Linking Matrix: Results from “Developing and Integrating Social Measures of Estuarine Restoration Success”

Authors: Julie Gonzalez, Vanessa Robertson-Rojas, Catherine de Rivera, Melissa Haeffner, Edwin Grosholz, Paul Englemeyer, Shon Schooler, Sabra Comet, Shersten Finley

Project Website: https://nerrssciencecollaborative.org/project/deRivera20

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. Values for Mammal Use of restored habitat and Fish Use of restored habitat were recorded as “P” if present. Red lettering depicts scores based on numeric values from monitoring data. NA values are given where data is not available, or not collected.

The purpose of this matrix is to understand whether restoration projects across three bays in Oregon (Alsea Bay, Coos Bay, Yaquina Bay) adequately address the social values of the public community members living near those bays. Previous work in forestry management used surveys to assess social values relative to biological monitoring data (Hegetschweiler et al. 2020). As a first step towards a broader survey study, we used focus groups to compare the values of Oregonians living near these bays with past and present day monitoring data from nine restoration projects in those three bays, and the number of mentions of each metric category in project reports as a proxy for priority restoration goals outlined by managers. This information can be used to prioritize metrics that best identify with social values and to create outreach materials that align with community member perspectives. Please see the "Considerations for Managers" document on our project website for more detailed recommendations from this work.

Methods for Developing the Linking Matrix

Ecological score

We compiled ecological information for nine projects across three estuaries in Oregon. We entered information from reports from the initial monitoring of each project, categorizing the findings into the seven metric categories of the matrix; we also sampled vegetation and measured channel sinuosity in 2021. We had pre-restoration and present day data for vegetation and hydrology only, so we were able to assign scores for these but not the other categories. For the vegetation category, we assessed multiple vegetation parameters, including invasive species and cover of invasives, salt tolerant species and cover, dominant plant species, plant diversity, and native plant species and cover of natives. We took into account both the final value (present day) of each parameter and the change from pre or just post implementation to present day ("lift" of the restoration). These vegetation performance values were averaged and data were binned on a 1-10 scale. We also measured sinuosity pre-restoration and for present day aerial imagery. We created a formula that took into account both the present day value and the change over time that summed a percent "Change Index" and a present day "Value Index", both binned on 1-10 scales, to produce a performance value, which was also binned on a 1-10 scale.

Social Score

The social score was derived using quantitative data from two activities during focus groups we held at each bay. The focus groups included restoration managers, direct receivers of information about restoration, such as port managers, and indirect receivers of information, such as area residents who may learn about the restorations from the news (see Summary of Focus Group Findings on the project webpage). The first was a Q-sort (forced ranking) activity where participants ranked statements about how they valued a variety of environmental topics associated with restoration projects. We compiled statements into the same broad categories of metrics that were also used to compile ecological data (above), with an additional category for "Human Benefits" for statements that could not be categorized under the ecological metric categories. Statement rankings were binned so data were on a 1-10 scale. We also held a photo ranking exercise during the focus groups where participants in breakout groups had to come to a consensus on how to rank ten photos. The photos included two per each of five of the ecological metric categories (e.g. bird use, fish use, mammal use, vegetation, hydrology), where one photo was chosen to portray a "high ecological function" representation of that metric category and the other photo to show a "low function" representation (Fig 3). The photo rankings for the high ecological function photos were binned so that data were on a 1-10 scale, and scores from each activity were averaged to produce the overall social score per bay.

Number of Mentions in Project Reports

Scores for the metric categories from the ecological scorecard and scores derived from social rankings are compared in Figure 1, along with the number of mentions of each metric category. Eighteen project reports related to the nine projects considered in this work were mined for mentions of goals and objectives using the Atlas.Ti software, and from those results a list of thematic coding terms (Saldaña 2021) were developed to match these goals to the seven metric categories: Fish Use, Bird Use, Mammal Use, Invertebrate Use, Hydrology, Vegetation, and Human Impacts. All project reports related to each project were identified and loaded into Atlas,Ti. All reports were then searched for mention of the terms: "goal", "goals", "objective", "objectives", "purpose", and/or "purposes". Each found occurrence within a phrase or paragraph were documented in the "goalsandObjecives" tab within the "Reportminingdata_FINAL" dataset. Records were associated with project name, project bay, implementation year, data collection year, the report title, goals listed, restoration actions used to achieve said project goals or objectives, and the report was read to identify whether the author confirmed, denied, or did not address the achievement of the listed goal or objective. The identification of language describing goals was used to develop a list of goals that fit within the seven metric categories, and thus the identified goals were condensed into seven categories. One or multiple goals were listed within each record, depending on the nature of the text. The terms used to describe goals and objectives with the six metric categories were then used to develop a list of thematic coding terms for each metric (see table below for search terms). Atlas.Ti was used to search all project reports for these specific lists of terms which describe the seven metric categories. These instances were counted, and the totals were summed on a bay-by-bay scale and were recorded in the “GoalsDescription” tab of the “Reportminingdata_FINAL” dataset.

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 for 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.

Discussion

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. Managers may consider taking advantage of prior or regularly collected bird data including local breeding bird counts and Christmas bird counts, or eBird lists, to address this public value and communicate the importance of salt marsh restoration for birds. Managers may also consider community outreach communicating how other commonly measured ecological monitoring metrics, like vegetation, are linked to resources for birds (e.g. habitat, food). To this end, we created an informational brochure for distribution by our project partners, and which is available on our project website (https://nerrssciencecollaborative.org/project/deRivera20).

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.

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 fish data from online repositories and highlighting overall fish diversity and/or presence or abundance of species of interest such as salmonids (Table 1).

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 scorecard (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.

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	None	https://www.anecdata.org/projects/view/302	Beaver surveys
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	

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.

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.

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.

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 Considerations for Managers document on our website 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 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.

Acknowledgements: The research was sponsored by the National Estuarine Research Reserve System Science Collaborative, which supports collaborative research that addresses coastal management problems important to the reserves. The Science Collaborative is funded by the National Oceanic and Atmospheric Administration and managed by the University of Michigan Water Center (NA19NOS4190058).

References:

Adamus, P.R. 2006. Hydrogeomorphic (HGM) Assessment Guidebook for Tidal Wetlands of the Oregon Coast, Part 1: Rapid Assessment Method. Produced for the Coos Watershed Association, Oregon Department of State Lands, and U.S.E.P.A.-Region 10. Charleston, OR: Coos Watershed Association.

Adamus, Morlan, Janet C, Verble, Kathy K, & Wetlands Program. (2020). *Manual for the Oregon Rapid Wetland Assessment Protocol (ORWAP)* (Version 3.2.). Wetlands Program, Oregon Dept. of State Lands.

Brophy, Greene, C. M., Hare, V. C., Holycross, B., Lanier, A., Heady, W. N., O'Connor, K., Imaki, H., Haddad, T., & Dana, R. (2019). Insights into estuary habitat loss in the western United States using a new method for mapping maximum extent of tidal wetlands. PloS One, 14(8), e0218558–e0218558. https://doi.org/10.1371/journal.pone.0218558

Bernhardt, E. S., E. B. Sudduth, M. A. Palmer, J. D. Allan, J. L. Meyer, G. Alexander, J. Follastad-Shah, B. Hassett, R. Jenkinson, R. Lave, J. Rumps, and L. Pagano. 2007. Restoring rivers one reach at a time: results from a survey of U.S. river restoration practitioners. Restoration Ecology 15:482-493. http://dx.doi.org/10.1111/j.1526-100X.2007.00244.x

Druschke, C. G., and K. C. Hychka. 2015. Manager perspectives on communication and public engagement in ecological restoration project success. Ecology and Society 20(1): 58. http://dx.doi.org/10.5751/ES-07451-200158

Goman, Malamud-Roam, F., & Ingram, B. L. (2008). Holocene Environmental History and Evolution of a Tidal Salt Marsh in San Francisco Bay, California. Journal of Coastal Research, 24(5), 1126–1137. https://doi.org/10.2112/08A-0005.1

Grossinger, R. M.; Stein, E. D.; Cayce, K.; Dark, S.; Askevold, R. A.; Whipple, A. 2011. Historical Wetlands of the Southern California Coast: An Atlas of US Coast Survey T-sheets, 1851-1889. SFEI Contribution No. 586. SFEI: Oakland.

Hegetschweiler, K., Fischer, C., Moretti, M. and Hunziker, M., 2020. Integrating data from National Forest Inventories into socio-cultural forest monitoring–a new approach. Scandinavian Journal of Forest Research, 35(5-6), pp.274-285.

Janousek, C., Bailey, S. J., & Brophy, L. S. (2020). Early Ecosystem Development Varies With Elevation and Pre-Restoration Land Use/Land Cover in a Pacific Northwest Tidal Wetland Restoration Project. *Estuaries and Coasts*, *44*(1), 13–29. https://doi.org/10.1007/s12237-020-00782-5

Saldaña, J. (2021). The coding manual for qualitative researchers. Sage. Thousand Oaks, CA

Tessa Hegetschweiler, K., Fischer, C., Moretti, M. and Hunziker, M., 2020. Integrating data from National Forest Inventories into socio-cultural forest monitoring–a new approach. Scandinavian Journal of Forest Research, 35(5-6), pp.274-285.

Whipple, A.; Grossinger, R. M.; Rankin, D.; Stanford, B.; Askevold, R. A. 2012. Sacramento-San Joaquin Delta Historical Ecology Investigation: Exploring Pattern and Process. SFEI Contribution No. 672. SFEI: Richmond.