Five-Year Evaluation Report
Fall 2011 – Fall 2016

Howard T. Odum Center for Wetlands

April 27, 2017

David A. Kaplan, Director

1. OVERVIEW STATEMENT

The Howard T. Odum Center for Wetlands is dedicated to facilitating wetland research and education at the University of Florida and helping in the intellectual marketing and technology transfer of these programs at the state, national and international levels. The Center has played a major role in advancing knowledge on wetlands by conducting research and offering statewide seminars and workshops on wetlands, environmental policy, landscape ecology, and environmental education. Over its 42 years as a research center at the University of Florida, Center faculty, staff, and students have been involved in a diverse array of projects concerned with wetlands ecology, wetlands management, wetland and landscape reclamation, and wetlands ecosystem health. Of particular importance to the Center's identity and mission is a continued dedication to interfacing engineering, science, conservation, management, and policy as they relate to wetlands.

Mission Of The Center For Wetlands

The mission of the Howard T. Odum Center for Wetlands is to provide sound scientific knowledge about wetlands that will lead to a better understanding of their role in a sustainable partnership of humanity and nature. The Center works toward this goal by conducting, facilitating and coordinating interdisciplinary research and teaching on wetland-related resource management issues.

Historical Perspective

The Center for Wetlands (CFW) was founded in 1973 by H.T. Odum and has been housed in Phelps Lab since that time. The CFW was founded with support from a multi-year project to assess the use of wetlands for the recycle of wastewater funded jointly by the Rockefeller Foundation and the Engineering Directorate of the National Science Foundation under the Research Applied to National Needs program. A companion grant was awarded to Robert Kadlec of the Department of Chemical Engineering, University of Michigan. Over the next thirty years, Florida and Michigan become recognized as pioneers and leaders in the field of wetland creation and management for engineering purposes.

While the Michigan program remained focused on chemical processes of constructed and natural treatment wetlands, the University of Florida program expanded quickly in the late 1970's to focus on wetland ecology, management, restoration, conservation and policy. The strength of the UF wetland program is due in large part to H.T. Odum's vision of the CFW as a campus-wide focal point for both basic ecological research on wetlands and their sustainable use in meeting the needs of society. The CFW has been the forum for interfacing traditional engineers with

ecologists, especially regarding the use of natural and constructed wetlands for wastewater and stormwater treatment. Not only was the first research on the use of natural systems for wastewater treatment conducted at the Center, but the pioneering research led by H.T. Odum to integrate humanity and environment at many scales was largely responsible for the development of the new disciplines of "ecological engineering" and "ecological economics".

Due largely to the studies of wastewater recycle and reuse through wetlands conducted at the Center, the State of Florida's Department of Environmental Protection (FDEP) instituted a set of permit regulations that encouraged full-scale wastewater recycling tests. Then, in 1987, the FDEP initiated new rules for wastewater recycle through wetlands. No longer an experimental exemption, wastewater recycling through wetlands has since been accepted as a low-energy alternative to waste treatment, based in significant part on the research conducted by CFW faculty, staff, and graduate students. There are currently nearly 50 treatment wetlands in operation in the state of Florida, including the newly constructed 125-acre Paynes Prairie Sweetwater Enhancement Wetland in Gainesville.

In its years as a research and outreach program of the University of Florida, over 200 students have participated in funded research activities at the Center. A partial accounting of students and their departmental affiliations is as follows: Botany, 7; Environmental Engineering Sciences, 136; Forest Resources and Conservation, 7; Geology, 4; Geography, 6; School of Natural Resources and Environment, 14; Soil and Water Sciences, 11; Urban and Regional Planning, 8; Zoology, 4. Faculty participation in research projects at the Center mirrors the diversity of student participation. In all, the Center has benefited from the participation of over 40 faculty members from various Departments across the University, along with over 50 visiting research scholars and faculty from both national and international wetlands programs. The Center's research and education activities have generated over 500 graduate theses, dissertations, technical reports, and professional publications.

Institutional Framework

As a Type II Center authorized by the Board of Regents and approved by the President of the University of Florida (on July 5, 1973), the Center for Wetlands administrative structure, was originally under the Vice President for Academic Affairs. Later (ca. 1980) authority over the Center shifted to the Dean of the Graduate School. In the late 1980's authority shifted again to the Vice President for Research and then in the mid 1990's shifted to the Departmental level, with the Center reporting through the Chair of the Department of Environmental Engineering Sciences to the Dean of Engineering. The administrative arrangements were designed to facilitate interdepartmental projects, stimulate flow of faculty, students, and learning among departments, and generate a unified consideration of the systems of humanity and environment, especially related to wetlands. The Center continues to support graduate students, provides academic and research support services related to wetlands, operates field research sites (Odum Cypress Dome, Orange Lake site, Oak Hammock stormwater site, northern Gulf of Mexico coastal research network, among others) and coordinates the Interdisciplinary Concentration in Wetlands Sciences. Thus, the Center's activities enrich resources for graduate research and teaching and promote the advancement and sharing of knowledge across the University and at the state, regional, and international levels.

The Center has operated at times with a small, full-time staff for continuity. The Director receives no salary support and, like other faculty participants, his/her primary home is in a specific department. Faculty who are Principal Investigators or Co-Principal Investigators on active research projects through the Center become members of its Advisory Board. Faculty and students are reported as active participants as long as they are formally part of the Center's organized research activities. Thus, the staff changes each year as new projects are started and older projects are completed.

Facilities

Research activity is centered at Phelps Laboratory, located on Museum Road, and at various field sites distributed across the state, region, and world. Phelps Laboratory is organized into workshop rooms assigned to active research projects. Student desks are assigned as available in workshops in which project work is conducted. The Center has provided student "co-housing" for a number of large, interdisciplinary projects, including the $3 million NSF IGERT program (PI Brown) and the 2013 and 2015 UF Water Institute Graduate Fellows programs (PIs Brown and Kaplan, respectively). Workspace is also provided for numerous postdocs and visiting scholars. The Center also houses research library collections, computer facilities, and small chemical and biological lab facilities. The Center has three vehicles, two boats, and several canoes for field research, purchased on project and PI startup funds.

Over the years, the Center has had active field research sites in Florida (Apalachicola River floodplain, Kennedy Space Center, Orange County Treatment Wetlands, Osceola and Ocala National Forests, Lake Apopka Marsh, Upper Ocklawaha River floodplain, among *numerous* other sites) as well as around the country and world (Okefenokee Swamp [GA], Savannah National Wildlife Refuge [GA], Redwood National Park [CA], Costa Rica, Panama, South Africa, Botswana, Vietnam, and *many* other sites). Additionally, through our long standing research program with the Florida Institute of Phosphate Research and the courtesy of phosphate mining companies, field study sites for phosphate mine reclamation are located throughout central and north Florida phosphate districts.

Currently CFW faculty and students have active research sites in the iconic Silver River/Springs, Everglades and Big Cypress National Preserve systems, as well as in marshes, swamps, mangroves, and oyster reefs along the entire southeastern United States coastline from Texas to North Carolina (Lower Suwannee and Cedar Key National Wildlife Reserve, Waccasassa Bay State Wildlife Preserve, St. Marks National Wildlife Refuge, Pellicer Creek and Guana River estuaries, Savannah Coastal Refuges Complex [GA], Jean Lafitte National Park [LA], Big Thicket National Park [TX]). This recent work represents a new emphasis on "Coastal Wetland Resilience." This Center-supported research focuses on the resilience of coastal wetlands to a variety of disturbances, including drought, invasive species, and sea-level rise, and seeks to develop the science and design tools essential for creating living coastlines of highly functional ecological communities that are integral components of resilient coastal infrastructure.

Significance of Center for Wetlands to UF

UF Interdisciplinary Concentration in Wetlands Science. The Center was instrumental in the development of an interdisciplinary graduate program in wetlands at UF in 1988 and began offering a Wetlands Certificate. In 2004, a campus-wide cluster of faculty with interests in

wetland sciences formed the Wetland Academic Cluster and developed the Interdisciplinary Concentration in Wetlands Sciences (ICWS). The concentration requires 15 credit hours of wetlands- related courses and a wetlands research project. Completion of the ICWS is included on student's transcripts. To date, over 100 UF graduate students have been awarded the "wetlands certificate" by taking the prescribed list of courses and participating in a wetland research project. Many state agencies and private consultants throughout the State recognize this certificate and the training it implies. The CFW is currently in negotiations with the Society of Wetlands Scientists (SWS; the premier international wetland professional and academic organization) to coordinate our Wetlands Certificate curriculum with the Professional Wetland Scientist certification requirements; when complete, this collaboration will allow our students to earn their professional certification contemporaneously with the ICWS.

Student Internships. The Center has worked with the Oak Ridge National Laboratory, the St. Johns River Water Management District, the Alachua County Environmental Protection Department, and several environmental consulting firms to provide UF students with internships on a semester basis. The CFW has also coordinated with the USEPA Wetlands Division in the past to provide Washington D.C. based summer internships and serves as a host to the international Wetlands Ambassador program.

Water, Wetlands, and Watersheds (W3) Seminar Series. For over 40 years, the Center has coordinated a weekly "brown-bag seminar" during the academic year, drawing speakers from UF, state agencies and the private sector to speak on a variety of topics of current and projected interest. The W3 seminar is the longest-running seminar series on campus, with presentations that focus on water, wetlands and watershed issues locally, nationally and internationally. Presenters are often existing or previous students and faculty, but also include staff and scientists from state and federal agencies, local consultants and other professionals. *Over 1000 speakers have participated in this program* since its inception in 1973. In addition to severing as the primary venue for wetlands and water related research on campus, a major goal of the seminar is to disseminate this information more broadly. Seminars are recorded and made available online to students and the public (http://cfw.essie.ufl.edu/seminars/). This electronic library currently hosts ten years of recorded seminars (nearly 200 recordings), and is the world's largest online repository of recorded wetlands-focused research and management information. Website tracking indicates over 1,500 seminar views since 2012.

Visiting Scientists and Engineers. The Center has at least one visiting scientist or engineer in residence each semester (and sometimes up to six). Visiting scholars have come from Australia, Brazil, China, Germany, Israel, Italy, Mexico, South Africa, Botswana, and Uganda. These visiting scholars give guest lectures in classes and the Center seminar series, and they work actively with our graduate students (see list under *International Significance*). These visiting scientists and engineers often reciprocate by hosting or coordinating visits by our faculty and students.

Undergraduate Research Opportunities. Since 2010, the Center has supported ~20 undergraduate research assistants through the University Scholars program, the HHMI Science for Life program, and via research assistantships.

Significance of Center for Wetlands to the State of Florida

Mined-Land Reclamation. The Center has been the principle UF focal point for research needs of the Florida Institute for Phosphate Research related to the creation and management of aquatic and wetland ecosystems on phosphate-mined lands of central Florida.

Wetlands for Wastewater Treatment. The Center was the pioneer in this area of research and has worked from its inception with the private and public sectors on the design and management of treatment wetlands for wastewater and stormwater.

Coastal Wetland Resilience. A newer research thrust supported by the Center focuses on the resilience of coastal wetlands to a variety of disturbances and seeks to develop the science and design tools essential for creating living coastlines of highly functional ecological communities that are integral components of resilient coastal infrastructure. Major research efforts are to identify the mechanisms that foster the establishment, growth and resilience of coastal ecosystems (including marshes, mangroves, estuaries, coastal dunes, oyster bars and coral reefs) that provide key services to coastal communities. Research progress on this front is critical to the state of Florida, which is uniquely vulnerable to the effect of climate change.

National Wetland Condition Assessment. Funded by US Environmental Protection Agency, this Center project focused on assessment of wetland condition as part of the US EPA National Wetland Condition Assessment (NWCA) in both 2011 and 2016. Information collected from this assessment has been used by the US EPA in support of the first ever nation-wide evaluation of wetland condition based on chemical, physical, and biological parameters.

Library and Publications. The Center maintains a library of student theses, dissertations, and "gray" literature including project reports from university, state and private sector research on wetlands. A complete list of all publications developed through the Center is provided on the Center's website. Hard copies of all literature are made available to the public at cost and scanned PDFs at no cost. Members of the public are welcome to visit the library and use the collection.

UF Digital Library Center. Center staff have created the Howard T. Odum Center for Wetlands Publications, a digital collection of reports published by the Center and theses and dissertation of students supported on Center research initiatives. As part of the University of Florida Digital Collections, the Odum collection is available to the public and the increase in usage since developing the collection has been dramatic. ***From June 2007 until June 2017, 260,040 items have been viewed by over 10,000 unique visitors.*** This represents a substantial increase of exposure and sharing of Center research to UF researchers and the general public.

Howard T. Odum Papers. Center staff worked with UF library staff to create the Odum papers collection in 2009. The collection contains the papers of H.T. Odum, Graduate Research Professor, Department of Environmental Engineering Sciences. The Odum Papers document Odum's the life and career. The collection spans the majority of his life, with materials dating from 1935 to 2003. The bulk of the collection is comprised of Odum's professional files related to his research and educational activities.

Florida Wetland Condition Index Development: Research at the Center led to the development of the Florida Wetland Condition Index (FWCI), a biological indicator of wetland condition that is used across the state in wetlands management, assessment, and mitigation.

UMAM Training Courses for Professionals. The Center instituted training courses in Florida's Unified Mitigation Assessment Methodology (UMAM) for environmental professionals and government agency personnel. The Center developed a training manual and conducted annual short courses that are used by both the consulting industry and government agencies (FDEP and WMD's) for training new hires in the methodology now employed by the State of Florida for all mitigation assessment requirements.

Significance of Center for Wetlands Internationally

Global Wetlands Consortium. In 2006, the Center took the lead role in organizing the Global Wetlands Consortium (GWC), which includes nine international wetlands research centers. The GWC fosters international comparative research, scholarly exchange of researchers and students, and international workshops and symposia.

Active linkages with International Centers/Programs. The Center maintains active linkages with the US Geological Survey's National Wetlands Research Center, as well as with several international centers/programs, including the Center For African Wetlands at the University of Ghana, the National Centre for Tropical Wetland Research in Australia, the Okavango Research Institute at the University of Botswana, and the International Center for Research in Agroforestry in Nairobi, Kenya

Visiting International Scholars (2011 – 2016). The Center hosts several international scholars each year that provide important opportunities for students and faculty. Visiting Scholars offer seminars and short courses in their areas of expertise and often work with students on shared research. Most scholars co-author peer-reviewed journal articles following from their collaborative work with Center faculty. *Thirteen visiting Scholars were hosted by the Center during this five-year reporting period*:

Huilong Lin (2011–2012). *Professor, Lanzhou University College of Pastoral Agriculture Science and Technology, Lanzhou China.* Professor Lin modeled wetland systems of the Mongolia region in northern China.

Cheong-Jo Cheong (March 2012 – Feb 2013). *Associate Professor, Environmental Engineering, Sunchon National University, Sunchon, Jeon-nam, South Korea.* Cheong-Jo spent his sabbatical at the Center in order to learn and apply systems ecology methods to his research in nutrient dynamics, geochemistry, and management of the coastal wetlands of Suncheon Bay.

Sonila Papathimiu (September 2012 – March 2013). *Fulbright Scholar, Lecturer at University of Tirana, Albania.* Sonila chose the Center for her Fulbright project: Establishment of Ecotourism Management Plan for the Albanian Coastal Wetlands.

Juliana Alencar (August 2013 – Aug 2014). *PhD student, Federal University of Ceará,* Brazil. Juliana visited in order to learn systems ecology principles and techniques and participate in

seminars to further her knowledge and augment her research project of developing a methodology to study the risk of eutrophication in reservoirs using Fuzzy Theory.

Fangli Su (August 2014 – September 2015). *Professor, Shenyang Agricultural University, China.* Fangli promoted the exchange of information and shared research interests in wetland ecology, restoration and watershed management, which led to a recent publication with Center faculty (Su et al., 2017).

Oldemar Junior (August 2015 – July 2016). *Neotropical Otter Sub-Group Coordinator, IUCN/SSC Task Force, Institute EKKOBrasil, Santa Catarina, Brazil*. Oldemar collaborated with Center faculty to apply emergy methods to conservation tourism in the Pantanal Biome of Mato Grosso do Sul state, Brazil, including simulation of giant and neotropical otter populations.

Carolina Joana da Silva (September 2015 – July 2016). *Professor and former Dean, University of the State of Mato Grosso, Brazil*. Caroline performed postdoctoral research at the Center on comparative studies between the Pantanal and Florida Everglades wetlands.

Ji Wenyuan (August 2016 – December 2016). *Director, Convention on Wetlands Management Office, State Forestry Administration, P.R.China*. Ji worked with Center staff to evaluate Chinese national 30-year wetland planning efforts.

Ma Xiaohui (August 2016 – December 2016). *Program Coordinator, Academy of Forest Inventory and Planning of the State Forestry Administration, P.R.China.* Ma worked with Center staff to evaluate Chinese national 30-year wetland planning efforts.

Victoria Isaac (August 2016 – May 2017). *Professor, Federal University of Pará, Brazil.* Victoria worked with Center facutly to apply environmental time series modeling to Amazon river fisheries catch.

Zhao Sheng (September 2016 – February 2017).

Xiaojia Liu (September 2016 – September 2017).

Xiaoqi Sun (September 2016 – September 2017).

2. FACULTY AND KEY PERSONNEL

Director: **David A. Kaplan**, Assistant Professor
Environmental Engineering Sciences

Faculty: **Mark T. Brown**, Professor Emeritus
Environmental Engineering Sciences
Christine Angelini, Assistant Professor
Environmental Engineering Sciences

Postdoctoral Researchers: **Subodh Acharya**

Office Manager: **Sharlynn Sweeney**

Affiliated Faculty

The following UF faculty members have interacted regularly with the Center through participation in weekly seminars, as co-PIs on research proposals, and/or though participation on graduate committees:

Carrie Reinhardt Adams, UF / Environmental Horticulture Department
Peter Adams, UF / Geology
Mary Jane Angelo, UF / Levin College of Law
Thomas T. Ankersen, UF / Levin College of Law
Michael Annable, UF / Environmental Engineering Sciences
Benjamin Baiser, UF/ Wildlife Ecology and Conservation
Thomas Bianchi, UF / Geology
Stephanie Bohlman, School of Forest Resources and Conservation
Mark Brenner, UF / Geological Sciences Department
Jean-Claude Bonzongo, UF / Environmental Engineering Sciences
Treavor H. Boyer, UF / Environmental Engineering Sciences
Margaret Carr, UF / Landscape Architecture
Mark Clark, UF / Soil and Water Science
Matthew Cohen, UF / School of Forest Resources and Conservation
Katherine Ewel, UF School of Forest Resources and Conservation
Alyson C. Flournoy, UF / Levin College of Law
Thomas Frazer, UF / School of Forest Resources and Conservation
Peter Frederick, UF / Wildlife Ecology and Conservation
Paul Gader, UF / ESSIE
Wendy Graham, UF / Water Institute
Richard G. Hamann, UF / Levin College of Law
Stephen Holland, UF / Tourism, Recreation & Sport Management
Patrick W. Inglett, UF / Soil and Water Science
John M. Jaeger, UF / Geological Sciences
James Jawitz, UF/ Soil and Water Sciences
James W. Jones, UF / Agricultural and Biological Engineering
Michael E. Kane, UF/Environmental Horticulture
Gregory A. Kiker, UF / Agricultural and Biological Engineering
Wiley M. Kitchens, UF / Wildlife Ecology and Conservation
Bette Loiselle, UF / Tropical Conservation and Development Program
Kai Lorenzen, UF / School of Forest Resources and Conservation
Frank J. Mazzotti, UF / Wildlife Ecology and Conservation
Daniel McLaughlin, UF / School of Forest Resources and Conservation
Rafael Munoz-Carpena, UF / Agricultural and Biological Engineering Department
Todd Z. Osborne, UF / Soil & Water Science
Hector E. Perez, UF / Environmental Horticulture Department
Edward J. Phlips, UF / School of Forest Resources and Conservation
Frances E. Putz, UF / Biology Department
Ramesh K. Reddy, UF / Soil & Water Science

Katrina Z. S. Schwartz, UF / Political Science Department
Y. Peter Sheng, UF / Coastal & Oceanographic Engineering Department
Cynthia Simmons, UF/ Geography
Nigel J. Smith, UF / Geography Department
Bron R. Taylor, UF / Religion Department
Denis Valle, UF / School of Forest Resources and Conservation

University Academic/Research Advisory Board
Composed of faculty members representing the following colleges: College of Engineering, College of Design Construction and Planning, College of Liberal Arts and Sciences, College of Agricultural and Life Sciences, and College of Law.

Ag-Bio Engineering
Rafael Munoz-Carpena, carpena@ufl.edu
College of Design Construction and Planning
Margaret Carr, mcarr@dcp.ufl.edu
College of Law
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Soil and Water Sciences
Mark Clark, clarkmw@ufl.edu
Wildlife Ecology and Conservation
Peter Frederick, pfred@ufl.edu
Water Institute
Windy Graham, wgraham@ufl.edu

3. PUBLICATIONS SINCE 2011 (CFW FACULTY, STUDENTS, AND VISITING SCHOLARS ARE UNDERLINED; ONLY *WETLANDS-RELATED* PUBLICATIONS LISTED HERE):

a. Publications – Peer reviewed

Acharya, S., D. Kaplan, S. Casey, M.J. Cohen, and J. Jawitz. 2015. Coupled local facilitation and global hydrologic inhibition drive landscape geometry in a patterned peatland, *Hydrology and Earth System Sciences* 19, 2133-2144. DOI:10.5194/hess-19-2133-2015.

Angelini C., Griffin J.N., van de Koppel J., Derksen-Hooijberg M.G, Lamers L.P.M., Smolders A.J., van der Heide T., Silliman B.R. 2016. A keystone mutualism underpins resilience of a coastal ecosystem to drought. Nature Communications 12473, DOI: 10.1038/ncomms12473.

Angelini C., van der Heide T., Griffin J.N., Morton J.P. G, Derksen-Hooijberg M. G, Lamers L.P.M., Smolders A.J., Silliman B.R. Foundation species, biodiversity hotspots, and the

landscape-scale multifunctionality of a coastal ecosystem. *Proceedings of the Royal Society B* (282): 1811. DOI:10.1098/rspb.2015.0421.

Angelini, C., T. van der Heide T., J. N. Griffin, J. P. Morton, M. Derksen-Hooijberg, L. P. M. Lamers, A. P. Smolders, and B. R. Silliman. 2015. Foundation species' overlap enhances biodiversity and multifunctionality from the patch to landscape scale in southeastern US salt marshes. *Proceedings of the Royal Society B***:** 20150421.

Arias, M. E. and M.T. Brown. 2010. Feasibility of using constructed treatment wetlands for municipal wastewater treatment in the Bogotá Savannah, Colombia. *Ecological Engineering* 35:1070-1078.

Arias, M.E., M.T. Brown, and J.J. Sansalone, 2013. Characterization of Storm Water–Suspended Sediments and Phosphorus in an Urban Catchment in Florida. J. Environ. Eng. 2013.139:277-288.

Atkins R.L., Griffin J.N., Angelini C., O'Connor M.I., Silliman B.R. 2015. Consumer-plant interaction strength: importance of body size, density and metabolic biomass. *Oikos*. DOI: 10.1111/oik.01966.

Blair, S., C. Adams, T. Ankersen, M. McGuire, and D. Kaplan. 2015. Ecosystem services valuation for estuarine and coastal restoration in Florida. *Florida Sea Grant /IFAS Extension Publication* TP-204. University of Florida, Gainesville. http://edis.ifas.ufl.edu/sg134.

Boyd, M. C., M. T. Brown, and S. Brandt-Williams. 2015. Addressing pollutant load reduction goals for impaired water bodies through biomass harvest of Gulf Coast type *Phragmites australis* (common reed). *Wetlands Ecology and Management*.

Brown, M.T., M.J. Angelo. 2009. Valuing Nature: The Challenge of a National Environmental Legacy Act. In D. M. Driesen and A. C. Flournoy (eds), Beyond Environmental Law: Policy Proposals for a Better Environmental Future. Cambridge University Press, NY. Pp 81-208

Casey, S., M.J. Cohen, S. Acharya, D. Kaplan, and J. Jawitz. 2016. On the spatial organization of the Ridge-Slough Patterned Landscape, *Hydrology and Earth System Sciences* 20, 4457-4467, DOI:10.5194/hess-20-4457-2016.

Davidson A.U, Griffin J.N., Angelini C., Coleman F., Atkins R.L. U, Silliman B.R. 2015. Non-consumptive predator effects intensify grazer-plant interactions by driving vertical habitat shifts. *Marine Ecology Progress Series* 537: 49-58.

Davidson, A., J. N. Griffin, R. Atkins, C. Angelini, F. Coleman, and B. R. Silliman, 2015. The spatial dimension of trait-mediated indirect interactions: Predators intensify grazer-plant interactions by driving vertical, not horizontal, grazer habitat shifts. *Marine Ecology Progress Series* 450: 185-190.

Johnson, A., N. Reaver, and D. Kaplan. 2016. Evaluating the Raz-Rru tracer system for use in Florida Springs. *Journal of Undergraduate Research* 17(3)1-6.

Kaplan, D. and R. Muñoz-Carpena. 2014. Groundwater salinity in a floodplain forest impacted by saltwater intrusion. *Journal of Contaminant Hydrology* 169:19-36.

Kaplan, D., M. Bachelin, C. Yu, R. Muñoz-Carpena, T. Potter, and W. Rodríguez Chacón. 2014. A hydrologic tracer study in a small, natural wetland in the humid tropics of Costa Rica. *Wetlands Ecology and Management*.

Kaplan, D., M. Olabarrieta, P. Frederick, and A. Valle-Levinson. 2016. Freshwater Detention by Oyster Reefs: Quantifying a keystone ecosystem service. PLoS ONE 11(12): e0167694. DOI:10.1371/journal.pone.0167694.

Kaplan, D., R. Paudel, M. Cohen, and J. Jawitz. 2012. Orientation matters: Patch anisotropy controls discharge competence and hydroperiod in a patterned peatland. *Geophysical Research Letters* 39: L17401.

Langston, A., D. Kaplan, and C. Angelini. 2017. Biotic and abiotic controls on the northern range expansion of black mangrove (*Avicennia germinans*). *Hydrobiologia* DOI 10.1007/s10750-017-3197-0.

Lee, S. and M.T. Brown. 2011. An energetic perspective on the relationship between disturbance and ecosystem productivity. *Ecological Modelling* 222 (2011) 3577– 3586.

McLaughlin, D., D. Kaplan, and M.J. Cohen. 2014. A Significant Nexus: Geographically Isolated Wetlands Influence Landscape Hydrology. *Water Resources Research* 50:7153–7166.

McLaughlin, D., M. Carlson Mazur, D. Kaplan, and M. Cohen. 2014. Estimating effective specific yield in inundated conditions: a comment on a recent application. *Ecohydrology.*

McLaughlin, D.L., D. Kaplan, and M.J. Cohen. 2013. Managing Forests for Increased Regional Water Yield. *Journal of the American Water Resources Association* 49(4):953-965.

McLaughlin, D.L., M.T. Brown, and M.J. Cohen. 2011. The Ecohydrology of a pioneer wetland species and a drastically altered landscape. Ecohydrology. 5, 656–667.

Murray-Hudson, M., C. R. Lane, S. North and M. T. Brown. 2012. Macrophyte Species Distribution, Indices of Biotic Integrity, and Sampling Intensity in Isolated Florida Marshes. *Wetlands* DOI 10.1007/s13157-012-0278-8.

Murray-Hudson, M., P. Wolski, L. Cassidy, M. T. Brown, K. Thito, K. Kashe, E. Mosimanyana. 2014. Remote Sensing-derived hydroperiod as a predictor of floodplain vegetation composition. *Wetlands Ecology and Management*. DOI 10.1007/s11273-014-9340-z

Palacio, D., D. Kaplan, and J. Mossa. 2016. A synthesis of stream restoration efforts in Florida (USA). *River Research and Applications* 32(7):1555-1565. DOI:10.1002/rra.3014.

Porzecanski, I., L. V. Saunders and M. T. Brown. 2012. Adaptive management fitness of watersheds. *Ecology and Society* 17(3): 29.

Reiss, K.C., E. Hernandez, M.T. Brown. 2014. Application of the landscape development intensity (LDI) index in wetland mitigation banking. *Ecological Modeling*. 271 (2014) 83– 89.

Sharp, S.J. and C. Angelini. 2016. Whether disturbances alter salt marsh soil structure dramatically affects Spartina alterniflora recolonization rate. Ecosphere 7(11): e01540.

Su, F., D. Kaplan, L. Li , H. Li , F. Song, and H. Liu. 2017. Identifying and classifying pollution hotspots to guide watershed management in a large multiuse watershed. *International Journal of Environmental Research and Public Health (MDPI)* 14(260). DOI:10.3390/ijerph14030260.

Watts, A., C. Schmidt, D. McLaughlin, and D. Kaplan.2015. Hydrologic implications of smoldering fires in wetland landscapes. *Freshwater Science* 34(4). DOI:10.1086\683484.

Watts, A., D. Watts, M. Cohen, J. Heffernan, D. McLaughlin, J. Martin , D. Kaplan, A. Murray, T. Osborne, and L. Kobziar. 2014. Evidence of biogeomorphic patterning in a low-relief karst landscape. *Earth Surface Processes and Landforms.*

White, E. and D. Kaplan. 2017. Restore or Retreat? Saltwater Intrusion and Water Management in Coastal Wetlands. *Ecosystem Health and Sustainability (ESA)*3(1): e01258. DOI: 10.1002/ehs2.1258.

Yuan, J., M. Cohen, D. Kaplan, S. Acharya, L. Larsen, and M. Nungesser. 2015. Linking metrics of landscape pattern to hydrological process in a lotic wetland. *Landscape Ecology* 219:1-20. DOI:10.1007/s10980-015-0219-z.

Zhang, Y., R. Wang, D. Kaplan, and J. Liu. 2015. Which components of plant diversity are most correlated with ecosystem properties? A case study in a restored wetland in northern China. *Ecological Indicators*, 49:228-236. DOI:10.1016/j.ecolind. 2014.10.001.

b. Research Reports and Outreach Publications

Atahyde, S., J. Dutka-Gianelli, D. Kaplan, and S. Bohlman. 2014. Engineered Landscapes: Society, the Environment, and Shifting Values in Brazil and the United States. October 2014, Gainesville, FL.

Kaplan, D. 2012. "What is the structure of water?" and "Why do whales sing?" In M. Lamothe, J. Rothman, J. Volvovski (Eds.): *The Where, The Why and The How: 75 Artists Illustrate Wondrous Mysteries of the Universe*. Chronicle Books, San Francisco.

Kaplan, D. 2013. How Do Watersheds Dictate the Ecological Integrity of Florida Lakes? *Invited* workshop at the Florida Lake Management Society, 24th Annual Conference & Symposium: Integrating Lake and Watershed Management, June 2013, Daytona Beach, FL.

Kaplan, D. Going Dry in the Land of Plenty? Florida's Hydrological History and Looming Water Crisis. ***Invited*** talk at the Friendship Fellowship at Pineda (Unitarian Universalist Church), September 2015, Rockledge, FL.

Kaplan, D. and S. Arden. 2015. Past, Present, and Future: Using Climate Data and Models to Inform Lake Management in Florida? *Invited* workshop at the Florida Lake Management Society, 24th Annual Conference & Symposium, June 2015, Naples, FL.

Reiss, K. and M.T. Brown. 2015. Dissolved Oxygen in Coupled Riverine and Wetland Systems. Final Report Submitted to the Florida Department of Environmental Protection under Contract WQ009

4. AWARDS AND OTHER INDICATORS OF NATIONAL/INTERNATIONAL RECOGNITION

M. Brown, Distinguished Visiting Professor, Key Laboratory of Land Surface Pattern and Simulation, Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing (2015 – Present)

Distinguished Visiting Professor, Shenyang Agricultural University, Shenyang, China (2015 – Present)

M. Brown, Distinguished Visiting Professor, School of the Environment, Beijing Normal University (2014 – present)

M. Brown, Distinguished Fulbright Chair of Energy and Environment, Parthenope University of Naples, Italy

D. Kaplan, UF College of Engineering International Educator of the Year (2016)

D. Kaplan, UF Term Professorship (2017-2020)

5. GRADUATE STUDENTS SUPPORTED

The following students are/have been supported on wetlands-related research from 2011-2016:

PhD Students:

Student	Research Topic	Home Dept.	Complete Date
Al-Quariashi, Ali	Restoration of the Mesopotamian Marshes (Iraq)	EES	5/19
Bresoza, Ada	Oyster reef restoration	EES	5/19
Arden, Sam	Distributed water networks	EES	12/17
Boyd, Mary	Nutrient dynamics in a Phragmites marsh in central Florida	EES	08/12
Burkett, Valerie	PAH degradation in coastal wetlands following the Deepwater Horizon oil spill	EES	08/15
Carton, Charles	Nutrient dynamics in soils of treatment wetlands following flooding	EES	08/12
Crotty, Sinead	Foundational species dynamics in salt marshes	EES	5/20
Crouch, Trey	Impact of dams on Amazon ecohydrology	EES	05/19
DeVilbiss, Chris	Global Emergy Baseline	EES	8/16
Dooley, Jenet	Sound impacts on ecological function of wetlands	EES	08/15
Henson, Kevin	Managing forests for increased water yield	EES	05/18
Glodzik, Katie	Saltwater intrusion in coastal ecosystems	SNRE	12/17
King, Sean	Effects of flow on filamentous algae and nutrient limitation in lotic systems	ENE	12/12
Langston, Amy	Effects of climate change and sea level rise on groundwater-dependent ecosystems	EES	08/17
Lee, Dong Joo	Global ecosystem services	EES	5/18
Lee, Seungjuen	Effect of Disturbance on Ecosystem Processes	EES	12/10
Mainella, Alexa	Wetland Avian Ecology	EES	5/21
McLaughlin, Daniel	Hydrologic simulations of water balance on Phosphatic Clay settling Basins for establishment of wetland ecosystems	EES	05/11
Palacio, Darina	Quantifying and Prioritizing Stream Restoration Needs in Florida	EES	08/12
Prince, Kimberly	Environmental contaminants in coastal communities	EES	5/19
Rath, Sagarika	Sustainable agricultural and water quality	ABE	5/20
Reaver, Nathan	Connection between hydrologic change and the ecology of spring ecosystems	EES	05/18

Sharp, Sean	Feral hog disturbance in coastal marshes	EES	12/17
Sindelar, RJ	Coupled Chemical/Biological Systems For Maximizing Phosphorus Removal From Natural Waters	EES	08/13
Walker, Julie	Trophic interactions	EES	5/20
Weinkam, Grant	Long Term Management of Phosphorus in Land Applied Reclaimed Water	EES	08/15
White, Elliott	Coastal wetland ecology	EES	05/19

Masters Students

Casey, Stephen	Geomorphology of Florida Everglades Ridge and Slough system	EES	05/13
Compton, Bobby	Development of Oxygen criteria for Florida Wetlands	EES	12/12
Fleischman, J	Ecological engineering of a closed basin stormwater management system	ENE	05/14
Hernandez, Erica	Wetland condition index for Florida Wetlands	SNRE	08/14
Hoyord, Torren	Ecologically engineering stormwater facility on UF campus	EES	08/13
Timpe, Kelsie	Environmental flows for dam management in the Amazon	SNRE	05/16

6. INTERNAL AND EXTERNAL FUNDING (SINCE 2011)

Title of Grant	Funding Agency	PI/CoPI	Effective Dates		Value of Contract
			Start Date	End Date	
NSF-IGERT in Adaptive Management	NSF	Brown (PI)	09/05-	09/12	$3.2M
NSF IGERT Match	UF-RGP	Brown (PI)	09/05	09/12	$625K
NSF IGERT Match	UF-COE	Brown (PI)	09/05	09/12	$162.5K
Assessing Visitor Use Impact In Botany Bay Plantation Using An Adaptive Management Framework	NOAA	Brown (PI)	06/09	06/11	$20K
Level 1 Landscape Scale Analysis of Wetland Condition	EPA region 4	Brown (PI)	10/10	04/12	$154.5K
FY 2010 Section 106 Monitoring Initiative Funds: Water Monitoring Program Enhancements and National Wetland Condition Assessment	FDEP/USEPA	Brown (PI)	03/11	03/14	$174K
National Wetlands Condition Assessment - 2011	FDEP/USEPA	Brown (PI)	04/11	03/14	$434.7K
Water Institute Graduate Fellows Program titled: Adaptive Watershed Management in the Face of Numeric Nutrient Criteria	UF - CLAS, CALS, COE and WI	Brown (PI)	12/10	8/15	~$840k
Water Institute Graduate Fellowship Support	Water Institute	Brown (PI)	08/11	08/15	$100K

Dissolved Oxygen in Coupled Riverine and Wetland Systems	FDEP	Brown (PI)	06/13	05/14	$40K
Lake Jesup Total Phosphorus (TP) Removal Treatment Technologies Feasibility: Floating Island Project	SJRWMD	Brown (PI)	12/08	09/10	$200K
Lake Jesup Total Phosphorus (TP) Removal Treatment Technologies Feasibility: Experimental Phragmites Harvest to Reduce TP in Lake Jesup	SJRWMD	Brown (PI)	09/09	06/10	$50K
Modeling the connections between hydrology, water quality, and ecosystem health to support coastal preservation efforts across the Northern Gulf Coast	USGS/NPS	Kaplan (PI)	10/2014	10/2016	$294K
Springs Protection Initiative: Collaborative Research Initiative on Sustainability and Protection of Springs	SJRWMD	Kaplan (Co-PI)	4/2014	7/2017	$3,000K
Managing Forests for Increased Regional Water Availability	FDACS, SJRWMF, SRWMD, SWFWMD, SFWMD, NWFWMF	Kaplan (Co-PI)	3/2014	3/2018	$637K
Predicting the effects of water use, climate change, and sea-level rise on saline and freshwater communities of the Lower Suwannee and Cedar Keys National Wildlife Refuges	US Department of Interior, Fish and Wildlife Service	Kaplan (PI)	9/2013	9/2015	$39K
Quantifying a novel ecosystem service of oyster reefs: estuarine freshwater entrainment	FL SeaGrant	Kaplan (Co-PI)	9/2013	9/2014	$10K
Establishing a Natural Resources-Based "Adaptation Action Area" for the town of Yankeetown	FL Dept. of Economic Opportunity	Kaplan (Co-PI)	6/2013	6/2014	$25K
Energy, society, and environment in the Amazon: understanding social-ecological transformation from dam development in the world's largest watershed	UF/Water Institute	Kaplan (PI)	8/2015	5/2019	~$1,200K
Agricultural Water Security Through Sustainable Use of the Floridan Aquifer: An Integrated Assessment of Economic and Environmental Impacts	USGS	Kaplan (PI)	3/2016	2/2017	$80k
National Wetlands Condition Assessment - 2016	US EPA	Kaplan (PI)	4/2016	3/2019	$414.2k
Long-term trends in floodplain forest tree growth across salinity gradients in along Florida's Big Bend coastline	USGS	Kaplan (PI)	5/2016	5/2018	$65k
Data Collection for Improvement of the Florida Wetland Condition Index	FL DEP	Kaplan (PI)	7/2016	3/2019	$111,788
Agricultural Water Security through Sustainable Use of the Floridan Aquifer: An Integrated Assessment of Economic and Environmental Impacts	USDA – NIFA	Kaplan (Co-PI)	3/2017	2/2022	$4,918k

CNH-RCN: Amazon Dams Network: advancing integrative research and adaptive management of social-ecological systems transformed by hydroelectric dams	NSF	Kaplan (Co-PI)	9/2016	8/2021	$498,997
Eager: Secondary Foundation Species as Drivers of Ecosystem Resilience (00097757)	NSF	Angelini (PI)	9/2015	8/2017	$150k
Re-engineering Living Shorelines to Halt Erosion and Restore Coastal Habitat Functioning in High-energy Environments (00098773)	NOAA	Angelini (PI)	1/2016	8/2017	$446k
Biomagnification of Aroclor1268 in Coastal Food Webs (00099202)	UF Foundation	Angelini (PI)	4/2016	3/2017	$8k
Assessing and Enhancing the Value of Coastal Marshes for Protecting Coastal Communities from Storm Surge and Flooding in a Changing Climate	NOAA	Angelini (Co-PI)	11/2016	9/2019	$242k
CAREER: Accelerating Natural Self-organization and Restoring Coastal Ecosystem Services with Reef-mimicking Substrate Arrays	NSF	Angelini (PI)	4/2017	3/2022	$503k
A Web-based Interactive Decision-support Tool for Adaptation of Coastal Urban and Natural (ACUNE) in Southwest Florida	NOAA	Angelini (Co-PI)	7/2017	5/2020	$997k
Quantifying nutrient and water fluxes in treatment wetlands using sediment passive flux meters to evaluate and improve performance	UF Foundation	Angelini (Co-PI)	7/2017	6/2018	$8k

7. OTHER CENTER ACTIVITIES

Major Conferences in Area of Focus – The Center was a sponsor of the 9th INTECOL International Wetlands Conference in Orlando Florida June 3-9, 2012 and hosted the 2016 9th Emergy Conference.

Funding of Graduate Student Travel – The Center provides competitive funding opportunity for graduate student to travel to national wetlands conferences.

Graduate Student Stipend – The Center provides one graduate student stipend each academic year to a student conducting wetlands related research.

Wetlands Scholarships – The Center awards two scholarships to graduate students who are conducting wetlands related research.

Exchange Agreements – The Center has cooperative agreements in place with the Okavango Research Institute in Maun, Botswana and the Department of Environmental Science at Parthenope University of Naples, Italy.

Strategic Goals

The Howard T. Odum Center for Wetlands' overarching goals focus on providing leadership for

interdisciplinary research, education and outreach regarding wetlands and related resources at the state, national and international level through: 1) conducting, facilitating, and coordinating wetlands related research, 2) providing a forum for discussion and interdisciplinary dialog between faculty and students, 3) articulating and catalyzing research in emerging areas of wetlands science and policy, 4) providing opportunities for graduate education in wetlands sciences, and 5) providing disciplinary, professional, institutional, and community service.

Goal 1: Wetlands Related Research

- Facilitate and encourage interdisciplinary research that integrates science, engineering, management and policy directed at wetlands and related resources.
- Focus on areas of existing strengths including, wetlands ecology, restoration, ecological engineering, wetlands policy, wetlands valuation.
- Further develop areas of emerging strength including coastal resilience and watershed hydrology and ecology.
- Promote workshops, conferences, and symposia related to wetland science and policy.

Goal 2: Interdisciplinary Dialogue

- Foster campus wide opportunities for interdisciplinary discussion of wetlands issues, ecosystem resilience, adaptive management, and integrative graduate education.
- Continue to coordinate the Wednesday "wetlands seminars" and possibly combine with other programs by soliciting faculty and student speakers.
- Coordinate Wetlands Academic Cluster and the Interdisciplinary Concentration in Wetlands Sciences.

Goal 3: Catalyze Research in Emerging Areas of Wetlands Science and Policy

- Sponsor retreats with faculty to identify emerging research opportunities and to develop innovative research proposals.
- Sponsor faculty travel to funding agencies for the purposes of conferences and discussions related to proposals in preparation.

Goal 4: Opportunities for Graduate Education in Wetlands Science

- Enhance the visibility of the Interdisciplinary Concentration in Wetlands Sciences.
- Actively pursue donations to establish graduate fellowships in wetlands sciences. The Center currently has one fellowship donated by the Poole family of Orlando and named after H.T. Odum.
- Aggressively pursue research opportunities that include graduate stipends.
- Further develop student internship programs with Water Management Districts and local governments.

Goal 5: Service to Disciplines, Professions, Institutions, and Communities

- Offer workshops in wetlands delineation, and Unified Mitigation Assessment Method.
- Actively sponsor the student run UF Wetlands Club.
- Sponsor travel awards for graduate students to attend professional meetings.

- Continue to solicit research reports and gray literature from agencies and industry to maintain up-to-date depository of wetlands related literature.
- Continue to disseminate information from the Center's Library and to make all documents available in electronic format.

8. PLANNED ACTIVITIES

Water Wetlands and Watersheds Seminar. The Center will continue to coordinate the weekly "brown-bag seminar" during the academic year drawing speakers from UF, state agencies and the private sector to speak on a variety of topics of current and projected interest.

UF Interdisciplinary Concentration in Wetlands Science (ICWS). The Center will continue to coordinate the ICWS. In the coming year, working in conjunction with the Society of Wetlands Scientists and the faculty on the ICWS Board, we will initiate the first national Distance Education program in Wetlands Science, leading to registration as a Professional Wetlands Scientist (http://www.wetlandcert.org).

Proposal Preparation. The Center will continue to participate in proposal preparation for interdisciplinary research related to wetlands, ecological engineering, restoration ecology in terrestrial, aquatic and estuarine environments. Center staff have been key participants in the ESSIE ERC proposal on Resilient Coastal Systems as well as in three resilience-focused proposals to NOAA (two submitted, one in preparation). Center faculty are also central to the UF Water Instiute-led $5,000,000 proposal to the USDA NIFA focused on landscape-scale land use, water quantity, and water quality changes across the southeastern US, which was recently funded.

National Wetlands Condition Assessment. Based on its preminence in the field of wetlands ecology and management, the Center has been selected (again) to lead the next phase of the EPA-funded 2015 National Wetlands Condition Assessment for Florida.