Considerations for Managers: Results from "Developing and Integrating Social Measures of Estuarine Restoration Success"

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Introduction

Although restoration science would benefit from identifying outcomes that stem from specific implementation methods, evaluative conclusions from assessment are elusive. Salt marsh restoration implementation methods can include many approaches and techniques, and outcomes are influenced by site-specific conditions. Monitoring metrics to assess projects typically include hydrologic, elevational, vegetative, and/or broader habitat parameters and may not capture all valued outcomes. Therefore, rather than focusing on statistical conclusions based on common metrics, we identify more nuanced project-specific considerations based on projects we assessed, that together generate both site-based and broader conclusions. Nine projects from three separate bays along the Oregon coast were included for consideration in this document. We compiled ecological monitoring data at the project-site scale for each project and also compiled information on social values at the bay-scale based on focus groups conducted in summer 2020. Project goals were identified by mining reports about the projects for frequency of mention. Implementation methods noted in the project reports were also recorded. The ecological and social data scores are compared across seven metrics: Vegetation, Hydrology, Fish Use, Bird Use, Invertebrate Use, Mammal Use, and Human Benefits (e.g., Table 2). We describe connections between methods used in Alsea, Yaquina and Coos Bays, and make recommendations for future implementation and monitoring methods, and focal areas for public outreach. Focus group data, Q-sort data, conversations with practitioners, and a review of project reports together highlighted the gaps between specific ecological metrics being measured and the values of end-user groups along the Oregon coast. Several of the recommendations below seek to bridge gaps between current *restoration actions* and the *social values* documented in this work. Additional recommendations seek to highlight areas within ecological monitoring specifically where updated frameworks could improve the understanding and overall impacts that result from restoration implementation and project monitoring.

How to Use this Document

This document contains recommendations for managers based on findings from the 2021 NERRS-funded Catalyst project: *"Developing and Integrating Social Measures of Estuarine Restoration Success".* More information about this project can be found at https://nerrssciencecollaborative.org/project/deRivera20. This work sought to compare ecological metrics of estuarine, specifically salt marsh, restoration projects to social values and perceptions of restoration within three Oregon bays: Alsea, Yaquina, and Coos. Comparison of project implementation methods, measured metrics, stated project goals, and final ecological outcomes are summarized here, and are contrasted with the social data collected on local community member values. This comparison is used to make recommendations to managers where possible. This document contains summarizing information, and narrative language describing these recommendations.

Broad Considerations for Restoration Practitioners

1. Our work highlights site-specific attributes of projects that may hinder general evaluation of implementation strategies but comparison to reference sites and following adaptive management strategies can help improve outcomes. One or a few years of assessment are likely inadequate for assessing the longer term ecological and social outcomes of restoration because intricacies of sites can affect their trajectories. Adaptive management can help address site specific variability in trajectories. In addition, adaptive restoration can more directly account for impacts of climate change (e.g. sea level rise and storm surges) and ongoing human land use after restoration actions have occurred (Zedler 2017). Similarly, we found that community members value minimizing the impacts of climate change, and these findings support considering climate change as a part of adaptive management strategies. Practitioners can take advantage of the technical guide to adaptive management for coastal systems (Fischenich et al. 2012 and Fischenich et al. 2019).

2. In our work, large scale estuarine function was recognized as valuable to the public, land managers, and restoration practitioners. Therefore, we suggest that individual projects are considered as relevant to the larger landscape context or even planned at a landscape scale (von Holle et al. 2020). Projects could be contextualized by their watershed, landscape position, hydrologic inputs, and project scale (size, timeline,

implementation effort). Within Oregon, the historical extent of an estuarine habitat can be identified (Brophy et al 2019) and a restoration site then can be placed in the broader context of its watershed. Data from individual projects could be collected into a database within a given basin to assess project outcomes through time in the context of the larger system.

Comparing Social Values and Ecological Outcomes of Oregon Salt Marsh Restorations

We created a framework for comparing social data to ecological data using rankings from Alsea, Coos, and Yaquina Bays (Fig. 1). We grouped the ecological monitoring data and social data gathered from focus groups into seven broad metric categories: Bird Use, Fish Use, Mammal Use, Invertebrate Use, Vegetation, Hydrology, and Human Benefits. Ecological data, where available, were collected at the site level and averaged to produce bay-wide scores for comparison with social data, which was taken at the bay-scale. Ecological scores in the Hydrology and Vegetation categories incorporated both the final value of each metric and the amount of change from pre-restoration to present day. All social and ecological monitoring data were normalized and put on a 1-10 scale for comparison. The Linking Matrix document on our project website, https://nerrssciencecollaborative.org/project/deRivera20 provides a detailed description of how the ecological and social scores were derived. Current rapid assessments, such as the ORWAP or HGM methods (Adamus et al. 2020 and Adamus 2006, respectively), allow practitioners to characterize ecological function in project areas by evaluating various categories. These methods require an *in situ* assessment so we would not have been able to include the valuable data we compiled on pre-project conditions. The projects included here took site-level data pertaining primarily to vegetation, which was incompatible with the data resolution of rapid assessments and its broader consideration of soils, hydrology, fish habitat, and more at the site scale and larger watershed context. Importantly, none of the rapid assessments currently consider social data, nor do they categorize ecological functions in ways that allow comparison of social and ecological data. The nature of the data provided to the research team from participating project partners required that we develop a novel scoring index to compare the data at hand.

Linking Matrix

Shared Metrics	Alsea Bay			Coos Bay			Yaquina Bay		
	# of Report Mentions	Social Score	Ecological Score	# of Report Mentions	Social Score	Ecological Score	# of Report Mentions	Social Score	Ecological Score
Bird Use	3	8.8	no data	0	9.4	no data	4	6.5	no data
Fish Use	24	6	no data	11	5.0	P	144	6.0	P
Mammal Use	33	8.5	no data	2	8.8	P	50	7.9	no data
Invertebrate Use	1	6.3*	no data	14	6.3*	P	0	6.3*	no data
Vegetation	280	6.0	6.4	38	6.0	5.8	324	8.7	6.4
Hydrology	111	5.1	10	109	4.1	7.5	250	4.9	6.3
Human Factors	1	4.2*	no data	1	4.2*	no data	6	4.6*	no data

Figure 1. A matrix that links ecological scores, social scores, and number of mentions in project reports for each of six common restoration assessment metrics, in each of three bays. Asterisk indicates that these scores do not include photo ranking data, only Qsort data

Management Recommendations based on Linking Matrix Findings

We suggest including as many metric categories that are highly valued by the public as possible into the design and assessments of salt marsh restoration. Our linking matrix (Figure 1) shows that several valued aspects of salt marshes are not included in a standardized way in metrics measured to assess restoration. Although salt marsh restoration creates habitat for animals and so theoretically aligns well with outcomes valued by residents, the lack of data on bird and mammal use of restored salt marshes and lack of outreach materials about these benefits creates a disconnect between social and ecological scores of restoration identified by the Linking Matrix. One clear discrepancy is a high social ranking for bird use, along with limited mention in project reports and no monitoring of bird use of habitats in restoration projects. If funding for monitoring is limited, managers may consider taking advantage of prior or regularly collected data including local breeding bird counts and Christmas bird counts, or eBird lists (Sullivan et al. 2014) to address this public value and communicate the importance of salt marsh restoration for birds. Suggestions for potential datasets to tap into are provided in Table 1. Within a certain resolution, citizen science can provide high quality data across a wide variety of disciplines (Fucillo et al. 2014; Sullivan et al. 2014; Lewandowski & Specht 2015; Vermeiren et al. 2016; Schmeller et al., 2017).

Mammal use was also ranked highly, yet managers rarely cited this as a goal in project reports and minimal data were gathered to assess mammalian use of the habitat. This is likely due to the difficulty in gathering these data. However, some projects assessed beaver use by using aerial imagery and counting the number of beaver dams at the site. This is a simple method if aerial imagery is available, and should be considered where beavers are a species of interest. For restoration sites that are adjacent to an area with public access, managers may consider setting up an iNaturalist project for the site (https://www.inaturalist.org/projects). A QR code on an interpretive sign linked to the iNaturalist project page can allow public end users to report any birds or mammals they encounter during their visit.

Fish use of habitat was ranked of moderate importance by community members, and mentioned more often by managers in project reports. The only moderate ranking by the general public may suggest an opportunity to share findings from relatively recent research that shows salt marsh channels as important habitat for salmonids and other fishes and about the role of salt marshes in their food web. Fish use was measured by restorationists and scientists involved in some restoration projects, but collection methods were not standardized. Although standardization across restoration projects would be ideal, a variety of methods are needed to assess fish populations, and the method used is dependent on such aspects as the research question, site accessibility, type of habitat, and fish species of interest. We addressed this by transforming disparate datasets into presence/absence data for comparison across sites. For projects where gathering data on fish abundance/presence is not feasible, we suggest using data often collected or sponsored by state agencies (e.g., fish surveys) and highlighting overall fish diversity and/or presence or abundance of species of interest such as salmonids (Table 1). Future studies could work towards standardizing fish datasets such as using an index for comparison across restoration sites or using standardized protocols in addition to whatever site-specific ones are desired.

Managers may also consider community outreach that clearly communicates how commonly measured ecological monitoring metrics, like vegetation, are linked to resources for birds (e.g. habitat, food) and therefore act as proxies for what the public values. To this end, we created an informational brochure for distribution by the South Slough National Estuarine Research Reserve and The Wetlands Conservancy, which is available on our project website (https://nerrssciencecollaborative.org/project/deRivera20). See also the Messaging Strategies below.

Table 1. Possible sources for additional data across the seven metric categories included in this work. These data sources often do not include data connected to specific restoration projects but might instead be used to contextualize areas adjacent to or within the same watershed of a restoration project.

Metric	**Data Type**	**Data Repository**	**Notes on Use**
Bird Use	Location, counts	https://www.audubon.org/content/cbc-data-bird-trends	Christmas Bird Count data
	Wide variety of data types	https://ebird.org/science/use-ebird-data/download-ebird-data-products	
Fish Use	Wide variety of data types	https://nrimp.dfw.state.or.us/DataClearinghouse/default.aspx?ReturnUrl=%2fDataClearinghouse	
Mammal Use	Beaver surveys	https://www.anecdata.org/projects/view/302	
Invertebrate Use	None	None identified	
Vegetation	Location, ID info	https://www.inaturalist.org/	Does not include % cover
	Location, ID info	https://oregonflora.org/	Does not include % cover
	Location, ID info, phenology	https://www.usanpn.org/data	Does not include % cover
Hydrology	Water quality	https://www.awqms.com/	Site specificity is variable
	Water levels	https://tidesandcurrents.noaa.gov/stations.html?type=Water+Levels	Site specificity is variable
Human Factors	None	None identified	

Vegetation is an important proxy for other important marsh functions and was mentioned frequently as a goal in project reports and also ranked favorably by public end users. Vegetation scores were higher in Alsea and Yaquina Bays, where vegetation was also mentioned more frequently in project reports as a goal. Lower ecological scores for vegetation are likely driven by low final diversity index values of plant communities and/or minimal increase in diversity over time. The average Simpson's Diversity Index scorecard (standardized to a scale of 10 to be comparable to the other metrics) score for all projects was 4.2 ±1.7 (see Eco Metrics Scorecard deliverable); Simpson's Diversity assesses species evenness or relative abundance in addition to the richness or a total number of species present, averaged across the 1m^2 sampling quadrats of a project. The projects with higher Simpson's Diversity scores consequently scored higher on their overall vegetation score. While vegetation is an important metric to assess salt marsh function overall, species diversity within salt marshes can be relatively low (Goman et al. 2008) so it is more useful to compare the relative abundance value from pre- and post- restoration data than a measure of total species. For example, the Y27 restoration site in Yaquina Bay had a Simpson Diversity (standardized to scale of 10) score of 8 (reflecting a change in Simpson Diversity from 0.26 to 0.58 in 2021), and a final scorecard vegetation score of 7.33, the highest of all nine projects. Additional research is necessary to understand how to best shift restored plant communities on a trajectory towards the more diverse plant communities seen in older, less manipulated marshes. We also suggest a comprehensive review of vegetation parameters to assess both diversity and function in restored marshes. Our comprehensive evaluation of plant communities of these restoration sites included several other plant metrics in addition to diversity: native and non-native species, dominant species, and salt-tolerant plant species and percent cover.

We found very little monitoring data related to hydrology. To fill in these data gaps, we measured channel sinuosity, which is used as an effective proxy for fish habitat and system function in marshes (Stone 2012). Hydrology was mentioned frequently by managers in project reports and valued as of moderate importance to public end users (social rankings ranged from 5.7-6.10 out of 10). This disconnect is likely due to public end users' limited knowledge of the importance of hydrology to other marsh functions. Outreach to educate community members on how hydrology affects vegetation and animals in marshes may help to address this disconnect. Projects performed well under the hydrology category; with an average score of 7.5/10 in Coos Bay, 6.3/10 in Yaquina Bay, and 10/10 in Alsea Bay (though this was based on one project, Drift Creek). The lowest scoring project for hydrology was Kunz Marsh is Coos Bay with a score of 4/10; This lowish score was driven by a slight decrease in average channel sinuosity. However, channel sinuosity was relatively high to begin with and Kunz Marsh post restoration still has sinuous channels despite the slight decrease in sinuosity. We demonstrate that our method for assessing channel sinuosity is both efficient and effective, and can be done remotely using aerial imagery (see a detailed account of our method on our project website). Managers should consider incorporating this simple yet informative metric into restoration assessments. Ideally these remote sinuosity measurements would be coupled with ground truthing of these measurements in the field. One important metric related to hydrology is water quality, which was highly valued by community members. Due to the lack of water quality monitoring data available, we additionally suggest including water quality assessments in restoration monitoring designs. Lastly, as with vegetation, we suggest that managers should focus outreach on how measured metrics, such as channel sinuosity, serve as a proxy for other functions that align with the publics' values, like fish habitat.

We also include the category of Human Factors, which incorporates such social values/metrics as mode of communication, sentiment, sense of place (experience, affect, change over time), economic values, physical health and well-being, political values, community values, and environmental benefits. These metrics are not currently assessed in salt marsh restoration projects. However, it would be useful to understand how these metrics are affected by completed restoration projects to communicate the importance of salt marsh restoration to the general public. Better communication will likely result in more public buy-in and increased community support for habitat restoration projects. See the "Social Perceptions of Restoration in Coastal Oregon" section of this paper for a discussion of our findings and possible messaging strategies for use in outreach and public engagement, summarized in Table 3. Previous studies in forestry management have used surveys to gather data on these values relative to biological monitoring metrics (Hegetschweiler et al. 2020), and surveys of community members pre- and post- restoration may be a way to track these metrics. See our project website for more information about how we are working to incorporate these social values in restoration assessments.

Implementation Methods as Compared to Projects Scores

We searched project reports for mention of restoration implementation methods and desired goals, which showed little discernible correlation with desired outcomes (summarized in Table 2) when compared to project scores for vegetation or hydrology (the only two metrics available in the ecological score column in Figure 1). However, sites with full dike removal seemed to score higher in the Vegetation category relative to partial removal or dike breaching. Practitioners we spoke with suggest that full dike removal in particular re-introduces both sheet flow and channel flow, and thus restores greater hydrological function overall including more potential for seed dispersal. Hydrological scoring is difficult to link with implementation methods because most restoration sites included here had pre-existing sinuous channels or included some measure of channel excavation.

Conversations with project practitioners highlighted the unique circumstances, and uniquely variable long-term goals associated with each project. This variability complicates any correlation between implementation methods and project outcomes. For example, dike breaching in a site lower in an estuary system reintroduces flooding, but the salinity content of this marsh may be higher than a marsh higher in the system, and thus the trajectory of each marsh's vegetation community will differ. It may be that a lower elevation marsh would show more indicators of a functional salt marsh than a marsh that would naturally receive floodwater with lower salinity concentrations and contain different native plant communities. Another example is Cox Marsh in Coos Estuary, where beaver damming caused higher water table levels than expected and resulted in a transition to a more freshwater dominant plant community. However, practitioners involved in the project would not consider the project to be "unsuccessful" - it ended up providing valuable habitat for a species of interest, beavers. In fact, the growth rates of juvenile coho salmon (*Oncorhynchus kisutch*) in the pond behind this Cox beaver dam were the highest of any juvenile coho in upper South Slough estuary habitats (Miller and Sadro 2003). These contextual details and unintended outcomes are necessary to consider when assessing implementation strategies. In addition, variable historic land use in the past, present, and future of a site may continue to instigate variable plant community trajectories, not to mention broader ecosystem functions (Janousek et al. 2020). Our work highlights the need to consider restoration site history and starting condition, and the broader landscape context, when assessing the efficacy of implementation strategies. Aerial imagery and remote sensing data can be used with *in situ* field data and watershed-scale models to track a basin's inundation, tidal regime, and overarching land management (Van Belzen et al. 2017, Buckley 2006). Current efforts include the HGM Rapid assessment for Coos Bay (Adamus 2006), and a current assessment of projects in the Columbia River Basin, led by the Lower Columbia River Estuary Partnership, assigns projects a score using a landscape-scale model to compare projects. This assessment uses a basin-wide framework for analyzing a single project's data, and then compares it to a collection of projects. This framework is replicable in other basins and should be considered.

Table 2. Vegetation and hydrology scores (see Eco-metrics Scorecard or Linking Matrix) for each restoration project along with the main methods of restoration implementation Vegetation and Hydrology were the only two metric categories with comparable data. We were unable to assess channel sinuosity/Hydrology for Lint Slough.

Project	Vegetation Score	Hydrology Score	Restoration Method (s)	Degree of Action Rating by Managers (1-5)	Common Methods
Y27	7.33	9	Dike removal, tidal channel excavation	**4**	Dike Removal
Kunz	7.67	4	Dike removal, excavation	**5**	
Lint Slough	7.2	NA	Dike removal, fill placement	**4**	
Y3	6.33	5	Dike removal, tidal channel mouth widening	**3**	
Fredericks on	6.4	8	Dike removal, agricultural ditch enhancement, large wood placement	**3**	
Drift Creek	5.6	10	Dike removal, nonnative plant removal	**3**	
Poole Slough	5.5	5	Partial dike removal	**3**	Partial Dike Removal
Cox	4.6	9	Dike removal, reconnect historic channel, plug agricultural ditch	**4**	Dike Removal
Dalton	4.0	9	Partial dike removal, channel construction, large wood placement, channel excavation	**4**	Partial Dike Removal

Social Perceptions of Restoration in Coastal Oregon

Below are six notable "persona" types, and recommendations for how to consider their associated values. Of the ten social metrics, the category that was most germane to our group were ecological outcomes like water quality and biodiversity. We developed six typologies based on the way respondents constructed estuary restoration narratives that supported the goals of: 1) conservation, 2) community building, 3) local coastal safety, 4) worldwide coastal safety, 5) economic prosperity (without destroying the environment), and 6) supporting communities around the world.

Overwhelmingly, the strongest perspective explaining 42% variance had highest-ranking statements about ecological outcomes of restoration such as habitat, water quality, ecological function, reducing pollution, tidal channels, native vegetation, and beavers. We named this perspective (P1) the "Total Conservationist." The second perspective (P2), with 8% explained variance was named "Local Sense of Community." The core of this perspective is community with a specific focus on their local community. The third perspective (P3), with 7% explained variance was named "Local Coastal Safety." Participants affiliated with P3 used words associated with a sense of place and emotionally charged words. We named the fourth perspective (P4), with 5% explained variance, "Globally Conscious Coastal Safety." While P4 shares similarities with P3 in that they are both concerned about coastal safety, P4 took a more global view. For example, one of the higher-ranked distinguishing statements for this group was minimizing the impacts of sea-level rise ($p \leq .01$). The fifth perspective (P5) explained 5% variance. We named this one "Economic Prosperity." Contrary to media narratives that people either support the economy or the environment, P5 appreciates both. Finally, we named the sixth perspective (P6) "Globally Conscious Sense of Community," a perspective that explained 4% variance. P6 shares a sense of community like P2 ("increasing my community's resilience" is highly ranked in both), but like P4, the view takes a broader view of community.

Table 3. The six personas identified from the Q-sort exercise in our focus groups, the top two values from that exercise associated with each persona, and possible messaging content.

Persona	Top Two Values	Important Messaging Content
Total Conservationist	Increasing habitat for fish and wildlife, Enhancing water quality	Use the words “habitat,” “fish,” “wildlife,” and “water quality”. Demonstrate trustworthiness. Show how your organization helps the environment.
Local Sense of Community	Increasing ecological function in general, and local government's management of the ecosystem	Emphasize working together. Describe how your project helps the community. Make it personal.
Local Coastal Safety	Increasing habitat for fish and wildlife, and reducing flood damages to my property	Use emotional and sensory words. Emphasize security, safety, and health. Make it visual.
Globally Conscious Coastal Safety	Minimizing the impacts of sea-level rise, and increasing habitat for fish and wildlife	Emphasize security, safety, and health. Use words like resilience and adaptation. Be detailed.
Economic Prosperity	Increasing habitat for fish and wildlife, and enhancing water quality	Highlight both economic and environmental benefits. Emphasize how solutions are “effective.” Show how your project compares to other solutions.
Globally Conscious Sense of Community	Increasing my community's resilience, and that everyone benefits from natural places equally	Describe how your project helps communities near and far. Emphasize resilience and adaptation. Be detailed.

Possible Messaging Strategies

Given these findings, we recommend that managers situate outreach and communication in widely shared values before addressing beliefs or attitudes. For example, beginning with water quality and wildlife habitat in this community promoted open-mindedness before addressing more controversial topics like dredging. Because our sample trended toward one main perspective, messages might not have to be different for early adopters to be effective.

Practitioners interested in developing messaging for constituents residing in any of the three bays addressed in this work can employ one or both of the two following strategies. The first strategy entails choosing one persona to focus on, and developing targeted messages for that perspective. For example, the “Total Conservationist" resonated the most with our group so messages could be focused to be effective for this group. The second strategy would entail focusing on the overlap to capture more perspectives and develop messages that will appeal to a wide range of perspectives. For example, three of our groups appreciate detailed information and being able to compare solutions to understand the benefits of estuarine restoration. Appealing to the ecological benefits, community, and safety, in addition to economic prosperity, will likely have a broader reach (see Table 3). Our participants wanted to be ensured that estuarine restoration projects were advancing adaptation, addressing conflict through community balance, and were avoiding mistakes. Focusing on these values may help natural resource managers reach their target audiences. Lastly, given that the focus group participants discussed their values at the scale of an estuary, it is likely useful to communicate how restoration projects contribute to the overall functioning and services of a whole estuary. Focus group participants discerned the need for landowner buy-in at the site scale, with simultaneous habitat management and regulation at the watershed scale. Follow up work seeks to verify that these messages resonate with the personas and identify the demographics associated with each persona and set of messages.

Conclusions

We found discrepancies between social values and the ecological metrics measured to observe project outcomes. Resolving these discrepancies could greatly improve public support for future projects and foster more holistic designs. Social engagement is positively correlated with the success of river restoration project success (Bernhardt et al. 2007). Oregon's salt marsh restoration design, assessments, and public outreach efforts can benefit from using the information provided by the linking matrix (Figure 1). The information in the matrix could be used to determine new restoration goals or ecological assessment metrics that align with social values or to develop surveys of the community or use social indicators directly as part of assessment. Communications can highlight Oregon's salt marsh restoration successes that support ecological function that aligns with topics that the public cares about or can show how other values (e.g., support of salmonid populations) that are not indicated in the matrix as a specific value for salt marsh restoration are indeed an outcome of salt marsh restoration.

Based on conversations with restoration practitioners and the data from our focus groups, we found that the values of the practitioners align with public values. However, there are constraints practitioners face when implementing restoration projects that affect the decisions they make and particularly the goals they choose to focus on in restoration project goals, implementation, or assessment. Several restoration practitioners we talked with identified funding as one of the main constraints limiting their restoration project design. Practitioners suggested that more funding for project design, and monitoring of the restoration site and reference sites in tandem, would improve project outcomes. Funding availability often depends on the political climate and because of this can fluctuate on short temporal scales. Inconsistent funding can complicate the restoration process that occurs on a much longer timeline, from planning and permitting through implementation and monitoring. The impacts of politics on restoration are hard to track due to the lag in effects from environmentally unfriendly policy, but future work should assess how politics and funding intermingle to affect habitat restoration outcomes.

A consequence of this lack of funding is a lack of monitoring in some areas of interest. For example, despite public interest in bird and mammal use of restored areas, we found minimal ecological data for the restored salt marshes that were associated with those categories across all three bays. In addition, the low number of mentions in project reports corroborate the observation that within the practitioner framework, these two particular metrics are underrepresented. When asked which metrics practitioners would include if they had limited funding, they listed several that are not generally included in assessments, including data related to groundwater and surface water salinity to understand carbon dynamics, good surveys of topography and how it changes, carbon sequestration capabilities, sediment accretion, elevation, soil salinity, soil bulk density and organic content, eelgrass, oysters, fish, and water quality. They also suggest a need for more replicates through space and time. Fortunately, as the understanding for project costs has grown in recent years, practitioners describe a transition towards more support for estuarine restoration by funding institutions. Additional funding for individual projects allows project managers (or groups of managing entities) to plan and implement projects with greater stakeholder group participation, to monitor projects using more ecological metrics, and to adaptively manage projects as needed. Allocating more funding towards tracking the metric categories favored by community members will help to bridge the gap between practitioners and the public. Our work provides clear data on where those funds would be best spent to improve public perception, and ultimately public support of restoration projects.

Another constraint mentioned by practitioners is that some regional estuary management plans are outdated. This limits estuary-scale coordination of projects, with individually funded projects left to determine goals and objectives based solely on considerations of their specific site rather than how that site contributes to larger scale functional processes. Recent efforts create maps outlining historical marsh extent and habitats from historical documents (t-sheets, notes, older maps), and use this information to guide their management of estuaries (i.e. historical mapping of southern California estuaries and the Sacramento-San Joaquin Delta by the San Francisco Estuary Institute, Whipple et al. 2012, Grossinger et al. 2011). Other work uses digital elevation and water level models to predict historical extent of estuaries (Brophy et al. 2019). These approaches could account for the “shifting baselines” of ecological function and habitat, where current generations of land managers lack the historical knowledge of sites and are unsure what to restore towards.

Lastly, we suggest targeted messaging that describes how the metrics that practitioners do measure align with social values (i.e., Vegetation, Hydrology). A discussion of the most common personas and associated messaging strategies is provided in the Social Perceptions section above to offer deeper insight into community perspectives. Next steps towards aligning restoration with social values as well as ecological function and communicating about these efforts can build on established methods for communication with the public and evaluation of impacts from public engagement (Druschke and Hychka 2015).

Overall this work illuminates the extent to which project goals and outcomes align with public values by linking ecological and social datasets. We also provide guidance for integrating our findings into future restoration projects throughout this document. Future research needs include investigating whether these social values are maintained across a broader geographic range, and whether ecological datasets in those regions consistently align or do not align with those social values. Additional research is also needed to assess the utility of citizen science databases to fill in data gaps, general impacts of projects on their respective watersheds, adaptive management strategies, and which ecological metrics consistently indicate long term functionality. Lastly, we suggest practitioners work to include designs and processes that intentionally include the community and assessments of social values over time to garner support for restoration by demonstrating how restoration projects affect the populace in addition to ecological function.

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