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ARTICLE

# Cost-Efficacy in Wetland Restoration Projects in Coastal Louisiana

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**Abstract** The Coastal Wetlands Planning Protection and Restoration Act (CWPPRA) provides one of the largest sources of U.S. funding for wetland restoration. A preliminary economic analysis of the CWPPRA program questioned the program's selection of cost efficient wetland restoration projects, specifically related to the funding of barrier island projects, and recommended a more rigorous statistical analysis of the data (Aust 2006). We conducted an analysis to determine what available variables, such as wetland loss, influence CWPPRA project selection for funding. We found that the program was selecting cost-effective projects overall. Cost efficacy varied significantly by restoration project type, with barrier island restoration having the greatest cost/benefit. We present possible justifications for funding these projects despite the higher cost/benefit. This paper will help participants of this restoration program and others in evaluating how projects are developed, evaluated and selected for funding.

**Keywords** Barrier island · CWPPRA · Policy · Protection

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## Introduction

Ninety percent of the coastal marsh loss in the lower 48 states is in Louisiana (Barras et al. 2003). These losses have adverse impacts on national resources (U.S. Army Corps of Engineers (USACE) and the Louisiana Department of Natural Resources (LDNR) 2004). The U.S. government funds wetland restoration programs in an effort to halt wetland losses (Boesch et al. 1994).

One of the largest single sources of U.S. Federal funding toward wetland restoration has been the Coastal Wetlands Planning Protection and Restoration Act (CWPPRA) of 1990. The CWPPRA has provided approximately $560 million for more than 155 restoration projects since 1991 and was reauthorized by Congress to 2019. The CWPPRA was authorized in 1990 to be guided by a partnership of government representatives from five federal agencies and the state of Louisiana. Every year since authorization, restoration project ideas are proposed, reviewed, and selected for funding in a year-long process initiated at public planning meetings and ending with government representatives voting to determine which projects to fund. After being selected for initial funding, projects are designed and constructed, then maintained and monitored for 20 years.

The CWPPRA authorizing legislation mandates economic justifications as part of the project selection process just like all publicly funded activities:

> *"...coastal wetlands restoration projects in Louisiana (will) provide for the long-term conservation of such wetlands and dependent fish and wildlife populations*

*in order of priority, based on the* <u>*cost-effectiveness*</u> *of such projects in creating, restoring, protecting, or enhancing coastal wetlands*...” [Underline added] (Public Law 646 1990, Sec. 3952 1(b))

U.S. Army Corps of Engineers project selection guildelines and most government purchasing use cost effectiveness as the sole consideration in providing funding, i.e. projects only need be the most cost effective when compared to the alternatives to receive funding. Cost effectiveness is embedded within the CWPPRA process for project selection but is not the sole consideration in project selection for funding.

Studies of the CWPPRA program can influence larger restoration efforts as well as the CWPPRA program. By request of Congress, the U.S. Government Accountability Office (GAO) reviewed the CWPPRA program. The report of that review states that Federal agencies “carefully consider the lessons learned from the CWPPRA Program as they propose significantly larger efforts to restore Louisiana’s coast (GAO 2007).” Other wetland restoration efforts are influenced by the CWPPRA activities, such as the Louisiana Coastal Area- Ecosystem Restoration, and the Coastal Impact Assistance Program (Public Law 109-58 2005 Sec 384).

An economic evaluation of the CWPPRA by Aust (2006) questioned the program’s selection of cost efficient wetland restoration projects and recommended a more rigorous statistical analysis of the data. Aust (2006) reported that projects selected to receive CWPRRA funding from 1999 to 2004 were the least cost effective of the projects proposed those years. Her results suggested that costly projects had perceived benefits that were not accounted for in the evaluation of those projects and questioned the benefit of some project types, such as barrier islands. As an economic analysis, Aust (2006) selected variables and grouped data along theoretical lines, such as program changes to funding or similarities and differences in project types. The cost of restoring barrier islands was raised by Aust (2006), and has been a topic of discussion less formally for many years among restoration planners.

We provide a similar but more rigorous statistical analysis than the Aust (2006) economic analysis with specific consideration of barrier island restoration benefits. We evaluate the selection of projects for funding within the CWPPRA program to determine if cost effectiveness is a significant predictor of selection. Our analysis differs in allowing the variables to lead the analysis rather than justifying inclusion or exclusion of variables that introduced subjectivity in the Aust (2006) economic analysis.

Our evaluation of the CWPPRA projects can help guide wetland restoration spending and benefits evaluation. Our results may be useful for managers and the public participating in the remaining 10 years for which the CWPPRA program is authorized or similar restoration program appropriations. Those involved in evaluating wetland mitigation, wetland mitigation banking or with general interests in wetlands restoration may find this paper useful because it broadly summarizes the functions within CWPPRA and presents an analysis that could be completed for other programs.

We outline the CWPPRA program’s project selection process to describe our analysis here. Details of the process are available on the program’s website, www.lacoast.gov, in the Project Priority List Reports. Selection of wetland restoration projects for funding by the CWPPRA is a publically transparent process and more complex than can be fully explained here (USACE 2009). When a restoration project idea is proposed for funding consideration, a review of the project concept is initiated. Project reviews are conducted by a committee of wetland restoration specialists that visit proposed project sites and review current data related to project needs and proposed benefits. Project feasibility, site-specific environmental needs, and costs are considered. Adjustments to the original project concept are made to increase benefits, decrease costs, or improve project design. The review includes a wetland value assessment (WVA) and economic analysis that in combination provide a measure of cost effectiveness. The outcome of the WVA is a standard unit of benefit, called average annual habitat units (AAHU). The outcome of the economic analysis is an average cost per AAHU that allows for project comparisons.

The AAHU represents a determination of the fish and wildlife habitat quality and quantity expected to result from a proposed project. Models that develop the AAHU differ by ecosystem (intermediate marsh, emergent marsh, brackish marsh, saline marsh, swamp, barrier island, barrier headland, and coastal chenier) and include key habitat variables, such as vegetative percent cover, organism access, and growing season salinity. Variables are defined specific to each ecosystem model based on habitat characteristics for 32 common coastal Louisiana species (10 estuarine fish and shellfish, four freshwater fish, 12 birds, three reptiles and amphibians, and three mammals). The AAHU introduces habitat function consideration to the project selection process and provides one standard unit of comparison across ecosystems.

Project cost development includes a review by economic and engineering committees, where current costs for project components are reviewed and applied to all projects. The intent is both to provide the best estimate of cost, and standardize cost estimates among potential projects each year. Costs in our analysis were additionally standardized to 2003 dollars to allow for across year comparisons. Program dollars available to fund projects each year are fairly stable. Any variation influences the number of projects that can be funded each year.

Our objective was to statistically identify the predictor(s) of restoration projects selected for funding within the CWPPRA program and determine what influences the predictor. Our interest was in how projects become selected for funding initially, rather than how future funds were disbursed among those initially-selected projects, because some level of funding support has been provided to all initially-selected projects by the CWPPRA program. We compare and contrast our results to those of the Aust (2006) economic analysis.

## Methods

Data were obtained from the public CWPPRA program sources that are maintained and updated annually by agencies participating in CWPPRA. As of 2005, 356 restoration projects had been proposed by public and government agencies for CWPPRA funding. Of these, 305 projects warranted designation as candidates for funding and proceeded to receive a full evaluation under the WVA process. Of those candidates, 161 projects were selected for funding. Approximately 30% of those projects selected for funding were classified as demonstration, complex, or deauthorized projects. The economic data for those project classifications were unavailable or incomplete, and therefore were removed from analysis.

Project candidates for funding were classified as either selected for funding (selected), or not selected for funding (unselected). To determine which variables influenced project selection, we used a stepwise logistic model selection procedure (PROC LOGISTIC, SAS version 9.1, SAS Institute Inc. Cary, NC, USA). Because the outcome of this model identified a continuous response variable (cost/benefit), we used the stepwise general linear model procedure (PROC GLMSELECT) for the second analysis. The logistic model is the appropriate analysis of the binary response outcome: selected or unselected, whereas a general linear model is the appropriate analysis for the continuous variable cost/benefit. Both stepwise selection methods have a termination criteria for each variable to enter and stay in the model. For the logistic procedure, the Akaike Information Criterion is used. For the general linear procedure, the Schwarz Bayesian Information Criterion (Schwarz 1978) is used. Both procedures take into account the correlation among other variables already in the model at each step. A final set of variables is retained and used for the final analysis using the maximum likelihood estimation method for the logistic model and the analysis of variance method for the general linear model. We verified the logistic model met all convergence and asymptotic normality requirements and the general linear model met normality, homogeneity of errors, and between variables correlation (variance inflation factor $\leq$10, Neter et al. 1989) requirements.

We used the natural log transformation for variables when the untransformed data would inhibit explanation or calculation of probability. For any relevant pairwise comparisons between intercepts or slopes, we used odds ratio estimates for the logistic analysis and regression comparison estimates for the general linear model where one level of the class variable being compared was set to the overall intercept and slope. We compared cost/benefit values of selected versus unselected by year using a *t*-test. All possible two-way interactions were included. An $\alpha$=0.05 was used for all analyses.

In the stepwise models, we included all variables that may influence project selection for which data were available. The variables are listed alphabetically with a brief of description below.

### Average Annual Habitat Unit (AAHU)

The AAHU is the project benefit, a measure of both quality and quantity of habitat change expected by implementing the project. Habitat models are similar to the species-specific Habitat Evaluation Procedures developed by the U.S. Fish and Wildlife Service (USFWS 1980). For example, the barrier island model includes variables for dune, supratidal, and beach/surf zone habitats that are specific to the barrier island fish and wildlife habitat (Louisiana Coastal Wetlands Conservation and Restoration Environmental Working Group (LCWCREWG) 2002).

### Basin

There are nine hydrologic basins in coastal Louisiana that differ in size, loss rates, and area of wetland (Barras et al. 1994). These basins include numerous compositions of habitat including marshes, swamps, lakes, ridges, bays, and bayous.

### Cost

There are two necessary costs to define in CWPPRA: total and average annual (AA). Costs for the first five years of the project life include the funds required for engineering design, easements and land rights, federal supervision and administration, project management, inspection, construction, and a 25% contingency. These costs are added to the monitoring, operations, and maintenance costs estimated over the total life of the project (20 years) adjusting for inflation to derive total cost estimates. This variable was expressed in terms of 2003 dollars ($US) by adjusting to the civil works construction cost index (USACE 2005).

Cost/Benefit

Cost/benefit is the average annual (AA) cost of a project divided by its AAHU benefit. Cost/benefit is used in the CWPPRA as a method to compare projects to one another within the funding year. More recently the program began reporting cost/net acres benefited, which may remove bias among the various habitat models that generate the AAHU, but net acres was not available across all years for this analysis.

Parish

There are 18 geographic and political boundaries within Louisiana, comparable to counties in other states. Parish representatives nominate and vote to prioritize projects during the review process, but do not have a vote on the final list of projects to be funded by the CWPPRA.

Population

The population of each parish for the year the project was proposed as reported by the U.S. Census Bureau (2000) was included as a measure of political influence.

Project Size

Project size is the geographical extent of a project's potential area of benefit. It is the sum of the hectares (ha) anticipated to be created and protected by successful implementation of the project.

Region

Four geographic areas based on hydrologic basins were established to group areas for public meetings and for agency employee representation.

Sponsor

The agencies that sponsor projects for consideration include the USACE, the USFWS, the Environmental Protection Agency, the National Marine Fisheries Service, and the Natural Resources Conservation Service (NRCS). The Office of Coastal Protection and Restoration (formerly Louisiana Department of Natural Resources) is a co-sponsor of all funded projects and votes on final project selection.

Type

There are a variety of restoration types used in CWPPRA. Vegetative planting involves planting native wetland vegetation to stabilize and hold together sediment. This type of restoration is often used in combination with shoreline protection, barrier island restoration, sediment trapping, and marsh creation. Hydrologic restoration projects try to restore more natural hydrologic conditions where human-induced changes have damaged wetlands. These projects utilize a combination of different materials for bank stabilization. Freshwater diversions are the controlled release of fresh water into coastal marshes. Sediment (and nutrient) trapping projects involve the construction of earthen terraces in patterns to induce settlement of suspended solids in open areas of water. Outfall management is designed to maximize the benefit of large-capacity river diversion projects. These projects utilize water-control structures and management regimes to assist in optimizing the distribution of fresh water to nourish coastal wetlands. Sediment diversion projects involve breaching river levees to allow sediment-laden water to flow into and create marsh. Marsh creation projects use material dredged from navigation channels and canals, bays, lakes, or the Gulf of Mexico. The dredged sediments are placed into deteriorated wetland areas to create marsh. Shoreline protection includes various structural methods to decrease shoreline erosion; like rocks, segmented breakwaters, and wave-dampening fences. Barrier island projects include placement of dredged material to increase the height and width of the coastal islands, as well as vegetative planting and sand-trapping fences to stabilize sediment (U.S. Department of the Interior 2000). A combination of restoration techniques may be used within a project, but one of these types is identified as the primary technique.

Wetland Area

This variable is a measure of available wetland acres per basin where each project is located. We derived this variable from 1978 to 2000 wetland loss rates applied to reported wetland acres per basin (Barras et al. 1994; LDNR 2004).

Year

We used data from the first 14 years of the program (1990–2004), due to their availability (Louisiana Coastal Wetlands Conservation and Restoration Task Force 2004). During this 14-year time span, there were policy changes in this adaptively managed program.

## Results

Selection

Of the 12 variables included in our analysis, we found that only cost/benefit significantly influenced project selection

($p$=0.0003). Due to missing values, only 303 observations were used in the analysis: of these, 113 were selected projects and 190 unselected for funding. The final model that included only the cost/benefit variable correctly predicted the level of outcome 66.1% of the time. This model correctly predicted projects selected for funding 22.8% of the time, whereas it correctly predicted projects not selected with 92.1% accuracy. Model false predictions were low; projects that were selected for funding were predicted falsely 36.6% (false positive) and 33.5% (false negative) of the time.

Cost/benefit was negatively related to the probability of a project being selected ($p$=0.0003, Table 1); the lower a project's cost/benefit, the more likely it would be selected for funding. However, the model was best at predicting which projects were not selected for funding, so it is more accurate to state that when cost/benefit increased, project selection decreased.

We calculated the probability of a project being selected for funding given specific hypothetical conditions of the significant variables. The minimum, mean, and maximum cost/benefit of all possible projects (selected and unselected) are \$82, \$7,850, and \$75,837, respectively. Using these values in the logistic model provided above, the probability of selection for funding of hypothetical projects with the lowest, mean, and highest cost/benefit are 69%, 38%, and 19%, respectively, as calculated:

$$\text{Probability} = \exp^{-2.0705-0.3176\,(\log \text{cost/benefit})} / 1 + \exp^{-2.0705-0.3176\,(\log \text{cost/benefit})}$$

## Cost/Benefit

Three variables influenced cost/benefit: project size, year, and project type (Table 2). The interaction of project size and year was negatively associated with cost/benefit (Table 2). Average costs per AAHU ranged from a low of \$700 in 1993 to more than \$15,000 in 2004 (Fig. 1). The mean cost/benefit of selected projects was lower than the mean cost/benefit of unselected projects ($p$=0.0007, Fig. 1). The mean cost/benefit for selected projects was significantly lower than unselected projects for years 1992 ($p$=0.030), 1993 ($p$<0.001), 1996 ($p$=0.022), 1997 ($p$=0.030), 1998 ($p$=0.023), and 1999 ($p$=0.010), where as for all remaining years there were no significant differences between the mean cost/benefit of selected and unselected projects.

Cost/benefit differed by project type (Table 2, Fig. 2). The largest cost/benefits were from barrier island projects, while the lowest cost/benefits were vegetative planting, hydrologic restoration, and sediment trapping projects (Fig. 2). While the mean cost/benefits of shoreline protection and barrier island projects were similar, barrier island projects had a significantly higher cost/benefit when adjusted for the significant project size by year interaction of the logistic model (Fig. 2). Vegetative planting had a low cost/benefit and is incorporated in many CWPPRA projects, but was a primary project type on only 2% of CWPPRA projects (Table 3). Hydrologic restoration was the primary project technique for the majority of projects and had a low cost/benefit (Table 3, Fig. 2).

**Table 1** Maximum likelihood estimates (MLE) from a stepwise logistic model showing which variables influence project selection for funding in the Coastal Wetlands Planning Protection and Restoration Act from years 1991–2005. The model converged with an Akiake Information Criterion of 392 (404 for intercept only)

| Parameter | DF | MLE | Error | Wald Chi-Square | P |
|---|---|---|---|---|---|
| Intercept | 1 | 2.207 | 0.718 | 8.464 | 0.004 |
| Cost/benefit | 1 | −0.318 | 0.087 | 13.342 | <0.001 |

## Discussion

Our findings show that the CWPPRA program has been acting within its Congressional mandate by funding cost effective wetland restoration projects. In contrast to Aust (2006), the only variable we found to significantly predict project selection was the cost effectiveness variable (cost/benefit). Cost/benefit likely best predicted which projects were not selected for funding because there were more unselected than selected projects. While many projects of various types, sizes, and cost were proposed each year for CWPPRA funding, projects that were too costly, or had too few benefits to be worth the expense were probably the first to be dismissed in the decision to fund. The mean cost/benefit for projects selected for funding were lower than the mean cost/benefit of unselected projects, which confirms the program was selecting cost efficient projects overall.

Cost/benefit of all proposals has increased over time. Although the cost of construction rises concurrent with energy costs (Day et al. 2007), other factors that may have influenced the increasing cost/benefit of proposed projects include: the least expensive projects were chosen first, leaving the more expensive projects for future proposals; realization of true construction costs after gaining experience in the earlier years of the program; fewer projects could realistically be proposed each year as technical, landowner, or permit issues were discovered; or any combination of the above. Each of these could influence other restoration programs as part of the general development of any program.

**Table 2** Results of a stepwise general linear model showing which variables influence cost effectiveness (cost/benefit) of wetland restoration projects of the Coastal Wetlands Planning Protection and Restoration Act from 1991 to 2005

| Variable | | Parameter Estimate | SE | t value | Pr > \|t\| |
|---|---|---|---|---|---|
| Intercept | | 9.999 | 0.593 | 16.87 | <0.0001 |
| Project size × Year 1991 | | −0.709 | 0.060 | −11.86 | <0.0001 |
| Project size × Year 1992 | | −0.619 | 0.052 | −11.92 | <0.0001 |
| Project size × Year 1993 | | −0.692 | 0.058 | −11.98 | <0.0001 |
| Project size × Year 1994 | | −0.636 | 0.061 | −10.43 | <0.0001 |
| Project size × Year 1995 | | −0.580 | 0.056 | −10.36 | <0.0001 |
| Project size × Year 1996 | | −0.534 | 0.050 | −10.58 | <0.0001 |
| Project size × Year 1997 | | −0.486 | 0.062 | −7.85 | <0.0001 |
| Project size × Year 1998 | | −0.496 | 0.065 | −7.58 | <0.0001 |
| Project size × Year 1999 | | −0.473 | 0.062 | −7.66 | <0.0001 |
| Project size × Year 2000 | | −0.437 | 0.054 | −8.15 | <0.0001 |
| Project size × Year 2001 | | −0.366 | 0.056 | −6.55 | <0.0001 |
| Project size × Year 2002 | | −0.406 | 0.065 | −6.55 | <0.0001 |
| Project size × Year 2003 | | −0.378 | 0.075 | −5.03 | <0.0001 |
| Project size × Year 2004 | | −0.412 | 0.083 | −4.99 | <0.0001 |
| Project size × Year 2005 | | −0.502 | 0.080 | −6.30 | <0.0001 |
| Type | barrier island[a] | 2.478 | 0.518 | 4.79 | <0.0001 |
| Type | freshwater diversion[a] | 1.504 | 0.520 | 2.90 | 0.004 |
| Type | hydrologic restoration[a] | 0.970 | 0.510 | 1.90 | 0.060 |
| Type | marsh creation[a] | 1.651 | 0.511 | 3.23 | 0.001 |
| Type | outfall management[a] | 1.506 | 0.612 | 2.46 | 0.015 |
| Type | sediment diversion[a] | 1.227 | 0.560 | 2.19 | 0.029 |
| Type | sediment trapping[a] | 1.076 | 0.576 | 1.87 | 0.063 |
| Type | shoreline protection[a] | 1.928 | 0.507 | 3.80 | 0.0002 |
| Type | vegetative planting[a] | 0.000 | . | . | . |

Overall model significance $p<0.0001$, f=24.69, df=23, $R^2=0.688$

Significant variables, $\alpha=0.05$

[a] The overall intercept is the value for 'Type vegetative planting', probabilities reported for project types are comparable to this base type. The cumulative analysis of significant differences among project types is presented on Fig. 2

The differences in mean cost/benefit between selected and unselected projects may have decreased over time, because projects not funded one year are often proposed the next. As expected, the cheapest projects are funded first. This does not explain why in recent years, such as 2002 and 2004, there are low cost/benefit projects that were unselected.

Project type significantly influenced cost/benefit. Project types have specific applications for restoration, which influence their cost/benefit and the proportion of project

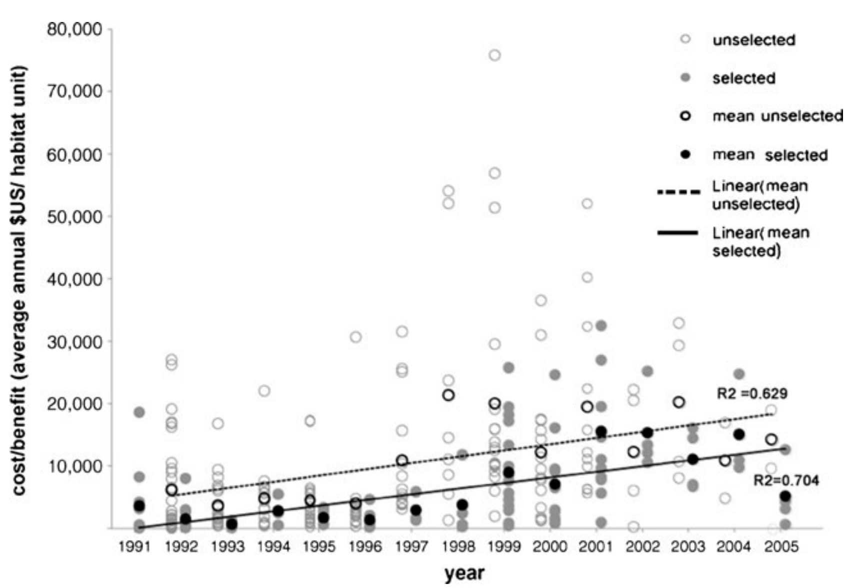


**Fig. 1** Cost/benefit (average annual cost in 2003 dollars per average annual habitat unit) by year of projects proposed for funding in Coastal Wetlands Planning Protection and Restoration Act Program from 1991 to 2005. Nominations are either selected or unselected for funding in the annual project list review

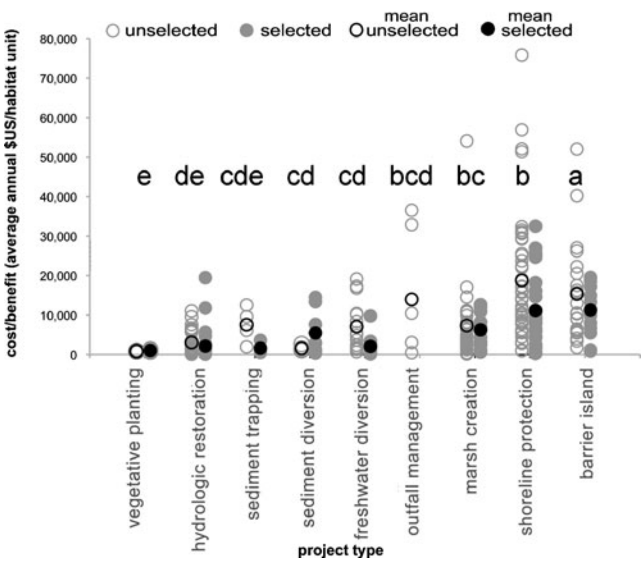


**Fig. 2** Mean cost/benefit (average annual cost in 2003 dollars per average annual habitat unit) by wetlands restoration project type in the Coastal Wetlands Planning Protection and Restoration Act Program. Average annual habitat unit is an estimate of habitat value gained for fish and wildlife. Proposals are either selected or unselected for funding in the annual project review. Letter differences indicate statistically significant differences between means

type selection. For example, sediment (and nutrient) trapping can only be constructed in areas with sufficient soils, such as in the coastal bays of western coastal Louisiana basins. Freshwater diversion projects that are large in size and funding required, such as the Caernarvon and Davis Pond Freshwater Diversions, are typically funded under the Water Resources Development Act. Smaller diversions, such as siphons, are more likely to be constructed by CWPPRA. Sediment diversions are limited to locations on major rivers and downriver from populated areas because they are less controlled than other project types. Barrier island projects had a significantly higher mean cost/benefit than other restoration types, which is similar to the finding of Aust (2006).

Aust (2006) suggested that the higher cost of barrier island (and shoreline protection) projects may be a result of planners selecting protection of wetlands. This would follow the first principle of the Ramsar Convention: preservation of existing wetland habitat should take precedence over restoration (Barbier et al. 1997). However, the amount of area protected by each project type (as calculated by the CWPPRA process) did not support that idea (Fig. 3). Barrier island projects were not projects with the greatest area protected (Fig. 3). Most barrier island projects were not protection projects, but restoration of habitat (personal communication Kevin Roy, USFWS Lafayette, Louisiana).

One reason barrier island projects had a higher cost/benefit ratio may be the method of estimating benefits in the WVA for this project type. Within the benefits calculation model for barrier islands, this outcome was expected: "Model refinement [for barrier island benefits] can only occur after practical application through which model shortcomings are identified (LCWCREWG 2002)." Barrier island project benefits were determined using different models prior to and after 2001. Prior to the development of a barrier island habitat model in 2000, project benefits were developed using the best available model, an emergent saline marsh model. The differences in benefits determined by these models may account for the higher cost/benefit in our results. To test this, we analyzed data for years 2001–2005 to see if we would get the same results in cost/benefit by project type for barrier islands. We found that barrier island projects did not have significantly different cost/benefit than sediment diversion, sediment trapping, or outfall management projects for those years. However, there were only two sediment diversion projects and one each of sediment trapping and outfall management projects in that limited data set. Like barrier island projects, shoreline protection projects had a higher mean cost/benefit than other project types (Fig. 2). The comparison of 2001–2005 shoreline protection projects to barrier island projects generated the

**Table 3** Wetlands restoration project types annually selected for funding by the Coastal Wetlands Planning, Protection, and Restoration Act between 1991 and 2005 in order of average cost in 2003 dollars per average annual habitat units (AAHU) and proportion of projects by type, excluding demonstration, deauthorized, and complex projects

| Project Type | Proportion (%) of projects | Average cost/benefit ($US/AAHU) |
|---|---|---|
| vegetative planting | 2 | 900 |
| hydrologic restoration | 28 | 1,736 |
| sediment (and nutrient) trapping | 4 | 2,839 |
| outfall Management | 1 | 3,602 |
| freshwater diversions | 11 | 2,341 |
| sediment diversions | 7 | 4,077 |
| marsh creation | 11 | 4,698 |
| shoreline protection | 26 | 9,461 |
| barrier island | 10 | 10,416 |

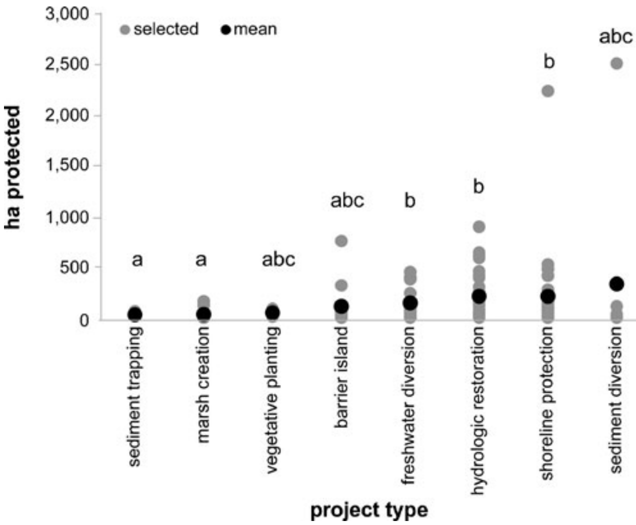


**Fig. 3** Area anticipated to be protected, opposed to area created, of various wetlands restoration projects selected for funding under the Coastal Wetlands Planning and Protection Act since 1991. There were no data for the outfall management project type. Letter differences indicate statistically significant differences between means

same result as those for all years: cost/benefit was higher for barrier islands ($n=9$) than shoreline protection ($n=10$) ($p=0.0143$).

Refining estimates of barrier island restoration requires data. While geography, hydrology, and ecology of barrier island systems has been studied (Hester et al. 1994; Dean 1997; Finkle and Khalil 2005), little is known about the success of barrier island restoration. In 2002, the CWPPRA program reviewed five major barrier island restoration projects to better understand their challenges and successes (Penland et al. 2003). These projects were reported to be successful in increasing the island size by an average of 42.2%. The most cost effective of the projects was estimated to cost $17,165/ha, and was predicted to add an average of 12 years to island survival. The increased island longevity was an estimate and predicted prior to the very powerful hurricanes of 2005 (Day et al. 2007). More recently, Khalil and Lee (2006) reviewed three Louisiana barrier island restoration projects and found the goals of increasing height and width were met, but it was too early to make conclusions about the ability of the projects to increase island sustainability or longevity. Much information is still needed to assess the success, and therefore benefit, of barrier island restoration. Substantial progress has been made toward that effort in the establishment of the Barrier Island Comprehensive Monitoring (BICM, www.lacoast.gov) program designed to generate and manage Louisiana shoreline data. It is premature for the BICM program to provide the wealth of information needed to establish barrier island restoration benefits; future funding for the program is needed. The data availability for barrier island restoration is less than other restoration techniques, which have a longer history of use and study.

Ironically, one reason for funding barrier island restoration projects despite their higher cost/benefit is cost savings. Louisiana's barrier islands are rapidly being lost (Finkle and Khalil 2005), and wave energy will increase in the bays concurrent with barrier island losses (Stone and McBride 1998). Van Heerden and DeRouen (1997) described the value of Louisiana's barrier islands including a calculation of the cost to restore one of the islands at approximately 1/3 the value ($400/ha) of their harvesting and hurricane protection value ($1200/ha/year). We have shown that the cost to restore wetlands increases over time, so there is a value in restoring them sooner rather than later. While all wetland types are being lost, the significant losses at barrier islands (Finkle and Khalil 2005), coupled with the higher cost to restore that habitat (Fig. 2), indicate there is a greater cost savings to addressing the needs of barrier islands earlier rather than later.

In addition to cost considerations, the reasons for supporting barrier island restoration are public demand and their time-limited feasibility for restoration. The Louisiana barrier islands are believed by members of the public to be the "first line of defense" to storm energy. As such, public demand for these restoration projects is evident at CWPPRA meetings. From a technical view, barrier islands become less feasible to restore and much more expensive to restore over time. The options are to either fund restoration projects early or lose the capability to do so as the islands erode and breaching occurs. Of several methods used to restore barrier islands, all require the presence of a basic foundation or island footprint. Without some boundary to confine sediment or place sediment confinement structures, barrier islands would require re-creation, not restoration. Once an island is breached it requires much more effort and better quality sands to fill breaches and rebuild beaches and dune habitats. Those higher quality sands are not always in close proximity to the restoration site, thereby significantly increasing construction and restoration costs. Thus, it is seen as a future cost savings to the restoration program to fund barrier island projects early, rather than invest more funds later after those land forms had degraded significantly.

While the BICM is a program that provides needed data to monitor changes in barrier islands, other restoration programs dedicated to the Louisiana barrier islands do not exist. In contrast, vegetative planting projects have a low cost/benefit, but are rarely funded by CWPPRA. However, these projects are often supported by other sources with more limited funding than CWPPRA, because of their relatively low cost/benefit. For example, the Louisiana

Office of Coastal Protection and Restoration have funded over 300 vegetative planting projects (http://dnr.louisiana.gov). The availability of other funding sources is likely a consideration in selecting projects for funding, although it is not a criterion for the program.

Even while funding the costly barrier island projects, CWPPRA has remained cost-effective. However, the program will need to close the benefits data gap on costly projects like barrier islands to maintain this cost-effectiveness. We hope this paper helps the scientific community that generates the information needed for more accurate assessments of barrier island restoration benefits, and addresses many of the questions that public and policy makers have asked regarding the funding of barrier islands.

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