Understanding and improving the ecological function of managed shorelines

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Context of today’s talk

• Part of Hudson River Sustainable Shorelines Project, which addresses many aspects of shoreline management
• I’ll focus on the ecological functioning of different kinds of shorelines, and how to improve it
• Work done with Stuart Findlay and others at Cary Institute and HRSSP
Outline

• Shorelines and their ecological condition matter
• Ecological performance of different shoreline types
  • There is a wide range in performance of different shorelines
  • Several factors broadly affect performance
  • Detailed data about performance are still sparse and messy
• Complications
  • Performance of different functions may be poorly correlated
  • Performance is context dependence
  • System-wide consequences of local actions are hard to know
• HRSSP uses multiple tools and approaches to reach users
  • We try to translate technical information into English
  • I’ll show examples of products
  • Discussion about a decision-support tool
Shore zones can have enormous ecological value

- High biodiversity
- Hot spots for ecological processes (e.g., produce and capture food, capture and process pollutants)
- Highways for plants and animals (corridors)
- Can protect infrastructure
Shore zones are highly altered

- Half of the world’s population lives in or near shore zones
- Humans have vastly changed shore zones
  - About half of the Hudson’s shores have been engineered
- Usually done without considering the ecological consequences
  - This attitude seems to be changing
What do we know about ecological performance of shorelines?
Ecological performance varies greatly across shorelines

Data from the freshwater tidal Hudson River

Strayer and Findlay 2017
...and built shorelines often underperform
So we have great opportunity to improve ecological performance of shorelines
We know what factors generally improve ecological performance

• High physical complexity at all scales
• Low pollution from nutrients and toxicants
• High connectivity
• Low deviations from natural conditions at that site
  • Hydrologic regime
  • Disturbance regime
  • Slope and bathymetry
  • Inputs of physical energy
  • Grain size
• Predominance of native species
• And more...
(which explains why vertical walls have such low ecological value)
...and which lead directly to a series of general recommendations

- Preserve or enhance physical complexity at all scales (wood, wrack)
- Reduce pollution from nutrients or toxicants
- Preserve natural connectivity (don’t increase or decrease)
- Protect or enhance native biodiversity (e.g., plant native species)
  - Reduce biological invasions
- Mimic natural physical conditions for the site (hydrology, physical energy, slopes, elevations, disturbance regime, grain size), or reduce deviations from these conditions
  - Reduce light pollution
Preserve or enhance physical complexity
Reduce pollution
Preserve connectivity
Protect and enhance native biodiversity
Mimic natural physical conditions
Improvements can occur at any stage in the process

• **Planning**
  • Include ecological and resilience goals along with cost and engineering goals
  • Choose site uses that are compatible with these goals (e.g., keep sensitive infra-structure out of harm’s way)
Improvements can occur at any stage in the process continued...

- **Construction**
  - Use a mixture of materials, soft if possible
  - Grade unevenly
  - Don’t erect barriers (curbs, walls)
  - Use multiple, native plant species
Improvements can occur at any stage in the process continued...

- **Retrofitting**
  - Modify ecologically harmful or useless structures to improve their ecological performance (plantings, bulkhead enhancements)
Improvements can occur at any stage in the process continued...

- **Management**
  - Leave a vegetated buffer strip – don’t mow to the water’s edge
  - Don’t always remove wrack and driftwood
  - Leave aquatic vegetation if you can
  - Keep dangerous materials out of the shore zone
  - Consider restricting access to sensitive areas
How good are these generalizations?

• I’d say that these generalizations are robust – robust enough to guide management
• They are based on general ecological understanding as well as many studies of human impacts and ecological functioning of shore zones
• However, they are qualitative rather than quantitative, and subject to exceptions
• What if we need more detailed information?
Detailed, site-specific data are still sparse and messy: flatter shores often have better ecological performance.
Wall roughness and offshore water depth affect fish communities

Strayer, Miller, & Findlay, unpublished
Conclusions about detailed, site-specific information

- Requires a targeted study (or maybe models better than those we have today)
- Often subject to large errors or has lots of unexplained variation
- But may be needed when deciding whether to protect or restore a site, or in planning management
When is detailed information needed?

• In many cases, detailed, site-specific information may not be needed
• In other cases, detailed, site-specific information will be useful or essential
• Users will need to think carefully about this
• To the extent that we need site-specific information, we will need to extend research on shore zone ecology
Complications and challenges

• Context dependence – the value of a management action may vary from one place or one ecosystem type to another

• Uneven correlations between different ecological functions

• Difficult to know system-wide consequences of local actions
Context matters – be careful about applying marine approaches to fresh waters
Context matters

• The effects of shoreline hardening depend on the type of hardening and the hydrodynamic environment

Dugan et al (2018, Estuaries and Coasts)
Different ecological functions don’t necessarily vary in parallel with one another.

No “all-purpose” shore type good for all ecological functions.
Ecological functions aren’t always correlated

Strayer et al, unpublished
System-wide effects of local management are hard to know

- If we make a small, local change to a shoreline, how much will ecological performance of the whole system change?
- E.g., do fishes or birds just move into or out of the changed area, without any change in overall abundance?
- Are cumulative effects or thresholds important?
Part 2: How have we tried to spread ecological knowledge and change practice?

• Multiple approaches for multiple audiences
• Technical publications for academic and technical experts* (see HRSSP website)
• Multiple outreach activities and products
  • Workshops, webinars, etc.* (ask Emilie)
  • Brochures and handbooks
• Decision-support tools
Translate scientific understanding into plain-language recommendations

- Preserve physical diversity
- Resist tidiness
- Don’t squeeze the shore zone!
- Give the shore zone room to move
- Provide dispersal corridors
- Tread lightly
- Prevent pollution
- Don’t make it so hard!
- Reduce wave damage
- Be careful about building in the shore zone
Short version

Why shore zones?

The shore zone is the place where land and water meet. It includes the shallower waters offshore, the vegetated or human structures on land, and the shoreline itself. Shore zones contain high ecological diversity and values, and have been used and accessed by people for thousands of years. Careless human uses have badly damaged many shore zones. The shore zone is also a region that will be heavily affected by the coming changes in climate, as sea level rises, and changes in temperature and rainfall cause inland shorelines to advance or recede. As we move forward, it makes sense to try to preserve or enhance the ecological value of shore zones as much as we can while still meeting human needs.

Human uses of the shore zone

Shore zones are vitally important to humans. Since the beginning of civilization shore zones have been used for transportation, agriculture, a source of water, waste disposal, a place to harvest plants, animals, and geologic resources, recreation, aesthetic and spiritual inspiration, and desirable sites to build homes, businesses, and factories. As shoreline development has increased, so has the desire to build protective structures (pier, dikes). Unfortunately, many of these structures reduced the ability of shore zones to support plants and animals and provide ecological services such as water purification and flood abatement. In the Hudson, about half of shore lines are artificial (pier and breakwater), and most of the “natural” shorezone have been shaped by human activities such as invasive species, boat wakes, and pollution.

Shore zone ecology 101

Shore zones can be among the most valuable habitats on our planet. They contain an extraordinary diversity of plants and animals, including many species that live nowhere else. Shore zones are boundaries between land and water ecosystems, and contribute to the healthy functioning of both. The physical structure and vegetation of the shore zone protect the land from erosion. Healthy shore zones provide many benefits: habitat for many species, recreation and harvestable resources for people, high plant production that provide food for animals on the land and in the water, capture of nutrients and toxins from the land, absorption of wave energy, improvement of water quality, and dispersal pathways for plants and animals.

Effects of a changing climate

Scientists believe that sea level in the Hudson probably will rise by 1-2 feet (and perhaps more than 3 feet) by the year 2100. This will cause coastal shorelines to move inland, and flood more frequently and severely. Climate change will challenge us to maintain human infrastructure and use of shore zones without further damaging their ecological function. Because the infrastructure that we build lasts for decades or more, we need to plan for these changes now.

Managing Shore Zones for Ecological Benefits

A guide for shore zone managers and users for protecting the ecological benefits that healthy shore zones can provide.

The “Shorelines Project” is a joint project of the Hudson River National Estuarine Research Reserve (HRNERR) and its partners. It is supported by National Oceanic and Atmospheric Administration (NOAA) and National Estuarine Research Reserve (NERR) Science Collaborative.

Visit our website at:
www.hrner.org/public/SustainableShorelines/SHIndex.html

Hudson River Sustainable Shorelines
Ten steps to better shore zones

1. Preserve physical diversity

Complex habitats usually support more species and ecological functions than those that are simple. Resist the urge to grade everything smooth, use the same materials everywhere, and build straight shorelines. Shore zones that have uneven topography, varied soils and vegetation, and irregular shorelines are likely to provide better ecological value.

2. Resist tidiness

“Debris” such as driftwood and windrows of vegetation along the shore provide perching spots for birds, cover for fish and other animals, nursery areas for young plants and animals, and food for the little animals that feed birds and fish. It’s okay to pick up garbage like plastic, paper, and glass, but messy shore zones are better for ecological functions than shore zones that look like Martha Stewart’s living room.

3. Don’t squeeze the shore zone!

It seems obvious that if you squeeze the shore zone out of existence by dredging or filling the shallows and wet areas, building vertical walls, and destroying vegetation, you will eliminate its ecological value. However, that’s just what people have been doing for thousands of years. So don’t.

4. Prevent pollution

Pollution released into the shore zone can both damage the shore zone itself and easily move into nearby waters. Try to avoid land uses in and adjacent to the shore zone that could release or spill pollutants. It’s also a good idea to use as little fertilizer and pesticide as possible in the shore zone.

5. Reduce wave damage

Large waves, whether from the wind or passing boats, can damage shore zones. Offshore dredging and shoreline hardening can increase wave damage by removing the natural structures that absorb wave energy. Reduce the damaging effects of waves by limiting these activities, and consider imposing no-wake zones near sensitive shorelines.

6. Tread lightly

Shore zones are popular places for fishing, swimming, bird-watching, boating, hiking, and other recreational activities. Unfortunately, these activities can sometimes damage shore zones by frightening away animals, trampling plants and animals, and eroding shorelines. So watch for signs of erosion, consider protecting parts of your shore zone as “no wake” areas where human activities are restricted, or prohibit some activities during sensitive times such as nesting seasons.

7. Don’t make dead ends

Animals (and plant seeds, too) use shore zones as highways when they’re migrating, so wetting sites to nest or feed, or rechanneling areas that were disturbed by nature or humans. When we put sterile habitat like a sewer or a parking lot along the shore, or build walls or roads that keep animals from moving between the water and the land, we block these highways and so damage shore zone biodiversity. Try to preserve continuity of behavior along the shore zone both above and below the water line, and avoid building walls, curbs, and other barriers that block shore zone animals.

8. Don’t make it so hard!

Many natural shore zones are made of a mixture of materials, including “soft” materials such as sand, mud, and gravel, often covered with vegetation. Humans frequently replace such soft materials with large stone, concrete, or steel. These hard materials change habitats and reflect waves, leading to erosion offshore and on adjacent properties. Where possible, try not to replace naturally soft shore zones with hard materials, and try to soften existing hard shorelines.

9. Give the shore room to move

If you build in a shore zone by building right up to the shore, it will be squeezed away when water levels rise. This will reduce or eliminate its ecological value, so wherever possible, give shore zones room to move. Because we’ve already harmed in many shore zones with homes and other valuable infrastructure, this will be hard to do for many sites. But where it is possible, this is an important strategy to preserve ecological functioning in the face of rising water levels in the coming century.

10. Be careful about building in the shore zone

If you must build in the shore zone, reduce ecological impacts by using permeable materials that let water seep into the ground, minimizing roads, walls, and curbs that block animal movement, and limiting bright lights that attract emerging aquatic insects.

Tidy, structurally simple shore zones like this one offer little habitat for plants and animals, and may be inhospitable to animal migration.

Leaving intact vegetation above and below the water line provides good habitat for plants and animals.

Vertical walls can block animal migrations and reflect wave energy, and should be avoided.

Nature trails and parks may be better uses of the shore zone than buildings and hard structures.
Long version

Don’t mow right down to the water’s edge

A lawn that reaches right to the water’s edge may look orderly, but provides poor ecological value, and opens up the shoreline to erosion. Except where people need access to the water, try to preserve a buffer strip of unmowed vegetation. Wider buffer strips are better, but even a 10-foot wide buffer is much better than a mowed lawn.

A lawn that is mowed to the water’s edge allows erosion and provides little habitat for birds and wildlife.
A few thoughts about decision-support tools
Decision trees

- Guide users to a best choice
- Can be dichotomous or not (e.g., expert systems keys like Lucid)
Concerns about decision trees and other simple decision-support tools

• Who will use these tools?
  • Will a coastal engineer or architect need such simple tools?
  • Will an untrained person be able to operate the tool correctly?
    • Diagnostic criteria (exposure, erosion, site use)
    • Recommended solutions

• A wrong decision can have expensive and long-lasting consequences

• So I decided not to release such a tool

• Would you?
What information do we provide to people?

• Technical information and recommendations to experts
• Broad, background information and general guidance to laypeople
  • Why are shorelines important?
  • Do I have a problem with my shoreline?
  • What are the threats to the health of my shoreline?
  • How can I improve the health of my shoreline?
  • What are the costs, risks, and benefits of different kinds of treatments?
• Two-way interaction is important so that we have some idea of what our audience needs, and how well our messages are getting across
Our new brochure

10 QUESTIONS to Ask When Building Defenses to Protect Hudson River Shorelines

RESOURCES to help you choose the right treatment for your site:

Hudson River Sustainable Shorelines Project
www.hrsr.org/hudson-river-sustainable-shorelines

New Jersey’s “Living Shorelines Engineering Guidelines”
www.state.nj.us/dep/comp/docs/living-shorelines-engineering-guidelines-final.pdf

1. How strong are the physical forces acting on your shoreline?

The strength of physical forces from waves, tides, currents, ice, and floating debris determine whether shoreline defenses are necessary, and whether they are needed. In general, you have more options at sites where physical forces are mild. Be sure to think about the strength of physical forces not just on a fine summer day, but during severe storms and when the water level is higher—during a flood or after years of sea-level rise. During high water, waves, ice, and debris may be able to reach and damage areas that are usually dry. You can use the link below to get a general idea about the strength of physical forces.

WEB RESOURCES:
Google Earth
www.google.com/earth

Historic Avails
www.historicavails.com

Is Your Shoreline Eroding?

2. How quickly is the shoreline eroding?

Sites that are eroding rapidly often need to be treated differently from sites that are eroding slowly or are stable. You can see how badly your shoreline has been eroding by looking at historical photographs (e.g., at Google Earth or Historic Avails) or by using “Is Your Shoreline Eroding?” to help you interpret the condition of your shoreline.

WEB RESOURCES:
Google Earth
www.google.com/earth

Historic Avails
www.historicavails.com

Is Your Shoreline Eroding?

3. What do people use the site for?

Human uses of the site and nearby properties are critically important for choosing the best shoreline treatment. Is there valuable infrastructure on the site? Do large boats need to have deepwater access? Will people need to go to the water’s edge to anchor in bulk to a site and need ready access for fishing and bird watching? Would occasional flooding completely ruin the planned use of the site, or just be a mild inconvenience?

Sites that can tolerate some erosion and flooding (e.g., a park) will benefit from different shoreline protection than sites with valuable and sensitive infrastructure (e.g., sewage treatment plants). Is there enough room to build anything that you’d like, or do current or planned uses need to account for the site’s impact on the site limit the size of possible designs? And because many kinds of shore defenses have visual and physical impacts (e.g., seawalls), consider sites, it is important to consider current and future uses to the neighborhood as well. Be sure that your choice fits the planned uses of your site, and does not harm your neighbors.

WEB RESOURCES:
Google Earth
www.google.com/earth

Historic Avails
www.historicavails.com

Is Your Shoreline Eroding?

People use the site for fishing, boating, or access to the water’s edge or shoreline, and occasional flooding probably will not. (Photo: DMC)
Conclusions

• We know a lot about ecological functioning of shorelines - enough to offer robust management recommendations

• Important challenges remain, so we must vigorously pursue research

• These challenges include knowing how best to define, educate, and motivate our audiences
For more information...

Visit the Hudson River Sustainable Shorelines website for more information on

• ecology
• engineering
• local demonstration sites
• free publications
• useful links
• and more!

https://www.hrnerr.org/hudson-river-sustainable-shorelines