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A synthesis of the Great Lakes Restoration Initiative according to the Open Standards for the Practice of Conservation

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ABSTRACT

The Great Lakes Restoration Initiative (GLRI), designed to restore and protect the ecology of the Laurentian Great Lakes, is one of the largest environmental funding programs in the United States. Over 5,400 grants have been awarded in the last 11 years (2010–2020), representing over $3.5 billion in federal spending. A publicly available database that contains a written description about each grant is available online. However, analysis cannot easily be performed given that the descriptions are only textual. Therefore, we applied a modified version of the Conservation Action Classification (CAC 2.0), an established framework from the Open Standards for the Practice of Conservation, to synthesize the number of restoration actions, target species, and specific threats mentioned using thematic content analysis. The framework was modified to expand the CAC 2.0 by adding actions specific to GLRI. For example, we created typologies for the monitoring performed, site stewardship actions, and maritime ballast management practices. Based on this tally, we provide a summary of all the GLRI efforts to date. In addition to the more widely known restoration actions, we also describe the extent of educational, capacity building, and the non-monetary value projects that considered human wellbeing and/or focused on traditional ecological knowledge, recreation, or public outreach and engagement. Finally, we conclude with a discussion about the state of GLRI, the extent of the social or community-oriented efforts, and possible areas for adaptive management. This systematic coding process, and our shared supplementary data, can assist future GLRI research and strategic planning.

Introduction

The historic degradation and multiple threats that face the Laurentian Great Lakes have created the need for environmental protection, restoration, and contaminant remediation (Graziano et al., 2019; Tuchman et al., 2018; Creed & Laurent, 2015; Wang et al., 2018; Gregg et al., 2012). Efforts to address these environmental challenges date back over 100 years and include international agreements between the U.S. and Canada and multiple funding programs to address the contamination and manage invasive species (Cassidy et al., 2020; US GAO, 2015). These efforts have been funded and managed by multiple federal agencies, regional and bi-national commissions, state governments, and local non-government organizations, which have created a complex context for understanding environmental governance in the region (Jordan, 2020; Maclean, 2018; Méthot et al., 2015; Campbell et al., 2015). To consolidate these efforts under a single initiative and improve coordination to better protect and restore the ecological and economic value of the Great Lakes, the U.S. Congress established the Great Lakes Restoration Initiative (GLRI) in 2010 (US GAO, 2015; Sheikh, 2014; GLRI, 2010). Since then, GLRI has generated over 5,400 project records across all 8 of the Great Lakes States (GLRI, 2020). These records are available to the public in an online database, which only contains a title and a short description from which to determine the purpose of the restoration effort, implemented actions, and threats addressed. However, given the qualitative nature of the dataset, any analysis of the types of actions cannot be readily performed. As a result, members of the public cannot evaluate the program without reading each record. Therefore, to improve accessibility of the information within the database and provide a summary of GLRI, we classified these

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records according to an established framework from the Open Standards for the Practice of Conservation (CS, 2019).

GLRI is governed by an Interagency Task Force and a Regional Working Group, led by the Environmental Protection Agency (EPA), –which is based at the Great Lakes National Program Office (GLNPO) in Chicago, Illinois. The GLRI database is the public version of the record-keeping performed by the EPA, which is required to be available by law. To comply, these records have been successively hosted by a series of websites. Presently, these records that are based on grant recipient reports can be found at the website www.glri.us. Originally, the reports were submitted to the Great Lakes Accountability System (GLAS) and the agency that funded the project. However, after calls to improve oversight, transparency, and coordination of GLRI, a new system was developed (US GAO, 2015; Sheikh, 2014). Now, quarterly reporting to multiple entities has been replaced by biannual reporting solely to the funding agency through the second-generation reporting system named Environmental Accomplishments in the Great Lakes (EAGL). Information entered in the EAGL system includes general updates for project metrics, or indicators, and percent completion. The data about progress, results, and indicators are then compiled to develop annual reports for Congress (GLRI, 2017). These reports collectively present a streamlined version of progress across the region according to GLRI's focus areas, but do not contain specific information about the characteristics of the actions conducted. Further, this monitoring data is not available for viewing in the online GLRI database; the public only has access to the basic project information and qualitative descriptions and cannot view a project's progress or results to date.

The goal of this research is to contribute to the adaptive management of GLRI by providing a synthesis of all the actions carried out at the project level by utilizing the publicly available descriptions. With this synthesis, we also seek to highlight the limitations and inconsistencies of the publicly available information to make recommendations for improved usability. To create this synthesis, we reviewed each of the GLRI records to classify the actions, and this paper presents the results of this classification process. Below, we provide a brief review of GLRI beginning with its predecessors and the political agreements in the region that led to GLRI's creation. Next, we describe our methodology for coding the qualitative records. Then, we provide a series of figures to convey the results of this process and summarize the actions of GLRI. Finally, we conclude with a discussion about the nature of the actions to date, emergent threats, and possible future directions for GLRI. Additionally, we share the classification data–as supplementary materials–with the Great Lakes research community (Electronic Supplementary Material (ESM) Table S1).

Restoration in the Great Lakes Region

In 1909, the Boundary Waters Treaty established the precedent for binational cooperation between Canada and the US on Great Lakes issues and stipulated the formation of the International Joint Commission (IJC; Barlow, 2011). The IJC has since evaluated and provided guidance on improving water and air quality and investigating emergent issues. Over the next century, the Great Lakes benefited from extensive funding programs and many large-scale projects designed to improve the conservation of the region's natural resources and mitigate contamination from industrial activities (Cassidy et al., 2020). The Great Lakes Water Quality Agreement (GLWQA) was initially signed in 1972 and has since been revised several times. However, this agreement was designed to focus primarily on water quality issues and includes only one general objective related to habitat, which led to calls for more specific ecosystem objectives to be developed for each Great Lake (Government of the United States and Government of Canada, 2012). As an amendment to the GLWQA, the Area of Concern (AOC) program was initiated in 1987 by Canada and the US to specifically address these impairments within defined shoreline geographies (Hartig et al., 2020). Later, the Great Lakes Legacy Act (GLLA) in 2002 helped to secure funding for the AOC program (Cassidy et al., 2020). The state of the AOCs is measured according to 14 Beneficial Use Impairments (BUIs) that range from degraded habitat for fish and wildlife to tainting of fish flavor for consumption (US Policy Committee, 2001). Currently, there are 43 AOCs with 26 in the US and 17 in Canada. Ten have been delisted after reaching goals defined by the EPA and Environment and Climate Change Canada in remediation progress, though delisting does not signal a complete end to treatment and monitoring efforts. Now, these multiple on-going efforts have been consolidated into a single appropriation by Congress under GLRI for the US.

The Great Lakes Interagency Task Force was created by the Bush Administration to improve coordination in the US to address environmental impacts (Exec. Order No. 13340, 2004). GLRI was then proposed in 2009 by the Obama administration and implemented in 2010 to improve the coordination of US Great Lakes environmental funding. To guide its efforts, GLRI has created three action plans to set its funding agenda, with the current plan set to run through federal fiscal year 2024 (Action Plan I: FY 2010–2014, Action Plan II: FY2015-2019, Action Plan III: FY 2020–2024). Sixteen Federal agencies distribute funding to recipient organizations through the GLRI program. The Interagency Task Force makes an annual report to Congress to provide an update on progress. The annual budget of GLRI is subject to congressional approval and is projected within each Action Plan. The current Great Lakes Restoration Initiative Act of 2019 was signed into law in January 2021 by the Trump administration with bipartisan support. This is regarded as a major success for restoration in the Great Lakes Region, especially after the Trump administration had originally proposed a 90% budget reduction. Moving forward, the Biden administration has expanded the budget as part of an infrastructure bill. GLRI began its first year with the largest amount received to date, and with this recent move by Congress, is expected to return to that initial amount by 2025 (Table 1).

The overall guiding vision for GLRI is based on the 5 Focus Areas outlined in the Action Plans and annual reports to Congress:

Table 1
The Great Lakes Restoration Initiative's discretionary budget by year. Complete budgetary information for efforts is available at: https://glri.us/funding and anticipated amounts for the future are available in the house bill 4031 available at: https://www.congress.gov/bill/116th-congress/house-bill/4031/all-info.

Year	Funding ($ in millions)
2010	$475.0
2011	$299.4
2012	$299.5
2013	$283.5
2014	$288.9
2015	$300.0
2016	$300.0
2017	$300.0
2018	$300.0
2019	$300.0
2020	$300.0
2021	$375.0 (anticipated)
2022	$400.0 (anticipated)
2023	$425.0 (anticipated)
2024	$450.0 (anticipated)
2025	$475.0 (anticipated)

1. **Toxic Substances and Areas of Concern** targets contaminated sites and soils primarily within the Areas of Concern established by the GLWQA. This focus revolves around removing the Beneficial Use Impairments (BUIs). There are also follow-up plans after de-listing to ensure progress continues after the initial goals have been met.
2. **Invasive Species** targets the management and removal of both aquatic and terrestrial animal and plant species that degrade the environment and compete with native species.
3. **Non-point Source Pollution Impacts, and Nearshore Health** includes activities to reduce the runoff of phosphorus and harmful nutrients that lead to Harmful Algal Blooms (HABs) by working primarily with private landowners to implement conservation strategies.
4. **Habitat and Species** projects address wetland and ecosystem degradation through either restoration or protection.
5. **Foundations for Future Actions** is the broadest focus area and includes monitoring and evaluation efforts, capacity building, education and outreach programs, and efforts to build partnerships to improve the response to threats moving forward.

Additionally, if a project addresses two or more of the focus areas it is categorized as a Multiple Focus Areas project within the GLRI database. Together, these focus areas are designed to reach 23 measures of progress on the long-term goals of delisting all AOCs, help make fish safer to eat, provide safe recreation on the lakes, maintain drinking water quality, avoid new invasive species while controlling existing invaders, prevent HABs, and protect and restore ecosystems (GLRI, 2020; Tuchman et al., 2018).

The GLRI records also include several other funding sources that were initiated separately and have subsequently been grouped into the database because the funds contribute to Great Lakes restoration. For example, the Farm Bill programs that are implemented by the Natural Resource Conservation Service (NRCS) to promote soil conservation practices by private landowners are now combined in GLRI's records. In addition, the NRCS Environmental Quality Incentives Program (EQIP) project efforts are listed within the database. GLRI also includes complementary work to the EPA's separate Brownfield and Superfund program sites as it is common to leverage multiple funding sources to address the region's contamination challenges.

Evaluation of GLRI

To evaluate the success of GLRI, many projects have built-in monitoring efforts to assess the outcomes or effectiveness of restoration, remediation, and protection projects. There are also monitoring efforts that are conducted at the systems level by the EPA, or within specific sectors or focus areas, that assess the state of the Great Lakes ecosystem at a broader scale (Burlakova et al., 2018). These efforts include both non-profit and government entities, including some binational arrangements. For example, the Great Lakes Observing System (GLOS) is a binational non-profit that is supported by NOAA to make both real time and historical data available to the Great Lakes community (Jenny et al., 2020). The EPA also operates the Lake Guardian, one example of the many US and Canadian research vessels that sample water quality, aquatic life, sediments, and air with the goal of tracking the overall health of the Great Lakes ecosystem. Additionally, Environment and Climate Change Canada maintains a public dataset–Great Lakes Water Quality Monitoring and Aquatic Ecosystem Health Data–that publishes physical, chemical, and biological monitoring data to ensure Canada's commitments to the GLWQA are upheld (available at: https://open.canada.ca/data). Further, the EPA leads the Great Lakes Coastal Wetland Monitoring Program (CWMP) and the Cooperative Science and Monitoring Initiative (CSMI) for US waters. However, CWMP is a collaboration in both the U.S. and Canada between agencies, states, and academia to track the habitat quality and health of Great Lakes wetlands (Uzarski et al., 2017). The CSMI is also a binational effort to generate information about the Great Lakes for management agencies to use. The Great Lakes Fishery Commission (GLFC) coordinates management activities between agencies, tribal groups, and fishers and makes several management databases available to the public. The GLFC also coordinates fish stocking activities to maintain the populations of both commercial and recreational species.

Apart from the official annual reports to Congress, independent researchers have evaluated both biological and social elements of GLRI's impact. Ecologically, researchers have explored the state of the Great Lakes in terms of contaminated sediments (Tuchman et al, 2018), aquatic invasive species (Escobar et al., 2018), fisheries (Taylor et al., 2019), wetlands (Harrison et al., 2020), water quality (Mahdiyan et al., 2021), and climate change (Gregg et al., 2012). In addition, several efforts have focused on determining the value of the ecosystem services associated with the Great Lakes (Steinman et al., 2017; Krantzberg and De Boer, 2008). The social science research conducted to date has primarily focused on economic benefits associated with revitalization and restoration in Great Lakes AOCs (Liesch and Graziano, 2021; Hartig et al., 2020), and cultural ecosystem services that support recreation activities like beach going and fishing (Allan et al., 2015). One recent master's thesis also considered GLRI in terms of Equity and Environmental Justice (Garcia et al., 2021). Another thesis explored "life after de-listing AOCs, beyond BUIs," and called for improved inclusion of community perspectives and social indicators (Knauss et al., 2019). Additional efforts, like the new "R2R2R" framework, which was proposed to consider the links between remediation, restoration, and revitalization, further call for increasing the focus on social indicators (Williams and Hoffman, 2020).

In terms of the socio-economic impact of GLRI, the Seminar on Quantitative Economics at the University of Michigan performed a study, which is available on the Great Lakes Commission's (GLC) website (Ehrlich et al., 2018). For this research, the research group conducted an overall impact assessment and eight case studies on how GLRI funds have influenced economic benefits in Buffalo, New York; Duluth, Minnesota; Waukegan, Illinois; Sheboygan, Wisconsin; Muskegon, Michigan; Detroit, Michigan; Ashtabula, Ohio; and Erie, Pennsylvania. They estimated that every dollar spent on GLRI produced $3.35 of additional economic output: restoration efforts increased property values, tourism was boosted, and over 5,000 jobs were created (Ehrlich et al., 2018). Related to the GLWQA and the AOCs, further research considers the positive impact of remediation dollars spent in terms of the property value recovery under the GLLA (Cassidy et al., 2020) and community revitalization (Hartig et al., 2020). Together, these conservation social science research efforts have led to calls for further focus on community voices and social indicators to expand the measurement of impacts and achievements generated by the AOC program (Holifield and Williams, 2019; Angradi et al., 2019), and fit with growing efforts to look beyond the traditional ecological metrics for restoration success more broadly (Leisher et al., 2021; Wells et al., 2021; Galbraith et al., 2021; Galbraith et al., 2016; Heck et al., 2016). To that end, we also include a tally of the social or community-oriented project efforts.

Methods

To synthesize all the GLRI's funding efforts between 2010 and 2020, the primary researcher accessed the database of funding records maintained by the EPA at www.glri.us. The database, as

of the download date in July 2020, included 5,335 records. These records were divided into two broad categories. First, records were categorized according to the five focus areas highlighted above. Second, records were categorized by their funding status: new projects, continuations, revisions, and increases. Each record had a title and a textual description of the project, which varied in length from three to 504 words and must be read to determine the project's purpose. Finally, the records also included the funding agency's name, the funding recipient's name, latitude, longitude, the relevant state, a start date, and an end date. The latitude and longitude coordinates typically display where a GLRI project took place. However, in some instances the funding recipient's office is displayed instead of the actual project location.

To capture the actions within each project record, we drew from the Open Standards for the Practice of Conservation (or CS for "conservation standards") framework as a categorization template (CS, 2019). CS is maintained and updated by the Conservation Coaches Network (CCNet); it is designed to serve as a common terminology, providing specific definitions to be used for sharing ideas among practitioners to help plan, design, and implement conservation projects (Stephanson and Mascia, 2014; Schwartz et al., 2012). CS is employed widely by the conservation practitioner community, including The Nature Conservancy. In addition, the International Union for the Conservation of Nature (IUCN) utilizes a framework heavily based on CS for their project planning and implementation.

Beyond the CS guide that provides a structure and specific steps for the conservation planning process, CS features a classification system for conservation threats and actions. Here, we specifically applied a modified version of the Conservation Action Classification version 2.0 (CAC 2.0; CS, 2019) from CS to all the GLRI funding records to document their actions and objectives. CAC 2.0 defines actions for site stewardship, ecosystem (re)creation, incentivizing private landowner actions, building capacity, and conducting public outreach, engagement, and education (Salafsky et al., 2008). The framework includes 10 umbrella action categories with 30 subcategories. As such, the framework takes a broad view of conservation by including the prior planning, development, and institutional capacity building actions necessary to implement conservation (Galbraith et al., 2021; Clewell and Aronson, 2006). In addition, policy development, enforcement, and research are included. Given this diversity of actions, CAC 2.0 appeared to be the most appropriate existing framework to start with for classifying GLRI projects. The ten primary CAC 2.0 actions and definitions (CS, 2019) are:

1. **Land and Water Management**: Actions directly managing or restoring sites, ecosystems, and the wider environment.
2. **Species Management**: Actions directly managing or restoring specific species or taxonomic groups.
3. **Awareness Raising**: Actions making people aware of key issues and/or feeling desired emotions, leading to behavior change.
4. **Law Enforcement and Prosecution**: Actions monitoring and enforcing compliance with existing laws and policies at all levels to deter threats or compel conservation action.
5. **Livelihoods, Economic, and Moral Incentives**: Actions using livelihoods and other economic and moral incentives to directly influence attitudes and behaviors.
6. **Conservation Designation and Planning**: Actions directly protecting sites and/or species.
7. **Legal and Policy Framework**: Actions developing and influencing legislation, policies, and voluntary standards affecting conservation.
8. **Research and Monitoring**: Actions collecting data and transforming it into information to support conservation work.
9. **Education and Training**: Actions enhancing the knowledge and skills of specific individuals.
10. **Institutional Development**: Actions creating the institutions needed to support conservation work.

In addition, we developed codes specific to the GLRI database to add greater detail to the classification process and tailor it to the Great Lakes region (a full copy of our classification key can be found in ESM Table S2). To determine the final list of action subcodes, a list of potential additions was created based on the recurrent themes and keywords in the GLRI funding records during reading (Flick, 2018). If an action did not fit in CAC, it was added to this on-going list of novel themes. Then, consistent themes of the same nature were grouped into new action subcodes with corresponding definitions. For example, Maritime Ballast actions would not fall under Land and Water Management as they are not managing a site, ecosystem, or the wider environment, and green infrastructure was mentioned frequently enough that it became a subcode as a specific type of site infrastructure. Then, the primary researcher conducted a series of peer debriefings (Spillett, 2003), to share the action list with the coauthors and conservation/restoration professionals that work within the Great Lakes region to ensure the relevance of the codes to GLRI.

Additional examples of the GLRI subcodes that emerged during the thematic analysis and passed peer debriefing include the following. Under the CAC 2.0 outreach and communication code, a code for "fish consumption advisory" was added to capture that type of outreach specific to the Great Lakes region in response to water quality issues (e.g., mercury levels). Within the site and area stewardship code, we added invasive species management, native planting/reforestation, channel and sediment dredging, toxic substance dredging, capping toxic substances, landfill leakage, and discharge mitigation as subcodes. Within the ecosystem and natural process (re)creation code, we added habitat restoration, wetland restoration, erosion control, instream and hydrological restoration, flood control, dam removal, and fish passage as subcodes. In site infrastructure, under the conservation planning category, a specific subcode for electric fish traps was included. For the basic research code, modeling and mapping methods were added as well as eDNA, vulnerability, toxicity, ecological, and pathogen assessments. New methods or technologies and feasibility studies were added to the evaluation/effectiveness code. In terms of people and communities, an equity code was added to capture any mentions of traditional ecological knowledge or efforts designed specifically for minority, youth, or at-risk communities.

The actual coding process was then carried out by the primary researcher between July and October 2020. To start this process, the primary researcher read each record to answer a series of questions (Fig. 1) to apply Thematic Content Analysis (e.g., if channel or harbor depth mechanical management actions were described, they were coded as dredging for sediment) to determine if the text fit with the definitions from the modified CAC 2.0 framework. To document the actions performed within each record, a binary yes or no code was assigned to the action key during the reading to create a frequency count. To ensure consistency after the initial reading of the records, a randomized spot check was performed to confirm accuracy (i.e., 500 random records were re-coded with a < 5% change to their tally). Next, during the reading every new species or threat name was added to a list, which was then used to sort records in excel using a keyword search to determine frequencies (e.g., heavy metals, nutrients, phosphorus, climate change, polychlorinated biphenyls, persistent organic pollutants, mercury, sediment, and runoff as threats and Lake Sturgeon, Piping Plover, Mitchell's Satyr, and Coregonus species).

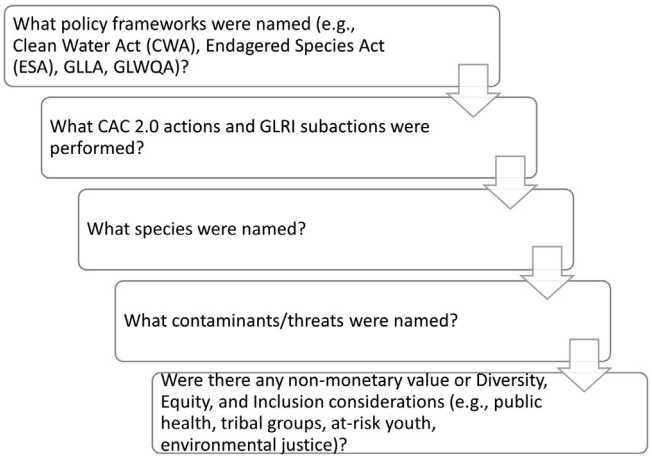

Fig. 1. The qualitative content analysis questions used to determine the content of each record for the coding process.

Analysis

We used summary statistics to describe the frequency, or tally, of the actions performed and the species and threats named. We also calculated the percentage of the total project number (n = 5,335) for each action that was larger than one percent. Codes were not mutually exclusive. Each funding record may have completed multiple actions (e.g., conservation planning, site stewardship, and monitoring). In many cases, a project could have as many as ten positive codes as it completed scoping and planning stages, feasibility studies, site characterizations, method testing, and design, within the same funding record as the implementation of the stewardship or restoration actions. In addition, multiple projects were sometimes bundled into a single funding record, or grant application even if they were managed as separate projects at the local level which also resulted in multiple positive codes within the same record.

Alternatively, and depending on the recipient, projects were broken into multiple records in the database in some cases, potentially highlighting a staged process or multiple grant applications for the same project site. For example, projects, particularly within Areas of Concern, requested multiple grants, creating multiple line items for the same site in unique fiscal years. In these cases, each record might have a smaller total number of actions as one grant may be for a planning stage and the next for an action stage. Many of these staged type projects applied for increases, revisions, or continuations using the same project title. As a result, the tally of positive codes should be considered as the sum of the discrete total number of actions for all the records, or line items, for the duration of the GLRI program as of our download date. For example, even if a single record indicated the project would run multiple years it was only coded once, while if the same project title and description were recycled and awarded a new grant, or line item, each was coded.

We created two maps using ArcGIS Pro 2.9 to visualize the efforts of GLRI. First, we used the GLRI database coordinates to determine the county for each of the records and displayed a Great Lakes region map by the highest frequency action within each county. Second, for both the species targeted for stewardship and the threats we used the coordinates to create a map displaying the distribution of these efforts. We used an offsetting function to reduce overlap and ensure that each discrete record was displayed in the visualization. As a result, project points are approximate.

Results

The coding process resulted in 41,392 total codes ascribed to 222 action categories. The total number of unique local recipients of funds was 502. The process also revealed 68 records that were described as terminated, discontinued, or on hold in the database. Reasons for termination included failure to find a local co-sponsor for matching funds, a negative determination after site characterization or scoping processes, or pursuit of the project using alternate funding sources. However, these records were retained in the analysis because it was not clear how much of the project was completed before termination or if the funding was returned. Through 2020, 4,569 project end dates had passed, and 766 projects had an end date still in the future (Fig. 2), which highlights that about 17% of our codes may be active.

The coding process began with a classification of the legal or policy area of the record. For actions within an AOC, there were 1,188 (22.27%) records, while 646 (12.11%) mentioned BUIs either generally or by name in the project descriptions. Additional regulatory or policy mentions in the records included the Endangered Species Act (n = 183, 3.43%), Great Lakes Legacy Act (n = 152, 2.85%), Great Lakes Water Quality Act (n = 109, 2.04%), the Clean Water Act (n = 29), National Environmental Policy Act (n = 20), Superfund (n = 11), and Brownfields (n = 9).

GLRI's actions

GLRI has implemented a diversity of conservation and restoration actions according to CAC 2.0 primary categories (in **Bold**) (Fig. 3) across the Great Lakes region (Fig. 4). The **Land and Water Management** (n = 2,887, 54.11%) category was divided into its two separate subcategories–*Site/Area Stewardship* (n = 1,758, 32.95%) and *Ecosystem and Natural Process (re)Creation* (n = 1,827, 34.25%) for this figure to provide a broader view of GLRI and for scaling, but combined it was the category with the most codes. **Research and Monitoring** (n = 2,178, 40.82%) had the second most coded projects followed by **Conservation Designation and Planning** (n = 1,644, 30.92%), **Institutional Development** (n = 1,497, 28.06%), and **Livelihood, Economic, and Moral Incentives** (n = 755, 14.15%). Next, came **Education and Training** (n = 549, 10.29%) followed by **Awareness Raising** (n = 435, 8.15%), and **Species Management** (n = 422, 7.91%), which in CAC 2.0 does not address invasive species but rather actions to control populations like white-tailed deer or to help endangered or species of concern with nesting, propagation, or transplantation. Next, **Law Enforcement and Prosecution** (n = 19) was the second smallest category and included projects that mostly focused on maritime related invasive mussel enforcement and sanctioning. Lastly, in **Legal and Policy Framework** (n = 18), all records were for projects that included an element to determine or designate Total Maximum Daily Loads (TMDLs) for 303d Impairments (i.e., the EPA's formal list of water quality contaminants). Maritime actions–primarily conducted by the US Coast Guard, included ballast treatments (n = 52), ballast detection (n = 2), and cleaning/inspection stations (n = 50)–were kept separate as a unique feature of the GLRI program, instead of falling under Site/Area Stewardship invasive species actions.

Beyond the ten main CAC 2.0 categories, we also coded for the CAC 2.0 tier two codes and the subcodes that were added specific to the GLRI program (*in italics*) (Fig. 5). *Site/Area Stewardship* was led by actions for both *Plant* (n = 720, 13.5%) and *Aquatic Animal* (n = 483, 9.05%) *Invasive Species*, followed by *Native Planting and Reforestation* actions (n = 287, 5.38%). The invasive species records included a GLRI-specific *Early Detection and Rapid Response* project code (n = 63, 1.61%). *Ecosystem and Natural Process (re)Creation* was

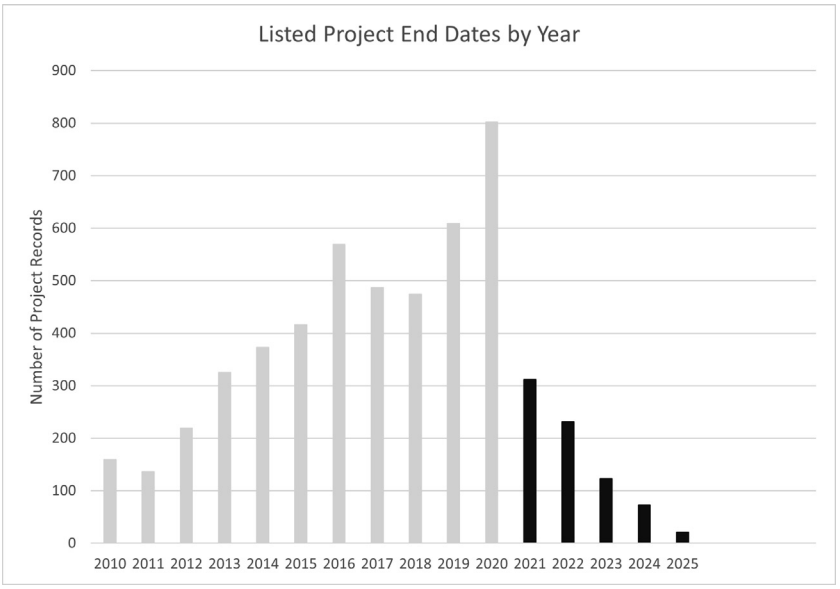

Fig. 2. The end dates of the 5,335 records according to the GLRI database. (Projects scheduled to end in the future are in black.)

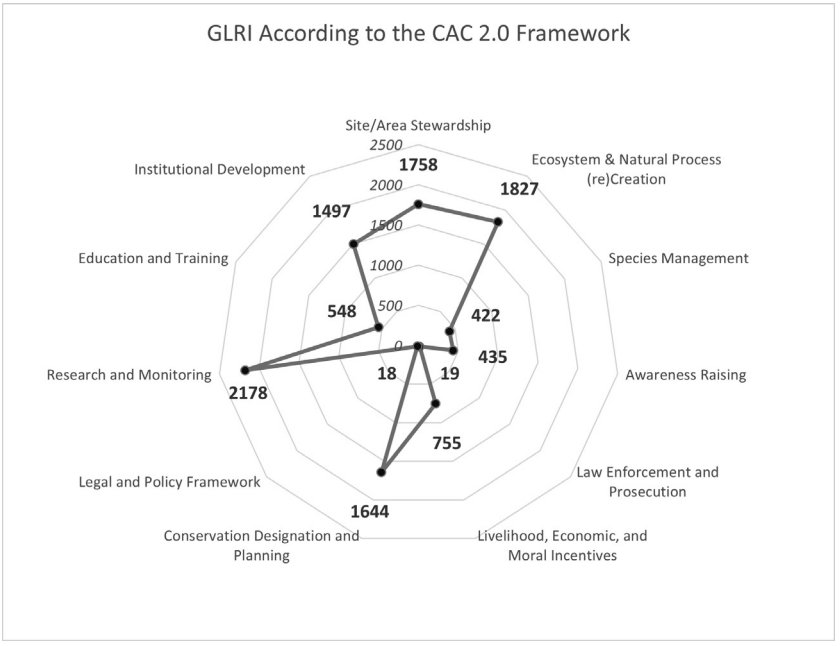

Fig. 3. The number of GLRI records that fall within the primary CAC 2.0 categories.

led by general *Habitat Restoration* (n = 1,319, 24.72%), followed by specific *Wetland Restoration* projects (n = 507, 9.5%) and *Erosion Control and Bank Stabilization* along Great Lakes shorelines and bluffs as well as inland riparian areas (n = 464, 8.7%). Next, the broad **Conservation Designation and Planning** category included *Conservation Planning* actions (n = 1,116, 20.92%). These records addressed mostly general design plans and specifications for project sites as well as broader scale planning as in the *Lakewide Action and Management Plans* (LAMPs; n = 308, 5.77%) and *Remedial Action Plans* (RAPs; n = 191, 3.58%). In addition, there were *Protected Area Designations* (n = 124, 2.32%), mostly through donations and acquisitions to local municipal or state park systems. *Site Infrastructure* (n = 468, 8.77%) included mostly *Maintenance of Fish Passage Structures* (n = 135, 2.53%), *Green Infrastructure* projects in urban areas (n = 131, 2.46%), and Sea Lamprey and Asian Carp control efforts that utilized *Traps and Electric Fences* (n = 69, 1.29%).

Under **Livelihood, Economic, and Moral Incentives**, *Better Products and Management Practices* (n = 411, 7.7%) led with records mostly focused on cover crops and other agricultural practices like buffering water bodies from farmland. *Direct Economic Incentives* (n = 355, 6.28%) was composed of mostly *EQIP* (n = 225, 4.22%) and *Farm Bill* (n = 86, 1.61%) engagements with private landowners. *Non-Monetary Values* are discussed in greater depth below. **Education and Training** was subdivided into "professional" *Training and Individual Capacity Building* that came in the form of workshops, technical assistance, coaching, or developing training materials (n = 455, 8.53%); and *Formal Education* or classroom activities (n = 94, 1.76%), with some actions for youth (K-12) student audiences, with specific mention of the *B-WET (Bay Watershed*

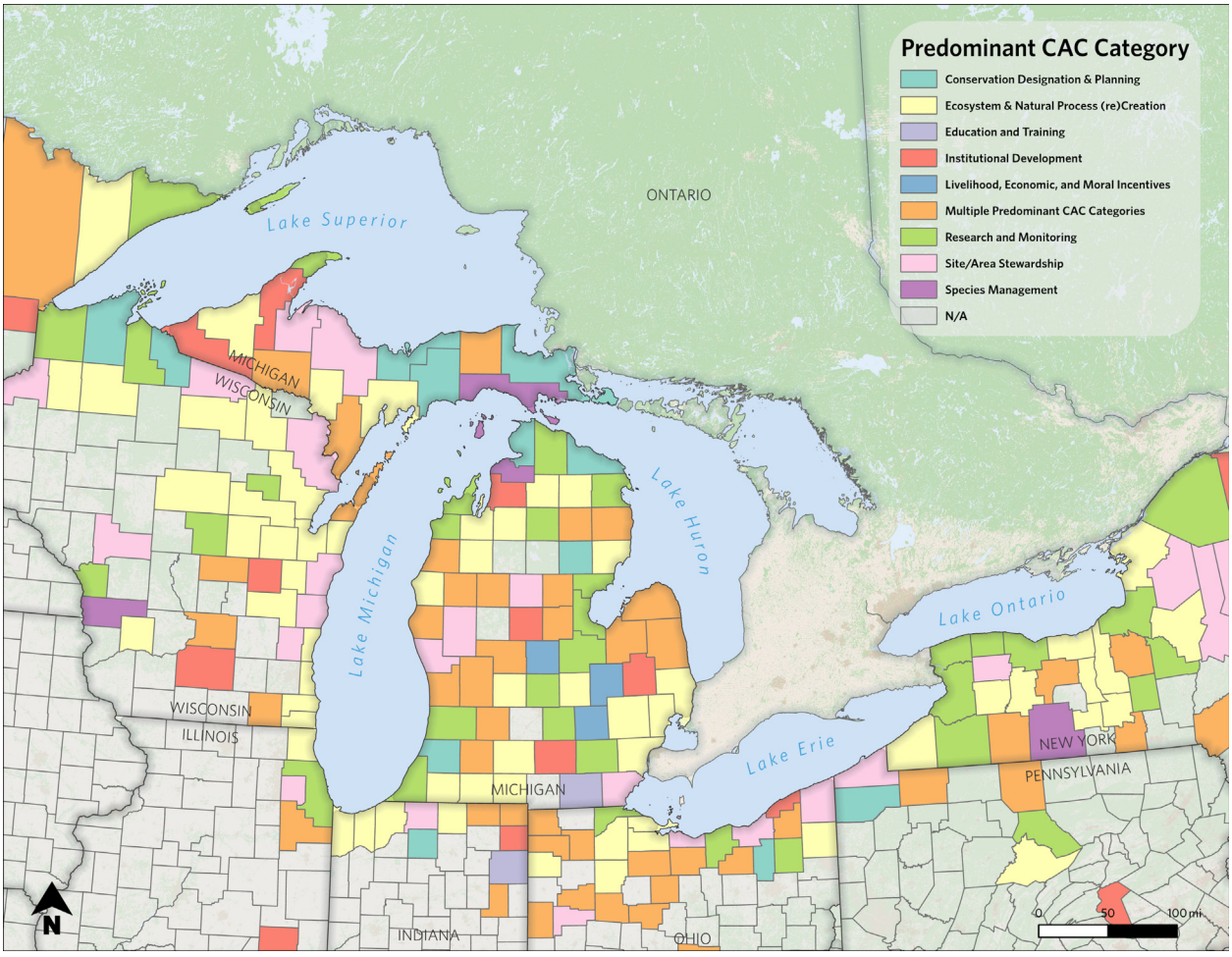

Fig. 4. Predominant CAC 2.0 categories aggregated by county. Data sources: Great Lakes Restoration Initiative, National Land Cover Database and U.S. Census Bureau.

Education and Training) Program (n = 10). Under the umbrella **Species Management**, the *Species Stewardship* code (n = 212, 3.97%) included nest protections, population culling, and even one project that used trained dogs to prevent *E. coli* contamination by scaring gulls away from beaches. *Ex-situ Conservation* (n = 206, 3.86%) included fish rearing, captive breeding, and stocking efforts for trout and Coregonus varieties. *Species Re-Introductions & Translocations* projects were listed for lynx, elk, wolves, and beavers (n = 29).

To assess the effectiveness of GLRI, CAC 2.0 includes codes for monitoring and evaluation. The main CAC **Research and Monitoring** code was broken into *Basic Research and Status Monitoring* (n = 1,697, 31.81%) and *Evaluation, Effectiveness Measures, and Learning* (n = 660, 12.37%). *Basic Research and Status Monitoring*, which was performed as a unique project effort as well as a part of a specific restoration project, was broken into assessments related to *Ecological Conditions* (n = 593, 11.12%), *Toxicity* (n = 250, 4.69%), *Contaminant, Invasive, or Treatment Modelling* (n = 173, 3.24%), *eDNA* (e.g., for tracking the presence of invasive species via DNA in the environment) (n = 72, 1.35%), and *Risk or Vulnerability* assessments (n = 22). Under *Evaluations, Effectiveness Measures, and Learning*, the *Feasibility and Site Characterizations* (n = 401, 7.52%) are specific evaluations to determine the suitability of a project site for remediation or restoration. These evaluations are a mandated part of the GLWQA process. Experiments were also performed to evaluate *New Technologies or Methods* (n = 117, 2.19%) mostly for managing invasive species, but also for some remediation of legacy contaminants, and restoration projects. There were 11 projects that mentioned the use of *Social Science or Anthropology* for evaluating a historic/cultural site or gathering public opinion.

Under **Institutional Development**, the CAC framework breaks capacity building efforts into internal and external organizational support. *Internal Organizational Support* (n = 493, 9.24%) focuses on activities that strengthen the management or administration of an organization. In the case of GLRI, this also included *Equipment Purchase* (n = 67, 1.26%) for conservation projects and activities for *Training Volunteers* (n = 12) to boost organizational capacity. *External Organizational Support* (n = 957, 17.94%) includes activities like technical assistance or consulting from an agency for the planning or design of a restoration project. This also included the development and provision of management tools such as *General Decision Support* through interaction with experts (n = 235, 4.4%), *Decision Support Tools* (e.g., runoff risk advisory tool) (n = 114, 2.14%), and the creation of *Technical Reports* to inform restoration efforts or share outcomes (n = 98, 1.84%). To improve the coordination of restoration and build partnerships regionally, GLRI has supported multiple *Meetings, Conferences, and Symposiums* (n = 53, 1.0%) which fell into the category for *Alliance and Partnership Development* (n = 241, 4.52%). This category also included descriptions that reference efforts to foster alliances, learning networks, and coordination of activities between local partners, agencies, and multiple levels of government.

Also, under the broader idea of **Institutional Development** there was *Financing Conservation* or *Sub-Granting*. While GLRI typ-

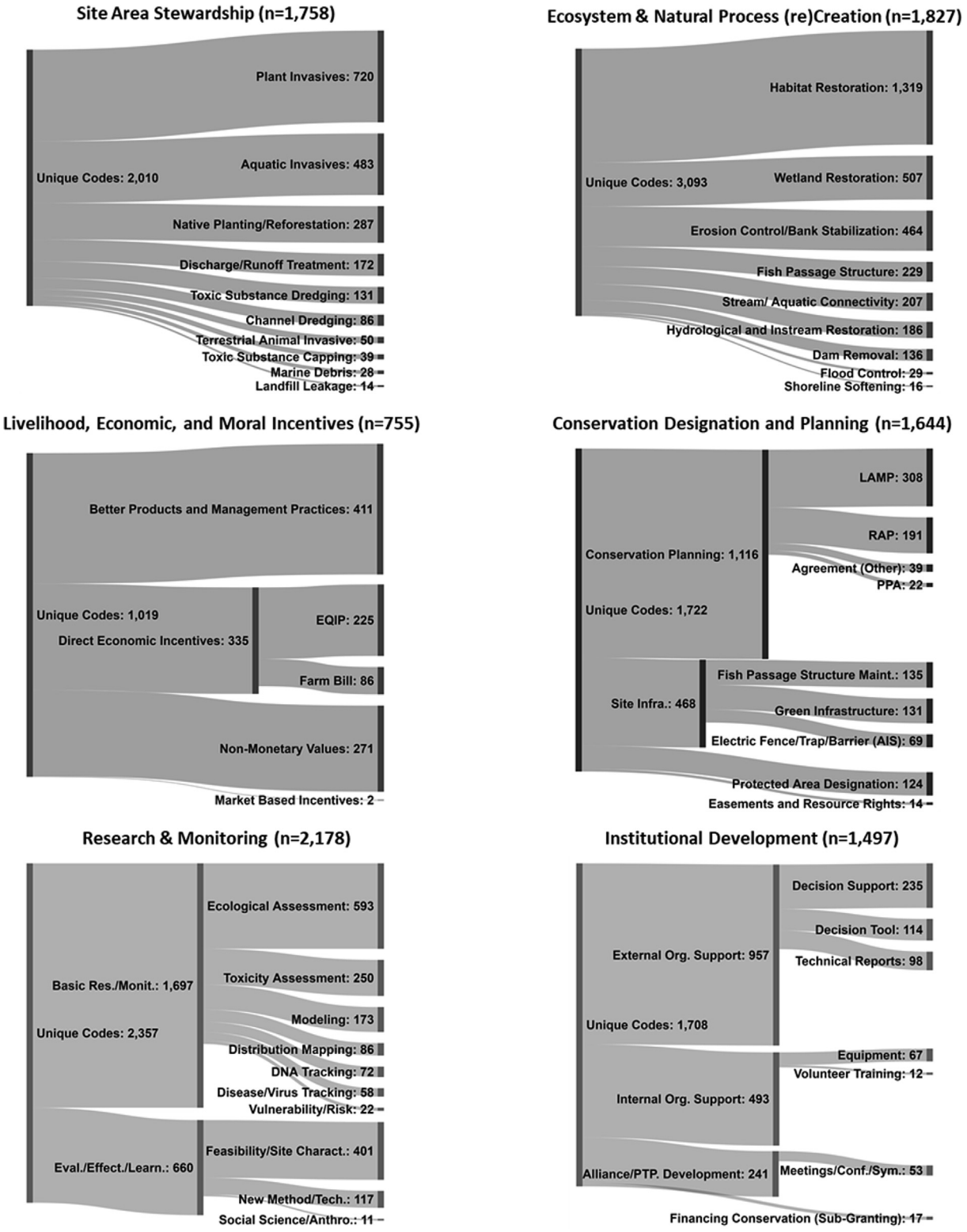

Fig. 5. The primary CAC 2.0 categories distributed by the secondary categories and the additional GLRI action subcodes.

ically focuses on funding specific discrete projects, some project descriptions included mention of securing funds within a recipient organization but then redistributing them in a subsequent sub-grant award (this does not include hiring a contractor to complete an element of a project). In some cases, a federal agency is listed as the local recipient of the funding (e.g., NOAA, USGS, and FWS) at the GLRI database level but these agencies also redistribute funding to local recipients and maintain separate databases (e.g., NOAA maintains a restoration atlas that includes many GLRI projects available at https://www.habitat.noaa.gov/apps/restoration-atlas/index.html). At least 1,500 federal records among APHIS, EPA, FWS, NOAA, NRCS, USACE, and USGS may meet this description,

where the separate agency records would have to be consulted to attempt to identify the true local recipient. Additionally, there were also several instances in which an actual local recipient performed a *Sub-Granting* action (n = 17).

Foci by species and contaminants

In terms of species management, the coding revealed the frequency of GLRI efforts to improve, conserve, or cull native or generally desirable populations (Fig. 6) and were mapped by their coordinates (Fig. 7). Note that invasive species were separated into the contaminant/threat table as they code under the *Site/Area Stewardship* definition. Efforts to propagate or stock Lake Trout (n = 178, 3.34%) led the species codes. White-Tailed Deer projects (n = 10) were an example meant to cull overabundance. In addition, the records included several endangered species namely, piping plover (n = 97, 1.82%), sturgeon (n = 141, 2.64%), Pitcher's thistle (n = 24), and the Karner blue butterfly (n = 11). Finally, the coding process documented several generalized or colloquial categories. For example, migratory birds (n = 150, 2.81%) and *Coregonus* (n = 102, 1.91%) were mentioned. Further, while the *Coregonus* code was generally applied in project text, there were also individual coregonine species codes that emerged in the process (e.g., lake herring, whitefish, cisco, and bloaters) that were later grouped into the *Coregonus* tally due to inconsistency of use.

The mention of specific threats unique to the Great Lakes region were also coded (Fig. 6) and mapped by the coordinates (Fig. 7).

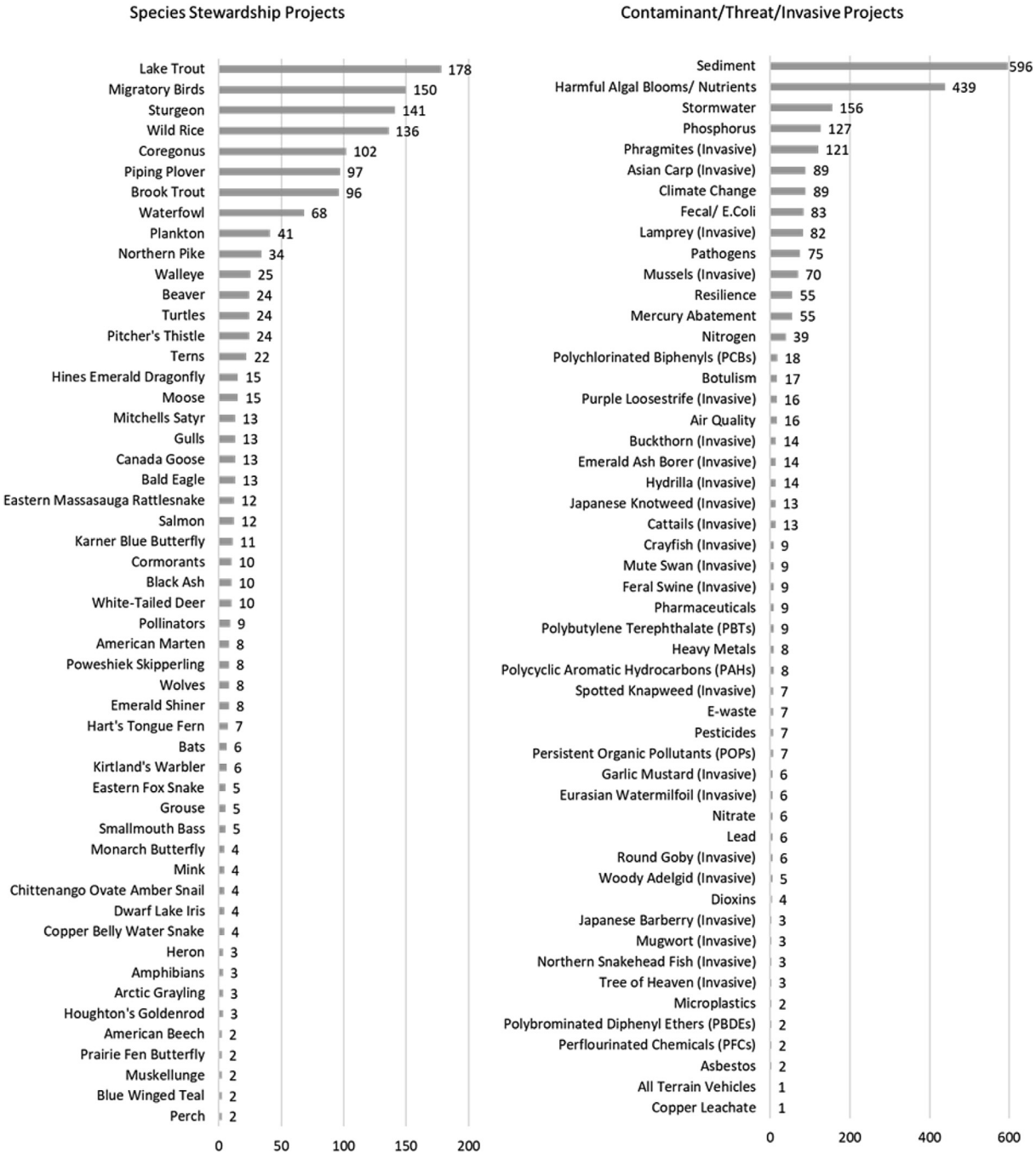

Fig. 6. The frequencies for species and contaminants, threats, and invasives foci within the GLRI records.

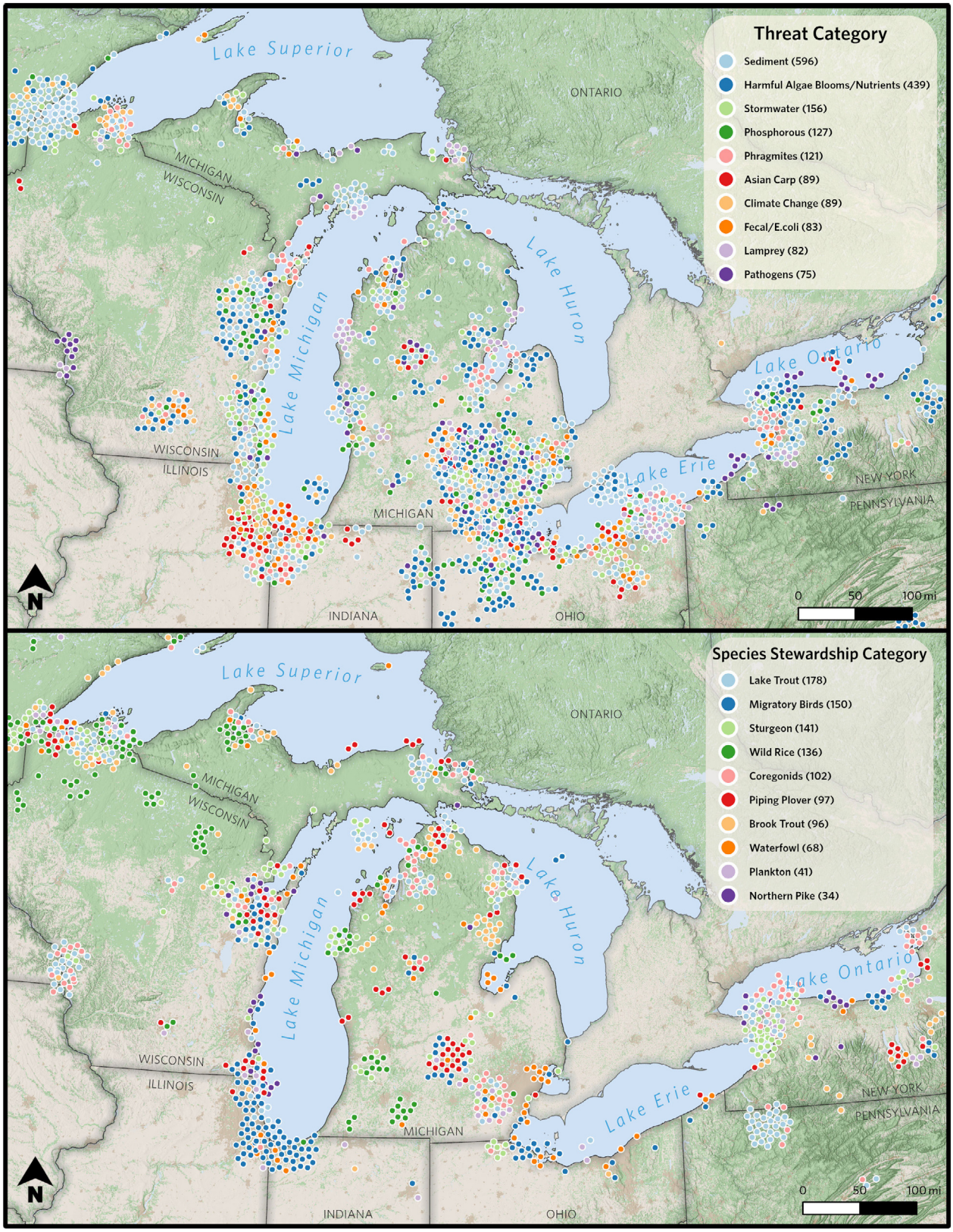

Fig. 7. GLRI project locations for the top 10 contaminants, threats, and invasives foci occurrences and top 10 species coded from the GLRI records. Project points are dispersed where overlapping projects exist at the map scale. **Some project points are mapped by GLRI at the award recipient's staff office location.** Data sources: Great Lakes Restoration Initiative and National Land Cover Database.

Sediment remediation projects (n = 596, 11.7%) were designed to address both agricultural erosion impacts and to maintain navigational waterways and harbors through dredging. Projects also focused on agriculture impacts; nutrient reduction projects to mit-

igate harmful algal blooms (HABs; n = 439, 8.23%) were coded as well as specific mentions of phosphorus reduction projects (n = 127, 2.38%). Stormwater runoff was coded as a separate non-point source impact for generally urban focused projects (n = 156, 2.92%). GLRI addressed multiple legacy contaminants, contaminants that are no-longer being emitted, like polychlorinated biphenyls (PCBs; n = 18), polybutylene terephthalate (PBTs; n = 9), and persistent organic pollutants (POPs; n = 7). Pharmaceutical projects (n = 9) were designed to raise public awareness of contamination from flushing expired medication or to host collection events to pre-emptively prevent the flushing of medicines. Similarly, several E-waste drives to collect old electronic equipment were performed to avoid potential contamination (n = 7). The invasive species codes included both aquatic and terrestrial plant and animal species, namely *Phragmites* (n = 121, 2.27%), Asian carp (n = 89, 1.67%), invasive mussels (70, 1.31%), invasive cattails (n = 13), and the hemlock woolly adelgid (n = 5). Climate change was mentioned in 89 (1.67%) projects and general resilience building was mentioned in (n = 55, 1.03%) projects.

Non-monetary values and equity and inclusion

Several project types included *Non-Monetary Value* actions (n = 271, 5.07%), or efforts that link conservation with public health, food security, or religious and cultural arguments for conservation. Within the *Outreach and Education* records (n = 435), the *Fish Consumption Advisories* (n = 83, 1.55%), beyond fitting under *Outreach and Engagement*, were also coded as a *Public Health* action under *Non-Monetary Values*. These advisories were designed to primarily warn about the dangers of mercury consumption to pregnant women and subsistence fishers from tribal groups. Recreation made up most of the rest of the projects, with actions to improve recreation at project sites, share water quality conditions at beaches or inform the public about beach closures at specific locations to avoid exposure to bacteria (e.g., *E. coli*; n = 83). Here, we also classified several equity-oriented records with actions that engaged underserved, disadvantaged, or low-income youth with general interpretation programming and fostering community connection (n = 14). Efforts beyond typical outreach and engagement were designed to specifically boost community or public input and participation in democratic or local governance processes (n = 32).

The GLRI records included a variety of efforts to target historically marginalized groups, communities, and individuals. There were two specific mentions of engaging "environmental justice" communities, one to hire a specialist and the other for conducting an engagement effort. The records that focused on tribal groups or concerns (n = 676, 12.67%) went through primarily the Bureau of Indian Affairs (n = 506, 9.48%) with additional tribal projects funded by the EPA, FWS, and NOAA. Thirty separate tribes received funding for their conservation efforts as well as four consortiums that focus on tribal issues. Within those tribal efforts, most of the projects focused on lake sturgeon (n = 141), wild rice restoration (n = 136), moose (n = 15), and wolf management actions (n = 8). However, efforts were also made for cultural preservation or engaging tribal youth (n = 14) and including or considering Traditional Ecological Knowledge (TEK) in planning processes (n = 13).

Discussion

The publicly available GLRI database appears to be underutilized, likely due to the relative inaccessibility of the textual descriptions. To our knowledge, this study is the first attempt to utilize the entirety of this database to synthesize GLRI's efforts, but also one of the first attempts to synthesize a primarily textual federal database by converting it to a simple tally of the actions performed according to a classification framework. The U.S. federal government has other textual data resources that are also underutilized given the time-intensive process of qualitative analysis. For example, NOAA maintains textual records about weather, natural hazards, and marine forecasts. Our research, which overlaid an established classification framework on a publicly available database of textual descriptions of restoration projects, could be used as a model for making use of the other government textual resources. In addition, this classification provides an in-depth summary of the program to complement the annual reports to Congress while sharing supplementary data with the Great Lakes community to better understand the full scope of GLRI and some of the potentially lesser-known actions.

While GLRI appears to be unique in its organization and consolidation, the U.S. does fund multiple restoration initiatives across the country. For example, there are similar efforts in the Puget Sound and Chesapeake Bay as well as for specific habitat types (e.g., migratory bird joint ventures programs https://mbjv.org/). One such habitat type, similar in structure and amount of funding received, is represented by the national river restoration efforts, which has also received a large-scale research synthesis effort. The National River Restoration Science Synthesis (NRRSS) working group published a series of articles based on their research evaluating restoration outcomes across the country (Bernhardt et al., 2007; Bernhardt et al., 2005). To accomplish this synthesis, NRRSS had to consolidate over 800 databases to draw their sample. While NRRSS took a critical review of river restoration, calling for improved goal setting, monitoring, and record keeping, it appears that GLRI has at least addressed the record consolidation critique despite similar criticisms calling for improved accountability, vision, and coordination (Maclean, 2018; US GAO, 2015; Sheikh, 2014). GLRI has consolidated multiple funding streams into a single database, created an online reporting tool, and provides annual reports to Congress. In addition, multiple systems-level monitoring efforts complement the local monitoring and reporting to the EAGL online platform (Barbiero et al., 2018; Burlakova et al., 2018). However, calls for GLRI to address emergent threats, engage in adaptive management, and improve governance are still common (Johns and VanNijnatten, 2021; Hartig et al., 2020; Pebbles, 2020; Sheikh, 2014).

It is also important to note that ecological restoration in general faces criticism for lack of accountability and the subjective nature of determining success. Researchers cite lack of data from pre and post monitoring to prove success while local project managers have been found to perceive higher levels of success than experts (Galbraith et al., 2021). Further, there is growing international interest in monitoring for improved human-nature relationships that emerge from restoration (Leisher et al., 2021; Soto-Navarro et al., 2021). For example, efforts like the United Nations Decade of Ecosystem Restoration 2020–2030 are taking a more involved approach to include social and community perceptions into account in restoration efforts (Galbraith et al., 2021). While the level of monitoring within the GLRI database might suggest more effort for accountability and transparency–as compared to the more dispersed riparian restoration efforts–it is not exempt from these general critiques. Namely, researchers have highlighted that the congressional reports rely heavily on qualitative information and project manager opinions (US GAO, 2015; Sheikh, 2014), which are influenced by individual subjectivities (Galbraith et al., 2021). Further, actual GLRI monitoring data to corroborate the project manager entries is still not available to the public. Therefore, third-party reviews cannot be conducted to measure GLRI projects' success objectively. Additionally, there are emergent critiques that question the extent of social or community input in planning pro-

cesses and the distribution of the benefits achieved by GLRI with an equity lens (Garcia et al., 2021; Knauss et al., 2019).

Emergent threats in the great lakes

Recent research highlights that ecological systems can no longer be considered static for management purposes given the extent and speed of environmental change (Rissman and Wardropper, 2020). To that end, part of our goal with coding the records is to contribute to the Science-Based Adaptive Management goal within the GLRI Action Plan III by creating a summary of all the efforts to date. Moving forward, tracking GLRI's foci while regularly conducting processes to determine new directions for GLRI will be crucial. For example, research has highlighted that TMDLs, which are based primarily on historic flow levels, developed by each state and approved by the EPA, may be particularly ill equipped for climate change (Rissman and Wardropper, 2020). Therefore, TMDL evaluations–with only 19 records to date–may need to take on a larger focus within GLRI to respond to changing conditions in the future. Further, microplastics are of growing concern in the Great Lakes (Earn et al., 2021), but the database had only two mentions of plastic as a pollutant. Nonetheless, there are some examples of adaptation to track emergent threats. The Early Detection and Rapid Response program is designed to identify new invasive species and respond to these threats in real time (GLRI, 2017). Similarly, the Contaminants of Emerging Concern (CEC) efforts led by USFWS are a proactive adaptive response to changing conditions in the Great Lakes region (Cornwell et al., 2015). Through evaluating the health of fish species (e.g., sturgeon), the CEC program identifies new contaminants in the lakes that are impacting the region.

Independent research groups have also conducted strategic visioning exercises for the Great Lakes to identify and address emergent threats (Weinstein et al., 2021; Laurent et al., 2015). As outlined in the Great Lakes Futures project (Creed and Laurent, 2015) and the Grand Challenges for Research Workshop (Sterner et al., 2017), climate change will be one of the major threats to the Great Lakes. Climate driven precipitation variability has already led to drastic changes to water levels in the Great Lakes over the last decade (Gronewold and Rood, 2019). As a result, erosion has become a major focus of concern, having caused millions of dollars in damages that has led to home relocations, increasing flood-related insurance settlements, and new public works projects (Perello, 2019; Gregg et al., 2012). Further, the growing need for resilience-building activities and research objectives has been highlighted for the region (Jordan, 2020; Gallagher et al., 2020). However, there are only 89 mentions of climate change and another 55 mentions of resilience-related activities in the GLRI database. While resilience was applied to both human and natural systems for the Great Lakes, these results suggest that climate is not yet a significant focus of the GLRI program in contrast to the increasing calls for its inclusion in restoration design by federal and state agencies (Jordan, 2020; Timpane-Padgham et al., 2017). Nonetheless, we do recognize that there may be political reasons for why climate terminology did not appear at a higher frequency and this tally may not be representative of the actual extent of adaptation.

At the same time, it is important to consider that conservation in general may offer climate adaptation co-benefits over the long-term (Arkema et al., 2017; Sutton-Grier et al., 2015). For example, local actors like The Nature Conservancy (TNC) are working to protect and restore wetlands in multiple states as a nature-based solution for coastal flooding and erosion. TNC developed a wetland conservation tracking tool that also documents benefits for nature and people; that tool was transferred to the Great Lakes Commission and is publicly available as part of the Blue Accounting Open Data Portal (https://blue-accounting-glcommission.hub.arcgis.com/). Efforts led by NOAA and funded by GLRI track the extent of Great Lakes hardened shorelines (available at: https://noaa.maps.arcgis.com/), which have been shown to shift erosion and degrade coastal habitat (Perello, 2019), to identify and prioritize future shoreline restoration opportunities utilizing nature-based solutions. Moving forward, efforts to maintain existing wetlands and restore degraded wetlands–while it will play an important role in conserving habitat–could also be argued as contributing to coastal resilience and climate adaptation though not described as such in the GLRI database (Sun and Carson, 2020. Arkema et al., 2017; Sutton-Grier et al., 2015).

The social foci of GLRI

This synthesis highlights many of the ecological restoration and stewardship actions of GLRI, particularly within the Habitats focus area. However, GLRI projects are also addressing a variety of social, public health, and human wellbeing goals in the Foundations for Future Action Focus Area. Given the evidence presented here on GLRI efforts that engage tribal groups, vulnerable populations, or youth, while considering citizen science, Traditional Ecological Knowledge, environmental justice, and community input about proposed conservation actions, there is more complexity than what is presently reported annually to Congress. Including these social foci and any corresponding benefits in annual reports may improve both public and political support for restoration (Matzek and Wilson, 2021; Clewell and Aronson, 2006). Further, the actions coded here are beyond what is typically conceived of as traditional conservation, restoration, and remediation actions as outlined in CS or conservation practice more broadly (Soto-Navarro et al., 2021; Bennett et al., 2017). GLRI project outcomes, specifically within AOCs, also demonstrate the ability to strengthen local residents' connection to place and enhance overall socio-spatial awareness of AOC areas (Liesch and Graziano, 2021). In addition, the extent of efforts that are designed to improve the safety or accessibility of recreation, both at beach waterfronts and through the development of trails and signage within protected areas, provide reason to believe that human wellbeing benefits created by GLRI could exist, which could potentially be documented with further research (Annis et al., 2017).

The people- and community-focused actions also include extensive education and outreach efforts throughout the Great Lakes region that could help secure long-term public support for GLRI (Gornish et al., 2021; Guo et al., 2019). The National Park Service is implementing multiple interpretation programs about the Great Lakes. The Bay Watershed Education and Training Program (B-WET)–along with other programs designed to engage K-12 students–are reaching youth and student audiences (NOAA, 2021). There is also the Center for Great Lakes Literacy, an Illinois-Indiana Sea Grant collaboration hosted at https://www.cgll.org/ that has received GLRI funding, which works to raise awareness about the Great Lakes ecosystem and emergent threats to gain public support for conservation efforts. Beyond education, we also highlight the extent of outreach projects designed to address specific public health concerns. In particular, mercury abatement measures and messaging for subsistence fishers and pregnant women highlight greater diversity of effort beyond solely restoration and remediation activities. Potentially, these outreach and public health centered projects are some of the lesser-known aspects of GLRI, and we hope that we have made the existence of such projects clearer here.

Although the GLRI Action Plans and reports to Congress highlight community revitalization benefits–which have been docu-

mented because of the restoration of AOCs and the elimination of the associated BUIs (Hartig et al., 2020)–and state the importance of restoration for environmental justice communities (GLRI, 2020; GLRI, 2017), there are no specific action items. Similarly, while Environmental Justice is a rapidly expanding research area and new focus under the new Biden administration (Exec. Order No. 13985, 2021), we found that there were only two mentions in the publicly available records. Further, diversity, equity, and inclusion (DEI) has already emerged as a source of concern for GLRI (i.e., lack of these topics being addressed; Garcia et al., 2021; Knauss et al., 2019). Nonetheless, we did document several efforts to improve DEI, which may have been facilitated by regional efforts to promote this topic. For example, we documented extensive restoration actions funded through the Bureau of Indian Affairs that were performed by Tribal groups or consortiums. The International Joint Commission has a program to promote TEK, or the more specific Indigenous Knowledge (IK), and also created an adaptation management tool for tribal groups (TAMT, 2019). The International Association of Great Lakes Research (IAGLR) has a Justice, Equity, Diversity, and Inclusion panel and has implemented trainings for board members. Though they may exist, the coding process did not allow for any comment on the effectiveness of these outreach efforts, only their current frequency in the records.

Therefore, we would make two cautionary recommendations in terms of DEI. First, because social science mentions in the monitoring and evaluations category were limited, it may be necessary to increase the focus on setting goals and measuring progress on social indicators to capture any corresponding benefits from DEI efforts. Second, as we push for greater focus on DEI and TEK, it is important to ensure revitalization is considered in a broader and more equitable sense to avoid some of the pitfalls that arise with "Green Gentrification" (i.e., when revitalization efforts impact property value and drive out long-time residents from a restoration site; particularly from minoritized groups; Rigolon et al., 2019; Gould and Lewis, 2012). In terms of planning, there is also growing consensus that DEI is unlikely to be considered if there is no explicit language or action items in planning documents (Chu & Cannon, 2021; Fitzgibbons and Mitchell, 2019), which suggests the need to increase DEI's incorporation into GLRI Action Plans and annual reports. Requiring a DEI element for GLRI projects could elevate the importance of this issue and help ensure projects are planned and implemented in underserved communities (Holifield and Williams, 2019).

Limitations and future research

Institutional subjectivities and "framings of nature" are highly influential in determining the priorities and "ways of knowing (i.e., epistemologies)" in conservation and restoration (Woroniecki et al., 2020). This leads to the question of how representative the textual descriptions of each project presently are, and what biases were involved in their creation. Project managers clearly varied in effort from noticeably short statements to elaborate explanations of the work performed. Further, it is possible that the local project managers who entered equity information into the EAGL system are more sensitized to DEI issues. Therefore, the range of quality of the textual descriptions undoubtedly influenced the assigned action codes during the thematic content analysis. As a result, the reader should interpret these qualitative codes as the sum of actions for every project, or line item, added across all GLRI's years of existence, and regard it as more of a general summary than a rigorous quantitative assessment. In the future, if all managers were instructed to create more thorough descriptions of their work for the publicly available GLRI database, it is likely that any subsequent coding efforts would document greater nuance and diversity of actions.

To reduce subjectivity, the CS classification presented here could inform future research that engages with local project managers about their consideration of human wellbeing and potentially reveal novel indicators for measuring restoration success. Such research could inform new socio-ecological focused metrics to demonstrate more holistically the impact of GLRI, help strengthen the case for continued funding, and identify local manager capacity-building needs for including a conservation social science lens (Liesch and Graziano, 2021; Soto-Navarro et al., 2021; Bennett et al., 2017; Milner-gulland et al., 2014). Subsequently, improved project proposal and EAGL interfaces could incorporate a more survey-based reporting system where restoration and remediation actions are presented as choices on a list along with human wellbeing and equity criteria. This approach could improve the uniformity of the descriptions that become publicly available as well as populate a spreadsheet with additional quantitative metrics beyond the five focus areas. This would also eliminate the need for conducting another extensive thematic content analysis to code the contents of the database. Even with the use of an existing classification scheme and this study as a foundation, any replication would likely require multiple months of coding. Similarly, a machine learning approach might be able to more quickly code the database, but it would still require time for interpretation.

Finally, given that the publicly available dataset only included the total project award amount, and no budgetary information, the codes did not provide a way to document the flow of funds into specific actions accurately. Therefore, this synthesis cannot offer any greater budgetary information than what is publicly available in the GLRI database. It would be useful to be able to compare actions by funding received to understand for example, how much is spent on planning as compared to implementation or capacity building. Further, many of these projects received local matching funds or leveraged other grant opportunities, so the costs presented in the database are likely not representative of the true investment in the restoration work performed. Similarly, spatial analyses are also not possible because of the inconsistency of geolocations within the database. Some points are clearly placed at a local recipient's office or university. We suggest that GLRI reports only the actual project locations in the future. If a project location is sensitive, GLRI could use coarser latitude and longitude coordinates instead of defaulting to the recipient's office location.

Conclusion

This study offers complementary insight into the actions of GLRI in conjunction with the Action Plans and reports to Congress. Overall, with the proposed increases to the GLRI budget in the coming years, we would urge greater use of conservation social science to better document the successes of GLRI to date and promote the much-needed community centric epistemologies that will help ensure equity in the future (Bennett et al., 2017). To that end, the accompanying supplementary data (ESM Table S1) can serve as a tool to guide future GLRI efforts and research. For example, the Healing Our Waters-Great Lakes Coalition, which has begun to investigate the equity and social impacts of GLRI, could use our data as a baseline for promoting the inclusion of social equity in their capacity building and outreach efforts in the region (Garcia et al., 2021). In addition, further discussion about the subjectivities in ecological restoration in general and in the GLRI database in particular could lead to capacity building for local managers to broaden their project framing lens. Finally, improving the GLRI database to make it more user-friendly could help improve trans-

parency, coordination, and public support in the future. Therefore, we recommend: 1) adding project identification numbers to allow for easy navigation of the records; 2) nesting revisions, increases, and continuations underneath the original project to allow for summative award amount calculations; 3) ensuring all geolocations are at project sites to allow for accurate spatial analysis; and 4) developing a survey of project actions for EAGL to allow for more in-depth categorical analysis.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jglr.2022.01.008.

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