National Coastal Resilience Fund Monitoring

Purpose and Approach

NFWF continually seeks to better understand the impact of National Coastal Resilience Fund (NCRF) grantmaking investments on human community and fish and wildlife resilience. This document describes the NCRF monitoring approach. It provides a **list of the required monitoring metrics** for common restoration nature-based solutions (NBSs), **appendices describing methods** for each metric**, templates for monitoring plans**, and links to **data reporting templates**.

- These monitoring metrics are not intended to evaluate individual grantee performance but to help NFWF understand NBS outcomes in general.
- The monitoring metrics are intended as basic, relatively universal indicators of an NBS's ability to persist and provide ecosystem services, including hazard mitigation and ecological benefits. Comprehensive monitoring, as well as *maintenance* or *active management*, is strongly recommended to confirm these outcomes and to enable active management.
- NCRF monitoring documents can be found at https://www.nfwf.org/programs/national-coastal-resilience-fund-program/national-coastal-resilience-fund-monitoring.

NCRF requires *Restoration Implementation* grantees to perform monitoring using standard metrics, protocols, and data submission standards:

1. **Monitoring Plan**
    - If you are applying for a *Restoration Implementation* project, include a monitoring plan in your full proposal. The *Restoration Implementation* project category is described in the Request for Proposals.
    - Your monitoring plan should describe how you will collect monitoring data.
    - This document includes sample monitoring plan summary tables and a blank template.
2. **Standard Metrics and Protocols**
    - *Restoration Implementation* grantees must carry out monitoring during the grant period using monitoring metrics based on common NBS types as given in this document.
    - If your project falls into more than one NBS type, for example, stream restoration and aquatic organism passage, *use the metrics for both types.*
    - Data collection methods for each metric are given in the appendices.
3. **Timing of Data Collection**
    - Collect data at three key points unless a metric's description specifies otherwise:
        - **Before implementation** (baseline)
        - **Immediately after implementation** (within ~3 months)
        - **About one year after implementation**
    - Timing may vary for some metrics. For some, a baseline measurement may not be required. For some, observations during or shortly after a storm may be requested, *when this can be done safely.*

- Some metrics may take longer than one year to show changes, but early monitoring provides a baseline to assess longer-term performance. Longer-term monitoring is encouraged to support active management of nature-based solutions (NBSs).
- NFWF welcomes additional monitoring data collected optionally after the grant period.

4. **Data Submission**
    - Use NCRF's standardized data reporting templates, available at https://www.nfwf.org/programs/national-coastal-resilience-fund-program/national-coastal-resilience-fund-monitoring.
    - A data form should only include data from one survey period.
    - Upload monitoring data to NFWF's repository: https://resiliencedata.nfwf.org/
    - If you collect other data (e.g., for site assessment, modeling, project design, or partner requirements), please upload this with your monitoring data.
    - NFWF urges grantees to submit any longer-term monitoring data when possible. Reach out to NCRF@nfwf.org if you want to submit longer-term monitoring.
5. **Control and Reference Sites**
    - *Optionally*, (1) monitor a control site that is similar to the restored site to enable before-after-control-impact analysis, and (2) monitor a reference site that is as intact as possible to serve as a benchmark for a successful restoration.

Please reach out to NCRF@nfwf.org if you have any questions.

Third-Party Data Collection

In addition to requiring monitoring by awardees, NFWF also assesses economic and ecosystem services outcomes of restoration projects, including those related to flood hazard mitigation. NFWF works closely with third-party contractors to assess economic and ecosystem services outcomes of NCRF grants. While this data collection is not covered in this document, NFWF may request that NCRF *Restoration Implementation* awardees engage with third-party contractors when needed.

Monitoring Plans

Restoration Implementation applicants invited to submit a full proposal to the NCRF must include a monitoring plan in their full proposal. Make sure your budget provides sufficient funding to conduct monitoring as described in the plan. Restoration work funded by NFWF must be monitored, even if the monitoring is not funded by NFWF.

1. Find your proposed NBS in the list below and note the list of required monitoring metrics for this NBS type. Methods for each are described in the appendices.
2. Below the list of core metrics find several sample monitoring plan summary tables that you may modify to fit your project, if applicable, followed by a blank table for use as a generic template.
3. Along with the table, include in your proposal any relevant narrative on monitoring. The key attributes of the monitoring plan should be included in the table.

4. If you plan to conduct any additional monitoring in excess of NCRF requirements, please include this monitoring in your table and narrative.
5. Submit your monitoring plan with your full proposal.

Reach out to NCRF@nfwf.org if you have any questions about this process.

Data Reporting Templates

Submit monitoring data using NCRF data reporting templates, available at https://www.nfwf.org/programs/national-coastal-resilience-fund-program/national-coastal-resilience-fund-monitoring. The templates include fields for the core metrics, related survey data, and metadata. *The template may contain more metrics and data fields than are required for your project.*

General Data Collection Notes

Data collection and format: You may collect data with other methods than those described, if they have equal or greater accuracy. However, please use the data reporting templates to report core metrics in a consistent format. For example, if you are measuring elevation by using a drone to produce a digital elevation model (DEM) of your site, you may define transects in GIS software and sample your DEM elevations along the transects. In cases like this, please optionally submit the original dataset along with the data you entered in the data reporting sheet. Some metrics, e.g., distances, can be measured directly or calculated later from GPS coordinates.

Statistical analysis: The NCRF has no requirements for statistical analysis. However, if you plan to analyze your data statistically, a basic statistical power calculation can estimate the number of samples needed to determine whether a measured value differs meaningfully from some reference value. A procedure is given in Bagget, et al. (2014), p. 11 (see Appendix D) in the context of oyster restoration.

Photographs: Wherever relevant, include photographs documenting the condition and performance of the NBS. Photos should include relevant details such as a description, the date, and the orientation. A whiteboard can be used to include this information in the photograph.

About This Document: 2025 Update

This document was created for the NCRF by NFWF in collaboration with our partners. It was updated in 2021 to add guidance for coral reef restoration projects. This 2025 update covers a more comprehensive list of NBS activities.

Data collection methods in the appendices are synthesized from authoritative sources and expert opinion, or, in some cases, are directly excerpted from public-domain documents published by U.S. federal agencies. Where an appendix contains direct excerpts, this is explained in the appendix's first paragraph.

Core Metrics by NBS

The following metrics are required for restoration activities funded by the NCRF. Methods are described in the appendices indicated below. Check the "Monitoring Overview" that appears at the top of most appendices for any general guidance on methods.

Only the metrics listed here for your NBS are required, even if the appendix contains additional metrics. Projects can fit more than one NBS type.

If your project does not align with these NBS categories and their associated metrics, or if you have other questions, please reach out to NCRF@nfwf.org.

Marsh Restoration

- Percent cover by species (Appendix A)
- Elevation (Appendix A)
- Shoreline position (Appendix A)
- Water level (Appendix A)
- Salinity (Appendix A) (Required only for projects that install or modify levees or water control structures with the goal of managing salinity, otherwise optional)

For stormwater treatment wetlands, see Nature-Based Stormwater Infrastructure below instead.

Living Shoreline Restoration

- Percent cover by species (Appendix A)
- Elevation (Appendix A)
- Shoreline position (Appendix A)
- Water level (Appendix A)
- ***Oyster Reef Restoration*** *metrics listed below are required if project includes oyster reef elements (engineered oyster reef products, oyster culch, seed oysters, etc.)*

Beach and Dune Restoration

- Beach and Dune Elevation Profile (Appendix B)
- Shoreline position (Appendix B)
- Beach width (Appendix B)
- Beach-Dune volume (Appendix B)
- Backshore width (Appendix B)
- Dune width (Appendix B)
- Dune height (Appendix B)
- Dune volume (Appendix B)
- Grain size (Appendix B)

Coral Reef Restoration

- Coral reef area (Appendix C)
- Coral species abundance and survival (Appendix C)
- Coral survival (Appendix C)
- Coral reef rugosity and height (Appendix C)
- Fish species abundance (Appendix C) *(optional but recommended)*
- *Watershed restoration activities: Although the NCRF has not established a standard metric or method, coral reef restoration grantees implementing watershed restoration activities that reduce terrestrial erosion with the goal of reducing sediment, nitrogen, and phosphorus inputs near a coral reef are strongly encouraged to monitor changes to hillside and stream bank erosion and stream water quality. Please submit this optional data with your other monitoring data.*

Oyster Reef Restoration

- Oyster Reef Area (Appendix D)
- Oyster Reef Height (Appendix D)
- Live Oyster Density (Appendix D) *(required for intertidal reefs, optional for subtidal)*

Seagrass Restoration

- Percent Cover of Seagrass (Appendix E)
- Seagrass Canopy Height (Appendix E)

Kelp/Macroalgae Restoration

- Stipe Density (Appendix K)
- Urchin Density *(if restoration includes urchin control activities)* (Appendix K)
- Canopy Area (Appendix K) *(optional but recommended)*

Stream Restoration

- Elevation *(Appendix A) (one post-restoration survey, optional)*
- Stream Width and Bank Height (Appendix G)
- Bank Erosion Hazard Index (Appendix G)
- Maximum Jump Height (Appendix G) *(optional, recommended once pre-implementation and once post-implementation for projects with earthmoving activities that reshape the stream bed, such as channel realignment)*
- Percent Cover by Species (Appendix A) *(if herbaceous vegetation was restored)*
- Tree outplant density and survival (Appendix H) *(if trees were restored)*

Riparian Restoration

- Percent cover by species (Appendix A) *(if herbaceous vegetation restored)*
- Tree outplant density and survival (Appendix H) *(if trees restored)*
- Elevation (Appendix A) *(optional)*

Floodplain Restoration

- Elevation (Appendix A) *(if earthmoving activities are being conducted or subsidence is a concern)*
- Percent cover by species (Appendix A) *(if restored vegetation is herbaceous)*
- Water level (Appendix A)
- Bank Erosion Hazard Index (Appendix G) *(if applicable, i.e. if project involves activities that modify stream channels, create new channels, may impact channel erosion/stability, etc.)*
- Tree cover metrics (Appendix H) *(if trees were restored)*

Aquatic Connectivity

- Stream width and bank measurements (Appendix G)
- Channel profile and bed slope (Appendix G) *(for dam removals only)*
- Maximum jump height (Appendix G) *(for dam removals only)*
- Culvert remediation indicators (Appendix G) *(for culvert removal or replacement only, once pre-implementation and once post-implementation)*

Nature-Based Stormwater Infrastructure[1]

- NBSI condition assessment (Appendix F)

Coastal Forest Restoration (Including Mangroves)

- Tree cover metrics (Appendix H) *(if trees were restored)*
- Water level (Appendix A) *(if in wetlands)*
- Elevation (Appendix A) *(if in tidally or seasonally flooded wetlands where subsidence is a concern)*
- Shoreline position (Appendix A) *(if reducing shoreline erosion is a project goal)*

Habitat Conservation Practices

- *No **standard** metrics. Monitoring plans will be reviewed on a case-by-case basis. Please reach out to NCRF@nfwf.org if you would like to discuss an appropriate monitoring plan.*

Monitoring Plan Summary Tables

Blank Template Table

Below is a blank monitoring plan summary table for you to use in your full proposal. Refer to "Monitoring Plans" above.

Generic monitoring plan summary table:

<Your Project Name> <Your NBS Type>					
Metric (include units)	**Difference from Recommended Methods and Protocols (if any)**	**Spatial extent of metric monitoring**	**Baseline yr**	**Frequency/ Timing**	**Data Limitations/ Considerations**

Sample Tables

Below are some example monitoring plan summary tables that you may modify to fit your project. Refer to "Monitoring Plans" above.

Sample monitoring plan summary for a marsh restoration project:

Metric Name (include units)	Recommended data collection protocols	Spatial extent of metric monitoring	Frequency/ Timing	Use of metric

Percent Cover of biomass by species or cover type (% ranging from 0-100)	Use transects and quadrats method. In each quadrat determine the % of canopy cover (e.g., aerial view looking down) for each plant species.	At each quadrat	Annually, around the time of peak marsh biomass (e.g., July-August), to include, Pre-implementation, immediately post-implementation, and one year post-implementation.	Increased biomass can indicate increases in ecosystem services, e.g., marsh vegetation supports wildlife, reduces erosion, traps sediment, and attenuates waves.
Elevation (cm)	Benchmark method with a laser level, optical level, or an RTK GPS unit.	At each quadrat	Annually, in the same seasons every year (e.g. spring and fall every year) and after storm events. Pre-implementation, immediately post-implementation, and one year post-implementation.	Provides range of elevation over which marsh species occur (useful for diagnosing plant failure or species shifts). Provides change in elevation (~ 1 cm resolution when tied to a permanent benchmark).
Shoreline position	When establishing quadrats for the plant community monitoring, we will include permanent quadrat at the shoreline (e.g., at the edge of vegetation) and mark the edge landward and seaward.	Shoreline quadrat	As above.	Indicates impacts to the shoreline (i.e. wave energy, erosion, etc.)
Water Level *(Tidal Influence)*	Measure water level and marsh surface elevation to the same established benchmark reference point. We will measure water level with one logger that we will purchase and install.	Logger will be installed in adjacent subtidal or low intertidal areas.	Measure at 15-minute intervals for at least 30 days, preferably a year. Pre-construction preferred.	This measurement is needed to calculate the amount of time that the water level is greater than the marsh surface level, e.g., inundation. The distribution of marsh plant species is determined by inundation and salinity. Although it is not a measure of restoration success, measures of inundation time that marsh is covered by tidal water provides valuable data on where the marsh is in the tidal frame. Ideally, this should be determined BEFORE the restoration.

Sample monitoring plan summary for a beach/dune restoration project:

Metric Name (include units)	Recommended data collection protocols	Spatial extent of metric monitoring	Frequency/ Timing	Use of metric

Shoreline position (m)	Cross-shore topographic profile. RTK GPS following shoreline and beach berm	Statistically significant changes in shoreline position measurements along profile taken no greater than 6 m onshore 9-12 m offshore	Bi-annually in the same seasons every year (e.g., spring and fall every year) and after storm events. Pre- and post-construction.	This measurement (in combination with others) will give you an idea about the impacts to the shoreline (i.e., wave energy, erosion, design success, etc.)
Beach width (m)	Cross-shore topographic profile	See general guidelines above	Bi-annually in the same seasons every year (e.g., spring and fall every year) and after storm events. Pre- and post-construction.	This measurement (in combination with others) will give you an idea about the impacts to the shoreline (i.e., wave energy, erosion, design success)
Beach and Dune Elevation Profile (m)	Cross-shore topographic profile	Statistically significant changes in elevation measurements along profile taken no greater than 6 m onshore 9-12 m offshore	Bi-annually in the same seasons every year (e.g., spring and fall every year) and after storm events. Pre- and post-construction.	This measurement (in combination with others) will give you an idea about the impacts to the shoreline (i.e., wave energy, erosion, design success)
Beach volume (m^3)	Cross-shore topographic profile	See general guidelines above	Bi-annually in the same seasons every year (e.g., spring and fall every year) and after storm events. Pre- and post-construction.	Tells how the beach develops and performs in storms

Backshore width (m)	Cross-shore topographic profile	See general guidelines above	Bi-annually in the same seasons every year (e.g., spring and fall every year) and after storm events. Pre- and post-construction.	This measurement (in combination with others) will give you an idea about the impacts to the shoreline (i.e., wave energy, erosion, design success)
Dune width (m)	Cross-shore topographic profile	See general guidelines above	Bi-annually in the same seasons every year (e.g., spring and fall every year) and after storm events. Pre- and post-construction.	This measurement (in combination with others) will give you an idea about the impacts to the shoreline (i.e., wave energy, erosion, design success)
Dune height (m)	Cross-shore topographic profile	See general guidelines above	Bi-annually in the same seasons every year (e.g., spring and fall every year) and after storm events. Pre- and post-construction.	This measurement (in combination with others) will give you an idea about the impacts to the shoreline (i.e., wave energy, erosion, design success)
Dune volume (m^3)	Cross-shore topographic profile	See general guidelines above	Bi-annually in the same seasons every year (e.g., spring and fall every year) and after storm events. Pre- and post-construction.	Tells how the beach develops and performs in storms. Also relevant for FEMA interests.

Grain size (mm)	Core sample or Sand gauge chart	See general guidelines above	Bi-annually in the same seasons every year (e.g., spring and fall every year) and after storm events. Pre- and post-construction.	Can be an indication of change in slope and accretion. Helps to determine what kind of wave energy is needed to move sand around.

Sample monitoring plan summary for a coral restoration project:

Metric Name (include units)	Recommended data collection protocols	Spatial extent of metric monitoring	Frequency/ Timing	Use of metric
Acres restored	Mapping, photo mosaics, length/width	Sum of plots with <2 meters between corals	-Restoration site: Within 1 month of outplanting and then annually post-outplanting.	Understand the extent of the restoration effort and then track expansion or loss of restored area over time.
Coral Species Abundance (# of outplants/colonies and mean width cm or size class distribution)	Ecological Footprint Survey, photo mosaics, Transects, Plots/Quadrats - should be fixed to monitor change over time	Ecological Footprint of the restoration site + two transects at the control and reference sites	-All sites: Pre-restoration and annually -Restoration site: <1 month post planting	Evaluate the success of the restoration corals (growth) in relation to reference and control sites, thus factoring out 'natural' failure.
Coral Survival (% of outplants/colonies without signs of mortality or partial mortality class distribution)	Ecological Footprint Survey, photo mosaics, Transects, Plots/Quadrats - should be fixed to monitor change over time, Fate Tracking	Ecological Footprint of the restoration site + transect at reference site	-All sites: Pre-restoration and annually -Restoration site: <1 month post planting	Evaluate survivorship by maintaining >80% live tissue/cover of outplants in first year and >50% after 5 years and compare this to 'natural' mortality.
Coral Rugosity/Reef Height (cm)	Ecological Footprint Survey for mean Coral Height (Chain length or photomosaic for branching dominated restoration)	Ecological Footprint	-Restoration site: <1 month post planting and then annually	Evaluate change in reef structure over time

Reef Fish Species Abundance (g/m2)	Belt transect, Roving/Timed Diver or Video Transect for biomass by species/families/functional guilds (herbivores, corlivores, etc.)	Ecological Footprint + transect at reference site	-Reference site: Pre-restoration and annually -Restoration site: Pre-restoration, <1 month post planting and then annually	Evaluate ecological impact of restoration effort and overall reef health relative to reference site.