Baseline Estuarine-Upland Transition Zone
for SF, San Pablo and Suisun Bays

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Prepared for
San Francisco Bay Joint Venture (SFBJV)

Prepared by
Brian Fulfrost, Principal
bfaconsult@gmail.com

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Goal

Calculate baseline transition zone acreage within San Francisco, San Pablo and Suisun Bays in order to enable the San Francisco Bay Joint Venture (SFBJV) to track changes to these habitats over time. Use the baseline transition zone datasets to assess the condition of estuarine and other habitats.

Background

As a component of its Science Program program, the San Francisco Bay Joint Venture (SFBJV) has a need to identify the baseline acreage of transition zone within its area of responsibility . The SFBJV requires this data as a foundation for tracking changes to the distribution and acreage of transition zone as a means for evaluating progress towards meeting habitat goals. The SFBJV hired Brian Fulfrost to assist with assessing the utility of using the 'Bay Margin' GIS datasets (Fulfrost and Thomson, 2015) to meet these needs.

Upland transitional habitats found along the margin of estuaries are critical to tidal marsh ecosystems. However the status, distribution and extent of these habitats is generally not well understood. Land managers and estuarine planners require an understanding of these habitats to make proper choices regarding the conservation of estuaries. The Bay Margin Decision Support System (DSS) was the first to both describe and map the distribution and extent of estuarine-terrestrial transitional habitats throughout SF, San Pablo and Suisun Bays, and propose a ranking system for predicting their likely conservation value. Rankings are based on indicators of habitat function described in the transition zone definition report that is component of the DSS. The metrics used to represent these indicators utilize commonly available landscape-scale datasets to compare and contrast the likely value of mapped upland transitions. The DSS took a forward thinking approach and mapped both transitional elevations that were exposed to tidal action ("actual") as well as transitional elevations not currently exposed to tidal action ("potential" that are behind water control structures).

We used the metrics of habitat quality from the Bay Margin DSS to identify a subset of transition zone that could be used as a 'baseline' for the SFBJV Science Program program. With the assistance of the SFBJV's Science Steering Committee and other project partners, we identified the criteria (tidal and adjacent to a saline wetland) and improvements necessary to create a GIS layer that could justifiably serve as 'baseline' for the distribution and extent of transition zone in SF, San Pablo and Suisun Bays.

GIS (and documentation)

The GIS dataset represents the 'baseline' distribution and acreage of estuarine-upland transition zone elevations that are both (a) exposed to tides; and (b) adjacent to a saline marsh. The baseline data can be used to track changes to transition zone distribution and acreage over time. The GIS dataset not only represents the current baseline distribution of transition zone, but also distinguishes between transition zone that is either in the 'backshore' (adjacent to both a tidal wetland and an upland) or in the 'mid marsh' (only adjacent to a tidal wetland).

The distribution and quality of transition zone are based on GIS models that use best available (and the most recent) tidal and habitat datasets. As a result, the accuracy of the baseline transition zone layer produced from this process is only as good as the underlying datasets used in our model. Included below are links to either download the GIS layer (and metadata) of SFBJV baseline transition for SF, San Pablo bays or to access it via an interactive map on Data Basin.

Accessing and Using GIS Dataset(s)

Acreages can be quantified using different areas of interest (e.g. by bay, by management unit, by project area) using GIS software. Changes to baseline transition zone acreages can be tracked by appending new tidally exposed transition zone elevations (i.e. polygons) and evaluating their adjacency to saline wetlands and uplands. Transition zone polygons can also be queried and/or visualized based on whether they are either (a) in the backshore (adjacent to both saline wetland and upland) and/or (b) in the mid-marsh (adjacent only to saline wetland).

Baseline transition zone distributions in SF, San Pablo, and Suisun Bays (download GIS files)

1. GIS data (ESRI shapefile) w/ metadata (.xml) - https://bfa.egnyte.com/dl/ZtsKXQ67GA/SFBJV_transitionzone_baseline_July2018.zip_

    - *Visualize distribution (and acreage)* of 'baseline' transition zone
    - *Quantify and track acreage(s)*:
        - Acreage of all bays
        - Acreage by bay
        - Acreage by management area
        - Acreage by project area
    - *Query* 'backshore' or 'mid-marsh' (and/or other transition zone metrics)
    - *Export maps* (including acreages and query results)

Interactive Map (viewing, querying, and exporting)

2. Data Basin - https://databasin.org/datasets/09ef1c151c174c0cbf8f3f17c04de0dc

- *Visualize distribution (and acreage)* of 'baseline' transition zone
- *Query* 'backshore' or 'mid-marsh' (and/or other transition zone metrics)
- *Export maps* or *download data* (including acreages and query results)

Total Acreages

Transition Zone "Type"	**Acres (Sum)**	**Acres* (Average)**
Backshore	1,416	0.37
Midmarsh	1,923	0.06
Total	**3,339**	**0.09**

* Averages were calculated by averaging the area of all transition zone polygons

Acreages by Bay

Bay	Acres (backshore)	Acres (midmarsh)	**Acres (Total)**
South SF Bay	247	623	**870**
Central SF Bay	59	99	**158**
San Pablo Bay	451	800	**1251**
Suisun Bay	402	658	**1060**

Limitations

Transition zone distributions and habitat 'function' were mapped using best available landscape level datasets available estuary wide. The accuracy of the resulting GIS layers are largely dependent on the accuracy of the underlying data used to model transition zone distribution and habitat quality. We conducted an extensive QA/QC, both in the lab and in the field, which indicated a high degree of overall accuracy (in distribution as well as quality) in our final datasets. However, during Phase 2 we identified errors in the Lidar we used to model tidal elevations. The "bare earth" elevations *in locations of freshwater or brackish marshes* were not actually 'bare earth' but instead top of vegetation. As a result, we falsely identified a significant amount of potential Transitional elevations, mostly in Suisun and San Pablo bays. We successfully removed a large amount of these errors using recent vegetation datasets, although some error likely remains. Elevations located in the backshore, that are adjacent to both saline wetlands and upland, are unlikely to be locations of fresh or brackish marshes and therefore unlikely to be error due to Lidar processing. Although 'mid marsh' transition zone elevations are likely either levee flanks, transitional elevations adjacent to sloughs/channels, or other transitional elevations not adjacent to upland, some of these locations could be remaining error, especially in locations of freshwater and brackish marsh. As a result, we have distinguished transitional elevations as either being in the 'mid-marsh' (possible transitional elevation or Lidar error) or in the 'backshore' (probable transitional elevations). Regardless of any remaining errors, we are confident that the GIS layer of SFBJV baseline transition zone more than meet the necessary levels of accuracy for similar landscape level datasets used for high level planning.

Methods

The SFBJV baseline transition zone GIS dataset is derived from the 'Bay Margin' estuarine-upland transition zone decision support system (DSS) funded by the USFWS and California Coastal Conservancy. Included below is an overview of the steps taken to modify and improve the current transition zone distribution (and rankings) layer in order to establish a 'baseline' for transition zone acreage through the SFBJV area of responsibility. The method description begins with an overview of the mapping methods used to develop the Bay margin GIS datasets. The SFBJV baseline transition zone GIS layer differs from the original dataset in that it contains only transition zone, that: (1) is exposed to tides ("actual" transition zone); and (2) is adjacent to a saline emergent wetland. It also has had a significant amount of error in San Pablo and Suisun bay removed. The resulting SFBJV baseline transition zone GIS layer is considered to represent the distribution of actual transition zone elevations still connected to the tidal estuary in SF, San Pablo and Suisun bays.

1. 'Bay Margin' Transition Zone

Our first step was to develop a technical report (for a complete discussion of the products and methods used to develop these original GIS datasets see the 'Bay Margin' website on the California Climate Commons) containing a detailed characterization of the physical and biological properties of transition zones with respect to the functions of the tidal marsh ecosystem, including resilience to sea level rise, and the needs for obligate fauna. A list of indicators were developed based on these habitat functions and utilized to map their distribution and assess their quality. For the purposes of tidal marsh ecosystem recovery in San Francisco Bay, critical habitats at the bay's margin are defined as those occurring between the marsh "plain" or the zone of regular flooding, through estuarine-terrestrial transitional habitats ("Transitions"), and into some portion of adjacent terrestrial habitats.

Our second step, was to map the distribution of transitional zone distributions via tidal elevation modeling based on tidal elevation ranges documented in the Transitional Zone Definition Report. The resulting GIS data includes both 'actual' (exposed to tides and within potential tidal elevation range) and 'potential' (not exposed to tides but within potential tidal elevation range) transition zone distributions.

Finally, current transition zone distributions (actual and potential) were then ranked according to a range of mappable metrics of habitat function, including linkages to both wetlands and uplands, landscape metrics (width, size and shape), and adjacency to development. Rankings are based on indicators of habitat function described in the Transitional Zone Definition Report.

Transition Zone Distributions

Once we had characterized transition zone habitat with the help of experts, we *mapped the distribution of transitional zone based on tidal and elevation constraints*. The width of transitional habitat is largely determined by the extent of the irregularly-flooded tidal zone, which modifies the salinity of the soil, and the consequent distribution of flora. High resolution Lidar (1 meter) was combined with tidal surfaces created from NOAA tidal gauges to identify and map the range of tidal elevations corresponding with transition zone habitat. Two tidal rasters (converted to NAVD88) were generated from the tidal gauge data to assist with mapping the lower and upper limits of Transitions. The first was an interpolated surface of MHHW (using ~ 40 tidal gauges) and the second was a trend surface of the difference between MHHW and HOWL (using around ~16 tidal gauges) to account for tidal variability at the upper limit of the estuary. The Lidar elevation data was merged with the MHHW surface in ArcGIS so elevation represented elevation relative to MHHW for the entire SF Bay. The "range" of potential Transitions was identified as .31 meters above MHHW as the lower limit to HOWL + .27 meters as the upper limit. Raster output from the first order model was converted to vector polygons, simplified and adjacent polygons (w/i 1 meter) were merged. The final transitional zone patches were categorized as either 'tidal' or 'non-tidal' based on boundaries provided by Point Blue.

Ranking Transition Zone Habitat Quality

Each transition zone polygon identified was then ranked according to a series of 9 metrics representing the indicators of habitat quality. Index values (positive and negative) were created for each metric in order to rank each transition polygon according to habitat quality. Indicators values were summed into a combined index representing potential value to tidal marsh ecosystem management. Both actual transitional elevations ("levee on") and potential transitional elevations ("levee off") were assigned index values.

A major use of the characterization report was to identify indicators of habitat "quality" and function, that could be used to map and rank the restoration potential of Transitions. We identified the 3 most salient (and practical) indicators to be used in our GIS based suitability model. These included: (a) Transition width - 30 meters was identified as a minimum width for functional habitat; (b) Transition Shape and Size - areas with more core area were determined to provide better overall habitat function (especially for wildlife) and a minimum area of 900 m2 (based on the 30 m width) was used as threshold of adequate habitat size ; and (c) adjacent habitat (or development). Habitat connectivity was identified as a major influence on habitat function and as a result we ranked transition zones positively according to their adjacency to wetlands (tidal and freshwater) and uplands. We ranked the restoration potential of transition zones patches (actual and potential) using the following nine metrics (max = 200+):

1. Mean Width (-10 to 30)	6. Adjacent Urban (-30 to 0)
2. Shape (-10 to 10)	7. Adjacent Agriculture (-15 to 0)
3. Adjacent Tidal Wetland (0 to 30)	8. % developed (0 to 50)
4. Adjacent Freshwater Wetland (0 to 30)	9. tidal/non-tidal (50/25)
5. Adjacent Upland (0 to 30)	

Data Sources: NOAA (C-CAP), CDFW (CalVeg), NOAA/USGS (2m BathyTopo Lidar), NOAA (tides and currents), Point Blue (tidal/non-tidal mask), and GreenInfo (CPAD).

2. SFBJV Baseline Transition Zone

The SFBJV baseline transition zone layer was derived from the *current transition zone distribution (and rankings)* GIS layer created for the Bay Margin DSS. A number of additional processing steps were used to modify (and improve on) the GIS layer of restoration rankings in order to create the SFBJV baseline transition zone GIS layer

SFBJV Science Steering Committee (SSC)
After a year long review and discussion, the SSC made a decision to adopt the use of the bay margin GIS data for calculating baseline transition zone - with some key modifications (and additional improvements). Since the function of the baseline data was to be able to track changes to current conditions, the committee decided that to be included in the ‘baseline’, transition zone elevations needed to meet the following conditions:

- exposed to tidal action (‘actual transition zone), and
- adjacent to a saline wetland.

GIS Processing
We utilized the attributes already available in the Bay Margin GIS to remove transitional elevations not meeting the criteria identified by the SSC. As part of this process, and with the help of the SSC, we also identified and removed a significant amount of error in Suisun bay and to a much lesser degree in San Pablo bay.

Step 1a: Identify Tidal Only
We queried the Bay Margin GIS layer for *transition zone distributions that were tidal. As part of* Transitional elevations had already been categorized as either tidal/non-tidal using a mask provided by Point Blue. Polygons meeting these criteria represent ‘actual’ transition zone elevations since they are currently exposed to tidal action. The accuracy of this query depends largely on the tidal/non-tidal mask developed by Point Blue for their predictive tidal marsh planning tool (Veloz et al, 2014), which we used to differentiate transition zone elevations. After some QA/QC (and edits) early on in the Bay Margin project, we found the mask more than adequate to meet our needs, especially at the landscape scale.

Step 1b: Identify Adjacent to Saline Wetland
We queried the results of Step 1a to only include tidal transitional elevations that were also adjacent to a saline wetland. We used the index value representing the size (and length of shared boundary) of adjacent tidal wetland. This attribute was part of the metrics used for ranking restoration potential of transitions for the Bay Margin DSS. It was calculated using vegetation data from CalVeg. Transition zone elevations were selected for any value (representing saline wetland adjacency) over zero. As a result, transitions included in the baseline dataset can be adjacent to a saline wetland of any size (and length of shared boundary).

Step 2: Identify and Remove Error from Lidar
We reviewed the transitional elevations resulting from Step 1 with the help of the SSC. During this process we identified errors in the Lidar we used to model tidal elevations. The “bare

earth" elevations *in locations of freshwater or brackish marshes* were not actually 'bare earth' but instead top of vegetation. As a result, we falsely identified a significant amount of potential Transitional elevations, mostly in Suisun Bay. Two major techniques for removing locations with these errors were suggested (see below). These techniques included, either:

- reprocessing lidar with offsets; or
- using available vegetation datasets to remove transition zone elevations in locations of freshwater or brackish vegetation.

Although reprocessing Lidar has been used in other places to mitigate this bare earth issue in wetlands, we determined the work involved was potentially too time intensive and costly. At the same time, GIS datasets of vegetation in Suisun Bay, where most of the errors existed, are readily available. As a result, we chose to use using available vegetation datasets to remove these underlying lidar issues.

Removing Errors using Vegetation Datasets

We identified all the brackish and freshwater vegetation polygons from the most recent GIS datasets from Napa, Sonoma and Solano counties. We then removed these areas of brackish and freshwater vegetation that overlapped with the chosen transition zone elevations (tidal and adjacent to wetland).

- CDFW Suisun Bay vegetation (2015) - Solano county only
- Sonoma Vegetation (2017)
- CDFW Napa vegetation (2002)
- SF Bay NERR Rush Rush vegetation data (2014)

Any multipart polygons that remained after removing the area of overlap were 'exploded' into single part polygons so habitat adjacency could be recalculated. Also, any remaining polygons smaller than 8 square meter were removed. After final error processing, we removed a significant amount of transitional zone error within Suisun Bay (~2300 acres) and to a much lesser degree within San Pablo Bay (~40 acres).

North Suisun Bay

We evaluated two other approaches to remove errors in north Suisun Bay (where most of the error existed) based on suggestions from the SSC members and project partners. These included:

- Only removing errors where fresh or brackish vegetation persisted over time within these marshes (using CDFW vegetation data from 2012 and 2015) in order to account for the shifting salinity of marshes within Suisun Bay

- Using an “offset” raster provided by Point Blue that accounted for the underlying Lidar issue with bare earth heights in locations of fresh and brackish marshes

After a significant amount of QA/QC of the results of these approaches using high resolution aerial photography, neither adequately removed enough of the obvious error, which was especially clear when compared to the results using just the most recent vegetation data (2015).

South Suisun bay
In south Suisun bay (Contra Costa County) we manually removed vegetation based on an online literature search of the vegetation composition of relevant marshes and shoreline. We reviewed online materials with a focus on identifying if marshes were either saline or brackish/freshwater. We removed approximately 300 acres as a result of this process.

Step 3: Recalculate Saline Wetland and Upland Habitat Adjacency
After the areas of freshwater and brackish vegetation were removed from the preliminary baseline transition zone polygons, we recalculated (using CalVeg) the index values of any polygons modified by previous steps. Index values that were recalculated included *upindex*, the metric of upland adjacency, and *tideidx*, the metric of salt marsh adjacency.

Step 4: Backshore vs. Mid-Marsh ‘Transition Zone’
Although we removed a significant amount of error (~2650 acres), the resulting transition zone datasets continued to contain locations of transitional zone elevations within the ‘mid marsh’. In some locations (e.g. Rush ranch) these were identified by members of the SSC as error (at the same time the Rush ranch vegetation dataset provided by NERR identified these ‘errors’ as locations of salt marsh vegetation). As a result of this concern, we added an attribute to the SFBJV baseline transition zone that distinguishes transition zone within the ‘mid-marsh’ from that at the ‘backshore’. In order to do this efficiently (without the need of additional analyses), we used the underling bay margin attribute data used for ranking restoration potential.

Backshore
Transitional elevations that were (tidal and) adjacent to both a saline wetland and an upland (both metrics values greater than zero) were tagged as ‘backshore’.

Mid-marsh
Transitional elevations that were (tidal and) adjacent to a saline wetland (metric value greater than zero) were tagged as ‘mid-marsh’. Transition zone elevations that have been categorized as being within the mid marsh plain, are either one of the following:

- *remaining error* from the Lidar and/or in our tidal modeling, or
- *potential transitional zone ground elevations.*

The ”mid marsh” as it is used here includes not only locations that are actually within the marsh but also could include: levee flanks, areas along the periphery of the marsh but not adjacent to uplands (or not identified as adjacent to uplands by the Calveg datasets), and areas adjacent to sloughs - all of which could be potential transitional elevations.

Although we are confident that our approach enhances the product at the landscape level, our ability to distinguish the two types of transition zones is only as good as the underlying data we used to identify tidal wetlands and uplands (CalVeg). As a result, we do not expect the additional attribute distinguishing the two types of transition zone (backshore and mid marsh) to be 100% accurate.

References

Cowardin, L. M.; Carter, V.; Golet, F. C.; LaRoe, E. T. 1979. "Classification of wetlands and deepwater habitats of the United States". Technical Report to the U.S. Department of the Interior, Fish and Wildlife Service. https://www.fws.gov/wetlands/Documents/Classification-of-Wetlands-and-Deepwater-Habitats-of-the-United-States.pdf

Fulfrost, B. and Thomson, D. 2015. *San Francisco Bay Margin Conservation and Management Decision Support System (DSS*). Report of pilot project produced for USFWS Coastal Program

Fulfrost, B. and Thomson, D. *San Francisco Bay Estuarine-Terrestrial Transitional Zone Decision Support System (DSS)*. (2015/2018). DSS for pilot area (Phase 1) developed for and funded by US Fish and Wildlife Service (USFWS) Coastal Program. DSS completed (Phase 2) with funding from California Coastal Conservancy. Reports, documentation and GIS datasets can be downloaded at: http://climate.calcommons.org/dataset/san-francisco-bay-estuarine-terrestrial-transitional-zone-decision-support-system.

Harvey, T. et al. (1978). *Determination of transition zone limits in coastal California Wetlands*. Report to the Environmental Protection Agency (EPA).

Kent, M., Gill, W. J., Weaver, R. E., & Armitage, R. P. (1997). Landscape and plant community boundaries in biogeography. *Progress in Physical Geography*, *21*(3), 315-353.

National Research Council (2012). *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past. Present and Future*. National Academies Press. Washington DC. 2012.

Thomson, D., et al. (2013). *Critical Tidal Marsh Ecosystem Habitats at the Bay's Margin : A description*. Report of pilot project produced for USFWS Coastal Program. Available at: http://climate.calcommons.org/dataset/san-francisco-bay-estuarine-terrestrial-transitional-zone-decision-support-system

Veloz, S., M. Fitzgibbon, D. Stralberg, S. Michaile, D. Jongsomjit, D. Moody, N. Nur, L. Salas, J. Wood, M. Elrod, and G. Ballard. (2014). Future San Francisco Bay Tidal Marshes: A climate-smart planning tool. [web application]. Petaluma, California. (see www.pointblue.org/sfbayslr)