Cost-Benefit Analysis of a Small-Scale Living Shoreline Project

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Volunteers install a living shoreline at Camp Wilkes in Biloxi, MS

Table of Contents

Abbreviations:

EDGe$ - Economic Decision Guide Software

OMB Circular - Office of Management and Budget

LLC - Limited Liability Company

NPV - Net Present Value

BRC - Benefit Cost Ratio

CBA - Cost Benefit Analysis

ROI - Return on Investment

Key Takeaways

- Over a 60-year time period, implementing a living shoreline is more economically efficient than repeatedly replacing a bulkhead.
- Even if the initial cost of a living shoreline is 3.25 times the initial cost of a bulkhead, the living shoreline is still more efficient over a 60-year time period.
- Most benefits of implementing a living shoreline come from avoided bulkhead maintenance and repair costs.
- The costs of this project were significantly less than other comparable living shoreline projects due to the small size of the Camp Wilkes living shoreline and the unique multi-organizational partnership involved in its implementation

1. Background

Across the Mississippi Gulf Coast, bulkheads are the dominant method of shoreline stabilization among private properties. Along the Back Bay of Biloxi, over half of all private shorelines are hardened (Sparks et al. 2020). In recent years, living shorelines have become an increasingly popular alternative. As their designs are more adaptable than those of bulkheads, living shorelines may perform better over time, particularly under changing conditions associated with sea-level rise and hurricane intensification. However, formal economic analyses of small-scale green (e.g. living shorelines, constructed wetlands) and grey (e.g. bulkheads, riprap) shoreline protection infrastructure in the region are lacking.

Camp Wilkes is a privately-owned recreational campground located along Biloxi Bay, MS. A 150 linear foot (L.F.) bulkhead was installed at Camp Wilkes in 2016; however, it failed shortly after. To replace the bulkhead, Camp Wilkes worked with Mississippi State University's Coastal Research and Extension Center and The Nature Conservancy to implement a living shoreline.

Fig. 1: Before and after images of the Camp Wilkes living shoreline (Sparks et al. 2020).

In July 2020, we conducted a cost-benefit analysis of the living shoreline after its implementation. All cost and benefit values are relative to a baseline scenario in which a wooden bulkhead would replace the pre-existing one; additional replacements would occur every 25 years, in accordance with the maximum bulkhead lifespan generally reported by contractors. Damage-related benefits associated with the living shoreline were quantified as follows:

$$\textit{Damage related benefits} = \textit{Costs}_{\text{bulkhead}} - \textit{Costs}_{\text{living shoreline}}$$

Our results therefore reflect the cost-effectiveness of the living shoreline as compared to continually replacing the pre-existing bulkhead.

2. Initial Assumptions

The Economic Decision Guide Software (EDGe$) online tool produces analysis parameters for the cost-benefit analysis of community resilience projects (Helgeson 2020). The program requires that you make several initial assumptions that are used in calculating the analysis parameters. For this analysis, these assumptions were:

- **Protection against minor hurricanes:** We considered avoided hurricane damage costs for Category 1 and 2 hurricanes only. This decision was based on the limited availability of quantitative data about hardened and natural shoreline responses to Category 3 or greater hurricanes. The data was based on damages produced by Hurricanes Irene and Arthur in coastal North Carolina (Smith et al. 2017). Based on flooding during those storms, we assumed a 100-year flood recurrence interval for our analysis.
  - Notably, anecdotal evidence from the 2020 hurricane season suggests that living shorelines sustain little to no damage in such storms, whereas bulkheads require significant repairs (Polk et al. 2021).
- **60-year planning horizon (2018-78):** A 60-year planning horizon allows us to capture the long-term cost-effectiveness of the living shoreline.
- **2.3% real discount rate:** The 2020 OMB Circular reports a discount rate of 2.3%, which we applied to our analysis.

3. Costs Considered

For our initial analysis, we used actual costs recorded for the project. These were for materials ($12,000) and labor ($2,514). All labor was volunteer-based and valued at $20.95/hr for 120 hours (Independent Sector; personal communication with Eric Sparks). These are the only costs considered in our results.

Table 1: Living shoreline costs considered. Both items are actual costs associated with the 2018-19 implementation at Camp Wilkes.

Category	Cost	Source
Materials	$12,000	Actual project costs reported by Eric Sparks
Labor	$2,514	
Total	**$14,514**	

It is worth noting that the living shoreline at Camp Wilkes was significantly less costly than other comparable living shorelines. This difference is attributed to the fact that it was completed by Extension, The Nature Conservancy, and volunteers. A contractor was hired for minimal operation time of a backhoe for moving sediment. Additionally, an engineering stamp was not required for this project, although one may be needed for other living shorelines. To account for this difference, we also ran analyses assuming that costs were equal to that of a bulkhead, as well as two, three, and four times the cost. See Section 7 for these results.

4. Benefits Considered

4.1 Disaster-Related Benefits

As described in Section 2, we only considered disaster-related benefits for minor hurricanes based on survey results from shoreline property owners in North Carolina (Smith et al. 2017). That study reports hurricane damage costs for bulkheads, natural shorelines, and riprap. We estimated that living shoreline costs would be between those for bulkheads and natural shorelines and 20% closer to that of bulkheads.

Repairing damages after a hurricane costs $219 more when using a bulkhead compared to a living shoreline. We calculated this as the difference between costs for the bulkhead and costs for the living shoreline.

4.2 Non-Disaster Benefits

The only non-disaster benefits we considered were avoided maintenance and replacement costs associated with the bulkhead. Replacement costs were determined after discussion with Eric Sparks and local contractors. Maintenance costs were based on survey results gathered from bulkhead owners in Mobile Bay, AL (Scyphers et al. 2015; Table 2).

Table 2: Non-disaster benefits associated with living shoreline implementation.

Category	Cost	Frequency	Source
Avoided replacement costs	$30,000	Every 25 years	Eric Sparks; On the Water, LLC (both value a wooden bulkhead at $200/L.F.)
Avoided maintenance costs	$1,417.25	Every year	Survey results from 195 homeowners surveyed along Mobile Bay, AL, which valued annual maintenance at $31/m (Scyphers et al. 2015)

5. Results

Using EDGe$, we determined the net present value (NPV) and benefit-to-cost ratio (BCR) of the living shoreline as compared to continually replacing the bulkhead. NPV indicates the economic value in today's dollars of a particular action, while BCR indicates the balance between economic benefits and costs. A BCR greater than one indicates that benefits exceed costs (and vice versa).

The living shoreline's **NPV equals $73,000**, and its **BCR equals 6.03.** Positive return on investment (ROI) begins in the first year after implementation.

6. Interpretation

The NPV and BCR of the living shoreline indicate that it is highly cost-effective. The NPV of $73,000 is over five times the initial cost of $14,514 for the living shoreline. Additionally, the BCR of 6.03 is well above one. If the BCR were less than or equal to one, then implementing the living shoreline would pose no additional benefit over continually replacing the pre-existing wooden bulkhead.

Worth noting is that most of the benefits associated with the living shoreline are non-disaster related, as the majority of benefits are from avoided replacement and maintenance costs. Given that typical bulkheads have an estimated design life of 25 years or less (whereas living shorelines have an indeterminate, but generally longer, design life) and are less capable of adapting to changing biophysical conditions, this result is unsurprising.

7. Cost-Effectiveness of Hypothetical Scenarios

As this effort is intended to inform decisions made by other private coastal landowners, we also considered the cost-effectiveness of different hypothetical scenarios. These situations can be divided as follows:

Increase in Living Shoreline Costs:

At Camp Wilkes, the shoreline was designed and implemented by Mississippi State University Extension, The Nature Conservancy, and volunteers. One contractor was hired to operate a backhoe for a short period of time. No other outside contractors or engineers were involved. As such, the implementation costs associated with the living shoreline at Camp Wilkes were relatively inexpensive compared with similar living shorelines. To make our results more widely applicable, we considered how they would change if the initial costs increased.

All other factors held constant, the living shoreline remains cost-beneficial (i.e. with positive NPV and BCR greater than one) even when its cost is 3.25 times the cost of a bulkhead ($30,000). Beyond that, the living shoreline would no longer be cost beneficial.

Table 3: NPVs, BCRs, and years until positive ROI for hypothetical living shoreline costs. The bold line between $90,000 and $120,000 indicates the threshold at which the living shoreline is no longer cost-beneficial relative to the bulkhead.

Hypothetical Cost of Living Shoreline	Multiple of Bulkhead Cost ($30,000)	NPV	BCR	Years Until Positive ROI
$30,000	1	$70,800	3.36	1
$60,000	2	$40,800	1.68	26
$90,000	3	$10,800	1.12	51
$120,000	4	-$19,200	0.84	N/A

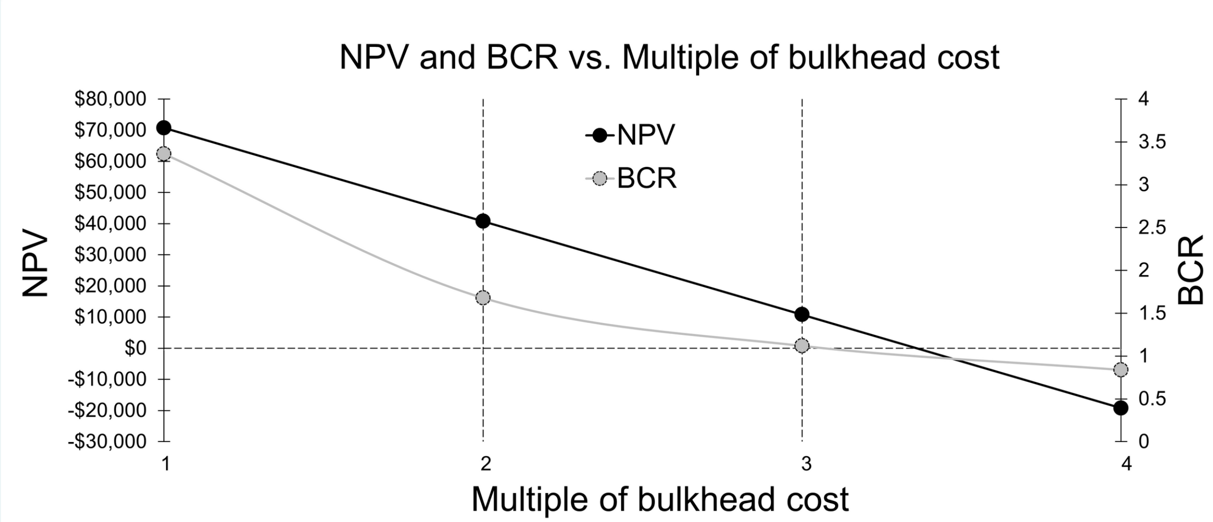

Fig. 2: NPV (net present value; blue) and BCR (benefit-to-cost ratio; orange) vs. multiple of bulkhead cost (i.e. $30,000).

For living shoreline costs of one, two, or three times the cost of a bulkhead, positive ROI occurs 1, 26, or 51 years, respectively, after the living shoreline's implementation. That is, a living shoreline that costs as much as a bulkhead would have positive ROI one year after a bulkhead would initially be installed; a living shoreline twice the cost of a bulkhead would have positive ROI one year after the bulkhead would first be replaced; and a living shoreline three times the cost of a bulkhead would have positive ROI one year after a second bulkhead replacement. A living shoreline four times the cost of a bulkhead would not yield positive ROI over a 60-year planning horizon.

Shorter Planning Horizon:

For our analysis, we assumed a 60-year planning horizon. Other landowners may be more interested in shorter-term planning. We thus also considered the NPV and BCR over a 30-year planning horizon. In this case, NPV equals $61,710 and BCR equals 5.25. These values are slightly lower than those for the 60-year planning horizon, but still indicate that the living shoreline is cost-beneficial relative to continually replacing the bulkhead.

Shorter Bulkhead Lifespan:

We assumed earlier that the bulkhead would be replaced every 25 years. This lifespan is higher than what is frequently estimated by contactors and reported anecdotally by homeowners. Bulkheads can be designed in multiple ways and their success is influenced by environmental factors at the implementation site. It follows that their lifespans can vary widely. Rising sea levels and hurricane intensification may also contribute to shorter bulkhead lifespans. Here, we consider the NPV and BCR if the bulkhead lifespan were shorter than 25 years.

Table 4: NPVs and BCRs with hypothetical bulkhead lifespans.

Bulkhead Lifespan (years)	NPV	BCR
10	$137,900	10.50
15	$106,300	8.33
20	$90,700	7.25

7% Real Discount Rate:

We assumed earlier that the real discount rate was 2.3% in accordance with the most recent OMB Circular. Here, we consider the results with a 7% real discount rate (the value used in FEMA's benefit-cost analysis). With a 7% discount rate, NPV = $38,446 and BCR = 3.65. These values still indicate that the living shoreline is more economically efficient than a continually replaced bulkhead.

8. Limitations and Considerations

As described in Section 7, the particular costs and conditions at Camp Wilkes are not necessarily applicable to other living shorelines. When making decisions regarding shoreline stabilization methods, one must consider the unique site conditions, as well as economic factors such as permitting costs or availability/local cost of materials.

In addition, this CBA only considers storm damage costs for minor hurricanes (i.e. Category 1 and 2). The differential effects of larger storms on living shorelines and bulkheads are not clear, so were not considered for this analysis; further research may elucidate the impact of larger storms.

This CBA also omits non-disaster benefits other than avoided replacement and maintenance costs, e.g. ecosystem services and recreational value. We did not quantify such benefits as they are difficult to quantify given the small-scale of the Camp Wilkes living shoreline. These benefits should be considered in more detail for larger projects and the aggregates of multiple small-scale living shorelines in close proximity.

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