Oregon's future tidal wetlands

Evaluating potential habitats, human impacts, & adaptation

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The Nature Conservancy

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Image attributions

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Acronyms

AET	actual evapotranspiration
API	application programming interface
COMID	NHD common identifier
DEQ	Oregon Department of Environmental Quality
DLCD	Oregon Department of Land Conservation and Development
DOGAMI	Oregon Department of Geology and Mineral Industries
DWSA	drinking water source area
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GIS	geographic information system
IUCN	International Union for the Conservation of Nature
IWI	Index of Watershed Integrity
LMZ	Landward Migration Zone
NBS	Nature-Based Solutions
NHD	National Hydrography Dataset
NOAA	National Oceanic and Atmospheric Administration
NRCS	U.S. Natural Resources Conservation Service
OR-IRIS	Oregon Incidence Response Information System
PET	potential evapotranspiration
RA	relative abundance
SDI	Simpson's Diversity Index
SEU	sub-estuary unit
SFEI	San Francisco Estuary Institute
SLR	sea level rise
SPUR	San Francisco Bay Area Planning and Urban Research Association
TNC	The Nature Conservancy
UGB	urban growth boundary

What is needed to prepare for sea level rise?

Sea level rise (SLR) is expected to reshape the extent and configuration of Oregon's estuaries, affecting vegetation, wildlife, and nearby communities. The intensity, frequency, and duration of rainfall are predicted to increase along with higher tides, resulting in longer and more extensive flooding, making homes and development in those areas subject to increasing impacts. In most estuaries, the habitat zones capable of supporting salt marsh and tidal swamp are projected to shrink. Because these tidal wetlands play a critical role in natural flood processes and many species—including salmon—protecting both existing and future habitat is essential.

Research suggests that widespread global loss of coastal wetlands could be avoided if these systems are given space to migrate inland through thoughtful, nature-based adaptation approaches to coastal management (Schuerch et al., 2018). The International Union for the Conservation of Nature (IUCN) defines *Nature-Based Solutions* (NBS) as "actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (Cohen-Shacham et al., 2016). For example, recent hydrodynamic modeling in Coos Bay, Oregon, showed that restoring tidal wetlands can reduce flooding from extreme tides and SLR, protecting the places where people live and work (Brand et al., 2025).

How can you help?

Keeping SLR in mind is critical when planning infrastructure projects, developing environmental restoration projects, advocating for a city's long-term planning goals, and more. The Nature Conservancy (TNC) research team has developed analytical tools that can help you identify areas within Oregon's estuaries suitable for NBS and restoration efforts. Our intent is to support ecological function under a range of SLR scenarios while providing benefits to human communities wherever possible.

Specifically, this project focused on the *Landward Migration Zones* (LMZs) identified for 23 of Oregon's coastal estuaries, as mapped by Brophy and Ewald (2017). (See Figure 1 for an example.) LMZs illustrate how tidal wetlands are expected to shift under specific SLR scenarios. We integrated these LMZ data with additional spatial datasets describing the potential ecological functions of present and future estuary areas, as well as social and demographic information such as community characteristics related to coastal hazard resilience, population density, and infrastructure distribution.

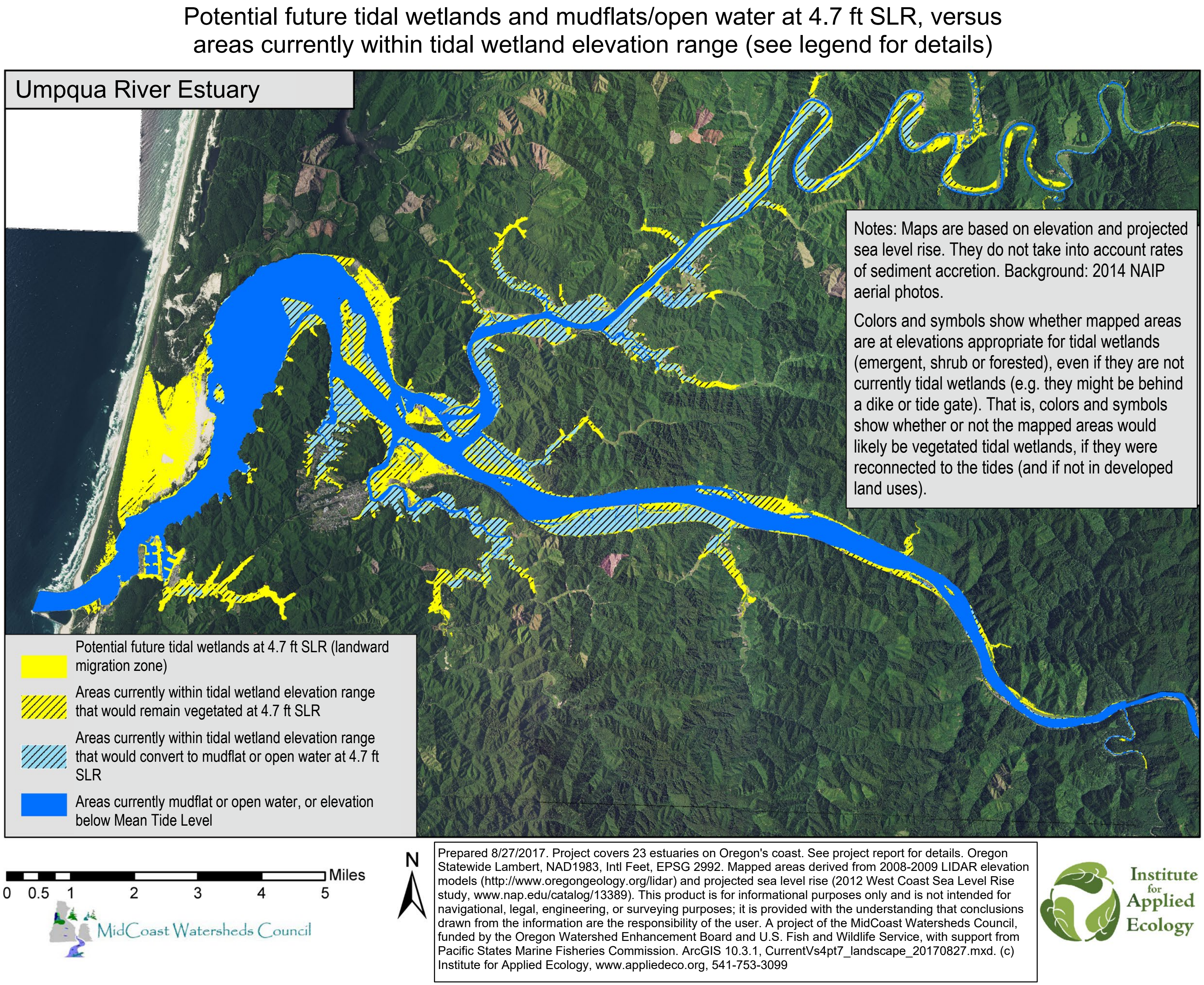
Incorporating social characteristics is important (see McEvoy et al., 2026), as they help reveal which communities may be vulnerable to and have the capacity to recover from coastal hazards. This work represents the first effort to overlay community capacity and vulnerability data onto LMZs on the Oregon Coast, filling a notable gap in available planning information. We hope the results will assist you, as conservation partners, planning department staff, and local communities, in preparing for SLR impacts.

You can use the products from this report to identify areas within the LMZs where preparing now could have the most benefits in the future. Active restoration—as well as land use planning that ensures compatibility with future tidal wetlands—could provide ecological function and help human communities adapt to SLR.

This report provides the following tools to assist in these efforts:

- a Sub-Estuary Unit (SEU) Metrics Consequence Table that summarizes ecological and infrastructure metrics, described later in this report, to help define the best return on investment when deciding the locations for NBS projects and what types to pursue; and
- a Social Data Consequence Table that organizes census data related to a community's capacity to adapt to or recover from coastal hazards like flooding to better understand how potential NBS projects may intersect with considerations around equity.

Figure 1. Example from Umpqua River Estuary of the LMZ at the 4.7-ft (1.4-m) SLR scenario (Brophy & Ewald, 2017).



The information in these tools is color-coded so it can be interpreted without the need for technical expertise. You may wish to use these tables to evaluate specific sections of your relevant estuaries for vulnerabilities, as well as where NBS projects may provide some relief.

The "Initial Observations and Interpretations of the Data" section of this report provides some examples of how to use the tools for this purpose. The following sections describe how we conducted this analysis.

Ecological and infrastructure data methods and products

This section outlines the rationale and methods used to develop the datasets described in this report, as well as guidance on how to apply them within a decision-making framework. We incorporated datasets appropriate to multiple spatial scales, with the smallest unit of analysis being relatively fine-grained (mean area of 0.27 ac [0.001 km^2]). See Appendix A for details. Each LMZ-unit (described in the next section) was attributed with its corresponding estuary, relevant soil information, and specific SLR scenarios projected to inundate that unit. Each LMZ-unit was a member of at least one SLR scenario, though most were involved in two or more scenarios.

Defining the LMZ-units

The LMZ data showed the potential extent of tidally influenced lands under seven SLR scenarios (baseline [0 ft], 0.8 ft, 1.6 ft, 2.5 ft, 4.7 ft, 8.2 ft, and 11.5 ft). While all of these scenarios were included in the ecological metrics' analysis, we only conducted the analysis of infrastructure impacts for one—the 4.7-ft (1.4-m) SLR scenario—because, as Brophy and Ewald (2017) observed, this is the point where many estuaries are predicted to have a marked change in area. According to recent SLR modeling by the National Oceanic and Atmospheric Administration (NOAA; Sweet et al., 2022), in the next 80 years, SLR in Oregon will reach at least 3 ft (0.9 m) and could reach as much as 6 ft (1.8 m) by 2100. For much of Oregon, the 4.7-ft SLR represents an intermediate-high to high SLR scenario that provides a long-term planning horizon in which to prepare for the changes. Importantly, some infrastructure may still be impacted under low to intermediate SLR (i.e., below 4.7 ft), but those are not assessed here.

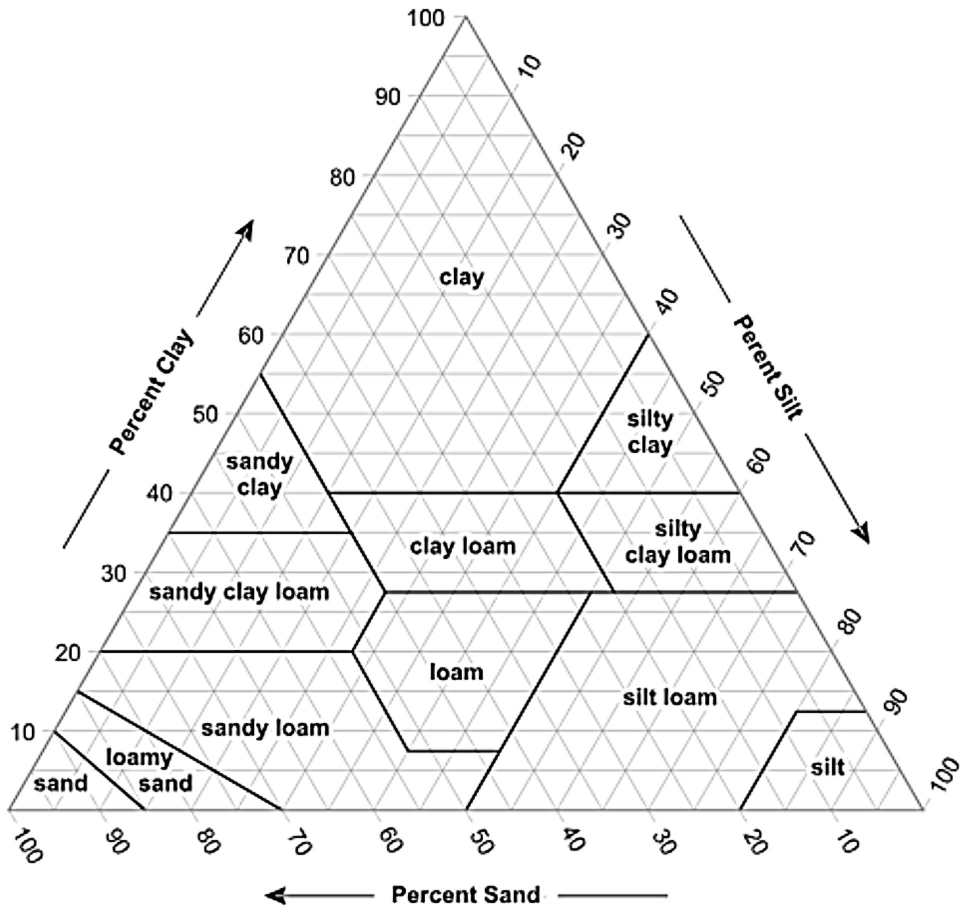
Each LMZ-unit was attributed with its mean land surface elevation from the 1/9th arc-second (~ 3 m) digital elevation models provided by the NOAA National Centers for Environmental Information.

Tide station Bench Mark Sheets from three estuaries distributed across the coast—Tillamook, Alsea, and Coos Bay—were used to establish the current average mean tide level (the average of the mean high water and mean low water over a specified period, representing a central reference point for tidal heights). This average, 4.35 ft (1.33 m), was used to correlate the elevations of the SLR scenarios to mean tide levels. For example, an SLR of 0 ft corresponds to a mean tide level of 4.35 ft. By comparing the mean elevation of each LMZ-unit to its adjusted SLR scenario mean tide level, the LMZ-unit could be placed into its tidal zone relative to that scenario: below mean tide, between mean tide and mean higher high water, or above mean higher high water. For example, if a polygon was projected to be inundated when the water is between mean tide and mean higher high water, it suggested the polygon would be regularly inundated by tides but not submerged so deeply that it would not support estuarine vegetation under that SLR scenario.

The next attribute assigned to the LMZ-units was soil texture, defined by the Natural Resources Conservation Service (NRCS). Soil texture is an important determinant of potential vegetation and can have relevance to restoration actions. Each polygon was assigned its relative proportions of clay, silt, and sand from NRCS's Web Soil Survey soil texture map (Soil Survey Staff, 2023). Soil texture was then derived using the NRCS soil texture triangle (Figure 2).

Soil information might be useful to determine what habitat projects may be appropriate for a project area. Sandy soils, for example, might not be suitable

Figure 2. Soil texture triangle (NRCS, 2018, Figure 3-7).



for shoreline hardening, while clay soils might best lend themselves to channel restoration.

Most estuaries in Oregon have multiple streams flowing into them and/or have distinct areas somewhat separate from the main estuary, such as sloughs and embayments. We used these geographic features within each estuary to assign all LMZ-units to the National Hydrography Dataset (NHD) feature most closely associated with their location and attributed them with the appropriate NHD common identifier (COMID). The LMZ-units were then dissolved into larger polygons called *sub-estuary units* (SEUs) using their COMIDs (e.g., Figure 3). Oregon's 23 estuaries were broken into 62 SEUs. These SEUs are a better match to the spatial scale of many of the attributes needed in project planning, such as building densities, population density, critical infrastructure, etc. The SEU scale is sufficiently large to estimate coarse estuarine function. A diversity of relative elevations and soils throughout an SEU area will probably provide more estuarine function than a homogenous suite of LMZ-units.

As a proxy for habitat diversity for each SEU in each SLR scenario, the summed area of unique *Tidal Zones and Soil Textures* was tabulated. For example, the total area within each SEU projected to be between mean tide and mean higher high water was summarized by its proportions of soil textures. As illustrated in Figure 4, these values were used to calculate:

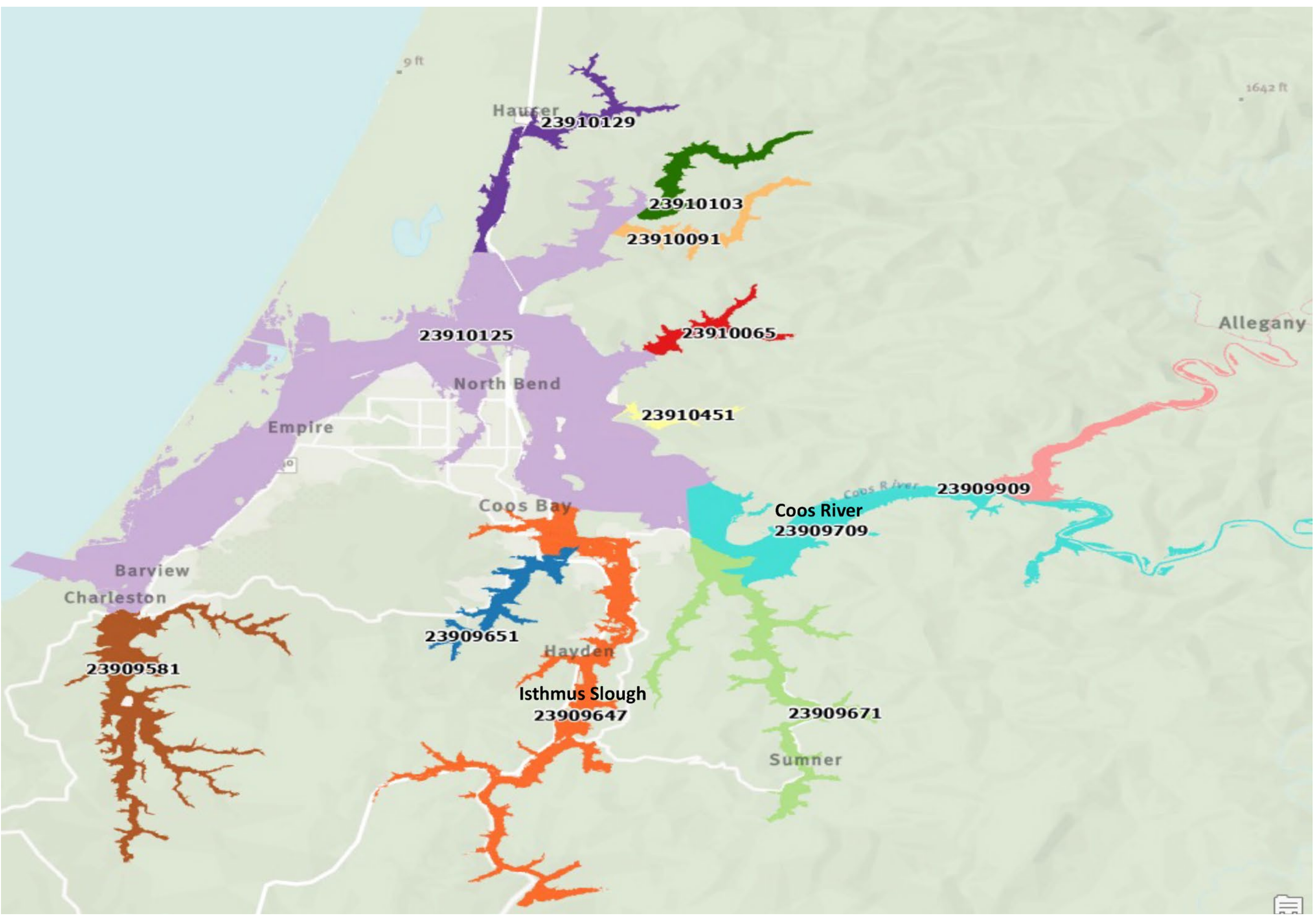
- The sum of potential habitat acres within each SEU in each SLR scenario.
- The Simpson's Diversity Index (SDI; Simpson, 1949) of those habitats within each SEU in each SLR scenario. Higher values indicate the SEU is

more likely to have a more diverse complement of habitats for that SLR scenario.

The graphs in Figure 4 show the change in habitat acres (top) and SDIs (bottom) for two SEUs within Coos Bay across all SLR scenarios (measured in feet of SLR). Both SEUs lose habitat over time as the estuary becomes confined by the Coast Range, but the Coos River SEU retains approximately 4 times as much habitat as Isthmus Slough and maintains higher SDI values at each time step. These findings suggest the Coos River SEU may be a better investment for habitat projects than Isthmus Slough.

Metrics such as the ones in this example can help define the best return on investment. For example, a conservation nonprofit might use the data to support an adaptation project when applying for grants. Or a city planning department might use the data to help choose the best among three potential improvement projects. The data values for all SEUs were included in a consequence table described in this report's upcoming section called "Ecological and Infrastructure Data Product." Also, Figure 5 summarizes the effects for different SLR scenarios for all major estuaries in Oregon south of the Columbia River, with sums of habitat acres for all their constituent SEUs (black lines in the graphs) and area-weighted averages of their SDIs (green lines).

Figure 3. Coos Bay example of SEUs at the 4.7-ft (1.4-m) SLR scenario created by dissolving LMZ-units by their COMIDs.



Note. The 8-bit numeric codes on the map are the NHD COMIDs assigned to the LMZ-units that fall within each of the shaded SEUs.

Figure 4. Examples from Coos Bay of (A) habitat acres and (B) SDI for two SEUs across all SLR scenarios.

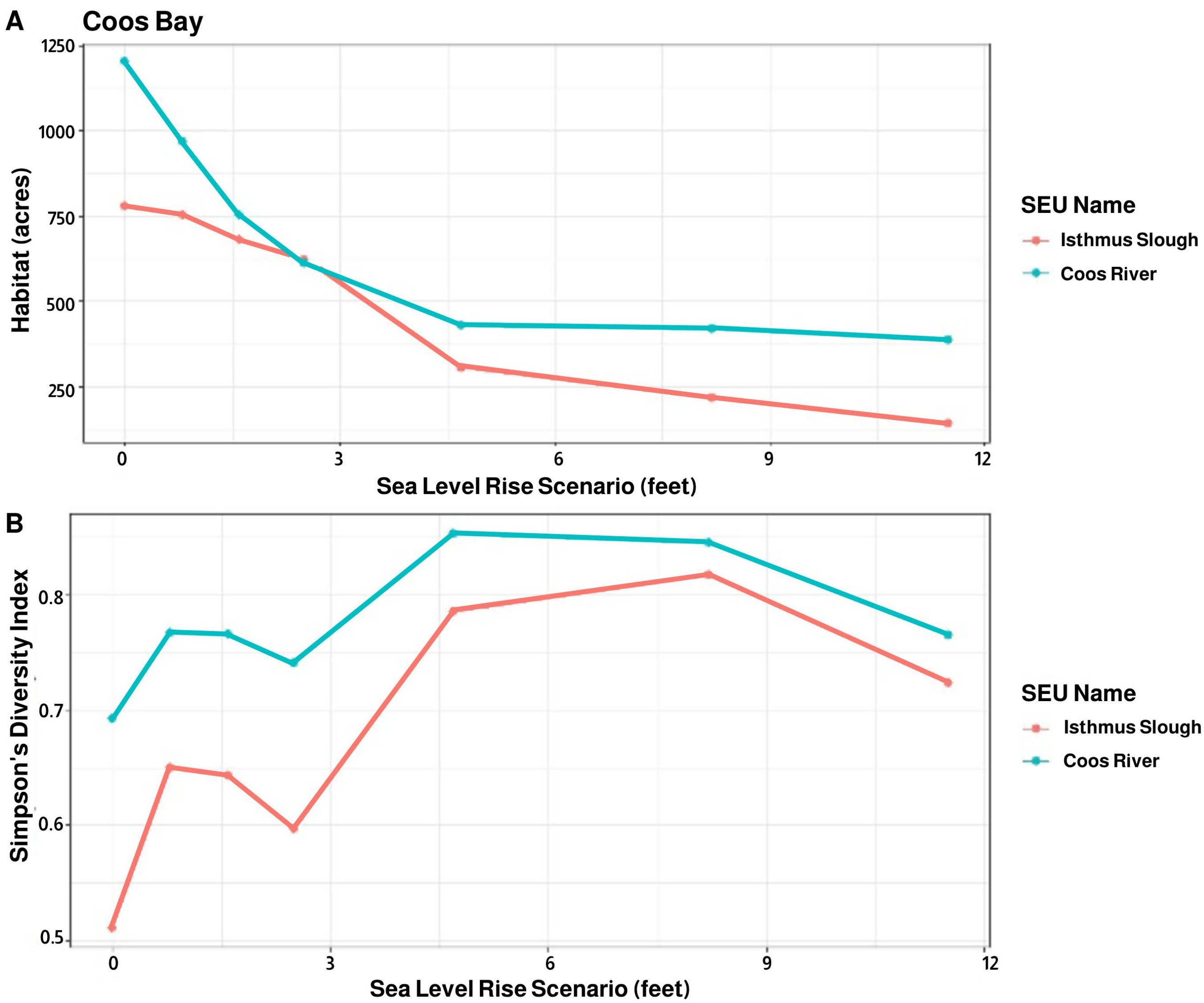


Figure 5. Summaries of SLR scenario effects for Oregon's major estuaries, with sums of habitat acres (black lines) and area-weighted averages of the SDIs (green lines).

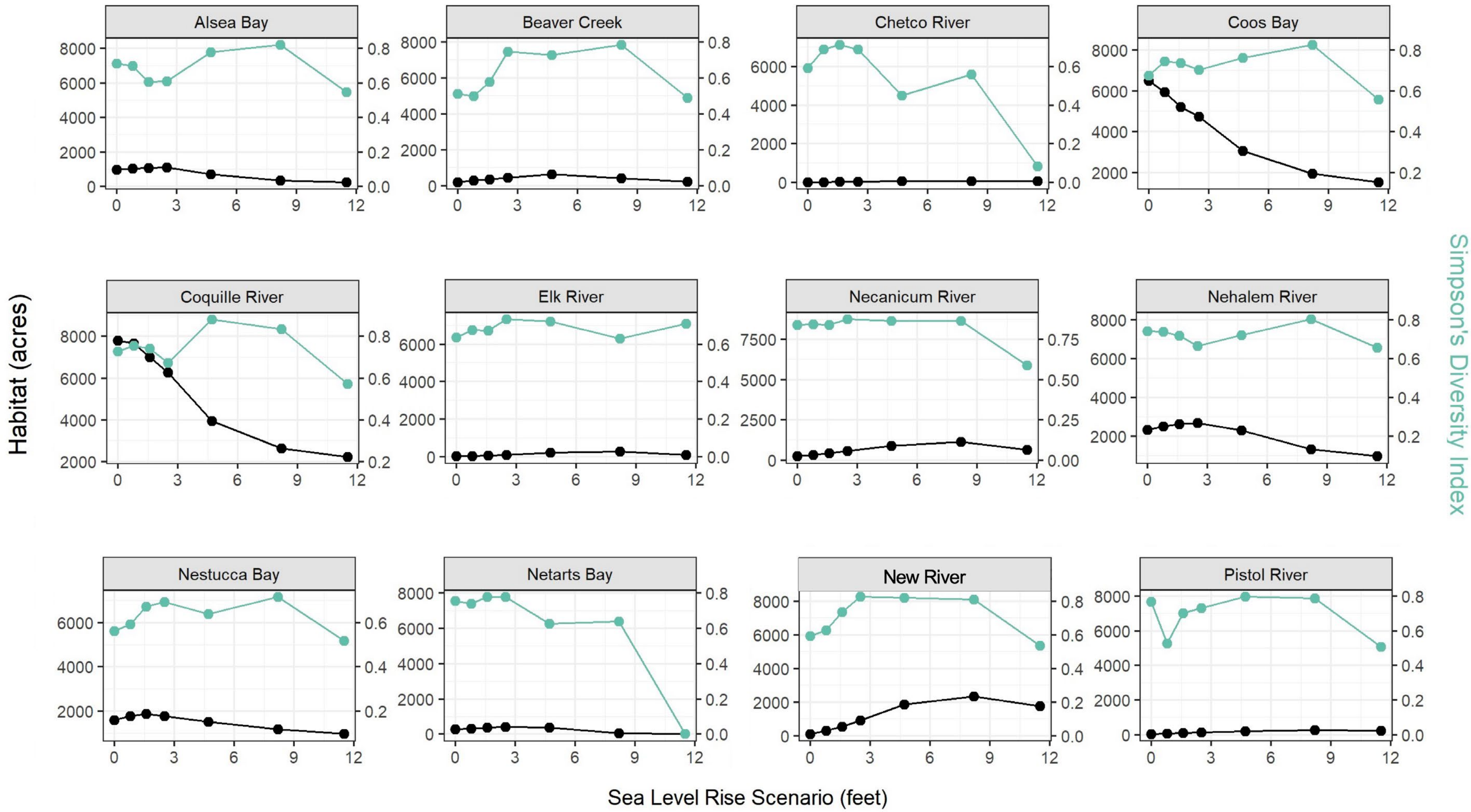
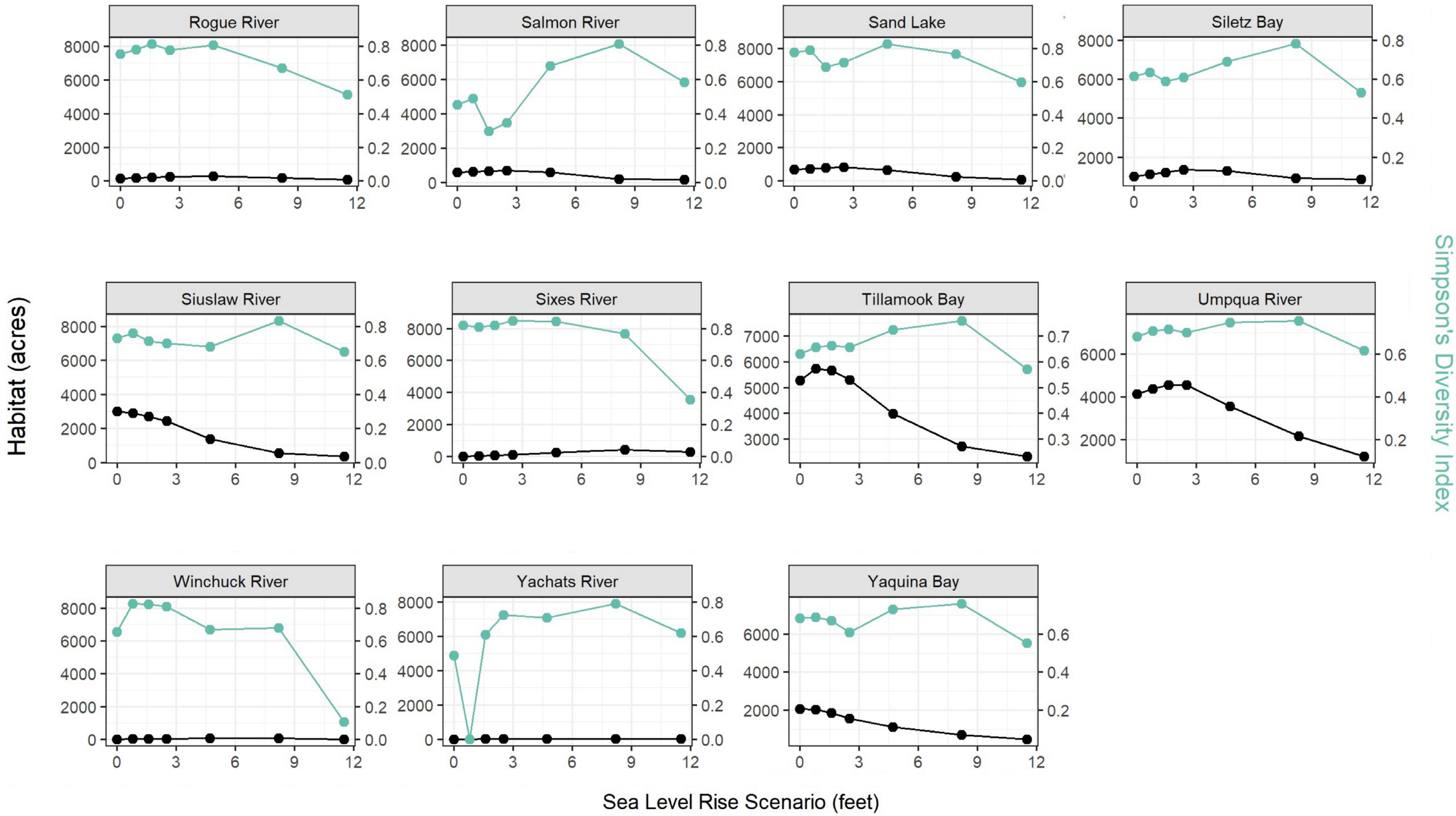


Figure 5 (continued).



Nearly all 23 estuaries in this analysis lose habitat as SLR changes over time, relative to the present day (Figure 5). While many estuaries retain habitat area until about 3 ft (0.9 m) of SLR, some, such as Coos Bay and the Coquille River, are projected to lose habitat area even under low levels of SLR. These findings powerfully demonstrate the importance of conservation or adaptation actions to allow remnant tidal wetlands to adapt to SLR and maximize habitat function. Examples of such adaptations include opening dikes to allow sediment inputs to raise wetland elevations or removing low-lying infrastructure to make more room for future tidal wetland habitat. Also, some areas may be better candidates for projects in the near term, and others at a later time, to retain the largest and most diverse assemblage of estuarine habitat over time.

Several other data layers were assigned to each SEU to give you additional context when evaluating potential project areas. Appendix B provides the complete set of data sources and attributes, along with explanations of how each dataset was applied in the SEU summaries and why it was included.

To incorporate these data layers, our project used the concept of *relative abundance* (RA). RA is a dimensionless measure that expresses the area-weighted abundance of a given attribute within a polygon. It allows direct comparison of that attribute's abundance in one polygon relative to all other polygons where the attribute occurs. Many of the data sources in Appendix B use RA as the reported metric.

RA was calculated as:

$$\frac{\textit{(Quantity of X within SEU / Total quantity of X across all SEUs)}}{\textit{(Area of SEU / Total area of all SEUs)}}$$

where X is the given attribute within the polygon (e.g., drinking water sources, flood hazard areas, public facilities).

Ecological and infrastructure data product: SEU Metrics Consequence Table

These datasets were analyzed using an SEU Metrics Consequence Table, prepared in Microsoft Excel, that summarizes the ecological and infrastructure metrics described in Appendix B. Consequence tables are commonly used in structured decision-making to compare the performance of different options using a consistent set of evaluation criteria (Hammond et al., 1999). Going forward, this table is intended to be used locally, allowing you and other users to compare SEUs across a wide range of planning needs. The SEU Metrics Consequence Table can be downloaded from the same webpage where this report is featured: www.conservationgateway.org/collections/oregon/oregons-future-tidal-wetlands.

While many of the underlying geographic information system (GIS) datasets have been mapped, data-use restrictions prevent us from making the maps publicly available. If you have specific mapping needs, you are welcome to contact the corresponding author listed on this report's inside cover to discuss access options or request customized maps.

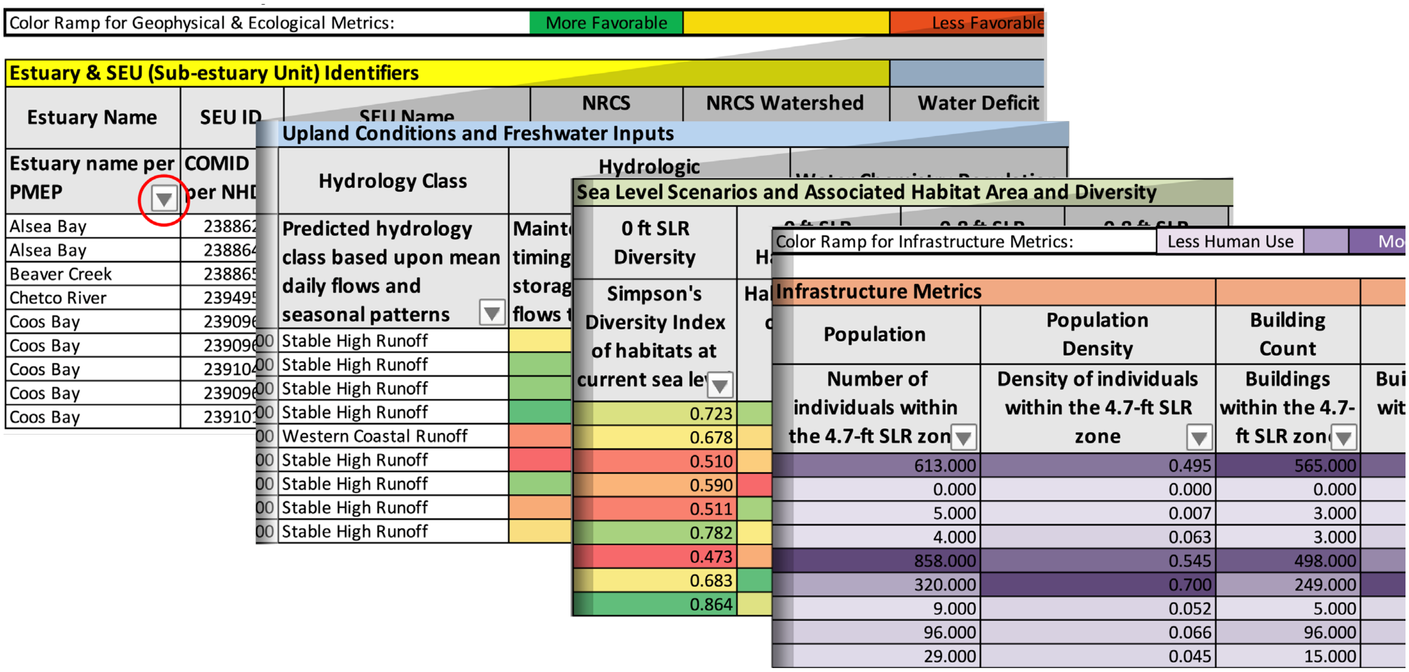
Figure 6 provides a sample of the SEU Metrics Consequence Table and the attributes available for viewing and comparison. When the table is opened, you will see three header rows that apply to all SEUs (note that Figure 6 displays only a subset of rows and columns):

- **Row 1** groups the data columns into four broad categories: Estuary and SEU Identifiers; Upland Condition and Freshwater Inputs; Sea Level Scenarios and Associated Habitat Area and Diversity; and Infrastructure Metrics.
- **Row 2** lists the metric names, generally matching the attribute names used in the GIS tables.
- **Row 3** provides a brief description of each metric.

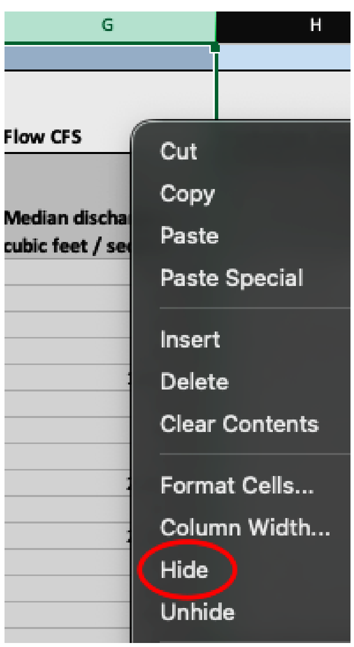
Rows 2 and 3 together function as a data dictionary when querying SEU features in the GIS environment. The second row is intentionally left blank for the RA calculations within the Infrastructure Metrics section, as those values are not included in the GIS data table.

Figure 6. (A) A screenshot from portions of the SEU Metrics Consequence Table and (B) the Excel context menu that allows you to hide columns.

A



B



The third row also includes the filter and sort functions supported by Excel, as indicated by the drop-down arrows in the lower right corner of each cell in Row 3; the first of these arrows is circled in red in Figure 6A. The filter function can be especially useful if you wish to compare a few SEUs without the clutter of all SEU data.

Columns can also be hidden to remove metrics from view that may not pertain to your needs. Select the column (or contiguous columns) you wish to hide, right-click at the very top of the column, and select "Hide" from the drop-down menu, as shown in Figure 6B. Use "Unhide" later to restore the column(s).

Two color ramps are used throughout the SEU Metrics Consequence Table to highlight the fields most relevant to interpreting these data. Attributes in the Geophysical and Ecological categories use a green-to-red gradient, where greener tones indicate stronger or more favorable natural conditions. Infrastructure metrics use a light-to-dark purple gradient, with darker shades reflecting higher levels of human use or habitat modification. Each color ramp is scaled across all 62 SEUs in a given column, meaning the full color range appears for every metric regardless of how wide or narrow its underlying values are. As a result, strong color contrasts may occur even when the actual numerical differences are small or unevenly distributed. Examples of how to interpret the color variations and contrasts are provided in this report's "Initial Observations and Interpretations of the Data" section, which illustrates some project types you might pursue based on these data.

Social data methods and products

Rationale

Social datasets were incorporated into this analysis to better understand how opportunities for potential NBS projects may intersect with equity considerations. Our goal was to increase awareness and opportunities for conservation activities to provide benefits equitably and avoid causing harm or negative consequences for the communities involved. Going forward, you can use the social datasets to provide a quantitative estimate of the ability of a community to adapt to or recover from coastal hazards like flooding, storm surges, and SLR. The term "vulnerability" is broadly used to reflect multiple factors that potentially influence adaptation and recovery, including:

- Vulnerability due to characteristics in demographic or household composition that may make the household more likely to require assistance in the event of a natural disaster, including financial support, transportation, or medical care.
- Vulnerability due to characteristics that increase the likelihood of damage to persons or property or provide barriers for evacuation or temporary relocation. They include residential characteristics like mobile homes or multiunit housing, as well as household access to transportation.
- Vulnerability due to barriers to participation in local flood protection decisions, actions, or disaster-related communication efforts, such as language barriers.

The above list of factors contributing to a community's level of vulnerability to coastal hazards is simplified and imperfect. It does not explicitly address any interactions among factors and does not address the complex and historical causes that contribute to inequities within a community.

Social data product: Social Data Consequence Table

The social variables collected for this project were extracted at the block group and census tract levels (U.S. Census Bureau, 2023). See Appendix A for details. Similar to the ecological and infrastructure data product described earlier in this report, the social data were organized into a Social Data Consequence Table, which is intended to assist you by providing a visual guide to compare the ranking of social variables among SEUs. The Social Data Consequence Table can be downloaded from the same webpage where this report is featured: www.conservationgateway.org/collections/oregon/oregons-future-tidal-wetlands. When the table is open (see Figure 7), you will notice a color ramp in the second row above a series of columns containing information describing each estuary and unit. These are followed by the social data.

We divided each estuary into smaller SEUs, as described previously. However, SEU boundaries do not coincide with the boundaries of the census block groups. The block groups were intersected with the SEU boundaries to map the social variables to the units of this analysis.

The social variables in the Social Data Consequence Table are organized into four dimensions: Demographics, Socioeconomic Status, Language and Education, and Housing and Transportation. These dimensions encapsulate group variables that contribute to the definition of vulnerability discussed in the previous "Rationale" section. See Table 1 for a more detailed explanation of how each variable addresses aspects of vulnerability to coastal hazards. The color ramp is a visual indicator of each variable's directionality relative to its ranking within the dataset. The data are ranked so that higher values indicate higher levels of vulnerability to coastal hazards and appear in darker colors. The only exceptions are for the variables Per Capita Income and Houses Where the Owner Resides Elsewhere, which are ranked in reverse (e.g., areas with lower per capita income are more vulnerable), but the color ramp is preserved for visual consistency.

Figure 7. Screenshot from portions of the Social Data Consequence Table.

LMZ Social Data Consequence Table

Color Ramp: Less Vulnerable — Most vulnerable

Estuary Name	SEU_ID	SEU_Name	GEOID	Demographics: Households with Members <17 (%)	Households with Members >65 (%)	Single Parent Households (%)	People living with a Disability (%)	People with Difficulty Living Independently (%)	Socioeconomic Status: Per Capita Income ($)	People Below Poverty Level (%)	People Unemployed (%)
Yaquina Bay	23880632	Yaquina Bay	410419511002	16.10	50.13	23.13	16.44	6.30	27086.00	19.79	2.24
Yaquina Bay	23880636	Yaquina River (Boone Slough reach)	410419511002	16.10	50.13	23.13	16.44	6.30	27086.00	19.79	2.24
Yaquina Bay	23880660	Yaquina River (Elk City reach)	410419514001	52.97	27.06	16.51	17.32	6.84	22686.00	13.76	11.72
Yaquina Bay	23880718	Upper Yaquina River	410419514001	52.97	27.06	16.51	17.32	6.84	22686.00	13.76	11.72
Yaquina Bay	23882302	Depot Slough	410419514001	52.97	27.06	16.51	17.32	6.84	22686.00	13.76	11.72
Yaquina Bay	23882306	Olalla Creek	410419514001	52.97	27.06	16.51	17.32	6.84	22686.00	13.76	11.72
Siuslaw River	23889434	Lower Siuslaw River	410390007052	6.58	77.02	1.09	28.44	10.36	24700.00	21.22	0.00
Siuslaw River	23889434	Lower Siuslaw River	410390007021	16.50	57.52	10.51	20.74	7.52	25204.00	35.92	6.75
Siuslaw River	23889434	Lower Siuslaw River	410390007082	11.81	56.12	0.00	25.10	11.69	38473.00	16.28	5.49
Siuslaw River	23889438	Siuslaw River	410390005001	21.80	50.17	12.37	24.12	8.83	26603.00	20.06	2.08
Siuslaw River	23889438	Siuslaw River	410390007021	16.50	57.52	10.51	20.74	7.52	25204.00	35.92	6.75
Siuslaw River	23889438	Siuslaw River	410390007082	11.81	56.12	0.00	25.10	11.69	38473.00	16.28	5.49
Siuslaw River	23889454	Sweet Creek	410390005001	21.80	50.17	12.37	24.12	8.83	26603.00	20.06	2.08
Siuslaw River	23889874	North Fork Siuslaw River	410390007082	11.81	56.12	0.00	25.10	11.69	38473.00	16.28	5.49
Umpqua River	24526588	Scholfield Creek	410190200002	9.97	56.70	3.85	23.70	8.01	25209.00	4.89	9.36
Umpqua River	24526614	Umpqua River	410190200002	9.97	56.70	3.85	23.70	8.01	25209.00	4.89	9.36

Note. The top red circle highlights the color ramp's legend. For all variables, darker colors indicate greater vulnerability to coastal hazards. In most cases, higher values indicate greater vulnerability levels, except for Per Capita Income and Houses Where the Owner Resides Elsewhere, for which lower values indicate greater vulnerability. The lower-left red circle shows the SEU attributes and related information, including the estuary name and the unique identifiers (GEOIDs) for census block groups. The lower-right red circle highlights a portion of the data categories and social variables.

Table 1. Dimensions and variables used to assess communities' vulnerability to coastal hazards and how they relate to disaster response, as reported in the Social Data Consequence Table.

Dimension	Variables	Rationale	Relationship to Vulnerability
Socioeconomic Status	Per Capita Income	High-income households are more likely to have assets and resources to prepare or recover from natural disasters	–
	Persons Below Poverty Level (%)	Monetary losses represent a larger proportion of total household assets compared to high-income households	+
	Persons (age 16+) Unemployed (%)	Employment is associated with per capita income as well as benefit plans that provide income and cost assistance	+
Language and Education	People Without a High School Diploma (%)	Education is indirectly associated with reduced poverty and increased social capital	+
	People With Limited English Proficiency (%)	Successfully communicating during a disaster and comprehending related notifications is generally more difficult with limited English proficiency	+
Housing and Transportation	Households Without a Vehicle (%)	Evacuating from natural disasters is more difficult without access to transportation	+

Dimension	Variables	Rationale	Relationship to Vulnerability
	Households Living in Mobile Homes (%)	Mobile homes are not designed to withstand severe weather or flooding and are often clustered in dense communities, increasing overall vulnerability	+
	Houses Where Owner Resides Elsewhere (%)	Homes owned for vacations or other temporary living arrangements do not represent the same level of risk as homes with permanent residents	−
	Houses That Are Renter-Occupied (%)	People living in rented households are less likely to benefit from the same level of protections that homeowners are provided, such as insurance assistance and governmental support	+
	Households Living in Multiunit Structures (%)	Multiunit housing is associated with overcrowded escape routes and building owners less likely to pursue hazard mitigation strategies	+
	People Living in Crowded Conditions (%)	Crowding within housing units exacerbates congested escape routes and evacuation difficulties	+
	People Living in Group Quarters * (%)	Individuals in group quarters—such as skilled nursing facilities, worker dormitories, and prisons—can present special concerns during evacuation due to staffing, specialized transportation needs, and the specialized needs of the individuals	+
Demographics	People Living With a Disability * (%)	People with physical, sensory, or cognitive challenges may require assistance from others, specialized medical care, or other forms of support	+
	People With Difficulty Living Independently (%)	People who have difficulty living independently are more likely to require assistance or special accommodations	+
	Single-Parent Households * (%)	Single-parent households are associated with lower socioeconomic status and may face unique challenges associated with being the sole caretaker	+
	Households With Members > 65 (%)	Elders may require special needs, transportation assistance, or medical care	+
	Households With Members < 17 (%)	Children lack the ability and resources to protect themselves in the event of a disaster and are rarely considered in disaster scenario planning	+

Note. All data were extracted at the block-group scale unless otherwise noted. Variables reported at the tract level are denoted with an *.

Interpreting the social data

The intention of the Social Data Consequence Table is to provide a rigorous evidence base to help you understand and describe the social characteristics of an SEU. However, this information is not intended to be used as the sole source of information for prioritizing opportunities or identifying project areas. Appropriate uses of these data include querying for descriptive information to include in grant proposals and reports, comparing social characteristics between estuary sites, cross-walking with ecosystem services and benefits that can potentially be conferred following project implementation, and describing the local social characteristics where conservation work touches down.

When using these data, take care in interpreting and communicating findings to prevent perpetuating negative connotations or harmful narratives. For example, labeling a community as "vulnerable" insinuates that the community is somehow problematic or weak. This kind of language can contribute to harmful assumptions about intrinsic characteristics of certain groups that make them more likely to experience negative outcomes compared to others. One best practice to consider when using data like the ones presented here is to use people-first language. For example, saying "natural disasters affect vulnerable communities" implies that some communities are inherently weaker than others, and natural disasters are one of many things that will contribute to negative outcomes. Alternatively, saying "communities that are vulnerable to natural disasters" more clearly communicates that there are factors of concern related specifically to risks associated with natural hazards without implying that the community is inherently flawed.

Decision tree by project type

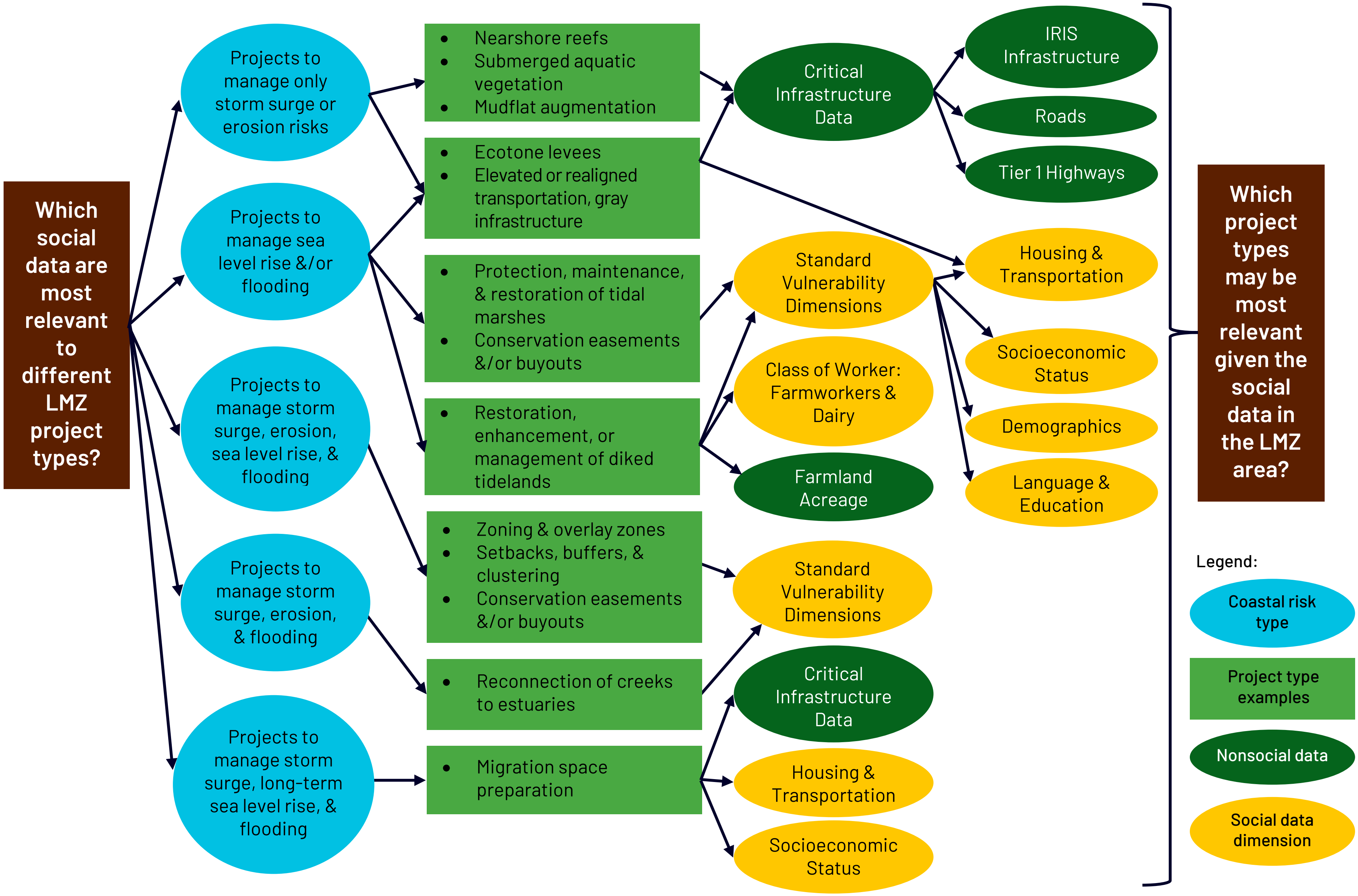
Decisions regarding which social data to include in this report were influenced by the type of project you and others are likely to assess when using the tools described in this report. For example, when considering reopening diked lands to restore tidal inundation, it would be prudent to consult data on the class of workers in the farming or dairy industry that could be negatively impacted by a significant reduction in farmland acres.

We constructed a Social Data and Project Type Decision Tree to provide guidance for selecting relevant social data or projects given specific social vulnerabilities to be addressed (Figure 8). The *San Francisco Bay Shoreline Adaptation Atlas* (SFEI & SPUR, 2019) provided a good source of project types and kinds of coastal risks they could help address.

The "Standard Vulnerability Dimensions" mentioned in Figure 8 are all four social data dimensions found in the Social Data Consequence Table: Socioeconomic Status, Language and Education, Housing and Transportation, and Demographics. See Table 1 above for more details.

Flooded houses in Neskowin, OR, with Proposal Rock in the distance; drone footage from 2021. © Kami Ellingson, TNC.

Figure 8. Social Data and Project Type Decision Tree.



Initial observations and interpretations of the data

This section provides examples of how you can use the consequence tables to assess potential project areas to address SLR vulnerabilities, considering both ecological and human characteristics. Using the color ramps in the SEU Metrics Consequence Table, some of the SEUs can be placed in different categories of potential project types. Examples from the SEU Metrics Consequence Table and the Social Data Consequence Table appear in Figure 9 to Figure 19. Primarily, these examples show the broad differences among three category groupings:

- **Group 1**: SEUs with good potential for ecological outcomes,
- **Group 2**: SEUs that might offer good potential for NBS projects—i.e., ecological and people benefits, and
- **Group 3**: SEUs with data indicating unfavorable conditions for ecological or people benefits.

For interpretation of the ecological data (other than acres) and much of the infrastructure data, the color of the cell will be more meaningful than the number in the cell since the number represents the RA factor described in the "Ecological and Infrastructure Data Methods and Products" section. To see the full set of details associated with all SEUs, please open the SEU Metrics Consequence Table available from the same webpage where this report is featured: www.conservationgateway.org/collections/oregon/oregons-future-tidal-wetlands.

Group 1. SEUs with good potential for ecological outcomes

Ecological SEUs are those with characteristics that make them resilient to water level change across SLR scenarios (i.e., lots of green and yellow cells) but have limited people or infrastructure conflicts (very few dark purple cells). For SEUs with fewer people (Population and Population Density), the social data should still be consulted for equity considerations (see the upcoming discussion in this section). The SEUs in the following list (and in Figures 9 and 10) have good potential for ecological outcomes:

- Alsea Bay, Drift Creek (Alsea), 23886466
- Elk River, 23920488
- New River Area (Twomile Cr. S., Fourmile Cr.), New River, 23920852
- Tillamook Bay, Trask River, 23875817
- Tillamook Bay, Tillamook River, 23875797
- Umpqua River, 24526614

The most illustrative SEU in Group 1 is the **New River Area**. Under current conditions (SLR 0-ft), the habitat acres (83 ac [0.34 km^2]) are on the low side, but both acres and habitat diversity are projected to increase under future SLR scenarios (Figure 9). The tidal habitats could increase to cover around 2,000 ac (8.09 km^2) in the 4.7-ft to 11.5-ft (1.4-m to 3.5-m) scenarios! This is the only SEU projected to increase in acres across all scenarios. And under the 4.7-ft scenario, there are currently no people living in the LMZ area, only two buildings, and very little transportation infrastructure. Only a small portion of the area is zoned for development. So, estuary restoration projects in this area are likely to have greater success under SLR. The one upland and freshwater condition with a moderate ranking is Hydrologic Regulation, so projects to improve this condition would also be prudent. Protecting this area from changes in the current development status and zoning might also be warranted.

Even though the population and infrastructure data table (Figure 10) indicates that the LMZ SEU in the New River is not currently inhabited (Population and Population Density are zero), there are still social elements (Figure 11) worth considering with respect to project scoping. The New River area coincides with a block group that includes a high proportion of households with people over the age of 65, as well as people living with a disability and difficulty living independently. These populations typically require more assistance in the event of a disaster, such as access to appropriate transportation or medical facilities. On the other hand, this census block is also characterized by a relatively low proportion of renters, low levels of crowding or congestion due to multiunit housing or group quarters, and a high proportion of households with access to a vehicle—all characteristics that can contribute to a person's ability to recover from a hazardous event.

Given this information, additional considerations in the conservation planning process might focus on ways to improve accessibility and access. For example, plans might be made to ensure the restoration site is accessible to those with diverse abilities, or special care may be taken to prevent any negative impacts to roads or important routes of egress should coastal hazards occur (e.g., flooding).

Another example of how social data might inform projects within this ecologically focused group is the **Trask River** in Tillamook Bay (Figure 12).

This area seems to be a multigenerational community (relatively high proportion of households with members below 17 and over 65) with a high percentage of people with limited English proficiency and low per capita income. One or two of the block groups have a high percentage of single-parent households, people without a high school diploma, and/or people below the poverty level. Most of the houses are renter-occupied, and there is a moderate proportion of people living with disabilities and difficulty living independently.

If restoration projects are considered in this SEU, it will be necessary to research which languages are typically spoken, to ensure outreach efforts are available in those languages, and to use imagery as much as possible. Given that households are mostly primary residences of low-income families, projects might be designed to help protect homes from future flooding, such as with setback levees. Care should be taken to look for sources of information that can help evaluate the effect on employment for farm workers to get a sense of how much this community might be burdened by taking land out of production.

Figure 9. Ecological data for SEUs in Group 1.

Color Ramp for Geophysical & Ecological Metrics: More Favorable — Less Favorable

Estuary & SEU (Sub-estuary Unit) Identifiers		Upland Conditions and Freshwater Inputs						
Estuary Name	SEU Name	Hydrologic Regulation	Water Chemistry Regulation	Sediment Regulation	Hydrologic Connectivity	Temperature Regulation	Habitat Provision	Integrated Watershed Index
Alsea Bay	Drift Creek (Alsea)	0.999	0.970	0.987	0.993	0.991	0.985	0.928
Elk River	Elk River	0.995	0.959	0.990	0.991	0.990	0.987	0.916
New River Area (Twomile C	New River	0.997	0.975	0.988	0.991	0.989	0.986	0.928
Tillamook Bay	Trask River	0.988	0.957	0.976	0.980	0.976	0.970	0.857
Tillamook Bay	Tillamook River	0.988	0.959	0.979	0.974	0.980	0.973	0.862
Umpqua River	Umpqua River	0.989	0.979	0.976	0.982	0.981	0.968	0.882

Estuary & SEU (Sub-estuary Unit) Identifiers		Sea Level Scenarios and Associated Habitat Area and Diversity													
Estuary Name	SEU Name	0 ft SLR Diversity	0 ft SLR Habitat Acres	0.8 ft SLR Diversity	0.8 ft SLR Habitat Acres	1.6 ft SLR Diversity	1.6 ft SLR Habitat Acres	2.5 ft SLR Diversity	2.5 ft SLR Habitat Acres	4.7 ft SLR Diversity	4.7 ft SLR Habitat Acres	8.2 ft SLR Diversity	8.2 ft SLR Habitat Acres	11.5 ft SLR Diversity	11.5 ft SLR Habitat Acres
Alsea Bay	Drift Creek (Alsea)	0.678	210.706	0.664	223.504	0.536	237.487	0.575	253.236	0.722	151.148	0.745	60.753	0.680	43.208
Elk River	Elk River	0.634	5.339	0.674	15.970	0.673	40.544	0.733	83.433	0.721	210.740	0.628	260.144	0.841	69.388
New River Area (Twomile C	New River	0.594	83.121	0.627	277.554	0.735	517.561	0.825	901.518	0.819	1,861.013	0.810	2,340.764	0.731	1,748.281
Tillamook Bay	Trask River	0.729	773.770	0.734	886.971	0.732	1,003.210	0.730	1,105.430	0.758	1,139.128	0.769	1,027.463	0.758	991.605
Tillamook Bay	Tillamook River	0.595	2,137.366	0.630	2,187.932	0.680	1,939.159	0.681	1,441.421	0.737	950.238	0.765	606.074	0.768	439.714
Umpqua River	Umpqua River	0.655	810.837	0.733	852.235	0.730	819.158	0.767	702.033	0.744	539.702	0.857	287.134	0.847	220.958

Figure 10. Population and infrastructure data for SEUs in Group 1.

Color Ramp for Infrastructure Metrics: Less Human Use — More Human Use

Estuary & SEU (Sub-estuary Unit) Identifiers		Infrastructure Metrics				
Estuary Name	SEU Name	Population	Population Density	Building Count	Building Density	Building SqFt
Estuary name per PMEP	Reach/NHD feature name	Number of individuals within the 4.7-ft SLR zone	Density of individuals within the 4.7-ft SLR zone	Buildings within the 4.7-ft SLR zone	Building density within the 4.7-ft SLR zone	Square footage of buildings within the 4.7-ft SLR zone
Alsea Bay	Drift Creek (Alsea)	0.000	0.000	0.000	0.000	0.000
Elk River	Elk River	0.000	0.000	0.000	0.000	0.000
New River Area (Twomile Ci	New River	0.000	0.000	2.000	0.001	3,005.286
Tillamook Bay	Trask River	163.000	0.098	158.000	0.095	1,472,816.204
Tillamook Bay	Tillamook River	215.000	0.075	164.000	0.057	1,027,623.959
Umpqua River	Umpqua River	30.000	0.026	28.000	0.024	67,273.012

Estuary & SEU (Sub-estuary Unit) Identifiers		Infrastructure Metrics										
Estuary Name	SEU Name	Relative Abundance (RA) is an area-weighted measure of abundance within the 4.7-ft SLR zone. The metrics below are all based on RA. RA = (Quantity of *X* within SEU/Summed quantity of *X* within all SEUs)/(Area of SEU/Summed Area of all SEUs)										
Estuary name per PMEP	Reach/NHD feature name	Drinking Water Resources (Range: 0 - 24.6 Avg. 2.8)	Emergency Response Resources (Range: 0 - 29.6 Avg. 1.2)	Flood Hazard Areas (Range: 0 - 6.3 Avg. 1.25)	Potential Toxics Source (Range: 0 - 52 Avg. 1.9)	Public Facilities (Range: 0 - 18.4 Avg. 1.1)	Transportation Infrastructure (Range: 0 - 112 Avg. 4.3)	Tsunami Critical Facilities (Range: 0 - 19 Avg. 1.6)	Urban Growth Boundary (Range: 0 - 24.5 Avg. 1.6)	Zoning - Commercial and Industrial (Range: 0 - 27.2 Avg. 1.5)	Zoning - Farm, Forest and Open Space (Range: 0 - 5.4 Avg. 1.2)	Zoning - Residential (Range: 0 - 10.8 Avg. 1.5)
Alsea Bay	Drift Creek (Alsea)	1.032	0.000	1.197	0.000	0.000	0.065	0.000	0.000	0.000	0.942	0.076
Elk River	Elk River	0.597	0.000	0.665	0.000	0.000	0.235	0.000	0.000	0.000	0.574	0.000
New River Area (Twomile Ci	New River	0.476	0.000	0.634	0.000	0.000	0.028	0.000	0.000	0.018	0.341	0.085
Tillamook Bay	Trask River	1.660	0.000	0.099	2.109	0.000	2.693	0.983	0.446	0.323	0.606	0.245
Tillamook Bay	Tillamook River	4.269	0.000	0.004	0.741	0.000	2.162	1.768	0.000	0.365	1.147	0.407
Umpqua River	Umpqua River	1.376	0.000	1.348	0.077	0.000	0.448	0.000	0.200	1.251	2.235	0.000

Figure 11. Social data for the New River SEU.

Color Ramp for Social Data: Less Vulnerable → Most Vulnerable

		Demographics					Socioeconomic Status			Language and Education		Housing and Transportation						
Estuary Name	SEU_Name	Households with Members <17 (%)	Households with Members >65 (%)	Single Parent Households (%)	People living with a Disability (%)	People with Difficulty Living Independently (%)	Per Capita Income ($)	People Below Poverty Level (%)	People Unemployed (%)	People Without a High School Diploma (%)	People with Limited English Proficiency (%)	Households without a vehicle (%)	Households living in multi-unit structures (%)	Houses where owner resides elsewhere (%)	Houses that are Renter Occupied (%)	Households Living in Mobile Homes (%)	People living in crowded conditions (%)	People Living in Group Quarters (%)
New River Area (Twomile Cr. S., Fourmile Cr.,	New River	7.73	47.68	0.00	27.67	12.33	33392.00	11.44	0.00	0.00	0.00	0.00	0.00	0.00	28.46	21.01	0.00	2.87
New River Area (Twomile Cr. S., Fourmile Cr.,	New River	11.99	68.32	5.57	28.86	14.01	20698.00	19.63	4.52	3.83	0.07	3.77	0.00	0.00	5.98	5.21	2.23	0.31

Figure 12. Social data for the Trask River SEU.

Color Ramp for Social Data: Less Vulnerable → Most Vulnerable

		Demographics					Socioeconomic Status			Language and Education		Housing and Transportation						
Estuary Name	SEU_Name	Households with Members <17 (%)	Households with Members >65 (%)	Single Parent Households (%)	People living with a Disability (%)	People with Difficulty Living Independently (%)	Per Capita Income ($)	People Below Poverty Level (%)	People Unemployed (%)	People Without a High School Diploma (%)	People with Limited English Proficiency (%)	Households without a vehicle (%)	Households living in multi-unit structures (%)	Houses where owner resides elsewhere (%)	Houses that are Renter Occupied (%)	Households Living in Mobile Homes (%)	People living in crowded conditions (%)	People Living in Group Quarters (%)
Tillamook Bay	Trask River	17.93	27.59	22.86	20.29	6.50	29222.00	17.81	7.22	13.11	17.12	13.79	4.76	17.37	41.18	1.75	2.07	0.00
Tillamook Bay	Trask River	51.62	27.57	70.50	20.29	6.50	21260.00	8.22	0.99	2.09	17.12	9.19	1.62	17.37	76.24	0.00	4.86	0.00
Tillamook Bay	Trask River	4.45	18.49	0.00	23.48	10.33	19395.00	41.73	3.45	8.18	2.37	3.08	2.83	12.76	45.45	41.01	0.00	0.28
Tillamook Bay	Trask River	35.82	40.30	33.33	20.29	6.50	26758.00	25.35	0.00	2.13	17.12	10.45	1.37	17.37	54.16	0.00	6.47	0.00
Tillamook Bay	Trask River	40.57	41.99	18.30	20.10	7.84	18273.00	4.33	0.00	20.66	16.18	4.98	20.41	0.00	67.11	0.00	38.08	0.63
Tillamook Bay	Trask River	28.30	28.30	41.21	20.10	7.84	24913.00	42.93	5.40	20.33	16.18	0.00	0.00	0.00	55.43	28.78	0.00	0.63
Tillamook Bay	Trask River	34.18	42.94	7.89	20.10	7.84	22508.00	13.74	0.00	9.50	16.18	15.75	15.90	0.00	53.49	13.21	13.67	0.63
Tillamook Bay	Trask River	17.38	48.93	13.89	20.10	7.84	22984.00	21.96	15.72	9.95	16.18	11.59	9.84	0.00	34.39	0.00	0.00	0.63

Neskowin Creek at the bridge on South Beach Rd. during the 2021 flood.
© Kami Ellingson, TNC.

Group 2. SEUs that might offer good conditions for NBS projects

The NBS SEUs, which appear in the following list and in Figures 13 and 14, are those in a given LMZ with potential ecological and people benefits. The units in Group 2 have fairly good upland and freshwater ranks and should be resilient across SLR scenarios (i.e., lots of green and yellow cells). They also have populations and infrastructure within the SEU (more dark purple cells), indicating that it might be possible to design projects that can benefit both people and nature (Table 2).

- Alsea Bay, Alsea River, 23886240
- Coos Bay, Coos Bay, 23910125
- Coos Bay, South Slough, 23909581
- Coquille River, Coquille River, 23914377
- Necanicum River, Necanicum River, 23871167
- Nehalem River, Nehalem River, 23871847
- Nestucca Bay, Nestucca River, 23875653
- Pistol River, Pistol River, 23949869
- Siuslaw River, Siuslaw River, 23889438
- Siuslaw River, North Fork Siuslaw River, 23889874
- Umpqua River, Smith River, 24526612
- Umpqua River, Lower Umpqua River, 24526582

Figure 13. Ecological data for SEUs in Group 2.

Color Ramp for Geophysical & Ecological Metrics: More Favorable | | Less Favorable

Estuary & SEU (Sub-estuary Unit) Identifiers		Upland Conditions and Freshwater Inputs							Sea Level Scenarios and Associated Habitat Area and Diversity													
Estuary Name	SEU Name	Hydrologic Regulation	Water Chemistry Regulation	Sediment Regulation	Hydrologic Connectivity	Temperature Regulation	Habitat Provision	Integrated Watershed Index	0 ft SLR Diversity	0 ft SLR Habitat Acres	0.8 ft SLR Diversity	0.8 ft SLR Habitat Acres	1.6 ft SLR Diversity	1.6 ft SLR Habitat Acres	2.5 ft SLR Diversity	2.5 ft SLR Habitat Acres	4.7 ft SLR Diversity	4.7 ft SLR Habitat Acres	8.2 ft SLR Diversity	8.2 ft SLR Habitat Acres	11.5 ft SLR Diversity	11.5 ft SLR Habitat Acres
Alsea Bay	Alsea River	0.997	0.971	0.984	0.986	0.985	0.981	0.908	0.723	734.340	0.710	786.572	0.627	821.041	0.620	836.231	0.793	526.526	0.839	269.744	0.752	192.820
Coos Bay	Coos Bay	0.996	0.976	0.979	0.984	0.983	0.976	0.899	0.749	1,000.890	0.763	1,088.279	0.760	1,194.120	0.759	1,251.062	0.714	868.763	0.849	412.853	0.792	372.766
Coos Bay	South Slough	0.998	0.980	0.987	0.998	0.997	0.986	0.946	0.708	386.663	0.747	422.182	0.741	442.182	0.742	438.445	0.743	272.372	0.772	118.678	0.693	82.185
Coquille River	Coquille River	0.993	0.976	0.982	0.980	0.980	0.977	0.893	0.745	5,874.983	0.779	6,175.651	0.771	5,805.945	0.707	5,204.285	0.892	3,350.892	0.852	2,269.130	0.767	1,944.146
Necanicum River	Necanicum River	0.998	0.954	0.975	0.980	0.976	0.973	0.864	0.838	219.304	0.842	310.078	0.839	410.641	0.875	548.331	0.862	880.100	0.864	1,108.864	0.767	631.023
Nehalem River	Nehalem River	0.997	0.967	0.984	0.987	0.986	0.982	0.906	0.800	1,683.120	0.805	1,745.301	0.754	1,800.822	0.721	1,814.590	0.796	1,477.991	0.814	917.741	0.806	611.011
Nestucca Bay	Nestucca Bay	0.996	0.966	0.981	0.985	0.983	0.977	0.893	0.750	117.200	0.660	165.735	0.558	209.619	0.625	260.335	0.643	354.492	0.491	235.691	0.678	90.780
Pistol River	Pistol River	0.999	0.968	0.989	0.996	0.996	0.988	0.937	0.767	16.142	0.526	65.063	0.702	89.205	0.729	117.049	0.795	201.452	0.788	251.274	0.711	222.196
Siuslaw River	Siuslaw River	0.997	0.978	0.985	0.986	0.985	0.981	0.915	0.794	1,496.439	0.805	1,435.962	0.808	1,352.918	0.820	1,204.646	0.872	624.022	0.884	317.401	0.832	220.840
Siuslaw River	North Fork Siuslaw River	0.997	0.973	0.987	0.987	0.989	0.984	0.921	0.680	901.083	0.777	805.657	0.781	631.471	0.760	493.743	0.810	285.863	0.843	156.399	0.754	119.127
Umpqua River	Smith River	0.999	0.980	0.984	0.991	0.989	0.981	0.926	0.694	1,807.488	0.725	1,828.011	0.737	1,725.650	0.675	1,499.773	0.838	851.231	0.837	545.313	0.822	497.542
Umpqua River	Lower Umpqua River	0.990	0.979	0.977	0.983	0.982	0.970	0.886	0.734	835.345	0.729	964.731	0.760	1,241.222	0.760	1,573.573	0.713	1,694.513	0.675	1,054.605	0.658	303.572

Figure 14. Population and infrastructure data for SEUs in Group 2.

Color Ramp for Infrastructure Metrics: Less Human Use | | More Human Use

Estuary & SEU (Sub-estuary Unit) Identifiers		Infrastructure Metrics					Infrastructure Metrics										
Estuary Name	SEU Name	Population	Population Density	Building Count	Building Density	Building SqFt	Relative Abundance (RA) is an area-weighted measure of abundance within the 4.7-ft SLR zone. The metrics below are all based on RA. RA = (Quantity of *X* within SEU/Summed quantity of *X* within all SEUs)/(Area of SEU/Summed Area of all SEUs)										
Estuary name per PMEP	Reach/NHD feature name	Number of individuals within the 4.7-ft SLR zone	Density of individuals within the 4.7-ft SLR zone	Buildings within the 4.7-ft SLR zone	Building density within the 4.7-ft SLR zone	Square footage of buildings within the 4.7-ft SLR zone	Drinking Water Resources (Range: 0 - 24.6 Avg. 2.8)	Emergency Response Resources (Range: 0 - 29.6 Avg. 1.2)	Flood Hazard Areas (Range: 0 - 6.3 Avg. 1.25)	Potential Toxics Source (Range: 0 - 52 Avg. 1.9)	Public Facilities (Range: 0 - 18.4 Avg. 1.1)	Transportation Infrastructure (Range: 0 - 112 Avg. 4.3)	Tsunami Critical Facilities (Range: 0 - 19 Avg. 1.6)	Urban Growth Boundary (Range: 0 - 24.5 Avg. 1.6)	Zoning - Commercial and Industrial (Range: 0 - 27.2 Avg. 1.5)	Zoning - Farm, Forest and Open Space (Range: 0 - 5.4 Avg. 1.2)	Zoning - Residential (Range: 0 - 10.8 Avg. 1.5)
Alsea Bay	Alsea River	613.000	0.495	565.000	0.456	1,333,142.699	1.737	6.845	1.475	1.652	8.833	4.170	1.595	1.975	0.000	1.937	5.001
Coos Bay	Coos Bay	644.000	0.283	422.000	0.186	2,276,096.175	1.433	2.074	1.640	4.530	2.141	3.100	1.289	11.439	10.795	0.592	2.595
Coos Bay	South Slough	54.000	0.093	70.000	0.120	201,687.732	2.138	0.000	1.342	1.065	0.000	1.910	0.000	0.000	1.167	0.809	0.013
Coquille River	Coquille River	80.000	0.009	126.000	0.015	340,688.295	2.275	0.000	1.608	0.235	0.278	0.828	0.418	0.316	0.070	1.105	0.332
Necanicum River	Necanicum River	1,914.000	1.248	1,341.000	0.874	2,883,161.704	0.852	2.048	1.091	1.224	5.284	2.391	0.636	2.808	0.934	0.418	5.339
Nehalem River	Nehalem River	135.000	0.050	407.000	0.152	1,001,720.406	0.703	2.439	0.000	0.533	0.000	1.765	0.758	0.366	0.545	0.822	1.120
Nestucca Bay	Nestucca Bay	8.000	0.021	10.000	0.026	19,243.807	1.307	0.000	0.000	0.000	0.000	0.611	0.000	0.000	0.000	0.416	0.442
Pistol River	Pistol River	0.000	0.000	0.000	0.000	0.000	9.631	0.000	0.660	0.000	0.000	1.116	2.779	0.000	0.007	0.261	1.010
Siuslaw River	Siuslaw River	131.000	0.065	193.000	0.095	420,591.166	1.992	0.000	2.038	0.597	1.491	4.435	1.794	0.000	0.121	2.035	0.672
Siuslaw River	North Fork Siuslaw River	10.000	0.009	18.000	0.016	59,613.204	3.129	0.000	2.417	0.000	0.000	1.645	1.959	0.000	0.000	1.454	1.218
Umpqua River	Smith River	15.000	0.006	35.000	0.014	74,257.831	2.208	0.000	1.799	0.049	0.000	1.828	0.329	0.654	0.000	1.578	0.000
Umpqua River	Lower Umpqua River	260.000	0.102	260.000	0.102	1,058,410.018	0.328	2.127	0.947	1.345	2.196	1.360	0.826	0.776	1.847	1.365	0.252

Table 2. Summary of the characteristics of the SEUs in Group 2, demonstrating the NBS potential for both people and nature.

SEU Name	SEU #	Ecological Uplift	Infrastructure	Social Vulnerabilities
Alsea River	23886240	Watershed - Fair LMZ Acres - Fair to Good SDI - Good	Population – High Buildings – High	Demo – High SocioEcon – High Education – Low to Mod Housing & Tran. - Mod
Coos Bay	23910125	Watershed - Fair LMZ Acres - Fair to Good SDI - Good	Population – High Buildings – High Flood Hazards Toxics Urban growth boundary (UGB) Commercial/Industrial Zoning	Demo – High SocioEcon – Mod - High Education – Mod Housing & Tran. - Mod
Coos Bay – South Slough	23909581	Watershed - Very Good LMZ Acres - Good SDI - Good	Population – Moderate Buildings – Mod Flood Hazards Drinking water	Demo – High SocioEcon – Mod Education – Mod Housing & Tran. - Mod
Coquille River	23914377	Watershed - Fair to Poor LMZ Acres - Very Good SDI – Very Good	Population – Moderate Buildings – Mod Flood Hazards Drinking water	Demo – High SocioEcon – Mod Education – Mod Housing & Tran. - Mod
Necanicum River	23871167	Watershed – Poor LMZ Acres – Low to Good SDI - Good	Population – Very High Buildings – Very High Flood Hazards UGB Residential Zoning	Demo – High SocioEcon – Mod Education & Language - Mod. Housing & Tran. - High
Nehalem River	23871847	Watershed - Fair LMZ Acres - Good SDI – Good	Population – Moderate Buildings – High Emergency Response	Demo – Mod to High SocioEcon – Mod Education - Mod. Housing & Tran. - Mod
Nestucca River	23875653	Watershed - Fair LMZ Acres - Fair to Good SDI – Fair	Population – Moderate Buildings – High Drinking water	Demo – Mod SocioEcon – Mod Education - Low Housing & Tran. – Mod to Low

SEU Name	SEU #	Ecological Uplift	Infrastructure	Social Vulnerabilities
Pistol River	23949869	Watershed – Very Good LMZ Acres – Poor (currently) to Good SDI – Fair to Good	Population - None Buildings - None Drinking water Some emergency response	Demo – Mod SocioEcon – Mod Education - Mod to Low Housing & Tran. - Mod
Siuslaw River	23889438	Watershed – Fair to Good LMZ Acres - Fair SDI - Good	Population – Moderate Buildings – Mod to High Flood hazard Emergency response	Demo – High SocioEcon – High Education – Mod to High Housing & Tran. – Mod to High
North Fork Siuslaw River	23889874	Watershed - Good LMZ Acres - Fair to Low SDI - Good	Population - Low Buildings - Low Flood hazard Drinking water	Demo – High SocioEcon – High to Mod Education – High Housing & Tran. - Mod
Smith River	24526612	Watershed - Good LMZ Acres - Fair to Good SDI - Fair to Good	Population - Low Buildings - Low Flood hazard Drinking water Zoning	Demo – Mod to High SocioEcon – Mod Education - Mod Housing & Tran. - Mod
Lower Umpqua River	24526582	Watershed - Poor LMZ Acres - Fair to Good SDI - Good	Population – Moderate Buildings – High Flood Hazard Emergency Response	Demo – Mod to High SocioEcon – Mod to High Education - Mod Housing & Tran. - Mod

Examples by project type for Group 2

Eco-friendly city responses

The **Coos Bay** SEU includes parts of the cities of Coos Bay and North Bend. The watershed has a fair rating for upland and freshwater metrics. This unit has fair estuary acres now, but they are projected to increase until the 4.7-ft (1.4-m) scenario, with a good diversity of habitats. Both the population and number of buildings are high within the 4.7-ft LMZ, and its flood hazards, toxics, UGB area, and commercial/industrial zones are also comparatively large. There are a large number of census blocks in this unit, making it difficult to summarize overall (see the Social Data Consequence Table at www.conservationgateway.org/collections/oregon/oregons-future-tidal-wetlands).

Projects in this SEU could involve adapting the city's SLR approaches to be more inclusive of eco-sensitive approaches. A number of tools might need to be deployed in combination to help do this. To prepare some areas that might be inundated, the city could make zoning changes now and prevent new development in vulnerable areas. In some areas, critical infrastructure could be moved out of the LMZ, and perhaps buyouts could be offered for private properties already experiencing frequent flooding. Cleaning up areas with toxins before they get inundated and contaminate the bay would also be wise.

TNC's report (Pickering et al., 2018) on the impacts of roads on estuaries, *Where Road Projects Could Improve Estuaries and Benefit Local Communities*, identified Coos Bay as one of the estuaries where road improvements would have the most potential to improve hydrologic connectivity while also enhancing coastal communities' natural disaster escape routes and access. This LMZ analysis supports these conclusions, so implementing those recommendations would be especially beneficial. There may be places where some innovative tools suggested in the San Francisco Bay Adaptation Atlas (SFEI & SPUR, 2019), such as ecotone levees or other green/gray infrastructure combinations, might be used to protect roads or other sections of the city that cannot or will not be moved.

Marsh restoration with potential NBS benefits

The **North Fork Siuslaw River** has mostly good watershed ratings. The estuary acres are fair up to the 4.7-ft (1.4-m) scenario, then they are low but with good habitat diversity. The population and number of buildings in the LMZ are low, with some flooding hazards and drinking water sources. This area mostly has an older population with a low to moderate proportion of people living with disabilities or difficulty living independently (Figure 15). Some census blocks are associated with lower education levels.

Depending on where the buildings and homes are, restoring tidal marshes in this area might alleviate some flooding by providing room for floodwaters to spread out over the marsh (Fairchild et al., 2021). The community might also need to look for ways to protect or move their drinking water source before it becomes inundated in the LMZ.

Migration space preparation

The **Pistol River** has very good upland and freshwater metrics, indicating it has a good landscape context for ecological benefits. It has very low acres currently and up through an SLR of 2.5 ft (0.8 m), but it then gains acres at 4.7 ft (1.4 m) and above. No one is currently living in the 4.7-ft LMZ, and there are no buildings, but it appears to be an important area for drinking water resources and some tsunami critical facilities.

Projects for the unit could include helping prepare the community to relocate the drinking water and tsunami facilities to areas outside of the projected LMZ zones and keeping the zoning at compatible levels. This Pistol River example can illustrate how one might use the Social Data and Project Type Decision Tree described in the previous "Decision Tree by Project Type" section, since work in Pistol River could be the type of project that falls in the decision tree's category of "Migration Space Preparation." In addition to the critical infrastructure data, one should consult the social data on housing and transportation, as well as socioeconomic status.

Since no people actually live in the SEU, presumably the critical resources noted in the SEU Metrics Consequence Table serve the communities in the nearby census blocks. Two census block groups intersect the SEU (see Figure 16). They have a high number of households with members over 65, a relatively high percentage living in mobile homes, a low or zero percentage of homeowners residing elsewhere, and income levels in the moderately vulnerable level.

Protecting drinking water and addressing other flood hazards

Coos Bay's South Slough has very good upland and freshwater metrics, indicating it has a good landscape context for ecological benefits. The estuarine acres and diversity remain good until the 8.2-ft (2.5-m) scenario. There is a moderate population and number of buildings, resulting in some flood hazard. There is also a drinking water source located within the 4.7-ft (1.4-m) LMZ.

This SEU overlaps with three census blocks. It seems to be a multigenerational community (relatively high proportion of households with members below 17 and over 65). A moderate proportion of people are living with disabilities in all three areas (see Figure 17). A moderate number of households reside in mobile homes, and a moderate proportion of renter-occupied households exist in two of the three areas. These factors contribute to this community's vulnerability to SLR and other types of flooding.

Projects might include identifying which homes are most at risk and designing NBS that would best alleviate it, or addressing the vulnerable drinking water source by searching for alternative locations or ways to protect it in its current location.

In addition to the project types illustrated in this section, the approach of managed or planned retreat (to relocate people and assets out of harm's way) has been implemented elsewhere in the U.S. and around the world (O'Donnell, 2022). While this approach can be a complex and controversial topic that needs to address governance, policy, institutional factors, property rights, and social justice considerations, there may be some areas where it is necessary.

Data in this report may suggest areas where managed retreat might be considered. For example, future development could be planned in a way that ensures high-density housing, mobile homes, and "residential" facilities (e.g., retirement communities, nursing homes, etc.) are located (or prioritized for relocation) in such a way to align with SLR scenarios. These conditions might indicate an opportunity for managed retreat. Mobile homes might be able to be moved, or buyouts could be considered since these homes would require less compensation.

Figure 15. Social data for the North Fork Siuslaw River SEU.

Color Ramp for Social Data: Less Vulnerable — Most Vulnerable

		Demographics					Socioeconomic Status			Language and Education		Housing and Transportation						
Estuary Name	SEU_Name	Households with Members <17 (%)	Households with Members >65 (%)	Single Parent Households (%)	People living with a Disability (%)	People with Difficulty Living Independently (%)	Per Capita Income ($)	People Below Poverty Level (%)	People Unemployed (%)	People Without a High School Diploma (%)	People with Limited English Proficiency (%)	Households without a vehicle (%)	Households living in multi-unit structures (%)	Houses where owner resides elsewhere (%)	Houses that are Renter Occupied (%)	Households Living in Mobile Homes (%)	People living in crowded conditions (%)	People Living in Group Quarters (%)
Siuslaw River	North Fork Siuslaw River	11.81	56.12	0.00	25.10	11.69	38473.00	16.28	5.49	4.59	0.00	5.70	3.04	3.51	20.40	23.72	6.12	0.00
Siuslaw River	North Fork Siuslaw River	16.81	49.43	13.50	25.29	9.13	28833.00	14.85	12.82	19.06	0.02	6.83	17.65	7.39	40.97	8.01	1.52	1.48

Figure 16. Social data for the Pistol River SEU.

Color Ramp for Social Data: Less Vulnerable — Most Vulnerable

		Demographics					Socioeconomic Status			Language and Education		Housing and Transportation						
Estuary Name	SEU_Name	Households with Members <17 (%)	Households with Members >65 (%)	Single Parent Households (%)	People living with a Disability (%)	People with Difficulty Living Independently (%)	Per Capita Income ($)	People Below Poverty Level (%)	People Unemployed (%)	People Without a High School Diploma (%)	People with Limited English Proficiency (%)	Households without a vehicle (%)	Households living in multi-unit structures (%)	Houses where owner resides elsewhere (%)	Houses that are Renter Occupied (%)	Households Living in Mobile Homes (%)	People living in crowded conditions (%)	People Living in Group Quarters (%)
Pistol River	Pistol River	11.47	69.91	0.00	14.86	6.19	32482.00	10.41	0.00	8.64	1.82	0.00	7.02	0.00	6.31	35.99	0.00	0.34
Pistol River	Pistol River	18.83	40.17	1.52	19.01	4.12	31477.00	9.70	5.96	6.65	2.59	2.93	0.59	5.21	31.57	29.60	6.90	1.17

Figure 17. Social data for the Coos Bay South Slough SEU.

Color Ramp for Social Data: Less Vulnerable — Most Vulnerable

		Demographics					Socioeconomic Status			Language and Education		Housing and Transportation						
Estuary Name	SEU_Name	Households with Members <17 (%)	Households with Members >65 (%)	Single Parent Households (%)	People living with a Disability (%)	People with Difficulty Living Independently (%)	Per Capita Income ($)	People Below Poverty Level (%)	People Unemployed (%)	People Without a High School Diploma (%)	People with Limited English Proficiency (%)	Households without a vehicle (%)	Households living in multi-unit structures (%)	Houses where owner resides elsewhere (%)	Houses that are Renter Occupied (%)	Households Living in Mobile Homes (%)	People living in crowded conditions (%)	People Living in Group Quarters (%)
Coos Bay	South Slough	13.48	37.30	3.55	29.45	7.33	35560.00	10.40	2.03	13.22	1.07	0.00	0.00	5.15	6.93	39.67	6.58	5.83
Coos Bay	South Slough	3.51	74.44	0.00	29.45	7.33	34692.00	9.47	8.58	4.21	1.07	1.60	3.27	5.15	30.73	2.10	8.63	5.83
Coos Bay	South Slough	31.34	53.52	0.00	25.48	6.46	34463.00	11.25	0.00	0.38	0.75	0.00	0.00	16.09	7.28	6.70	0.00	0.00

Group 3. SEUs with data indicating unfavorable conditions for ecological or people benefits

Note that Group 3 includes lots of red cells in the SEU Metrics Consequence Table, as shown in Figure 18.

- Coos Bay, Coalbank Slough, 23909651
- Nehalem River, Foley Creek, 23872355
- Siletz Bay, Schooner Creek, 23881064
- Yaquina Bay, Depot Slough, 23882302
- Yaquina Bay, Olalla Creek, 23882306
- Yaquina Bay, Upper Yaquina River, 23880718

An example of this group is Olalla Creek in the Yaquina Estuary. The upland and freshwater indicators are all rated poor. Current and future habitat acres and diversity are also poor (Figure 18). Plus, there is a moderate level of population and infrastructure in the 4.7-ft (1.4-m) SLR scenario (Figure 19).

Several other SEUs fall somewhere between these more obvious groupings. The consequence tables and decision tree can be consulted on a case-by-case basis to evaluate more opportunistic potential projects.

Figure 18. Ecological data for SEUs in Group 3.

Color Ramp for Geophysical & Ecological Metrics: More Favorable | Less Favorable

Estuary & SEU (Sub-estuary Unit) Identifiers		Upland Conditions and Freshwater Inputs							Sea Level Scenarios and Associated Habitat Area and Diversity														
Estuary Name	SEU Name	Hydrologic Regulation	Water Chemistry Regulation	Sediment Regulation	Hydrologic Connectivity	Temperature Regulation	Habitat Provision	Integrated Watershed Index	0 ft SLR Diversity	0 ft SLR Habitat Acres	0.8 ft SLR Diversity	0.8 ft SLR Habitat Acres	1.6 ft SLR Diversity	1.6 ft SLR Habitat Acres	2.5 ft SLR Diversity	2.5 ft SLR Habitat Acres	4.7 ft SLR Diversity	4.7 ft SLR Habitat Acres	8.2 ft SLR Diversity	8.2 ft SLR Habitat Acres	11.5 ft SLR Diversity	11.5 ft SLR Habitat Acres
Coos Bay	Coalbank Slough	0.987	0.964	0.965	0.961	0.954	0.951	0.801	0.782	236.451	0.804	199.712	0.705	142.824	0.701	118.184	0.821	45.438	0.792	24.045	0.722	17.049
Nehalem River	Foley Creek	0.998	0.960	0.977	0.980	0.978	0.970	0.869	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.099	0.361	7.243	0.605	10.965	0.601	7.753
Siletz Bay	Schooner Creek	0.998	0.961	0.980	0.983	0.978	0.976	0.882	0.376	74.378	0.473	93.809	0.670	108.699	0.718	127.273	0.645	147.108	0.845	87.566	0.725	67.920
Yaquina Bay	Depot Slough	0.997	0.973	0.980	0.979	0.973	0.975	0.884	0.401	210.461	0.429	214.924	0.406	216.842	0.479	197.829	0.585	149.154	0.722	120.597	0.730	92.014
Yaquina Bay	Olalla Creek	0.989	0.967	0.971	0.967	0.958	0.954	0.821	0.577	191.011	0.630	205.235	0.683	198.041	0.702	163.333	0.704	125.295	0.690	70.777	0.708	35.243
Yaquina Bay	Upper Yaquina River	0.998	0.974	0.982	0.980	0.977	0.977	0.893	0.000	2.797	0.000	2.598	0.498	3.154	0.500	3.984	0.426	5.551	0.448	16.897	0.559	35.471

Figure 19. Population and infrastructure data for SEUs in Group 3.

Color Ramp for Infrastructure Metrics: Less Human Use | More Human Use

Estuary & SEU (Sub-estuary Unit) Identifiers		Infrastructure Metrics					Infrastructure Metrics										
Estuary Name	SEU Name	Population	Population Density	Building Count	Building Density	Building SqFt	Relative Abundance (RA) is an area-weighted measure of abundance within the 4.7-ft SLR zone. The metrics below are all based on RA. RA = (Quantity of *X* within SEU/Summed quantity of *X* within all SEUs)/(Area of SEU/Summed Area of all SEUs)										
Estuary name per PMEP	Reach/NHD feature name	Number of individuals within the 4.7-ft SLR zone	Density of individuals within the 4.7-ft SLR zone	Buildings within the 4.7-ft SLR zone	Building density within the 4.7-ft SLR zone	Square footage of buildings within the 4.7-ft SLR zone	Drinking Water Resources (Range: 0 - 24.6 Avg. 2.8)	Emergency Response Resources (Range: 0 - 29.6 Avg. 1.2)	Flood Hazard Areas (Range: 0 - 6.3 Avg. 1.25)	Potential Toxics Source (Range: 0 - 52 Avg. 1.9)	Public Facilities (Range: 0 - 18.4 Avg. 1.1)	Transportation Infrastructure (Range: 0 - 112 Avg. 4.3)	Tsunami Critical Facilities (Range: 0 - 19 Avg. 1.6)	Urban Growth Boundary (Range: 0 - 24.5 Avg. 1.6)	Zoning - Commercial and Industrial (Range: 0 - 27.2 Avg. 1.5)	Zoning - Farm, Forest and Open Space (Range: 0 - 5.4 Avg. 1.2)	Zoning - Residential (Range: 0 - 10.8 Avg. 1.5)
Coos Bay	Coalbank Slough	320.000	0.700	249.000	0.545	897,757.337	9.269	0.000	6.306	51.969	0.000	13.990	0.000	6.925	27.197	1.347	8.073
Nehalem River	Foley Creek	0.000	0.000	0.000	0.000	0.000	0.546	0.000	0.000	0.000	0.000	0.127	0.000	0.000	0.000	1.830	0.000
Siletz Bay	Schooner Creek	351.000	1.497	247.000	1.054	566,162.176	0.794	0.000	0.999	4.506	12.645	1.938	1.903	2.319	0.583	0.245	2.225
Yaquina Bay	Depot Slough	71.000	0.130	110.000	0.201	972,760.739	4.624	0.000	2.304	5.555	6.236	9.107	11.261	3.221	0.000	1.527	0.000
Yaquina Bay	Olalla Creek	58.000	0.167	37.000	0.107	65,858.457	2.879	0.000	1.736	0.992	0.000	3.447	4.468	5.118	0.000	0.601	6.159
Yaquina Bay	Upper Yaquina River	0.000	0.000	0.000	0.000	0.000	1.252	0.000	1.238	0.000	0.000	0.066	0.000	0.000	0.000	3.129	0.000

Conclusion

Sea level rise will alter the extent and configuration of Oregon's estuaries, with impacts to tidal wetlands, species, and people. The goal of this project is to provide analytical products that allow conservation planners to identify areas that might be suitable for Nature-Based Solutions and restoration projects to best support habitat functions under various SLR scenarios, while also benefiting human communities to the extent practicable.

The consequence-table approach described in this report provides a decision-support framework to evaluate multiple elements, including ecological, infrastructure, and social elements together, to identify potential project areas within the projected Landward Migration Zones under future sea level rise scenarios. Though informative, the results are not intended to be used as the final say in decision-making. The results should be interpreted based on the objectives of the organization using them and the types of projects they want to pursue. Additionally, project feasibility must be considered in the broader local context (e.g., cities are not likely to abandon their current locations, willing sellers, etc.).

Conservation planners across all of Oregon's estuaries could benefit from the tools introduced in this report. Indeed, locations that were not highlighted may still have potential for projects that are resilient to or help to mitigate sea level rise. The Boone Slough area in the Yaquina estuary is a good example. It did not show up in any of the categories we identified because it has mostly middle-of-the-road rankings (i.e., mostly yellow, pale green, and orangish/light-red cells); however, its prospects under different SLR scenarios look fine at least up to the 8.2-ft (2.5-m) level. So, investments in estuary restoration currently underway in this location have a good chance of persisting under future sea level rise scenarios.

Our project has provided a snapshot of current and potential future conditions. This perspective can, and hopefully will, change over time as projects implemented in the near-term help communities prepare for the changes to come. Proactive restoration of potential tidelands by removing or breaching dikes to allow tidal and freshwater to carry in sediments, or even adding sediment, can raise the elevation of marshes projected to be inundated, potentially allowing them to survive sea level rise (Temmerman et al., 2004). Thus, these tools can be used to better analyze where conservation planners are already working, not just to pick new places to work.

Once an organization identifies potential project areas, the next step is to engage the local communities where the proposed projects could take place. This collaboration is essential for realizing the potential social benefits hinted at in this report.

At Siletz Bay looking northeast over Hwy 101 toward the LMZ of Drift Creek. Photo by Oregon ShoreZone.

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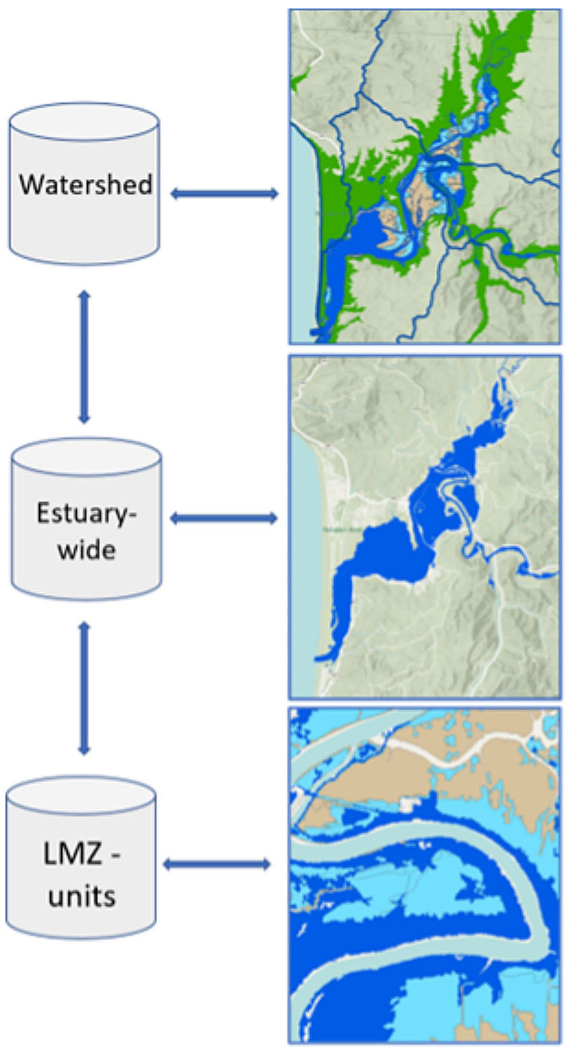
Appendix A: Analysis scale

The scale of Landward Migration Zone units (LMZ-units)

Several analytical scales are required to meet project goals. Employing various scales (Figure A1) ensures the pertinent ecological and social metrics can be mapped at the scale appropriate to each. As an example, planning specific restoration projects requires information at a fine scale, while policy decisions might require information at coarser scales.

The LMZ data from Brophy and Ewald (2017) formed the starting point for this project by The Nature Conservancy (TNC) and mapped the potential extent of tidally influenced lands under seven SLR scenarios. The data were comprised of a single polygon for each combination of *Estuary and Land Condition (impervious or permeable) for each SLR scenario*. For our project, additional finer-scale planning units were required to better match the scale of habitat projects we might initiate and/or to evaluate the inundation levels of specific parcels under an SLR scenario (Figure A2). These finer-scale planning units are called LMZ-units.

Figure A1. LMZ data spatial scales and their definitions.



LMZ data – Spatial scales

The various processes that affect estuaries operate at different scales. Data for each of these scales can be developed into a relational structure that will allow integration across scales.

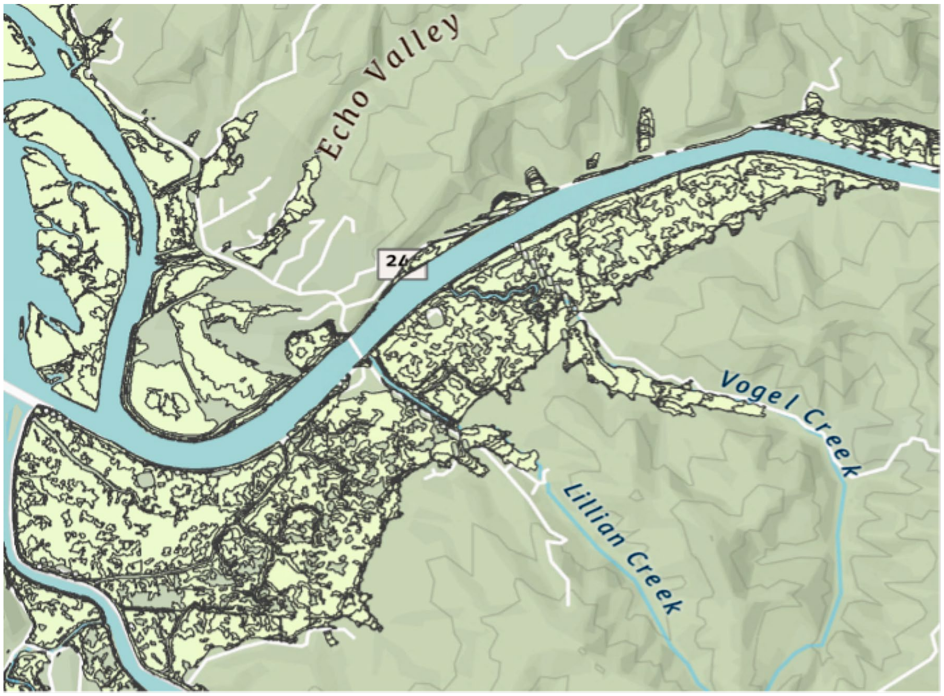
Watershed data – Information that describes the type of land uses, the quantity and quality of estuary freshwater inputs, socioeconomic variables, and other variables that may affect estuary habitats and the ability of communities to adapt to sea level rise (SLR).

Estuary-wide data – Information that is best summarized to entire estuaries. Some attributes may only apply to certain types of estuaries.

Sub-estuary units (SEUs) – Data developed for portions of estuaries, usually corresponding to the major freshwater tributaries flowing into the estuary and/or portions of the estuary that are somewhat geographically distinct from the main estuary body, such as sloughs.

LMZ-units – These polygons are quite small, with a mean area of 0.27 ac (0.001 km^2; SD = 2.9 ac [0.012 km^2]). This size is appropriate for project planning at the scale of property (tax lot) boundaries. Each polygon is attributed with tidal inundation and soil data.

Figure A2. Example of unioned SLR polygons. Each polygon has tabular attributes describing its membership in one or more SLR scenarios.



The data representing each of the seven scenarios were combined and flattened into a single layer using the ArcGIS union function to create the LMZ-units. Each polygon was a member of at least one SLR scenario, though most were involved in two or more scenarios. These polygons are quite small, with a mean area of 0.27 ac (0.001 km^2; SD = 2.9 ac [0.012 km^2]).

Each of these LMZ-units was then attributed with its mean elevation from the 1/9th arc-second (~ 3 m) digital elevation models from the National Centers for Environmental Information at the National Oceanic and Atmospheric Administration (NOAA).

Tide station Bench Mark Sheets from three estuaries distributed across the coast—Tillamook, Alsea, and Coos Bay—were used to establish the current average mean tide level. This average, 4.35 ft (1.33 m), was used to correlate the elevations of the SLR scenarios to mean tide levels. For example, an SLR of 0 ft corresponds to a mean tide level of 4.35 ft. By comparing the mean elevation of each LMZ-unit to its adjusted SLR scenario mean tide level, the LMZ-unit could be placed into its tidal zone relative to that scenario: below mean tide, between mean tide and mean higher high water, or above mean higher high water. For example, for a given SLR scenario, if a polygon will be inundated when the water is between mean tide and mean higher high water, it suggests that the polygon will be regularly inundated by tides but not submerged so deeply that it would not support estuarine vegetation under that amount of SLR.

The scale of social data

The variables collected for this project were extracted at the block-group and census-tract levels from the 2021 U.S. Census American Community Survey 5-year estimates (U.S. Census Bureau, 2023). Since the block group is the focal unit of data, block groups are treated as an imperfect proxy for communities. Block groups do not necessarily correspond to the social dynamics and shared meaning implied when defining a community. However, at the time of this writing, no other social dataset rivals the coverage and availability of the data published by the U.S. Census Bureau. All data were accessed and retrieved through the Census Bureau's application programming interface (API) using the tidycensus package (Walker, 2026) in RStudio (Version 1.2.1335).

Appendix B: Landward Migration Zone (LMZ) data sources

The full suite of data sources—and their attributes used in the sub-estuary unit (SEU) summaries—includes the following:

Federal Emergency Management Agency (FEMA) national flood hazards – The FEMA National Flood Hazard Layer (FEMA, 2025) was used to calculate the relative abundance (RA) of flood hazard areas within each SEU. These RA values can be used to identify populated areas at risk of flood events.

LandScan USA – LandScan (landscan.ornl.gov) employs a dasymetric population distribution model to depict the location of people in both space and time. Nighttime (residential) and daytime population data are produced at 3 arc-second (~ 90 m) resolution. The population distribution model incorporates census data at the block level; incorporates demographic attributes, including age, sex, and race; and integrates other socioeconomic data, such as journey to work. Ancillary spatial data—including high-resolution imagery, transportation infrastructure, lidar and automated building extractions, and parcels—are used to spatially refine the population distribution. LandScan data were used to calculate the population and population density for each SEU.

McManamay & DeRolph stream classification – "A Stream Classification System for the Conterminous United States" (McManamay & DeRolph, 2019) describes a classification based on emergent natural variation in six habitat layers meaningful at the stream-reach resolution: size, gradient, hydrology, temperature, network bifurcation, and valley confinement. The data provided are coded by COMID, which we used in this project to match data values to their respective SEUs. Metrics used include Stream Class as well as Median Stream Flow. These metrics give an indication of the volume and stability of freshwater inputs to the SEU portion of the estuary.

Microsoft building footprints - Microsoft Maps (2019) released building footprints datasets derived from 2019-2020 satellite imagery, which The Nature Conservancy (TNC) edited in June 2021 to add missing buildings or remove those indicated as buildings that are not, and to attribute with building data from OR-IRIS (see upcoming OR-IRIS paragraph) where available, including general land manager type. These data were used to calculate building counts, building densities, and building square feet for each SEU.

Oregon Department of Environmental Quality (DEQ) public drinking water source areas (DWSAs) and wells – Oregon's DEQ is the lead agency in charge of mapping DWSAs for both surface and groundwater. DWSA and well data (DEQ, n.d.) were used to identify areas with drinking water sources at risk from sea level rise (SLR) and to calculate the RA of drinking water sources within each SEU.

Oregon Department of Geology and Mineral Industries (DOGAMI) tsunami critical resources – Tsunami critical resources (DOGAMI, 2021) include assembly areas, areas of higher ground, evacuation routes, and tsunami scenarios. These data were used to calculate the RA of tsunami critical resources within each SEU.

Oregon Department of Land Conservation and Development (DLCD) urban growth boundaries (UGBs) – UGBs, developed by DLCD, were used to identify jurisdictions that have expressed their intent to build within LMZs. The RA was then calculated for the area of UGBs within each SEU.

Oregon DLCD zoning – These data were obtained from the Zoning layer compiled for the state by DLCD, with support from the Oregon Department of Transportation. The layer contains zoning data from multiple jurisdictions that are compiled into a statewide standard data model. These data were used to identify SEUs that may have critical infrastructure and/or dwellings built within the LMZs.

These data were grouped into three classes: Commercial and Industrial; Farm, Forest, and Open Space; and Residential. The RA was then calculated for each class within each SEU.

Oregon Incidence Response Information System (OR-IRIS) – OR-IRIS is an assemblage of many existing and some purpose-built datasets for geographic information systems (GIS). These datasets are useful for understanding the natural, physical, and jurisdictional setting of a hazardous material release or emergency response incident within a single platform.

For each SEU, OR-IRIS data (Oregon Explorer, 2015) were used to calculate the RA of the following:

- Emergency response resources (fire stations, hazmat team bases, urgent care centers, etc.)
- Public facilities (schools, museums, libraries, etc.)
- Transportation infrastructure (airports, Amtrak stations, rail bridges, etc.)
- Potential toxic sources (hazardous waste facilities, leaking underground storage tanks, confined animal feeding operations, etc.)

TNC water balance data – TNC, in partnership with Resilient Forestry, has mapped climatic water balance metrics across Oregon at a 90-m resolution. Three primary datasets are of interest: potential evapotranspiration (PET), actual evapotranspiration (AET), and water deficit (Deficit). Deficit represents the amount of evaporative demand that cannot be met because soil water has been depleted during the summer dry period; deficit is moisture stress. The entire analysis period encompasses two 30-year time frames: one representing current conditions (1981–2010) and the other representing future conditions (2041–2070).

For this analysis, we calculated the mean percentage increase, relative to current conditions, of future water deficit across the entire watershed contributing to the estuary. This value gives robust indications of the magnitude of future climate stress and associated impacts of modified surface water availability.

U.S. Environmental Protection Agency (EPA) StreamCat - EPA has produced data to measure the capacity of a watershed to support and maintain the full range of ecological processes and functions essential to sustainability. Using information from EPA's StreamCat dataset, an Index of Watershed Integrity (IWI) was calculated and mapped for 2.6 million watersheds in the conterminous U.S., with first-order approximations of relationships between stressors and six watershed functions: hydrologic regulation, regulation of water chemistry, sediment regulation, hydrologic connectivity, temperature regulation, and habitat provision.

For this analysis, we reported all six indices and the IWI values for the watershed contributing to each SEU. These data give important context to the freshwater inputs to an SEU, such as land use impacts on water quality.

U.S. Geological Survey NHDPlus HR coarse-scale hydrography data – This dataset includes a suite of metrics describing aspects of each COMID feature's hydrology, such as seasonality and median flows. These hydrologic attributes can be useful when deciding which areas are good candidates for various habitat projects, and many were assigned to this project's SEUs.

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