Framework to Advance Great Lakes Coastal Wetland Conservation (U.S. and Canada)

Great Lakes Coastal Assembly

September 2021

Executive Summary

The Great Lakes Coastal Assembly (GLCA) drafted this framework from 2020-2021 to help advance and accelerate strategic coastal wetland conservation efforts. Although a product of the GLCA, the Framework was shaped by input, feedback, and recommendations from over 30 organizations and 70 individuals through GLCA working group discussion, Advisory Team meetings or other comments on the draft document. There are three interrelated and interdependent objectives and four anticipated products of this framework.

Objectives:

1. Establish existing baseline extent and condition of Great Lakes coastal wetlands
2. Determine extent and condition of coastal wetland types needed to help achieve healthy Great Lakes and coastal communities
3. Identify where to focus coastal wetland efforts to achieve healthy Great Lakes and coastal communities

Products anticipated after piloting the Framework:

1. Range of total existing wetland acres, wetland acres by geomorphic type or classification type, ecological conditions of existing wetlands, annual variation and change over time, and water level variation (Objective 1)
2. Qualitative or quantitative desired status for extent and condition for coastal wetland types, that if achieved, represents success (Objective 2)
3. Family of maps depicting metrics associated with desired status and a decision support tool that helps partners identify where to focus coastal wetland efforts to achieve desired status (Objective 3)
4. Outreach materials including a publicly available web browser-based dashboard for data access and visualization (Framework)

The Framework is intended to be implemented on a lakewide scale (e.g., all of Lake Michigan or all of Lake Superior, etc.) with the potential to scale down to smaller sub-lake units especially to fulfill Objective 3. This finer scale may help transition this planning effort to on-the-ground coastal wetland conservation implementation and action by partners. The Framework is intended to be iterative and flexible, promoting learning and adapting to the unique circumstances and partnerships within each lake.

Through the development of this framework, the GLCA has identified Lake Erie as the first pilot geography for testing, learning, and adapting this framework. If financial and technical resources are made available, we anticipate that significant progress on piloting the Framework can be made over the next 3 years.

Statement of Purpose

Great Lakes coastal wetlands are critical habitats with high ecological, economic, and cultural importance. Intact and healthy coastal wetlands provide several ecosystem services which directly benefit people, including capturing excess nutrients, sediment, and contaminants from upstream sources; sequestration of carbon; protection against shoreline erosion and property damage from waves and high water; reduction in severity of flooding during heavy rains; habitat for culturally and economically important species as well as threatened and endangered species; and many opportunities for recreation. Coastal wetlands that are more intact are healthier, more resilient ecosystems with high biodiversity and can provide more ecosystem services than those that are degraded or fragmented.

Given the significance of wetland ecosystems in the Great Lakes region, there is now considerable interest and investment in both the U.S. and Canada to restore, enhance, and protect Great Lakes coastal wetlands [1] [2]. However, key questions remain regarding the basin-wide extent and condition of existing coastal wetlands as well as the area of wetlands needed to achieve desirable conditions and ecosystem services at basin-wide, lakewide, or sub-lake unit scales. In addition, partners in both the U.S. and Canada are dedicated to adaptive management strategies that link science and monitoring with conservation actions. Effective adaptive management ensures that conservation actions are prioritized, targeted, and measurable. The processes for developing science-based extent and condition estimates, desired status, and identifying where to focus conservation actions for Great Lakes coastal wetlands will be iterative and interrelated.

Led by the Great Lakes Coastal Assembly

The Great Lakes Coastal Assembly (GLCA) is a voluntary binational forum of coastal wetland ecologists, wetland managers, conservation planners, and environmental regulators with a shared vision of a resilient system of coastal wetlands across the Great Lakes basin (Appendix A). Numerous efforts have been initiated by federal, state, provincial, tribal, academic, NGO, and local entities to address various components of conserving Great Lakes coastal wetlands. Despite the merits of these efforts, which have taken advantage of resources, expertise, capacity, and technology available at the time, a comprehensive approach is still needed to advance and accelerate coastal wetland conservation. The GLCA represents a renewed effort to initiate a holistic framework. Building on previous, largely independent efforts, this diverse group is actively collaborating to fill key information gaps and promote a science-based methodology to coastal wetland conservation. This framework, outlined by the GLCA, addresses the need to bring together 1) monitoring efforts that establish baseline conditions and measure management response; 2) input and engagement of partners; 3) biological and human values data; and 4) geospatial mapping. When these activities converge and work concurrently, the GLCA believes that significant progress toward coastal wetland conservation will be achieved.

Support for coastal conservation and partnership networks has grown in recent years, resulting in ideal timing for the GLCA platform. For example, in 2010, the U.S. launched the Great Lakes Restoration Initiative (GLRI), which commits significant capital to restoring Great Lakes coastal wetlands [1]. Additionally, the importance of fish and wildlife resources was recognized in the 2012 update to the binational Great Lakes Water Quality Agreement and an annex was devoted to species and habitats, including coastal wetlands [3]. Given the growing interest in Great Lakes coastal wetlands, technological advancements, professional knowledge, products from previous efforts, and commitment to a collaborative approach, the GLCA provides a nexus for developing a strategic framework for Great Lakes coastal wetland restoration and protection.

This document outlines a framework with three objectives to advance and accelerate conservation and management efforts to support Great Lakes coastal wetlands, which are linked to the vision and goals established by the GLCA (Appendix A). Specifically, these objectives will help the GLCA achieve its vision of a resilient system of coastal wetlands that support economic, social, and environmental benefits to the Great Lakes Region. The three objectives in this framework include:

1. Establish existing baseline extent and condition of Great Lakes coastal wetlands
2. Determine extent and condition of coastal wetland types needed to help achieve healthy Great Lakes and coastal communities
3. Identify where to focus coastal wetland efforts to achieve healthy Great Lakes and coastal communities

Process for Refining the Framework and Identifying a Pilot Geography

The GLCA formed a workgroup and designated co-leads to populate an initial template for each Objective. Co-leads then assembled Advisory Teams of subject matter experts to review each Objective for feasibility and missing critical concepts (Appendix B). Each Advisory Team made recommendations for methods, activities, and steps needed to fulfill each Objective. Advisory Teams also recommended a pilot geography or geographies where each Objective template could initially be applied, tested, and refined. A key consideration for outlining methods for the pilot geography was that they could be scaled up to the Great Lakes basin. Co-leads developed the following criteria for selecting a pilot geography:

1. Great Lakes coastal wetlands are a conservation priority
2. Existing or completed efforts to achieve similar objectives
3. Available resources including data, personnel, time, and effort
4. Binational support

Given these criteria and input from Advisory Teams, we recommend piloting the Framework in Lake Erie with areas in additional Great Lakes specifically for training the model as part of Objective 1. This hybrid approach best fits our criteria and accounts for potential trade-offs in piloting the Framework in one lake versus a sub-lake unit. Partners in each of the Great Lakes have either identified coastal wetlands as a conservation priority or have made efforts to achieve similar objectives for coastal wetlands as described in this framework. Lake Erie was identified by Advisory Teams as having strong partnerships in place, such as the Lake Erie Lakewide Action Management Plan (LAMP), the St. Clair Detroit River Systems (SCDRS) Initiative, and the Saginaw Bay – Western Lake Erie Landscape Conservation Design (SB-WLEB LCD), that may be ready to invest personnel, time, and effort into implementing the Framework. However, Lake Erie lacks diversity of wetland types needed to calibrate models determining coastal wetland baseline extent. To account for this, we recommend that analysts identify additional training areas outside of Lake Erie to fill data gaps. Piloting the Framework on Lake Erie would build upon existing efforts in Canada and the U.S. including Environment and Climate Change Canada's Baseline Habitat Survey and Michigan Technological Research Institute's Great Lakes Coastal Wetland Mapping. Additionally, Advisory Teams identified that Lake Erie has a greater sense of urgency due to more coastal wetlands experiencing stressors compared to other lakes that share a binational border. Each of the Great Lakes could benefit from tools and resources developed under the Framework and pilot effort in Lake Erie. Ultimately, we aim to implement the Framework throughout the Great Lakes basin.

Partner Engagement

The identification of partners in this work will be ongoing as these efforts are initiated and training geographies are identified. Partners have been identified broadly to include individuals and organizations that are interested in coastal wetland conservation. This may include Federal, State, Tribal,

and local agencies, and land managers as well as wetland researchers. We recommend this also include representatives from the GLCA and a LAMP working group representative from the pilot geography.

The goal for developing and piloting this framework is to advance conservation of coastal wetlands across the Great Lakes basin. Although products like online extent mapping tools, decision support tools, and static maps are all expected outputs of this work, we ultimately aim for these products to be used and refined by land managers, scientists, funding organizations, and other decision makers. In other words, successful piloting of this framework includes putting these products into action through decisions that impact on-the-ground conservation activities. To accomplish this, partners need to be engaged to ensure products are tailored to their needs and are useful. Engaging partners will also raise awareness of the Framework and, hopefully, continue to build support for the effort. We recommend engaging a diversity of organizations and perspectives to gather feedback, build support for coastal wetland conservation, and ensure use of the final products with the following engagement efforts:

- Pilot Kick-Off and Invitation – Develop a distribution list of interested partners in pilot geography or across the basin. Invite partners and ask how they'd like to be engaged (see below – Steering Team, Ad Hoc Technical Teams, Management Briefings, Periodic Updates)
- Steering Team – Form an overarching team to ensure coordination in piloting the Framework with team members representing expertise and interest in each of the three Objectives. Ensure representation from a diversity of organizations and empower team members to be ambassadors that elevate and seek feedback within their organizations and networks. The Steering Team will help to ensure coordination and management occurs across the three Objectives.
- Technical Teams – Convene ad hoc Technical Teams for specific work or to engage needed expertise. Technical Teams should engage new organization representation where possible.
- Great Lakes Regional Leadership and Management Briefings – Provide briefings and seek feedback at critical steps with regional leadership groups including:
    - Great Lake Water Quality Agreement – Annex 7
    - GLRI – Focus Area 4 and others
    - Relevant LAMP groups
    - Great Lakes Coastal Assembly
- Periodic Updates – Develop brief summaries and progress reports to share with a larger partner group via web or email distribution.

Connections among Objectives

The three Objectives are interrelated and interdependent. Therefore, we recommend initiation of work on all three Objectives simultaneously, which will offer myriad opportunities for collaboration, feedback, and refinement among the members of the Steering Team and Technical Teams. Simultaneous development is not only beneficial, but also critical in some cases. For example, coastal wetland values cannot be modeled or mapped until those values are articulated through the recommended approach outlined for Objective 2. Understanding these interdependent activities at the outset will assist with logical flow of information and work. We recommend the following steps to maintain connections and allow for simultaneous development among Objectives:

- Coordinate a shared timeline that identifies Objective milestones and dependencies:
    - Refine a timeline for each Objective at initiation of the project
    - Identify interdependent activities in each Objective
    - Identify timing for cross-Objective feedback

    - Build in external partner feedback intervals that are same for all three objectives (e.g., leadership/management briefings and periodic updates)
- Establish a line of communication between the Steering Team and Technical Teams:
    - Designate a coordinator that sits on all future established teams whose role is to identify connections and dependencies among the three Objectives
    - Provide regular updates to Steering Team regarding progress on all objectives
    - Schedule periodic collaboration calls

Recommended Next Steps for Piloting the Framework

The Framework outlined in this document establishes a foundation of a shared vision and goals to help guide partners in identifying and taking actions to implement on-the-ground projects and track progress toward protecting and improving the health of Great Lakes coastal wetlands through adaptive management. It is a recommended set of guidelines that is iterative and expected to evolve over time. The pilot is intended to test the Framework and may be adjusted as the Steering Team and Technical Teams learn from the recommended approaches outlined below. GLRI Focus Area 4 funding has been requested for Fiscal Year 2023. If funding is received through GLRI or other sources by 2023 or earlier, we expect that significant progress could be made towards completing the pilot within 3 years of kick-off. Over the next several months, co-leads will conduct partner outreach to build support for the Framework, identify members to form a Steering Team to pilot the Framework in Lake Erie and a Technical Team to identify data processing methods and additional training areas.

The following sections provide background information about each Objective and outline the recommended approach for achieving each Objective based on input from the Advisory Teams. It will take differing amounts of time to develop working prototypes for the three Objectives within the pilot geography. Once prototypes are developed, we recommend that they are applied to each of the Great Lakes with the goal to collectively allow for reporting on a basin-wide scale and to update outputs at a frequency that fulfills partner needs. Update cycles to consider include those used for the Triennial State of the Great Lakes (SOGL) reporting cycle or the 5-year cycle of the Great Lakes Coastal Wetland Monitoring Program (CWMP) and LAMPs. The different objectives may need to be updated at different frequencies depending on partner needs.

Objective 1: Establish existing baseline extent and condition of Great Lakes coastal wetlands

Problem statement

To measure progress on coastal wetland conservation and related Great Lakes health, we must determine the current extent, or baseline area, of these diverse wetlands within each of the Great Lakes and the river systems that connect them. Despite advancements in satellite and imagery technologies, recent comprehensive estimates have not been made due to the time commitment and cost. Since the extent and position of coastal wetland types (e.g., meadow, marsh, emergent marsh, aquatic bed, shrub-scrub) fluctuate over time in response to changing lake levels, and some of the Great Lakes water levels are managed, we recommend identifying the range, or baseline, of wetlands present during recent periods of normal, high, and low lake levels. We recommend developing a mostly automated approach that relies primarily on open-source satellite data so that coastal wetland extent can be regularly estimated in a consistent way throughout the basin in the future. Relying on open-source satellite data is an important goal of this work because the cost and labor required when using tools such as LiDAR and high-resolution commercial satellite imagery would reduce the frequency with which estimates of wetland extent could be made. The outputs needed from this approach include estimates of the range of total wetland acres, wetland area by wetland geomorphic type, variation and change over time, and information about ecological condition (e.g., vegetation type and condition) of existing wetlands if possible [4] [5].

Recommended Approach

The following sections help to outline an approach for estimating various parameters related to wetland area for Great Lakes coastal wetlands:

a. Methods: The proposed methods used to achieve the goals above would:
   - Utilize open-source satellite remote sensing data as the primary data source (Figure 1, 2) due to availability, spatial coverage, repeated overpasses, and well-established timely data workflows from sensor to data model ingestion.
   - Utilize a fusion approach for ground truthing and model validation by using high resolution imagery, drone imagery, and LiDAR when and where such resources are available (note that not all of these data can be used for publicly available derived products).
   - Utilize a professionally and binationally supported wetland field data collection template/app
   - Utilize a professionally and binationally supported wetland classification standard developed upon openly available remote sensing technologies by establishing a classification schema that is compatible with entities that use different classification standards (e.g., Cowardin, Canadian Wetland Classification System, Brinson) and allows for cross-walking between national classification standards.
   - Estimate past and present wetland extent starting at a time when accurate and reliable satellite and field data are both available for training and pilot geographies.
   - The approach should be practical and repeatable (automated/semi-automated) at a frequency supporting the needs of the partners and allowing for regular incorporation of new satellite data as well as vegetation data from monitoring efforts so that changes in wetland extent and classification can be estimated and tracked over time.
   - Utilize georeferenced GLCWMP vegetation and ecosystem condition data (Figure 3) and any other available wetland ancillary datasets for classification and validation purposes.
   - Build upon existing wetland mapping layers and those currently under development to the maximum extent possible (currently available datasets include CWMP wetland map layer,

Canadian Wetland Inventory, Canadian Habitat Baseline Survey, US National Wetland Inventory, MTRI Great Lakes Coastal Wetland Mapping).

- The approach shall provide the following information:
    - Range of wetland acres
    - Acres by geomorphic type or classification type
    - Ecological conditions (where temporally paired field data allow)
    - Annual variation
    - Change over time (or difference between time periods)
    - Water level information (included as a contextual covariable)
    - Outputs from this project should keep in mind the outreach and partner engagement goals listed below

b. Model training geographies and pilot geography/Geographic Extent and Justification: Developing a model for (recent) past and present coastal wetland extent mapping at a basin-wide scale will require geospatial analysts and wetland ecologists to agree on a set of model training geographies that will account for the variation in wetland types and landscapes across the basin. Training geographies for model development should:

- Include areas that span the range of latitude and longitudes of the Great Lakes Basin and accounts for periods of high, low, and average water levels, and managed and unmanaged water levels in these geographies.
- Focus on areas where wetland extents and densities are favorable for model calibration and where vegetation data are available, such as from the GLCWMP (figure 3). Training geographies can (and likely should) include areas in the rivers connecting the Great Lakes and Lake St. Clair.

Once a working model has been developed based on these training geographies, extent estimates for different periods of water levels should be made for a pilot geography. The proposed pilot geography for this work is the Lake Erie Basin (including Lake St. Clair and the St. Clair and Detroit River), which is an area that aligns with the goals of Objectives 2 and 3 in this document. However, the ultimate goal of this work will be to scale up the approach for basin wide application.

c. Technological Resources Needed: This approach should:

- Leverage platforms like Google Earth Engine for data processing and access to readily available open-source government satellite imagery (e.g., Sentinel, Landsat).
- Automate the analytical process using Python and/or other scripting languages where possible to optimize the efficiency, shareability, and repeatability of the methods.
- Utilize additional remote sensing data (where available and allowable) in data fusion approaches to improve wetland classification, field work prioritization, and model output validation.
- Utilize any additional new remote sensing platforms and data that become available.
- Organize and store training and validation data, and intermediate and final classifications in a central database that can be accessed by all.

d. Expertise Needed: This approach will require a technical team of remote sensing experts and analysts to work closely with coastal wetland ecologists to develop the model and methods to complete these goals. This will ensure that the process is efficient from a methodological perspective and will provide meaningful and useful outputs for partners.

e. Other Resources: Funding for fieldwork, data processing and validation, and data storage are anticipated to be the primary costs for this approach.

Milestones

The timeline of activities to achieve the desired outcome include several phases. These phases will take varying amounts of time depending upon the following caveats within each phase and scale of geography. These include:

- Data collection and compilation – Previous basin-wide mapping efforts have taken multiple years due to the time required to compile large datasets and complete pre-processing steps prior to model construction and validation. However, with new platforms like Google Earth Engine, much of the data is now readily available in user friendly, cloud optimized formats making data preparation and processing nearly seamless. One remaining issue with optical imagery in the Great Lakes is the amount of time it takes to collect or create cloud free images that can be used in modeling workflows. Incorporating ancillary datasets that may not exist in the cloud may also add additional time to the project.
- Data analysis and synthesis – Having clearly defined desired outputs will minimize the number of iterations required to develop and validate the model and develop meaningful outputs. Partners should be surveyed for desired components in the outputs if they differ from those listed in the methods section above. However, there are limits to the ability of remote sensing to estimate wetland condition for example, and not all partner needs can be addressed. Partners should also specify the ideal interval at which new estimates should be made and reported so that change can be assessed over time. It is important to note that the methods outlined above are intended for interannual comparisons rather than seasonal comparisons. The analytical steps for completing these types of analytical questions are distinct. Lastly, constructing a model that can identify and quantify transitional areas within wetlands will likely take additional time.
- Harmonization – Anticipating this phase from the beginning will minimize time spent and should be part of the approach from the start by developing the necessary crosswalk between national classification standards. This ensures that all coastal wetlands being evaluated can be referenced, no matter which part of the basin is being analyzed. Additional harmonization will be needed within wetland areas to account for data processing artifacts and segmentation. This can be achieved through data fusion approaches.
- Reporting – The results and outputs from this work should be repeated at an interval that is useful for partners. In recent years, it has become relatively simple to construct online user-interfaces for mapping remotely sensed data products. The more features incorporated into such a tool would determine the amount of time needed both to build the model, but also to construct a user-friendly platform that houses and displays the outputs.

Outreach or Partner Engagement

It is critical that the data and results of this effort are available and useful to the widest audience possible. For this reason, we recommend that a publicly available web browser-based dashboard be developed for data access and visualization. Such a tool would allow the greatest amount of flexibility to meet end user needs and would allow the user not only to visually explore the data, but also to download raw data if desired. The approach should provide information that is directly relevant and useful for Objectives 2 and 3 in this document. The approach should also be capable incorporating information about wetland status and restoration outcomes from Objectives 2 and 3 over time.

We recommend that this dashboard would include features that allows the user to specify the time periods they wish to compare, thereby allowing the user to define a baseline period that is suited to their purpose. We also recommend that this dashboard have features that provide range of wetland

acres by wetland type, estimates of ecological condition, context regarding water level ranges during time periods specified, and information about adjacent landscape stressors if possible.

Lastly, this dashboard should allow the user to download spatial data in raster or vector format. Because remote sensing data have limited resolution and analytical procedures are not completely accurate, this dashboard will communicate the uncertainty associated with any final products. The dashboard will also include a disclaimers or explanations of how the data can and cannot be used.

Caveats and Limitations

There are several caveats and limitations to the proposed/desired approach. These include:

- By focusing on the use of publicly available and open remote sensing data, we expect limitations in the spatial resolution of 10 - 15 meters and corresponding minimum mapping units; we consider this acceptable since this is intended to be a basin-wide baseline approach.
- The 1918-present monthly water level information currently available may not account for the range of water levels we may experience in the future. However, historical water levels will help to inform potential trends within each lake basin as this work progresses.
- The approach will only account for wetlands with surface water hydrologic connections to the Great Lakes or their connecting river systems (including Lake St. Clair).
- Due to the dynamic nature of wetlands, especially during periods of rapidly changing water levels, this approach may not be able to consistently capture the extent of transitional wetland areas, such as those where water levels are changing drastically, rapidly, and or regularly. This limitation will need to be well communicated with partners.
- This approach will likely need to be constrained to estimates representing individual years rather than individual seasons due to the different methods and amounts of data needed to estimate both.

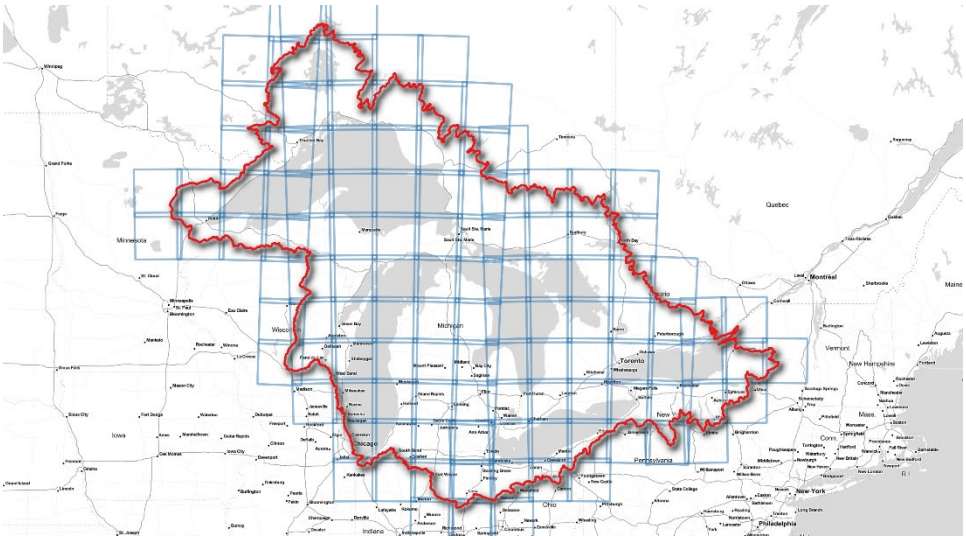

Figure 1: Sentinel 2 satellite imagery tiling index over the Great Lakes basin.

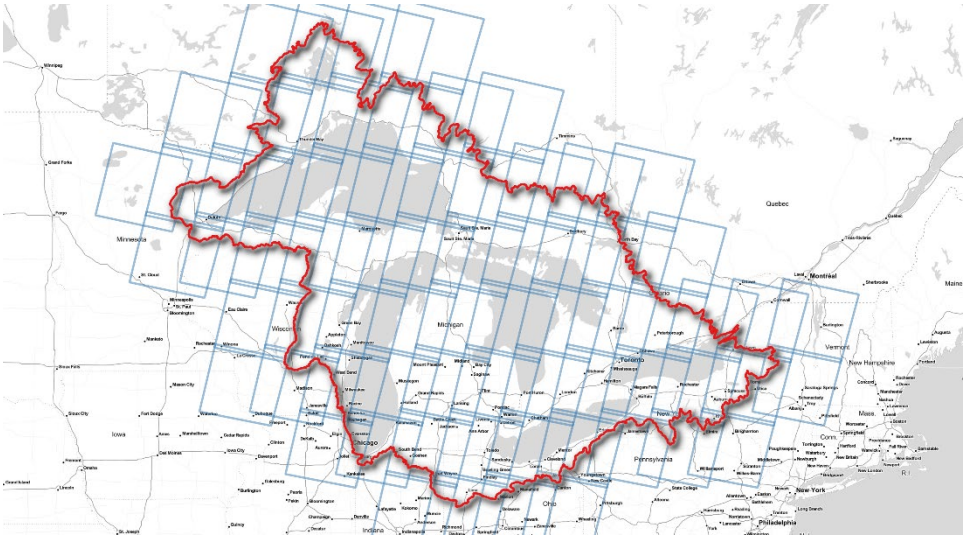

Figure 2: Landsat imagery tiling index over the Great Lakes basin.

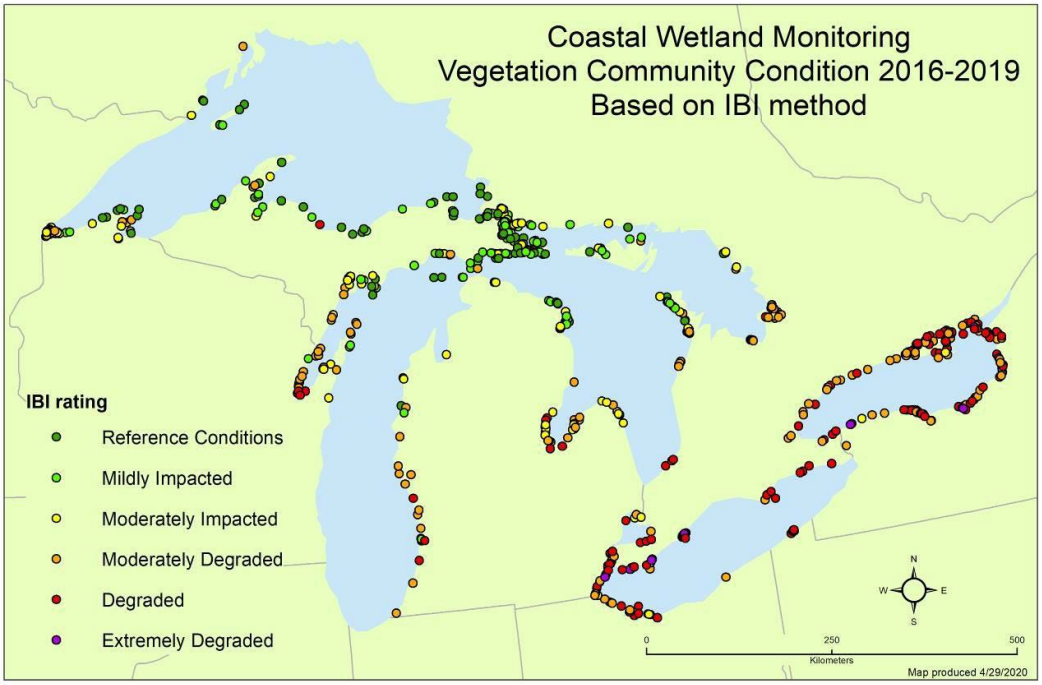

Figure 3: Condition of coastal wetland vegetation at sites across the Great Lakes. Circle color indicates vegetation community quality. The indicator is labeled “draft” while this indicator is investigated for robustness against varying water levels and latitude. Based on data from 2016 through 2019. Data are available at some of these and some other wetland sites during 2011-2015. Image and data are from the Coastal Wetlands Monitoring Program.

Objective 2*:* Determine extent and condition of coastal wetland types needed to help achieve healthy Great Lakes and coastal communities

Problem statement

Conservation of Great Lakes coastal wetlands, including protection, restoration, and enhancement, is critical for addressing the loss and degradation of coastal wetland ecosystems and striving to achieve the net habitat gain goal outlined in the GLWQA [3]. Numerous plans and strategies throughout the Great Lakes recognize the overarching need to protect coastal wetlands, restore wetlands to increase extent, and enhance their condition. Some of these, such as the Biodiversity Conservation Strategies (BCSs), outline a desired status of coastal wetlands for extent or condition in a broad sense, yet are not specific enough to guide and accelerate strategic coastal wetland conservation actions. For example, the Lake Erie BCS establishes a value of < 20% coverage of Phragmites in coastal wetlands for a status of "Good" and < 5% coverage for a "Very Good" status [6]. The values of 20% and 5% represent thresholds for achieving a Good or Very Good status rating. These desired status statements are primarily based on the collective assessment of experts incorporating the best knowledge and data available; there is a need to improve on this good work by incorporating known relationships between extent and condition and the ability of coastal wetlands to provide ecosystem services and contribute to healthy Great Lakes and coastal communities. The desired ecological status of coastal wetland extent and condition by wetland type will take into consideration those human well-being needs or ecosystem services relevant to healthy Great Lake coastal areas. At a minimum, recommend using Great Lakes hydrogeomorphic wetland types (lacustrine, riverine, and barrier-protected) when determining desired status for extent and condition, including any unique or rare wetland communities identified as important [4]. The intent is to outline a systems approach that can be implemented consistently for each Great Lake building off existing partnerships, efforts, and plans with a recommendation to pilot the approach first in Lake Erie. The output from this objective will be a set of desired status ratings for extent and condition of coastal wetland types for each Great Lake that can be rolled up for reporting on a Great Lakes wide scale. Desired status could also be developed for sub-lake units, as defined within each LAMP. Ideally desired status ratings would be adopted and incorporated into the LAMPs.

Recommended Approach

To develop and inform desired status values for extent and condition by coastal wetland type for each Great Lake, we will coordinate with the LAMP Partnership and other key partners with expertise and knowledge of coastal wetlands and health of the selected lake and build off existing coastal wetland efforts. During this process, we recommend utilizing status assessments and data from the State of the Great Lakes (SOGL) coastal wetland sub-indicator reports whenever possible. Other sources to consider include but are not limited to: Biodiversity Conservation Plans, Great Lakes Coastal Assembly, Blue Accounting, State Wildlife Action Plans, Joint Venture Plan, Audubon Great Lakes Water Bird Priorities, and the Great Lakes Fishery Commission Environmental Objectives. Ideally, desired status will be established first at a lakewide scale to then inform more specific desired status ratings for each sub-lake unit. The planning team for each lake will develop an understanding of relevant Landscape Conservation Designs (LCDs) and other systems-approach planning efforts and decide what is feasible to apply at a lakewide scale. Further, we suggest that each LAMP Partnership adopt an adaptive management approach, committing to periodic updates to account for new information or significant ecological or societal changes. Additional details related to this recommended approach include:

a. Methods:

- Coordinate with Objective 1 team to ensure consideration of the most recent data on coastal wetland extent, condition, and distribution of coastal wetland hydrogeomorphic types within each lake and sub-lake unit
- Refer to the 2019 (or newer if available) State of the Great Lakes Report coastal wetland sub-indicators to establish desired status for coastal wetland extent and condition by wetland type that can be applied to a given lake or sub-lake unit for reporting out on a Great Lakes basin-wide scale, but also allow for additional conservation targets to be established for a given sub-lake unit as needed.
- In addition to the SOGL reports, review and compile additional/prior status or target-setting efforts, including LAMPs, Biodiversity Conservation Strategies, Blue Accounting, LCDs, the SCDRS Initiative, State Coastal Management Program strategies, and others.
- Gain understanding of current condition and trends of overall health of lake ecosystem and coastal wetlands, including threats, stressors and resiliency to climate change impacts as outlined in the State of the Great Lakes Report, LAMPs, and other resources.
- Identify the ecological and human well-being issues and needs for a given lake or sub-lake unit.
- Starting with the initial list of ecosystem services developed by the Objective 2 Advisory Team (Appendix D), work directly with the LAMP or other partner to select a manageable set of priority ecosystem services for each specific area. Consider criteria such as relevance and availability of data.
- Compile available data that supports evaluation of desired status to understand how extent, condition and specific wetland types influence ecosystem services and values provided by coastal wetlands.
- If the relationship between specific ecosystem services and coastal wetland extent and condition for wetland types is poorly quantified or understood, consider constructing ecosystem service models to assess how coastal wetland functions and services contribute to the health of the selected lake and to coastal resilience.
- Compile available coastal wetland-related data to gain understanding of historic, current, and future extent and condition of coastal wetlands for a given lake or sub-lake unit. This includes, but is not limited to, historic loss (LAMPs), current extent/condition (Objective 1), State of the Great Lakes Report, and Climate Change Impact Plans.
- Design and facilitate a process to establish desired status that has consensus support of members of the LAMP or other applicable partner group.
- Provide information on desired status to the Objective 3 team through regular communication and coordination.

b. Technological Resources Needed: Datasets on coastal wetland extent and condition including but not limited to:

- Great Lakes CWMP (basin-wide) and State of the Great Lakes Reporting
- Biodiversity Conservation Strategy Report Card (how was A/B/C score determined)
- Michigan Tech Research Institute (MTRI) Coastal Inundation data (currently limited to lower MI and the U.S. coast of Lake Erie; Lake Superior is in process)
- Historic coastal wetland extent (currently being mapped by TNC)
- Current coastal wetland extent and condition (Objective 1)
- Climate Change Impact Assessments and NOAA/USACE Coastal Resiliency Study
- Linkages between current threats and the area of wetland needed to mitigate them
- Potentially restorable coastal wetlands map as suggested in the Great Lakes Coastal Wetland Restoration Assessment (https://glcwra.wim.usgs.gov/)

- NOAA hardened shoreline mapping

c. Expertise Needed:
- Expertise on lake condition, stressors and threats for specific lake or location
- Coastal wetland ecologists and biologists
- Coastal wetland managers and restoration specialists
- Conservation design and planning
- Social scientist(s) with coastal experience
- Spatial analyst(s)
- Community partners (human well-being)

Milestones

The timeline of activities to achieve the desired outcome include several phases. These phases will take varying amounts of time depending upon the following caveats within each phase and level of partner engagement. These include:

- Develop Steering Team & Coordination – Identify key partners and individuals with specific lake and/or coastal wetland expertise to form a Steering Team that will guide framework for all three objectives and facilitate collaboration and partner engagement between objectives. Identify interdependent activities between Objectives 1, 2 and 3. If necessary, establish an Objective 2 technical team and refine the approach that includes LAMP representation and input.
- Compile Plans & Data – Identify and compile available plans that outlines goals, objectives, and priorities for Great Lake of focus that are applicable to coastal wetlands. Gather historical and existing data on coastal wetland extent, condition, and wetland types, including threats and stressors. Objective 1 will provide existing baseline coastal wetland extent and condition.
- Assess Needs & Opportunities – Based on available data and knowledge partners will identify what coastal wetland functions and ecosystem services are critical to restore and protect to make progress toward meeting established LAMP objectives and a healthy lake and community.
- Establish Desired Status – With knowledge and understanding of existing status of coastal wetlands, conservation opportunities and needs of the lake and community, partners will establish a suite of coastal wetland desired status ratings for extent and condition by wetland type that can be qualitative or quantitative.

Outreach or Partner Engagement

- Engage LAMP Partnership in Pilot Area to promote implementation of approach at whole-lake scale and incorporation of desired status ratings into the LAMP and Biodiversity Conservation Strategy for that lake as appropriate.

Caveats and Limitations

- This approach assumes that “net habitat gain” will be defined uniformly by Annex 7, and that specific desired status ratings will be established by the LAMP Partnerships (or other regional entity) for each lake and sub-lake unit
- This approach assumes that if desired status for wetland extent and condition by wetland type is achieved, then coastal wetlands will convey the desired ecosystem services.
- Wetland protection, restoration, and enhancement is a necessary but insufficient strategy for abating threats to the Great Lakes and providing ecosystem services to GL communities, so desired status should be established based on an estimate of the desired contribution of

coastal wetland functions to threat abatement and service provision. We should not and do not assume that coastal wetlands are a silver bullet.

Objective 3: Identify where to focus coastal wetland efforts to achieve healthy Great Lakes and coastal communities

Problem statement

Great Lakes coastal wetland data and decision support tools continue to expand. For example, the Great Lakes Coastal Wetland Decision Support Tool (CWDST) synthesizes data collected throughout the basin and is designed to inform conservation planning at a landscape scale [7]. Coastal wetland loss is significant and there is high interest and capacity for conservation. However, there is a gap in assessing where conservation actions could be leveraged to have lasting beneficial impacts. Additionally, there may be trade-offs among conservation actions; an action requiring resources at one location results in an 'opportunity cost,' meaning those resources become unavailable for a different, perhaps more strategic, location. Therefore, it is important that short-term conservation actions at local or regional scales are coordinated for lasting impacts at a landscape scale. A landscape-level systems approach has the potential to link the science and monitoring needs for coastal wetland conservation to the necessary conservation actions. Here, we outline a recommended approach that can be used to determine where to focus coastal wetland conservation efforts in the Great Lakes. The outputs needed from this approach includes a family of maps and a spatial prioritization tool that identifies priority locations and the actions needed in order to achieve healthy Great Lakes and coastal communities.

Recommended Approach

Objective 3 will bring together coastal wetland baseline extent (mapped in Objective 1) and desired status ratings for extent and condition of coastal wetland types (identified in Objective 2) to help guide coordinated on-the-ground conservation actions. Because Objective 3 is dependent on Objectives 1 and 2, we recommend Objective 3 is completed as an iterative process where new ratings and refined datasets can be included throughout the process. Objective 3 work will start simultaneously with Objective 1 & 2 allowing feedback among all three Objectives. The following methods and resources should be considered when piloting Objective 3.

a. Methods:
   - Collaborate closely with Objective 2 team to ensure seamless integration and refinement of desired wetland status ratings with spatial data availability and limitations.
   - Obtain available coastal wetland baseline extent and condition information. If Objective 1 data is not available at initiation, use best available data to begin mapping and bring in Objective 1 information prior to finalizing map products.
   - Gather data needed to identify where desired status ratings could be achieved.
   - Identify where to focus coastal wetland conservation by creating a set of spatial data layers for the various biological and social metrics, then weighting them based on technical and partner input [8]. This could include:
     - Spatial layers related to desired status ratings identified by Objective 2.
     - Spatial layers that identify where partners are working and their conservation actions (i.e., where locations and actions align with respective land manager and partner jurisdiction or similar objectives).
     - “Conservation Capital” decision support layer depicting areas that are currently providing resources; conservation actions might include acquisition, protection, maintenance, or enhancement to ensure continued value [9].
     - “Conservation Opportunities” decision support layer depicting areas that have potential resources; conservation actions for these areas could include restoration or creation [9].
     - “Cumulative” decision support layer weighting all spatial datasets [8] [9].

    - Each decision support layer involves consideration of hierarchical vs. additive characterization of map overlays and potential trade-offs.
    - Each spatial layer incorporates technical and partner guidance.
- Obtain additional partner input to refine spatial layers. This could include:
    - Review and refinement of priority actions and locations (i.e., optimization: phragmites control may reduce coverage and improve bird population).
    - Review of partners and actions by geography.
    - Collate current and ongoing conservation actions.
- Bring together draft spatial layers and develop a draft spatial prioritization tool that integrates all mapping elements.
- Reiterate above steps with further partner input, Objective 2 insights, and Objective 1 refined data.
- Re-evaluate spatial layers and spatial prioritization tool with partner input as new or updated data are made available.

b. Technological Resources Needed:
- Existing and publicly available spatial and monitoring data that help identify where to focus conservation efforts, including:
    - Great Lakes Coastal Wetland Monitoring Program and State of the Great Lakes Report
    - Great Lakes Coastal Wetland Restoration Assessment
    - National Wetland Inventory
    - Data related to climate change and coastal resiliency
    - Information on existing large-scale wetland restoration efforts, current protected and managed lands, and existing prioritization efforts in the pilot geography
- Mapping and modeling programs including ArcGIS and Python

c. Expertise Needed:
- GIS mapping and optimization
- Data management and modeling
- Large lake and wetland science
- Social science and survey design
- Conservation design and planning
- Policy interpretation and permit guidance
- Meeting facilitation
- Partner engagement
- Website design and outreach

Milestones

The timeline of activities to achieve the desired outcome include several phases. These phases will take varying amounts of time depending upon the following caveats within each phase and level of partner engagement. These include:

- Initial Coordination – Collaborate with Objective 1 and 2 on engagement with partners in pilot geography and initiation of work. Identify interdependent activities between Objectives 1, 2 and 3. Establish a technical team and refine the approach for Objective 3.
- Data Collection and Compilation – Gather data resources and develop data layers.
- Spatial Analysis, Weighting, and Mapping – Compile data layers and look for optimizations. Produce draft maps and seek partner input. Engage partners on weighting and prioritization of metrics. Refine maps and spatial prioritization tool with partner input, refined metrics, and data.

- Reporting – Finalize maps and prioritization tool. Prepare outreach materials for partners.

Outreach and Partner Engagement

We recommend preparing supporting outreach materials for land managers and agencies that are expected to use products developed under this approach. These materials could include but are not limited to fact sheets, story maps, and a publicly available web browser-based dashboard for data access and visualization. Ideally, the approach should be capable of integrating outcomes into any outreach materials from Objectives 1 and 2. A key component of piloting the Framework will be determining where to house products. We recommend that all Framework products are hosted on one public-facing platform.

It is important that the resources developed under this approach are useful to the widest audience possible. Therefore, we recommend that this approach provide training and technical assistance for partners that are predicted to or are interested in using any final products.

Caveats and Limitations

There are several caveats and limitations to implementing this approach, including but not limited to:

- Coastal wetland extent, desired status, and conservation targets can be used as a surrogate for economic and social benefits.
- Methods described for Objective 3 assume that coastal wetland baseline extent and desired status have been established for the pilot geography following steps defined by Objectives 1 and 2. However, depending on the pilot geography and existing resources, the Objectives may not always be implemented in sequence.
- The Great Lakes Coastal Assembly (formerly the Coastal Conservation Work Group) set a priority to complete the SB-WLEB LCD project. USFWS will obligate funding for the project by December 2021. The SB-WLEB LCD project has components of Objectives 1 and 2 completed in the recommended pilot geography. Therefore, it presents a good opportunity to learn from stepping through Objective 3 as outlined above. USFWS will communicate lessons learned with the Framework Steering Team and Technical Teams.

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Appendix A: Great Lakes Coastal Assembly Coastal Wetland Vision and Goals

Vision: A resilient system of coastal wetlands that support economic, social, and environmental benefits to the Great Lakes Region.

Goal 1: A resilient system of Great Lakes coastal wetlands containing a balanced assemblage of native fish, wildlife, and plant species and which accommodates specific priority species at desired population levels.

Goal 2: A resilient system of Great Lakes coastal wetlands with diverse wetland type representation and having hydrologic and other wetland processes within the observed and potential future range of variability.

Goal 3: A resilient system of coastal wetlands with characteristics supporting positive economic and social benefits to the Great Lakes Region.

Goal 4: Coastal towns, cities, and communities promote the protection, restoration, and conservation of, and recognize the many benefits, of coastal wetlands.

Appendix B: Advisory Teams

Objective 1: Establish existing baseline extent and condition of Great Lakes coastal wetlands

Co-Leads: Matt Pawlowski (EPA) and Brandon Krumwiede (NOAA)
Advisory Team Members: Molly Reif (USACE), Glenn Suir (USACE), Laura Bourgeau-Chavez (MTU), Michael Battaglia (MTU), Bahram Salehi (SUNY-ESF), Lori White (CCRS), Joel Mostoway (OMNRF), Benjamin Heumann (CMU), Don Uzarski (GLCWMP)

Objective 2*:* Determine extent and condition of coastal wetland types needed to help achieve healthy Great Lakes and coastal communities

Co-Leads: Cherie Hagen (WI DNR) and Doug Pearsall (TNC)
Advisory Team Members: Liz Berg (FWS), Christie Deloria (FWS), Greg Soulliere (FWS), Matt Cooper (GLCWMP), Nat Miller (GL Audubon), Dani Fegan (Sault Tribe), Janice Kearns (Old Woman Creek NERR), John Jereczek (MDNR), Bretton Joldersma (MI EGLE), Matthew Walderon (PA DEP), Stacy Hron (WI DNR), Kristina Heinemann (EPA), Luca Cargnelli (ECCC), Jennifer Dunn (NY DEC), Katie Grantham (SE MI Council of Governments)

Objective 3: Identify where to focus coastal wetland efforts to achieve healthy Great Lakes and coastal communities

Co-Leads: Christie Deloria (FWS) and Liz Berg (FWS)
Advisory Team Members: Chris May (TNC), Doug Pearsall (TNC), Mohammed Al-Saffar (FWS), Kurt Kowalski (USGS), Michelle Selzer (EGLE), Matt Cooper (GLCWMP), Don Uzarski (GLCWMP), Gust Annis (TNC), Betsy Galbraith (FWS), Robb Macleod (DU), Andrew Hinickle (GL Audubon), Laurie Rounds (NOAA)

Appendix C: Glossary of Terms

The following definitions are included to standardize the use of terms in relation to this work. This list may be edited and augmented as this work develops.

Adaptive management: Integration of project design, management, and monitoring, to provide a framework to systematically test assumptions, promote learning, and supply timely information for management decisions [10].
Coastal wetlands: All types of hydrogeomorphic wetlands (lacustrine, riverine, barrier protected) with current hydrologic connectivity (continuous or periodic) to, and directly influenced by, one of the Great Lakes (adapted from Pearsall et al 2013). This definition includes wetlands in the rivers connecting the Great Lakes but does not include historic wetland areas that are unlikely ever to be restored or reconnected to the Great Lakes. Factors that are common to multiple classification systems include 1) wetlands support the growth of hydrophytes (aquatic plants), and 2) consist of poorly drained or undrained soils [11].
Conservation: Activities that promote the preservation, protection, enhancement, and/or restoration of coastal wetland habitat in the Great Lakes.
Conservation goal: A formal statement detailing a project's desired (future) status, such as the desired future status of a target. A good goal meets the criteria of being specific, measurable, achievable, results-oriented, and time-limited (SMART) [10].
Conservation targets: Ecological Targets + Human Wellbeing Targets [10].
Desired status: An agreed-upon, quantitative or qualitative value for coastal wetland extent and condition by wetland type that, if achieved, represents success [6].
Ecological targets: Specific species or ecological attributes/systems/habitats that are chosen to represent and encompass the full suite of biodiversity in the project area for place-based conservation or the focus of a thematic program [10].
Human wellbeing targets: In the context of a conservation project, Human Wellbeing Targets focus on components of human wellbeing affected by the status of conservation targets. All human wellbeing targets at a site should collectively represent the array of human wellbeing needs dependent on the ecological targets [10].
Landscape conservation design (LCD): Partner-driven process that integrates societal values with science and traditional knowledge, assesses spatial-temporal patterns and trade-offs for landscape elements, and results in a set of spatially explicit products and adaptation strategies [12].
Objective: A formal statement detailing a desired outcome of a project, such as reducing a critical threat. A good objective meets the criteria of being specific, measurable, achievable, results-oriented, and time limited (SMART). If the project is well conceptualized and designed, the realization of a project's objectives should lead to the fulfillment of the project's goals and ultimately its vision [10].
Open Standards for the Practice of Conservation: A systematic approach to designing, managing, implementing, monitoring, and adapting conservation efforts at any geographic, temporal, or programmatic scale [10].
Range of Water Levels: This takes into account the recorded monthly high and record monthly low water levels for each of the Great Lakes and may also consider the range of water levels at individual water level recording stations associated with each lake to inform information on water levels within the surrounding local wetlands.
Protected: There are multiple useful definitions for this term. The International Union for Conservation of Nature (IUCN) defines a protected area as "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values (IUCN 2008)" [13]. The IUCN uses seven

categories to classify protected areas according to their management objectives. This classification system is globally recognized and used to define protected areas and report on them. Environment and Climate Change Canada use this classification system in their Canadian Protected and Conserved Areas Database (CPCAD). The USGS has also developed classification codes for protection. A coastal wetland is considered protected if it falls into the USGS GAP status codes 1, 2, or 3, defined as:

- Status 1: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management.
- Status 2: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance.
- Status 3: An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging, Off Highway Vehicle recreation) or localized intense type (e.g., mining). It also confers protection to federally listed endangered and threatened species throughout the area [14].

Wetland condition: Ecological status of a coastal wetland. Status can be documented in qualitative (e.g., Good, Fair, or Poor) or quantitative terms. There are several indices of biotic integrity developed for coastal wetlands (i.e., SOGL coastal wetland sub-indicators) that may be used independently or in aggregate to define wetland condition.

Wetland extent: The range in areal extent of coastal wetlands, by hydrogeomorphic type, for a given time period, calibrated by lake level (and precipitation?) for the given time period.

Wetland type: Great Lakes hydrogeomorphic coastal wetland types include lacustrine, riverine, and barrier-protected, as well as other coastal wetland community types that are unique or rare within a specific geographic region (specific definition of community name/type may vary by organization).

Appendix D. List of ecosystem services for use in Objective 2*.

Category:	General service	Specific service
Supporting	Habitat	Fish habitat/ Fisheries support Wetland bird habitat Amphibian/reptile habitat Mammal habitat
Supporting	Nutrient cycling/storage	Nutrient sequestration
Regulating	Water filtration	Sediment retention
Regulating	Attenuation of wave energy	Coastal protection
Provisioning	Food	Wild rice, fish, waterfowl
Cultural	Recreation and tourism	Waterfowl hunting, birding, fishing, hiking
Cultural	Aesthetics (HWB)	
Cultural	Sense of place (HWB)	
Regulating	Climate regulation	Carbon sequestration
Regulating	Climate regulation	Water storage

*The Advisory Team for Objective 2 agreed on this list during a virtual meeting held June 24, 2021. The team also suggested the inclusion of biodiversity as an ecosystem service. However, as defined by the Millennium Ecosystem Assessment, biodiversity is not itself an ecosystem service, but a property of ecosystems that underpins ecosystem services in all four of the categories listed above – Provisioning, Supporting, Regulating, and Cultural.