

PROJECT INFORMATION

Project Director's Name*	Christopher Esposito
Organization*	The Water Institute of The Gulf
Project Title*	Transport Thresholds for Fine Sediment in Vegetation
Reporting Period*	Nov 2017 - Aug 2021

Note to Grantees: In sections 1 to 5, we ask you to highlight your accomplishments (including outputs and outcomes) through this grant award. These sections of the final grant report will be made available to the public.

1. GOALS AND ACCOMPLISHMENTS

1.1 Please restate the goals and objectives of your project.*

The overarching goal of this project has been to better understand how vegetation modulates fine sediment delivery to coastal wetlands, and sediment retention therein.

Many coastal restoration schemes depend on the use of vegetation to trap fine sediment. Because seasonal changes in vegetation can have a profound influence on sediment transport, a deep understanding is needed to operate restoration infrastructure for optimized sedimentation. But coupled measurements of flow, vegetation, and sediment transport at frequencies that are sufficient to guide operational decisionmaking are difficult to obtain.

Our objectives therefore were:

1. Develop techniques to collect high frequency measurements of vegetation, flow, and sedimentation in coastal wetlands.
2. Using these newly developed techniques, document the interaction of vegetation, flow, and sedimentation.
3. Incorporate lessons learned into physics-based numerical models that are commonly used in restoration planning, as well as into lab experiments to gain further insight into the physical mechanisms of sediment transport in marshes.
4. Engage with restoration practitioners through a Practitioner Advisory Panel so that the scientific ideas that are developed during the project have an outlet in real world restoration practice.

1.2 Describe the accomplishments of your project. You should include both the anticipated accomplishments that you outlined in your project proposal as well as any *unanticipated* accomplishments that have since occurred. Describe any activities you have conducted, programmatic progress made, or project benchmarks and milestones met.*

The project team developed a suite of novel data collection methods to monitor the flow of water and sediment in vegetated wetlands. These included the use of drone-based imaging of dye releases, and a novel sediment tile sampling technique that can be used in highly unconsolidated sediments during flooded conditions, where traditional measurement techniques (sediment traps, feldspar horizons, radioisotopes) all fail.

Using these methods in the field, we collected the first measurements of sedimentation rates in a marsh as they change throughout the growing season, and that can be coupled with measurements of vegetation. These measurements can serve as the basis for plans to operate diversions and managed marshes in ways that will optimize sediment delivery and retention.

Critically, the measurements that were collected in a freshwater deltaic marsh showed that due to vegetation conditions, sediment that arrives at the marsh in early spring or in late summer is most likely to penetrate into the vegetated areas and to be retained there; but in the early summer vegetation is so dense that sediment that arrives is not delivered to the marsh. These results will significantly influence operational strategies for river diversions.

The field results are documented in a Master's thesis from Tulane University (Burgos, 2020), and in an associated Manuscript (Burgos et al., (in prep)).

The data collected in the field also informed a novel paper (Xu et al., in review) that used a lab scale simulation to explore the relationship between vegetation density, sediment delivery due to flow, and sediment erodibility due to vegetation stem generated turbulence. This paper suggests an optimum vegetation density that will yield the maximum deposition, an idea which will inform future restoration designs.

The field data and lab scale data were combined to develop an add-on to Delft3D, which is a commonly used numerical modeling software in coastal restoration applications. An article that applies this model to simulate conditions in the West Bay Sediment Diversion is in preparation (Yuill et al., in prep).

A final outcome of this project is a series of practitioner workshops that were held throughout the period of performance. These workshops were directed conversations among scientists, federal and state resource managers, academic and government researchers, coastal stakeholders, and NGO's. The conversations were initiated as a way of exchanging ideas related to the effective use of vegetation plantings in optimizing marshes for sediment retention and wetland management. Through those conversations a subset of the group was able to

plan and gain approval for a wetland vegetation planting that will take place in 2022. Through the iterative process of designing the planting we came to see that the best way to draw upon both skill sets is to create a space for cooperative experimentation and restoration.

This vegetation planting has become the seed for an unanticipated new project, The Bay Denesse Living Lab. The Living Lab will consist of the physical infrastructure, logistical support, and curated community that are needed to foster a sustained effort to engage both researchers and practitioners in ongoing collaborations to improve the best ways to manage and optimize the marshes of Coastal Louisiana.

In sum, the anticipated output products of this grant are:

- One student thesis. (Burgos, 2020)
- We anticipate four journal articles to come from this grant, to be published within the next year. Three of these are direct research products of this grant.
 - o (Burgos et al., (in prep))
 - o (Xu et al., in review)
 - o (Yuill et al., in prep)
 - o (Cox et al., in review)
- Conference presentations and seminar talks (see list below)
- Data sets showing vegetation influences on flow and sedimentation in two coastal locales are now available on GRIIDC.

THESES, PAPERS, AND REPORTS

Burgos, M. B. (2020). Effects of vegetation seasonality on sediment dynamics in a freshwater marsh of the Mississippi River Delta | Tulane University Digital Library. Tulane University, New Orleans, LA. Retrieved from <https://digitallibrary.tulane.edu/islandora/object/tulane%3A121971>

Burgos, M. B., Esposito, C. R., Baustian, M. M., Nepf, H. M., & Di Leon, D. ((in prep)). Seasonal Changes to Vegetation Determine Deltaic Marsh Sedimentation.

Cox, J., Paauw, M., Nienhuis, J., Dunn, F., Deijl, E. van der, Esposito, C. R., et al. (in review). Saved by Sediment: A Review of Sediment Enhancing Strategies for River Deltas. Nature Communications.

Xu, Y., Esposito, Christopher, Burgos, Maricel Beltrán, & Nepf, H. M. (in review). Competing effects of vegetation control sedimentation in freshwater deltaic marshes. Nature Geoscience.

Yuill, B. T., Esposito, C. R., & Nienhuis, J. (in prep). Accounting for vegetation turbulence in a morphodynamics model of a delta. Presented at the AGU Fall Meeting Abstracts. Retrieved from <https://ui.adsabs.harvard.edu/abs/2020AGUFMEP056..08Y>

CONFERENCE TALKS AND SEMINAR PRESENTATIONS

Esposito, C.R. (2020) "Basin-Side Sediment Diversion Considerations in the Lowermost Mississippi River", Sedimentation Strategies in Deltas Workshop; Utrecht, Netherlands / Virtual

Esposito, C.R. (2020) "Rapidly Changing Transport Conditions in a Vegetated Marsh", U.S. Fish and Wildlife Service Hydrology and Aquatic Resources Conservation Seminar

Esposito, C.R. (2019) "Putting Ecogeomorphology Into Practice: The Future of Coastal Management", AGU Fall Meeting, Young Scientists View of The Future

Esposito, C.R. (2019) "Rapidly Changing Transport Conditions in Deltaic Marshes", Louisiana State University School of the Coast and Environment, Baton Rouge, LA.

Esposito, C.R. (2019) "Restoration and Monitoring Activity in the Bay Denesse Wetland Restoration Planting", Plaquemines Parish Coastal Zone Advisory Commission, Port Sulfur, LA.

Esposito, C.R. (2019) "Exchange Processes Between Channels and Wetlands: Understanding and Application", Woods Hole Oceanographic Institution, Woods Hole, MA.

Burgos, M.B.†, Esposito, C.R., Baustian, M.M., Di Leonardo, D, Nepf, H.M., 2020: Accounting for Vegetation Turbulence in a Morphodynamics Model of a Delta, AGU Fall Meeting, online.

Yuill, B.T., Esposito, C.R., Nienhuis, J., 2020: Accounting for Vegetation Turbulence in a Morphodynamics Model of a Delta, AGU Fall Meeting, online.

Esposito, C.R., Courtois, A.J., Miner, M.D., 2020: Dredging as a Geomorphic Process, AGU Fall Meeting, online.

Esposito, C.R., Nepf, H.M., Burgos, M.B., Baustian, M.M., 2019: Rapidly Changing Transport Conditions In a Mississippi River Marsh, AGU Fall Meeting, San Francisco, CA.

Tevis, L., Mahon, R., Esposito, C.R., 2019: Flow and Sediment Dynamics Through Complex Emergent Marsh Vegetation, AGU Fall Meeting, San Francisco, CA.

Esposito, C.R., Nepf, H.M., Burgos, M.B., Baustian, M.M., 2019: Sediment Retention Processes in Coastal Marshes, CERF, Mobile, AL.

2. Outputs

Before the form is completed, you may click "Save & Continue Editing" at the bottom of the page at any time to save your work or "Next" to move onto the next page of this form.

When the form is completed, you may click "Mark as Complete" at the bottom of the page to save your work and return to the dashboard.

** denotes required fields*

2. OUTPUTS

Outputs are tangible or measurable deliverables, products, data, or publications produced during the project period.

2.1. Please indicate the number of students (K-12, undergraduate, or graduate), postdoctoral scholars, citizen scientists, or other trainees involved in the project. *

Please enter 0 if none were involved.

K-12 students	0
Undergraduate students	0
Graduate students	1
Postdoctoral scholars	1
Citizen Scientists	0
Other Trainees	0

2.2. Has your project generated any data and/or information products? *

Generation of data includes transformations of existing data sets and generation of data from existing resources (e.g., maps and images). Information products include publications, models, software, code, curricula, and digital resources.

(Check all that apply.)

Responses Selected:

Data

Information Products

2.3. Briefly describe how you fulfilled the approved Data Management Plan and, if applicable, any changes from the approved plan. *

The data management plan was followed as written. The only notable change is that data has been uploaded to GRIIDC, per updated instructions from NAS-GRP.

If your project has generated data, please download the Excel worksheet entitled [GRP Data Management Reporting](#). Use the “Data Report” tab in the worksheet to create an inventory of data sets that you produced and to verify deposit in a curation facility. Upon completion, please upload the worksheet to your task list. If you need guidance on how to complete the Data Report, please e-mail gulfgrants@nas.edu. A member of GRP’s data management staff will reach out to you.

If your project has produced publications, websites or data portals, GIS applications, models or simulations, software packages or digital tools, code, curricula, or other interactive media, please download the Excel worksheet entitled [GRP Information Management Reporting](#). Use the “Information Products Report” tab in the worksheet to create an inventory of these products and to verify deposit in a curation facility. Upon completion, please upload the worksheet to your task list. If you need guidance on how to complete the Information Products Report, please e-mail gulfgrants@nas.edu. A member of GRP’s data management staff will reach out to you.

2.4. Aside from data and information products, what other tangible or measurable deliverables or products (e.g., workshops, trainings, and outreach events) were produced during the project period? *

Upon completion of this form, you may upload supplemental material that represent the tangible or measurable deliverables or products to complement this narrative report.

The Practitioner Advisory Panel workshops that occurred from 2018 through 2021 were a tangible product of this grant. They represented an opportunity for researchers and restoration practitioners to exchange ideas related to the effective use of vegetation for sediment retention and wetland management. In total, three in-person workshops were held (2018, 2019, 2020), and one virtual workshop (2021).

As a result of the interactions during these workshops, a subset of the advisory panel applied for a wetland vegetation planting to be conducted by the Louisiana Coastwide Vegetative Planting program to design a planting of 10,000 plugs of Giant Cutgrass (*Zizaniopsis miliacea*) in the shallow water on the Southern and Western portions of Bay Dennesse, Louisiana. The planting will occur after the Mississippi River's spring flood in 2022 and will accelerate the transition of open water to emergent freshwater marsh. The Coastwide Vegetative Planting program is a CWPPRA-funded restoration program that is administered by the Natural Resources Conservation Service. It has been active since 2011. More information on the program can be found at:

<https://lacoast.gov/new/Projects/Info.aspx?num=LA-39>

While wetland vegetation plantings are important and valuable in their own right, the most exciting component of this collaboration is that it provides an opportunity for the Water Institute and its collaborators to actively participate in the design of the restoration planting. By doing so, and by working closely with the managers of the Louisiana Coastwide Vegetative Planting program, we have been able to leverage the restoration activity into a series of controlled experiments that will provide information about the most effective planting configurations for sediment retention, organic matter accumulation, or other restoration goals.

By planning our activities in this way – with researchers and restoration practitioners co-designing projects – we foster organized coordination and the exchange of creativity between the coastal restoration practitioner and research communities. The Bay Dennesse Living Lab will be built around the idea that while members of the research community are skilled at controlled experimentation, they do not usually have the ability to alter landscapes and ecosystems at scale; and while restoration practitioners do have that ability, their work would be enhanced and improved over time with rigorous experimentation and in-depth monitoring efforts to facilitate comparisons between projects and improvements to techniques.

The Bay Dennesse Living Lab is intended to provide the architecture to support this type of collaboration.

3. Data Management

Before the form is completed, you may click "Save & Continue Editing" at the bottom of the page at any time to save your work or "Next" to move onto the next page of this form.

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** denotes required fields*

3. DATA MANAGEMENT

In this section, please provide a response to each question to complement the **Data Report** in the GRP Data Reporting Excel worksheet.

3.1 If you listed multiple data sets in the data reporting table, please briefly describe how these data sets relate to one another. *

Two data sets were submitted.

The first was data collected in Cubit's Gap, in the Mississippi River Delta, Louisiana.

Dataset UDI: H3.x878.000:0001

DOI: 10.7266/TX087C8W

The second was collected near Port Fourchon, Louisiana.

Dataset UDI: H3.x878.000:0002

DOI: 10.7266/XKA817A4

3.2. Please provide a list of additional documentation to describe the data listed in the reporting table (e.g., code books, lab manuals, workflow procedures). Enter none if you did not produce any additional documentation to describe the data. *

none. The data is documented in the repository.

3.3. Beyond depositing data and metadata in a repository, what other activities have you undertaken or will undertake to ensure that others (e.g., researchers, decision makers, and the public) can easily discover project data? What other activities have you undertaken to ensure that others can access and re-use these data in the future? *

The Water Institute will provide a link to the data sets on a writeup that appears on the Institute website.

3.4. Are any data products you produced sensitive, confidential, and/or proprietary? *

No

4. Information Products

Before the form is completed, you may click "Save & Continue Editing" at the bottom of the page at any time to save your work or "Next" to move onto the next page of this form.

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4. INFORMATION PRODUCTS

In this section, please provide a response to each question to complement the **Information Products Report** in the **GRP Information Products Management** Excel worksheet.

4.1. Please select the type(s) of information products that your project produced. *

Responses Selected:

- 1. Scholarly publications, reports or monographs, workshop summaries, or conference proceedings
- 5. Models or simulations

Scholarly publications, reports or monographs, workshop summaries, or conference proceedings *

Please provide a list of citations for project publication, reports and monographs, workshop summaries, and conference proceedings.

Burgos, M. B. (2020). Effects of vegetation seasonality on sediment dynamics in a freshwater marsh of the Mississippi River Delta | Tulane University Digital Library. Tulane University, New Orleans, LA. Retrieved from <https://digitallibrary.tulane.edu/islandora/object/tulane%3A121971>

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Curricula for education and training, GIS applications, Models or simulations, Software packages or digital tools, or other interactive media, and Other *

If you produced any additional documentation to describe information products, please provide a list of this documentation (e.g., model or simulation documentation, software manuals, source code annotation).

none.

4.2. Beyond depositing information products in a repository, what other activities have you undertaken or will undertake to ensure that others (e.g., researchers, decision makers, and the public) can easily discover and access the listed information products? *

Output from this grant has been presented at conferences, shared with colleagues, and will be made available upon request.

4.3. Are any of the information products you produced confidential, proprietary, or subject to special license agreements? *

No

5. Project Outcomes

Before the form is completed, you may click "Save & Continue Editing" at the bottom of the page at any time to save your work or "Next" to move onto the next page of this form.

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5. PROJECT OUTCOMES

Outcomes refer to the **impact(s), consequence(s), result(s), or effect(s)** that occur from carrying out the activities or outputs of the project. Outcomes may be environmental, behavioral, health-related, or programmatic. Example outcomes include, but are not limited to: increased learning, knowledge, skills, and motivation; policy changes; actions taken by a group as a result of information generated by your project.

5.1. Please describe the outcomes achieved during your project and how they were assessed. For this question, we are interested in learning about the immediate short-term outcomes that have already occurred during or as a result of your project. Do not include long-term outcomes you foresee your work contributing to beyond the end of the project. *

Beyond the intellectual outputs of this grant, the initial phases of the Bay Denesse Living Lab (described in Section 1) have provided a platform for collaboration between restoration practitioners and researchers.

5.2. We're interested in hearing not just the results of your project but what are their implications for or contributions to:

- offshore energy system safety,
- environmental protection and stewardship, and/or
- health and community resilience

Please describe what you consider to be the most remarkable accomplishment or finding of your project. What can others learn from your accomplishment and finding? How do you see it fitting in with your greater field of study or community of practice? *

The results of (Burgos et al., (in prep)) and (Xu et al., in review) make clear that the interaction between vegetation and wetland sedimentation is far more complex than is commonly understood. Critically, the ability of wetlands to receive and retain sediment does not vary consistently throughout the year. These measurements point the way towards a program that uses careful measurements of the physical characteristics of vegetation throughout the growing season to provide information on optimizing diversions and other actively managed marshes.

The nascent Bay Denesse Living Lab, which has roots in this grant's Practitioner Advisory Panel will provide a platform for collaboration between wetland restoration practitioners and researchers.

6. Communication

Before the form is completed, you may click "Save & Continue Editing" at the bottom of the page at any time to save your work or "Next" to move onto the next page of this form.

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** denotes required fields*

Note to Grantees: In Section 6, we seek input from you to help us evaluate the Gulf Research Program's funding strategy. This section will not be made available to the public.

6. Information to Inform GRP Evaluations

6.1. Sharing the difficulties you encountered helps us learn from your experience. Describe any challenges you encountered in your project and how you addressed or overcame them. Challenges are inherent to conducting any complex project. These may include (but are not limited to): unexpected staffing changes, changes in the community you are working in, appearance of a new technology or dataset in the field you are working in, challenges accessing a field site, policy or regulatory changes that affect the issue you are addressing, low recruitment rates, delays in setting up services, or other problems in implementing and conducting your project. *

- Many of the techniques that we deployed during the first year of fieldwork did not work as intended. There was a learning experience, and we were able to adapt during the second field season.
- Significant institutional turmoil affected the first 18 months of the grant, leading to a change in key personnel, and general delays.
- The final practitioner workshop was intended to take place in the summer of 2020, but was delayed by Covid until 2021, and ultimately was held at an alternative venue.
- The vegetation planting that was planned during the Practitioner Advisory Panel workshops was initially planned to occur in 2020, but has been delayed due to Covid until 2022.

6.2. We like to hear about what you learned from your work and how you feel it affects future work or the work of others. Think back on your project strategies, methods, and activities, what worked and what did not? Is there anything you would do differently in the future? If so, tell us what and why. *

- The project would have benefitted from a longer planning/scouting phase in Year 1 prior to full scale data collection efforts.
 - The project would have been benefitted from a second graduate student.
-

6.3. What are the next steps for this work, either for you and your project team or other researchers? Has this project led to other opportunities to work in this area? *

The Water Institute and much of the project team is working to establish the Bay Denesse Living Lab.

PI's Esposito and Nepf have received funding to continue working in the mangroves near Port Fourchon. The project team will be extracting cores along with aboveground biomass for analysis in the MIT flume lab.

PI's Esposito and Nepf, along with members of the Practitioner Advisory Panel collaborated on a proposal to the NOAA RESTORE program to work with stakeholders in the Birdsfoot Delta. This proposal was not successful, but the team is researching other avenues of funding.

6.4. Have you developed new collaborations or partnerships (formal or informal) as a result of this work? If yes, please describe the new collaborations or partnerships. *

The practitioner advisory panel was a fantastic network building tool, and has led to several ongoing collaborations among its members. These center around the aforementioned Bay Denesse Living Lab.

The relationship between the Water Institute and MIT is strong, and continuing.

6.5. What, if any, positive changes in policy or practice do you foresee as a result of your work? *

I expect the work to contribute to optimizing coastal wetlands for maximum sediment delivery.

I also expect continued progress in experimental methods at the landscape scale.

6.6. If you could make one recommendation to the Gulf Research Program for how best to build on the work you conducted in this project, what would it be? *

I recommend that NAS-GRP focus on more formal co-development activity between researchers, stakeholders, and restoration practitioners.

7. Communication and Dissemination

Before the form is completed, you may click "Save & Continue Editing" at the bottom of the page at any time to save your work or "Next" to move onto the next page of this form.

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** denotes required fields*

Note to Grantees: In Section 7, we ask you to help us communicate the importance, progress, and accomplishments of your work. Information provided in this section will be used by the Gulf Research Program to highlight its funded projects in print and electronic informational and promotional materials. The intended audience for the information provided in this section is different and should be thought of as a general audience. When you return to the dashboard, you may upload images that represent and illustrate the work of your project.

7.1. Please describe the most exciting or surprising thing you have learned while working on this project in a way that is understandable by a general audience. *

It is common in many settings to assume that vegetation always enhances land building and sediment capture in coastal wetlands. We showed with field observations that this is not necessarily true, and that high vegetation density can actually prevent sediment from being delivered to a wetland. This observation will play a critical role in optimizing restoration activity to maximize land building.

7.2. Do you have any stories that capture the impact of this project? (optional)

If so, please share one or two. Examples of what we are interested in include stories of people/communities that the project has helped; lives that have changed; work that led to policy change, such as legislation or regulation; and research breakthroughs.

(No response)

7.3. Have any communications, outreach, or dissemination activities occurred in relation to your project?*

Please describe:

- Any press releases issued (other than that issued by the National Academies of Sciences, Engineering, and Medicine) about the project.
- Any media coverage or news stories about the project.
- Any social media accounts, websites, listservs, or other communication vehicles used to communicate information about this project. Please include relevant web addresses if available.

Press releases, tweets, and archived public presentations:

<https://twitter.com/TheH2OInstitute/status/956198863500664832>

<https://twitter.com/TheH2OInstitute/status/1316025982889779204>

<https://fws.rev.vbrick.com/#/videos/575d74a2-0a22-4d1f-8caa-7dd023611b86>

<https://twitter.com/TheH2OInstitute/status/981923944570777600>

<https://thewaterinstitute.org/media/press-releases/webinar-the-possibilities-of-creating-a-living-lab-in-bay-denesse-la>