 0.58$). Leaf numbers counts were significantly different ($p<0.05$) only during the second count of study but did not show difference at the end of the study. Overall, there was a coinciding period of increased growth in the nutrient enriched group of seedlings. This might be because of the nutrients being washed away and their effects reduced towards the end of the study. Mass seedling death occurred probably caused by excessive inundation times and due to also encrusting of barnacles. The results of this study suggest that there might be other factors present in determining the existence of mangroves in the study area.

Contact Information: Daniel Solomon Kahsay, University of Bremen, LeobenerStr. 4, 7-10, 28359 Bremen, Germany; Phone: +491799510131; Email: danielsolo_k@yahoo.com

TOWARD THE CONSERVATION GENETICS OF MANGROVES ON A GLOBAL SCALE

Tadashi Kajita[1]*, Koji Takayama*[2]*, Gustavo Maruyama Mori*[1,3]*, Alison Kim Shan Wee*[4]*, Junya Ono*[5] *and Takashi Yamamoto*[5]

[1]Iriomote Station, Tropical Biosphere Research Center, University of the Ryukyus, Okinawa, JAPAN
[2]Museum of Natural and Environmental History, Shizuoka, JAPAN
[3] Laboratório de Análise Genética e Molecular, CBMEG – UNICAMP, BRAZIL
[4]College of Forestry, Guangxi University, Nanning, Guangxi, CHINA
[5]Graduate School of Science, Chiba University, Chiba, 263-8522, JAPAN

Genetic diversity is one of the three levels of biodiversity along with Ecosystem and Species diversities. However, genetic diversity is paid less attention to conservation than the other two. Although the "genetic" information is fundamental to all living organisms, and it was the main subject of the Aichi Biodiversity Target 13, we still don't have any concrete idea about conservation of genetic diversity even for cultivated and endangered species. Genetic diversity of mangroves is even paid less attention, because many species of mangroves are, in general, common and widespread. However, the rapid and global loss of mangroves alarms to invisible loss of genetic diversity of mangroves. To understand the present status of genetic diversity of mangroves on a global scale, prompt actions were required. As an attempt to shed more light on the genetic diversity of mangroves, we initiated international collaboration on conservation genetics of mangrove in SE Asia as well as in the New World in the 2000s. Since 2009, we established an International Network for Conservation Genetics of Mangroves supported by the Japan Society for the Promotion of Science (JSPS) and expanded the research project. The network aimed to provide a wide scale understanding of the genetic diversity of major mangrove component species of the genus *Rhizophora*, *Bruguiera*, *Xylocarpus*, *Sonneratia* and *Acrostichum*. We employed phylogeographic approaches in attempts 1) to collect population samples with a good coverage of the whole distribution range of each species, 2) to use various as well as comparable molecular methods (sequencing of cpDNA and nucDNA, and microsatellite (SSR) markers to all species groups, and 3) to reveal genetic structures of major mangrove species to understand common factor that shaped them. The data we have obtained to date show that 1) despite wider distribution ranges of distribution, mangroves have less genetic diversity than other plants; 2) genetic variation of some species of mangroves are with deep history; 3) some species showed similar pattern of genetic structure; 4) gene flow among populations are less frequent than we expected. Based on these findings, we suggest that conservation units based on the genetic structure of some species and further studies on adaptive genetic markers to evaluate the units.

Contact Information: Tadashi Kajita, Iriomote Station, Tropical Biosphere Research Center, University of the Ryukyus. 870 Uehara, Taketomi-cho, Yaeyama-gun, Okinawa, 907-1541, JAPAN. Phone: +81-980-85-7034, Email: kajita@mail.ryudai.jp

DECOMPOSITION OF *RHIZOPHORA APICULATA* (BLUME) AND *XYLOCARPUS GRANATUM* (KOENIG) LITTER COMPONENTS IN A TROPICAL MANGROVE

*M M Hoque[1], **M K Abu Hena**[1], M H Idris[1], O H Ahmed[2], M M Billah[1], M H Nesarul[1], and M K A. Bhuiyan[1]*

[1]Department of Animal Science and Fishery, Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Sarawak Campus, 97008 Bintulu, Sarawak, Malaysia

[2]Department of Crop Science, Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Campus Bintulu, 97008 Bintulu, Sarawak, Malaysia

Researches investigating the decay rates of non-leafy components in tropical mangroves are scarce worldwide, especially in Malaysia. Thus, this study was carried out to determine the decay rates of Rhizophora apiculata and Xylocarpus granatum non-leafy components along with leaves in Sibuti mangrove, Sarawak, Malaysia during dry and wet months. The litterbag method and Olson exponential model were applied to determine the decay rates. For leaves, the decomposition pattern of both the species was found to be similar to those reported in the literature, while the rate of decomposition for non-leafy components were rather different. The initial weight loss of all the components was rapid up to 90 days and then gradually became slow until at the end of the experiments, especially for non-leafy components. Except leaves degradation in dry months for both the R. apiculata and X. granatum, the higher microbial degradation rate was found for stipule, flower, propagule and twig litters in wet months. The slow decay rates of maximum litter components for both the species were positively related with higher content of lignin, suggesting the profound influence of lignin on the rate of litter decomposition processes. Decay constants of almost all the litter components for both the species were found to be varying among the components, and within the species. However, except the decomposition of flower for R. apiculata and leaf for X. granatum, the other litter components of both the species did not vary significantly between dry and wet months. The half-life ($T_{50\%}$) and 95% lifespan ($T_{95\%}$) of non-leafy components of both the species like flower, propagule, stipule and twig were remarkably high compared to the leaves. This suggests that the non-leafy components play significant roles in nutrient cycling processes at later stages in the mangrove ecosystems, especially when the leaf litters are either being decomposed rapidly and/or washed away via tidal flush and river runoff.

Contact Information: Abu Hena Mustafa Kamal, University Putra, Malaysia, Animal Science and Fishery, Nyabau Road, Bintulu, Sarawak, 97008 Malaysia, Phone: 6086855366; Email: hena71@yahoo.com

COMPARATIVE REPRODUCTIVE PHONOLOGICAL STUDIES OF THREE SUBTROPICAL MANGROVE SPECIES

Md. Kamruzzaman[1]*, Akira Osawa* [1]*, Sahadev Sharma*[2]*, Mouctar Kamara*[1]

[1]Laboratory of Forest Utilization, Graduate School of Global Environmental Studies, Kyoto University, Japan

[2]Department of Natural Resources and Environmental Management, University of Hawaii at Manoa, Honolulu, HI, USA

Mangrove phonological study is important for understanding ecosystem functioning as well as the contribution of mangroves to near-shore productivity. Okinawa Island is near the northern most limit of the bio-geographical distribution of mangrove species and its mangrove must cope with substantial changes in environmental factors. However, mangroves growing in the subtropical region of Japan, have little information about the reproductive phenology of the species. In light of these, we aimed to investigate and compare the reproductive phenology of *Bruguiera gymnorrhiza*, *Kandelia obovata*, and *Rhizophora stylosa* in Manko Wetland, Okinawa Island, Japan, over five years. The three mangrove species of the Rhizophorace family focused on this study yielded reproductive organs throughout the entire annual cycle, with the exception of *K*. *obovata*. In case of *B*. *gymnorrhiza*, flowers were observed throughout the year, with a massive production in September, whereas propagule production was highest in May and July. Reproductive organs of *K*. *obovata* followed a very specific monthly periodicity, where flowers were observed from May to October with the greatest abundance in August, and propagules were observed from March to June with the massive abundance of mature propagule in April to May. The highest production of flowers and fruits were observed in July for *R*. *stylosa*, whereas massive production of propagule was observed in September. The highest number of flowers was recorded in *R*. *stylosa* (7,603,565 $ha^{-1}yr^{-1}$) followed by *K*. *obovata* and *B*. *gymnorrhiza*. However, propagule setting was lowest in *R*. *stylosa* as compared to *B*. *gymnorrhiza* and *K*. *obovata*. The largest propagule size (length, diameter, surface area, and weight) was also observed in *R*. *stylosa*. This was significantly different from that of *B*. *gymnorrhiza* and *K*. *obovata*. Multiple regression analysis showed that reproductive organs of the three species were pronouncedly influenced by monthly mean air temperature and monthly day length. Mean production of reproductive organs in *B*. *gymnorrhiza*, *K*. *obovata*, and *R*. *stylosa* was 10.1, 9.9, and 12.3 Mg ha^{-1} yr^{-1}, respectively which contributed 37.5, 18.7, and 21.5 % to the total litterfall, respectively.

Contact Information: Md. Kamruzzaman, Laboratory of Forest Utilization, Graduate School of Global Environmental Studies, Kyoto University, 606-8501, Japan e-mail: zaman_dulu@yahoo.com

MANGROVES AND NATURE DEFICIT DISORDER

***Martin Keeley**, and Alfredo Quarto*
Mangrove Action Project, Cayman Brac, Cayman Islands

Ten years ago Richard Louv, in his book *Last Child in the Woods*, coined the phrase Nature Deficit Disorder to describe the disconnect of young people with their natural world. Now more than 50% of the world's population lives in cities. Add to that the addiction of children to the screen – be it computer, cell phone or TV – and their detachment from the planet's natural ecosystems becomes even more significant.

Last year a Chinese study of 100,000 families in six cities showed the full extent of Nature Deficit Disorder in that country. A country which boasts five megacities with a population over 10 million and 14 with more than 5 million. The study showed that – as in the US – Chinese children spent over 50 hours a week staring at a screen. Certainly not exploring the natural world.

Marvellous Mangroves is a curriculum-based, hands-on science program which – since it started in 2001 – has been introduced to thirteen countries worldwide. Based on an award winning wetlands education program developed in Western Canada and the Pacific Northwest, the program emphasizes in-depth mangrove ecosystem exploration by teachers and their students.

The 350 + page manual has to be translated and adapted for use in each country where it is introduced to interface with national and regional curriculum, plus incorporate local flora, fauna, geology and geography. It is introduced to local teachers through extended in-depth workshops, and in turn to their students in the classroom and field through Mangrove Clubs in each school.

It is not enough to teach the true value of mangrove ecosystems through a superficial means of communications. Posters, fliers, displays, websites and one-day stand-alone field trips are not enough if we are going to change the focus and understanding of teachers, students and their communities. In-depth programs like Marvellous Mangroves need to teach core values through traditional education systems to fight Nature Deficit Disorder.

This paper will review the implementation of the *Marvellous Mangroves* program around the world.

Contact Information: Martin A Keeley, Mangrove Action Project, General Delivery, Cayman Brac, KY2-2200, Cayman Islands. Tel: 345-526-5072. Email: mangroveteacher@yahoo.com.

Alfredo Quarto, Mangrove Action Project, PO Box 1854 Port Angeles, WA, 98362-0279. Tel: 360-452-5866.
Email: mangroveap@olympus.net

GENETIC AND MORPHOLOGICAL VARIATION OF EAST FLORIDA BLACK MANGROVE (AVICENNIA GERMINANS)

John Paul Kennedy[1] *and Ilka C. Feller*[2]
[1]Smithsonian Marine Station, Ft. Pierce, FL, USA
[2]Smithsonian Environmental Research Center, Edgewater, MD, USA

Mangroves are intertidal foundation species that influence both ecosystem function and associated community structure. Mangrove encroachment into temperate salt marsh has been documented worldwide, including along the East coast of Florida. Black mangrove (*Avicennia germinans*) currently occupy the northernmost range edge of all Florida mangrove species and are projected to experience further range expansion in the future. We present preliminary findings of our assessment of both genetic and morphological variation among ten *A. germinans* populations that encompass this species' East Florida range, using a combination of microsatellite molecular markers and functional leaf traits. The results of this study provide baseline information on East Florida *A. germinans* population structure and contribute to our understanding of the potential impacts a shift from salt marsh to mangrove dominance may have on Florida coastal ecosystems.

Contact Information: John Paul Kennedy, Smithsonian Marine Station, 701 Seaway Drive, Ft. Pierce, FL 34949,
Phone: +1.772.462.0979, Email: kennedyjp@si.edu

TROPHIC FOOD WEB DYNAMICS ACROSS A MANGROVE/UPLAND ECOTONE

***Erin P. Kiskaddon**, and Susan Bell*
University of South Florida, Tampa, FL, USA

Understanding the activity of heterotrophic organisms is critical in exploring nutrient cycling and productivity in systems like mangrove forests. Mangrove crabs, mainly of the family Sesarmidae, are considered to be important agents of nutrient cycling. Direct grazing of primary productivity in mangrove forests by semi-terrestrial crabs and other detritivores is thought to substantially reduce export of energy to adjacent aquatic systems, however there has been very little consideration for how energy is moved landward into adjacent terrestrial systems. Moreover, while the basic structure of mangrove food webs is relatively well-established for "Old World" (Eastern Hemisphere) systems, the specific contributions of different components of "New World" (Western Hemisphere) mangrove food webs is not well described.

Semi-terrestrial crabs are ideal for studying the connectivity between marine and terrestrial food webs because they are viewed as an important energetic link. The wharf crab, *Armases cinereum* (Family: Sesarmidae)*,* is a highly abundant sesarmid crab that inhabits the coastal forest benthos of Florida as well as the upland ecotone. In this project, we compared the trophic food webs of two mangrove/upland ecotone habitats (one with adjacent natural upland forest habitat, one without adjacent or near-by upland forest habitat) in Tampa Bay, FL, to assess whether habitat connectivity impacts the trophic position of-, and energy transfer by-, *A. cinereum*. We examined how *A. cinereum* facilitates the transfer of carbon across a mangrove/upland-forest interface using laboratory preference experiments and field-based isotopic techniques. Laboratory feeding preference experiments assessed *A. cinereum's* detritivorous activity with 1) locally-abundant and intermixed mangrove species (*Rhizophora mangle, Laguncularia racemosa, Avicennia germinans*) at differing levels of decomposition (fresh, senescent, partially-decomposed), and 2) abundant vegetation and insect prey present at the mangrove/forest ecotone. Stable $\delta^{13}C$ and $\delta^{15}N$ isotopic analyses were used to examine whether feeding preferences from the laboratory experiments supported observed field-based trophic food webs and was used to reveal how habitat characteristics influenced trophic structure.

The results from the laboratory trials revealed that *A. cinereum* exhibited preference for *A. germinans* mangrove leaves at more advanced stages of decomposition, and this preference was maintained when offered both abundant mangrove and upland forest vegetation forage options. Insect prey was favored over all vegetation food varieties indicating a possible Nitrogen requirement to supplement an otherwise herbivorous diet. This omnivorous feeding behavior was confirmed with isotopic analysis in both habitats examined. The stable $\delta^{13}C$ and $\delta^{15}N$ isotopic analyses showed us that the presence of upland forest habitat influenced the trophic position of *A. cinereum,* which may have fitness-related and population-level consequences for this species. Thus, habitat connectivity may be an influential component in the facilitation of energy transfer across the marine/terrestrial interface of mangrove forests.

Contact Information: Erin P. Kiskaddon, Master's Student, Department of Integrative Biology, University of South Florida 4202 E. Fowler Avenue, SCA 110 Tampa, Florida 33620-5200. Phone: 510-334-3037, Email: ekiskaddon@gmail.com

TROPHIC INTERACTIONS IN BENTHIC FOOD WEBS OF MANGROVES SUBJECT TO MULTIPLE HUMAN ACTIVITIES

***Judith C. Klein*[1]*, Vincent Peres*[1]*, Duong Thi Thuy*[2]*, Benoit Lebreton*[3]*, Nguyen Nguyen Dinh Tu*[4]*, and Thi Xuan Phuong*[4]

[1]Institute for Research for Development, UMR 9190 MARBEC, University of Montpellier, France
[2]Institute of Environmental Technology, Vietnam Academy of Science and Technology, Hanoi, Vietnam
[3]Littoral, Environnement et Sociétés, UMR 7266 LIENSs, CNRS - University of La Rochelle, La Rochelle, France
[4]Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology, Hanoi, Vietnam

In the tropical and subtropical regions of the world, the highly productive mangrove forests grow at the interface between land and sea. These coastal ecosystems represent an important blue carbon sink as well as crucial habitat, nursery and spawning grounds for many terrestrial and aquatic species. Recent studies have highlighted the fact that benthic communities play a largely underestimated role in the cycling of matter, nutrients and carbon within the mangrove ecosystem. However, the functioning of mangrove food webs still remains poorly studied and little information is available on the importance of herbivory in this threatened system. Previous work has suggested that mangrove trees were the main source of organic matter and that other sources merely played minor roles. Recent studies, however, have started to challenge this view. The present study investigated plant-herbivore interactions at the individual and community level in a tropical estuarine mangrove ecosystem. The objectives were to (i) identify the stable isotope compositions ($\delta^{13}C$ and $\delta^{15}N$) of primary producers and consumers to infer trophic relationships, (ii) determine the relative contribution of the different organic matter sources to the diet of each consumer, and (iii) test whether the dominant consumers change their diet depending on size or habitat.

The presentation discusses the results from an observational field study on the natural isotopic composition of benthic primary producers and consumers. Field studies were conducted in the Xuan Thuy National Park situated in the densely populated Red River delta Biosphere Reserve in northern Vietnam.

Contact information: Judith Klein, Institute for Research for Development, UMR 9190 MARBEC, University of Montpellier, cc093, Place Eugène Bataillon, 34095 Montpellier cedex 5, France. Phone: 0033-699198238. Email: judith.klein@ird.fr

MANGROVES – CAPTURED BY THE KEEN EYE OF A 17TH CENTURY LANSCAPE PAINTER

Nico Koedam[1]*, Farid Dahdouh-Guebas*[2]*, Roberto Limas Barcellos*[3] *and Tom Van der Stocken*[1]

[1]Vrije Universiteit Brussel (VUB), Brussels, Belgium
[2]Université Libre de Bruxelles (ULB), Brussels, Belgium
[3]Universidade Federal de Pernambuco, Recife, Brazil

When the colonial enterprise of modern times, starting in Europe from the 15th – 16th centuries, ventured into the Atlantic and Indian Ocean, Europeans first came in contact with mangroves. Though mangroves are a predominant vegetation type along many tropical coasts, first encountered by any maritime visitor approaching land, they left little record in early colonial records, let alone in graphical representation, at least in an unambiguous and recognizable way. The early colonial powers from Europe moving along tropical coasts, both in Africa, Asia and the New World, i.e. Portugal, Spain and the Low Countries (approximately 15th – 17th centuries) apparently showed little interest in the products from mangroves, which offered no mercantile or strategic interest, as may be documented through colonial texts. This is in stark contrast with the importance mangrove services must have had, also during those centuries, for local communities. No need was apparently felt to represent mangroves, even marginally, along other features of strategic interest or for curiosity in spite of striking mangrove features, at least to the modern observer. This neglect was slightly overcome when increasingly scientists, sometimes accompanied by good artists, started playing a role in the expeditions and colonial trade. Artists depicted flora and fauna by curiosity, for the markets in their respective home countries and for customers who were financing the colonial enterprise, but also to inventorise. The taxonomic context of this work often proves its usefulness until today. The artistic endeavour and taxonomic survey was strongly stimulated by the various colonial companies, such as the Dutch and English East and West India companies. From that moment, information on natural features was paradoxically both shared in a modern scientific process of communication, and kept 'classified' in view of potential mercantile interest. The process also included mangrove species, yet as a vegetation they remained largely unreported, because effective and naturalistic landscape painting only started in the 17th century in the Low Countries. We have studied how mangroves appear in the pictural (landscape) record on tropical coasts and set this against a background of colonial texts and early taxonomy on mangroves. This includes pictural records which are to our knowledge the first representation of mangroves as a formation or landscape type.

Contact Information: Nico Koedam, Laboratory of Plant Biology and Nature Management, Vrije Universiteit Brussel (VUB), Pleinlaan 2, B-1050 Brussels, Belgium, Phone: +32-2-6293413, Email: nikoedam@vub.ac.be

SPIRITUAL VALUE OF COASTAL NATURAL FEATURES AND MANGROVES – WHAT MUST WE PROTECT AND FOR WHOM ?

***Nico Koedam*[1]*, Kimio Leemans*[1]*, and Jean Hugé*[1,2]
[1]Vrije Universiteit Brussel (VUB), Brussels, Belgium
[2]Université Libre de Bruxelles (ULB), Brussels, Belgium

Though mangrove forests have often been described as inhospitable and even hostile places, this is in contrast with the existence of communities living near and even in these ecosystems, worldwide. The advantages offered by remoteness and hence security, but in particular the numerous direct use resources, obviously outbalance the health risks and the difficult accessibility. In view of this close link of indigenous communities with mangroves it is not unexpected that spiritual values may also be attached to mangroves or to features within mangroves. Indeed, the way a modern observer or scientist delineates mangroves, either as a collection of tree species with their associated fauna, or as an assemblage, an ecosystem, is not the perception of a community living in and depending on an interconnected complex of ecosystems. Such a complex consisting of seagrass beds, bays and creeks, coral reefs,… in a marine-terrestrial ecotone constitutes a range of products and services that determine the community's livelihood. Though communities solely depending on mangroves or exclusively living within their range are probably rare or no longer existing, spiritual values attached to natural features including those associated with mangroves may persist beyond the close human-ecosystem relationship which once existed.

We have investigated whether such values effectively survived and could or should be part of a full valuation scheme and also whether societal evolution, creating a loss of direct dependence on mangroves and other natural features possibly erodes spiritual significance. While spiritual values may have constituted an informal protection or incentive for conservation in the -recent- past, the erosion of such values could result in a loss of respect and hence of earlier protection. If this is the case, what are the conditions for the sustained protection of mangroves in times of rapidly changing and/or relict spiritual values? How can ecosystem and cultural loss be countered jointly? With a focus on the East African coast and particularly Zanzibar, we give an overview of the sacred status or spiritual values in a coastal environment and explore the role this can play in sustainable management.

Contact Information: Nico Koedam, Laboratory of Plant Biology and Nature Management, Vrije Universiteit Brussel (VUB), Pleinlaan 2, B-1050 Brussels, Belgium, Phone: +32-2-6293413, Email: nikoedam@vub.ac.be

BIOTIC AND ABIOTIC DRIVERS OF CARBON STORAGE DURING MANGROVE ESTABLISHMENT IN SALT AND FRESHWATER MARSH ECOSYSTEMS: A MECHANISTIC FRAMEWORK

John S. Kominoski[1], *Sean P. Charles*[1], *Natalie Damaso*[1], *Priyanka Kushwaha*[1], *DeEtta Mills*[1], *Shelby M. Servais*[1], *Benjamin Wilson*[1], *Steven C. Pennings*[2], *Hongyu Guo*[2], *Sayatani Dastidar*[2], *Zoe Hughes*[2], *Anna R. Armitage*[3], *Carolyn A. Weaver*[3], *and Ashley Whitt*[3]

[1]Department of Biological Sciences, Florida International University, Miami, FL, USA
[2]Department of Biology and Biochemistry, University of Houston, Houston TX, USA
[3]Department of Marine Biology, Texas A&M University at Galveston, Galveston TX, USA

Coastal ecosystems are significant stores of carbon (C), and global increases in sea level rise (SLR), temperatures, and habitat loss threaten this ecosystem service. Mangroves are expanding to higher latitudes due to global warming and inland due to sea-level rise, dominating ecosystems previously dominated by salt and freshwater marsh communities. This ecosystem state change from grass and forb-dominated to woody-dominated communities has unknown effects on above and belowground C storage. We outline a mechanistic framework to test differential pathways and drivers of changes in plant and soil C in ecosystems transitioning from marsh (salt and freshwater) to mangrove. Abiotic drivers are the triggers of ecosystem state changes, whereby increases in minimum temperatures enable cold-tolerant mangrove species to expand poleward in salt marshes, and increases in SLR and storm surge shift mangroves from the coast to inland freshwater marshes. Mangroves themselves alter microclimate conditions through: reduced UV exposure, reduced variation in temperature and light, increased organic matter entrainment, changes in soil biogeochemical and redox conditions, and changes in above and belowground C allocation. We experimentally tested changes in abiotic and biotic parameters in established (marsh or mangrove) and transitional (mixed) ecosystems in Texas and Florida, USA. In Texas, we used ten experimental plots (24×42 m) along a gradient of mangrove cover (0 to 100%) to study how plot-level mangrove density affects patch-level (3×3 m) soil and plant C stocks. We observed 50% declines in soil C breakdown, deeper root allocation, and lower rates of sediment accretion in mangrove versus marsh soils. In Florida, we are comparing how soil microbial communities, mangrove and sawgrass densities, and above and belowground C change along freshwater to marine gradients. We are testing the following mechanistic framework: 1) Texas: mangroves enhance C storage in coastal ecosystems through reductions in abiotic conditions that enhance C loss and increased C retention and deeper soil C allocation than marsh plants, 2) Florida: under a specific abiotic condition (freshwater or marine), soils associated with sawgrass versus mangrove plants will have dissimilar microbial community structure and function (C processing rates) that determine soil C storage, whereas C storage in the freshwater-marine ecotone will be determined by competition among plants for phosphorus (P), and salinity tolerance and P-limitation of soil microbial communities. Global climate changes are enabling mangroves to fundamentally change the structure of salt and freshwater marsh ecosystems, but differences in underlying abiotic conditions in these two ecosystem types determine the mechanisms that maintain mangrove dominance and alter ecosystem function.

Contact Information: John Kominoski, Florida International University, 11200 SW 8th Street, Miami, FL, USA 33199, Phone: 305-348-7117, Email: jkominos@fiu.edu

ASSESSING THE USE OF SPACE-BORNE SYNTHETIC APERTURE RADAR FOR MONITORING MANGROVE FOREST IMPACTS FOLLOWING MAJOR OIL SPILL EVENTS

***John M. Kovacs*[1, 2]*, Norman C. Duke*[1, 2] *and Duncan J.E. Hill*[1]**

[1]Nipissing University, Department of Geography, North Bay, ON, Canada
[2]James Cook University, TropWATER Centre, Townsville QLD, Australia

Given the difficulties of monitoring mangrove forests in quasi-permanent cloud covered regions of the world we evaluate the use of various space-borne Synthetic Aperture Radar (SAR) systems for assessing the condition of these wetlands following major oil spill events. Specifically we examined the use of ALOS PalSAR L-band, RADARSAT-2 C-band and COSMO SkyMed X-band imagery for identifying the extent of damage incurred in mangrove forests resulting from two massive oil spill events in western Africa. From the preliminary results we suggest that the wavelength, incidence angle and polarization are all key parameters that need to be considered if monitoring oil spill impacts on mangroves is to be successful. A comparison with passive satellite imagery would indicate that with the appropriate configuration, SAR imagery alone could be used for mapping the extent of damage incurred by these events as well as for monitoring their recovery. We also show how the various types of mangroves, including the species composition, also need to be considered for accurately assessing the impacts from such catastrophic events.

Contact Information: John M. Kovacs, Department of Geography, Nipissing University, 100 College Drive, North Bay, ON, P1B 8L7, Canada, Phone: 705-474-3450 ext. 4336, Email: johnmk@nipissingu.ca

FLORISTIC SURVEY OF THE MANGROVES OF KITAY, TAGKAWAYAN QUEZON PROVINCE, PHILIPPINES

Natividad F. Lacdan, *Daniel Marc dela Torre, John Paul S. Llido, and Arnold V. Hallare*
Department of Biology, CAS, University of the Philippines Manila

Mangroves, aside from seagrasses, are good natural filtering systems in marine environments. These are increasingly becoming important with the onslaught of impacts of climate changes. Despite their significant role, mangroves are continuously being threatened due to unsustainable use in the Philippines, one of the disaster centers of the world. Regular monitoring of mangrove forests becomes imperative as these are good buffers to offset the damaging effects of storm surges and tsunamis. Current floristic study of the mangroves of Kitay, Tagkawayan, Quezon was compared with studies conducted in 1999. Using four belt transects, nine true mangrove species, Aegiceras floridum, Avicennia officinalis, Brugiera cylindrica, Brugiera gymnorrhiza, Camptostemon philippense, Osbornia octodonta, Rhizophora apiculata, Rhizophora mucronata, and Sonneratia alba were identified. S. alba was the important species. In a scatter plot diagram showing distinct zonation patterns, S. alba and A. officinalis dominated the seaward and middleward sites, while R. mucronata dominated the landward fringe. Regeneration of wildlings was high at 1,543 wildings/ha. Productivity was low, registering a leaf area index of 1.54 and a net primary productivity of 20,005 tons/ha/yr. Comparing this current study with the 1999 study, S. alba remained the most important species. O. octodonta remained as the species with the highest regeneration/ha. Shannon-Weiner Biodiversity Index (H) was 2.04 as compared to H=2.59 in 1999, indicating a decrease in biodiversity. Apparently, human disturbances are the main contributors to the decline in biodiversity. The study emphasizes that more efforts be undertaken to conserve and manage the remaining mangrove stands in Sitio Kitay.

Contact Information: Natividad Lacdan, University of the Philippines Manila, Department of Biology, Rizal Hall, P. Faura St., Ermita, Manila, 1000, Philippines, Phone: 6325265861; Email: nlf2662@yahoo.com

MANGROVE DEVELOPMENT PATTERNS: CANOPY GAINS AND LAND EXPANSION IN DELTAS

***David Lagomasino*[1,2,*], *Temilola Fatoyinbo*[2], *SeungKuk Lee*[2], *Emanuelle Feliciano*[2], *Carl Trettin*[3], *Viviana Zalles*[4], *Matt Hansen*[4], *Aurélie Shapiro*[5]**

[1]Universities Space Research Association, Columbia, MD, USA
[2]NASA Goddard Space Flight Center, Greenbelt, MD, USA
[3]United States Forest Service, Cordesville, SC, USA
[4]University of Maryland, Department of Geography, College Park, MD, USA
[5]World Wildlife Fund for Nature, Germany

Mangroves are highly regarded coastal forests because of their ecosystem services and high carbon storage potential. In addition, these forests can develop rapidly in some locations depending on environmental conditions and sediment supply. The newly established mangroves are considered to have higher growth rates than older, mature forests. However, much of the information that exists for growth rates are confined to localized areas, individual trees, or seedling development. Since mangroves may colonize newly formed mudflats within deltaic coastlines, those areas provide an excellent basis to assess the development of the stand at the large scales. We used satellite-derived surface elevation and land change data to estimate mangrove growth at regional and continental scales. Areas of land generation were determined by the difference in NDVI as measured from Landsat imagery and supplemented with published land cover change maps for 2000 and 2013. The date of land generation was used as the initial tree height (0 m). Annual canopy height growth rates were estimated by the duration between land generation times and canopy height models derived from TanDEM-X radar interferometry and very-high resolution optical data collected in 2013.

Using this approach to assess mangrove canopy height growth, we compared mangrove forests in different geographic river deltas: the Zambezi (Mozambique), Rufiji (Tanzania), and Ganges (Bangladesh). Preliminary results report similar maximum growth rates ranging from 1.5 to 1.9 m per year for mangrove forests across the Indian Ocean. Mean canopy growth rates of 0.5-0.75 m per year were also paralleled among each of the sites. The spatial patterns of growth rates coincided with characteristic successional paradigms and stream morphology, where the maximum growth rates typically occurred along prograding creek banks. Both the vertical (e.g., canopy height) and horizontal (e.g., expansion) growth rates measured from remote sensing can garner important information regarding mangrove succession. Continued research will combine mangrove growth rates with biomass concentrations in order to predict changes in carbon stocks related to delta evolution.

Contact Information: David Lagomasino, Universities Space Research Association, GESTAR, NASA Goddard Space Flight Center, Greenbelt, MD 20771, United States, Phone: 301-614-6666; Email: david.lagomasino@nasa.gov

EFFECTS OF LAND COVER CHANGE ON SOIL ORGANIC CARBON FRACTIONS IN A SUBTROPICAL MANGROVE WETLAND

Derrick Y.F. Lai*, and Suvadip Neogi*
Department of Geography and Resource Management, The Chinese University of Hong Kong, Shatin, Hong Kong SAR, China

While coastal mangrove is regarded as one of the most carbon (C) rich ecosystems in the world, there is a need to characterize the magnitude of different fractions of soil organic C (SOC) pools to facilitate a better understanding of the lability of these stored C. Moreover, anthropogenic modifications of land cover for various purposes could alter the SOC fractions and thus the soil C sequestration potential of sites originally dominated by mangrove vegetation. In order to address the issue, we quantified the different SOC fractions, including the active (microbial biomass C, MBC; readily mineralizable C, RMC; oxidizable organic C, OC; water hydrolysable carbohydrate-C, WSC; acid hydrolysable carbohydrate-C, AHC; potassium permanganate oxidizable-C, POC), slow (water stable aggregates mass fractions C, particulate organic matter C, POMC), and passive (humic acid C, HAC) pools in the top 20 cm soils at three different locations, namely a natural mangrove dominated by *Kandelia obovata*, a reedbed dominated by *Phragmites australis* inside a tidal pond, and a bare mudflat with no vegetation. Irrespective of management practices, the different SOC fractions were found to be 15-40% higher in the top 10 cm soils. Overall, the magnitudes of various SOC pools and fractions were larger in the soils of the natural mangrove and reedbed than in the mudflat, which could be attributed in part to the enhanced rate of root growth and rhizodeposition. Also, considerable differences in the relative amount of active and passive SOC pools were identified among the three sites, and the possible causes of such variations will be further discussed. Our findings demonstrate the importance of taking into account the changes in land cover in maximizing the potential of mangrove soils in sequestering C over the long term.

Contact Information: Derrick Y.F. La, The Chinese University of Hong Kong, Department of Geography and Resource Management, 2/F Wong Foo Yuan Building, Hong Kong, 000, Hong Kong, Phone: 85239436528, Email: dyflai@cuhk.edu.hk

INVESTIGATING TOP-DOWN AND BOTTOM-UP INFLUENCES ON BLACK MANGROVE (AVICENNIA GERMINANS) ENCROACHMENT IN FORESTED FRESHWATER ISLANDS ALONG THE BIG BEND COAST OF FLORIDA

*David Kaplan, and **Amy Langston***
Engineering School of Sustainable Infrastructure and Environment, University of Florida, Gainesville, FL, USA

Manifestations of climate change (e.g., sea level rise, extreme weather events, and rising temperatures) are changing the coastal landscape by altering the physical conditions that affect the survival, distribution, and reproductive success of wetland vegetation. Such changes are evident along Turtle Creek, a tidal creek located in Waccasassa Bay Preserve State Park along the Big Bend coast of Florida, where the decline of forested freshwater islands and expansion of mangroves are simultaneously occurring due to climate change. Long-term field data collected along Turtle Creek show that forested freshwater islands, historically characteristic to the Big Bend coast, cannot withstand the combined effects of increased tidal flooding and extreme storm and drought events. Concurrently, sea level rise and fewer freeze events in this region are promoting the northward and landward expansion of mangrove populations, making the Big Bend coast a conspicuous ecological transition zone where climate change may be driving the replacement of one forest community by another.

In this work, we investigate the potential for replacement of forested freshwater islands by mangroves by comparing mean propagule response across four landscape positions (creek edge, marsh plain, forested freshwater island edge, and forested freshwater island interior) within and between three sites subject to different tidal flooding frequencies. Due to intense predation by crabs, we are also testing the effectiveness of caging and propagule tethering in limiting crab predation across landscape positions. Finally, we are complementing these field experiments with lab experiments investigating crab and propagule density thresholds on propagule survival and comparing the vulnerability of propagules and seedlings to crab predation. Though these experiments are ongoing, to date our results show that while climate change may promote bottom-up factors that favor mangrove encroachment in sites formally occupied by healthy forested freshwater islands, top-down factors, such as crab predation, may inhibit the expansion of black mangroves into new areas not adjacent to established, high-density mangrove populations. These results can inform potential mangrove expansion patterns and demonstrate the likelihood of black mangroves replacing forested freshwater islands as the dominant wetland forest along the Big Bend coastal fringe.

Contact Information: Amy Langston, University of Florida, 5 Phelps, Gainesville, FL, USA 32611, Phone: 352-392-2424, Email: amylangston@ufl.edu

SEEING THE TREES AS WELL AS THE FOREST: QUANTIFYING THE RELATIONSHIP BETWEEN HABITAT SP ATIAL COMPLEXITY AND MANGROVE ECOSYSTEM SERVICES

***Joe S.Y. Lee**, Shafagh Kamal, Jan Warnken*
Griffith University Gold Coast campus, Queensland, Australia

The ecosystem services offered by mangroves, namely, coastal protection, carbon export/storage, nursery function, were evaluated based on investigations relating function with mangrove abundance at large spatial scales (km or higher). While metrics related to forest-scale measurements such as total area and tidal inundation pattern do drive these services, characteristics of the trees determine the biology as well as the physics underpinning these services. Structural complexity of the trees, particularly the aerial roots, of mangroves have long been attributed to the efficient dampening of wave hydrodynamic forces, shelter to juvenile nekton from predators and extreme physical conditions, as well as trapping of sediment and organic particles. The relationship between this complexity and the capacity of mangrove forests for ecosystem services is, however, yet to be quantified, as no satisfactory indices for measuring and comparing spatial complexity is available.

We reported a low-cost method for capturing and quantifying the 3D spatial complexity of mangrove stands at the scale of metres (Kamal et al. 2014). By capturing the complexity of mangrove aerial root structure in a digital model with a high degree of realism, various analyses of patch characteristics key to mangrove ecosystem services may be measured with a high degree of accuracy. For example, the standing biomass of aerial roots may be estimated non-destructively based on the volume of roots, which can be easily and accurately measured using the 3D model. Indices of complexity such as fractal dimension or the surface area to volume ratio (AVR) may be computed for individual habitat blocks.

Field and laboratory experiments were conducted to investigate how spatial complexity measured using these approaches may drive the coastal protection, sediment trapping and nursery function of mangrove forests. Results indicate that complexity offered by trees strongly influence ecological and physical processes at the metre scale, underpinning the services observed for mangroves at the forest and landscape scales.

Contact Information: Joe S.Y. Lee, Australian Rivers Institute and School of Environment, Griffith University Gold Coast campus, Southport, Queensland 4222, Australia. Phone: +61-7-55528886; Email: joe.lee@griffith.edu.au

NET ECOSYSTEM CO_2 EXCHANGES BETWEEN A DWARF *AVICENNIA MARINA VAR. AUSTRALASICA* MANGROVE AND THE ATMOSPHERE: APPLICATION OF THE EDDY-COVARIANCE FLUX TOWER TO "LE COEUR DE VOH" MANGROVE (NEW CALEDONIA)

*Cyril Marchand[1], **Audrey Leopold[2,1]**, Michel Allenbach[2], Alexandre Renchon[1,2,3], Jonathan Deborde[1], Carine Bourgeois[4,1], and Thomas Quiniou[2]*

[1]Insitut de Recherche pour le Développement, Nouméa, New Caledonia, France
[2]Université de la Nouvelle-Calédonie, Nouméa, New Caledonia, France
[3]Hawkesbury campus, Science road, Richmond NSW 2753, Sydney, Australia
[4]Auckland University of Technology, Auckland, New Zealand

In a context of climate change, the last years have seen an increasing interest from the scientific community to mangrove carbon cycling. Mangroves are among the most productive ecosystems and carbon rich ecosystems in the world. However, mangrove carbon cycling is not fully constrained because of a lack of data on carbon export. Moreover, most of the studies about mangrove carbon cycling only focused on low spatial and temporal scales. Eddy covariance (EC) flux tower measures net ecosystem exchanges, and represents a powerful tool as it integrates the different components that come into play to define the ability of an ecosystem to act as a CO_2 sink or source. EC towers are installed in a lot of ecosystems through the world but they remain extremely rare in mangrove forests. We used EC to study CO_2 net exchanges (NEE) between an *Avicennia marina* dwarf mangrove, which grows in the high tidal zone under semi-arid climate, and the atmosphere. Biophysical controls of NEE were investigated, and net ecosystem production (NEP) was determined over one year. Maximum values of daytime NEE ranged from -6 -11 $\mu mol.m^{-2}.s^{-1}$ to less than -11 $\mu mol.m^{-2}.s^{-1}$ both during and at the end of the wet and warm season. Nighttime NEE ranged from 0.38 -11 $\mu mol.m^{-2}.s^{-1}$ to 8.80 $\mu mol.m^{-2}.s^{-1}$, and was the highest during the wet and warm season. Solar radiation, temperature and vapor pressure deficit were identified as determining factors of NEE seasonal and daily variations. Moreover, water availability from tides and rainfall is a major determining factor of NEE. Maximum daytime NEE occurred during high tide as a result of lower direct contribution of below-canopy respirations to the ecosystem respiration and because photosynthesis rate may increase during submerged conditions. Moreover, the importance of water availability on the productivity of this ecosystem productivity was shown by the NEP seasonal variation. The latter was the highest at the end of wet season. During this season, photosynthesis rates were the highest but ecosystem respiration strongly increased, resulting in a very low and even negative NEP. Such increase in ecosystem respiration is likely to be related to growth resumption because of freshwater availability from rainfall. During the dry season, the absence of rainfall and the high evaporation lead to high salinities of porewaters, and to low growth and net ecosystem productions. Thus, during the wet season, the low NEP is related to an important increase of ecosystem respiration while during the dry season, the low NEP is related to a decrease of growth photosynthesis. We estimated that this mangrove was a CO_2 sink of 72.8 $gC.m^{-2}.yr^{-1}$, even if carbon tidal exports are expected to be relatively low because of low tidal range, they may slightly lower this value.

Contact Information: Audrey LEOPOLD, BPA5 98848 Noumea, New Caledonia, Email: leopoldaudrey@gmail.com

STRESS IN MANGROVE FORESTS: EARLY DETECTION AND PREEMPTIVE REHABILITATION ARE ESSENTIAL FOR FUTURE SUCCESSFUL WORLDWIDE MANGROVE FOREST MANAGEMENT

Roy R. Lewis III[1], *Eric C. Milbrandt[2], Benjamin M. Brown[3], Ken W. Krauss[4], André S. Rovai[5], Jim W. Beever III[6], and Laura L. Flynn[1]*

[1]Coastal Resources Group, Inc., Salt Springs, Florida, USA
[2]Sanibel-Captiva Conservation Foundation, Sanibel, Florida, USA
[3]Charles Darwin University, Darwin NT 0909, Australia
[4]U.S. Geological Survey, Lafayette, Louisiana, USA, USA
[5]Federal University of Santa Catarina, Florianópolis, SC, Brazil
[6]Southwest Florida Regional Planning Council, Fort Myers, Florida, USA

We contend that mangrove forest rehabilitation should begin much sooner than the point of catastrophic loss as perhaps the only mechanism to preempt large scale losses of mangroves and the resulting loss of ecological services and carbon storage. We describe the need for "mangrove forest heart attack prevention" as part of that process, and how that might be accomplished by embedding plot and remote sensing monitoring within sentinel sites as part of strategic coastal management plans. The associated monitoring data would provide information on deteriorating conditions prior to collapse while, depending on location of a subset of sentinel sites, providing reference condition for restoration targets.

The major cause of mangrove stress at many sites globally, based upon our decades of international experience, relates to modified (most often reduced) tidal water flows and exchanges, which are essentially analogous to blocked blood flows in human veins and arteries. The medical parallels are clear; long-term degradation of function leads to acute mortality prompted by acute events. Often, mangroves are abruptly lost within just a few years; however, the vulnerability of many mangrove forests is increased decades earlier when seemingly innocuous hydrological modifications are made (e.g., road construction, tidal channel modifications, port dredging and disposal, etc.), but remain undetected without reasonable large-scale monitoring.

With so much development occurring around mangroves globally, simply protecting forest patches from direct physical destruction is not enough unless provisions are made for detecting and ameliorating impacts that drive mangroves to unhealthy states, which we term "preemptive rehabilitation". Whether mangroves are degraded immediately or in degrees over decades, their eco-physiological requirements for long-term persistence are sensitive enough to affect a loss either way, but "preemptive rehabilitation" can preserve many of the essential functions and allow for rapid recovery back to reference conditions.

Contact Information**:** Roy R. "Robin" Lewis III, Coastal Resources Group, Inc., 23797 NE 189th Street, Salt Springs, Florida, USA 32134. E-mail: LESrrl3@gmail.com

STRUCTURAL PARAMETERS, CHANGE DETECTION AND CONDITION OF MANGROVES FORESTS IN TWO CONTRASTING UTILIZATION PATTERNS IN THE NORTHERN MOZAMBIQUE

***C. Macamo**, S. O. Bandeira, and H. Mabilana*
Universidade Eduardo Mondlane, Departamento de Ciencias Biologicas, Maputo, Mozambique

This study documents mangrove forests in contrasting communities: one peri-urban agriculture-dependent (Pemba Bay) and a rural fishing community (Olumbi, Lalane and Vamize, all in Palma district). The study aimed to identify and compare the impact of different patterns of utilization of mangrove forest resources on the forest dynamics, condition and availability of woody resources. Kauffman and Donato (2012) protocol, was adapted and applied to collect data on species composition, regeneration, poles quality and tree conservation condition. Interviews with key informants were also conducted to identify the main forms of use of mangrove resources. Landsat imagery (1991-2013) was used to map changes in cover area. The results indicate distinct patterns of resources use, with more impacted mangroves in the rural settings due to timber extraction and clearance for fishing boats path. In Pemba Bay most impacts were conversion to saltpans and aquaculture farm. In Palma forms of use included intensive logging, collection of invertebrates, sanitary uses and others. Differences among the forests extend to species composition: 4 species in Pemba, *C. tagal* dominates (68.78%); 7 in Palma, and *R. mucronata* dominates (44.6%). All forests are structurally small (mean DBH and height in Pemba Bay were 6.69 cm and 3.07m; in Palma figures are 6.11 cm and 2.37m, respectively). The forests of Palma were patchy, with more than 40% of main trunks cut, and most standing poles were not useful for construction (the main form of use of poles). The in Pemba Bay had more intact individuals and better quality poles. The analysis of satellite images showed a loss of almost 30% of the total area in the rural settings (about 8% of the total area lost every year), while in the peri-urban site there was an increase of 22% of the area. This study shows that, more important than being located in a populated and accessible area, the role of mangroves as source of livelihood will determine the pattern of use of resources and its condition. A mangrove recovery strategy for the rural sites (Olumbi, Vamize and Lalane) would include raising awareness of local population, replantation and monitoring programs. Payment for ecosystem services projects can be alternative to sustain conservation programs.

Contact Information: Mrs. Celia Macamo, Universidade Eduardo Mondlane, Av. Juluis Nherere, Campus Principal, Maputo, Maputo, 257, Mozambique, Phone: 25821493377; Email: celiamacamo@yahoo.com

STATUS AND CHALLENGES OF MANGROVES IN CARBON MARKETS

Sarah K. Mack
Tierra Resources, New Orleans, LA, USA

In the last decade, considerable global, national, regional and state-level governmental participation in the stabilization of atmospheric greenhouse gases has facilitated significant growth in emissions trading markets. Deforestation and forest degradation, including mangrove loss, account for nearly 20% of global greenhouse gas emissions. Mangrove restoration and conservation can demonstrate carbon savings and produce carbon credits for sale on voluntary or compliance markets. Carbon markets that facilitate financial investment into mangrove restoration and conservation efforts can provide a wealth of co-benefits such as storm surge reduction, fish and wildlife habitat, recreation, job creation, and economic development that are vital to the sustainability of coastal areas.

To ensure quality and credit validity, protocols and methodologies must provide a transparent accounting methodology for the development, certification, and monitoring of carbon offset projects, and be approved through a transparent process that provides opportunities for stakeholder engagement and scientific review. Currently mangrove restoration and conservation efforts are eligible in voluntary and compliance markets using Wetland Restoration, and Reducing Emissions from Deforestation and Degradation (REDD+) protocols.

This presentation will provide background on voluntary and compliance carbon markets with a focus on mangrove carbon credits. An overview of project development will be discussed including eligibility rules, establishing a baseline, monitoring of eligible carbon pools, and estimating project emission reductions. The opportunities and challenges other mangrove projects have faced will be explored. The results will inform managers and developers on how to develop mangrove carbon credits that are compliance eligible, economically competitive, and scientifically defensible.

Contact Information: Sarah K. Mack, Tierra Resources LLC, 1310 St. Andrew St Suite 1, New Orleans, LA 70130 USA, Phone: 504-339-4547 Email: sarahmack@tierraresourcesllc.com

EFFECTS OF SEVERE FLOODING ON ESTUARINE MANGROVES - DISTURBANCE, RESILIENCE AND RESTORATION

Jock Mackenzie
James Cook University, Townsville, QLD, Australia

"I love a sunburnt country, a land of sweeping plains, of ragged mountain ranges of droughts and flooding rains, I love her far horizons, I love her jewel-sea, her beauty and her terror, the wide brown land for me" (excerpt from Dorethea Mackellar *My Country)*. Australia is a country typified by diverse and iconic landscapes, severe climate and severe weather events, which are at times terrifying in their power and destruction. Mangroves are highly adapted to extreme environments as demonstrated by their survival at the interface between land and sea, exposing them to short and long-term climate extremes such as cylcones, floods and droughts. But anthropogenic driven degradation of estuarine mangroves may threaten the capacity of mangroves to withstand extreme climate events. Direct damage leading to mangrove loss and fragmentation and indirect effects such as altered hydrology and eutrophication reduce the capacity of mangroves to withstand climate extremes and limits their resilience capacity. It is expected that extreme weather events will increase in both severity and frequency in coming years. It is therefore imperative that we understand how anthropogenic degradation of mangroves influences their resistance and resilience to extreme weather events in order to inform better mangrove management. Recently, a series of severe flood events impacted the east coast of Australia, causing extreme flooding in major coastal rivers and estuaries. These flood events caused widespread loss of shoreline mangroves, with an estimated loss of 30% of estuarine mangroves in some coastal estuaries. Some of the estuaries impacted form part of the monitoring network of MangroveWatch, a citizen-science based program designed to monitor long-term changes in the condition of shoreline mangroves using geotagged video. The MangroveWatch monitoring data enabled assessment of mangrove condition before and after flooding. Here we examine the effect of flooding on estuarine mangroves in three different coastal settings with differing levels of human impacts to assess the effects of estuarine and catchment modification on mangrove resilience to severe flood events. Our results show that shoreline mangrove forest fragmentation, eutrophication and estuarine shoreline modification result in greater risk of estuarine mangrove loss during severe flood events with recovery dependent on pre-existing forest structure, forest continuity, condition, level of anthropogenic disturbance and adjacent land use. This information is used to develop a strategic approach to mangrove rehabilitation investment in the target estuaries and inform future estuarine mangrove management.

Contact Information: Jock Mackenzie, James Cook University, TropWATER, James Cook Drv, Townsville, QLD, 4811, Australia, Phone: 61407578807, Email: jock.mackenzie@jcu.edu.au

UNDERESTIMATING THE ROLE OF LEAF LITTER IN SESARMID CRAB DIETS: THE IMPORTANCE OF ISOTOPE FRACTIONATION VALUES

Richard A. MacKenzie[1]*, Carmen Pipet*[2]*, and Lilah Xavier*[2]
[1]USDA Forest Service, Hilo, Hawaii, USA
[2]Palau Community College, Koror, Republic of Palau

Sesarmid crabs play an important role in mangrove forest carbon dynamics. Carbon from senescent leaves is quickly incorporated into mangrove sediments through crab consumption. Visual observations have documented that sesarmid crabs can be quite efficient at breaking down leaf litter and gut content studies have verified that certain sesarmid crab species are eating mangrove leaves. Despite these results, stable ^{13}C and ^{15}N isotopes suggest that sesarmid crabs are relying more heavily on microphytobenthos (MPB) as a food source than senescent leaf litter and while sesarmid crabs appear to be consuming leaf litter, they are not assimilating it.

We sampled *Parasesarma* spp. sesarmids and *Uca* sp. ocypodids from four mangrove forests around the island of Yap in the Federated States of Micronesia in 2005 and 2006. The $\Delta\delta^{13}C$ between *Parasesarma* spp. and *Uca* sp. crab tissue and of senescent mangrove leaf litter ranged from 4.4-11.6 ‰, suggesting that mangrove leaves were not an important food source in either crab's diet. Interestingly, the $\delta^{13}C$ and $\delta^{15}N$ of *Parasesarma* spp. crabs significantly shifted between 2005 and 2006, but not for *Uca* sp. This shift mirrored a shift also observed between the 2005 and 2006 mangrove leaves sampled. This suggested that *Parasesarma* spp. were assimilating C from mangrove leaves and that published ^{13}C and ^{15}N fractionation values may not apply to sesarmid crabs that feed on mangrove leaves. This idea was supported by recent findings by Bui and Lee (2014).

In 2008, we conducted a follow on, eight week-long feeding study with *Parasesarma* spp. and *Rhizophora* sp. leaves. Results revealed that crabs feeding solely on leaf litter had a ^{13}C and ^{15}N isotopic fractionation of 3.3 ± 0.5 and 2.8 ± 0.6 ‰, respectively. Using the Stable Isotope Analysis in R package (SIAR), we then calculated diet compositions of the Yap *Parasesarma* crabs using trophic enrichment factors (TEFs) from our feeding study as well as those published by McCutchan et al. (2003) (^{13}C - 0.1 ± 0.6; ^{15}N - 3.5 ± 0.2). Results revealed that published fractionation values underestimated the value of mangrove leave litter to sesarmid crab diets by 36.0 ± 0.3 % and overestimated the value of MPB and epiphytic algae 35.7 ± 0.04%. Thus, while MPB and epiphytic algae are still important basal food resources for some sesarmid crabs species, the value of leaf litter as a food resource will continue to be underestimated unless more accurate and species specific isotope fractionation values are determined.

Contact Information: Richard MacKenzie, USDA Forest Service, 60 Nowelo St., Hilo, HI 96720, United States,
Phone: 808-854-2616; Email: rmackenzie@fs.fed.us

SHIFTS IN NUTRIENT ALLOCATION DURING BLACK MANGROVE (AVICENNIA GERMINANS) ENCROACHMENT INTO SALT MARSH (SPARTINA ALTERNIFLORA)

***Aaron Macy*[1,2]*, Just Cebrian*[1,2]*, Michael Osland*[3]*, and Julia Cherry*[4]
[1]Dauphin Island Sea Lab, Dauphin Island, AL, USA
[2]University of South Alabama, Mobile, AL, USA
[3]U.S. Geological Survey, Lafayette, LA, USA
[4]University of Alabama, Tuscaloosa, AL, USA

In the coming century, warmer winter temperatures along the northern Gulf of Mexico are expected to enable the poleward migration of mangrove forests at the expense of some salt marshes. In Louisiana (USA), the black mangrove, *Avicennia germinans*, is expected to expand into coastal wetlands historically dominated by the salt marsh grass, *Spartina alterniflora*. While both species provide similar ecosystem services, including shoreline stabilization, carbon sequestration, nutrient filtration, and habitat provision, it is unclear how the magnitude of these services will change with *A. germinans* expansion.

In this study, we look to investigate seasonal allocations of carbon and nitrogen to different plant tissues and to the sediment environment of wetlands dominated by *A. germinans* or *S. alterniflora* in Port Fourchon, Louisiana. The two species have different seasonal growth patterns. Whereas *A. germinans* retains leaves during the winter, the aboveground biomass of *S. alterniflora* senesces each winter, and the grass resprouts the next year from belowground biomass reserves. As the dominant vegetation shifts from *S. alterniflora* to *A. germinans*, the associated seasonal changes in carbon and nitrogen availability could influence trophic fluxes through detrital and grazing communities. In Louisiana, high rates of nutrient removal during the spring and summer play an important role and help to diminish the extent of coastal eutrophication in the Gulf of Mexico's "Dead Zone". Changes in seasonal patterns of nutrient allocation could affect the rate of nutrient uptake during this critical period. Our study provides a foundation for better understanding the implications of mangrove expansion into salt marsh for ecosystem services related to nutrient removal and cycling.

Contact Information: Aaron Macy, Dauphin Island Sea Lab, 101 Bienville Blvd, Dauphin Island, AL, USA 36528,
Phone: 251-861-2141 x7564, Email: amacy@disl.org.

MAIN FACTORS DRIVING GHG EMISSIONS FROM MANGROVE SEDIMENTS

***Cyril Marchand*[1]*, and Erik Kristensen*[2]**

[1]Institut de Recherche pour le Développement (IRD), Nouméa, New Caledonia, France
[2]Department of Biology, University of Southern Denmark, Odense M, Denmark

Despite their generally organic-rich sediments, mangrove forests are usually characterized by low emissions of CO_2 and other greenhouses gases (GHG) like methane (CH_4) and nitrous oxide (N_2O). However, recent evidences suggest a high variability of GHG emissions among mangrove environments according to their productivity, position in the tidal range, seasons etc. In this presentation, we will review the variability in GHG emissions from mangrove forests, and discuss various factors that may potentially be responsible for this variability.

Highly productive mangrove forests at low latitudes may produce more GHG simply because of the higher input of labile organic carbon deposited in the sediments. In addition, the high sediment temperatures in tropical areas induce elevated decomposition organic matter and thus higher GHG emissions. Sediment water content may influence CO_2 emissions in two ways. 1/ Since the molecular diffusion of gases is much faster in air than water, CO_2 emissions increase when sediments are exposed to the atmosphere. This is caused by sediment desiccation during low tides and during the dry season, particularly in the high elevation part of the intertidal zone. 2/ Anoxic conditions prevailing in waterlogged sediment hamper microbial decay of organic matter and thus CO_2 emissions. Furthermore, microphytobenthos development at the sediment surface can limit GHG emission by the formation of protective EPS biofilm barriers that clog the pore spaces. The microphytobenthos within the surface biofilm may also consume CO_2 produced within the sedimentary column for growth. Conversely, deep crab burrows and aerial roots like pneumatophores induce higher emissions as they act as a conduits for gas exchange and allow the ascent of CO_2 and CH_4 produced in deep sediment to the atmosphere. In addition, the increasing human population along tropical coastlines has led to increased sewage release in mangrove environments resulting in higher GHG emissions.

GHG exchange measured at sediment surface does not represent the total GHG balance of mangrove forests. The largest CO_2 exchange actually occurs through canopy uptake and release, which can be difficult to measure. However, the use of the eddy-covariance (EC) technique in mangrove forests can improve our understanding of the gas exchange between mangrove forests and the atmosphere. Nevertheless, part of the primary production of these intertidal forests is exported in particulate or dissolved forms towards tidal creeks and the surrounding ocean through surface run-off or pore-water seepage. These pools may be quickly mineralized and emitted as CO_2 to the atmosphere. Waters surrounding mangroves may therefore be a hidden source of mangrove-derived GHG to the atmosphere, which actually should be included in mangrove GHG budgets.

Contact Information: Cyril Marchand, IRD - Institut de Recherche pour le Développement, BPA5, Noumea, 98848, New Caledonia, 1, Email: cyril.marchand@ird.fr

RELATIVE AND SYNERGISTIC IMPACTS OF CLIMATE AND DIRECT ANTHROPOGENIC PRESSURES ON THE PERFORMANCE OF *AVICENNIA MARINA* SUBSP *AUSTRALASICA*: AN *IN-SITU* LATITUDINAL APPROACH

Cyril Marchand[1], *Andrea Alfaro*[2], *Bourgeois Carine*[2,1], *and Audrey Léopold* [3,1]

[1]Institute of Research for the Development, Nouméa, New Caledonia, France
[2]Institute for Applied Ecology, Auckland University of Technology, Auckland, New Zealand
[3]University of New Caledonia, Nouméa, New Caledonia, France

In the context of global change, mangrove ecosystems are projected to experience severe variations within their environment. In order to model and anticipate mangrove ecosystem change, the main challenge is to assess the relative and synergistic impacts of climate change and direct anthropogenic pressures on mangrove stands. In the present study, we aimed at comparing the influence of soil characteristics, climate, seasons, and nutrient inputs on the performance of one mangrove species: Avicennia marina (Forsk.) Vierh subsp. australasica, (Walp.) J. Everett. This species is ubiquitous throughout the world and can survive in extreme conditions. It also can be a pioneer species, and thus may be the first to colonize new shorelines following dramatic changes in climate. We choose to focus on two geographic regions: semi-arid New Caledonia (21°S), and temperate New Zealand (36°S).

Relative and synergistic influences of climate and nutrient inputs on the performance of this species were explored in both latitudes over two seasons through three matrixes in multivariate analyses combining i) environmental factors, ii) functional traits linked to mangrove physiological performances, and iii) relative growth rates. A total of 322 trees were monitored in different mangrove stands, within various nutrient and transition metal contents, texture and topography.

In both latitudes, extreme temperatures occurring during winter in New Zealand and drought season in New Caledonia significantly affect stomatal conductance and growth rates of mangrove trees. In addition, limited light and high precipitation in temperate and semi-arid mangroves, respectively, were found to affect mangrove stands. The physiological performance of mangrove trees was lower in semi-arid mangroves compared to temperate counterparts due to high temperatures and low precipitation which induced a decrease in soil water content, and increase in salinity (higher than 70). This water stress induces the closure of stomata to prevent evapotranspiration, along with changes in the Na:K:Ca:Mg ratios in leaf tissues to maintain osmotic balance in cells. Generally, this physiological response occurs at the expense of calcium and magnesium concentrations in tissues, the magnesium being negatively correlated to chlorophyll content and therefore to photosynthetic activity.

In both latitudes, our observations show that these impediments to growth are often lowered by an input of nutrients, likely because this is often accompanied by a freshwater supply and consequently by a reduction of salinity. However, a dual effect of nutrient inputs on physiological performance of the trees was highlighted under both cold and drought stresses. At both latitudes, we observed a threshold of bulk density and topographic level under which organic matter supply had a detrimental effect on soil oxygenation, nutrients and metal availability, and thus on mangrove performance.

In conclusion, we provide a comprehensive model of the mutual interactions between biogeochemical and physiological processes of mangroves under climatic stresses and anthropogenic pressures. The output of this research is the isolation of the key processes explaining mangrove performance in low-latitudes within various types of substrates.

Contact Information: Carine Bourgeois, Auckland University of Technology, Faculty of Health and Environmental Sciences
33 Symonds Street, Auckland 1142, New Zealand, Email: carinebourgeois1@gmail.com

ECONOMIC VALUATION OF MANGROVES

***Carilyn Salanio-Martin**, Zaluma Gampal, Abelardo Corpuz and Sanico Bulawan*
Environmental Conservation and Protection Center, Alabel, Sarangani, Philippines

The mangroves in Glan, Sarangani Province, Philippines are one of the critical resource ecosystems in Sarangani Bay Protected Seascape (SBPS). This ecosystem serves as breeding and nursery ground of fishes while playing the role of buffer to strong winds and surges to the coastal inhabitants. The municipality of Glan has 114.44 hectares of mangroves with 21 species (ECPC Biozonification Study, 2008).

The SBPS-Protected Area Management Board (PAMB) needs legislations in order to protect and conserve the remaining resources of the bay, specifically the mangrove community. Thus, this study was conducted to determine the economic value of mangroves in Glan, Sarangani Province. Economic Value is measured by someone's willingness to give up something in order to obtain a good or service, thus the willingness to pay (Pearce and Turner, 1990). WTP can be determined through contingent valuation method (CVM), which is often used to estimate values for all kinds of ecosystem and environmental services, the use and non-use values (Bann, 1999).

The study is a descriptive research. Economic value was determined through contingent valuation method in which it directly asks people in a survey how much they would be willing to pay for environmental services. Sampling technique utilized was the proportional allocation method of total households of coastal barangays. Logistic regression was used to estimate the valuation function that relates the hypothesized determinants with WTP responses. Socio-economic characteristics of households, along with the mangrove awareness level were used as predictor for this analysis.

Results of the logistic regression analysis indicated that the four determinants were significant, namely, settlement location, gender, number of years spent in school and awareness on mangrove uses and benefits.

The influence of location of settlement or habitation was strong. People living in the coasts are seventy three percent more likely willing to pay for the conservation of mangroves than those who are living far from coastline, for every single point increase in the awareness level on mangrove uses and benefits, there is likely 0.8 percent increase in WTP and for every additional year spent in school, there is 5.3 percent more likely increase in WTP and being male is eight percent more likely WTP than females.

The willingness to pay a person has is equivalent to the amount he is willing to sacrifice to get the non market good. WTP is the economic value of the services, goods and functions of the mangrove ecosystem, which in this study, were conditioned by gender, awareness level, and the number of years spent in school and being a coastal inhabitant. Economic value, therefore, is the benefit that the community gets from using mangrove goods, services and functions. The economic values the respondents put on the mangroves per hectare and per mangrove tree are important input to policies in the conservation and protection of the mangrove ecosystem.

Contact Information: Carilyn Salanio-Martin, Environmental Conservation and Protection Center, Capitol Park, Alabel, Sarangani Province, Philippines Phone: 063-0929 693 1540, Email: carilyndianco@yahoo.com

WESTERN MANGROVE SPECIES IN FACE OF PAST AND CURRENT CLIMATE CHANGES: A MULTI-DISCIPLINARY APPROACH

Gustavo Maruyama Mori[1,2,3,4], *Mariana Vargas*[2], *Stephanie Karenina Bajay*[2], *Koji Takayama*[5], *Yu Matsuki*[6], *Rafael Silva Oliveira*[7], *Yoshihisa Suyama*[6], *Anete Pereira de Souza*[2,7], *Tadashi Kajita*[4], *Maria Imaculada Zucchi*[1]

[1]Agência Paulista de Tecnologia dos Agronegócios, Piracicaba, São Paulo, Brazil
[2]Centro de Biologia Molecular e Engenharia Genética – Universidade Estadual de Campinas, Campinas, São Paulo, Brazil
[3]Faculty of Sciences – Chiba University, Chiba, Chiba, Japan
[4]Iriomote Station – University of the Ryukyus, Taketomi, Okinawa, Japan
[5]Museum of Natural and Environmental History - Shizuoka, Shizuoka, Japan
[6]Kawatabi Field Science Center – Tohoku University, Osaki, Miyagi, Japan
[7]Departamento de Biologia Vegetal – Universidade Estadual de Campinas, Campinas, São Paulo, Brazil

The current global climate changes (GCC) are alterations on the climate properties whose biological effects are unquestionable. Although a wide range of organisms is affected by this global phenomenon, different species may differently respond to these changes. Mangrove forests are projected to be one of the most influenced environments by the current GCC. In this context, we aim to understand the commonalities and differences between unrelated mangrove genera and shed light into fundamental processes that influence mangrove evolution, distribution and adaptation. For this purpose, we are using a multidisciplinary approach that includes climatic niche, genetic diversity, transcriptome and ecophysiology analyses of mangrove trees (*Avicennia germinans, A. schaueriana, Rhizophora mangle, R. racemosa* and *R. harrisonii*) from the Atlantic-Caribbean-West Pacific biogeographic region.

Overall, the climatic niche pairwise comparison indicate that these species presented a similar (but not equivalent) niche. The only exception is when *R. mangle* and *A. schaueriana* were compared since their niches were not more similar than expected by chance. These species distributions models suggested that there was a poleward latitudinal distributional shift since the Last Glacial Maximum (around 22000 ybp). This result is consistent with previous works based on tens of neutral genetic markers that suggested past demographic expansion in higher latitudes populations. To unveil more precisely the past evolutionary history of these species, we are currently using new techniques that assess a broader portion of the species genomes (from hundreds to tens of thousands markers). Up to the present moment, our results support previous interspecific and intraspecific genetic structure findings. They show, for instance, that *A. germinans* and *A. schaueriana* are diverged evolutionary lineages that may hybridize in their sympatry zone. Moreover, we reconfirmed the American continent as a major barrier for *R. mangle* gene flow whereas the Atlantic and Pacific oceans do not impede the species migration. Besides corroborating previous results, we aim to go further and study non-neutral genetic markers (loci in the genome that are under the action of natural selection) whose functions will be possibly determined by transcriptome analyses that are being carried out for *A. germinans, A. schaueriana* and *R. mangle* from two genetically contrasting populations (from North and South coasts of Brazil). From these populations, we also performed a seven months greenhouse common garden experiment of *A. schaueriana.* Preliminary results indicate that plants from these populations have different water use, growth and biomass accumulation strategies.

By better understanding how mangrove trees have responded to historical changes we aim to have cues on how they may respond to the current GCC. As an outcome, we want to make available valuable information for means of management and conservation in different geographic scales of these threatened forests.

Contact Information: Gustavo Maruyama Mori, Agência Paulista de Tecnologia dos Agronegócios, Rodovia SP 127, km 30 - Bairro: Vila Fátima. Caixa Postal: 28 - CEP: 13400-970, Piracicaba-SP-Brazil. Email: gumori@gmail.com or mori@unicamp.br

STABLE ISOTOPES OF MACROBENTHOS AND FISH IN MANGROVE-FOREST FOOD WEBS OF SHARK RIVER, USA

Carole C. McIvor[1]*, William F. Loftus*[2]*, David P.J. Green*[3]* and Joel Trexler*[4]

[1]USGS – Wetlands and Aquatic Science Center, St. Petersburg, FL, USA
[2]Aquatic Research & Communication LLC, Vero Beach FL, USA
[3]Florida Gulf Coast University, Ft. Myers, FL, USA
[4]Florida International University, North Miami, FL, USA

The Greater Florida Everglades (GEE) in Southern Florida is the focus of a major hydrological restoration of a vast wetlands ecosystem. The goal is to restore the basic hydrological patterns of water quality and flow to prolong the period of low-salinity conditions in the upper reaches of tidal rivers and streams. We collected data on food-web relationships at two ends of the salinity gradient in Shark River, a major conduit of freshwater outflow from the GEE. Using stable isotopes of carbon and nitrogen, our objectives were to: (1) identify the major sources of organic matter for representative consumers at the two ends of the salinity gradient; (2) determine if the relative contribution of organic-matter sources differs over wet and dry seasons; and (3) identify pathways most likely to reflect trophic changes that could conceivably occur with modified freshwater inflow. This study provided information on the structure of that food web, including such basic questions as what species use the fringing forests and which primary producers support those communities.

We collected representative plant and animal taxa from fringing mangrove forests and adjacent subtidal waters at two fixed locations at the ends of the salinity gradient on Shark River three times a year, from 2005-2007. Analyses indicate that both red mangroves and BMA (benthic microalgae) were enriched in $\delta^{15}N$ and depleted in $\delta^{13}C$ at the most upriver site (Tarpon Bay, mean annual salinity = 5 psu). These unique values at the upriver site are indicative of its location at a salinity ecotone where freshwater influence dominates marine influence. The major *in situ* primary producers (red mangrove, BMA) overlapped considerably in both $\delta^{13}C$ and $\delta^{15}N$ at the upriver location, making it impossible to tease apart the relative contributions of those two potential organic matter sources. However, at the downriver location $\delta^{13}C$ values of BMA are enriched by 3-6 parts per mille, and most consumers follow the BMA pattern.

Upriver where hydrological restoration will have the greatest impact, the overlapping potential sources of organic matter (red mangrove, BMA) appear to be incorporated into resident killifishes, grass shrimp, mud crabs, snook and gray snapper. Upriver both fish and invertebrate data suggest the presence of an unidentified source of organic matter that is much depleted in $\delta^{13}C$ and enriched in $\delta^{15}N$ relative to other producers: this source is hypothesized to be phytoplankton. Phytoplankton appears to be incorporated into pink shrimp, water-column forage fish (silversides), and filter-feeding clams.

Most invertebrates from the upriver site were predictably intermediate in $\delta^{15}N$ values, an indication of a trophic level between plants and fishes. We identified three consumer levels at the upriver location. Low-level consumers included filter-feeding clams and combination detritivorous-herbivorous amphipods and coffee bean snails. Second-level consumers included mud crabs, blue crabs, pink shrimp, grass shrimp and the small killifish, mangrove rivulus. Gray snappers and juvenile and sub-adult snook constituted the top-level consumers. These data providing baseline information on food webs of fringing mangrove forests of Shark River will be useful for post-restoration comparisons.

Contact Information: Carole McIvor, 600 4th Street South, St Petersburg, FL USA 33701, Phone: 727-502-8022, Fax: 727-502-2032, Email: carole_mcivor@usgs.gov

SALTWATER ENCROACHMENT AND PREDICTION OF ECOSYSTEM RESPONSE TO THE ANTHROPOCENE MARINE TRANSGRESSION, SOUTHEAST SALINE EVERGLADES, FLORIDA

John F. Meeder[1], *Randall W. Parkinson*[2], *Peter W. Harlem*[1, 3], *Amy Renshaw*[4] *and Michael S. Ross*[1, 5]

[1]Southeast Environmental Research Center, Florida International University, Miami, FL, USA
[2]Division of Coastal Zone and Watershed Management, Environmental Remediation & Recovery, Inc., Melbourne, FL, USA
[3]GIS-RS Center and Southeast Environmental Research Center, Florida International University, Miami, FL, USA
[4]South Florida Natural Resources Center, National Park Service, Homestead, FL, USA
[5]Southeast Environmental Research Center and Department of Earth and Environment, Florida International University, Miami, FL, USA

Separating the effects of anthropogenic changes in fresh water delivery from that of sea level rise (SLR) on the rate of salt water encroachment (SWE) in the low relief southeast saline Everglades (SESE) is important for understanding how the Anthropocene Marine Transgression (AMT) might be best managed. During the last century, SLR along the SESE coast has been accompanied by SWE, minor inundation, coastal wetland retreat and increased shoreline erosion. However, the rate of SWE in the five basins studied varied by a factor of 14.8 despite being subject to the same rate of SLR. Our results document the rate of SWE is strongly influenced by fresh water management but is controlled in the long-term by SLR. Adequate fresh water delivery to coastal basins lessens SWE by increasing soil accretion rates. Depositional model results suggest that under conditions of diminishing fresh water availability and increasing rate of SLR little can be done at a scale large enough to prevent loss of the SESE within the next 50 to 200 years by coastal erosion, landward migration and ultimately submergence of wetlands, and the export of organic matter into an expanding subtidal environment. Landward migration of wetlands will terminate at the coastal ridge when sea level reaches +1.3 m. Inundation of the SESE will ultimately result in the northward expansion of Florida Bay and westward expansion of Biscayne Bay forming a series of shallow water embayments and hard grounds, respectively.

Contact Information: John Meeder, Florida International University, Southeast Environmental Research Center, 11200 SW 8 St, Miami, FL 33199, United States, Phone: 305-753-0327, Email: jackmeeder@gmail.com

DO NATIVE INTERTIDAL BURROWING CRABS BENEFIT FROM NON-NATIVE *SPARTINA ALTERNIFLORA*?

Yihui Zhang, ***Hanyu Meng,*** *and Xincong Chen*
Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems, College of the Environment and Ecology, Xiamen University, Xiamen, Fujian 361102, China

During the establishment and further spread of invasive species in native ecosystem, the interactions between invasive species and native species will occur. Although the interactions have been extensively investigated in plant and animal communities, the interactions and their mechanisms between invasive *Spartina alterniflora* and native burrowing crabs are largely unknown. *S. alterniflora* is invading the entire Chinese coast, occupying mudflats throughout this range and displacing mangroves in the upper intertidal of southern China. The ecotone between mangroves and *S. alterniflora* provides a useful study system for understanding the interaction between native burrowing crabs and exotic *S. alterniflora*. In this study, we mainly answer 1) whether the invasion of this exotic plant affects native crabs' distribution, and 2) what are the mechanisms that shaped the patterns of crabs' distribution.

We investigated densities of the dominant burrowing crabs *Parasesarma plicata* and *Metaplax longipes* in four habitats of native mangrove forest, mangrove-*Spartina* ecotone, exotic *Spartina* marsh and unvegetated mudflat, in the estuary of the Zhangjiang River, China. The results showed that the densities of *P. plicata* in the mangrove forest, mangrove-*Spartina* ecotone, *Spartina* marsh were significantly greater than those in the mudflat, with no difference between mangrove forest and *Spartina* marsh. On the contrary, the densities of *M. longipes* in the unvegetated mudflat were significantly greater than those in other three habitats. Moreover, more than half of the initial unvegetated mudflat plots were occupied by the rapid expansion of *S. alterniflora* within only one growing season, which resulted in the shift of dominant crabs from *M. longipes* to *P. plicata*. This study indicated that non-native *S. alterniflora* provided compatible habitats for native crab *P. plicata* but not for *M. longipes*.

Additional studies will be conducted to disentangle the roles of the biotic (vegetation, predator, food source) and abiotic (light, temperature, salinity, sediment) factors on the habitat selection of these two crabs. The results of this study might cast light onto coastal wetland biological invasion issues, as well as provide scientific support for restoration and protection of mangroves in China.

Contact Information: Hanyu Meng, College of the Environment and Ecology, Xiamen University, Xiamen, Fujian, China, Email: 33120141151671@stu.xmu.edu.cn

THE BENEFITS OF A MULTIPLE HABITAT RESTORATION STRATEGY BY COMBINING HYDROLOGIC RESTORATION, MANGROVE PROPAGULE PLANTINGS AND OYSTER SUBSTRATE ADDITIONS IN A SEMI-ENCLOSED FLORIDA EMBAYMENT

E.C. Milbrandt[1], *M. Thompson*[1], *L.D. Coen,* [2], *R.E. Grizzle*[3], *K. Ward*[3]

[1]Marine Laboratory, Sanibel-Captiva Conservation Foundation, Sanibel, FL, USA

[2]Florida Atlantic University, Ft. Myers, FL, USA

[3]Jackson Estuarine Lab, University of New Hampshire, Durham, NH, USA

Habitat loss and disturbance are ranked globally as the greatest threats to biodiversity. Development and coastal population growth are the leading causes for habitat losses. Recently, the restoration of marine habitats has increased, especially with the goal of increasing non-consumptive ecosystem services derived from mangrove and submerged aquatic vegetation (SAV) along with biogenic oyster reefs. Habitats reside in landscapes dominated by multiple species. Rather than focusing on a single habitat such as oysters or mangroves or SAV, we took an approach restoring multiple adjacent habitats to accelerate restoration in a Florida embayment that had been significantly degraded prior to the restoration of natural tidally generated flows. After multiple habitats died-off, a project was initiated in 2006 to reintroduce tidal flushing. The re-introduction of tidal flushing, however, did not result in immediate recovery of mangrove shorelines or oyster-dominated reefs. There was a lack of mangrove propagule production and significant substrate limitation in areas with appropriate salinity, sediment and tidal flows. From 2009-2012, red mangrove (Rhizophora mangle) propagules were collected (over 500,000) and planted for a total area of 3.24 hectares. From 2009-2010, five intertidal reefs were constructed by adding bagged and fossil shell (54 MT) for Crassostrea virginica larvae to recruit onto totaling over 779 m2. Monitoring of planted mangrove versus unplanted shorelines demonstrated that prop root and drop root densities were higher where propagules were planted (28 m-2) versus unplanted (2.3 m-2). Oyster densities and mean sizes (multiple year classes) at new and natural reefs were measured after 8, 12, and 24, and 36 months. An initial settlement pulse was observed in the first 8 months followed by an increase in the density of greater than 1-year old oysters. Xanthid crab densities (Eurypanopeus depressus and Panopeus spp.) in restored reefs and natural reefs were similar, while Petrolisthes armatus densities were lower in restored reefs. Whole reef seston filtration rates over restored reefs were -26 to 157 L m-2 hr-1 when measured at 4, 15, 28, and 40 months. A multiple habitat approach may be useful in accelerating the natural ecological succession, especially if the project site has reached a degraded, alternate ecological state. These results suggest a multiple habitat approach can be useful in providing non-provisioning ecosystem services to a Florida embayment.

Contact Information: Eric Milbrandt, Sanibel-Captiva Conservation Foundation, Marine Laboratory, 900A Tarpon Bay Rd., Sanibel, FL 33957, United States, Phone: 239-209-1814, Email: emilbran@sccf.org

LITTORARIA (GASTROPODA: LITTORINIDAE) AS BIOINDICATORS OF MANGROVE HEALTH

Renzo Perissinotto[1], Janine B. Adams[1], Ricky H. Taylor[3], Anusha Rajkaran[2], ***Nelson A. F. Miranda[1]*** *and Nasreen Peer[1]*

[1]Nelson Mandela Metropolitan University, Port Elizabeth, EC, South Africa
[2]University of the Western Cape, Bellville, WC, South Africa
[3]University of Zululand, Richards Bay, KZN, South Africa

Species belonging to the genus *Littoraria* exhibit a mainly tropical distribution and can be commonly found in mangroves of the Indo-Pacific region. These mangrove periwinkles are herbivorous and constitute an important component of mangrove macrobenthic communities. Adults can be found on stems, prop roots and leaves of mangrove trees. Several species, displaying contrasting adaptive variations in shell morphology and colour, can be found in different microhabitats of a mangrove forest.

Littoraria are expected to have strong ecological links with mangroves. Numerous studies have shown that even small changes in the physical environment of mangrove forests affect the diversity and abundance of these and other molluscs. Mangrove periwinkles have also been considered suitable bioindicators of contaminants due to their sensitivity to pollution.

South Africa represents the southern distribution limits of *Littoraria* as well as mangrove tree species in Africa. The mangrove forests can be found in estuaries with varying degrees of anthropogenic influence along the South African coastline. The effects of climate and land use changes on mangrove health have been more thoroughly monitored in recent decades. The occurrence of anthropogenic impacts (e.g. harvesting, trampling, pollution) have also been specifically addressed for mangrove forests.

This study aims to determine if *Littoraria* are suitable bioindicators of mangrove health. South Africa is used as a case study. The current and previously recorded patterns of *Littoraria* abundance, species richness, distribution and size are described within the country. A nested sampling design was used to assess the current spatial patterns of *Littoraria* at the different mangroves along the South African coast. Current data are correlated with recently calculated estuarine and mangrove health indices. Ecological health indices have been developed and systematically applied to South African estuaries. These indices are based on a scoring system which involves expert assessment of biotic and abiotic component variables. Component scores are weighed and aggregated according to standard rules to produce a final score which represents health as a percentage of probable pristine state (i.e. the closer the score is to 100 the heathier the area). Interestingly, some tropical mollusc species have disappeared from South African mangrove forests. This is likely a result of habitat changes due to anthropogenic impacts on mangrove forests rather than climate change. *Littoraria* can be suitable bioindicators as their species richness and abundance are positively correlated estuarine health indices and were also affected by the occurrence of anthropogenic impacts.

Contact Information: Nelson A F Miranda, DST/NRF Research Chair in Shallow Water Ecosystems, Nelson Mandela Metropolitan University, P.O. Box 77000, Port Elizabeth, 6031, South Africa, Phone: +27(0)415042832, Email: mirandanaf@gmail.com

INTERACTIVE EFFECTS OF ENVIRONMENTAL SETTING AND SEEDLING ORIGIN ON MANGROVE ESTABLISHMENT

***Althea F. P. Moore[1]**, Donna Devlin[2], A. Randall Hughes[1] and C. Edward Proffitt[2]*

[1]Northeastern University Marine Science Center, Nahant, MA, USA

[2]Florida Atlantic University Department of Biological Sciences, Harbor Branch Oceanographic Institute, Fort Pierce, FL, USA

The interaction between individual traits and environmental conditions can have strong evolutionary and ecological consequences. Individuals often differ in their plastic responses to environmental conditions depending upon their genetic background and non-genetic factors such as maternal provisioning. Interactions between individual traits and environmental conditions are particularly important for organisms that can disperse over a heterogenous environment. While some populations are adapted to local conditions, maladaptation is also common. We conducted a reciprocal transplant field experiment at two sites in Florida to test whether mangrove seedlings from different sites vary in their response to environmental conditions, and if so, whether this variation was indicative of local adaptation. We also examined whether the mangrove response depended on maternal partitioning (propagule mass).

To determine how seedlings from different source locations respond in common environments, we planted *A. germinans* propagules from 6 source locations into two common garden locations in St. Joseph Bay, FL (Gulf of Mexico) and Indian River Lagoon, FL (Atlantic) in Fall 2012. The St. Joseph Bay site is a salt marsh dominated area at the northern edge of the mangrove range. The Indian River Lagoon site is mangrove dominated and in the middle of the mangrove range in FL. Source locations included two sites from the Gulf of Mexico and four sites from the Atlantic coast. We weighed propagules before planting to account for the effects of maternal partitioning on seedling survival and traits. We determined seedling survival, growth (change in stem height), and morphology (branching and number of leaves) for three years following initial planting.

We found that seedlings differed by source location in their overall traits and response to conditions at the two field experiments. Seedlings tended to survive better at the Indian River Lagoon site but this effect was greater for some source sites than others. We found little evidence for local adaptation as seedlings did not survive or grow better in their home region. Seedlings showed plasticity between the two sites: seedlings grew taller in Indian River Lagoon and had shorter, more branched morphology in St Joseph Bay. Maternal partitioning in terms of propagule size was more important in St. Joseph Bay, yet the importance of this factor decreased over the course of the experiment. Our results highlight the importance of plasticity in mangrove response and suggest that success of range-expanding mangroves will depend on an interaction between source location and local environmental conditions

Contact Information: Althea F. P. Moore, Northeastern University Marine Science Center, 430 Nahant Rd., Nahant, MA, USA 01908, Phone: 781-581-7370, Email: moore.alt@husky.neu.edu

IN SEARCH OF SOIL INDICATORS TO EVALUATE THE IMPACT OF SEA LEVEL RISE -A STUDY FROM SUNDARBAN, INDIA

Chandan Mukherjee[1*], *Rajojit Chowdhury[1], Tapan Sutradhar[1], Sandip Kumar Basak[2], and Krishna Ray[1]*
[1]Environmental Biotechnology Group, Department of Botany, West Bengal State University, Barasat, West Bengal, India
[2]Department of Botany, Kandi Raj College, Kandi, Murshidabad, West Bengal, India

The intertidal mudflats in Sundarban, India are highly vulnerable ecosystems, dynamic with erosion and accretion increasing its instability. The effect of sea level rise and increased inundation is yet to be realized here as the erosion/ accretion seems to be the key factor governing the Sundarban mudflat stability. Characteristically, in Sundarban, the mudflats are densely populated by salt marsh grass Portersia coarctata, the pioneer colonizer grass species that stabilize the accreted load and pave way for mangrove seedling establishment attracting more rapid accretion. The mudflat habitats, already jeopardized in Sundarban, with hinterland ponds for shrimp culture, unrestricted mangrove felling and mudflats used as the ready source of mud for constructing mudbunds, would become the very first victims of global warming and consequent sea level rise. Sea level rise is also expected to extend the hour of submergence. The prolonged waterlogged condition will result in forced anaerobic respiration of recycling microbes that rely on hydrolases and oxidases for their decomposition activity and a slower decay and accumulation of phenolic compounds directly inhibiting microbial biodegradation can be predicted preventing the enzyme phenol oxidase from degrading phenolic compounds, accumulation of which is supposed to slow down the activity of all the major biodegradative hydrolase enzymes.

In our study concentrating on soil biochemistry of different study sites including degraded and non-degraded pristine forests of western part of Indian Sundarban, we endeavor to establish soil biochemical markers that can serve as indicator of soil anaerobicity and its effect on nutrient cycling by soil microbes. We have analyzed the soils of a large number of flooded mangrove swamps and fairly aerated mangrove swamps in terms of soil nutrients, soil sulfide, soil microbial enzyme activity and nutrient cycling microbial density across the western part of Indian Sundarban and compared the results. We conclude on the level of anaerobic condition prevailing at present in the referred zone of Indian Sundarbans.

Contact Information: Chandan Mukherjee, West Bengal State University, Environmental Biotechnology Group, Department of Botany, Berunanpukuria, Malikapur, Barasat, Kolkata, West Bengal, 700126, India, Phone: 919007386867,
Email: chandanmukherjee414@gmail.com

MANAGING TERRESTRIAL CARBON STOCKS THROUGH A LONG-TERM LOGGING ROTATION IN MANGROVE FORESTS IN BINTUNI BAY, WEST PAPUA

Daniel Murdiyarso[1,2], *Sigit D Sasmito[1,3], Meriadec Silanpaa[4], and Sartji Taberima[5]*

[1]Center for International Forestry Research, Bogor 16115, Indonesia
[2]Department of Geophysics and Meteorology, Bogor Agricultural University, Bogor 16680, Indonesia
[3]Research Institute for the Environment and Livelihoods (RIEL), Charles Darwin University, Darwin, NT 0810, Australia
[4]Green Forest Product and Tech, Singapore
[5]University of Papua, Manokwari 98314, Indonesia

Bintuni Bay is Indonesia's largest single block of mangroves in the archipelago, covering an area of 239,000 ha. Almost half of these areas are protected and the other half was logged since almost 30 years ago. We assessed and compared the ecosystem carbon (C) stocks in northern part of the Bay, which is categorized as Protection Forests and the southern part of the Bay, which has been systematically logged for timber and woodchip products over the past 25 years. The so-called "keyhole" logging technique was implemented allowing the construction of a one-hectare circle shape plot for clear felling, which is connected with a 25 m long narrow passage for skidding the cut logs to the river system. It was demonstrated that the protected forest stored 1,397±85 Mg C ha^{-1} and very close to the storage in the stand of 25 years after logging (1,359±367 Mg C ha^{-1}). Meanwhile, the C stocks in aboveground stands of 5, 15 and 25 years after logging were 71±13, 54±12, and 138±18 Mg C ha^{-1} respectively. These aboveground C stocks in logged forests are considerably lower than the one stored in pristine forests (324±85 Mg C ha^{-1}). However, soil C stock in these stands vary between 634±120 Mg C ha^{-1} (in 5 years after logging stands) and 1,296±37 Mg C ha^{-1} (in 15 years after logging stands). The logging technique clearly demonstrates the preservation of belowground C stocks. *Rhizophora apiculata* dominates the logged-over areas due to the abundance of propagules from remained seed-tress, and dense recruit was resulted, giving high aboveground C stocks in the first five years. As the stands getting older, natural mortality and declining C stocks were observed and reached their climax before the following cutting cycle takes place. Our findings suggest that ecosystem mangrove C storages could be maintained through rotational aboveground removal system and belowground soil protection.

Contact Information: Daniel Murdiyarso, Center for International Forestry Research, Bogor 16115, Indonesia,
Phone: +62 251 8622622, Email: d.murdiyarso@cgiar.org

RANGE-EDGE FECUNDITY OF A RANGE-EXPANDING SPECIES, THE BLACK MANGROVE (AVICENNIA GERMINANS)

Daniel Gruner, and ***Mayda Nathan***
University of Maryland, College Park, MD, USA

Climate change is currently altering species' distributions. The speed with which range-shifting plant species respond to climate change will depend on dispersal distances and reproductive rates of populations near the range edge. For a range-expanding plant like the black mangrove, *Avicennia germinans* (Avicenniaceae), in Florida, USA, whose distribution is limited by sensitivity to freezing temperatures, spatial variation in reproduction can facilitate or hinder the rate of expansion as temperatures warm. Pinpointing the nature of this spatial variation requires investigating plant reproduction at both the individual- and population levels. In this study, we sought to characterize the spatial variation in *A. germinans* fecundity along a gradient from the expanding northern range edge toward the range interior, in order to clarify the role that reproduction is playing in this species' range expansion. Over the summer and fall of 2015, at seven sites throughout the eastern Florida *A. germinans* distribution, we measured *A. germinans* density, height, flower production, fruit set rates, propagule production, and propagule size. Our results show that despite lower fruit set rates and small tree sizes, *A. germinans* maintains high per-tree fecundity in populations at the range edge due to increased flowering there. When variation in reproductive tree density is accounted for, population-level fecundity actually increases toward the range edge, relative to more southern sites. Moreover, propagules produced in edge populations were approximately 30% larger, on average, than propagules produced in the southernmost populations studied. Taken together, these results suggest that the region of peak *A. germinans* propagule production is shifting north with the expanding range edge, promoting the spread of this species.

Contact Information: Ms Mayda Nathan, University of Maryland, 4112 Plant Sciences Bldg., College Park, MD 20742, United States, Phone: 603-727-8321, Email: mnathan@umd.edu

CONTRASTING EFFECTS OF HISTORICAL SEA LEVEL RISE AND CONTEMPORARY OCEAN CURRENTS ON REGIONAL GENE FLOW OF *RHIZOPHORA RACEMOSA* IN EASTERN ATLANTIC MANGROVES

*Ludwig Triest[1], Nico Koedam[1], **Magdalene N. Ngeve[1]**, Tom Van der Stocken[1], Dimitris Menemenlis[2]*

[1] Laboratory of Plant Biology and Nature Management (APNA), Department of Biology, Vrije Universiteit Brussel (VUB), Pleinlaan 2, B-1050 Brussels, Belgium

[2] Earth Sciences Division, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA

Mangroves are seafaring taxa through their hydrochorous propagules that have the potential to disperse over long distances. Therefore, investigating their patterns of gene flow provides insights on the underlying processes involved in the spatial genetic structuring of populations. The coastline of Cameroon has a particular geomorphological history and a coastal hydrology with complex contemporary patterns of ocean currents. We hypothesize that these have effects on the spatial configuration and composition of present-day mangroves within its spans.

We investigated genetic diversity and structure of a widespread species in the region, *Rhizophora racemosa*, and genotyped 982 individuals from 33 transects (11 sites) across 4 estuaries, using 11 polymorphic SSR markers. Genetic diversity appeared low to moderate but genetic differentiation between nearly all population pairs was significant. Bayesian clustering analysis, PCoA, estimates of contemporary migration rates and identification of barriers to gene flow were complemented with estimated dispersal trajectories of hourly released numerical propagules using high-resolution surface current from a mesoscale and tide-resolving ocean simulation.

The results indicate that the Cameroon Volcanic Line (CVL) is not a present-day barrier to gene flow. Rather, the Inter-Bioko-Cameroon (IBC) corridor, formed due to sea level rise, allows for connectivity between two mangrove areas that were isolated during glacial times by the CVL. Both genetic data and numerical ocean simulations were congruent and indicated that an oceanic convergence zone near the Cameroon Estuary complex (CEC) presents a strong barrier to gene flow, resulting in genetic discontinuities between the mangrove areas on either side. This convergence however did not result in higher genetic diversities at the CEC as could be hypothesized, likely due to the westward jets formed by ocean currents which push propagules to the open ocean rather than to suitable intertidal habitats were they can strand.

In conclusion, the genetic structure of *Rhizophora racemosa* is influenced by the contrasting effects of the contemporary oceanic convergence and historical climate change-induced sea level rise.

Contact information: Magdalene N. Ngeve, Laboratory of Plant Biology and Nature Management (APNA), Department of Biology, Vrije Universiteit Brussel (VUB), Pleinlaan 2, B-1050 Brussels, Belgium, Email: ngevem@yahoo.com or magdale@vub.ac.be s

EFFECTS OF ENVIRONMENTAL CHANGE ON MANGROVE BIODIVERSITY, COMMUNITY DYNAMICS AND ECOSYSTEM FUNCTIONS IN JAVA, INDONESIA

Inga Nordhaus[1], *Ann-Kathrin Seiz*[1,2], *Tania E. Romero G.*[1,2], *Shannon Rose*[1,2], *and Marijana Toben*[1,3]

[1]Leibniz Center for Tropical Marine Ecology (ZMT), Bremen, Germany

[2]University of Bremen, Bremen, Germany

[3]Carl von Ossietzky University, Oldenburg, Germany

Essential functions of mangrove forests may depend on particular tree or macrobenthic species. For instance, crabs and gastropods enhance carbon storage and nutrient cycling through feeding and burrowing. Since data on the functional structure and diversity of benthic communities and their response to environmental change are scarce, consequences for the ecosystem are largely unknown. Forest degradation can cause changes in community structure and a decline in species numbers which can lead to a loss in functional diversity and redundancy.

Indonesia has the largest area and the highest tree species richness but also one of the highest loss rates of mangroves worldwide. We investigated the response of macrobenthic communities to human-driven environmental change in the Segara Anakan Lagoon between 2005 and 2015. The lagoon is a mangrove-fringed estuarine system in Java that is largely affected by deforestation. The study combined a taxonomic diversity analysis with a functional traits analysis. Behavioural, life history and morphological characteristics were used to define functional groups. Species-specific trait data were gained through laboratory experiments, field studies, and literature research. Macrobenthic communities were determined in mixed mangrove stands and deforested areas which are overgrown by understorey plants.

We found a high species richness but a low biomass of benthic invertebrates compared to other Indo-West Pacific mangrove forests. A comparison of mixed mangrove and deforested sites showed that the crab communities have a similar number of species but differ in taxonomic composition and functional structure. Functional diversity (Rao´s Quadratic Entropy) was similar in both areas, but functional redundancy was significantly higher in the mixed mangrove sites, suggesting that habitat degradation has a detrimental effect on ecosystem functioning in the long-term. Some functional groups are only represented by a few species. The communities were dominated by small burrowing, opportunistic species with a short life span, whereas long-lived and large species were rare. Due to their small sizes crabs have very shallow burrows. This is likely to affect nutrient cycling and sediment oxygenation.

Abundances of facultative litter feeders increased significantly between 2005 and 2015, indicating their low vulnerability to vegetation changes. By contrast, abundances of species with other feeding modes decreased considerably. Overall, 51 crab species were recorded in 2005 of which 13 rare species were not found in 2015. The shift in taxonomic and functional community structure appears to be a response to a significant decline in tree density, a further spread of understorey plants and a decreasing habitat complexity.

Contact Information: Inga Nordhaus, Leibniz Center for Tropical Marine Ecology (ZMT), Fahrenheitstraße 6, 28359 Bremen, Germany, Phone: +49 421 2380074, Email: inga.nordhaus@leibniz-zmt.de

THE DETECTION OF DISTURBANCE IN THE SOUTHEAST SALINE EVERGLADES AND ITS RELATIONSHIP TO MANGROVE FOREST TRANSGRESSION

***Danielle E. Ogurcak*[1]*, Michael S. Ross*[1,2]*, Keqi Zhang*[2,3]*, and Jack Meeder*[1]**

[1]Southeast Environmental Research Center, Florida International University, Miami, FL, USA
[2]Department of Earth and Environment, Florida International University, Miami, FL, USA
[3]International Hurricane Research Center, Florida International University, Miami, FL, USA

The landward movement of low productivity dwarf mangrove forests into areas of freshwater marsh dominated by *Cladium jamaicense* has been documented in the Southeast Saline Everglades (SESE) of Florida during the second half of the 20thcentury, beginning with Egler's description of the 'white zone' in 1952. This landward movement has been attributed to the combined effects of 20th century sea level rise and reduction in fresh-water deliveries on vegetation and soil development in this region. Given the predicted increases in sea level rise for the 21st century, the rate of transgression and landward movement of communities are likely to increase. However, episodic disturbances in the form of hurricane storm surge or freeze events could lead to changes in the mangrove communities that may hasten these effects in some locales (storm surges that carry propagules landward) while staving off the effects in others (mangrove die-off).

The availability of legacy datasets in the form of satellite imagery permits the assessment of spatially-explicit effects of disturbances on mangrove communities that can be differentiated from seasonal and decadal trends in plant stress and community composition. Using a 27-year temporal sequence of Landsat TM 4-5 images from 1985 to 2011, we assessed trends in two spectral indices, the Normalized Differenced Vegetation Index (NDVI) and the Normalized Differenced Moisture Index (NDMI), and determined that NDMI performed best in identifying effects from episodic disturbances and capturing recovery trends. A present day land cover map of the region was derived from a combination of high-resolution satellite imagery and aerial photography (Digital Ortho Photo Quads). This permitted a comparison between an ongoing study and a 1995 study that assessed historical changes in the distribution of these vegetation zones. Since the 1995 survey, mangroves have moved landward in places, but in others the freshwater vegetation has been more resistant to change. This work provides a glimpse of the possible interactions between the ongoing press of sea level rise and episodic pulse disturbances, with implications for management of the SESE, enabling managers to target localized areas in need of immediate intervention. This research highlights the importance of adequate freshwater inputs to the region to ensure that the complex of freshwater to saline vegetation communities is maintained in the SESE for as long as possible.

Contact Information: Danielle Ogurcak, Florida International University, 11200 SW 8th Street, Miami, FL , USA 33199, Phone: 305-348-1658, Email: dogurcak@fiu.edu

CARBON BIOGEOCHEMICAL PROCESSES ALONG A MANGROVE-SALTMARSH ECOTONE

***Todd Z. Osborne*[1,2], *Lorae T. Simpson*[1,2,3], *Tracey B. Schafer*[1,2], *Monica Camacho*[1,4], *and Francesco Lane*[1]**

[1]Whitney Laboratory for Marine Bioscience, University of Florida, St. Augustine, FL USA
[2]Soil and Water Science Department, University of Florida, Gainesville, FL USA
[3]Smithsonian Marine Station, Ft. Pierce, FL USA
[4]Environemntal Engineering Department, University of Florida, Gainesville, FL USA

Over the last several decades, winter freeze events in northeast Florida have declined significantly resulting in the northward advancement of black mangrove (*Avicennia germinans*) and red mangrove (*Rhizophora mangle*) communities into more temperate cordgrass (*Spartina alterniflora*) dominated saltmarsh ecosystems. As organic carbon cycling processes are inexorably linked to ecosystem structure and function, we investigated the changes in organic carbon biogeochemical cycling along the mangrove to saltmarsh ecotone. As one foundational vegetation species is replaced by another of significantly different morphological and physiological character, the changes in carbon processes such as primary production, decomposition, and soil based carbon sequestration are expected to change also. We investigated primary production, seasonality of litter fall, decomposition, and soil carbon processes to evaluate potential changes to the carbon cycling induced by shifts in dominant vegetation. Results suggest that primary productivity and timing of liter fall change significantly among competing species and that liter quality and decomposition dynamics are dramatically altered under mangroves versus cordgrass. Implications of these changes of organic carbon biogeochemistry is wide ranging with respect to food web structure and ecosystem function.

Contact Information: Todd Osborne, University of Florida, Whitney Laboratory for Marine Bioscience, 9505 Ocean Shore Blvd St. Augustine, FL 32080, United States, Phone: 904-461-4047, Email: osbornet@ufl.edu

CLIMATE CHANGE AND THE GLOBAL DISTRIBUTION OF MANGROVE FORESTS

Michael J. Osland[1]*, Laura C. Hundy*[2]*, Kereen T. Griffith*[3]*, Kyle C. Cavanaugh*[4]*, Nicholas M. Enwright*[1]*, Richard H. Day*[1]*, Camille L. Stagg*[1]*, Ken W. Krauss*[1]*, and Rebecca J. Howard*[1]

[1]U.S. Geological Survey, Lafayette, LA, USA
[2]Hundy Consulting Services at U.S. Geological Survey, Lafayette, LA, USA
[3]Griffith Consulting Services at U.S. Geological Survey, Lafayette, LA, USA
[4]University of California, Los Angeles, Los Angeles, CA, USA

In the 21st century, climate change is expected to greatly alter the global distribution of mangrove forests. Warmer temperatures are expected to prompt the poleward migration of mangroves at the expense of salt marshes. Within arid and semi-arid estuaries, altered rainfall regimes are expected to lead to oscillations in mangrove coverage. Ecologists have long been aware of the influence of macroclimatic drivers (for example, temperature and rainfall regimes) upon the distribution of mangrove forests. However, the absence of suitable climate and coastal wetland data has constrained the quantification of these linkages at the global scale. Here, we used the best available data to quantify the role of macroclimatic drivers in controlling the distribution of mangrove forests. Along coasts that span tropical-to-temperate transition zones (for example, Australia and New Zealand, East Asia, South Africa, Eastern North America), we identified and compared minimum temperature-based ecological thresholds that characterize the transition zones between mangroves and salt marshes. Along coasts that span arid-humid gradients (for example, West Africa, Western South America, West Australia, Middle East), we quantified rainfall-based ecological thresholds that characterize the transition zones between mangroves and salt flats. Finally, we used these climate-coastal wetland linkages to evaluate potential changes in distribution under alternative future climate change scenarios. Collectively, our analyses quantify and compare important climate-driven ecological thresholds and better elucidate the influence of macroclimatic drivers upon the global distribution of mangrove forests. Such information is useful for better understanding the current distribution of mangrove forests as well as for preparing for the effects of climate change.

Contact Information: Michael Osland, U.S. Geological Survey, Wetland and Aquatic Research Center, Lafayette, LA, USA 70506, Phone: 337-266-8664, Email: mosland@usgs.gov

MODELING THE LINKED DISTRIBUTION OF MANGROVES AND ASSOCIATED EPIFAUNAL POPULATIONS IN A COASTAL LAGOON

John Hamilton[1] *and* ***Richard Osman***[2]
[1]University of Connecticut, Groton, CT, USA
[2]Smithsonian Environmental Research Center, Edgewater, MD, USA

The rates of spread of mangrove and associated epifauna were modeled for the Indian River Lagoon, Florida. The individual-based model divided the 150 km long lagoon into 157,330, 100-by-100 m cells and used current velocities generated from a separate hydrodynamic model. Data from the hydrodynamic model were used to generate current vectors for each cell at 10 minute intervals. Each cell was assigned a habitat type, and release or recruitment of mangrove propagules or epifauna larvae were based on the suitability of these habitats. Multiple species were included in the model, each with its own life-history parameters. Released larvae and propagules were followed until mortality or recruitment and any recruits were followed through juvenile and adult life stages or until mortality. Individuals that survived until adulthood could reproduce and release new larvae or propagules. This model was used to examine the rate of spread of species from various founding populations, the dependency of population sizes on habitat type, the impact of the introduction of anthropogenic habitat (docks, jetties) as an alternate habitat for epifauna, and the effects of disturbances such as freezing on population sizes and recovery rates. A primary goal was to examine and predict potential impacts on the expansion of mangroves with climate change.

Contact Information: John Hamilton, Department of Marine Sciences, University of Connecticut, 1080 Shennecossett Road, Groton, CT 06340, Phone: 860-405-9155, Email: john.hamilton@uconn.edu

THE USE OF MANGROVE WOOD PRODUCTS AROUND THE COLOMBIAN PACIFIC AMONGST SUBSISTENCE AND COMMERCIAL USERS

***Martha Lucia Palacios*[1]** *and Jaime Cantera*[2]

[1]Universidad Autónoma de Occidente, Departamento de Ciencias Ambientales

[2]Universidad del Valle, Departamento de Biología, A.A. 25360, Cali – ColombiaMartha Palacios

Colombian Pacific comprises mangrove forests and other marine resources that are of economic, ecological, and environmental importance to the local communities. In total 400 households (about 30% of the population), were interviewed to assess the human reliance on mangrove resources in Malaga (Juanchaco, Ladrilleros) and Buenaventura (Pianguita, La Bocana) Bay. The survey indicates that mangroves are an important source of wood for building houses and as under use mangrove products include materials for fuel. *Mora oleifera* (Nato) is the main source of piles for bridges, housing construction, beams, columns and floors. *Rhizophora mangle*, *Laguncularia racemosa* and *Avicenia germinas* are the main sources for fuel. The interview further described harvesting activities and construction of houses species revealing preferences for this particular case. As a result of resource destruction and pollution, has been equally affected shellfish harvesting as piangua (*Anadara similis* and *Anadara tuberculosa*). We believe that local use patterns will require more comprehensive data to establish a mangrove conservation policy and requirements for subsistence users.

Contact Information: Martha Lucia Palacios, Universidad Autonoma de Occidente, Departamento de Ciencias Ambientales, Cali – Colombia, Phone: 318800 ext 11399, Email: mlpalacios@uao.edu.co

WHAT CONTROLS POLEWARD RANGE LIMITS OF MANGROVES?

John Devaney, Candy Feller, and ***John D. Parker***
Smithsonian Environmental Research Center, Edgewater, MD, USA

Understanding the processes that limit the geographic ranges of species is one of the central goals of ecology and biogeography. This issue has become particularly important given that climate change, habitat loss, and biological invasions are altering the range and abundance of species worldwide. For example, temperate and tropical plants and animals are moving poleward in response to global warming, displacing native species, altering biodiversity patterns, and impacting ecosystem structure and function, i.e., 'the tropicalization of the temperate zone'. Mangrove forests represent an ideal system for testing the mechanisms driving this tropicalization because mangroves are globally distributed and their poleward range limits span a large gradient in abotic and biotic factors that control birth, death, and immigration rates.

Here, we report on the results of laboratory experiments investigating the individual and interactive impacts of abiotic drivers on propagule survival, growth, and physiology for two mangrove species: black mangroves *Avicennia germinans* and red mangroves *Rhizophora mangle*. These species represent the most poleward mangrove species in the New World, and the most broadly distributed and poleward genera in the Old World. We experimentally imposed different treatment regimes of water salinity and temperature, freezing air temperatures, and humidity levels, and measured the species and population-specific resistance and resilience of mangroves over a six-month period. To investigate the physiological mechanisms driving these impacts, we also measured photosynthetic assimilation rates, stomatal conductance, trichome density, and other water saving adaptations that might vary across species and populations.

For both red and black mangroves, we found dramatic and interactive effects of aridity (e.g., humidity) and water salinity on mangrove performance. Survival and growth was highest in high humidity and low water salinity, and lowest in low humidity and high salinity. Freezing air temperatures also influenced these interactions. For black mangroves, we found strong population-level variation in response to altered humidity levels. Populations from chronically-stressed regions performed better in every treatment regime compared to populations from regions with moderate temperature and rainfall.

Overall, we found that multiple abiotic drivers interact to affect mangrove propagule performance, and that response to these drivers varies across both species and populations. Thus, our results suggest that modeling of future mangrove range limits in response to climate change needs to be conducted at the species-level and incorporate the interactive effects of multiple drivers and the potential for adaptive evolution in range edge populations.

Contact Information: John D. Parker, Smithsonian Environmental Research Center, Edgewater, MD, USA, Phone: 443-482-2221, Email: parkerj@si.edu

INVESTIGATING THE RESILIENCE OF MANGROVE ECOSYSTEMS AND FIDDLER CRABS IN SOUTH AFRICA

Renzo Perissinotto[1], Janine B Adams[1], Ricky H Taylor[2], Anusha Rajkaran[3], Nelson AF Miranda[1], ***Nasreen Peer[1]****, and Jacqueline L Raw[1]*

[1]Nelson Mandela Metropolitan University, Port Elizabeth, South Africa
[2] University of Zululand, Richards Bay, South Africa
[3]University of the Western Cape, Cape Town, South Africa

Mangrove ecosystems appear to be quite resilient and are predicted to survive environmental change in the foreseeable future. However, do mangrove-associated fauna also exhibit resilience to temperature shifts, changes in hydrodynamics, and anthropogenic activity? This study aimed to provide a re-assessment of South African mangroves in terms of population dynamics, macrobenthic diversity, and abundance for comparison with past records. Furthermore, as fiddler crabs are key mangrove components, we assessed aspects of their ecology under unprecedented environmental disturbances.

The last report outlining the general trends of floral and faunal distribution in South African mangroves was compiled by Macnae in 1963. Following recent surveys of South African mangroves, we found that along with a poleward expansion of mangrove vegetation a few associated fauna displayed an increase in distribution, including poleward shifts as predicted to occur globally with a shifting climate. Similarities between Macnae's results and ours include the distinct grouping of the subtropical and temperate mangrove systems as seen by the distinct types of diversity in each group.

The St Lucia Estuary is largely closed off to the ocean and as a result the mangrove ecosystems in this estuary experience virtually no tidal action. We used *In situ* feeding experiments and video footage to determine feeding patterns and a series of controlled laboratory experiments to assess the survival of *U. annulipes* larvae under the unique environmental conditions experienced during retention within this mangrove system. We found that under non-tidal conditions feeding behaviour varied seasonally, diurnally and between sexes. *Uca annulipes* had an impact of up to 10.73% on standing MPB stocks in the summer. This is particularly significant when considering the lack of tide available for replenishment of these stocks. Although adults appear to be largely resilient, a non-tidal mangrove habitat may not be conducive to successful reproduction as larvae are unable to withstand non-marine salinity levels experienced during retention. The persistence of fiddler crabs here despite the disruption to their life cycle is largely dependent on nearby refuge populations which may be fundamental to the resilience of this particular system.

In a global sense, the unique mangrove habitats in South Africa provide a great opportunity to examine the response of these key species to global shifts in climate and environmental consequences such as non-tidal habitats, sea level rise, and rising temperatures. Mangrove macrobenthos, particularly true crabs, are resilient to many changes. Resilient species maintain ecosystem function despite environmental change. Perhaps the key to conserving ecosystems is to focus on the conservation of resilient species within these ecosystems. In this case, the conservation of key mangrove fauna should be a priority in South Africa to ensure the continued resilience and preservation of mangrove habitats in the future.

Contact information: Nasreen Peer, Nelson Mandela Metropolitan University Department of Zoology, Summerstrand South Campus, Port Elizabeth 6031, South Africa, Email: peer.nasreen@gmail.com

PHOTOSYNTHETIC PERFORMANCE OF MANGROVE SPECIES IN RESPONSE TO VARYING SALINITY

Enrique Peña [1], *Diego Morales* [1], *Jaime Cantera* [1], *and Martha Lucia Palacios* [2]

[1]Universidad del Valle, Departamento de Biología

[2]Universidad Autónoma de Occidente. Departamento de Ciencias Ambientales, Cali - Colombia

We determined the relationship between leaf gas exchange characteristics and salinity of the mangrove species *Rhizophora mangle* L, and *Mora oleifera*. Assimilation–light response curves indicated that the diurnal salinity changes in the estuary have significant effect on the photosynthetic performance of both species. However, short-term tidal flooding caused a 20% reduction in maximum leaf-level carbon assimilation rate. Although differences were evident between species for mostly all measured photosynthetic parameters in both species, there was little consistency of those physiological responses between stations. There were no significant effect or slight enhancement of carbon assimilation. We obtained little evidence that contrasting salinities affect leaf gas exchange characteristics of mangrove seedlings or saplings over long time intervals. However, tidal changes of salinity may cause short-term depressions in leaf gas exchange. The adaptation of mangrove plants to salinity will likely reveal photosynthetic and morphological adjustment to hydrological conditions of the estuary.

Contact Information: Enrique Peña, Universidad del Valle, Biologia, Calle 13 No. 100 – 00, Cali, Valle del Cauca, 760030, Colombia, Phone: 32121003227, Email: enrique.pena@correounivalle.edu.co

RESPONSES OF GROWTH, INTERACTIONS BETWEEN MANGROVES AND *SPARTINA ALTERNIFLORA* ACROSS TIDAL ELEVATION GRADIENT

Yihui Zhang, and ***Dan Peng***

Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems, College of the Environment and Ecology, Xiamen University, Xiamen, Fujian 361102, China

Intertidal mangrove forests occur on tropical and subtropical shorelines, and provide a wide range of ecosystem services, including the support of fisheries and coastal protection. Invasive plant of *Spartina alterniflora*, gradually being the dominant macrophyte in southern coast of China, changed the structure and function of native coastal wetland ecosystems. *Sonneratia apetala,* introduced in 1985 from Bangladesh, because of its higher survival and growth rate over native mangroves, has been used for restoration or affoestation in China. With its successful encroachment in many new habitats and high tolerance to environmental stresses, the potential invasiveness of the exotic *S. apetala* has attracted increasing concerns. In mangrove-salt marsh ecotone, plant interactions have important roles in determining the structure and composition of vegetations. Biotic interactions between species are environment-dependent, especially vary across tidal elevation gradient. In Zhangjiang Estuary, the invasion of *S. alterniflora* has significantly influenced the growth and regeneration of native mangroves in recent two decades. Successively, *S. apetala* has naturally diffused into intertidal zones of this area within 3-4 years, but the interactions between exotic *S. apetala* and invasive *S. alterniflora* is unclear.

To investigate the growth and interactions between invasive-native (*S. alterniflora, Kandelia obovata*), and invasive-exotic (*S. alterniflora*, *S. apetala*) along different tide gradient, we used 'marsh organ' to experimentally manipulate the elevation tidal gradient and conducted with or without competition from *S. alterniflora* in the Zhangjiang Estuary. The results showed that both native and exotic mangrove seedlings performed well at middle tidal habitat, but grew and survived poorly in high- and low-marsh habitats. *S. alterniflora* suppressed the growth of both native and exotic mangrove seedlings along all elevation gradients during the early establishment stage. Multi-years of transplant experiments showed that native *K. obovata* was persistently suppressed by *S. alterniflora* and had low growth rate and survival. In contrast, exotic *S.apetala* grew rapidly, with taller of *S.apetala* plants than their *S. alterniflora* neighbors within one growing season. These indicated that the effect of *S. alterniflora* on *S. apetala* may switched from negative (based on relative interaction intensity) to neutral on *S. apetala,* but maintained negative on *K. obovata.* We speculated that abiotic stress from extreme low or high inundation frequency by tide will decide the distribution of intertidal mangrove and salt marsh species along intertidal zones, and the plant-plant interactions will shape the vegetation patterns in middle tidal zone, where native mangroves may be replaced by *S. alterniflora* and exotic *S. apetala* in the future.

Contact Information: Dan Peng, College of the Environment and Ecology, Xiamen University, Xiamen, Fujian, China, Email: 33120141151673@stu.xmu.edu.cn

REDUCED PREDATION RISK DRIVES THE DISTRIBUTION PATTERNS OF TWO PULMONATE GASTROPODS IN A MANGROVE-SALTMARSH TRANSITIONAL HABITAT

***Yisheng Peng*[1,2,3], *Shing Yip Lee*[1], *and Min Zhang*[1,4]**

[1]School of Environment, Griffith University Gold Coast campus, Queensland 4222, Australia

[2]School of Environmental Science and Engineering / Research Center of Wetland Science, Sun Yat-Sen University, Guangzhou 510275, China

[3]Guangdong Provincial Key Laboratory of Environmental Pollution Control and Remediation Technology, Sun Yat-Sen University, Guangzhou 510275, China

[4]Guangdong Institute of Applied Biological Resources, Guangzhou 510260, China

The pulmonates, *Phallomedusa solida* and *Ophicardelus ornatus*, exhibit typical distribution patterns in estuarine mangrove and saltmarsh habitats on the east Australian coast. Past studies suggested inundation condition, soil salinity, and vegetation coverage were responsible for these patterns. In this study, the role of environmental parameters, food availability, physical stress and predation pressure in determining the distributional patterns of these gastropods was evaluated along transects spanning saltmarsh, mangrove, and ecotone habitats. For both species, the maximum population abundance occurred in saltmarsh or the ecotone between mangrove and saltmarsh as 392.5 and 347.5 ind. m^{-1}, respectively. In terms of environmental parameters (surface temperature, sediment salinity, moisture content) and food availability (organic content, and microphytobenthos abundance), mangrove was evaluated as the optimal habitat for the pulmonates. However, laboratory experiments revealed the oxygen intake of pulmonates when submerged dropped abruptly to 4.3-9.0% of aerial rates. Furthermore, the visiting frequency of predators (Yellowfin bream *Acanthopagrus australis* and toadfishes, Tetraodontidae) was 3.1-5.7 times higher in mangrove compared to those in the ecotone and upper saltmarsh. Underwater video recording also suggested high mortality of these gastropods as 29.4-84.4% resulting from the predators visiting the mangrove habitat during high tides. Despite the abiotic factors facilitating the distribution of the pulmonates in mangrove, the higher predation risk restricted the occurrence of *P. solida* and *O. ornatus* in mangrove areas. The results suggest that the distribution pattern of these pulmonates is a comprehensive outcome from environmental factors and species-specific interaction with predators.

Contact information: Yisheng Peng, School of Environmental Science and Engineering, Sun Yat-Sen University, No. 135, Western Xingang Road, Guangzhou 510275, China. Phone: +86-13539889410; Email: pyish@mail.sysu.edu.cn

VEGETATION REGIME SHIFT IN COASTAL WETLANDS AFFECTS TRAPPING OF WRACK SUBSIDIES FROM SUBTIDAL HABITATS

***Steven C. Pennings[1]**, Hongyu Guo[1], Sayatani Dastidar[1], Zoe Hughes[1], Anna R. Armitage[2], Carolyn A. Weaver[2], Ashley Whitt[2], Sean P. Charles[3], and John S. Kominoski[3]*

[1]Department of Biology and Biochemistry, University of Houston, Houston TX, USA
[2]Department of Marine Biology, Texas A&M University at Galveston, Galveston TX, USA
[3]Florida International University, Miami, FL, USA

Mangrove vegetation is spreading to higher latitudes due to global warming, with mangroves now invading locations previously dominated by salt marsh vegetation. This constitutes a striking regime shift from grass and forb-dominated habitats to taller, woody vegetation. We studied how this regime shift affects trapping of wrack in a Texas coastal wetland. In 2012, we experimentally created ten 24 x 42 m plots that vary in nominal mangrove cover from 0 to 100 percent by thinning mangroves on Harbor Island, near Port Aransas. Marsh vegetation colonized areas where mangroves had been removed. Starting in 2014, we used these plots to study how mangrove density affects trapping of marine wrack. At this site, wrack biomass is dominated by brown and red seaweeds and seagrasses. In plots with lower mangrove cover, wrack is transported by waves throughout most of the plot. In contrast, in plots with higher mangrove cover, almost all of the wrack is trapped by mangroves in the first 4 meters of the plot closest to the waterline. We are testing the hypotheses that these different patterns of wrack transport affect geomorphology (wrack trapping in the front of the plot promotes development of a levee), soil characteristics (wrack provides organic matter to sandy soils), plant nutrition (wrack fertilizes plants) and invertebrate communities (wrack supports a detritivore community dominated by amphipods and insects). In sum, we hypothesize that mangrove invasion makes coastal wetlands less permeable to wrack, and therefore concentrates wrack-mediated processes at the front edge of the wetland.

Contact Information: Dr. Steven Pennings, University of Houston, Department of Biology and Biochemistry, 3455 Cullen Blvd, Houston, TX 77204, United States, Phone: 713-743-2666, Email: spennings@uh.edu

AN INVESTIGATION INTO SOCIAL LEARNING DYNAMICS AND CONVERSION TO SUSTAINABLE INTEGRATED MANGROVE SHRIMP FARMING IN BINH DAI DISTRICT, BEN TRE PROVINCE, VIETNAM

Nguyen Thi Huynh Phuong*[1]*, *Romina Rodela[2], Roel H.Bosma[2], Arnold K.Bregt[2], Tran Thi Phung Ha[1], Tong Quoc Hiep[1], Michiel Oliemans[2]*

[1] Can Tho University, Ninh Kieu district, Can Tho city, Vietnam

[2] Wageningen University and Research Center, 6700 AH Wageningen, The Netherlands

In the Mekong Delta, the coastal area covered by mangrove forest has reduced quickly. For example, in 2000 in Ben Tre province, the area of mangrove forests was 8,593 ha, whereas in 2010 it was 4,202 ha. The importance of the tropical mangrove forest ecosystems for the coastal protection are considered in some districts, in others the mangrove are enclosed by dikes and thus contribute little to the ecosystems service relating to coastal protection and biodiversity. In order to realize these functions, some of the Mekong's government services supported by NGOs and donors, battle for the maintenance or expansion of the area covered by mangrove. Therefore, one of the policy recommendations from the Government is to promote mixed mangrove-shrimp systems in which farmers need to maintain at least 40% of their area covered by mangroves. Since 2012, the reforestation, care and protection of mangrove depend on projects of local authority that help the area of mangrove forest in Ben Tre has increased.

Many studies addressed the status, and changes of mangrove forest in Ben Tre and other coastal provinces in the Mekong Delta, but no research has sought to disclose the role of social dynamics in farmers' willingness to build or maintain Integrated Mangrove Shrimp systems. Specifically, the influence of information, group dynamics and social learning on decision-making of farmers is not well understood and hardly investigated in Vietnam.

This article reports on a study looking at social processes within three communes in Binh Dai district, Ben Tre province, Vietnam. We administrated forty-two semi-structure interviews (with thirty-four farmers and eight local officers) and used secondary data. The particular traits of social learning consist of interaction, integration, systems orientation and reflection. The preliminary findings indicate that social learning is issue-driven and plays an important role in adoption or conversion of farmers' into sustainable Integrated Mangrove Shrimp systems. However, the processes of learning varied among the three communes and knowledge levels are different.

Contact Information: Nguyen Thi Huynh Phuong, Department of History – Geography & Tourism, School of Social Sciences and Humanities, University of Can Tho, Can Tho city, Vietnam. Phone: (+84) 939 432 050, Email: nthphuong@ctu.edu.vn

MANGROVE CRABS (*ARATUS SP.*) HERBIVORY ON RED MANGROVE TREES (*RHIZOPHORA MANGLE* L.), IN MAGDALENA BAY AND CORE ZONE OF BALANDRA, BAJA CALIFORNIA SUR, MÉXICO

Rafael Riosmena-Rodríguezand ***Alejandro Pleités-Nieto***
Universidad de Baja California Sur, La Paz, B.C.S, México

Crab herbivory associated to mangrove trees highly influence ecological interactions. *Aratus*, a well studied genus of crabs in Western Atlantic, can be responsible of appoximately 40% of total leaf damage in a monotypic red mangrove stand, composing almost 84% of the crab's diet. This crabs, however, has also shown oportunistic feeding behaviour, as it is capable of supplementing their diet with animal tissue as well. These, organisms ingest such copious amounts of mangrove leaf material due to its availability, regardless their low nutritional value. This does not seem to happen in Eastern Pacific. There have been observations that in El Salvador, Central America, crabs prefer feeding on prop roots rather than canopy leaves. This research aims to explain the herbivory of Pacific *Aratus* crabs, and analysing their food sources.

In order to study *Aratus* feeding behaviour, from february 2015 to december 2015, we measured changes in crab density, and the organisms verticial position on the tree between high and receding tides. We installed $1m^3$ sampling cubes on red mangrove trees, at the tide highest height. Also, we marked prop roots every 10cm from 0 to -110cm, considering 0cm right below the cubes. Then, every 10 minutes, during the high tide, we counted all the crabs within the cubes, and the ones outside on their respective mark, and measured the diameter of the roots or branches where we founded them. In addition we characterized the sampling sites microhabitat, estimating the average prop root abundance, lenght, percentage of root epibionts, temperature, and relative humidity.

Crabs were the most abundant (17.1 crabs/m^3; ±7.13) on July, when the temperature was at its second highest value (32.26 °C; ±1.95), being June the highest (33.04 °C; ±2.09). Whereas, the lowest density was on December (1.83 crabs/m^3; ±2.39, 21.63°C; ±1.34). They were found mostly outside the cubes at -25 cm (±18.86). Prop root average abundance was 38.82 (±10.93), their height 132.76 (±46.87), and the percentage of epibiont coverage 50.71 (±22.18).

These organisms are likely to go lower on the prop roots as the tide lowers, which uncovers the epibionts they feed on. According to our findings, the crabs do no eat canopy leaves, but we are still to find out what are the they actually assimilating into their organisms. We have collected crab tissue, canopy fresh leaves, and prop root material, to analyse through stable isotopes and estimate their real food source.

Contact Information: Rafael Riosmena Rodríguez, Universidad de Baja Calfornia Sur, Carretera al Sur Km 5.5, 23080 La Paz, B.C.S., México. Phone: 01 612 123 8800. Email: riosmena@uabcs.mx

MARSH-MANGROVE INTERACTIONS: SHORT TERM EXPERIMENTAL RESULTS AND LONGER TERM CONSEQUENCES FOR PLOT DOMINANCE

C.E. Proffitt[1]*, D.J. Devlin*[1]*, G.A. Coldren*[2]*, K. Tiling*[1]*, J. Byron*[1]*, H. Standish*[1]

[1]Dept. of Biological Sciences, Florida Atlantic University, Ft. Pierce, FL, USA

[2]Biology Department, Villanova University, Villanova, PA, USA

As mangrove species shift their ranges with climate change, interactions with marsh species will become increasingly more important to habitat structure and ecological function. We have conducted a series of experiments and observational studies at several sites aimed at improving knowledge about some of the interactions. We hypothesized that colonizing mangrove seedlings will be affected differently by various marsh species and combinations of marsh species. These marsh effects will not change the fact that trees will eventually outcompete marsh plants, but will influence the relative dominance of mangrove seedlings and saplings establishing in a plot.

In one experiment in the Indian River Lagoon at Little Mud Creek, we established in 2008 different salt marsh treatments (8 replicates each of bare unvegetated plots, monocultures of each species, and 2, 3 and 4 groupings of species) using Spartina alterniflora, S. patens, Sesuvium portulcastrum, and Distichlis spicata. Eight months later, a target red mangrove (*Rhizophora mangle*) was planted in the middle of each experimental patch. We followed marsh plant clonal growth, growth and leaf production of the target seedling, and new recruitment by mangrove seedlings initially for a year, and later (2014) returned to assess long-term consequences of the initial effects seen. Both salt marsh clonal growth and *R. mangle* growth was generally less at lower elevations.

During the first year, presence of all salt marsh species (monocultures and combinations) promoted growth of the target *R. mangle* and reduced the adverse effects of deeper water seen in bare (no marsh) plots. *S. alterniflora* and *S. portulcastrum* monocultures had the greatest + effects on *R. mangle* growth, and *S. patens* and *D. spicita*, the least. Compared to growth in bare plots, *S. alterniflora* increased the stem growth of R. mangle by 2.5x after accounting for the covariates propagule size (stored maternal reserves) and max water depth. S. patens increased R. mangle growth 2x over that of bare plots, and the two-species combination, S. alterniflora - S. patens had an even greater + effect. The four-marsh-species combination increased the growth of R. mangle by 2.3x, and some combinations of 2 and 3 species had + effects on growth. Other combinations, especially several with *D. spicata* caused much smaller increases in *R. mangle* growth over that seen in bare plots. For newly recruited *A. germinans* seedling densities, *S. patens* and *D. spicata* monocultures, and the *S. alterniflora-S. patens* pair treatment had the greatest + effects. In contrast, *S. alterniflora* monoculture, and S. alterniflora-*D. spicata* combination, and the four species treatment all had negative effects on *A. germinans* recruitment. Also, area of marsh patches had a + effect, and maximum water depth had a – effect. *S. alterniflora* and *S. patens* monocultures and the treatment in which they were paired, had the greatest + effects on recruitment of *Laguncularia racemosa*. However, *S. alterniflora* had a strong negative effect on recruitment of new *R. mangle* seedlings, while the *S. patens-D. spicata* and *S. patens-S. portulcastrum* treatments produced + effects.

Five years later, mangroves ranging in size from <1 to >3 m tall dominate most of the site, although marsh plants still occur in varying abundance depending on degree of canopy closure. In plots subjected to the original marsh treatments *S. alterniflora-D. spicata*, *S. alterniflora- S. patens*, and *S. alterniflora- S. portulcastrum* (a marginal $p<0.07$ for the last one), the abundance of *A. germinans* trees was lower than in originally bare treatments. Abundance of *L. racemosa* trees were substantially greater in plots that had originally been planted with *S. portulcastrum* alone, with marginally significant ($p<0.06$) + effects also of S*. patens, S. patens- S. portulcastrum* paired treatment, and the four-marsh-species treatment. Despite effects on seedlings, no salt marsh treatments significantly influenced the eventual abundance of *R. mangle* trees.

The results of other experiments and large quadrat, multi-year observational studies of colonization and growth will be presented as time permits.

Contact Information: Ed Proffitt, Dept. of Biological Sciences, Florida Atlantic University, c/o HBOI, 5600 US 1 S, Ft. Pierce, FL 34946, United States, Phone: 772-242-2207, Email: cproffit@fau.edu

STAKEHOLDER ANALYSIS ON THE MANGROVE CHARCOAL PRODUCTION SYSTEM AT MATANG MANGROVE FOREST RESERVE, PENINSULAR MALAYSIA

Melissa R. Quispe-Zúñiga[1,2], Behara Satyanarayana[1,2,3], Jean Hugé[1], Ibrahim Sulong[3], Husain Mohd-Lokman[3], and Farid Dahdouh-Guebas[1,2]

[1]Laboratory of Systems Ecology and Resource Management, Université Libre de Bruxelles-ULB, Brussels, Belgium

[2]Laboratory of Plant Biology and Nature Management, Vrije Universiteit Brussel-VUB, Brussels, Belgium

[3]Mangrove Research Unit (MARU), Institute of Oceanography and Environment (INOS),Universiti Malaysia Terengganu-UMT, 21030-Kuala Terengganu, Malaysia

Mangrove ecosystems are closely related with the coastal communities, because of the goods and services that these forests provide. However, the ongoing degradation of mangrove forests worldwide highlights the necessity of understanding the linkages between the ecological and socio - economic dimensions of mangrove management in order to progress towards sustainability. In this context, the scientific insights on local stakeholders and their relationship with mangrove ecosystem for their daily needs or livelihood are essential. Matang Mangrove Forest Reserve (MMFR) in Peninsular Malaysia is known for its silvicultural management for more than a century (since 1902) and is still referred to as an example of sound mangrove management. As sustainability is a multi - dimensional and multi - interpretable concept, we performed a socio - economic questionnaire - based survey (Feb & Nov - Dec, 2014) for id entifying and characterizing the stakeholders involved in pole/charcoal production system – the prime goal of the current MMFR management regime. 155 interviews were performed with pole/charcoal contractors, workers, middle - men and consumers including the Forestry Department authorities. Based on the results, we performed a stakeholder analysis and quantified the economic - flow in the pole/charcoal production system. Our findings suggest that the workers from adjacent villages tend to depend on these activities, despite earning less than the minimum wage (<275.2 USD per month), due to nearby work places and ready availability of the job. While the majority of the produced charcoal (>80%) is exported to Japan, only a small fraction is used locally (by food shop vendors , workers , etc.) due to availability of the (unrestricted) subsidized gas cylinders in local markets. Overall, the present study enables to develop a sustainability assessment framework for Matang through the inclusion of the socio - economic aspects (i.e. the economic situation of stakeholders, the costs and earnings associated with pole and charcoal production) as well as the ecological and silvicultural dimensions of mangrove forest management.

Contact Information: Melissa Roxana Quispe Zúñig, University of Bonn, Center for Development Research (ZEF), Walter-Flex-Str. 3, Bonn, North Rhine-Westphalia, 53113 Germany. Phone: 49228736759, Email: melissa.quispe@uni-bonn.de

THE COASTAL HABITAT INTEGRATED MAPPING AND MONITORING PROGRAM (CHIMMP): STATUS AND EXTENT OF FLORIDA'S MANGROVES AND SALT MARSHES

Kara R. Radabaugh*, Christina E. Powell, and Ryan P. Moyer*
Florida Fish and Wildlife Conservation Commission, St. Petersburg, FL USA

The low coastal topography, frequent tropical storms, and highly developed shorelines make Florida coastal wetlands particularly susceptible to the effects of sea-level rise, habitat loss, and altered hydrology. The Coastal Habitat Integrated Mapping and Monitoring Program (CHIMMP) at the Florida Fish and Wildlife Conservation Commission's (FWC) Fish and Wildlife Research Institute (FWRI) has compiled data from mapping and monitoring efforts for mangroves and salt marshes across Florida. CHIMMP efforts include multiple workshops for coastal wetland experts and stakeholders, pilot mapping and monitoring programs, and a statewide report detailing regional programs and threats to coastal wetlands. Across much of Florida, large areas of salt marshes and mangroves have already been lost to coastal development. Remaining coastal wetlands face challenges from remnant mosquito ditches, concentrated and irregular stormwater runoff, invasive vegetation, climate change, and sea-level rise. CHIMMP has identified region-specific threats to coastal wetlands and compiled management recommendations from the input of federal, state, local, and academic experts. Sea-level rise, altered hydrology, and hardened or developed shorelines are repeatedly identified by these stakeholders as top threats to coastal wetlands, and recommended management strategies include both mitigation and adaptation. The most frequent recommendations focus on resisting saltwater intrusion through restoration of natural hydrology and on the establishment of elevation-appropriate buffer zones adjacent to extant coastal wetland habitat to facilitate landward movement in response to sea-level rise. Other components of this strategy include replacing hardened seawall structures with living shorelines and altering drainage systems that concentrate and accelerate stormwater runoff. CHIMMP provides a diverse perspective on the growing management challenges and region-specific approaches to the mitigation and protection of Florida's coastal wetlands.

Contact Information: Kara Radabaugh, Ph.D., Coastal Wetlands Research, Florida Fish & Wildlife Research Institute, 100 8th Avenue SE, St. Petersburg FL 33701, Phone: 727-502-4986, Email: kara.radabaugh@myfwc.com

ECOSYSTEM CARBON STOCK AND STAND STRUCTURE ACROSS THE INTERTIDAL ZONE IN SUNDARBANS RESERVED FOREST, BANGLADESH

Md. Mizanur Rahman[1], *Imran Ahmed[2] and Mamoru Kanzaki[1]*

[1]Kyoto University, Kyoto, Japan

[2]Bangladeah Forest Department, Bangladesh

Mangroves which are grown in between land and sea play a crucial role in mitigating global climate change. These different environmental settings make mangrove as a heterogeneous ecosystem in term of species composition, growth and productivity thereby, affecting forest structure and carbon sequestration. The present study analyzed a large scale forest inventory data collected by following a systematic grid sampling aimed at investigating the forest structural properties and ecosystem carbon stocks in landward, interior and seaward zone of Sundarbans Reserved Forest (SRF). The canopy cover (%) and stem density (trees ha^{-1}) in the three zones were not varied significantly ($p > 0.05$). While, mean canopy height and basal area showed an upward pattern from seaward to interior to landward zone of SRF ($p < 0.05$). The ecosystem carbon stocks varied significantly among the three zones in SRF ($p < 0.05$). In multiple comparisons (Least Significant Difference Test), it was found that the landward zone of SRF contained significantly highest carbon stocks (313.96±33.02 Mg C ha^{-1}) followed by interior (241.52±24.87 Mg C ha^{-1}) and seaward zone (198.96±24.36 Mg C ha^{-1}). However, this pattern of vegetation structure and ecosystem carbon stocks may alter if sea level rise continues at the current predicted level, coupled with removal of upstream flow by dam or barrage keep going. Because of these two factors, the seaward vegetation (mainly dominated by *Excoecaria agalocha* and *Ceriops decandra*) will move toward interior and landward zone as well the mangrove area will also shrink.

Contact Information: Md. Mizanur Rahman, Laboratory of Forest Resources and Society,Graduate School of Agriculture, Kyoto University Kitashirakawa Oiwake-cho, Sakyo-ku, Kyoto 606-8502, JAPAN; Phone:+8108083421915;
Email: md.rahman.58s@st.kyoto-u.ac.jp or mizanfwt04@gmail.com

WILL THE EXPANSION OF MANGROVES FORESTS ALTER THE NURSERY FUNCTION OF ESTUARIES IN SOUTH AFRICA?

***Anusha Rajkaran*[1], *Janine Adams*[2], *Uviwe Bolosha*[3], *Eugin Bornman*[3] *and Nikki James*[4]**

[1]University of Western Cape, Cape Town, W.C., RSA
[2]Nelson Mandela Metroplitan University, Port Elizabeth, E.C., RSA
[3]Rhodes University, Grahamstown, E.C., RSA
[4]South African Institute of Aquatic Biodiversity, Grahamstown, E.C., RSA

Along the eastern coast of Africa, mangroves are present from Somalia (2.03º N) to South Africa (33.00º S). Globally, climatic variables play a defining role in maintaining the distribution of plants. Climate change has already influence distribution patterns of flora and fauna and this will continue in the future. Increase in temperature and changes in atmospheric carbon dioxide levels may result in mangroves colonizing higher latitudinal areas replacing C4 species such as *Spartina maritima*, this is comparable to bush encroachment recorded in the grassland areas of the world, where tree species replace more palatable grass species.

Currently there are six species of mangrove found in South Africa and two associate species and it is considered to be most threatened and the rarest forest types in South Africa. In 1982 mangroves extended from Kosi Bay to Nahoon in South Africa but more recently mangroves have been recorded in two more estuaries this is related to changes in climate and also the artificial plantings. It is widely accepted that mangroves are important nursery areas for various fish species, most evidence is circumstantial and there is still debate as to the importance of mangrove habitat to fishes relative to other habitats. With the expansion of mangroves it is unknown how fish abundance and behavior will change. Recently, underwater video techniques have been used to study fish assemblages in estuaries. This method is ideally suited to study fish assemblages within difficult to sample habitats and allows for behavioural observations. This study correlates the structural complexity of emergent and submergent habitats with fish abundance and behavior in two estuaries and tries to draw conclusions on how this will change in the future as a consequence of changes in dominant intertidal species.

In the warm-temperate Bushmans Estuary complexity indices indicate that *Zostera capensis* (seagrass) is a more complex habitat than *Spatina maritima* (saltmarsh) and the non-vegetated sand flats. *Rhabdosargus holubi*, an estuarine-dependent marine species, was found in significantly higher numbers in seagrass beds compared to saltmarsh and non-vegetated habitats (sand). The higher incidence of fish slowly meandering in seagrass also indicates behaviour associated with high use. In the sub-tropical Mngazana Estuary results indicated that the prop roots of *Rhizophora* provides a higher degree of complexity than the roots of *Bruguiera*. The combination of *Z. capensis* and the associated mangrove complexities resulted in connected habitats having a higher complex submerged habitat than mangrove habitats that were only connected to mudflats. The total relative fish abundance correlated the increased structural complexity. The complexity in seagrass may provide a higher degree of protection from predators while mangroves will provide nutrition and microhabitat than saltmarsh and sand flats. The study shows the importance of diversified habitats in estuaries to support associated faunal communities. This study hopes to show how the loss of *Spartina maritima* due to mangrove expansion will influence the nursery function of estuaries.

Contact Information: Anusha Rajkaran, Department of Biodiversity and Conservation Biology, Faculty of Natural Science, Private Bag X17, Bellville, 7535, Phone: +27219599731, Email: arajkaran@uwc.ac.za

HABITAT RESTORATION INITIATIVES TO BUFFER POTENTIAL IMPACTS OF CLIMATE CHANGE IN THE TAMPA BAY ESTUARY

*Ed Sherwood[1], **Gary Raulerson[1]**, Holly Greening[1], Steve Crooks[2], Steve Emmett-Mattox[3], Ryan Moyer[4], Doug Robison[5], David Tomasko[5], and Kim Yates[6]*

[1]Tampa Bay Estuary Program, St. Petersburg, FL, USA
[2]ESA, San Francisco, CA, USA
[3]Restore America's Estuaries, Arlington, VA, USA
[4]Florida Fish & Wildlife Conservation Commission, St. Petersburg, FL, USA
[5]ESA, Tampa, FL, USA
[6]USGS, St. Petersburg, FL, USA

Several initiatives are underway in the Tampa Bay estuary to identify habitat restoration opportunities that could offset impacts related to future climate change. Initial vulnerability assessments have indicated that potential areal decline of seagrass, mangroves, saltwater marsh, salt barrens, and coastal freshwater wetlands may result from a variety of climate change related processes. Currently, opportunities to create subtidal and upland refugia to allow for habitat migrations or restoration of critical coastal habitats to occur are being prioritized in the watershed. Identifying these opportunities will not only allow coastal managers to maintain the areal extent of critical coastal habitats within the estuary, but also potentially buffer other anticipated impacts of future climate change. For instance, the Tampa Bay Estuary Program (TBEP), in partnership with Restore America's Estuaries and Environmental Science Associates, Inc. will determine the "Blue Carbon" benefits of continuing tidal wetland and seagrass restoration in the estuary to sequester and store greenhouse gases. In addition, anticipated impacts related to ocean acidification may also be buffered from continuing restoration efforts. Longterm monitoring data collected within the estuary have indicated a general increase in pH coincident with seagrass recovery since the 1980s. The TBEP, in partnership with the United States Geological Survey and Florida Fish and Wildlife Research Institute, will develop a longterm ocean and coastal acidification (OCA) monitoring framework to assess the extent to which seagrass recovery has helped buffer against the chemical impacts of ocean acidification. Together, these efforts will further guide future restoration and adaptation planning in the estuary in response to both climate change and continuing land development pressures in the watershed.

Contact Information: Ed Sherwood, Tampa Bay Estuary Program, 263 13th Ave. South, Suite 350, St. Petersburg, FL 33701, Phone: 727-893-2765, Email: esherwood@tbep.org

IMPORTANCE OF AUTOCHTHONOUS SOURCES FOR GASTROPOD CONSUMERS IN SUBTROPICAL ESTUARINE MANGROVES: A CASE STUDY FROM SOUTH AFRICA

Renzo Perissinotto, Nelson Miranda, ***Jacqueline Raw*** *and Nasreen Peer*
Nelson Mandela Metropolitan University, Port Elizabeth, South Africa

Mangrove habitats are considered to be oligotrophic as allochthonous material, predominantly from the marine environment, provides a major source of primary carbon to established food webs. At subtropical latitudes, mangrove forests provide resilient and stable habitats for typically tropical fauna. However, the high energy coastline of eastern South Africa restricts the occurrence of mangrove habitats to estuarine areas. These mangrove forests have limited connectivity to the marine environment unlike the truly coastal and lagoon-forming mangrove habitat types. It is therefore expected that primary consumers within estuarine mangroves may be more reliant on autochthonous carbon sources that could be limited in terms of availability.

The aim of this study was to identify the dominant autochthonous sources available to benthic primary consumers within estuarine mangroves. We focused on benthic deposit-feeding gastropods as they are key mangrove macrobenthos components that are expected to indiscriminately include a wide variety of resources in their diets. A stable isotope approach ($\delta^{15}N$ and $\delta^{13}C$), complemented with gut content identification, was used to determine the dominant sources utilized by benthic gastropods within estuarine mangrove habitats. We also used *in situ* experiments to estimate the potential feeding impacts of grazing snails on daily microalgal productivity.

Our results showed that benthic gastropods within estuarine mangroves are largely reliant on autochthonous sources however there is a clear partitioning of resources amongst species. Characteristic mangrove species such as the giant mangrove whelk, *Terebralia palustris* (Linneaus, 1767), and the climbing mangrove whelk, *Cerithidea decollata* (Linnaeus, 1767), had clearly defined diets consisting of a few prominent sources. Adult *T. palustris* fed almost exclusively on mangrove leaf litter while *C. decollata* consumed predominantly sedimentary organic matter. A native thiarid, *Melanoides tuberculata* (Müller, 1774), that occurs opportunistically within freshwater seepage areas of the estuarine mangrove habitat had a much broader diet that included a large proportion of mangrove-derived detritus. Seasonal variations in diet were only recorded for adult *T. palustris* and were presumably related to decreased leaf fall during the low rainfall period. Although both *M. tuberculata* and juvenile *T. palustris* consumed benthic microalgae, a significant grazing impact was only recorded for the latter.

The use and partitioning of available resources amongst mangrove consumers are important aspects to consider when assessing the overall functioning of these ecosystems. As autochthonous sources are integral to benthic consumers such as gastropods, their importance to other primary consumers within estuarine mangroves should also be assessed. If estuarine mangrove food webs are largely supported by autochthonous primary sources, these systems need to be considered as self-reliant, and potentially more vulnerable to localized impacts. Maintaining the integrity and functionality of estuarine systems is therefore a conservation priority for South African mangroves.

Contact Information: Jacqueline Raw, Nelson Mandela Metropolitan University c/o Department of Zoology, Summerstrand South Campus, Port Elizabeth 6031, South Africa, Phone: (+27)741278240, Email: s213476967@nmmu.ac.za

OSMOTIC ADAPTATION IN MANGROVES AND ASSOCIATES-A CHALLENGE FOR DEGRADED MANGROVE ECOSYSTEM

Krishna Ray[1*], *Tapan Sutradhar[1‡], Momtaj Begam[1‡], Sandip Kumar Basak[2]*

[1]Environmental Biotechnology Group, Department of Botany, West Bengal State University, Barasat, West Bengal, India

[2]Department of Botany, Kandi Raj College, Kandi, Murshidabad, West Bengal, India

Mangroves are a heterogeneous assemblage of plants belonging to different families of different lineages confined in a well characterized high salinity intertidal ecological niche. Convergent evolution has climaxed into common adaptation mechanisms in a taxonomically diverse assemblage of mangrove species to tolerate highly saline environment (30-40dS/m) and tidal water logging. Communities of other taxonomically remote species as mangrove associates, co-existing with mangroves in intertidal zone and mudflats, also stabilize and diversify the mangrove ecosystem in Sundarbans. Our extensive study in western part of Indian Sundarbans has emphasized on the adaptive physiological mechanisms underlying the turgor maintenance and osmotic adjustment, in 18 species of true mangroves and 18 species of mangrove associates from degraded and non-degraded mangrove ecosystems. Our observations establish energy intensive organic osmolyte accumulation as a major survival strategy of mangrove and mangrove associates with the associates exhibiting greater plasticity to survive in degraded mangrove ecosystems. Synthesis of nitrogen-rich and energy-intensive organic solutes and photosynthates proved to be strong selective advantage for mangroves to counter to salt stress, but this adaptation is too expensive in terms of metabolic costs resulting into inevitable trade-off against its growth. A common response observed under high salinity stress is that plastidic starch representing a reserve of sugars is rapidly converted to soluble hexose sugars and become the gateway for osmotic protection in mangrove and its associates whereas the nitrogen rich compatible solute accumulation is largely species specific. However, it is found to be far more challenging for mangroves, when they have to maintain this osmotic adjustment under degraded soil conditions. The nitrogen metabolism, initial photosynthetic carboxylation and starch to sugar conversion rates are the key factors that control the osmolyte synthesis and our research also focus on these enzymatic activities under both degraded and non-degraded mangrove ecosystems. How the mangroves and the associates fight back in degraded ecosystems to maintain the ecosystem homeostasis through osmotic adjustment is quite intriguing object of study.

Contact Information: Krishna Ray, West Bengal State University, Environmental Biotecnology Group, Department of Botany, Berunanpukuria, Malikapur, Barasat KOLKATA, West Bengal, North 24 Parganas 700126, India, Phone: 919433250057, Email: kray91@gmail.com

MANGROVES AT THE ARAÇÁ BAY, SÃO PAULO, BRAZIL: A HISTORICAL ECOLOGY APPROACH

***Armando S. Reis-Neto*[1]*, Yara Schaeffer-Novelli*[2]*, Guilherme M. O. Abuchahla*[1]**

[1]Institute of Energy and Environment, University of São Paulo, São Paulo, SP, Brazil

[2]Oceanographic Institute, University of São Paulo, São Paulo, SP, Brazil

Mangroves are tidal forests where native Brazilians have always reached out for food and protection. However, since the arrival of the Europeans to the Americas, in the 15th century, popular belief has linked these ecosystems to the spread of diseases and wastelands.

In Brazil, mangroves have historically being used as landfill and land reclamation, following anthropocentric models that foment predatory methods for capital reproduction. From the 17th to the 19th century, the industries of whaling, sugar cane, and coffee have strongly influenced human occupation in the coastal zone of Southeast Brazil, promoting cabotage transportation. With the intensification of industrial activities in the 20th century, the natural heritage has been even more compromised, threatening the way of life of traditional communities. The port of São Sebastião, in the state of São Paulo, was officially established as early as the year of 1939, as one of the strategies to support such industrialization process. In the following two decades, landfill and hydrological alterations formed an artificial embayment - the Araçá bay.

This research aim to describe the evolution of the mangroves in this bay from the point-of-view of Historical Ecology. The Araçá bay has currently an area of 62 km^2, in which 3.6 km^2 are occupied by resilient mangrove nuclei. Due to the social unrest caused by plans of port expansion, the relatively small area of mangroves (6% of the whole bay) has played a big role in conservationist efforts. Mangroves are considered areas of permanent protection (APP) by the Brazilian environmental legislation. The plans of port expansion would compromise up to 75% of the bay's area in 20 years, what caused both the Federal and the State Public Prosecutor offices ask the Superior Court of Justice (STJ) for the preclusion of such development - which has been granted in the year of 2015.

The Araçá bay has one of the last remaining mangroves in the northern state of São Paulo, and its conservation is crucial to human communities and to the environment itself, especially in the context of uncertainties brought by an alarming sea level rise scenario.

Contact Information: Armando Soares dos Reis-Neto, Energy and Environment Institute (IEE/USP), Avenida Professor Luciano Gualberto, 1289 – Cidade Universitária – CEP 05508-010 – Butantã – São Paulo, Phone: +55 11 98105-0817, Email: armando@usp.br

CANOPY GAP-SIZE NICHE DIFFERENTIATION AND GAP-PHASE REGENERATION AS CRITICAL MECHANISMS TO EXPLAIN FOREST STRUCTURAL AND FUNCTIONAL ATTRIBUTES IN THE EVERGLADES MANGROVE ECOTONE REGION

***Victor H. Rivera-Monroy[1]**, Edward Castañeda-Moya[1], Tess Danielson[1], Marc Simard[2], Richard Lucas[3]*

[1]College of the Coast and Environment, Department of Oceanography and Coastal Sciences, Louisiana State University, Baton Rouge, Louisiana, USA

[2] Jet Propulsion Laboratory – NASA, Pasadena, California, USA

[3] Centre for Ecosystem Science, School of Biological, Earth and Environmental Science, the University of New South Wales, High Street, Kensington, NSW 2052, Australia.

Canopy gap formation is a post-disturbance successional process representing a functional unit that maintains diversity and determines successional changes in tropical and subtropical forest ecosystems. Gaps also shape landscape patterns of vegetation distribution at larger spatial and temporal scales. Since canopy gap formation creates resources gradients, the question is to what extent trees species compete for these resources (niche partitioning) and contribute to the diversity of trees regenerating within gaps? Niche partitioning assumes that under constant environmental conditions the outcome of competition between individuals will be determined by their relative competitive abilities. Gap partitioning of the available resources (e.g. light, nutrients) to the plants within the gap provides an important mechanism to empirically examine interspecific competitive interactions among tree species. Opposite to the role of niche partitioning is the view that the stochastic availability of canopy gaps associated to recruitment limitations are the main factors filling the gaps by "chance species" rather than by the best adapted species. Here, we assessed these two hypotheses by selecting recently formed forest gaps in three mangrove sites with distinct forest structural development along the Shark River estuary located in the Florida Everglades Mangrove Ecotone Region (EMER). Forest regeneration and forest structure was monitored from 2008-2013. In addition we use the impact of Hurricane Wilma in 2005 (category 3) to evaluate the scale of disturbance on forest structure including seedling regeneration and forest growth (2006-2015). We observed two successional paths for species replacement depending on the scale of the disturbance. Mangrove succession triggered by natural tree death or lighting strikes is dominated by the initial colonization of *Rhizophora mangle* (a shade tolerant species) in gaps (<150 m^2)**.** This colonization occurs as long as salinities are <45 g kg^{-1} during the peak of the dry season under diurnal or semidiurnal tides and when soil total phosphorous concentrations are at least 0.1 mg cm^{-3}. This successional path resulted in the eventual dominance of *R. mangle* not only in the fringing regions but also at interior locations 100-300 m from shoreline with tidal ranges of 0.05-0.5 m. The second path was initiated by the mangrove species *Laguncularia racemosa* (shade intolerant) when large areas of forest (>1000 m^2) (patch scale) were available becoming the dominant species in the forest matrix as the forest developed within the first 5-10 years after disturbance. This path occurred at the mouth of Shark River estuary where hurricane-induced mortality was 100% in areas with porewater salinity <40 g kg^{-1} during the peak of the dry season and total P soil concentrations were > 0.1 mg cm^{-3}, particularly at TP concentrations >0.2 g m^{-3}. As the *L. racemosa* dominated forest canopy develops, shade tolerant species such as *Avicennai germinans* and *R. mangle* become the dominant species while *L. racemosa* mortality increases due to light reduction throughout the forest canopy. In the absence of large scale disturbances (i.e., hurricanes) this latter forest scenario is eventually dominated by *A. germinans*, although *R. mangle* could become dominant if the frequency of small gap openings (by tree fall or lighting strikes) are created, since *R. mangle* can grow faster than *A. germinans*. Our results show that mangrove succession in the EMER is driven by species-specific ecophysiological adaptations creating complex patch-gap dynamics patterns at the landscape level.

Contact Information: Victor H. Rivera-Monroy, College of the Coast and Environment Bldg., Room 3209, Louisiana State University, Baton Rouge, Louisiana, USA 70803, Phone: 225-578-2745, Email: vhrivera@lsu.edu

ESTIMATING SPECIES-SPECIFIC ABOVE-GROUND MANGROVE BIOMASS IN A CARIBBEAN OCEANIC ISLAND (SAN ANDRES, COLOMBIA)

*J.H Medina[1], J.E Mancera- Pineda[2], **V.H Rivera-Monroy**[3], and A. Pacheco[4]*

[1]Universidad Nacional de Colombia sede Caribe

[2]Universidad Nacional de Colombia sede Bogotá

[3]Department of Oceanography and Coastal Sciences, Louisiana State University Baton Rouge, Louisana USA

[4]Corporation for the Sustainable Development of the Archipelago Department of San Andres, Providencia and Santa Catalina, CORALINA

Mangrove forests are currently recognized as carbon sinks in tropical and subtropical coastal regions. However, there are few regional species-specific allometric models representing parameters associated to local environmental gradients controlling forest growth rates. The utilization of these local/regional models significantly reduces uncertainties in the estimating of aboveground carbon stocks, especially when extrapolating to landscape levels. The objective of this research was to develop allometric equations for three neotropical mangrove species that were felled during the construction of trail for environmental education in the Mangrove Regional Park Old Point in the Caribbean Island of San Andrés, Colombia. The number of trees used per species was variable depending on species age and spatial distribution along the trail (*Rhizophora mangle, N=13; Avicennia germi*nans, N=20, *Laguncularia racemosa, N=15*). The best fit was represented by the equation $y = b(DBH)^a$ (R^2 >90, $p < 0.05$) for total biomass, stems, branches and leaves. A regional comparison among equations published for the same species in other locations throughout the Neotropoics show that our estimations had a lower coefficient of variation ((<15%) when calibrated with other in situ measurements. Our results underscore the need to develop equations using *in situ* measurements to reduce uncertainty in the estimation of both aboveground biomass and carbon allocation.

Contact Information: Jairo Medina, Universidad Nacional de Colombia sede Caribe, Email: jhmedinac@unal.edu.co

MANGROVE DISTRIBUTION CHANGES IN AUSTRALIA AND THE VULNERABILITY OF MANGROVE TO SEA-LEVEL RISE

Kerrylee Rogers[1]*, Neil Saintilan*[2]*, Richard Lucas*[3]*and Colin D Woodroffe*[1]
[1]University of Wollongong, Wollongong, NSW, AUSTRALIA
[2]Macquarie University, Sydney, NSW, AUSTRALIA
[3]University of New South Wales, Sydney, NSW, AUSTRALIA

Mangroves flourish along low energy estuarine shorelines and coastlines in the tropics; whereas saltmarshes dominate temperate shorelines and coastlines. Mangroves of the species *Avicennia* exhibit cold tolerance that enables it to extend to higher latitudes than other species and studies have documented both latitudinal extensions and landward encroachment of *Avicennia* in temperate and sub-tropical settings. These distribution changes have been attributed to a range of factors, many of which are associated with climate change and variability, including increases in temperature, sea level, atmospheric carbon dioxide concentrations and rainfall variability.

In Australia, the latitudinal extension of *Avicennia marina* is limited to the mainland by the geographic barrier of Bass Strait, a 250 km wide oceanic passage hypothesized to exclude the distribution of *Avicennia marina* from the southernmost state of Tasmania. In temperate Australia, mangrove and saltmarsh occupy the upper and lower portion of the vegetated intertidal zone, respectively; and there is documented evidence of flourishing *Avicennia marina*, and associated saltmarsh displacement estimated to have occurred from at least the 1930s, but perhaps even from the 1870s. Mangrove encroachment into saltmarsh is now a well-documented occurrence throughout the region. Extension of mangrove along tidal creeks and large tidal estuaries and associated displacement of upland freshwater vegetation has also been documented in tropical Northern Australia; and latitudinal extension of *Rhizophora stylosa* has been recorded along the subtropical coastline of eastern Australia. The national scale of observations of landward mangrove extension imply that they are caused by processes that operate across the region, such as sea-level rise, increasing temperature or increases in atmospheric carbon dioxide, though the degree of change may be mediated by localized processes operating along shorelines. Studies seeking to link observations of mangrove distribution changes to climate change have applied numerous techniques, though a clear causal link remains elusive, in large part due to the complex and interacting effect of climate change and variability on coastal processes.

Successional theory seeks to place current intertidal vegetation distributions in the context of substrate evolution; however contemporary changes in mangrove distribution in Australia are inconsistent with successional theory, which dictates that over time, mangrove habitats build elevation to create higher intertidal substrates favourable for saltmarsh establishment. Contrary to successional theory, this paper seeks to demonstrate that contemporary changes in mangrove distribution in Australia are consistent with palaeo-indicators of changes in mangrove distribution over the Holocene, with changes in relative sea-level proposed as the corresponding process operating at both contemporary and geological timescales. By integrating information on substrate elevation and sedimentary dynamics with estimates of distribution change at a range of timescales, we project that the regional vulnerability of mangrove to sea-level rise in Australia is low. However, at the local scale, the vulnerability of mangrove to sea-level rise may be highly variable and dependent upon site-specific geomorphology and sedimentary dynamics. In contrast, the vulnerability of saltmarsh to sea-level rise is higher due to a range of factors that increase their sensitivity and limit their adaptive capacity. Understanding the interaction of global sea-level rise with local factors influencing relative sea-level rise is essential for implementing management actions that maintain or improve mangrove ecosystem services in the 21st century.

Contact Information: Kerrylee Rogers, School of Earth and Environmental Science, University of Wollongong, NSW, AUSTRALIA
Phone: +61-2-4239-2512, Email: kerrylee@uow.edu.au

DISTURBANCE, SITE AND VEGETATION FEEDBACKS CREATE LANDSCAPE STRUCTURE IN SOUTH FLORIDA COASTAL WETLANDS

***Michael S. Ross**, Bina Thapa, Keqi Zhang and John F. Meeder*
Florida International University, Miami, FL, USA

In the coastal zone of the sub-tropical hurricane belt, projected changes in cyclone and freeze regimes may interact with rising seas to alter landscape structure, including both marsh-mangrove mosaics and patchworks of dwarf and tall mangroves. We studied the responses of a southern Biscayne Bay, FL, coastal mangrove forest to hurricanes (Hurricanes Andrew 1992, Katrina and Wilma 2006) and multiple chilling events over a 26-year period, supplementing remote sensing analyses with field surveys following hurricane and freeze events. As recently as 1928, the study area consisted of a tall mangrove fringe backed by a relatively unproductive brackish and freshwater marshes that extended far inland. Today, dwarf mangroves have replaced the marsh, and the fringe forest has widened considerably, but canopy height still decreases sharply with distance from the coast, reflecting underlying transitions in soils (changeover from organic to carbonate sediment) and hydrology (reduced tidal flushing). The landscape pattern is made more complex by patches of large trees that form over bedrock depressions, and ditches whose levees support taller trees. We used LiDAR data to map current forest structure, and assessed disturbance response based on vegetation indices derived from a sequence of 150 Landsat TM images from 1985 to 2011. NDMI, the best-performing index, showed that mangrove responses to chilling and hurricane events exhibited distinct spatial patterns, as follows: severe damage from intense chilling events was concentrated in interior basin forests with tree heights less than 4 m, while severe damage from intense hurricanes was constrained to the Fringe mangrove forest near the coast. It took 4-7 months for damage from intense chilling events and hurricanes to reach their full extent, and 2-6 years for the mangrove forest to recover from these disturbances. Only severe damage from hurricanes and intense chilling events could be detected in Landsat images, as strong and consistent seasonal variation discernible in both Dwarf and Fringe mangrove forests limited the capacity of our method to detect weaker chilling events. However, field observations showed that cold nights in which temperatures did not reach freezing often caused extensive mortality and dieback in small frost pockets. Imagery and analytical methods addressed at these finer-scale responses may soon allow us to understand the morphogenesis of coastal landscapes as climate, sea level, and disturbance regimes change.

Contact Information: Michael Ross, FIU-SERC, MMC-OE148, Miami, FL 33199, Phone: 305-348-1420, Email: rossm@fiu.edu

ECOGEOMORPHOLOGY: TOWARDS A UNIFIED FRAMEWORK TO EXPLAIN STRUCTURAL AND FUNCTIONAL PROPERTIES OF MANGROVE ECOSYSTEMS

***Andre S. Rovai*[1]*, Robert R. Twilley*[2]*, Edward Castaneda-Moya*[2,] *Miguel Cifuentes-Jara*[3]*, Paulo A. Horta*[1]*, Jose C. Simonassi*[1]*, Alessandra L. Fonseca*[1] *and Paulo R. Pagliosa*[1]

[1]Universidade Federal de Santa Catarina, Florianopolis, SC, Brazil

[2]Department of Oceanography and Coastal Sciences, Louisiana State University, Baton Rouge, LA, USA

[3]Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba, Cartago, Costa Rica

Like their terrestrial counterparts mangrove forests hold evident relationship with climatic variables. However, unlike upland vegetation they evolved and respond to dynamic coastal settings. The environmental setting hypothesis (ESH) states that geomorphological, geophysical and biological processes, along with regional climate, control the structure and function of tropical coastal ecosystems. We hypothesized that mangrove soil properties are explained by regional rather than latitudinal effects. We predicted that mangrove soil nutrient availability (carbon:nitrogen:phosphorus; C:N:P) is controlled by river discharge - RD, tidal amplitude - TD, minimum temperature of coldest month - Tmin, minimum precipitation of driest month - Pmin, and potential evapotranspiration - PET. To test our assumptions we sampled a variety of coastal environmental settings (CES), that is deltaic, estuarine, composite wave/river dominated, and karstic coastal landforms, across the Neotropics (total of 27 sites; three 1-meter deep cores per site). P concentration (mg cm^{-3}) was not correlated with latitude (OLS; R^2=-0.007, p=0.515, df=79), while C and N, and N:P, C:N and C:P ratios were (R^2=0.191, 0.274, 0.191, 0.049, and 0.002, respectively; α<0.05 for this and following analyses). Although for all the variables differences were observed across CES and sites within CES (two-way ANOVA), the components of variation indicated the CES explained most of the variation (ranging from 42% for P to 64% for N), with sites accounting for a small portion of the variability (16% for N, and 40% for P). PERMANOVA (with variables C:N, N:P, and bulk density) showed differences across CES, except between tide- and wave-dominated deltaic, and carbonate and composite (wave/river-dominated) settings, both of which do not receive direct influence from RD. Tmin, Pmin, PET, TD, and RD, were significantly correlated to the multivariate dispersion (Sperman´s correlation), and explained the gradient formed ranging from sites that receive river input and have low N:P ratios to sites with little or no river input and are P-limited. Our findings challenge current views in mangrove macroecology and suggest potential bias in contemporary climate-based models as well as direct aboveground-belowground allometric relationships used to estimate global soil C budgets. Further, our results point out the relevance of scale when selecting environmental variables to predict vegetation productivity and successional processes. While some trends in mangrove vegetation may be readily apparent and straightforward to interpret in light of latitudinal variation, macroscale in these coastal wetlands comprises geomorphological regional boundaries, including climate and relative sea-level change. The ESH is proposed as a unified theory to explain much of the unaccounted structural and functional diversity of mangroves, including the system's strategies to allocate C, which is utterly linked to P availability.

Contact Information: Andre Rovai, Departamento de Ecologia e Zoologia, Universidade Federal de Santa Catarina, Trindade, Florianopolis, SC, Brazil 88040-900, Phone: + 55 48 3721-2548, Email: asrovai@gmail.com

TROPHIC STRUCTURE OF MANGROVE ECOSYSTEMS IN EASTERN AUSTRALIA AND THE INPUT OF ANTHROPOGENIC N: INSIGHTS FROM STABLE ISOTOPE ANALYSIS

Neil Saintilan *and Debashish Mazumder*
Macquarie University, Macquarie Park, Sydney, Australia

Urban development in coastal settings has increased the input of nitrogen into estuaries globally, in many cases changing the composition of estuarine ecosystems. By focussing on three adjacent estuaries with a gradient of anthropogenic N loadings, we used stable isotopes of N and C to test for changes due to increased anthropogenic N input on the structure of some key trophic linkages in mangrove forests (Alderson et al. 2015).

Stomach content analysis of itinerant fish exiting the saltmarsh/mangrove with the ebbing tide has demonstrated extremely high proportions of crab larvae in the gut of glassfish (Ambassis jacksoniensis), as well as flat tail mullet (Liza argentea) and blue eye (Pseudomugil signifer), and this trophic linkage holds consistently between estuaries in SE Australia (Mazumder et al. 2011). We found a consistent enrichment in δ15N corresponding to increased anthropogenic N at the three ecosystem levels studied: fine benthic organic matter, grazing crabs, and planktivorous fish. The degree of enrichment in δ15N between fine benthic organic matter and the grapsid crab Parasesarma erythrodactyla was identical across the three sites. The glassfish Ambassis jacksoniensis showed lower levels of enrichment compared to basal food sources at the higher N-loaded sites, suggesting a possible effect of anthropogenic N in decreasing food-chain length in these estuaries.

Contact Information: Neil Saintilan, Head, Department of Environmental Science, Macquarie University, Macquarie Park, Sydney NSW 2109, Australia, Phone: 61298508422, Email: neil.saintilan@mq.edu.au

A COMPARATIVE ASSESSMENT OF DAMAGES AND REGENERATION PATTERNS BETWEEN PLANTED AND NATURAL MANGROVE STANDS AFTER CATASTROPHIC TYPHOONS IN THE PHILIPPINES

Severino G. Salmo III *and Kayla Marie I. Castro*
Ateneo de Manila University, Quezon City, Metro Manila, Philippines

The Philippines, an archipelagic country located in the Western Pacific Region, is considered as one of the most vulnerable countries against catastrophic typhoons. Mangroves are also vulnerable as they first suffer the brunt of the typhoon. The vulnerability of mangroves against typhoon is further aggravated by the severe lost and degraded state of mangroves in the country. Massive mangrove planting programs have been implemented since the 1990s to restore forest cover and protect the coast against typhoons. However, most of these mangrove plantations are monospecific and are located in sub-optimal conditions (i.e. highly saline and frequently inundated) oftentimes with stunted growth and poor survival. In this study, we evaluated the impacts of three catastrophic typhoons in three sites in the Philippines: Typhoon Fengshen (June 2008; central Visayas); Typhoon Chan-hom (May 2009; Northwestern Luzon); and Super Typhoon Haiyan (November 2013; Eastern Visayas, Central Visayas and Southwestern Luzon). The latter is known as the strongest typhoon ever recorded in history (up to 315 km/hr; Category 5 in Saffir-Simpson wind scale). We compared the damages and post-typhoon regeneration in terms of vegetation and sediments between planted (monospecific) and natural (diverse) mangrove stands. Results indicate almost similar manifestation and extents of damages across sites (defoliated, snapped, uprooted). Canopy cover, tree density and aboveground biomass were reduced by 70-100 %, 60-80 % and 70-90 %, respectively. The sediments have increased salinity by 5-10 ppt, more reduced (-50 mV), and warmer by 8-10^{0}C. However, the regeneration rates (refoliation, coppicing, and seedling recruitment and growth rate) although slow are relatively more visible in the natural stands. Our findings cast doubts on the effectivity of current mangrove planting practices in the country in providing meaningful protection against typhoons.

Contact Information: Severino G. Salmo III, Ateneo de Manila University, Loyola Heights, 1108 Quezon City, Philippines. Phone/Fax: +63-2-4264321; Email: ssalmo@ateneo.edu

CARBON BURIAL FROM SALTPANS TO MANGROVES IN TROPICAL REGIONS OF BRAZIL AND AUSTRALIA

Christian J. Sanders[1]*and Luciana M. Sanders*[2]

[1]National Marine Science Centre, School of Environment, Science and Engineering, Southern Cross University,Coffs Harbour, New South Wales, Australia

[2]Southern Cross University Southern Cross Geoscience, P.O. Box 157, Lismore, NSW 2480, Australia

The sediment flux of total organic carbon (TOC), total nitrogen (TN) and total phosphorous (TP) was quantified in sediment cores taken in a transect from saltpans to mangrove forests near Rio de Janeiro, Brazil and near Gladstone, Australia. Results indicate that not only mangroves but saltpans are also sites sediment accumulation and TOC, TN and TP burial. The burial rates were determined from sediment accumulation rates (SAR), dry bulk densities and TOC, TN and TP content. The SARs were calculated using the 210Pb dating method. Sediment characterization (δ13C, δ 15N, TOC/TN and grain size analyses) indicate 100 years of SAR and TOC, TN and TP burial.

Contact Information: Christian Sanders, Southern Cross University, National Marine Science Centre, 2 Bay Drive, Coffs Harbour, NSW 2450, Australia

THE IMPACT OF MANGROVE CUTTING AND REGENERATION ON SURFACE ELEVATION DYNAMICS IN BINTUNI MANGROVE, WEST PAPUA, INDONESIA

Sigit D. Sasmito[1,2]*, Samsul Bachri*[3]*, Daniel Murdiyarso*[1,4]*, Daniel A. Friess*[5]*, Sartji Taberima*[3]

[1]Center for International Forestry Research, Bogor, Indonesia
[2]Research Institute for the Environment and Livelihoods (RIEL), Charles Darwin University, Darwin, Australia
[3]University of Papua, Manokwari, Indonesia
[4]Department of Geophysics and Meteorology, Bogor Agricultural University, Bogor, Indonesia
[5]Department of Geography, National University of Singapore, Singapore

Long-term mangrove resilience under sea level rise depends on surface elevation dynamics over time. Surface elevation dynamics to cope with sea level rise are increasingly well-documented for natural mangrove forests. However, there is still limited information for degraded forests, specifically on the impact of logging and regeneration on surface elevation change (SEC) and surface accretion rates (SAR).

A series of SEC and SAR field measurements were conducted over two years using the Rod Surface Elevation Table combined with Marker Horizons (RSET-MH). The study was conducted in Bintuni Bay, West Papua, which represents 50% of Indonesia's mangrove or 10% of world's mangroves. The area which extends to around 87,000 ha has been rotationally logged over the past 25 years. 24 RSET-MH benchmarks were established in May 2014, located within fringe and interior mangroves in four different locations, representing different levels of disturbance, namely 5-year and 15-year post-cutting, and mudflat and pristine forest as control. The effects of hydro-geomorphic mangrove settings (interior and fringe) were also investigated in this study.

We found that SEC differ across three monitored locations (5-year = 4.6 mm yr^{-1}; 15-year = 0.9 mm yr^{-1}; mudflat = 36.9 mm yr^{-1}). We also observed highly significant rates of surface accretion (SAR) on the mudflat as much as 24.9 mm yr^{-1}. This study suggests that forest regeneration plays a key role for positive surface elevation change, as belowground root volume grows rapidly in combination with effective aboveground sediment trapping. Our findings imply that natural mangroves colonization are supported by the availability of sediment through significant net elevation changes and accretion rates in the fringing mudflat ecotone.

Contact Information: Sigit D. Sasmito, Center for International Forestry Research, Bogor 16115, Indonesia,
Phone: +61 434095716, Email: s.sasmito@cgiar.org

RELATIONSHIP BETWEEN THE BIOMASS OF MANGROVE ROOTS AND THE DENSITY OF THE POLYCHAETE SPECIES *CAPITELLA* SP.

*Helio H. Checon[1]; Camila F. Silva[1]; Guilherme N. Corte[1]; **Yara Schaeffer-Novelli**[2]; A. Cecilia Z. Amaral[1]*
[1]Universidade Estadual de Campinas, Campinas, São Paulo, Brazil
[2]Universidade de São Paulo, São Paulo, Brazil

Mangrove roots are known to affect the composition of benthic communities. However, little is known regarding the effect of these structures on polychaete communities, despite their great abundance in mangrove ecosystems. Here, we evaluate the relationship between mangrove roots and the most abundant polychaete (Capitella sp.) at Araçá Bay, a benthic system in Southeast Brazil composed by different habitats such as soft and hard-bottoms, beaches, a wide intertidal flat, a shallow sublittoral and mangroves fragments. Capitella sp. belongs to the Capitella capitata complex, which comprises specimens considered to be opportunistic on organic enriched areas. We studied three mangrove formations with contrasting features: N1 situated at the upper intertidal area, composed by soft sediment and rocky shore; N2 situated at the upper intertidal area, with finer sediment; and IP, situated at the lower intertidal area, with coarser sediment. Sampling was carried out during 2014 (summer, March and winter, July), during low tide. Three transects with eight equidistant sampling points were established at each mangrove formation (3 points on the tidal flat, 2 at the transition, and 3 in the mangrove). Biological samples were collected with a corer (Diameter = 10 cm, Area = 0.07 m^2) at all sampling points. Samples were washed through sieves (1.0 and 0.5 mm), and the specimens and the mangrove roots were collected. The macrofauna was identified, the density of Capitella sp. was recorded, and the biomass of the mangrove roots was weighed (dry weight). A total of 5785 individuals of Capitella sp. were sampled, 3143 during summer and 2642 during winter. The polychaete density was higher at IP compared to the others. In contrast, root biomass was higher at N1 and N2, regardless of the sampling period. The density of Capitella sp. had a negative relationship with the root biomass, with densities higher at the tidal flat and transition sites. However, the magnitude of the effect was variables among formations, being relatively higher at N1 (R^2 = 0.632) and lower at IP (R^2 = 0.130) possibly due to the lower root biomass found at this site. Previous studies have shown that the occurrence of Capitella sp. is higher at mangrove surroundings, due to the nutrients exported by this ecosystem. Nevertheless, roots could limit the occurrence of this species as result of physical constraints to infaunal organisms, or sedimentary differences within mangrove stands, which will be further investigated.

Contact Information: Yara-Schaeffer-Novelli, Oceanography Institute, University of São Paulo, Brazil. Address: Praça do Oceanográfico, 191-CEP 05508-900, São Paulo, SP, Brazil. Email: novelliy@usp.br

EVALUATION OF AN ORGANIC CARBON TRAJECTORY ON A MANGROVE SPOIL ISLAND

Tracey B. Schafer[1,2]*, Rex Ellis*[3]*, Caitlin Hicks-Priès*[4]*, Todd Z. Osborne*[1,2]

[1]Soil and Water Science Department, University of Florida, Gainesville, FL, USA
[2]Whitney Laboratory for Marine Bioscience, St. Augustine, FL, USA
[3]St. John's River Water Management District, Palatka, FL, USA
[4]Lawrence Berkley National Lab, Berkeley, CA, USA

Long-term monitoring of coastal restoration projects are required to determine sustainability and stability of restored ecosystems. Organic carbon accretion, a valuable ecosystem service, is a significant indicator of healthy ecosystem function. SL-15, a spoil island in the Indian River Lagoon was restored to mangrove and seagrass habitat in 2005. Vegetation abundance and soil biogeochemical characteristics were measured at time =0, one year, and ten years to assess organic carbon accretion in both seagrass and mangrove areas. Sediment cores were collected in a set of four plots, located on the SL-15 mangrove island and analyzed for bulk density, % total organic matter, % total organic carbon, microbial biomass carbon, extractable organic carbon, and total nitrogen. Functional trajectories for restored areas were calculated based upon organic carbon accretion over the 10- year period. By comparison to a control site 500 m north of SL-15, realistic estimates of time required to reach natural levels of carbon and mangrove vegetative community structure were calculated at 34- 46 years. Carbon trapped in coastal systems, such as SL-15, is extremely important to blue carbon stocks and buffering of climate change.

Contact Information: Tracey Schafer, University of Florida Whitney Marine Laboratory, 9505 Ocean Shore Blvd., St. Augustine, FL, USA. Email: tschafer25@ufl.edu

IMPACTS OF BLACK MANGROVE EXPANSION ON FAUNAL COMMUNITIES IN THE NORTHERN GULF OF MEXICO

Ken L. Heck, Jr.[2,1], ***Whitney A. Scheffel***[1,2], *Just Cebrian*[2,1], *Matthew Johnson*[3]

[1]University of South Alabama, Mobile, AL, USA

[2]Dauphin Island Sea Lab, Dauphin Island, AL, USA

[3]Bureau of Ocean Energy Management, New Orleans, LA, USA

The tropically associated black mangrove (*Avicennia germinans*) is experiencing a climate-induced range shift and expanding into salt marshes of the northern Gulf of Mexico. This species has colonized temperate systems dominated by saltmarsh cordgrass (*Spartina alterniflora*) and black needlerush (*Juncus roemerianus*) in southern Louisiana, northern Florida and most recently on Horn Island, Mississippi. To date, little is known about the role black mangroves may play as nursery habitats for juvenile finfish and shellfish. The main objective of this study was to quantify and compare fish, epifaunal, and infaunal use in *Spartina*-dominated; black mangrove-dominated; and mixed *Spartina* and black mangrove habitats in two areas of varying colonization. Suction sample surveys and sediment cores were conducted every month from April to October in 2012 and 2013 to estimate finfish, shellfish, and infaunal abundances and diversity among the three habitats. Collections showed significant differences in community composition among black mangrove, mixed mangrove and salt marsh habitats. Abundances and estimates of secondary production for benthic epifauna were greatest in the mangrove habitat at Horn Island and in the marsh in the Chandeleur Islands. If black mangroves continue to increase in abundance, there will likely be a shift in community composition due to the higher position of black mangroves in the intertidal. This will restrict access to organisms due to decreased flooding duration and could, in turn, force organisms to use habitats that are flooded for longer periods of time (i.e. seagrasses, oyster reefs).

Contact Information: Whitney Scheffel, Dauphin Island Sea Lab, 101 Bienville Blvd., Dauphin Island, AL, USA 36528,
Email: wscheffel@disl.org

VARIATIONS IN MANGROVE SOIL CARBON STORAGE ACROSS CLIMATE GRADIENTS

Lisa Schile
Smithsonian Environmental Research Center, Edgewater, MD, USA

Coastal and marine ecosystems have the potential to produce and sequester organic carbon at rates that exceed tropical and temperate forests. Recent recognition of the value of these ecosystems as significant carbon sinks has strengthened worldwide interest in their management, conservation, and restoration for the purpose of climate change mitigation. However, many gaps in understanding carbon sequestration in coastal ecosystems remain, creating challenges for the application coastal ecosystem carbon research at local, regional and global scales. A major limitation is the fact that most research on this topic has been conducted in relatively few temperate and tropical ecosystems, despite a tremendous amount of spatial variability in carbon stocks across gradients of climate, hydrology, geomorphology, and tide range. Additionally, a standardized protocol has not been widely utilized, which would enable more rigorous comparison across ecosystems and climates. The main objective of this research was to apply a standardized method for documenting carbon storage and decomposition rates in vegetated coastal ecosystems along latitudinal gradients, focusing on mangrove ecosystems. Field sites were located in Twin Cays, Belize, three islands in Bocas del Toro, Panama, and the Indian River Lagoon, Florida. At each site, six deep soil cores were retrieved, ranging in depth from 70 to 496 cm. Organic carbon was quantified with depth and summed for each core. Additionally, a new approach to assessing decomposition rates was applied that involved the burial of green and rooibos tea bags for three months. Large differences in bulk density, ash-free dry weight, and organic carbon content were identified across sites and within dwarf and fringing mangrove locations, which was largely driven by the depth to core refusal and the content of the parent soil material (sand, coral rubble, and/or clay). Decomposition rates also varied by sites, with slower rates of decomposition in interior mangrove locations. A literature review of all published mangrove carbons stocks was conducted and combined with this study's data to generate a conceptual model of factors governing carbon storage along gradients in climate and soil conditions.

Contact Information: Lisa Schile, Smithsonian Environmental Research Center, 647 Contees Wharf Rd, Edgewater, MD 21037, United States, Phone: 443-482-2245, Email: schilel@si.edu

ASSESSING THE VERTICAL GRADIENT OF *DISCAPSEUDES SURINAMENSIS* AND *HALMYRABSEUDES SPAANSI* AT THE POMONA MUD BANK (SURINAME) IN RELATION TO THEIR BIOMETRICS

Ashvin Sewsaha[1] *and Chantal J. Landburg*[2]

[1]Anton de Kom Universiteit van Suriname, Leysweg 86, Paramaribo, Suriname
[2]Instituut voor de Opleiding van Leraren, Leysweg 86, Paramaribo, Suriname

Discapseudes surinamensis and *Halmyrabseudes spaansi* appear in estuarine mud banks and aquatic environments[1, 2], and serve as prey for migratory birds[3, 4] and fish[5, 6]. Not much is known about the vertical distribution of these species and whether or not this is related to their biometrics. Earlier studies[7, 8, 9, 10] pointed out that infaunal organisms have not been found at a depth greater than 35 cm, however, the studies primarily focused on their horizontal rather than their vertical gradient. The purpose of our study was to determine the vertical gradient of *D. surinamensis a*nd *H. spaansi* at the Pomona mud bank in relation to their respective biometrics (sex and length). We measured occurrence of the species at 11 intervals up to depths of 50 cm and found most of the *D. surinamensis* and *H. spaansi* at depths between 0 and 20 cm, with the highest occurrence between 0 and 5 cm. We also found more *D. surinamensis* than *H. spaansi* (ratio 12:1), overall greater number of females than males (ratio 8:5), and sizes ranging from 3 to 13 mm. We expect that this new understanding of the vertical distribution and biometrics will allow for a better understanding of prey availability for migratory birds and fish species inhabiting estuaries.

Contact Information: Ashvin Sewsahai, Anton de Kom University of Suriname, Biology, Leysweg, Paramaribo 0000, Suriname, Phone: 597465558, Email: asewsahai@hotmail.com

EVALUATING THE EFFECTS OF THE RANGE EXPANSION OF *AVICENNIA GERMINANS* ON EASTERN SHORELINE BIRD COMMUNITIES ALONG THE EAST COAST OF FLORIDA

***Michelle Shaffer**, Melinda Donnelly, and Linda Walters*
University of Central Florida, Orlando, FL, USA

The black mangrove *Avicennia germinans* is a natural component of estuarine ecosystems found along the central and southern coasts of Florida. Due to increased yearly temperatures, *A. germinans* has not recently suffered from winter freezes, allowing them to expand their range north along the eastern coast of Florida. This expansion may impede on the *Spartina alterniflora* (cordgrass) saltmarsh habitats naturally found along the northern coasts of Florida, changing the physical structure of the ecosystem. The community effects of this shift in ecosystems is largely unknown. This study examines the impact that the *A. germinans* range expansion is having on Florida's eastern shoreline bird communities.

We surveyed 3 different locations along the eastern coast of Florida; 1) Canaveral National Seashore, 2) North Penninsular State Park and 3) St. Augustine estuarine areas (Anastasia State Park, Lighthouse Park, Vilano Boat Ramp). Within each of these locations, 9 shoreline plots were surveyed, resulting in a total of 27 plots. Each of these plots were 20 m (parallel to shoreline) by 5 m (perpendicular to shoreline), resulting in 100 m^2 plots. Amongst these 27 plots, 3 different types of shorelines were observed: 1) *A. germinans* dominant, 2) *S. alterniflora* dominant and 3) a mix of the two species. Surveys were conducted from August 2015 to June 2016 to evaluate shoreline bird abundances and behaviors within each plot. These bird surveys occurred monthly at all 27 plots for 20 minutes each. The species and behavior of each bird within the plot was collected for the 20-minute time interval, at a minimum distance of 30 m.

In December 2015 and January 2016, plant morphometrics were collected within all 27 plots. Using transects and quarter meter quadrats, data was collected on: 1) percent cover of *A. germinans* and *S. alterniflora*, 2) *S. alterniflora* height, 3) the presence of other species of plants, 4) mangrove tree/canopy height, and 5) number of mangrove branches within each quadrat. A total count of mangroves (at least 75 cm in height) was collected. For 5 of these mangroves, individual characteristics [DBH (diameter at breast height), tree height, crown diameter] were examined. The plant structure characteristics for each plot will then be compared to shoreline bird abundances and behaviors. Correlations in this data will show how a change in dominant plant species affects these bird communities. This information will be used by ecologists to develop appropriate land management plans for the northern east coast of Florida, as they prepare for the ecological and economic impacts of this shift in ecosystems.

Contact Information: Michelle Shaffer, University of Central Florida Undergraduate, 4000 Central Florida Blvd, Orlando, FL, 32816, Phone: 407-739-1524, Email: michelleshaffer8@knights.ucf.edu

RESTORATION MAY INCREASE CARBON STOCK OF DEGRADED MANGROVE FORESTS ACROSS CAMBODIA

*Richard A. MacKenzie[1], **Sahadev Sharma[2]**, Patra Foulk[1], Geoffrey Blate[3], Amornwan Resanond[4], Natcha Tulyasuwan[4], Thida Tieng[4], Radtasiri Wachirapunyanont[4]*

[1]USDA Forest Service, Hilo, Hawaii, USA
[2]University of Hawaii at Manoa, Honolulu, Hawaii, USA
[3]USDA Forest Service, Bangkok, Thailand
[4]USAID LEAD Program, Bangkok, Thailand

Mangroves play an important role in mitigating climate change because of their ability to sequester large quantities of carbon in soil. Despite this important role, mangroves have been and continue to be lost to various human activities. To counter these losses, several countries in SE Asia have begun to restore mangroves through the creation of monospecific mangrove plantations through the outplanting of mangrove seedlings and saplings. However, it is not clear how effective these plantations are at providing similar levels of ecosystem services compared to intact forests. This includes carbon sequestration and storage.

To address this gap, we quantified total ecosystem carbon stocks in intact, restored and disturbed mangroves in 3 provinces across Cambodia that represent 95% of all Cambodia's mangrove forests. Our stratified sampling included 24 plots in intact, 8 plots in restored, and 14 plots in disturbed mangrove forests. Disturbance in mangrove forest caused by changing hydrological regime and cutting down the mangrove trees. We quantified ecosystem C stocks by measuring above and belowground biomass, downed wood, and soil C using the SWAMP (www.cifor.org/swamp) protocol.

Restored mangroves had the highest C stocks (922.7±67.5) followed by intact mangroves (856.4±50.1 Mg C ha^{-1}) and disturbed mangroves (591.7±76.9 Mg C ha^{-1}). Overall, there was a significant difference among ecosystem C stocks within the three classes, with intact and restored mangroves having similar and significantly larger C stocks compared to disturbed mangroves ($F_{2,43}$=6.31, p=0.004). Compared to degraded mangroves, our results suggest that restoration of mangrove forests through outplanting of seedling and saplings may maintain or actually increase the carbon stock of degraded mangrove forests.

Evidence of equivalent carbon stocks in restored and intact mangrove patches emphasizes the carbon sink potential for mangrove systems reestablished 20 years ago. Our results demonstrate the long-term carbon storage potential of intact and restored mangroves.

Contact Information: Sahadev Sharma, Department of Natural Resource and Environmental Management, University of Hawaii at Manoa, Sherman Lab 240, 1910 East-West Rd., Honolulu, Hawaii, USA 96822, Phone: 808-936-8546, Email: ssharma@hawaii.edu

SIMULATING THE EFFECT OF MANGROVES FOR REDUCING COASTAL INUNDATION DUE TO STORMS AND SEA LEVEL RISE

Y. Peter Sheng
Civil and Coastal Engineering Program, University of Florida, Gainesville, FL, USA

Mangroves have been found to be able to reduce coastal flooding during storm surges (e.g., Krauss et al. 2009) and tsunamis. However, the ecosystem value of mangroves for coastal flood protection has not been possible because the lack of robust surge-wave models which resolve the effect of mangroves on mean flow and turbulence. Here we present an integrated vegetation-resolving modeling system, the 3D Advanced Coastal Modeling System (ACMS), which consists of the CH3D hydrodynamic model (Sheng et al. 2010a, 2010b, 2012, Lapetina and Sheng 2014, 2015) and the SWAN wave model (Booij et al. 1999, Suzuki et al. 2012). The CH3D model resolves the frontal area, which contributes to the profile drag for the flow, as well as the wetted area of the vegetation, which contributes to the skin friction for the flow and turbulence. While Reynolds stresses are dissipated by the wetted area, turbulent kinetic energy is produced by turbulent wakes behind the frontal area. Both the frontal area and the wetted area vary significantly in the vertical direction. Mangroves provide a large wetted area at its top and large profile area at its prop roots, providing more reduction to mean flow and storm surge than marsh stems. CH3D is the only model that distinguishes profile drag and skin friction drag. CH3D can also simulate the salinity dynamics which can affect the sustainability of mangroves.

The ability of ACMS to simulate flow and turbulence in vegetated water has been verified (Sheng et al. 2012b; Lapetina and Sheng 2014, 2015) by laboratory experiments (e.g., Nepf and Vinoni 2000; Neumeier 2007) and field data in Texas during Hurricane (Lapetina and Sheng 2015). It has been shown to more accurately simulate the effects of coastal marsh (Sheng et al. 2015; Lapetina and Sheng 2015) and mangrove (Zou and Sheng 2015) in dissipating storm surge, wave, and inundation during Hurricane Ike (2009), Sandy (2012), and Andrew (1991), when compared to the results of conventional 2D surge-wave model. ACMS is fundamentally different from the status quo empirical models (e.g., Loder et al. 2009, Bunya et al. 2010, Zhang et al. 2012), which rely on the use of an adjustable empirical Manning coefficient to represent different land use features. Lapetina and Sheng (2015) showed that a 3D model produced much less error (14%) than 2D model with Manning coefficient (64%), based on High Water Mark data at 41 stations during Ike. Sheng et al. (2012) showed that coastal vegetation can reduce the total inundation volume in a coastal area during a hurricane by up to 40%, depending on the horizontal distribution and vertical structure of vegetation as well as hurricane characteristics.

Contact Information: Y. Peter Sheng, University of Florida, Coastal and Oceanographic Engineering Program, 365 Weil Hall, Stadium Road, Gainesville, FL 32611-6580, United States, Phone: 352-294-7764, Email: pete@coastal.ufl.edu

MANGROVE BIODIVERSITY AND A NOVEL SPECIATION MECHANISM -THE MIXING-ISOLATION-MIXING (MIM) CYCLES ON THE INDO-MALAYAN COASTS

Suhua Shi
Sun Yat-sen University, Guangzhou, China

High biodiversity may be a modern "mystery of mysteries" because hotspots usually do not have geographical features that promote speciation by imposing long term isolation. Indo-Malayan coasts, having one of the highest levels of global biodiversity that includes 70 % of the living mangrove species, may offer new insights into the possible connections between biodiversity, geography and speciation. Here, we analyze the pattern of species and population divergence on these coasts by collecting DNA sequences from ~1,700 plants of 5 common mangrove species. This large dataset, superimposed on the extensive biogeographical observations, reveals that mangrove speciation is driven mainly by the isolation at the Strait of Malacca. However, the isolation is periodically punctuated by migration phases due to fluctuations in sea level leading to the opening/closing of the Strait. As a result, speciation has generally proceeded through cycles of isolation and migration, with each cycle averaging 100,000 years. This mechanism of speciation, referred to as the mixing-isolation-mixing (MIM) cycles, supports the view of "speciation with gene flow" but retains aspects of allopatric speciation. In this model, periods of isolation are essential for speciation even though they may be intermittently interrupted. After n cycles, the mechanism could yield m^n (m>1) species at its theoretical maximum and may potentially drive speciation in biodiversity hotspots

Contact Information: Suhua Shi, Sun Yat-sen University, Department of Ecology and Evolution/School of Life Sciences, Room 302, He Dan Qing Hall, #135 Xin Gang Road, Guangzhou, Guangdong 510275, China, Phone: 862084113677,
Email: lssssh@mail.sysu.edu.cn

FISH ABUNDANCE AND SIZE ALONG THE FLORIDA REEF TRACT: THE INFLUENCE OF ADJACENT MANGROVE AND SEAGRASS HABITAT ON A REGIONAL SCALE

Geoffrey S Shideler [1], *Rafael J Araújo* [1], *Brian K Walker* [2], *Joseph E Serafy* [1, 3]

[1]Rosenstiel School of Marine & Atmospheric Science, University of Miami, Miami, Florida, USA

[2]Nova Southeastern University, Halmos College of Natural Sciences and Oceanography, Dania Beach, Florida, USA

[3]National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, Florida, USA

The mangrove-reef subsidy effect has been examined at various scales around the world, ranging from small stretches of continental shorelines, to comparisons among islands, to the wider Caribbean region. Recent work at the wider Caribbean scale (inclusive of Florida) revealed that the abundance of several fishes on reefs tended to increase as total mangrove forest cover in adjacent shallow water systems increased. However, for many studies, including those spanning large geographical areas, a pervasive caveat in the analysis has been the lack of detailed data on submerged habitat area, including the coral reefs and seagrasses. Florida's seascape, in contrast to most others, has been extensively surveyed and mapped for these critical marine habitats, providing an opportunity to test the effects that these coastal vegetated systems might have on the fishes occupying adjacent reefs. In the present study, we examine the regional-scale relationship of Florida mangrove cover and reef fish abundance on the Florida reef tract. Utilizing existing maps and long-term reef fish monitoring data, we test for evidence of the mangrove-reef subsidy effect at the Florida regional level after accounting for other factors including human population density (a proxy for fishing and habitat degradation) and the quantity and configuration of other submerged habitats.

Contact Information: Geoffrey Shidele, University of Miami - RSMAS, 4600 Rickenbacker Causeway, Miami, FL 3314, Phone: 305-421-4624, Email: geoffreyshideler@gmail.com

MANGROVE REGENERATION IN CONTEXT OF SUSTAINABLE FOREST MANAGEMENT: A WEST PAPUA CASE STUDY

Mériadec Sillanpää*[1]*, and Juliana Vantellingen*[1, 2]*,
[1]Green Forest Product and Tech. Pte. Ltd., Singapore
[2]University of Toronto, Toronto, Ontario, Canada

Bintuni Bay, located in the south of the Bird's Head Peninsula of West Papua, Indonesia, contains one of the largest mangrove forests in the world, growing in a variety of conditions and geomorphologies. About 82 000 hectares of the forest is actively undergoing a management regime conducted by PT Bintuni Utama Murni Wood Industries (BUMWI), focused upon woodchip production as well as sustainable forest management. Currently, PT BUMWI is approaching the completion of a 25-year rotation (with stands ranging from 0 to 25 years) which is a good time to examine and evaluate current management practices and their effects on the forest concession. Post-harvest forest regeneration was evaluated in the different aged secondary forest stands using a modified methodology presented by a CIFOR (Centre for International Forestry Research) working paper. Part of a successful regeneration of a forest stand is attaining the range of ecological integrity similar to primary forests

The first objective of the study was to observe if the forest structure and biodiversity in secondary stands, considered as proxies for ecological integrity, would regenerate to similar levels within the 25 years as untouched primary forests. Nonlinear regression was used to determine and predict different forest structure dynamics (sapling and stem densities, tree height, DBH) throughout and beyond the 25 year rotation period. Dynamics in species composition and biodiversity of tree species was also observed.

Results suggest that the forest structure in secondary stands follow a natural succession dynamic throughout the rotation period but do not attain yet the same structure and composition as primary forest at 25 years. Furthermore, forest structure models suggest that the harvest rotation would need to be extended to 30-35 years for the secondary stands to attain similar forest structure and composition to that of primary forests. These observations will help future forest management of the concession as the company will try to attempt to maintain secondary forests in order to achieve the ecological integrity observed in primary forests.

Contact Information: Mériadec Sillanpää, Green Forest Product and Tech. Pte. Ltd., No. 3 Shenton Way, #20-01, Shenton House, Singapore, 068805, Phone: (+65) 8577-5449, Email: meriadec.sillanpaa@outlook.com

GLOBAL TRENDS IN MANGROVE FOREST STRUCTURE

Marc Simard[1], *Lola Fatoyinbo*[2], *Victor H. Rivera-Monroy*[3], *Edward Castañeda*[3], *Charlotte Smetanka*[4] *and Nathan Thomas*[1]

[1]Caltech-Jet Propulsion Laboratory, Pasadena, California, USA
[2]NASA Goddard Space Space Flight Center, Washington D.C., USA
[3]Louisiana State University, Baton Rouge, Louisiana USA
[4]Université de Sherbrooke, Sherbrooke, Québec

We generated global maps of mangrove forest structure and derived relationships with environmental and geophysical variables. The maps were validated with in situ data collected throughout the World and accurately depict forest canopy height and above ground biomass. Maximum canopy height and above ground biomass were found to be strongly related to climatic variables with significant variation with geophysical setting.

Mangrove geographical distribution is taken from baseline maps produced by the United States Geological Survey and the World Wildlife Fund for the 2000 era. These maps exhibit significant distribution discrepancies, and allow for semi-independent (i.e. both maps are produced with Landsat data) assessments of extent accuracy at local and National scales. Canopy height was estimated from data acquired by the Shuttle Radar Topography Mission (SRTM) elevation dataset. The elevation measurements reported by SRTM are impacted by the presence of vegetation, resulting in an elevation bias. It is this bias that we use to estimate canopy height. To ensure SRTM-derived mangrove canopy heights are accurate and globally consistent, they are calibrated with the ICESat/GLAS (Geoscience Laser Altimeter System) estimates of maximum canopy height. Random differences of 5.6m (Root Mean Square Error) between SRTM and GLAS canopy heights were observed globally with R^2=0.78. We found no geographical error patterns in the SRTM-derived estimates indicating global SRTM measurement consistency. The resulting map of canopy height has a spatial resolution of 30meters.

We used allometry relating canopy height and above ground biomass to generate a global map of above ground biomass from the map of mangrove canopy height. The canopy height-to-biomass allometry was derived from in situ measurements of forest structure. We surveyed over 125 plots distributed around the World. For each tree within each plot, we measured diameter at breast height (DBH), tree height and identified species. Plot level biomass was estimated from published species-specific allometric equations relating tree DBH and height to tree biomass. We found a strong relationship between plot level maximum height and above ground biomass (R^2=0.75).

We analyzed the global and regional trends of mangrove forest structure as a function of environmental variables including minimum, mean and maximum temperature, mean precipitation, tidal range, ocean salinity and temperature. The regional analysis was to account for potential region-specific or unforeseen parameter dependencies that may occur from a coast versus another. Clear latitudinal trends were found. A Gaussian function envelope was found to best model the maximum mangrove canopy height as a function of latitude. It is important to note that both temperature and precipitation were strongly correlated with latitude, and the fitted Gaussian envelope intrinsically captures the impact of climate on potential mangrove height and biomass. General ocean variables were not found to be strong drivers of mangrove structure. However, the geomorphological setting was found to be the dominant factor driving the variability of structure found within a given region.

Contact Information: Marc Simard, Jet Propulsion Laboratory, MS 300-319D, 4800 Oak Grove Drive, Pasadena, California, Email:marc.simard@jpl.nasa.gov

CARBON STOCKS IN A SHIFTING ECOSYSTEM; CLIMATE INDUCED MIGRATION OF MANGROVES INTO SALT MARSH

***L.T. Simpson*[1,2,3]**, *T.Z. Obsorne*[2,3], *L.J. Duckett*[1], *and I.C. Feller*[1]

[1]Smithsonian Environmental Research Center, Edgewater, MD, USA
[2]Whitney Laboratory for Marine Bioscience, University of Florida, St. Augustine, FL , USA
[3]Wetland Biogeochemistry Laboratory, Soil and Water Science Department, Gainesville, FL, USA

Across the globe, climate change has driven modifications in the structure, function and distribution of many ecological communities. In parts of the southeastern United States, decreased incidence of freeze events have resulted in the poleward range expansion of mangroves at the expense of salt marsh habitat. The replacement of coastal wetland foundation species will likely have substantial functional and structural repercussions, ranging from important biota effects, to ecosystem stability, to biogeochemical processes. Understanding the long term viability of these habitats and their carbon (C) pools depends on habitat response to shifting regimes. We documented ecosystem C stocks and investigated aboveground decomposition and soil respiration along the Atlantic coast of Florida. The 342 km latitudinal gradient studied spans pure mangrove habitat, the salt marsh - mangrove ecotone, and pure salt marsh habitat and gives us an exceptional opportunity to document and investigate composition, structure and ecosystem function as mangroves transgress into salt marsh habitat. Habitat C pools are constrained by temporal and spatial differences along the latitudinal gradient. Modification of ecosystem services depends largely on the balance between organic matter production and decay, and an alteration in foundation species distribution will likely alter productivity and ultimately the C dynamics of these important systems.

Contact Information: Lorae' Simpson, Smithsonian Environmental Research Center, Edgewater MD, 21037,
Phone: 772-462-0974 Email: simpsonl@si.edu

GETTING TO THE ROOT OF THE PROBLEM: BLACK MANGROVE EXPANSION INTO SOUTHEAST TEXAS SALTMARSHES SMEE, DELBERT LEE, DISKIN, MEREDITH S.

Lee Smee

Texas A&M University – Corpus Christi, Department of Life Sciences, Corpus Christi, TX, USA

Climate change is enabling the redistribution of foundation species with potential consequences for ecologically and economically important ecosystem functions and organisms that are a part of these environments. One example of this distribution shift is evident in the black mangrove expansion into Gulf of Mexico saltmarshes. While the climate mechanism facilitating black mangrove expansion is understood, less is known about the consequences for replacing salt marsh habitat with black mangroves. Since salt marshes are essential habitats to many key species, such as blue crabs and Panaeid shrimp, understanding how vegetation shifts influence these species is of both economic and ecological important. We sampled both benthic and nektonic species and found that salt marsh habitats contain a higher density of shrimp, polychaetes and tanaids when mangroves are not present. These changes could have far reaching effects on trophic interactions within the ecosystem. No significant salinity or temperature differences were found between sites, suggesting that vegetation differences underlie these patterns.

Contact Information: Lee Smee, Texas A&M University – Corpus Christi, Department of Life Sciences, Corpus Christi, TX. 78412, Phone: 361-825-3637, Email: Lee.Smee@tamucc.edu

ENGINEERING COMMUNITY CHANGE FROM THE BOTTOM-UP: MANGROVE EXPANSION ALTERS DETRITAL INVERTEBRATE COMMUNITY COMPOSITION

Rachel S. Smith[1]*, Todd Z. Osborne*[2]*, and James E. Byers*[1]
[1]University of Georgia, Odum School of Ecology, Athens, GA, USA
[2]University of Florida, Whitney Laboratory for Marine Bioscience, St. Augustine, FL, USA

Tropical mangrove species are expanding into temperate saltmarshes worldwide, representing a global, climate-driven transition. Along the north Florida coast, the tropical engineer, black mangrove *Avicennia germanins*, is rapidly expanding into native saltmarshes, replacing the dominant saltmarsh species, smooth cordgrass *Spartina alterniflora*. Both mangroves and saltmarsh are detrital-based systems that perform similar ecosystem functions, but these two ecosystems differ greatly in provided habitat structure, as well as the frequency, quantity and quality of detrital inputs. We were interested in how changed habitat context and the presence of novel detrital inputs affect detrital invertebrate community composition following mangrove expansion. Litter from both *Avicennia* and *Spartina* was placed in mangrove and saltmarsh habitat within the mangrove-saltmarsh ecotone, as well as across a regional gradient of mangrove density from West Palm Beach, FL to Savannah, GA. Detrital invertebrate community composition was assessed after 3 months, and habitat context and identity of detrital input were shown to be important drivers of invertebrate community composition at both the local and regional scale. Crabs were the primary driver of the observed community changes, and an additional structural mimic experiment showed that crabs utilize both saltmarsh and mangrove detritus primarily for structural habitat refuge. Overall, our work suggests that mangrove expansion into saltmarshes may change detrital invertebrate composition by altering both habitat context and the structural qualities of detrital inputs.

Contact Information: Rachel Smith, Odum School of Ecology, 140 East Green Street, Athens, GA 30602, Phone: 804-310-2474, Email: Rssmith218@gmail.com

EFFECTS OF THE INTERACTIONS OF *CERIOPS TAGAL* AND BURROWING CRABS ON MANGROVE SEDIMENT CHARACTERISTICS

***Elise Snavely**, Lucy Gillis, Martin Zimmer and Catherine Lovelock*
Leibniz Center for Tropical Marine Ecology, Bremen, Germany

Sediments in mangrove forests are rich in stored organic carbon. Due to the anoxic nature of mangrove sediments and commonly high sediment accretion rates, organic carbon can be buried in these ecosystems for several thousand years. The burrowing activities of grapsid crabs cause turnover of the sediments which exposes older refractory carbon to oxic conditions, where it is prone to oxidative breakdown, and buries fresher more liable carbon. Burrows also introduce oxygen into deeper layers which directly alters the degradation pathways of organic carbon contained in the sediments. In this field study, we examined how crab burrows, in addition to trees, affected the sediment chemistry and characteristics in a mangrove located in Nudgee Beach, Queensland, Australia. This site was selected because there appears to be link between *Ceriops tagal* trees and burrowing grapsid crab abundance. To investigate how this crab-tree relationship impacts the sediment chemistry and carbon storage potential, in-situ redox measurements were taken beside natural burrows and in the absence of burrows, both near and away from individual *C. tagal* trees. The activity of the bacterial community was assessed using Biolog Ecoplates. Total carbon, total nitrogen and organic matter content and composition were determined from sediment cores collected at 5 and 20 cm depths. To further investigate how burrows impact the sediments, simple vertical artificial burrows were constructed to a depth of 25cm to expose deeper sediments to oxic conditions. The same samples, as above, were collected from beside these artificial burrows to determine changes to redox potential, bacterial communities, carbon, nitrogen and organic matter content and composition that occurred over a two-week period as a result of these simple burrow structures.

Contact Information: Elise Snavely, Leibniz Center for Tropical Marine Ecology, Fahrenheitstrasse 6, Bremen 28203, Germany, Phone: 49042123800162, Email: elise.snavely@leibniz-zmt.de

RATES OF MANGROVE FOLIVORY HIGHER THAN ASSUMED

Wayne P. Sousa
University of California, Berkeley, CA, USA

I present the results of a longitudinal monitoring study of folivory rates in the mangrove forest of Punta Galeta on the Caribbean coast of central Panama. Folivory, the consumption of living leaves by herbivores, has long been considered a significant interspecific interaction structuring terrestrial plant assemblages, but in contrast has been viewed as a relatively unimportant trophic interaction in mangrove forests. While extensive defoliation of mangrove canopies by occasional outbreaks of herbivorous insect populations has been documented in various locations around the world, under typical conditions, herbivores have been thought to consume only a small fraction of live-leaf biomass. This belief that folivory has little impact on mangroves derives from several, frequently cited, older studies that estimated rates of mangrove leaf area loss from levels of standing damage. These studies attributed the modest impact of folivores to high concentrations of putatively defensive chemicals in mangrove leaf tissues, particularly tannins. However, subsequent studies from a variety of forest types have shown that estimates of live-leaf consumption rates from snap-shot samples of missing leaf tissue can greatly underestimate actual rates of loss, by as much as 38 – 81%.

A handful of more recent investigations has estimated rates of folivory in mangroves using the more accurate method of monitoring the fates of marked leaves from initial flushing to maturity. These longitudinal studies have measured considerably higher rates of consumption than were reported by earlier studies. In the study presented here, rates of leaf area loss were measured for newly flushed and paired older leaves on juvenile stages of three species of mangrove, *Avicennia germinans*, *Laguncularia racemosa*, and *Rhizophora mangle*. Folivory rates were also compared for individuals growing inside lightning-generated forest gaps versus the adjacent shaded understory, and among gaps formed in different stand types along the tidal gradient. In addition, a variety of leaf properties thought to influence rates of folivory were assayed, including leaf water content, toughness, nitrogen content, C:N, and tannin concentration. Our main finding is consistent with that of Burrows' (2003) study of folivory in Australian mangroves: actual rates of leaf consumption are considerably higher than traditional estimates made from observations of standing leaf damage. In fact, mangroves suffer losses comparable to those measured for many upland rainforest tree species.

Contact information: Wayne P. Sousa, Department of Integrative Biology, University of California, Berkeley, CA, USA 94720-3140, Phone: 510-643-5782, Email: wpsousa@berkeley.edu

A COMPARATIVE ANALYSIS OF MANGROVE FORESTS AND STRUCTURAL CHARACTERISTICS USING THE PCQM AND PLOT METHODS

Elizabeth M. Jones[1] *and* ***Matthew St. Clair***[2]

[1]Marine Biologist, Cummins Cederberg, Inc., FL, USA

[2]Department of Marine Biology and Fisheries, University of Miami, RSMAS, Miami, FL, USA

Since the 1980's, mangrove forests have experienced rapid declines, at a rate of approximately 1% annually (Polidoro et. al, 2010). Throughout coastal regions of South Florida, mangrove wetlands have been greatly reduced in this time, largely due to coastal development and other anthropogenic impacts (Polidoro et. al, 2010). The loss of mangrove habitat has caused a subsequent decline in animal and plant life supported by these ecosystems, including a number of commercial and recreational fisheries (Fish and Wildlife Service, 1999). Therefore, accurate assessments of forest structure and stand characteristics across mangrove community types requires standard methods that can be readily applied to mangrove forests that range in terms of physiognomy (Ross et. al, 2001).

Comprehensive assessment and monitoring protocols are necessary to identify the extent of mangroves so that effective management strategies can be implemented to prevent continued loss of habitat. Although there are many methods for approximating forest characteristics, literature is limited regarding which methods yield the most accurate representation of an entire forest. Our study aimed to test for statistical differences in structural characteristics between two commonly used methodologies to measure mangrove forests, the plot method and point- centered- quarter method (PCQM). Through the use of both methodologies, we aimed to conclude whether one method more accurately represents the community as a whole, which method is more easily adoptable, repeatable, time and energy efficient, and cost effective.

We conducted two mangrove surveys at Broad Key and Key Biscayne, Florida for a total of four surveys. At each study site, we sampled the forests using the plot method and PCQM. Following quantitative analysis, we can conclude that there are no statistically significant differences between methods when measuring basal area (m^2 /1 ha) and density (stems/1 ha), as p-values>0.05 when running analysis of variance tests (ANOVAs) to compare methods at all four sites. This indicates that both methods yield comparable results to assess overall forest composition and structure. We did find however, that differences in height were statistically significant when comparing the two methods at three of the four study sites, with p-values <0.05. Results varied more widely when comparing the methods based on individual species, versus statistical analyses comparing total results of all species at each study site.

Contact Information: Elizabeth Jones, Cummins Cederberg, Inc., 7550 Red Road Suite 217, South Miami, FL, USA 33143-5318, Phone: 484-941-3544, Email: ejones@cumminscederberg.com

MANGROVE GROWTH FORM AND SALT MARSH INTERACTION ALONG ENVIRONMENTAL GRADIENTS

C. Edward Proffitt and ***Hilary Standish***
Florida Atlantic University, Boca Raton, FL, USA

Rising sea levels and changing climate threaten mangrove growth and survival worldwide. In Florida, mangroves have responded to climate change by slowly migrating northward into traditional salt marsh habitat. Many of these colonists adopt shorter, bushy growth forms, and below ground structure is also affected. However, little is understood about the relationships among mangrove growth form plasticity (plant height, root spread, canopy diameter, etc) and environmental conditions, such as salinity, nutrient concentration, and latitude. By examining how mangrove growth form and salt marsh community structure changes along gradients of latitude, elevation, and other environmental factors, this study will shed light on how environmental conditions determine mangrove growth.

Seven sites have been selected along the eastern coast of Florida, where the size, canopy structure, and root structure of the three mangrove species *Rhizophora mangle, Avicennia germinans,* and *Laguncularia racemosa* are being measured. In addition, the composition and density of neighboring salt marsh plants are being measured at each site, along with elevation, salinity, soil nutrients, light availability, and soil composition. Several predictions have been made about the interrelationships of these variables based on prior studies on both mangroves and other plants. Latitude is expected to greatly impact both mangrove height and canopy diameter, as nutrient partitioning may change under adverse conditions and frost may kill back lateral tips and promote bushier growth. This in turn is expected to inhibit salt marsh growth in areas shaded by mangroves, which may contribute to the long-term dominance of mangroves over salt marsh. These predictions were used to develop hypotheses expressed in the form of a structural equation model, which will evaluate the multivariate relationships between environmental and biotic variables.

Contact Information: Hilary Standish, Harbor Branch Oceanographic Institute, 5600 US-1, Fort Pierce, FL 34946, Phone: 917-846-4085, Email: hstandish2014@fau.edu

SPATIAL PATTERNS OF MANGROVE FOREST EXPANSION IN THE AUCKLAND REGION, NEW ZEALAND

***Suyadi*[1,2], *Jay Gao*[1], *Carolyn Lundquist*[3,4], *Luitgard Schwendenmann*[1]**

[1]School of Environment, University of Auckland, Auckland, New Zealand
[2]Indonesian Institute of Science (LIPI), Ambon, Indonesia
[3]Institute of Marine Science, University of Auckland, Auckland, New Zealand
[4]National Institute of Water and Atmospheric Research, Hamilton, New Zealand

Mangrove forest cover has increased in many estuaries of the North Island of New Zealand over recent decades. The expansion of mangrove forests has led to a push towards mangrove removal largely driven by local communities. To inform future mangrove management a detailed assessment of the spatial patterns of mangrove cover change is required. Only one mangrove species (*Avicennia marina* subsp. *australasica*) occurs in New Zealand. However, the monospecific stands differ in density and tree size along landward-seaward gradient. Taller trees (up to 6 m) are found near the seaward fringe or along tidal channels whereas trees in the interior are often more stunted (dwarf mangroves, 0.5-1 m). The objectives of this study were: to estimate the change in mangrove area of tall and dwarf mangroves and to assess the spatial pattern of mangrove cover change across all estuaries in the Auckland region between 1940 and 2014. We also investigated the relationship between the size of the watershed and subwatersheds and mangrove expansion rates. Watershed/subwatershed area was used as an indicator of sediment yield.

Aerial photographs, thematic maps, and Landsat images were used and ground truth field surveys were conducted. Mangroves were classified into four groups (shoreline, estuarine, riverine and delta mangroves) based on their location within the estuary. Within each group mangroves were classified into tall and dwarf trees based on stem density, canopy height, canopy coverage, and vegetation index. We developed an improved image analysis using a combination of ground control points and template matching, water column correction, and integration of parametric and non-parametric classifiers.

Mangrove forest cover in the Auckland region (492,131 ha) increased from 2,300 ha in 1940 to 10,400 ha in 2014. The annual increase rate was 4.8%. However, the expansion rates differed considerably between dwarf (20% y^{-1}) and tall mangroves (1% y^{-1}); estuary size (4-10% y^{-1}) and decades (5-11% y^{-1}). Mangroves were primarily expanding mid-river (33%) and seawards (28%). However, mangroves expanded also sideways of the river mouths (24%) and upstream (15%). The image analysis showed that dwarf mangroves dominate in shoreline, estuarine, and delta mangroves. A backward linear regression analysis revealed that watershed area (r^2 = 0.53, p< 0.05) and subwatershed areas (r^2 = 0.21, p< 0.05) were significant predictors of the rate of mangrove forest cover change.

These result demonstrate that a detailed pattern analysis of different mangroves groups is required to understand the dynamics of mangrove forest cover across scales and its relationship with upland areas (watershed).

Contact information: Suyadi, School of Environment, The University of Auckland, Private Bag 92019, Auckland 1142, New Zealand, Phone: +64 22 078 4699, Email: suy041@aucklanduni.ac.nz

LATERAL CARBON AND NUTRIENTS EXCHANGES IN A LOW LATITUDE MANGROVE TIDAL CREEK: A MULTI-STABLE ISOTOPE APPROACH

***Pierre Taillardat*[1]*, Alan D. Ziegler*[1]*, Daniel A. Friess*[1]*, David Widory*[2]*, and Cyril Marchand*[3]
[1]Department of Geography, National University of Singapore, Singapore
[2]GEOTOP - Department of Earth sciences, Université du Québec à Montréal, Montréal, Canada
[3]Institut de Recherche pour le Développement, Ho Chi Minh City, Vietnam

Mangroves act as both a sink and a source of carbon and nutrients within the tropical coastal marine environment. While their carbon storage role is well documented, less is known about the biogeochemical exchanges occurring with tides between mangrove sediments and tidal creeks. Paradoxically, the amount of carbon durably stored in the biomass and soils only constitutes a small fraction of the autotrophic production. Most of the carbon produced by mangrove vegetation is decomposed, mineralized, and exported to adjacent coastal ecosystems. Quantifying the origins, concentrations, composition, and transformation processes of carbon and nutrients in mangrove tidal creeks is highly relevant for understanding the fate of mangrove produced/transformed organic matter. This study determined (a) the importance of lateral carbon and nutrients fluxes, from the mangrove soil and the water column, in a mangrove tidal creek, and (b) the significance of the contribution of subsurface groundwater discharge (SGD) in this process.

Carbon (C), Nitrogen (N), and Phosphorus (P) exchanges between sediments and tidal creek were studied in a highly productive mangrove in Can Gio, UNESCO Biosphere Reserve, Vietnam. These three elements were quantitatively (concentrations) and qualitatively (multi-stable isotope approach) described under their dissolved (DOC, DIC, $\delta^{13}C_{DOC}$, $\delta^{13}C_{DIC,}$ PON, NH_4, NO_3, NO_2, PO_4, $\delta^{15}N_{NO3}$ & $\delta^{18}O_{NO3}$) and particulate forms (POC, PON, $\delta^{13}C_{POC,}$ $\delta^{15}N_{PON}$). Additionally, carbon dioxide (CO_2) dynamics were also addressed, both in the water column, and at the water – atmosphere interface. First, dynamics were studied in 24-h time series operated (x4) at the end of the dry and wet seasons in 2015 to describe the influence of physical parameters (e.g. seasons, day light, tide, and rain) on their dynamics. Second, porewater biogeochemical properties were studied along a transect from the tidal creek to the inner mangrove; with samples collected in mud-flat, *Avicennia* and *Rhizophora* stand, respectively. Finally, the relationship between those two distinct components was described, using radon concentrations (^{222}Rn). This work sheds light on the existing influence of subsurface groundwater discharge (SGD) on the studied elements export to the tidal creek water.

Our results show that a large amount of the organic and inorganic matter produced by the mangrove vegetation is transferred via surface runoff and subsurface groundwater discharge (SGD). In addition, tidal creek, particularly at low tide, acts as a source of carbon to be reemitted into the atmosphere - under its gaseous phase (CO_2), and in the coastal ocean via the tidal pumping process – under its dissolved and particulate phase. Unlike Phosphorus, concentrations and availability of the dissolved forms of nitrogen species are also correlated with tidal variations: NH_4 being higher at low tide while NO_3 being higher at high tide. Nitrogen and oxygen stable isotope compositions of nitrate ($\delta^{15}N_{NO3}$ & $\delta^{18}O_{NO3}$) were studied and are providing essential information for understanding N transformation mechanisms and their potential implications for the carbon production and transformation processes.

Contact Information: Taillardat Pierre, National University of Singapore – Geography Department, 1 Arts Link, Singapore 117570, Phone: +65-8669-5619, Email: taillardat.pierre@u.nus.edu

GENETIC AND EVOLUTIONARY CONSEQUENCES OF EXTREME LONG-DISTANCE SEED DISPERSAL OF THE MANGROVE GENERA, *RHIZOPHORA* AND *HIBISCUS*

Koji Takayama [1]; *Yoichi Tateishi* [2]; *Jin Murata*[3]; *Tadashi Kajita* [3]

[1]Museum of Natural and Environmental History, Shizuoka
[2]Faculty of Education, University of the Ryukyus, Okinawa, Japan
[3]Botanical Gardens, Graduate School of Science, The University of Tokyo, Tokyo, Japan
[4]Iriomote Station, Tropical Biosphere Research Center, University of the Ryukyus, Okinawa, JAPAN

The global distribution of mangroves is attributed to interactions between geographical barriers and long-distance seed dispersal via ocean currents, which are manifest in species distribution, genetic structuring and evolutionary history. Extreme long-distance dispersal (ELDD), especially, is an important process in mangrove biogeography, because such events can lead to changes in distribution ranges of mangrove species, to rapid diversification due to founder effects, and to secondary contact with sibling species.

Revealing the genetic and evolutionary consequences of ELDD in mangrove species, we conducted chloroplast and nuclear DNA sequencing and microsatellites analyses in *Rhizophora* and *Hibiscus* species collected worldwide. Both genera have pantropical distribution in the coastal area. According to the current distribution patterns of each species in *Rhizophora*, the East Pacific and African continent are the biggest geographical barriers for dispersal. On the other hand, in *Hibiscus*, the East Pacific and Atlantic are the ones.

The global phylogeographic analyses indicated the presence of ELDD in each genus and the difference of these consequences. In the case of *Rhizophora*, the genetic disjunction between Indo-West Pacific (IWP) and Atlantic-East Pacific (AEP) was strongly supported by all molecular markers. Molecular data also supported that IWP and AEP lineages met in South Pacific Islands by EDLL after long-term isolation (11 million years), and then produced the sterile hybrid, *R.* × *selala*, in these areas. In the case of *Hibiscus*, the genetic disjunction between Old World and New World species was strongly supported by nuclear DNA markers but not by chloroplast ones. Significant introgression between the two species occurred in Atlantic populations of New World, which might be caused by past EDLL from the African continent (no older than 3.6 million years). These results suggested that EDLL could bring different evolutionary dynamics depending on the development of reproductive isolation among sibling species.

Contact Information: Koji Takayama, Museum of Natural and Environmental History, Shizuoka, 5762 Oya, Suruga-ku, Shizuoka-shi, Sizuoka, JAPAN 422-8017, Phone: 81-54-260-7111, Email: gen33takayama@gmail.com

PRESENT STATUS OF MANGROVE RESTORATION IN BATTICALOA DISTRICT, SRI LANKA: IS IT SUCCESS?

Mathiventhan Thavanayagam *and Thangamuthu Jayasingam*
Department of Botany, Eastern University, Sri Lanka

Mangroves are discontinuously distributed along the coastline, surrounding lagoons and estuaries around Sri Lanka. Recent remote sensing studies have indicated that there are 6,296 ha of mangroves in the districts of Colombo, Ampara, Gampaha, Trincomalee, Batticaloa and Puttalam alone, and the total area of mangroves is likely to be close to 9,500 ha as indicated in 1996. Batticaloa has significant mangrove cover (around 1606 ha), but it is reducing in recent past. According to the data available, around 500 ha of mangroves had been reduced for a period of 22 years from 1985 to 2007, with an average annual change of 1.15%. The mangrove cover is not estimated in the recent past in the Batticaloa district.

Restoring mangroves is one of the alternatives to increase the area, which already lost. Restoration of mangroves had been mainly taken place around three estuaries (Batticaloa, Valaichenai and Vaharai) in the Batticaloa district. The restoration activities are improved significantly after the 2004-Asian Tsunami, which is severely affected the district. Mangrove restoration had been taken place mainly around the Batticaloa estuary while the other two estuaries shown limited restoration. It was noted that *Rhizophora apiculata* is the only species used for planting since 2006, as isolation and groups of 10-30 individuals. *Bruguiera* sp. and *Exoecaria* sp. were planted in minor scale. Around 160,500 numbers of seedlings of *Rhizophora apiculata* were planted in 15 sites, covering three divisional secretariat divisions. But at the end of 2014, there were 169 individual plants survived. More than 90% of the planted sites failed to establish mangroves and the success rate was 0.1% in Batticaloa district. Various studies revealed that failures are more common than success in mangrove replanting programme all over the world and it is more prominent in low tidal countries, like Sri Lanka.

Mangroves grow naturally in mixed-species of stands. Mixed-species planting have been recommended together with large-leave mangrove *Bruguiera gymnorrhiza* while restoring the mangroves. In our case, *Rhizophora* was planted as monoculture in Batticaloa. It is advisable to plant mixed mangroves, which shows better growth performance and more resilience for external shocks. The ambient level of mud and water coverage is another factor determines the success of mangrove restoration, but in the case of Batticaloa estuary, it is less favorable. Local knowledge, history of the restoration site and a suitable reference site are indispensable for early designing of the restoration site scientifically; such approaches were lacking in this case. Post planting care is also important to successfully restore the site, while in this case post planting care is minimal and the planted seedlings were damaged physically during the cattle movement, canoe riding by the fishers. Dumping household wastes into and the bank of the estuary also damage the seedlings. Long term post-plant management and protection measures were not practiced, due to financial restriction. In addition to that, impacts of two flood incidences in 2011 and 2012 in Batticaloa further exacerbate the existence of the planted seedlings.

In assessing the success of mangrove restoration, both positive and negative impacts need to be considered as indicated above and this emphasis on a proper scientific planning. It is important to scientifically assess the stress factors before be a large capital investment in growing mangrove seedlings in a nursery. This possibly prevents major failures while restoring the mangroves.

Contact Information: Mathiventhan Thavanayagam, Department of Botany, Faculty of Science, Eastern University, Sri Lanka, Phone: +94 779 684 166, Email: tmathiventhan@gmail.com

MANGROVE RESTORATION IN THE SOUTH PICHAVARAM MANGROVE FORESTS, SOUTH EAST COAST OF TAMIL NADU, INDIA

RAMANATHAN THIRUGNANA SAMBANDAM
Centre of Advanced Study in Marine Biology, Faculty of Marine Sciences, Annamalai University, PTamil Nadu, India

In India, Pichavaram has a well developed mangrove forest. Pichavaram consists of a number of islands interspersing a vast expanse of water covered with green trees. The area is about 1100 Hectare and is separated from the sea by a sand bar. They cover one third of the population, most of which has been severely overexploited. Worldwide concern to conserve mangroves necessitated propagation of mangroves to re-establish them on barren and swampy land along tidal creeks around South Pichavaram mangrove forest of Tamil Nadu. *Avicennia officinalis*, *Aegiceras corniculatum*, *Bruguiera cylindrica, Ceriops decandra*, *Excoecaria agallocha*, *Rhizophora mucronata*, *R. apiculata* were vegetatively propagated and planted over 5 ha of degraded salt-marshy wetlands of South Pichavaram in pure and mixed stands depending on the intensity and the frequency of tidal inundation at the experimental site. Survival was significantly higher (75%) in *R. mucronata* followed by *Avicennia marina, A. officinalis* and *Excoecaria agallocha.* (60–65%). *Avicennia marina* recorded the maximum growth in height (2.5 m after 2 years) whereas *C. decandra* showed the minimum growth (0.5 m). Growth performance was better with plants in mixed stands than the plantation with single species. This gives us hope to propagate and re-establish mangroves for conservation in scientifically managed plantations in a physiologically arid environment.

Contact Information: RAMANATHAN THIRUGNANA SAMBANDAM, Centre of Advanced Study in Marine Biology,Faculty of Marine Sciences, Annamalai University, Parangipettai – 608 502, Tamil Nadu, India, Phone: +91 – 9894175200,
Email: drtrcasmb@gmail.com or marinepharmacology@gmail.com

STRUCTURAL COMPARISONS OF NATURAL VERSUS SEA WALL SHORELINE MANGROVE FORESTS

Michael R. Timm *and Rafael J. Araújo*
Rosenstiel School of Marine & Atmospheric Science, University of Miami, Miami, Florida, USA

Recently, there has been growing interest in understanding and comparing the ecological role of artificial or restored mangroves vis-à-vis natural vegetative shorelines. These comparisons have focused on differences in community structure, mostly fishes, but have not examined if the structure of the mangrove shoreline differs between natural and artificial forests. In this study, we compared the structural complexity of mangrove fringes between natural and sea wall shorelines in Sanibel Island, Florida. Two sites were chosen for natural (East Gulf Drive) and sea wall (Beach Road) mangrove fringes on Sanibel's east end in the Shell Harbor canal system. We sampled two 10 x 6 m plots at each of the two (natural and sea wall) sites using standard structural methods to measure tree height, diameter at breast height (DBH), basal area, density, and mean stand diameter for red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), and white mangrove (*Laguncularia racemosa*). At both sites, we compared leaf length, width, and area for *R. mangle* sun leaves. We also recorded percent light transmission inside and outside the canopies. Our results indicated no significant structural differences between natural and sea wall shoreline mangrove forests (DBH; basal area; percent light transmission; and leaf length, width, and area) but species composition differed between sea wall and natural shorelines with *R. mangle* exhibiting higher relative dominance, frequency, and density at sea wall sites. Our results indicate that sea wall mangrove forest structures are comparable to natural shorelines and may represent structural complexities approaching or equaling those of classical fringe forests (sensu Lugo and Snedaker 1974). However, we observed a significant difference (two-tailed *t*-test, $P < 0.0001$) between natural and sea wall sites when comparing tree heights. Our results suggest that mangroves in sea wall-lined waterways could provide the same ecosystem functions based on structural complexity as mangroves in a natural setting. Results of this study could support the need for restoration of mangroves in developed areas and assist urban landscaping for engineering hybrid man-made mangrove ecosystems that promote mangrove propagule settlement, structural complexity, and ecosystem functions.

Contact Information: Michael Timm, Rosenstiel School of Marine & Atmospheric Science, University of Miami, Marine Ecosystems and Society, 4600 Rickenbacker Causeway, Miami, FL 33149, Phone: 305-421-4000,
Email: mtimm@rsmas.miami.edu

SEA LEVEL RECONSTRUCTIONS FROM THICK MANGROVE PEAT DEPOSITS IN FLORIDA, BELIZE AND PANAMA – AGE AND PALEO ELEVATIONS OF BASAL PEATS VS. CONTINUOUS SAMPLING, AND RELATIONSHIP TO GEOPHYSICAL SEA LEVEL MODELS.

Marguerite A. Toscano[1]*, Juan L. Gonzalez*[2]*, Kevin R.T. Whelan*[3]*, W.R. Peltier*[4]

[1]Smithsonian Environmental Research Center, Edgewater, MD, USA
[2]University of Texas-Rio Grande Valley, Edinburg, TX, USA
[3]National Park Service, Miami, FL, USA
[4]Universty of Toronto, Canada

Holocene mangrove peat deposits have been utilized to document rising sea levels for the past 8 kyrs from Florida to South America. While several studies, particularly in Belize, documented thick mangrove peat deposits that accumulated in response to rising sea level, issues with radiometric dating of peat (bioturbation, root contamination, age reversals) and factors affecting preservation of paleo peat elevations (decomposition and compaction) affect age accuracy and elevation constraints required of peats used as sea level index points. Compaction (due to decomposition and/or overburden pressure) is assumed to lower paleo elevations of intermediate depth samples in all peat forming environments such that current accepted procedure is to use only basal peats obtained on hard substrates as sea level index points because these cannot be further compacted. This not only limits the elevation range of sea level index points at any locality, it ignores the potentially complete sea level record stored in the overlying peat up to present sea level. It also assumes that the timing of basal peat formation corresponds to the timing of sea level arrival at the same elevation.

This study builds on previous work in the Florida Keys and the Mesoamerican Barrier Reef in Belize, where thick *Rhizophora mangle* peat deposits record Holocene sea level rise in open ocean areas unconnected to ongoing terrigenous sediment inputs. We collected and dated basal peats from the available range of bedrock depths on pre-Holocene topography of the Key Largo Limestone (Biscayne National Park, FL) and offshore Pleistocene carbonate banks in Belize. We took continuous long cores at each site, performed LOI, XRD and CT analyses to assess compaction, if any, of each peat sequence, then sampled and dated intermediate depths in the long cores corresponding to the depths of the nearby basal peats. We documented significant lag times of formation of basal peats at each locality compared to un-compacted continuous peats, and determined the errors these basal lags impose on sea level reconstructions.

Our new peat data are plotted with independently modeled ICE-6G relative sea level (RSL) curves for Florida, Belize, and Caribbean Panama to assess the utility of basal and intermediate *R. mangle* peat as sea level indicators. We make comparisons with related *Acropora palmata* coral-based sea level index points at each site, and infer tectonic influences affecting both peat and coral age/depth relationships in each area relative to the RSL models. These analyses provide insights into the interpretation of sea level-related datasets in varied geophysical settings, and whether geologic data should be interpreted in the context of modeled RSLs rather than used to develop sea level curves directly.

Contact Information: Marguerite A. Toscano, Smithsonian Environmental Research Center, 647 Contees Wharf Road, Edgewater, MD, 21037-0028, Phone: 202 633 1649, Email: toscanom@si.edu

A CASE STUDY OF ECOLOGICAL MANGROVE RESTORATION IN PORTLAND COTTAGE, JAMAICA

Chalene Roye-Myrie[1] *and* ***Camilo Trench***[2]
[1]National Environment and Planning Agency, Jamaica
[2]The University of the West Indies, Department of Life Sciences, Mona, Kingston, Jamaica

Jamaica has several towns and communities established within or in close proximity to coastal Mangrove forests. Portland Cottage in the southern parish of Clarendon is one such community with a population showing varying levels of dependence on the adjacent mangrove forests. The general area was severely affected by Hurricane Ivan (2004), which caused loss of human life, destruction of houses and the toppling of thousands of acres of mangrove trees. Extensive blocking of tidal channels occurred resulting in the slow of mangrove, due to anoxic and hyper-saline conditions.In April 2013, the National Environment and Planning Agency with assistance from the University of the West Indies (UWI) and European Union (EU) funding embarked on the ecological restoration of 5 hectares of mangrove forest. This project sought to rehabilitate and ultimately restore the ecological character and functional capacity of the forest. Activities included the construction of tidal canals, planting of nursery grown saplings and collected propagules, and fencing to exclude grazing by goats. Combining adaptive management techniques with intensive community involvement further enhanced the success of the project. This included training stakeholders to develop their skills in ecosystem monitoring.

The project site was monitored and after twenty five (25) months; there was 40% survival of planted mangrove saplings with development of prop roots and/or pneumatophores. Transplanted and naturally recruited seedlings accounted for an impressive increase in overall seedling density of 127% relative to Time Zero (September 2012) as well as a 1:2 ratio of transplanted versus naturally recruited seedlings. A successful mangrove restoration programme requires more factors to be assessed than seedling survival and recruitment. However, seedling survival in particular carries a heavy weighting in the evaluation process, as this indicates suitable tidal flow and hydrology in the transplant area. Since their initial planting, the mangrove forest has responded positively to ecological restoration approach.

Contact Information: Camilo Trench, The University of the West Indies, Centre for Marine Sciences, Mona, Kingston 7, Phone: 876 973-2241, E-mail: camilo.trench@uwimona.edu.jm

PALISADOES MANGROVE RESTORATION BY THE UWI

***Camilo Trench**, Mona Webber and Hugh Small*
The University of the West Indies, Department of Life Sciences, Mona, Kingston, Jamaica

Mangrove forests are the dominant coastal forest type in Jamaica covering approximately 9731 hectares or 97 km^2. Large areas of mangrove forest have been reclaimed since the country's discovery in 1492 and more-so during the post-sugar era. Though the rate of coastal development and thus mangrove destruction has slowed significantly since the 1990's, developmental pressure still persists with mangrove removal primarily to facilitate tourism and transport infrastructure.

The Palisadoes tombolo was altered to facilitate the airport and Port Royal roadway in the 1970's. Due to rising sea levels and violent hurricanes, especially post 2000, the roadway was being regularly inundated by the Caribbean Sea and blocked by sand from the dunes along the Palisadoes tombolo. The Jamaica government through the National Works Agency embarked on a project to raise and stabilize the roadway with large rock revetments. This work resulted in the removal of approximately 6000 m^2 of mangrove area (or just over 6,000 plants).

The University of the West Indies, Department of Life Sciences and Centre for Marine Sciences signed an MOU with the NWA in 2014 to effect the restoration of these lost mangroves through the replanting of a similar quantity of mangrove trees. Under the agreement, some of the obligations of the UWI were:
1. To provide the seedlings and plants (6,396 mangrove of mixed species) for replanting
2. Provide the manpower for replanting and monitoring of the project
3. Replace plants lost during the replanting and monitoring exercise to maintain a density of no less than 50 mangrove seedlings per 100 m^2

The UWI team conducted the baseline scientific studies, supervised the re-creation of the ideal mangrove forest slope at two sites along the Palisadoes and provided hardened 3-4 year old saplings from the mangrove nurseries. The project designed and implemented a solid waste management system to protect the young plants from the large quantities of solid waste that wash into Kingston Harbour especially during periods of heavy rainfall.

Four (4) months of monitoring has indicated a mean survival for all areas being 85.6%. Mangrove sapling survival is the most important index in these early stages as this indicates whether the species have adapted to their new environment. This mangrove rehabilitation has so far been very successful with minimal issues and good survival.

This mangrove rehabilitation project has been the most visible in Jamaica to date. It will not only see the regaining of greenery and ecological mangrove functions, but will provide valuable data and insight as the trees become established in an area that was severely altered and required ecological engineering.

Contact Information: Camilo Trench, The University of the West Indies, Centre for Marine Sciences, Mona, Kingston 7,
Phone: 876 973-2241, E-mail: camilo.trench@uwimona.edu.jm

ECOLOGICAL ROLE OF MANGROVE CRABS IN THE PACIFIC COAST OF COLOMBIA

***Natasha Valencia-Martínez**, and Jaime Cantera*
Ecomanglares, Universidad del Valle, Cali, Colombia

The influence of crustaceans in mangrove trophic systems was studied in the Pacific coast of Colombia, sampling in 3 localities of Buenaventura and Málaga bays, during two contrasting weather seasons, taking in to account 3 representative habitats: mud flats, mangrove roots and tidal pools. As most representative organisms 20 species of crabs and shrimps were identified. A descriptive model of contribution to the trophic web was developed in terms of biomass for different crustaceans groups. *Goniopsis pulchra* is the dominant species of mangrove roots habitat, the shrimp *Alpheus colombiensis* of tidal pools; and *U. vocator, U. stylifera* and *U .thayeri* of muddy flats in and out of the mangroves. With regard to biomass, the species that are constant between localities, like, presented greater contribution than species found in particular localities, without being the most abundant like *G. pulchra*, this could be related with its habits in the forest development. Systems are mainly represented by omnivorous species and some herbivorous, like *Ucides occidentalis*, being not only an important member providing biomass but also integrating energy into the system, conserving and oxygenizing the soil.

Contact Information: Natasha Valencia-Martínez, Universidad Del Valle, Cali, Colombia.
Email: natasha.valencia@correounivalle.edu.co

LONG TERM VEGETATION CHANGES IN ROOKERY BAY NATIONAL ESTUARINE RESEARCH RESERVE 1940-2012

Craig van der Heiden
Institute for Regional Conservation, Delray Beach, FL, USA

Coastal ecosystems form a natural front and barrier to the influence of marine waters on inland systems. However, worldwide sea-level rise is having catastrophic effects on low-lying coastal ecosystems. The coastal ecosystems of south west Florida are highly susceptible to sea level rise. Studies monitoring plant community dynamics, in relation to sea-level rise, have demonstrated that changes result from flooding by saline water and species with a greater tolerance becoming more established as the salt sensitive species die-back. We examine vegetation changes from aerial photographs taken in the 1940 to current in Rookery Bay National Estuarine Research Reserve. Data show the most significant vegetation changes in total area are from marsh vegetation types transitioning towards mangrove dominated communities. The vegetation changes with the highest loss of biodiversity are reduction in pine and palm woodlands to button wood communities. The probable causes of these dramatic changes include rising sea level, a reduced freshwater flow from upstream and “ditches/canals” that bring tides further in when freshwater flow is at minimum (dry season).

Contact Information: Craig van der Heiden, Institute for Regional Conservation, 100 E Linton Blvd, Delray Beach, FL 33483, Phone: 561-573-6302, Email: craig@regionalconservation.org

A MODELING STUDY ON THE ROLE OF DISPERSAL VECTOR INTERACTIONS IN THE POTENTIAL FOR LONG DISTANCE DISPERSAL IN MANGROVES

Tom Van der Stocken[1] *and Dimitris Menemenlis*[2]
[1]Vrije Universiteit Brussel (VUB), Brussels, Belgium
[2]Jet Propulsion Laboratory, California Institute of Technology, CA, USA

Mangrove forests are systems that provide ecosystem services and thrive at the edge of sea and land in the (sub)tropical areas of the world. They rely on floating propagules (*i.e.*, seeds and fruits) of which the dispersal trajectories are determined by ocean currents and winds. Quantifying connectivity of mangrove patches is an important conservation concern. Current estimates of connectivity, however, fail to integrate the link between ocean currents at different spatial scales and dispersal trajectories. Overall, this research aims to integrate interactions between propagule and vector properties and assess the role of these factors in determining effective dispersal in this enigmatic group of ocean faring trees. Here, we use high-resolution estimates of ocean currents and surface winds from meteorological and oceanographic analyses, in conjunction with experimental data on propagule and dispersal vector properties, to model dispersal trajectories of mangrove propagules in the Mozambique Channel. Model output shows the effect of oceanographic features such as eddy activity and tidal motion on dispersal tracks. In spite of the complex pattern of ocean surface currents and winds, some propagules are able to cross the Mozambique Channel. Our results demonstrate that wind can facilitate or counteract hydrochorous dispersal and hence determine the potential for long distance dispersal (LDD). Numerical modeling of mangrove propagule dispersal trajectories is a tool that can be used to explain past and current distributions of mangrove forests and assess the potential for natural expansion of these forests.

Contact Information: Tom Van der Stocken, Laboratory of Plant Biology and Nature Management, Vrije Universiteit Brussel (VUB), Pleinlaan 2, B-1050 Brussels, Belgium, Phone: +32-4-77304176, Email: tvdstock@gmail.com

BIODIVERSITY CONSERVATION IN SOCIAL-ECOLOGICAL SYSTEMS: THE LAST(ING) MANGROVES OF SINGAPORE

***Katherine Vande Velde[1]**, Jean Hugé[1], Daniel Friess[2], Nico Koedam[3] and Farid Dahdouh-Guebas[1]*

[1]Département de Biologie des Organismes, Université Libre de Bruxelles, Brussels, Belgium
[2]Department of Geography, National University of Singapore, Singapore
[3]Biology Department, Vrije Universiteit Brussel, Brussels, Belgium

Defining 'effective' biodiversity conservation is inhibited by the continued lack of agreement on 'what matters' in conservation. This is leading to uncertainty surrounding social and ecological best practices (i.e. conservation methods and objectives), while the need for more integrated and effective biodiversity conservation action remains high and urgent.

We consider the case of Singapore, which has lost almost 90% of its once extensive mangrove cover, causing a substantial decline in biodiversity and ecosystem service provision. Recent efforts have been made by the Singapore government to preserve some of these remaining fragmented mangrove forests (e.g. gazetting of Sungei Buloh Wetland Reserve in 2002). However, the question remains whether existing biodiversity conservation efforts are effective, based on social and ecological criteria.

As conservation objectives and approaches are multidimensional, we propose an open interpretation of 'effectiveness' of biodiversity conservation, based on multiple sources of knowledge and interpretations of what matters in mangrove conservation in the Singapore context. Our analytic framework is built on the paradigms of: (i) inclusive conservation and (ii) evidence-based conservation. To map and analyse discourses (integrating ecological and social knowledge) of local mangrove conservation we used the Q methodology, which studies participant's subjectivity and viewpoint (i). To review and summarize evidence-based ecological knowledge spread among experts we used the Delphi method, a systematic technique that synthesises expert-led, group judgements on a topic (ii). These are well-established methods used to move debate to productive grounds and bring new insights (e.g. effectiveness criteria) in different research fields.

The integration of these methods clarified the combinations of effectiveness criteria that would result in more or less effective biodiversity conservation for the locally (i.e. in Singapore) expressed objectives. Ultimately, this study aims to identify areas of conflict between discourses and evidence-based knowledge and assess possible remediating solutions through increased understanding of what constitutes effective biodiversity conservation for Singapore's threatened mangroves.

Contact Information: Katherine Vande Velde, Université Libre de Bruxelles, Avenue Franklin Roosevelt 50 - 1050 Bruxelles
Phone: +32 (0)488 23 23 50, Email: kathvdev@ulb.ac.be

DEVELOPING TOOLS FOR SUSTAINABLE MANGROVE FOREST MANAGEMENT IN WEST PAPUA, INDONESIA: ASSESSING SUSTAINABLE HARVEST YIELDS AND REGENERATION STRATEGIES

***Juliana Vantellingen*[1,2]*, and Mériadec Sillanpää*[2]**
[1]University of Toronto, Toronto, Ontario, Canada
[2]Green Forest Product and Tech. Pte. Ltd., Singapore

Building upon a study on regeneration and ecological integrity of secondary mangrove forests, this paper studies the mangrove forests in West Papua, Indonesia from a forestry perspective. The region has a huge area of mangrove forest that is currently at the end of a 25 year harvest cycle undertaken by PT Bintuni Utama Murni Wood Industries (BUMWI). This presents a huge opportunity for researching the first occurrence of secondary forest, and specifically for enhancing knowledge towards future sustainable harvests. Having well planned, informed management can enhance various aspects of sustainability, being capable of producing the same amount of yield from a harvest stand over successive rotations, while maintaining a steady flow of economic benefits. It also allows for other areas of mangrove forest to remain in their untouched state.

Based upon data collected in secondary forests of various ages, we present tools for the sustainable management of mangrove forest in West Papua, Indonesia, specifically focusing upon achieving sustainable harvest yields and maximizing stand productivity. This has been translated into studying the optimal rotation period to capture sustainable volumes and assessing planting strategies that would maximize yield within production stands. Using chronosequence data, an investigation of forest yield over time was implemented using nonlinear regression to determine if yields were comparable to those in primary forests. Mean annual increment (MAI) and periodic annual increment (PAI) were also calculated in order to estimate the biological rotation age of secondary mangrove forest. Finally, a model of forest yield was created using multiple regressions incorporating various stand characteristics (stand age, density, species richness and diversity) as predictors. This model was then used to simulate several scenarios of regeneration strategies to determine whether forest yield could be optimized using active management practices.

Results suggest that the current rotation of 25 years does not achieve comparable yields to those of primary forests, nor had the optimal biological rotation been reached based on incremental growth. These results suggest an extended rotation might be needed to produce sustainable forest yields. Forest yield was found to be predicted by stand age, density, species richness and diversity. Modelling regeneration scenarios found that planting can achieve higher yields than allowing natural regeneration to take place. Variations in species richness and diversity had a significant impact on forest yield; plantings that mimicked natural species distributions achieved the greatest yields as opposed to monocultures or evenly mixed forests. These findings have implications for future management of mangrove forests in West Papua as these tools can be used going forward to optimize harvest yields within already existing secondary forests through rotation length and planting tactics.

Contact Information: Juliana Vantellingen, Forestry Faculty, University of Toronto, 33 Willcocks Street, Toronto, M5S 3B3, Ontario, Canada. Phone: (+1) 506-999-2114, Email: juliana.vantellingen@mail.utoronto.ca

MANGROVE-BASED LIVING SHORELINES ALONG SHORELINES DOMINATED BY SHELL MIDDENS

Linda Walters[1], *Melinda Donnelly[1], Paul Sacks[2], Michelle Shaffer[1], Christian Pilato[1], Suzanne Connor[1], Kelly Kibler[1]*

[1]University of Central Florida, Orlando, FL, USA
[2]Winter Springs High School, Winter Springs, FL, USA

Native Americans created extensive refuse piles (shell middens) along coastal shorelines in the Southeastern United States. Many of these archeologically significant middens are now being washed away as erosion from wind and boat wakes repeatedly pounds the edges of the midden shorelines. To protect these locations, we have employed living shoreline techniques appropriate for the east coast of Florida. These efforts include stabilized oyster shells in the low intertidal (contained in bags or attached to mesh mats), the marsh cordgrass *Spartina alterniflora* in the mid-intertidal, and a mix of mangrove species (reds, blacks, whites) in the high intertidal.

We have employed this type of living shoreline deployment along seven sites in Florida (1000+ linear meters) over the past 5 years with the help of over 7000 volunteers. As long as the cordgrass and mangroves have sufficient above-ground height and sufficient root biomass to withstand times of local high water and local storm events, we can see over 90% survival of all plants. Within three years, all sites include plants that are reproductive. Most significant is that shoreline erosion has been replaced with sediment accretion at all successful sites.

While our deployed red mangroves have been very successful in terms of survival, growth and reproduction, natural recruitment following stabilization has been very limited. To better understand this, we tracked tagged red mangrove seeds and followed natural mangrove recruitment for 1 year. During this time, no new recruitment was found on our midden sites. This suggests there is something about the local midden sediments (coarse shell) that inhibits recruitment. To further understand this topic, we collected two additional types of data. First, we looked at the sediment directly surrounding red mangroves that did recruit to middens versus nearby non-midden shorelines. We found that red mangroves were always surrounded by fine-grained sediments in spite of the make-up of the midden sediments. Second, we grew red mangroves from propagules in a range of sediment types from very fine to very coarse. We found unique growth morphologies of roots in coarser-grained sediments, but survival was high in all treatments. Hence, recruitment limitation appears to be associated with the ability of red mangrove seeds to initially become wedged into the shell sediments in ways that facilitate retention long enough for initial growth. These results emphasize the importance of human-mediated interventions along shorelines altered by Native Americans.

Contact Information: Linda Walters, Department of Biology, University of Central Florida, 4000 Central Florida Blvd., Orlando, FL, USA 32816, Phone: 407-823-2148, Email: linda.walters@ucf.edu

MANGROVES IN A CHANGING WORLD: FROM POPULATION GENETICS TO ECOLOGICAL GENOMICS

Alison K.S. Wee[1]*, Kunfang Cao*[1]*, Tadashi Kajita*[2]*, Edward L. Webb*[3]

[1]Plant Ecophysiology and Evolution Group, State Key Laboratory of Conservation and Utilization of Subtropical Agro-bioresources, College of Forestry, Guangxi University, Nanning, Guangxi, CHINA

[2]Iriomote Station, Tropical Biosphere Research Center, University of the Ryukyus, Okinawa, JAPAN

[3]Applied Plant Ecology Lab, Department of Biological Sciences, National University of Singapore, SINGAPORE

Mangroves are one of the most threatened ecosystems in the world. Understanding the drivers and limitations of gene flow and genetic adaptation is crucial to effectively manage the threats and conserve the long-term evolutionary potential of mangroves. The first part of this presentation summarizes our studies over the past five years on five mangrove species from the Indo-West Pacific region (*Avicennia alba, Sonneratia alba*, *Bruguiera gymnorhiza*, *Rhizophora mucronata* and *Rhizophora stylosa*). These studies demonstrated that low propagule dispersal capabilities, land barriers and ocean currents may restrict gene flow in mangroves. This underscores the importance of effective long-distance propagule dispersal in genetically connecting fragmented mangrove populations and highlights the need to understand regional gene flow patterns via seascape genetics. The second part of the presentation outline our research plans for the coming five years to combine ecophysiological and genomics techniques to understand the genetic adaptation to salt stress and the thermal niche in mangroves. Through the application of ecological genomics, we aim to elucidate the physiological mechanism for adaptation to salt stress, to explain the wide distribution of mangroves across habitats with varying thermal regime, and to estimate the future adaptive potential under climate change scenarios in mangroves.

Contact Information: Alison K.S. Wee, Plant Ecophysiology and Evolution Lab, College of Forestry, Guangxi University, Nanning, Guangxi, CHINA. Phone: +86 183 7660 8304, Email: alisonwks@gxu.edu.cn; alisonwks@gmail.com

CALIBRATED DENSITY PROFILES OF THICK MANGROVE PEAT SEQUENCES FROM COMPUTED TOMOGRAPHY: APPLICATIONS FOR ASSESSMENT OF MANGROVE PALEOECOLOGY, PEAT COMPACTION AND SEA LEVEL RECONSTRUCTIONS

*Marguerite A. Toscano[1], Juan L. Gonzalez[2], and **Kevin R.T. Whelan[3]***

[1]Smithsonian Environmental Research Center, Edgewater, MD, USA
[2]University of Texas-Rio Grande Valley, Edinburg, TX, USA
[3]National Park Service, Miami, FL, USA

Intertidal mangrove peat forms thick deposits in response to sea level rise, yet its elevation accuracy as a sea level indicator, with an indicative range hypothetically defined by the local tide range, is considered to be affected over time by compaction. Plant tissue degradation and decay, as well as compression and dewatering due to sediment loading and overburden pressure, are generally assumed mechanisms; however actual measurements of, and corrections for, compaction are difficult to make across widely varying depositional regimes, sediment inputs, and tectonic influences.

This study obtained quantitative, calibrated peat densities and imagery from Computed Tomography (CT) and from standard peat petrologic analysis to assess the amount of compaction in three continuous Russian-cored peat sections from offshore carbonate platforms in Florida (6 m), Belize (12 m) and Panama (3.5 m). In all cases, peat density remains constant from the peat surface to basal depths at densities only slightly exceeding the density of water on the Hounsfield Unit (HU) scale. Peat also exhibits significant voids at all depths, and retains high water contents ranging from highs of >80% (in the absence of sediment) to ~50% (with sediment) throughout. Higher CT-density intervals in peat sections are directly related to compositional changes (sediment, coral), rather than to dewatering and compression of the peat. CT Analysis of dried peat (from stored cores) indicates preservation of voids and open structures of plant remains with depth, maintaining negative densities (~-600 HU) midway between Water (0.0 HU) and Air (-1000 HU). Sediment-free fresh peat (~75 HU) is largely composed of water-logged plant remains and water-filled voids.

Thus, where peat deposits on offshore platforms are not interrupted by thick sediment lenses, local hydrology and tidal forces maintain water pressure throughout the system, preventing dewatering and compaction of continuous peats and hypothetically maintaining the sea-level indicative elevation range of any sample at depth. Thick, un-compacted peat sections are therefore more valuable than basal peats in providing the full history of sea level rise at open ocean platform sites. Other factors affecting accurate sea level indicator status of un-compacted peat include hiatuses in peat formation, bioturbation, tissue degradation over time, and radiocarbon dating reversals attributed to younger root contamination of deeper samples, as well as upward remobilization of older carbon by these roots.

Contact Information: Kevin R. T. Whelan, National Park Service, 18001 Old Cutler Road Suite 419, Miami, Florida 33157, Phone: 786-249-0210, Email: Kevin_R_Whelan@nps.gov

A TALE OF TWO BLACK MANGROVE (*AVICENNIA GERMINANS)* DIE-OFFS & EFFORTS AT RESTORATION

KathyWorley[1]*, Robin Lewis III*[2]*, Dorothea Zysko*[3]*, Laura Flynn*[4] *and Jeffrey Carter*[5]

[1]Conservancy of Southwest Florida, Naples, FL., USA
[2]Lewis Environmental Services, Salt Springs, FL., USA
[3]Dorothea Zysko, The Ecology Group, Inc., Punta Gorda, FL., USA
[4]Laura Flynn, Coastal Resources Group, Inc., Salt Springs, FL., USA
[5]Jeffrey Carter, Rookery Bay National Estuarine Research Preserve, Naples, FL., USA

Two separate black mangrove die-offs in Collier County, Florida, USA share similar characteristics. Both sites are bound on at least two sides by roads or other development. Mangroves were visibly stressed after heavy rains in 1992 and completely dead by 1995. The Clam Bay (CB) die-off (~20 ha) is located in north Naples. The Fruit Farm Creek (FFC) die-off (~26 ha) is located near the southwest boundary of Rookery Bay National Estuarine Research Reserve. Urban encroachment adjacent to these estuarine areas interrupted the natural tidal flow, causing water impoundment, which ultimately resulted in mangrove mortality. Prior to restoration, these die-offs had no signs of sustainable mangrove reestablishment. The ecology of the areas had deteriorated as fish and invertebrates movements into and out of the areas was very restricted, and the export of detrital material to the adjacent estuary was reduced.

Restoration began in 1999 within the CB die-off and was for the most part completed in 2000. The FFC die-off is bisected by SR92 and limited funding confined restoration to the smaller northern section of the FFC die-off in 2012. In both cases, restoration consisted of improving the tidal flow by dredging main tidal arteries, reconnecting die-off areas to tidal tributaries, and installation of an array of hand-dug channels to drain excess surface water and encourage tidal flushing. Pre and post-restoration assessments of floristic composition are being performed at least annually to assess temporal changes to vegetation in comparison to the established pre-restoration baseline.

Shortly after restoration, results indicated that both die-offs were showing signs of recovery. Tidal flushing increased and a substantial amount of standing fresh water was removed from the die-off areas. As water levels subsided and the tides cycles re-established, the die-off areas were again suitable for mangrove establishment. Within one year, mangrove seedlings were attempting to colonize the die-off areas, and by three to six years post-restoration mangroves were well established. The degree and success of mangrove re-establishment was directly linked to whether or not areas within the die-offs were able to drain impounded water; the proximity to the hand-dug channels; and if the topography allowed for tidal exchange. The CB mangrove system has improved in the sense that the die-off areas present in 1999 have been greatly diminished. Seedlings have grown into mangrove trees, intra and interspecies completion is occurring, and annual assessments are now documenting shifts in mangrove tree percent composition. Weather events, disease and other stressors continue to impact the mangroves within this isolated estuary. A number of plots that were relatively healthy in 1999 are now stressed from both natural and/or anthropogenic stressors. The FFC mangrove system after 3 years has seen tremendous mangrove recruitment in the areas where water impoundment has abated and the tidal regime has been re-established. However, there is still has a long way to go to be able to say that the FFC restoration has been successful.

Contact Information: Kathy Worley, Conservancy of Southwest Florida, 1495 Smith Preserve Way, Naples, FL., USA 34109, Phone: 239-403-4223, Email: kathyw@conservancy.org

SPATIAL ASSESSMENT OF THE BIOCLIMATIC FACTORS DRIVING MANGROVE FOREST DISTRIBUTION ALONG THE BRAZILIAN COASTLINE

***Arimatéa Ximenes*[1,2], *Eduardo Eiji Maeda*[3], *Gustavo Felipe Balué Arcoverde*[4] and *Farid Dahdouh-Guebas*[1,2]**

[1]Université Libre de Bruxelles, ULB, Brussels, BE
[2]Vrije Universiteit Brussel, VUB, Brussels, BE
[3]University of Helsinki, Helsinki, FI
[4]National Institute for Space Research, INPE, São José dos Campos, BR

Brazil has one of the largest mangrove surfaces worldwide. Due to a wide latitudinal distribution, Brazilian mangroves can be found within a large range of environmental conditions. However, little attention has been given to the description of environmental variables driving the distribution of mangroves in Brazil. In this study we present a novel and unprecedented description of environmental conditions for all mangroves along the Brazilian coast. We apply a descriptive statistics and data-driven approach using Self-Organizing Maps (SOM) and we combine data from terrestrial and marine environmental geodatabases in a Geographical Information Science (GIS). We evaluate 25 environmental variables (21 bioclimatic variables, 3 sea surface temperature derivates and salinity). The results reveal 3 groups of correlated variables and that can be divided in groups of: (i) Air temperature derivates and sea surface temperature; (ii) Temperature, Evapotranspiration and Precipitation derivates and (iii) Precipitation derivates, aridity, and salinity. Our results unveil new locations of extreme values of temperature and precipitation. We conclude that *R. harisonii* and *R. racemosa* are more limited by precipitation and aridity and that they do not necessarily follow a latitudinal gradient. Our data also reveals that the lowest temperature of the coldest month are not necessarily found at the southernmost limits of mangroves in Brazil. However, the minimum sea surface temperature drops gradually with higher latitudes in the southern hemisphere and is probably a better indicator for the decrease of species at the latitudinal limits of mangroves than the air temperature and precipitation.

Contact Information: Arimatéa Ximenes, Université Libre de Bruxelles, Avenue F.D. Roosevelt 50, CPI 264/1, B-1050 Bruxelles, Belgium. Phone: ++ 32 2 6502, Email: ari.ximenes@gmail.com

THE EFFECTS OF TEMPERATURE AND SALINITY ON ANAEROBIC CH_4 AND CO_2 PRODUCTION POTENTIAL FROM SUBTROPICAL WETLAND SOILS

Jiaxing Xu *and Derrick Y.F. Lai*
Department of Geography and Resource Management, The Chinese University of Hong Kong, China

Global climate change can lead to alternations in the regional patterns of temperature, precipitation and runoff, which will in turn potentially affect the magnitude of greenhouse gas production from mangrove soils. A thorough understanding of the effects of temperature and salinity on the CH_4 and CO_2 production potentials from mangrove soils is needed for predicting their feedback on climate change. In this study, we examined the influence of temperature (15 °C, 25 °C, 35 °C) and salinity (0 ppt, 15 ppt, 25 ppt, 35 ppt) on anaerobic CH_4 and CO_2 production potentials from the soils in three different subtropical wetlands, namely a freshwater marsh, an estuarine mangrove, and an oceanic mangrove.

We found the lowest CH_4 and CO_2 production potentials in the freshwater marsh, which was 9-22 $\mu g\ g^{-1}\ d^{-1}$ and 3.2×10^3-$1.0 \times 10^4\ \mu g\ g^{-1}\ d^{-1}$, respectively. As for the other two sites, soil CH_4 production potentials were higher in the oceanic mangrove (19-90 $\mu g\ g^{-1}\ d^{-1}$) than in the estuarine mangrove (4-18 $\mu g\ g^{-1}\ d^{-1}$), while the opposite pattern was observed for CO_2 production potentials. Q_{10} (15°C-35°C) values of CH_4 and CO_2 production potentials from the three wetlands varied from 1.13 to 3.86, and from 1.28 to 2.50, respectively, demonstrating a significant influence of temperature on GHG production. The highest Q_{10} (15°C-35°C) values were in Mai Po, which could be attributed to the higher concentrations of soil nutrients such as available phosphorous and organic carbon. We observed significant differences in CH_4 and CO_2 potentials between 0 and 35 ppt at all sites, with a reduction of CH_4 production potential by 44%-94% at the highest salinity level. However, an increase in salinity from 0 to 35 ppt enhanced CO_2 production potential of soils by 55%-82%, 75%-92% and 23%-27% in the freshwater marsh, the estuarine mangrove, and the oceanic mangrove, respectively. Salinity had the least effect in affecting CO_2 production potential in the oceanic mangrove, which could be attributed to the already high salinity level initially at this site. Our results demonstrate the importance of changing temperature and salinity on the magnitude of greenhouse gas production potentials and hence the potential feedback to climate change in different types of coastal wetlands.

Contact Information: Jiaxing Xu, The Chinese University of Hong Kong, Geography and Resource Management, Room 251, Wong Foo Yuan Building, The Chinese University of Hong Kong, NT, Shatin, Hong Kong 999077, China, Phone: 91403209, Email: xujiaxing@link.cuhk.edu.hk

THE GENOME OF *RHIZOPHORA APICULATA* PROVIDES INSIGHT INTO ADAPTIVE EVOLUTION OF MANGROVE SPECIES TO THE INTERTIDAL ZONE

***Shaohua** Xu*
Sun Yat-Sen University, Guangzhou, China

Mangroves are woody plants that originated from inland ancestors and have invaded the intertidal zone. We generated the *de novo* assembled whole genome of the red mangrove, *Rhizophora apiculata*, as well as the genomic sequences of six related species of Rhizophoreae. Our phylogenetic analyses showed that Rhizophoreae originated during a time range of 48-55 million years before present. We also found genomic features that may underlying mangroves' adaptation into the intertidal zone, including: (1) the elevated evolutionary rate of Rhizohporeae species comparing with their inland relatives, which may resulted from the relaxation of purify selection; (2) Genes that related with viviparous embryo and high tannin content were found to have experienced significant alterations in copy number and mangrove-specific amino acid constitution. Furthermore, the extremely small effective population size of *R. apiculata* estimated by PSMC indicated that it's particularly vulnerable to the sea level fluctuation. The genomic data of *R. apiculata* also provide valuable resources for the future evolutionary studies in organisms occuring in the mangrove forest as well as predicting the response of the coastal ecosystem to global climate changes.

Contact Information: Shaohua Xu, Sun Yat-Sen University, No. 135, Xingang Xi Road, Guangzhou, 510275, P. R. China, Phone: 862084113677, Email: xushaohua08@163.com

GENETIC STRUCTURE AND POPULATION DEMOGRAPHY OF WIDESPREAD SEA-DISPERSAL PLANTS *VIGNA MARINA* IN THE PACIFIC

Takashi Yamamoto[1], *Yoshiaki Tsuda*[2], *Koji Takayama*[3], *Reiko Nagashima*[1], *Yoichi Tateishi*[4] *and Tadashi Kajita*[5]

[1]Graduate School of Science, Chiba University, Chiba, JAPAN
[2]Sugadaira Montane Research Center, University of Tsukuba, Nagano, JAPAN
[3]Museum of Natural and Environmental History, Shizuoka, JAPAN
[4]Faculty of Education, University of the Ryukyus, Okinawa, JAPAN
[5]Iriomote Station, Tropical Biosphere Research Center, University of the Ryukyus, Okinawa, JAPAN

Sea dispersal plants like mangrove plants produce specifically adapted diaspores (mainly seeds and fruits) to sea dispersal and can disperse them over the vast distance by ocean currents. As sea dispersal is often effective for long distance dispersal, many of the sea dispersal plants have extremely wide distribution range in tropics and subtropics worldwide. Distinct spatial genetic structures are common in many mangrove species across apparent geographic barriers (for example, *Bruguiera gymnorhiza* across Malay Peninsula and *Rhizophora mangle* across Central Panama Isthmus), and they are explained in the context of vicariance caused by land barriers that prevented migration of seeds by sea dispersal. However, some recent works on mangroves using genetic markers also reported clear genetic structure within oceanic regions where no apparent geographic barriers exist, which may imply the presence of "Cryptic Barriers". Although these genetic structures may promise to provide new insight into historical biogeography of mangroves, detail studies have not been well performed yet.

In this study, we employed a widespread sea dispersal legume *Vigna marina* (Burm.) Merr. as a model species to test the "Cryptic Barrier" hypothesis in the Pacific. This species distributes in IWP region and has wider distribution range than all other IWP mangroves. We conducted wide-scale phylogeographic analysis to understand detail patterns of population genetic structure using both cpDNA and nuclear microsatellite (SSR) markers for more than 300 individuals collected from 16 countries. Moreover, we employed Approximate Bayesian Computation (ABC) based approaches to infer past demographic history that formed the contemporary genetic structure in the focal region.

CpDNA sequences showed high levels of genetic diversity and clear population genetic structure within the distribution range. We recognized clear genetic structure divided into three groups; North Pacific (NP), South Pacific (SP) and Indian Ocean (IO), strongly differentiated each other (F'CT=0.954 to 1.000). Although the genetic structure was less distinct for nuclear microsatellite, regional tendency of genetic diversity was similar to the one for cpDNA. These results supported the presence of the "Cryptic Barrier" within the Pacific Ocean. Additionally, ABC analysis estimated the divergence time between NP and SP at last glacial maximum (LGM), which indicates a strong influence of past climatic events on the population genetic structure of sea dispersal species including mangroves. These finding may provide new insight into biogeography and conservation of coastal plants including mangroves.

Contact Information: Takashi Yamamoto, Department of Biology, Graduate School of Science, Chiba University, 1-33 Yayoi-cho, Inage-ku, Chiba 263-8522, JAPAN, Phone: +81-90-5414-8920, Email: t.yamamoto.vm@gmail.com

MANGROVE PROPGULE DISPERSAL AND ESTABLISHMENT AT THE SALT MARSH-MANGROVE ECOTONE: LINKING HYDROLOGY, DISPERSAL DISTANCE, AND PROPAGULE RETENTION

Mark Hester[1] *and* ***Erik Yando***[2]

[1]Institue for Coastal and Water Research, University of Louisiana at Lafayette, Lafayette, LA, USA
[2]Coastal Plant Ecology Laboratory University of Louisiana at Lafayette, Lafayette, LA, USA

Expansion of mangrove populations into salt marshes at their latitudinal limit requires successful propagule dispersal and establishment. Warmer winter temperatures are expected to allow for mangrove populations to expand into previously salt marsh dominated systems both in the northern Gulf of Mexico and worldwide. Hydrology, temperature, and marsh vegetation facilitation/competition play an important role in dispersal and establishment. Our study examined the influence of hydrology and marsh vegetation through a series of complementary studies near Port Fourchon, Louisiana. We dispersed 500 painted propagules at five elevation treatments across a gradient in a restored salt marsh using five different colors. We sampled propagule retention within the site, elevation, distance traveled and the surrounding vegetation structure of their location at one day, five days, and one month after dispersal. We observed >50% retention after one day and ~20% retention after five days, with most of the retained propagules moving up in elevation. Those propagules that were retained were most often found within moderately dense vegetation and wrack deposits. Propagules moved a minimum of 0 m to 42 m in distance, with areas of denser vegetation trapping greater numbers of propagules. Additionally, in the same area as the dispersal study we established six 0.7m^2 enclosures each containing 25 *Avicennia germinans* propagules at each of the same five elevations to examine the effect of hydrology on propagule survival, establishment, and growth in the first six months. Although monitoring of both studies is ongoing, it is already apparent that marsh structure may act as a barrier or as a facilitator to propagule stranding and establishment, and whether or not propagules are retained within a given area depend on the elevation they are dispersed to, which also differentially affects survival and establishment. This information will be useful for scientists and land managers looking to understand local and regional expansion patterns, and to inform restoration practitioners in the potential utilization of mangrove propagules rather than adult plants for mangrove restoration.

Contact Information: Erik Yando, Coastal Plant Ecology Laboratory, 410 E. Saint Mary Blvd, Billeaud Hall Room 108, Lafayette, LA 70503, Phone: 337-482-5235, Email: yando@louisiana.edu

PREDICTION OF PLANT VULNERABILITY TO SALINITY INCREASE IN A COASTAL ECOSYSTEM BY STABLE ISOTOPE COMPOSITION ($\Delta^{18}O$) OF PLANT STEM WATER: A MODEL STUDY

Lu Zhai
Biology, University of Miami, Coral Gables, FL, USA

Sea level rise and the subsequent intrusion of saline seawater can result in an increase in soil salinity, and potentially cause coastal saline-intolerant vegetation (e.g., hardwood hammocks or pines) to be replaced by saline-tolerant vegetation (e.g., mangroves or salt marshes). Although the vegetation shifts can be easily monitored by satellite imagery, it is hard to predict a particular area or even a particular tree that is vulnerable to such shift. In order to find an appropriate indicator for the potential vegetation shift, we incorporated stable isotope ^{18}O abundance as a tracer in various hydrologic components (e.g., vadose zone, water table) in a previously published model describing ecosystem shifts between hammock and mangrove communities in southern Florida. Our simulations showed that: (1) there was a linear relationship between salinity and the $\delta^{18}O$ value in the water table, whereas this relationship was curvilinear in the vadose zone; (2) hammock trees with higher probability of being replaced by mangroves had higher $\delta^{18}O$ values of plant stem water, and this difference could be detected two years before the trees reached a tipping point, beyond which future replacement became certain; (3) individuals that were eventually replaced by mangroves from the hammock tree population with a 50% replacement probability had higher stem water $\delta^{18}O$ values three years before their replacement became certain compared to those from the same population which were not replaced. Overall, these simulation results suggest that it is promising to track the yearly $\delta^{18}O$ values of plant stem water in hammock forests to predict impending salinity stress and mortality.

Contact Information: Lu Zhai, University of Miami, Biology, 1301 Memorial Dr, Coral Gables, FL 33146, Phone: 305-284-2802, Email: zhailu@bio.miami.edu

SAP FLOW CHARACTERISTICS OF TWO MANGROVE SPECIES, *SONNERATIA CASEOLARIS* AND *S. APETALA*, IN CHINA

*Luzhen Chen[1], **Hewei Zhao**[1], Xudong Guo[1], Shengchang Yang[1], QiongYang[2]*

[1]Key Laboratory of the Ministry of Education for Coastal and Wetland Ecosystems, College of Environment and Ecology, Xiamen University, Xiamen, Fujian, China

[2]Futian-City University Mangrove R&D Center, Shenzhen, China

Due to periodic flooding of tidal water, mangroves grow in saline and anaerobic conditions. On adapting to such severe conditions, mangrove species developed particular water use regimes which have interested scientists for decades. So far, only a few studies focus on the water use characteristics of a whole-tree or on stand levels of mangroves. There are two *Sonneratia* mangrove species, *S. apetala* and *S. caseolaris*, in Futian mangroves of Shenzhen, Guangdong Province in China. *S. apetala* was non-native and introduced from Bangladesh in 1985, while *S. caseolaris* is a native species in Hainan Province and transplanted in Shenzhen in 1993.

We carried out a study on sap flow characteristics of these two mangrove species with Granier-type thermal dissipation probes. Sap flow attenuation in xylem were determined by using probes with the function of evaluating sap flow at three radial depths in stems, which were 15mm, 50mm and 90mm, respectively. At the 50mm depth, sap flow in *S. apetala* and *S. caseolaris* trunks were reduced by 53% and 86% respectively compared to sap flow at the 15mm depth, however, both species had little sap flow measured at the depth of 90mm. Vapor pressure deficit (VPD) and photosynthetic active radiation (PAR) had varying influences on sap flow of both species. Significant difference of stand water uptake on sunny day occurred between the two species. *S. apetala* population had water use of 5.32 mm d^{-1} comparing to 3.58mm $d^{-1}$of *S. caseolaris*, indicating a higher water uptake of *S. apetala.* We concluded that non-native *S. apetala* had better water use regime than *S. caseolaris*, which was estimated to have greater influence on area water budget. These results were helpful to explain the invasive potential of *S. apetala* in Shenzhen mangroves in China.

Contact Information: Zhao Hewei, College of the Environment and Ecology, Xiamen University, Xiamen, Fujian, China, Email: healwee@foxmail.com, Corresponding author E-mail: luzhenchen@xmu.edu.cn

ORIGIN OF SEDIMENTARY ORGANIC MATTER AND ITS FATE UPON DECOMPOSITION

Thet Thet Nyein, Véronique Helfer, and ***Martin Zimmer***
Leibniz-Center for Tropical Marine Ecology

Recalcitrant organic matter stored under saline and anoxic conditions in mangrove sediments potentially contributes to climate change-mitigation through reducing CO_2 and N_2O emission into the atmosphere upon decomposition processes. Such sediment organic matter (SOM) is derived from root exudates of the mangrove vegetation and any kind of dead organic matter (detritus). How effective SOM is in preventing the evolution of climate-active gases and retaining carbon and nitrogen belowground depends on its structure and recalcitrance which, in turn, is governed by its origin and history. We will present an approach to characterize SOM chemically with high resolution to determine the relationship between SOM structure and mangrove community composition as a first step to correlate mangrove communities with service-relevant ecosystem processes.

Contact Information: Martin Zimmer, Leibniz-Center for Tropical Marine Ecology, Fahrenheitstr. 6, Bremen 28359, Germany, Phone: 4942123800161, Email: martin.zimmer@leibniz-zmt.de

MODELLING THE VALUE OF MANGROVE FISHERIES

Philine zu Ermgassen[1]*, Emma Garnett*[1]*, Ivan Nagelkerken* [2]*, and Mark Spalding* [3]

[1]University of Cambridge, UK
[2]The University of Adelaide, Australia
[3]The Nature Conservancy, University of Siena, Italy

Over 200 million people live within 10km of a mangrove forest, and a very large number of these depend on mangrove fisheries as a key source of employment, livelihood or food security. We are working towards the development of reliable models and maps to quantify the value of mangroves for fish-supply world-wide, and to show how that value varies across geographic space.

At a global scale, our aim is to build a conceptual model of the relative value of mangrove fisheries, validated using collated fisheries data from different locations and fisheries. This model will combine environmental and socio-economic data, using an iterative Delphi-style technique to weight variable importance by expert judgement. Sub-models may be used to incorporate different socio-economic or geographic variables for, for example, artisanal and commercial fisheries. The conceptual model/s will then be used to produce a global map of predicted fisheries catch derived from mangroves. In parallel with this work we hope to be developing an index of species dependency on mangroves.

The global map of catch values resulting from the conceptual model will be tested using both data from case study regions for which good quality fisheries data can been obtained, and the index of mangrove dependency.

In this paper we will present preliminary findings of the work, including the key environmental drivers of mangrove productivity and standing stock, and the key socio-economic drivers of fishing effort and value. We hope that by sharing our work at MMM4 we will also elicit further expert input and generate broader partnerships.

Contact Information: Philine zu Ermgassen, Department of Zoology, University of Cambridge, Phone. +44 (0)1223 336617.
Email: philine.zuermgassen@cantab.net

NOTES

THANK YOU SPONSORS

CHINA GREEN

UNIVERSITY of LOUISIANA LAFAYETTE | Institute for Coastal and Water Research

Smithsonian Environmental Research Center

USGS science for a changing world

Smithsonian TMON - MarineGEO

INDIAN RIVER LAGOON PROGRAM

UNISENSE

SCHEDA ECOLOGICAL ASSOCIATES

NASA

TAMPA Estuary Program

FLAGLER COLLEGE COASTAL ENVIRONMENTAL SCIENCE

eco environment coastal & offshore

Partnering Organizations

Smithsonian Environmental Research Center

GTM RESEARCH RESERVE

UF IFAS UNIVERSITY of FLORIDA

THE WHITNEY LABORATORY UNIVERSITY OF FLORIDA

USGS science for a changing world

FLAGLER COLLEGE COASTAL ENVIRONMENTAL SCIENCE

UF/IFAS Office of Conferences & Institutes
2311 Mowry Rd, Bldg. 78
Gainesville, FL 32611
PO Box 110750
Phone: (352) 392-5930
www.conference.ifas.ufl.edu/

UF IFAS UNIVERSITY of FLORIDA

Office of Conferences & Institutes (OCI)