# Aquatic Resource Type Conversion Evaluation Framework

*Literature Review and Summary of Existing State of Practice*


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## DISCLAIMER

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## List of Acronyms

CRAM – California Rapid Assessment Method
CWA – Clean Water Act
HEA – habitat equivalency analysis
HGM – hydrogeomorphic method
NOAA – National Oceanographic and Atmospheric Administration
NRDA - natural resources damage assessments
SPD – South Pacific Division
StPD – St. Paul District
USACE – US Army Corps of Engineers
USEPA – US Environmental Protection Agency

# I. GOAL/QUESTION

Wetland and stream restoration projects may sometimes involve converting one "type" of aquatic habitat to another "type" (e.g., managed salt ponds into tidal marshes, depressional wetlands into streams, marsh into transition zone habitat). This "type conversion" may be necessary and beneficial in the context of addressing watershed plans or regional restoration goals, or in achieving resiliency to climatic changes (Goals Project 2015). Conversion can also occur through other large-scale, complex actions (e.g., mitigation banking initiatives). Whether driven by habitat restoration goals or compensatory mitigation needs, regulatory oversight typically governs the process. Holistically assessing such conversion through the regulatory lens is challenging for permitting programs, whether it's a determination pursuant to federal statutes (e.g., CWA Section 404/401, Endangered Species Act) and/or independent state authorities (e.g., California State Supplemental Dredge or Fill Guidelines, California coastal zone permits, California ESA). The challenge stems from how to accurately determine the overall value of an aquatic resource based on site-specific ecological properties and in the context of larger regional ecosystem management and goals. This is further compounded when comparing between aquatic habitats that provide intrinsically different functions and services. Assessments must also account for the fact that wetlands and streams are not static ecosystems, but rather dynamically changing through time due to natural or anthropogenic factors, many of which are difficult to control or even accurately assess (e.g., sea level rise). These challenges are further exacerbated along most of the California coast due to urbanization, conflicting human-environment goals, and the evolving state of habitat restoration science.

As resource and regulatory agencies have different mandates and policies regarding aquatic resource protection, complex ecological issues such as type conversion can result in insufficient evaluation, conflicting permit requirements, and uncertainty for the regulated public. Type conversion is recognized by agencies as a "sand in the gears" problem that can stymie permitting as such actions typically require multiple agency authorizations, habitat resource trade-offs, and consensus on ecosystem goals. Most concerning, lack of consistent, defensible analysis based on transparent evaluation has been shown to impede critically-needed habitat restoration, and thus it is important to vet the notion that restoration projects automatically require compensatory mitigation due to type conversion. Several high-profile California restoration projects confronting this challenge include the South Bay Salt Ponds Restoration, Hamilton Wetlands/Bel Marin Keys Restoration, Buena Vista Lagoon, and the Ballona Wetlands. Collectively, we need a common science-based evaluation framework that agencies can work from to support the assessment of aquatic resource type conversion for use by state and federal permitting in California. Such a common framework can then subsequently be used in the regulatory process to assess permitting and mitigation requirements.

The overall goal of this project is to explore and develop consistent approaches for assessing the effect of type conversion on aquatic ecosystem function to support decisions made as part of resource management, regional restoration, and regulatory permitting processes. The project intends to provide a framework that can support regulatory evaluation of: 1) whether and when type conversion is appropriate, and 2) if so, how to analyze effectively. A first step in the project is to determine what critical information agencies need to provide a strong basis for type conversion evaluation. This requires a review of the current state of the science and includes understanding and cataloguing existing national and regional approaches and regulatory mechanisms. Information from this literature review will then inform our development of a vetted technical framework that effectively documents decision-making associated with aquatic resource type conversion proposals.

Through this literature review we aimed to address the following questions:

1. What approaches have been used or proposed to assess relative function or condition across different habitat types?
2. Can existing methods be adapted for use in the aquatic resource regulatory and management programs?
3. What policy guidance exists to assist regulators with type conversion analysis? What critical baseline information do regulators need to document and improve their decisions?
4. What are the most critical knowledge gaps that need to be addressed to advance the practice of assessing type conversion?

# II. Approach: Types of Papers/Documents Reviewed

A diverse cross section of available natural resources management literature was consulted for this review, including guidance documents, project-specific research papers, meeting presentations, websites, memorandums, and review articles. Thirty-two documents were used, which included information from federal and state agencies, local planning departments, and scientific literature. Dates of the publications ranged from 1990 to 2018, with about half of the documents (n=15) from before the 2008 compensatory mitigation rule[1], and about half after 2008 (n=17).

The range of affected habitat types in the documents was also diverse, and included wetlands, riparian zones, estuaries, intertidal salt marshes, fisheries habitats (macrophyte beds, bivalve reef, hard substrate, soft sediment), and offshore soft bottom benthic habitat.

We also reviewed literature relating to forest and range management and natural resources damage assessments (NRDA) to investigate approaches for comparing condition/function across different habitat types that may provide insight or ideas that could be adapted for use in aquatic resource type conversion analysis.

# III. Findings

## A. General Conclusions

As stated earlier, our literature review sought information to help address two overarching objectives: 1) whether type conversion is appropriate for specific restoration or mitigation projects, and if so under what circumstances, and 2) once a determination is made as to the

[1] 40 CFR Part 230 - [EPA–HQ–OW–2006–0020; FRL–8545–4] RIN 0710–AA55

appropriateness of type conversion, is there guidance on determining the value and amount of "new" habitat to be provided. While the existing literature provides insight, there were no clear answers to the four main questions of our analysis (Table 1). Guidance for considering type conversion is available, but varies between agencies and programs, with no generally accepted approach. Most of the available guidance primarily pertains to determination of regulatory compensation; however, the questions to be answered for the evaluation framework are much broader and compensatory mitigation is only one possible application. This literature review found no specific guidance pertaining to evaluating type conversion in the lens of restoration practices. While California state policies provide some implementation flexibility for ensuring "no overall loss" and achieving "…long-term net gain in the quantity, quality, and permanence of wetland acreages and values…", no established framework is available (California Wetlands Conservation Policy 1993). Some large restoration projects that involve type conversion have been considered to provide net environmental benefits, and no mitigation was required (e.g., Bair Island Restoration Project, Cullinan Ranch Restoration Project, and Hill Slough Restoration Project). However, the scarcity of published evaluations of aquatic resource type conversion impedes our ability to draw firm conclusions about the successes of the methods used to determine the appropriateness of type conversion actions in achieving overall project goals.

Despite a lack of clear guidance, the literature does provide information on several approaches for assessing habitat type tradeoffs. These tradeoffs can be made based on proportional comparisons of area or function. Most current regulatory guidance relies on comparisons of area. In contrast, natural resources damage assessment programs routinely used function or habitat-based equivalency analysis to analyze impacts to natural habitats, and many include discounting methods to account for temporal losses and maturation rates of different habitat types. There is opportunity to adapt some of these concepts for use in aquatic resource type conversion assessment.

**Table 1. Summary of findings.**

| Question | Documented Approach | Example |
|---|---|---|
| What approaches have been used or proposed to assess relative function or condition across habitat types? | -Reference site comparisons<br>-Pre-established ratios<br>-Habitat equivalency analysis | -Pechmann et al. 2001<br>-Minnesota Board of Water & Soil Resources 2015<br>-Hruby 2012<br>-Barrell et al. 2014 |
| Can existing methods be adapted for use in aquatic resource regulatory and management programs? | -Equivalency analysis could be adapted based on habitat points, species use, or overall ecosystem productivity<br>-Criteria could be developed to help determine when type conversion is appropriate<br>-Regulatory applications, such as mitigation ratio checklists, could be refined or expanded | -Hruby 2012<br>-Houghton and Roberts 2002<br>-Baker and Arismendez 2011 |

| Question | Documented Approach | Example |
|---|---|---|
| What policy guidance exists to assist regulators with type conversion analysis?<br><br>What baseline information do regulators need to document and improve their decisions? | -Type conversion is generally discouraged unless justified based on watershed approach, regional rarity, etc.<br>- Standard ratio adjustments are often recommended<br>-Common baseline information includes current and historic extent and distribution, current and expected future stressors, distributions of species, and habitats of management concern<br>- Function or condition assessment methods can inform decisions regarding tradeoffs | -USACE SPD 2016<br>-USACE CD 2010<br>-USACE StPD 2009<br>-Minnesota Board of Water & Soil Resources 2015 |
| What are the most critical knowledge information gaps that need to be addressed to advance the practice of assessing type conversion? | Need to qualify and/or quantify landscape context in terms of distribution of aquatic resource types, losses, and future objectives | -USACE SPD 2015<br>-Minnesota Board of Water & Soil Resources 2015<br>-Barrell et al. 2014 |

## B. Summary of Existing Agency Guidance

### Overview

Existing agency literature on type conversion is primarily restricted to considerations of "out-of-kind" mitigation in agency guidelines and recommendations. Of the 32 sources reviewed, few were found that specifically focused on type conversion and none that addressed the topic outside the regulatory context. Of the 32 documents reviewed, only 11 specifically addressed type conversion (vs. simply comparing different habitat types). Several documents mentioned the need to consider type conversion in the planning phases of a compensatory mitigation project but gave little details. Harper and Quigley (2005) found that creation of out-of-kind habitat represented 12% of the authorizations issued by Fisheries and Oceans Canada for the harmful alteration, disruption, and destruction of fish habitat. Many of the guidance documents either discouraged the use of type conversion, or considered it a less-preferred restoration option, except where it could be justified based on consideration of historical losses, regional rarity, or based on objectives established through watershed planning (Barrell et al. 2014, California Coastal Commission 1995, USACE Charleston District 2010, Minnesota Board of Water & Soil Resources 2015, USACE St. Paul District 2009). An example of this approach is illustrated through the USACE, South Pacific Division Mitigation Monitoring Guidelines (2015).

> "Out-of-kind compensatory mitigation (i.e., the habitat type of the compensatory mitigation project is different from the habitat type impacted by the proposed activity) may warrant a higher mitigation ratio. In some cases, out-of-kind compensatory mitigation may be appropriate (and result in a lower ratio) if the proposed compensatory mitigation habitat type would serve the aquatic resource needs of the watershed/ecoregion… In considering out-of-kind mitigation, project managers should consider whether impacts or mitigation would consist of rare or regionally significant habitat types (e.g., vernal pools). Project manager will determine the relative values of different habitat types and document herein."

The USACE St. Paul District Policy for Wetland Compensatory Mitigation in Minnesota (2009) provides additional guidance on use of a watershed plan to justify out-of-kind mitigation.

> "A watershed plan documents that out-of-kind compensation would reestablish key wetland/aquatic resource functions of the watershed. At a minimum, the watershed plan must consist of adequate data gathering and analysis to determine: (1) historical (pre-European settlement) locations/types/functions of wetlands; (2) current status and future trends of locations/types/functions of wetlands; and (3) strategic siting of wetlands by types/functions where the highest degree of wetland/ aquatic functions would be achieved."

The San Francisco Regional Water Quality Control Board's Basin Plan provides a mechanism for considering out-of-kind mitigation when it's determined to be environmentally preferable in consideration of regional restoration or management plans.

> "The Water Board may consider such sources as the (San Francisco Baylands) Habitat Goals reports, the Estuary Project's Comprehensive Conservation and Management Plan, or other approved watershed management plans when determining appropriate 'out-of-kind' mitigation."

## Ratio Approach

Most of the documents focusing on type conversion used a function-based approach, while only two used a set ratio approach. A set ratio approach is a regulatory tool to standardize the areal extent of replacement acreage needed to compensate for the acreage of lost habitat (colloquially known as "credits"). The credit ratio is usually a minimum 1:1 but can vary by State (Castelle et al. 1992), by the mitigation method used (e.g., creation, enhancement, preservation), or by the type of habitat impacted. The ratios used by the Minnesota Board of Water & Soil Resources depend on landscape criteria (the proximity to agriculture or the density of other wetlands in the area) and generally vary from 1:1 to 2.5:1; for type conversion mitigation projects, the ratio of wetland required for replacement is increased by 0.5 to 1 (Minnesota Board of Water & Soil Resources 2015). Guidelines for Wetland Compensatory Mitigation in Wisconsin (2013) suggest that mitigation ratios be increased by 0.25 for out-of-kind mitigation. Set ratios are easy to understand and apply, but using standardized acreage ratios alone to replace habitat may not account for important aquatic resource functions lost or gained (Castelle et al. 1992).

## Functional-based Approaches

Realizing that ratios do not fully account for functional change, more recent guidelines have incorporated function-based approaches (Table 2). Functional assessment approaches provide a systematic way to evaluate aquatic resource functions and determine the acreage necessary to replace lost functions (Minns 1997, Hruby 2012). For some approaches, a score assigned based on the level of function is multiplied by the acreage affected to provide an estimate of function-area (termed "acre-points" in Hruby 2012); other approaches evaluate function scores and areas separately. The Corps' Hydrogeomorphic Assessment Method (HGM; Smith et al. 1995) multiplies functional measures (termed Functional Capacity Indices) by area to produce Functional Capacity Units (FCUs) which can be used to compare across aquatic resource types.

In these cases, FCUs or acre-points lost must be made up by acre-points gained at the restoration or mitigation site. Functions that have been considered in this type of assessment have included HGM's measures of biogeochemical, hydrologic, and habitat functions, primary productivity, species diversity, species composition, biomass, and secondary trophic level measurements. (Barrell et al. 2014, Minns 1997, Houghton and Roberts 2002, Hruby 2012). As mentioned, few guidance documents include directions on function-based assessments. USACE South Pacific Division (2015) states that a functional assessment approach is desired, but defaults to ratios if suitable methods or metrics are not available.

Reference sites with similar functions to the new proposed habitat type have also been used to help "calibrate" assessment methods to a standard benchmark (Brinson and Rheinhardt 1996, Heaven et al. 2003, D'Avanzo 1990, Pechmann et al. 2001). In the approach by Brinson and Rheinhardt (1996), indices of ecological function are measured at project sites and scored from 1.0 (the level achieved in fully functioning conditions of reference wetlands) to zero (absence of the function when the ecosystem is totally displaced). In this way, the score indicates the habitat condition relative to reference. Because of this, the scores may be used to help determine the amount of function that must be accounted for across different hydrogeomorphic (HGM) aquatic resource types.

The functional assessment approach can support type conversion analysis by providing a common currency for estimating the effect of substituting one habitat type for another. For example, Baker and Arismendez (2011) were able to use the amount of benthic macrofauna productivity lost at an impacted offshore soft bottom habitat to determine the amount of marsh habitat at a mitigation site that was needed to compensate for the same amount of benthic macrofauna productivity.

A type of functional assessment that has been adapted for use with Natural Resource Damage Assessments is the Habitat Equivalency Analysis (HEA) (NOAA 2002, NOAA 2010, Baker and Arismendez 2011, Texas General Land Office 2000). HEA is used to estimate ecosystem services based on a series of metrics that vary based on the system and the services being evaluated. Different systems can be compared based on the assumption of equivalent value of all of the ecosystem services provided by one acre of the habitat in one year. Services for future years are discounted. The "discount rate" reflects society's willingness to shift the realization of public goods (such as ecosystem services derived from ecological functions) over time depending on the time scale of the impacts and time necessary for a damaged or restored system to recover.

Although more rigorous than ratio-based approaches, functional assessment-based approaches can be more difficult and time-consuming to apply and may not be appropriate in all circumstances. There is also a risk that, if not well documented, these approaches can be perceived as a "black-box" where the basis for making decisions is not readily understandable.

**Table 2. Features of ratio and functional assessment approaches to type conversion analysis.**

| Approach | Method | Feature used to determine equitable aquatic resource tradeoff | Pro | Con | Example |
|---|---|---|---|---|---|
| Ratio | Pre-set or Expert Judgement | • Area-for-area<br>• Habitat type<br>• Mitigation method<br>• Landscape characteristics | • Simple to understand and apply | • Relies on inference for function achieved<br>• Does not quantify relative improvement<br>• Subjective for scaling | • Castelle et al. 1992<br>• Malibu Local Coastal Program 2018<br>• Washington State Dept Ecology 2013<br>• Minnesota Board of Water & Soil Resources 2015<br>• Wisconsin Dept Natl Res 2013 |
| Functional assessment | Acre-points | • Rapid assessment methods<br>• Secondary production<br>• Hydrological, chemical, physical, geomorphological, biological, and landscape features | • Accounts for differences in ecosystem function or condition between habitat types<br>• Accounts for relative improvements | • Can be more difficult to apply<br>• Assumes the most important or susceptible functions are being identified<br>• Requires understanding of linkage between metric being measured and ecosystem function<br>• Requires understanding of ecosystem function at different habitat types<br>• Requires quantitation of temporal loss and risks associated with likelihood of success<br>• Assumption that creation of lower trophic layers will replace the category of higher-level organisms that were affected | • Houghton and Roberts 2002<br>• Hruby 2012<br>• WVDEP 2017 |
| | Habitat Equivalency Analysis (HEA) | • Biomass<br>• Benthic macrofaunal productivity | • Accounts for differences in ecosystem function between habitat types | • Requires assumptions about rate of recovery and assumed response trajectory<br>• Indicators may or may not account for all key aquatic resource functions | • NOAA 2002<br>• Baker and Arismendez 2011 |

# IV. Conclusions and Recommendations

We have confirmed that there is a lack of clear guidance for evaluating type conversion. Agencies acknowledge that type conversion is sometimes beneficial, particularly when viewing the cumulative impact of aquatic resource loss on a landscape level. Regional restoration plans, such as the "Strategies for Nearshore Protection and Restoration in Puget Sound" (Cereghino et al. 2012) and the "San Francisco Baylands Ecosystem Habitat Goals" (Goals Project 2015) provide a context to evaluate the desirability (or appropriateness) of restoring specific aquatic resource types over others to contribute to larger regional objectives. For compensatory decisions on aquatic resource loss, mitigation required for permitted losses of highly degraded wetlands (e.g., emergent wetlands dependent on artificial sources of hydrology) could be improved by utilizing out-of-kind replacement. In these instances, relatively common wetland types could be replaced with less common types (Quammen 1986, Good 1987). On a regional or watershed level, permitting authorities may consider cumulative impacts to specific aquatic resource types and risk of future loss due to changing land-use practices or climate change when determining the appropriateness of type conversion.

## A. Opportunities Based on Existing Approaches

Two basic approaches have been used to support regulatory decisions involving type conversion (once it is deemed appropriate): an area-based ratio approach and a functional assessment approach, each with distinct advantages and disadvantages (Table 2). The area-based ratio approach has been criticized as being too simplistic given the complexities of aquatic resource functions. However, area-based ratios have been used because they are simple to apply, and ratios can be adjusted depending on the constraints of the agency or judgement of an expert panel.

We suggest that functional assessment approaches may have utility for evaluating type conversion. Functional assessments can be used by both experts and non-experts to assess aquatic resource functions relatively rapidly. Functional assessments can be simple assessments of species richness or productivity or full detailed assessments of physical and biological structure and condition. Although often simpler, species-only assessment approaches may not represent the entire ecological community and may not account for all functions. Functions measured through rapid assessment methods have also been proposed, incorporating measures of habitat food webs, improved water quality, and hydrology (Hruby 2012). Hruby (2012) also incorporates a temporal multiplier that helps offset the amount of time to replace a function, as well as a risk factor multiplier, which attempts to offset the potential for failure in creating various habitat types. Rapid assessment methods may also serve as a useful tool to assess different types of aquatic resources and provide a convenient starting point for assessing type conversion (USACE South Pacific Division 2015).

Either approach (an area-based ratio or functional assessment) is most useful when used in the context of landscape-scale analysis of aquatic resource extent and function. For example, landscape profiles or regional goals can define desired overall conditions to maximize habitat support, diversity, and landscape-scale function. The result of this analysis could include preferences for type conversion over "in-kind" replacement.

## B. Recommendations

Developing a consistent, science-based framework for assessing type conversion would increase transparency and predictability in the evaluation process and would make it easier to evaluate the relative merits or desirability of type conversion under specific situations.

We recommend that future efforts begin with a process for evaluating whether type conversion is appropriate. Once a decision to proceed with type conversion is reached, a function-based approach, based on existing tools such as HEA, HGM, or CRAM, can be used to determine the appropriate tradeoff between aquatic resource types. However, these assessments should then be further coupled with landscape-scale assessments to inform trade-offs associated with type conversion. Landscape-scale assessments could take many forms:

1. Type conversion analysis can be informed by comparing distribution of aquatic resource types to a target distribution based on a reference watershed, established watershed goals, or knowledge of historical losses (Figure 1).

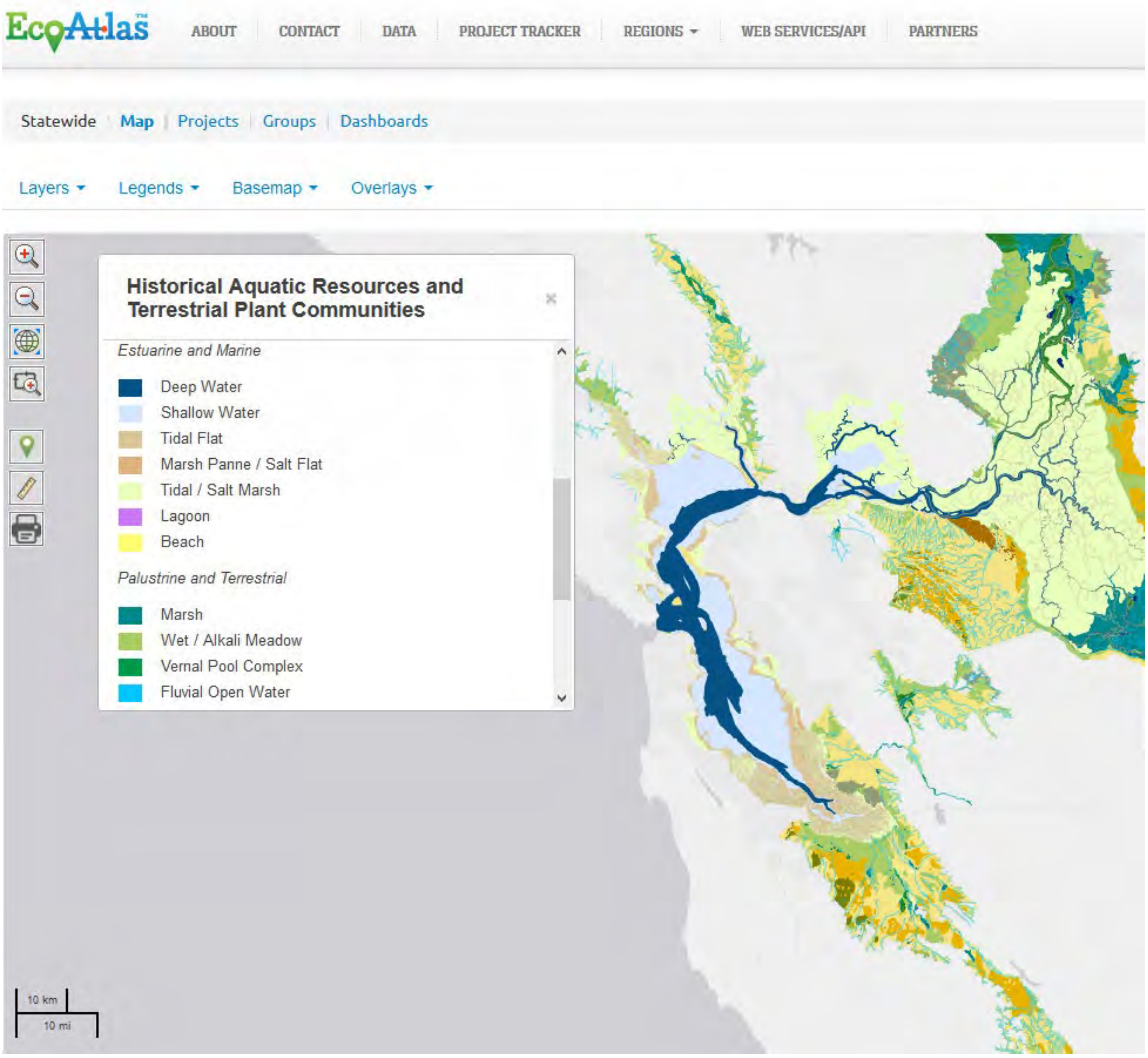


**Figure 1. Historic aquatic resources and terrestrial plant communities in the Bay Area, from the EcoAtlas landscape profile tool. Knowledge of the type or proportion of aquatic resources that previously existed within a watershed along with current opportunities to restore key landscape connections can help guide the selection of aquatic resources used in a type conversion evaluation project.**

2. Type conversion analysis could be informed by relative condition assessments of different aquatic resource types or expected changes in aquatic resource types based on future risks or vulnerabilities (Figure 2).

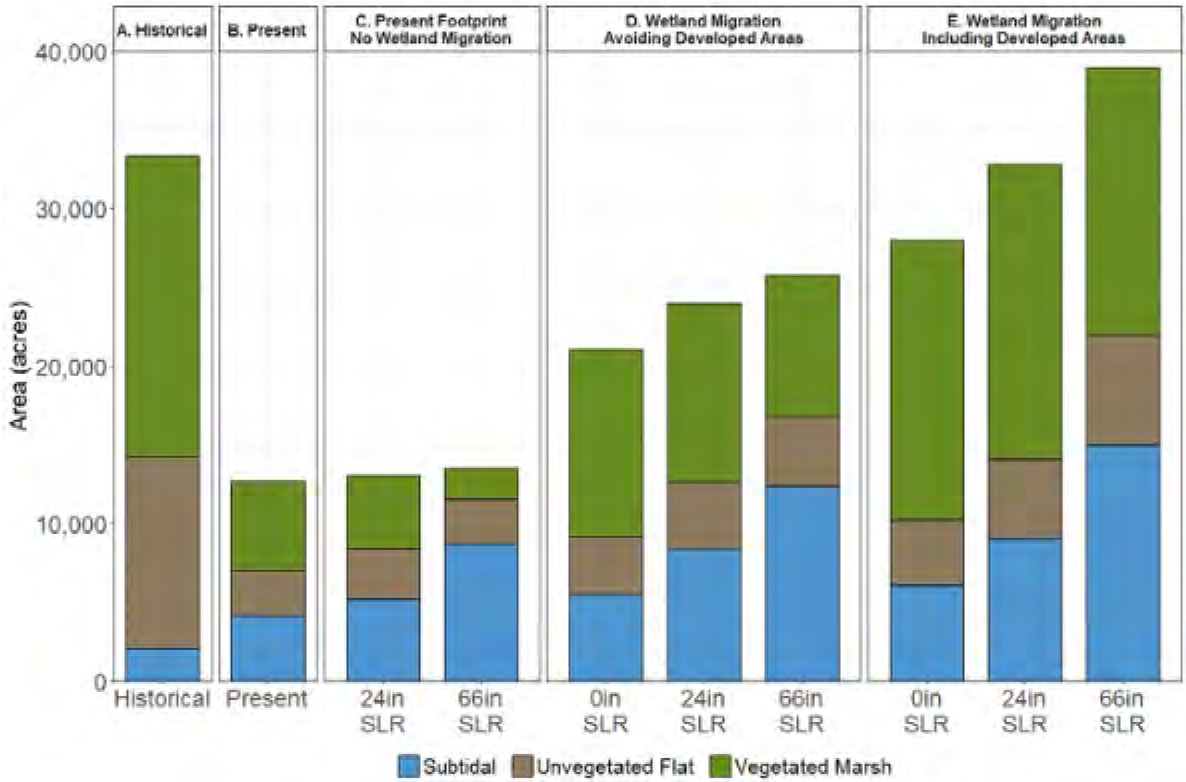


**Figure 2. Changes in overall extent and composition of southern California coastal wetlands between (A) historical, (B) present and (C, D & E) future habitat distribution based on predictions of 24-inch and 66-inch sea level rise. From SCWRP (2018). These scenarios can help direct choices for type conversion projects based on expected changes in habitat conditions.**

3. Type conversion analysis can be assigned based on landscape-scale assessments that allow for contextualization of a specific aquatic resources type based on watershed condition or vulnerability. For example, the South Florida Ecosystem Portfolio Model has been used to help understand the cumulative effects of regional landscape-level projects on ecological value, including decreases in habitat and restoration potential (Hogan et al. 2011). Some states have begun developing landscape assessment tools that allow relatively easy comparison of watershed condition or risk (e.g., State of Washington, see Figure 3).

## C. Baseline Data Needs

Landscape-scale data on historic, current, and projected future condition and stressors is a critical information gap to advance the capacity for evaluating type conversion. We recommend that programs begin to compile information on the following landscape parameters that can help inform future development of a type conversion assessment framework:

- Current extent and distribution of aquatic resources
- Historic extent and distribution of aquatic resources
- Distribution of species and habitats of management concern
- Distributed flow, surface water, and groundwater monitoring networks

- Distributions of major stressors, such as:
    - Anthropogenic land use
    - Diversions and discharges
    - Dams, barriers, and other hydrologic obstructions
- Expected future changes in stressors

We recognize that the availability of these data layers will vary by location around the state. Therefore, any framework that is developed should be hierarchical or tiered to allow for implementation in settings with different data availability. The framework should include a process for determining minimum data needs to assess if type conversion is an appropriate restoration or mitigation strategy. If it is determined to be appropriate, several alternative approaches should be provided to help determine the tradeoffs between aquatic resource types. The choice of a method may depend on the aquatic resource types involved and the amount of information available to conduct the evaluation.

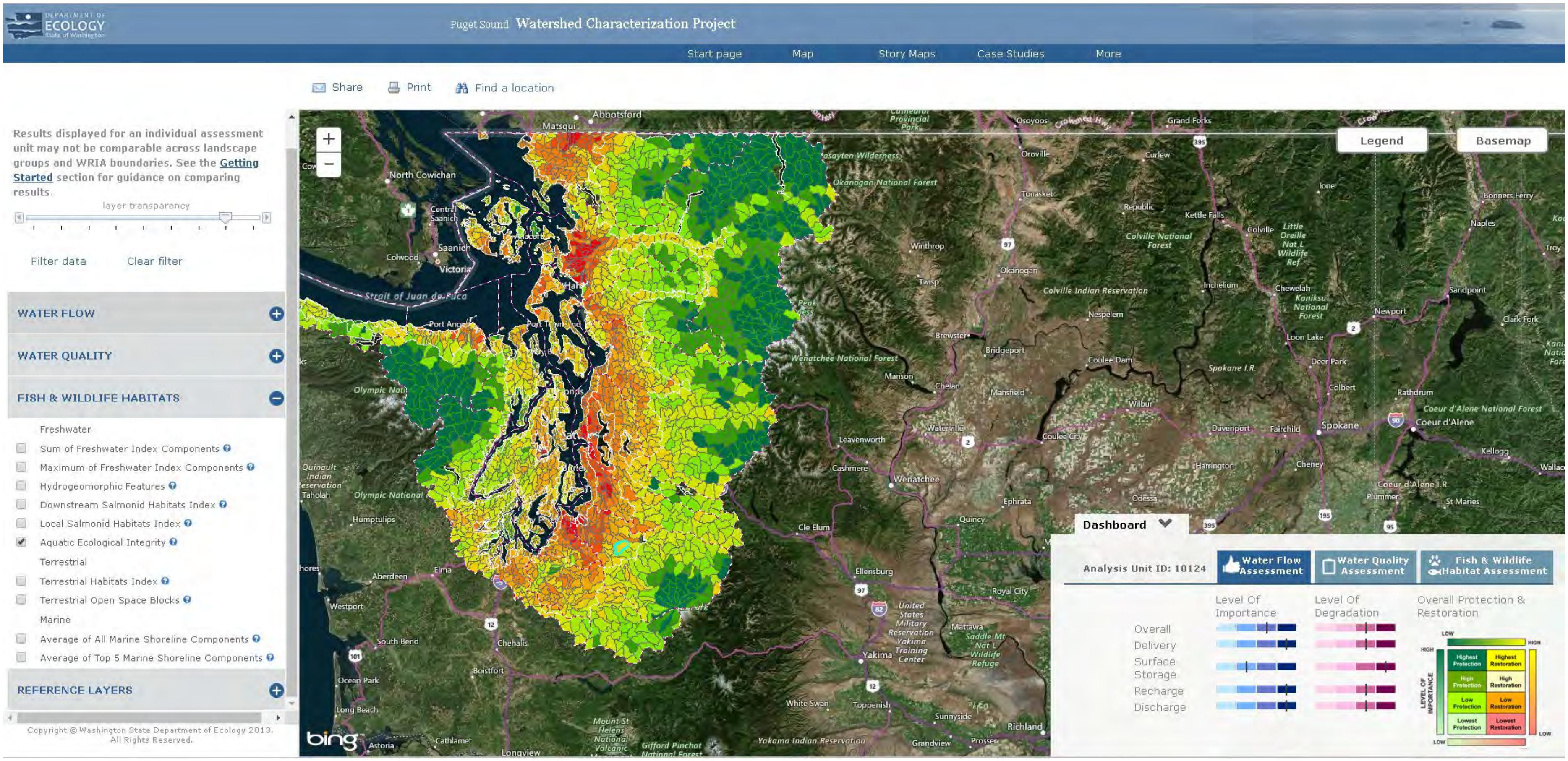


**Figure 3. Washington State landscape assessment tool. This tool allows for evaluation of relative condition and vulnerability of catchments as a means of prioritizing areas and habitat types for restoration.**

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