Development of Decision Support Tools for Natural and Nature-Based Adaptation Strategies

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Acknowledgements

- Michigan Natural and Nature-Based (NNBF) Decision Support Tool (DST) is being developed collaboratively with the Michigan Department of Environment, Great Lakes, and Energy
- New York Great Lakes NNBF DST is being developed with New York Department of Environmental Conservation, Department of State, Department of Parks, Recreation, and Historic Preservation, and Office of General Services

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ENVIRONMENT, GREAT LAKES, AND ENERGY

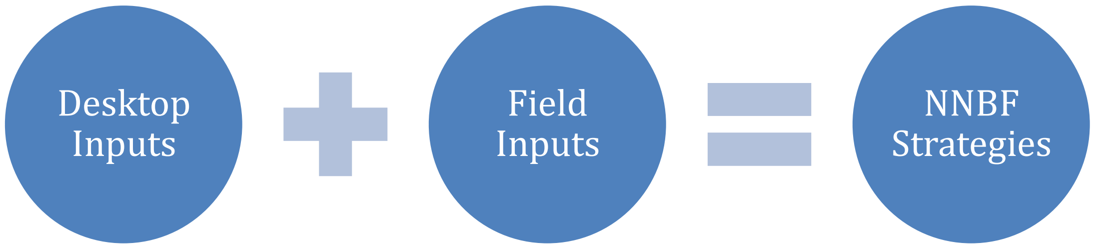
NEW YORK STATE

What is NNBF?

- Natural and nature-based features
- Use natural or nature-based principles to solve societal problems while maintaining ecological integrity
- Most common uses are for flooding and erosion control
- NNBF integrates ecology and engineering to create systems that are functional yet ecologically friendly

What is the Decision Support Tool?

- The Decision Support Tool (DST) is intended to be an educational tool that provides users with NNBF alternatives for a given site
- The DST is intended to fill a gap between complex design-level guidance and overly simplified high-level guidance
- The tool uses user-defined site-level inputs and a semi-quantitative logic
- Early version will be a spreadsheet tool, will eventually be web-based



Spreadsheet Tool

Michigan Great Lakes Coastal Natural and Nature-Based Shoreline Adaptation Strategy Decision Support

Version 2.0

February, 2023

Site Inputs Directions: Manually enter the "INPUT" for each parameter (Column C).

Site Parameter	Input	Parameter Definition (see instructions tab)	Data Source
Shoreline Type	Sand/Cobble Shore	The type of material the beach/bank are composed of	User provided
Critical Infrastructure Setback (feet)	50	The distance from the crest of dune/bank to critical infrastructure (define infrastructure, or use broader term)	User provided
Design Wave Height (feet)	2	The max wave height impacting the site, chosen by the designer	User or GIS defined
Ice Duration/Frequency	Rare	Frequency of ice damage	User provided
Shoreline Length (feet)	50	The length of shoreline for the proposed project	User provided
Project Area Slope (Run over rise)	10	Slope of project area (XRun:1Rise)	User or GIS defined
Shoreline width (feet)	50	Shoreline width for proposed project	User provided
Bank height (feet)	3	Elevation from water level to top of bank	User or GIS defined
Critical Dune Area	Not present	Michigan Critical Dune Area	Michigan Wetlands Map Viewer
OHWM	No	Is work proposed below the statutatorily defined Ordinary High Water Mark?	User provided
Effect on Regulated Wetlands	Yes	Will the Proposed Project Affect Regulated Wetlands?	
Threatened and Endangered Species	Not present	Are any state or federally protected species known to occur on or near the site that may be impacted by the proposed work?	User provided
Soil Disturbance Near Regulated Waterbody	No	Will the proposed project cause soil disturbance within 500ft of a regulated waterbody?	User provided
High Risk Erosion Area	No	Is the proposed project in a high risk erosion area?	User provided
Floodplain	No	Is the proposed project located in a floodplain?	User provided

Natural and Nature-Based Shoreline Adaptation Strategy Assessment

Natual and Nature-Based Shoreline Adaptation Strategies	Recommended Adaptation Strategies	State Regulatory Considerations: Joint Permit Application	High Risk Erosion Area	Critical Dune	SESC Permit	T&E Species Impacts	Floodplain
Structure Relocation/Raising	High Suitability	Yes	No	No	No	No	No
Vegetative Techniques	Not Recommended	Yes	No	No	No	No	No
Large Woody Habitat Structures	High Suitability	Yes	No	No	No	No	No
Biotechnical Techniques	High Suitability	Yes	No	No	No	No	No
Shoreline Grading and Sloping	Not Recommended	Yes	No	No	No	No	No
Bluff Grading and Sloping	-	Yes	No	No	No	No	No

Inputs

- Shoreline type
- Infrastructure setback
- Design wave height
- Shoreline Slope
- Ice
- Shoreline length and width
- Bank height
- OHWM/Wetlands/T&E species/SESC/ Critical Dune/High Risk Erosion Area/Floodplain

Site Parameter	Input
Shoreline Type	Sand/Cobble Shore
Critical Infrastructure Setback (feet)	50
Design Wave Height (feet)	2
Ice Duration/Frequency	Rare
Shoreline Length (feet)	50
Project Area Slope (Run over rise)	10
Shoreline width (feet)	50
Bank height (feet)	3
Critical Dune Area	Not present
OHWM	No
Effect on Regulated Wetlands	Yes
Threatened and Endangered Species	Not present
Soil Disturbance Near Regulated Waterbody	No
High Risk Erosion Area	No
Floodplain	No

Outputs

- Structure relocation/raising
- Vegetative techniques
- Large woody habitat structures
- Biotechnical techniques
- Shoreline grading and sloping
- Bluff grading and sloping
- Monitor/maintain/protect natural areas
- Each output will be tied to fact sheets that provide detailed information on the recommended techniques

INLAND LAKE FACT SHEET SERIES

Biotechnical Erosion Control (Higher-Energy)

Biotechnical Erosion Control is a best management practice in which both structural and vegetative measures are used to protect high-energy shorelines from erosion. This type of higher-energy bioengineering design is used in areas where erosive energy from waves and ice are relatively high, and vegetation alone would be inadequate in protecting the shoreline. Deep rooting, native plants in combination with coir logs and field stone protect against erosion and pollution, and provide habitat for fish and wildlife.

ADVANTAGES
of installing shoreline bioengineering

Erosion Control

Coir logs and shallow-sloped (4 horizontal:1 vertical) fieldstone provide a gentle runup for waves and ice. This provides immediate erosion protection. As vegetation becomes established, the roots grow through the coir, rock and soil, creating a strong form of shoreline protection that also provides habitat and water quality protection.

Improved Water Quality

Biotechnical erosion control uses native plants to intercept nutrients and pollutants before they enter the lake, leading to clearer water and decreased algal blooms.

Fish and Wildlife Habitat

The shallow-sloped fieldstone provides easy access to and from the water for frogs and turtles. Biotechnical erosion control also provides feeding habitat for fish, birds, butterflies, and other wildlife. This practice also deters property damaging geese!

The pictures above compare the shoreline of a Michigan inland lake in 1938 (top) to the same shoreline in 2014 (bottom). Over-engineered shoreline stabilization (seawalls) are not only costly, they lead to poor lakeshore habitat.

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This bioengineering design protects the shoreline on this high energy lake by dissipating wave energy from wind and boats while still providing lake access and not impeding lake views. Photo courtesy of Jennifer Buchanan, Tip of the Mitt Watershed Council.

DISADVANTAGES
of hardened shorelines and lawn to water's edge

Wave Reflection

Seawalls and hardened shorelines don't allow for the absorption and dispersal of wave energy, they reflect wave energy. The reflection of waves can make erosion worse in other areas through wave flanking and scour.

Weak Roots

Turf-grass (lawns) are not naturally found at the lake edge, and the shallow roots of turf-grass do not have enough strength to withstand waves and ice in high energy areas. Turf-grass also attracts property damaging geese.

Poor Water Quality

Seawalls degrade your lake by promoting runoff of nutrients and pollutants that lower water quality. Waves reflecting off seawalls suspend sediment in the water column, reducing water quality. Seawalls fragment the land and water interface and eliminate habitat required by fish and wildlife.

Outputs

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How the logic works

- Semi-quantitative
- Scores suitability based on weighted scoring system
- Recommendations are heavily weighted toward wave/slope calculations because waves tend to be the greatest forces on shorelines
- Drop down menus and user entered data
- Sites are ranked based on low/moderate/high suitability, or NNBF not recommended
- Triggers provided to cue users to permit needs

Site Parameter	Input	Par
Shoreline Type	Sand/Cobble Shore	The type
Critical Infrastructure Setback (feet)	50	The dista (define in
Design Wave Height (feet)	2	The max
Ice Duration/Frequency	Rare	equenc
Shoreline Length (feet)		e lengt
Project Area Slope (Run over rise)		ope of
Shoreline width (feet)	50	Shoreline
Bank height (feet)	3	Elevation

Constant
Frequent
Occasional
Rare

The wave-slope calculation

- Based on Hudson's equation, a formula developed by the US Army Corps of Engineers for determining rock sizes for shoreline protection
- User enters slope and design wave height
- "Crosswalk" of rock sizes to NNBF practices

Hudson's Equation

$$W_{50} = \frac{W_r H^3}{K_D (S_r - 1)^3 \cot\theta}$$

Where:

- W_{50} is the 50[th] percentile (median) weight of the stone (lbs)
- W_r is the unit mass of the stone (lb/ft³) Limestone typically is 160-165 lb/ft³
- H is the design wave height (ft) at the toe of the structure
- $S_r = W_r / W_w$; ($W_w = 62.4$ lb/ft³)
- K_D is an empirical value based on physical testing. For randomly placed, angular stone $K_D = 2.0$
- $\cot\theta$ is the design slope of the revetment. For a 2:1 slope, $\cot\theta = 2$

Vegetative Techniques

Critical Stone Weight for Wave/Slope Combinations (18" stone is ~500 lbs, 12" stone is ~160 lbs)

	Slope (XH:1V)																			
Wave Height (ft)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0.5	15	7.7	5.1	3.9	3.1	2.6	2.2	1.9	1.7	1.5	1.4	1.3	1.2	1.1	1	1	0.9	0.9	0.8	0.8
1	124	61.9	41	31	24.7	20.6	17.7	15.5	13.7	12.3	11	10	9.5	8.8	8.2	7.7	7.2	6.9	6.5	6.1
1.5	418	209	139	104	84	70	60	52	46	42	38	35	32	30	28	26	25	23	22	21
2	989	495	330	247	198	165	141	124	110	99	90	82.5	76	70	66	62	58	55	52	50
2.5	1933	966	644	483	386	322	276	242	214	193	175	161	149	138	129	120	114	107	102	97
3	3340	1670	1113	835	668	556	477	417	371	334	304	278	256	239	223	209	197	186	176	167
3.5	5305	2652	1768	1326	1060	884	758	663	589	530	482	442	408	379	354	332	312	295	279	265
4	7918	3959	2639	1979	1583	1319	1131	989	897	791	719	659	609	565	527	495	466	439	417	396

Challenges

- Data does not always exist to quantify NNBF practices, so parts of logic are built on collective practitioner experience and best available literature
- Tool will be tested and revised in 2024
- Must walk the line between "decision" tool and "design" tool
- NNBF practices are complex and subject to numerous natural forces which can be unpredictable

Next Steps

- Beta version of tool will be drafted by early 2024
- Tool will be tested and revised in 2024
- Eventual web development
- Will be accompanied by technical guidelines

Tool Demo

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