Appendix 9: Transition Zone Background & Methodology

of the *Wetlands on the Edge: The Future of Southern California's Wetlands Regional Strategy 2018*

Primary Author: April Robinson, San Francisco Estuary Institute
Contributing Authors: *Regional Strategy 2018* Authors

Protection and restoration of wetland-upland transition zones are critically important if tidal wetlands are going to persist. Objective 5 provides preliminary recommendations for the preservation of existing transition zone habitats. In order to implement this objective, project proponents need to map existing and proposed transition zones.

The wetland-upland transition zone connects tidal wetlands to adjacent terrestrial habitats, providing flooding refuge for wildlife, space to accommodate marsh transgression with sea-level rise, and other vital ecosystem functions. Much of the historical transition zone habitat in California has been lost due to competing land uses along the shoreline. Accelerating sea level rise increases the challenge of supporting transition zone habitats, and ecosystem services associated with transition zones, especially in heavily developed areas.

Ecosystem Services Provided by Transition Zones

The transition zone provides many important ecosystem services. These areas provide important refuge for marsh wildlife, and allow upland wildlife to access the marsh for food and other resources. These areas support gradients in environmental variables such as salinity, soil moisture, and temperature that can be important to supporting adaptation within wildlife populations, and can also support unique habitat types (e.g. alkali wetlands, salt pannes) that further contribute to landscape complexity.

Protection and restoration of marsh transition zones are critically important if tidal wetlands are going to persist. Objective 5 provides preliminary recommendations for the preservation of existing transition zone habitats.

To implement Objective 5, project proponents need to map existing and proposed transition zones. This document describes a method for defining an upper boundary for the wetland-upland transition zone. It can be used to determine how far up into the watershed to look in order to plan for transition zone management in an aspirational way. Defining an upper boundary for potential transition zone is meant to encourage wetland managers to think outside of the current wetland boundaries, and to consider larger-scale and longer time- horizon planning; think through how restoration and management actions within the region might fit together to restore and maintain transition zone habitats and processes over the long term. This boundary encompasses potential marsh migration area as well as providing an important habitat zone (Figure 1). While the marsh migration zone is defined by elevation (24 inches, see Appendix 4), the upper boundary is determined by extent upslope or upstream (see details below). As sea levels rise and marshes migrate landward the transition zone moves upslope in tandem.

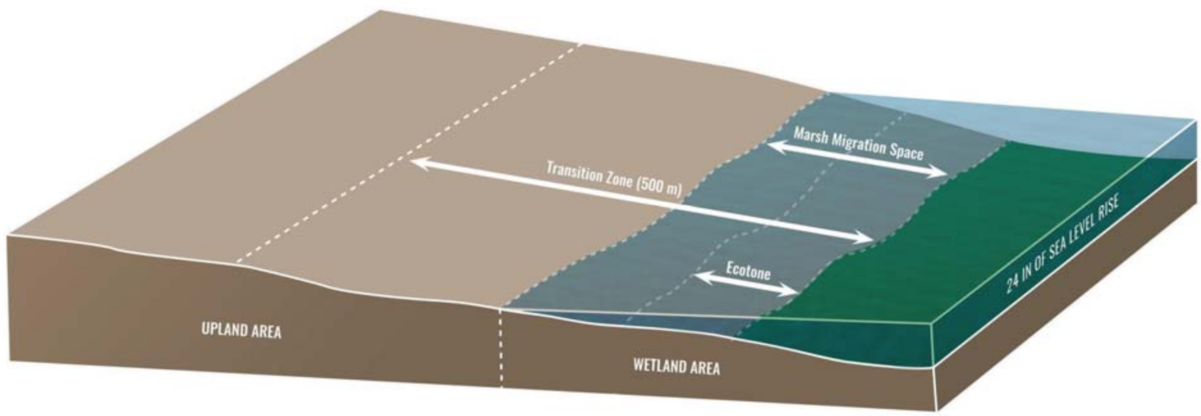


Figure 1. Diagram showing the relationship between "marsh migration space" and "transition zone".

Land use is a major consideration in determining what can be done within this transition zone boundary. Although many developed areas are unlikely to be considered for potential restoration, these areas may still support transition zone functions. For example, some land uses in developed areas (e.g., vacant lots, golf courses) may still provide some buffering functions. Actions taken in developed areas within this boundary can support wildlife movement (e.g., removal of barriers and planting of native vegetation in yards), and affect flood control (e.g., rain gardens and bioswales). Infrastructure realignment within these areas, to protect from increased flooding with climate change, may provide opportunities for transition zone restoration.

The first half of this document explains what the wetland-upland transition zone is, why it's important, and why mapping it is challenging. This context is necessary for understanding the assumptions made in the methodology. The second half of the document describes the proposed methodology for defining an aspirational transition zone boundary.

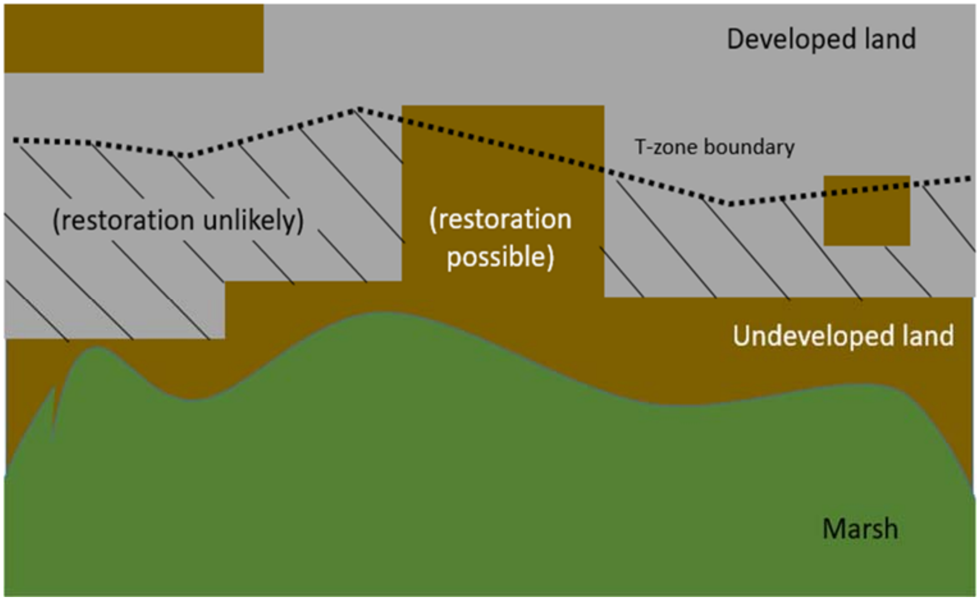


Figure 2. This boundary delineates an upper boundary for the existing and potential transition zone or potential transition zone.

Background on Transition Zones

What is the transition zone?

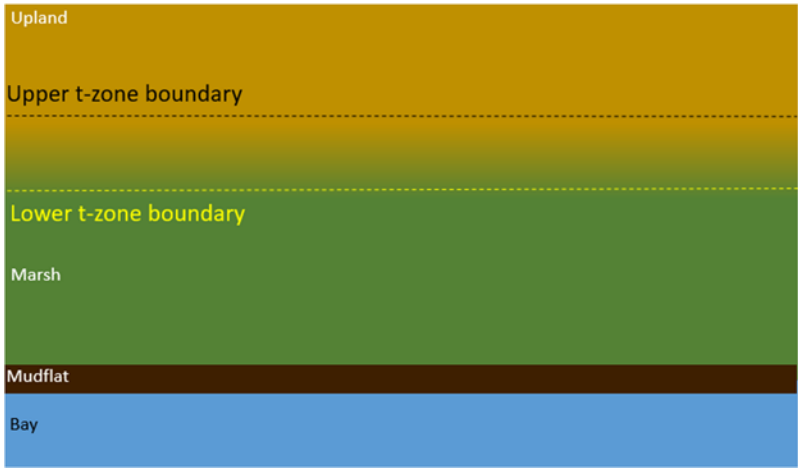
Wetland-upland transition zone definition[1]

The wetland-upland transition zone is the area of existing and predicted future interactions among tidal and terrestrial or fluvial processes that result in mosaics of habitat types, assemblages of plant and animal species, and sets of ecosystem services that are distinct from those of adjoining estuarine, riverine, or terrestrial ecosystems.

Conceptually, the transition zone spans from the upper reaches of land that is influenced by the tides, up to an area of land that is not currently influenced by tides, but may be in the near future with sea level rise. The upper boundary of the zone transitions into upland and a lower boundary that transitions into intertidal wetlands (Figure 2). The type of transition zone (determined by the slope, hydrology, soils and vegetation) can affect its width.

[1] From Bayland Ecosystem Habitat Goals Update (2015)

A)



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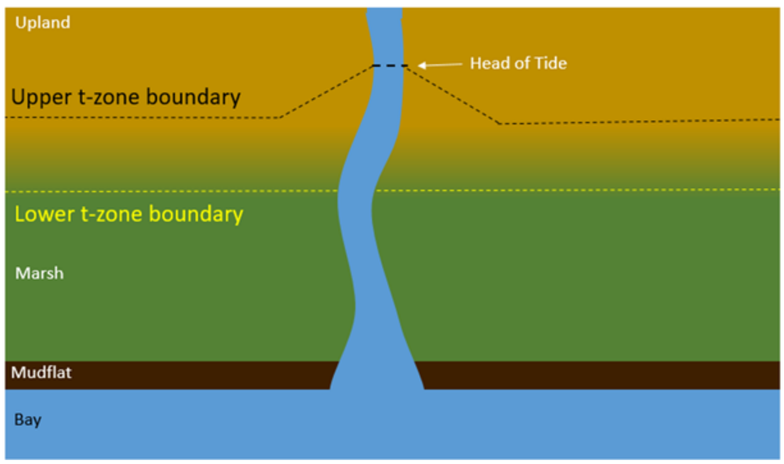


Figure 3. Simplified diagram of a wetland-upland transition zone, showing the lower boundary connecting to tidal marsh and the upper boundary connecting to adjacent upland (A) or streams/rivers (B). Different types of transition zones are shown in Figure 5.

The location of the transition zone moves over time as tidal marshes move with changing sea level (Figure 3). In areas with low gradient slopes, today's transition zone becomes tomorrow's marsh. As rates of sea level rise increase this marsh migration may not be able to offset marsh loss without ensuring adequate sediment supply and other conditions that promote marsh growth. Effective transition zone management can help support this process.

Where the transition zone is, or could potentially be, changes over time. For the methodology described here we specify the time period for which the boundary is being defined.

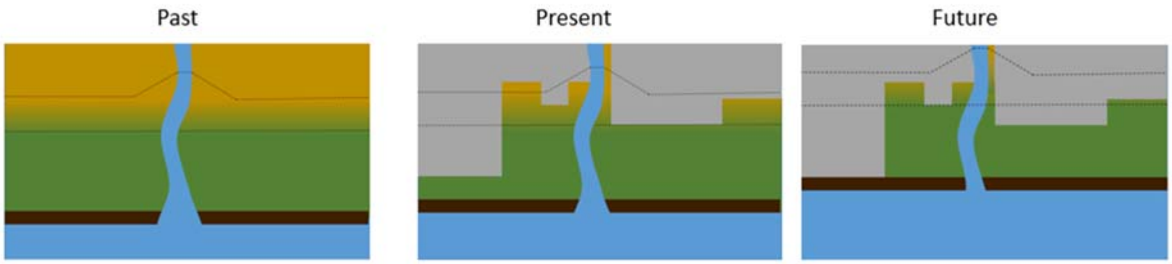


Figure 4. The location of the transition zone changes over time. Today much of the area that could potentially be transition zone has been developed. In this figure the area between the dashed lines is meant to represent transition zone or potential transition zone for different time periods.

What is the value of the wetland-upland transition zone?

The transition zone provides many important ecosystem services. Here we consider the benefits that the transition zone provides to terrestrial wildlife and terrestrial processes, as well as wetland species and processes, taking both an "estuary up" and "watershed down" approach. The value of the transition zone to the current and future health of our wetland ecosystems cannot be overstated. The list of ecosystem services used for this effort is focused on those ecosystem services most relevant to defining the outer boundary - wildlife refuge, wildlife foraging and predation, wildlife and plant movement, evolutionary adaptation, landscape complexity, fluvial flooding, and erosion control.

Buffering is one of the important ecosystem services that the transition zone provides. The transition zone acts as a buffer to prevent stressors from the larger landscape (e.g., contaminants, invasive species) from reaching the wetland. In a regulatory context, buffers are areas of upland surrounding a wetland, generally defined using a fixed width. The buffers defined by regulation will sometimes, but not always, overlap with the ecologically-defined transition zone. There is some regulatory guidance for defining a buffer around wetlands. For tidal marshes this regulatory buffer will overlap with part or all of the transition zone, depending on the site. This buffer may or may not include other important transition zone functions, depending on transition zone condition.

As sea level rises the wetland-upland transition zone provides space for marshes to migrate. Because transition zones areas have the potential to experience tidal flooding in the future, these zones are appropriate places for thinking about sea-level rise adaptation. Even in areas where tides are blocked by levees or seawalls, increasing groundwater levels can cause flooding issues. Sea-level rise adaptation actions might include raising structures out of flood prone areas, building levees to keep water out of low-lying areas and avoiding placement of new structures in vulnerable areas.

The wetland-upland transition zones provides several functions for terrestrial wildlife, both terrestrial and marsh species. Transition zones are especially important as wildlife movement corridors, especially in highly urbanized areas. These wildlife movement corridors can be important for daily movements, seasonal habitat shifts, and juvenile dispersal of both marsh and upland species. Wetland-upland transition zones provide critical support to tidal marsh species such as the Ridgway's Rail by providing areas to escape flood events. Providing access to food is also an important function, as high densities of marsh vertebrates in the transition zone during flood events provide opportunities for native predators such as herons and egrets.

The transition zone can also attract non-native and nuisance predators such as red foxes, rats and feral cats. The degree to which the transition zone supports these less desirable species likely depends on how the zone is managed, and the vegetation it supports, however wider transition zones are generally better at keeping out nuisance non-native species.

The survival of local populations of plants and animals depends on their adaptation to changes in habitat conditions. Such adaption is known to occur at the margins of habitats, including in ecotones. For some species, the transition zone may be critically important as a place for adaptations to changes in habitat conditions caused by sea level rise.

The transition zone contributes to a complex mosaic of estuarine habitat types that increase the local diversity and abundance of plant and animal species across landscapes at a regional scale. Historically this included freshwater wetlands, alkali wetlands, and willow groves. As described for San Diego lagoons historically "*extensive freshwater/brackish wetland complexes were present at the back edge of each estuary, creating a gradual transition zone between estuarine and upland habitat types that in some cases extended several miles inland."*

Different approaches for mapping the wetland-upland transition zone

While the importance of wetland-upland transition zones to support healthy estuarine systems is increasingly recognized, defining the extent of the zone is difficult. Estimates of transition zone extent can vary depending on the ecosystem services considered. There is substantial variation by site in how these functions and services are expressed across the zone, depending on the geomorphology, habitat types, and land uses in areas adjacent to the marsh. Mapping the transition zone boundary is further complicated by existing infrastructure and predicted changes to the extent of the zone over time as sea-level rises.

Recent efforts to map existing and potential transition zone areas for San Francisco Bay (Fulfrost and Thompson 2014) have defined the transition zone based on elevation, with the lower boundary mapped at current Mean Higher High Water (MHHW) plus 0.31m and the upper boundary defined as current Highest Observed Water Level (HOWL) plus 0.27m (note these values are specific to San Francisco Bay). These elevations were chosen to correspond with the approximate location of high marsh vegetation in San Francisco Bay, with an additional area to allow for high tide refuge for wildlife. Such mapping provides a critical resource for land use planning, particularly for managers looking to acquire and protect or restore transition zone sites in the near-term This methodology, however, does not encompass all possible transition zone functions and delineation considerations.

This document proposes a methodology for identifying a more aspirational "outer limit" boundary for wetland-upland transition zone planning in the Southern California Bight that considers climate change and encompasses a broader suite of ecosystem services than previous transition zone mapping efforts. This methodology is geared toward planning at longer time scales for planning at the landscape level, for purposes of protecting undeveloped transition zone areas with a defined outer boundary and identifying currently developed areas within the outer boundary that could be acquired, protected, and restored in the future.

Planning within an aspirational wetland-upland transition zone boundary: Considering landscape resilience

The wetland-upland transition zone "outer boundary" delineation method outlined in this document identifies an area within which transition zone management, and support of associated ecosystem services, should be considered when making land use planning and management decisions. This method is meant to be a quick yet robust way to delineate an inland extent of the transition zone that considers climate change, within which more site-specific considerations (including constraints of developed lands) will be addressed. The approach is meant to be used by planners and regulators to encourage larger-scale and longer-term thinking about incorporating transition zone functions into shoreline planning. The transition zone is a contested zone with both ecological and urban functions. This methodology is not meant to suggest that everything within this boundary remain undeveloped or be restored to open space. Rather, considering sea-level rise and transition zone function more holistically within these areas can help us develop better adaptive and multi-benefit shoreline solutions that improve both ecological and societal benefits over the long term.

The Landscape Resilience Framework (Beller et al., 2015) developed a set of 7 principles that should be considered when trying to achieve ecological resilience at a landscape scale. These principles can help guide actions within this transition zone boundary. More specific guidance for what might be recommended within this transition zone boundary will be provided in other documents.

Below are questions meant as an example on how to assess wetland-upland transition zone considerations using the by landscape resilience principles:

Setting: What habitat types characterized the transition zone in this area historically? Based on how landscape has changed, and projected future changes, are historical habitats still appropriate? What constraints and opportunities result from expected changes in land use and development?

Process: Does conservation/management in this area support conditions that allow marsh migration? Sediment transport to support marsh accretion? Do restoration and management actions match current and projected groundwater conditions? Extent of tidal and fluvial flooding?

Connectivity: How far apart are areas supporting transition zone habitats and processes? Are they close enough to each other and to the marsh to support the services of interest (e.g. wildlife movement, marsh migration?

Diversity: What different types of transition zone habitats are appropriate in this area?

Redundancy: Are there multiple areas where support for critical species and processes is being provided?

Scale: What is the total amount of transition zone habitat conserved/restored within an area, and is this a large enough scale to support the species and processes of interest?

People: Within this "outer limit" boundary some of the proposed actions that would provide biological diversity support (e.g., upland habitat restoration) would provide other societal benefits as well (e.g., recreation, flood protection).

Proposed methodology for mapping an aspirational upper wetland-upland transition zone boundary

For this effort it is helpful to think about different types of wetland-upland transition zone because of the space requirements for different ecosystem services they can provide. Different management opportunities and priorities present themselves within different transition zone types. Here we suggest different methods to determine the inland extent of the transition zone: A) Bluff or Cliff, B) Hillslope, Fan, Valley or Plain, and C) Riverine or Stream. Because we are interested in delineating an "outer boundary" we focus on those ecosystem services that go furthest upslope-watershed. Separate methodologies for delineating the outer boundary for these three transition zone types are detailed below.

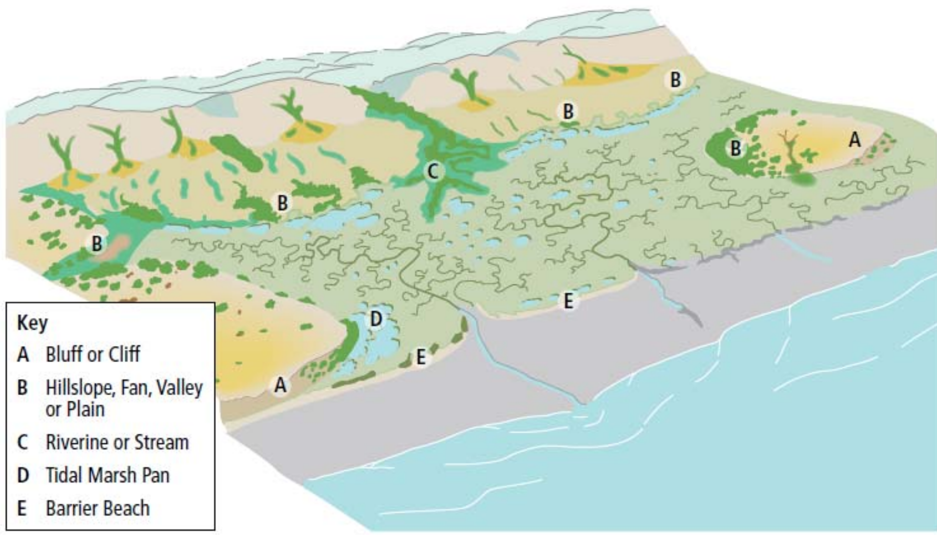


Figure 5. Transition zone types (from BEHGU).

Wetland Archetypes

Different transition zone types are represented to varied degrees in different coastal wetland archetypes. For Southern California, seven wetland archetypes have been identified. The most common archetype is small creeks, where the transition zone would be defined using the riverine/ stream transition zone method below. Small lagoon systems, lacking an associated creek, would be defined using the method for hillslope or cliff transition zone, depending on the topography. Larger systems, such as large lagoons and large river valley estuaries are likely to have multiple types of transition zone, and different methods will be applicable in different parts of the system. Additional guidance may need to be developed for intermittently open estuaries to account for differences in flooding extent between open and closed conditions.

Defining a lower boundary for the transition zone

For the hillslope and cliff transition zone types we must first define the lower transition zone boundary before we can define an upper transition zone boundary. This lower boundary can be determined using Highest Observed Water Level (HOWL) or similar methods. Alternatively MHHW can be determined from projections of future sea-level such as OCOF.

Upper boundary definitions by transition zone type

Determining the Upper Boundary for Hillslope Transition Zone

Hillslope, Fan, Valley or Plain (hereafter, hillslope) transition zone span gradual slopes that provide opportunities to support wide habitat gradients, biological diversity, and landscape complexity. These transition zones are also important for accommodating sea-level rise and allowing marshes to migrate upslope. For defining an outer boundary for transition zone planning we focus on biodiversity support and assumed that other ecosystem services associated with hillslope transition zone (e.g. buffering) would fall within a boundary set by these functions.

Supporting biological diversity within the transition zone includes 1) providing areas for wildlife refuge and predation, 2) facilitating wildlife movement, 3) supporting areas important for evolutionary adaptation, and 4) contributing to landscape complexity. How exactly the transition zone supports biodiversity can vary significantly by site, and is influenced by elevation, slope, soils, vegetation, and land use. To develop a coarse transition zone delineation method that would be broadly applicable across sites we focused on determining a zone width that would likely provide enough area for key ecological processes such as dispersal and adaptation to occur.

Table 1 shows a summary of widths over which these ecosystem services would be expected to occur. Most of the biological diversity support functions associated with the transition zone are captured within a range of tens to hundreds of meters, as shown below. To capture these functions to a high degree, without using the most extreme distances, we recommend a transition zone width of 500m.

Table 1. Summary of values from the literature which informed our methodology for hillslope transition zone.

Ecosystem Service	Width/Measurement	Notes and References
Wildlife refuge	20-50m	Refuge for Salt Marsh Harvest Mouse in SF Bay. Collins et al. 2007
Wildlife foraging and predation	150m	Distance of ground squirrels that forage in the marsh occasionally, Collins et al., 2007
Wildlife and plant movement	10-400m	Based on a variety of movement corridor values from the literature, including, on the upper end, Alexander et al., 2016
Evolutionary Adaptation	50-500m	Assumes gradients likely to support evolutionary adaptation (e.g., Collins and Collins 2007) likely play out on a scale of tens to hundreds of meters
Landscape complexity	50-1000m	Transition zone associated habitats could extend hundreds of meters historically, Beller et al. 2013

Mapping Guidance:

- Determine existing wetland boundary and add 500m from this boundary to determine the present day existing transition zone.
- Determine the future MHHW with sea-level rise contour and add 500m from this contour to determine the potential transition zone with sea-level rise and with the restoration of former tidal areas.
- Overlay land use layer to identify undeveloped transition zone that could be restored or conserved.

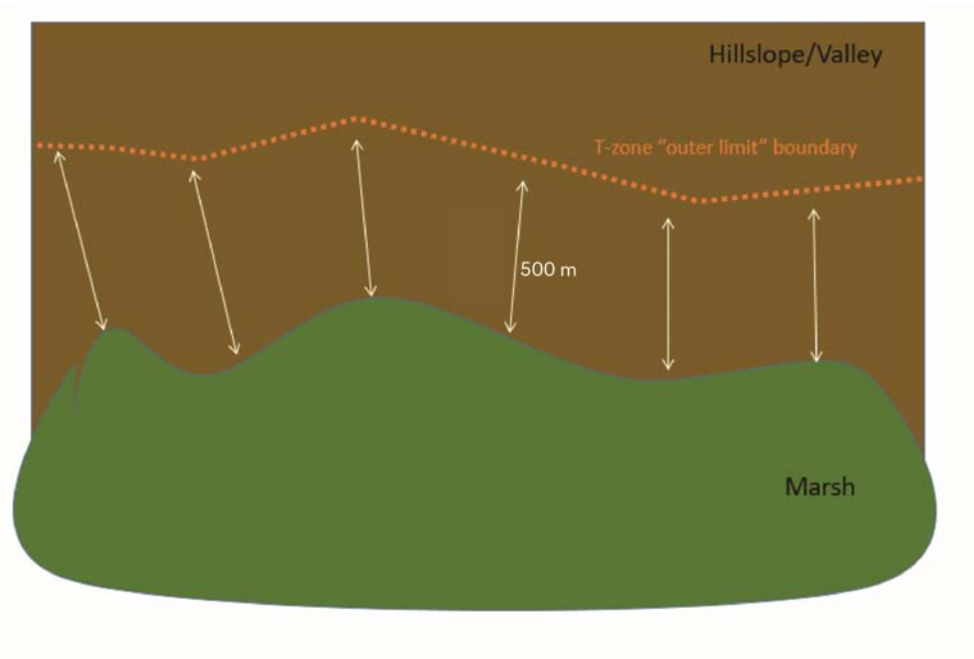


Figure 6. Method for defining an upper boundary for hillslope transition zone.

Outer Boundary for Riverine/Stream Transition Zone

Riverine transition zone transition between fluvial and tidal processes and conditions. The inland extent of tidal influence within streams, called the "head of tide", is primarily a function of the stream bed gradient, with lower gradient streams having head of tide locations that can be miles inland from the shoreline. This transition zone area can be important for floodwater storage and retention, as well as supporting a unique assemblage of plant and wildlife species. To define the outer transition zone boundary, both tidal and fluvial flooding need to be considered along with wildlife support functions. We add additional space (50m) beyond that tidal flooding extent to allow wildlife space to escape flooding and enough width to support riparian habitat for wildlife. For fluvial flooding, the 50-yr flood extent downstream of head of tide is used (i.e., the 50-yr flood on top of the tidal water in the channel).

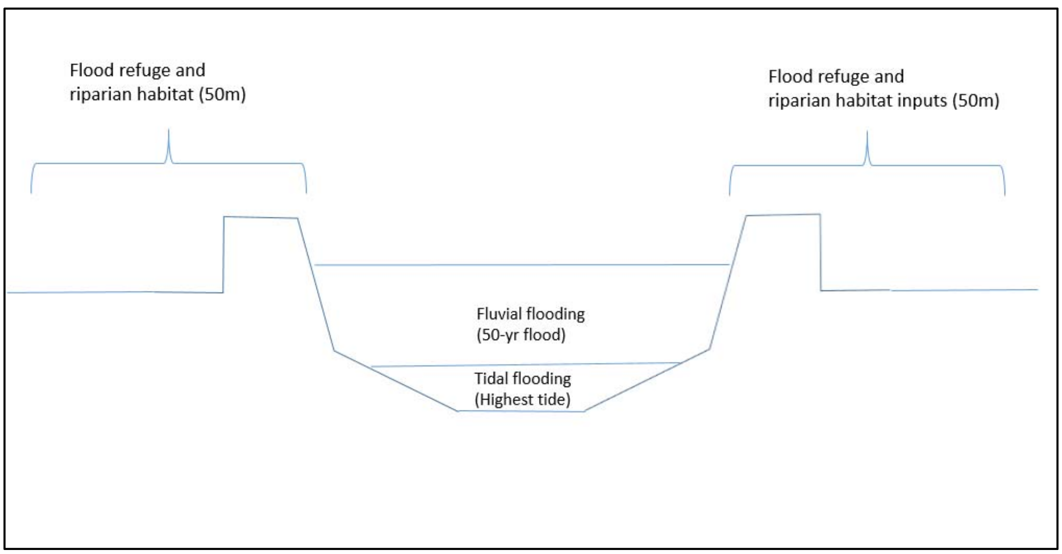
Table 2. Summary of values from the literature which informed our methodology for riverine transition zone.

Ecosystem Services	Width/Measurement	Notes and References
Flood control	Flooding extent for 50 year storm event	Likely high flooding within a relevant management time horizon
Wildlife refuge	50m	Guidance for flood refuge in Collins et al. 2007

Mapping Guidance:

- Add 50m width beyond river/stream boundary to determine current transition zone, or add 50m width beyond extent of flooding to determine future transition zone area that incorporates sea-level rise.
- Overlay land use layer to identify undeveloped transition zone areas that could be restored or conserved to support transition zone habitats.

An example of applying the transition zone mapping methodology can be found in Figure 7.



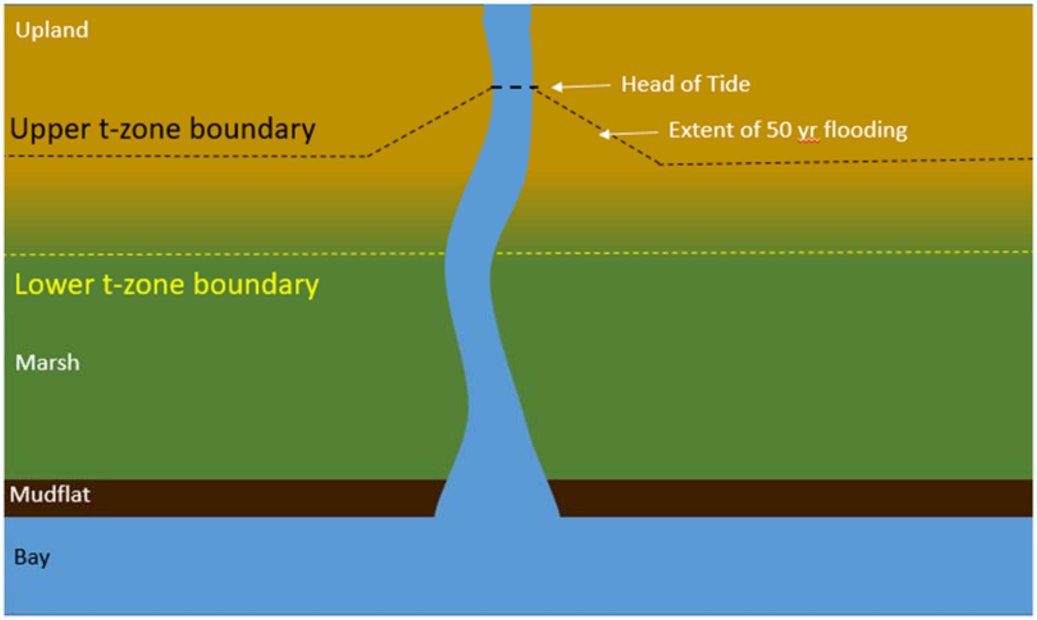


Figure 7. Method for defining an upper boundary for riverine transition zone.

Outer Boundary for Bluff Transition Zone

For bluff transition zones, the area at the top of the bluff is unlikely to provide the same flood control, habitat gradient, and movement corridor benefits as hillslope transition zones. Therefore we focus on erosion control to determine the extent of the transition zones, as this ecosystem service is more critical for these systems.

The transition zone was limited to slopes less than 15% and elevations less than 30m NAVD. Areas steeper than this are likely to be dominated by slope processes such as mass wasting, rather than fluvial or wetland processes.

Mapping Guidance:

- If the change in slope that marked the start of the bluff is more than 500m from the lower extent of the transition zone (as defined for hillslope transition zone above) then the transition zone should be determined using the hillslope method.
- If the change in slope is less than 500m from the lower extent of the transition zone, the hillslope transition zone layer is constrained to the area with a slope of less than 15%, or an elevation of less than 30m NAVD.
- Overlay land use layer to identify undeveloped transition zone areas that could be restored or conserved to support transition zone habitats.

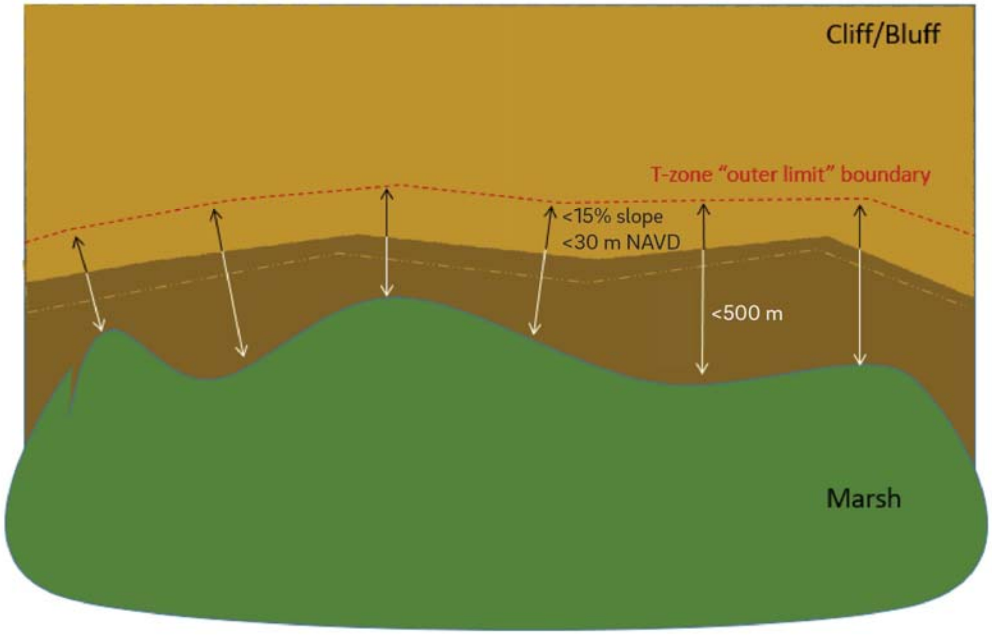


Figure 8. Method for defining an upper boundary for hillslope transition zones.

Setting Objectives and Targets

This aspirational approach can be used in tandem with a narrower mapping approach (e.g., Fulfrost method) to set targets for wetland-upland transition zone management and restoration in the near and long term, conservatively or aspirationally. A land development layer can be overlaid on this area as a coarse filter for identifying different types of opportunities. Objectives for the transition zone could relate to the amount of upland habitat/open space within the zone, the connectivity of open space, or the percent of the developed area where management actions such as low impact development (LID) /green infrastructure approaches are implemented.

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