

**FIGURES: Reference sites for San Francisco Estuary Tidal Marsh Edge Vegetation**

Figure 1. Tidal marsh and terrestrial edge: ecotone (gradient, transition zone)



1a. Contrasting distribution of gumplant vegetation within old and young tidal marshes.

(a) **Muzzi Marsh, Cortes Madera, Marin County**; view to south from north end. Homogeneous pickleweed vegetation in middle marsh plain on former dredge sediment terrace; tidal channels support little gumplant along high marsh banks. Narrow, concentrated gumplant zone is limited to high tide line of dikes (see also figure 6).

(b) Adjacent **Heerdt Marsh** (view to north), mixed pickleweed/saltgrass/jaumea plain with abundant gumplant along high marsh at channel banks. High marsh is well-distributed internally within marsh plain.

(c) **Cogswell Marsh, Hayward, Alameda Co.**, northwest end, view to southwest; pickleweed plain with hybrid cordgrass in channels; high marsh gumplant vegetation is scarce to absent near channel banks; high marsh (mustard/pickleweed edge) limited to levee toe.

(d) **Upper Newark Slough, San Francisco Bay National Wildlife Refuge**, Alameda Co. view to southwest. Diverse middle marsh plain vegetation (sea arrow-grass, saltgrass, jaumea, and variable abundance of low pickleweed), with well-distributed and abundant high marsh gumplant along tidal channels. Terrestrial ecotone: mixed native perennial and nonnative annual grasses, scarce gumplant.

Figure 2. Degraded habitats at terrestrial edges of tidal marshes



**Figure 2.1. Bay levee vegetation conditioned by past disturbance of maintenance or original construction:** (a) black mustard-dominated levee, **Cogswell Marsh, Hayward, Alameda Co., 2005** (b) wild radish-dominated levee, east end **Sonoma Baylands, Sonoma Co., 2005**. (c) first-season vegetation (annual grasses above shoreline) on engineered levee, **Petaluma Marsh Enhancement Project, Novato, Marin Co., 2006**. (d) raised/upgraded levee, **Whale's Tail Marsh mitigation site, Hayward, Alameda Co., 2005**., mixed salt marsh and non-native weeds, bare soil.



**2.2. Feral predator** (domestic cat) moving between non-native grassland/tidal marsh edge (foraging) and cover of adjacent scrub, **Roberts Landing, San Leandro, Alameda Co. 2006**.



**2.3. Road/trail weed corridors adjacent to tidal marshes.** Left: **Artesian Slough levee, Alviso** (San Francisco Bay National Wildlife Refuge) with narrow strip of bassia and poison-hemlock tracking previous year's maintenance disturbance; August 2006. Right: Stinkwort (*Dittrichia*) disperses in a linear colony along the edge of a foot trail above the bay, **Coyote Hills, Fremont** (East Bay Regional Park District); August 2006.



**2.4. Weed-dominated levees, tidal marsh restoration site: Sonoma Baylands, Sonoma Co.** northern levee around winter solstice, December 2003: annual weeds, dead in winter, dominate levee above high tide line (steep, abrupt, narrow gumplant/pickleweed gradient), and provide minimal cover during extreme high tides. Right: Annual nonnative grasses and weedy forbs dominate levee above narrow, linear strip of high tide line vegetation (pioneer pickleweed and gumplant), one year after tidal restoration (August 1997).



**2.5. Weed-dominated levees: tidal marsh restoration site: Muzzi Marsh, Corte Madera, Marin Co.** Left: Harding grass and fennel form solid, dense, tall stand broken by foot-trail; 2006. Right: wild oat, wild radish, Italian ryegrass form low, grassy, weedy cover inhibiting native vegetation, and providing little winter high tide cover.

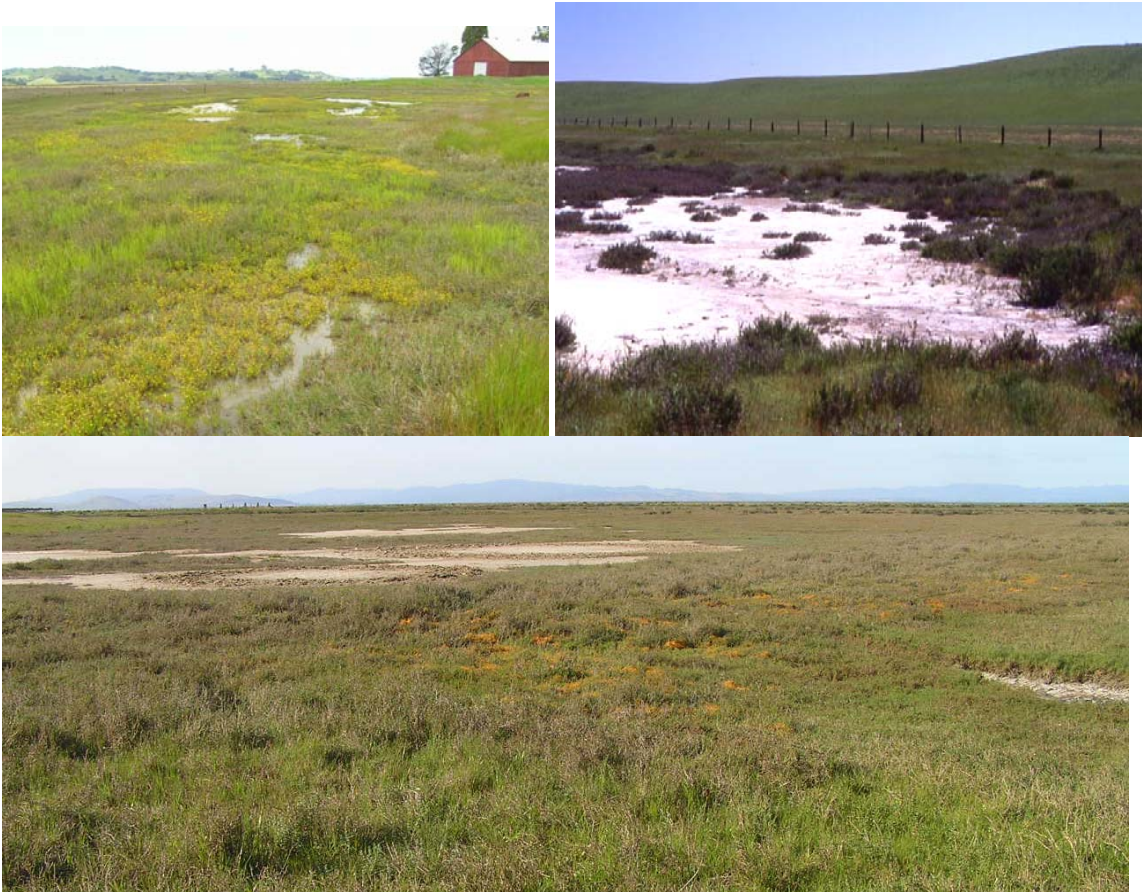


**2.6. Salt-intolerant trees grow and persist on levees adjacent to saline tidal wetlands,** indicating physiologically insignificant salinity in deeper soil horizons of bay mud levees. Fresh groundwater lens likely occurs in most levees. Left: two vigorous mature coast live oak-canyon oak hybrid intermediates (bearing acorns), growing on levee separating brackish tidal marsh and brackish seasonal pond, Bahia, Novato, Marin Co.; April 2006. Right: Monterey pine (healthy) and redwood (dieback; injured by salt spray at the bay edge) from old abandoned ranch house plantings persist without irrigation on levee adjacent to San Pablo Bay at Sears Point, Sonoma Co., June 2005.

Figure 3. **Natural landforms and soils with remnant native terrestrial vegetation bordering modern and historic tidal marshes: examples.**



3a. **Rush Ranch**, Solano County (Suisun Marsh) – hillslope, grassland. Left: arid, wind-exposed grassland hills of old ranch lands grade into brackish tidal marsh; minimal scrub or gumplant. Right: native creeping wildrye has regenerated dominant stands intergrading with tidal marsh where grazing has been excluded. August 2005.



3b. **High tidal marsh pans with elements of local alkali/saline vernal pool florae** form at the toes of old alluvial fans. Upper left: Lakeville, Sonoma County. *Lasthenia glabrata* co-occurs with brass-buttons). Upper

right: Potrero Hills, Suisun Marsh, Fairfield, Solano Co.; ecotone between vernal pool and salt pan, grassland with seasonal blooms of goldfields. Note apparently natural scarcity of scrub cover, gumplant, or tall emergent vegetation where seeps or riparian zones are absent in grassland. Bottom: active alluvial fan (clayey sand and silt deposits) form ecotones between salt marsh, pan, and alluvial grassland at the prehistoric Whittell Marsh Point Pinole.



3c. **Whittell Marsh, Point Pinole**, Contra Costa County, 2008. Prehistoric tidal marsh continuous with grasslands of alluvial fans. Upper left: low native annuals (saltmarsh owl's-clover, smooth goldfields, muilla). Gumplant (dark lines, background) here is restricted to banks of tidal channels and bay edge beach.. Upper right, meadow sedge (*Carex praegracilis*) grades into high pickleweed marsh. Lower left: gradient from basket sedge, meadow sedge, to pickleweed/saltgrass/alkali-heath and native salt marsh annuals. Lower right: dry grassland forms salt marsh ecotone on dense sandy clay soil with only sparse, low-growing native perennials (*Leymus triticoides*, *Nassella* spp.), but supporting abundant native bulbs (*Muilla maritima*) and native annuals (*Juncus bufonius*, *Castilleja ambigua*). Note lack of tall shrub or forb cover.



3d. **China Camp**, San Rafael, Marin County— hillslope grasslands and rush-grass tidal marsh ecotone (*Juncus arcticus*/*Leymus triticoides*/*Distichlis spicata*) along prehistoric salt marsh edge. Note relatively sparse distribution of gumplant compared with tidal creek banks, and sparse shrub cover at and above the high tide line.



3e. **China Camp**, San Rafael, Marin County— alluvial fan, grassland and riparian woodland ecotone with brackish tidal marsh (foreground: meadow sedge). Note absence of gumplant where sod-forming sedge stands occur.



3f. **China Camp**, San Rafael, Marin County— hillslope, oak woodland and mixed evergreen forest ecotone with tidal marsh includes wire and Mexican rush, meadow sedge, and creeping wildrye. Note scarcity of gumplant.



3.f. **Upper Newark Slough**, Don Edwards San Francisco Bay National Wildlife Refuge, Franciscan hillslope. Upper left, steep hillslope, non-native grassland near sea level, coastal scrub above (dark shrubs in background are non-native *Acacia*); Upper right, lower left: native creeping wildrye (green) below annual grasses (straw) locally dominates pickleweed tidal marsh edge on gentle hillslope toe. Lower right: dense creeping wildrye (foreground) and California blackberry (background) on hillslope with seeps intergrade sharply with alkali-heath and pickleweed high salt marsh. Note absence or scarcity of gumplant.





3.g. **Coyote Hills, East Bay Regional Parks District.** Historic bay edge along salt ponds retains tidal marsh terrestrial ecotone vegetation along saline wetland border of salt pond and seeps. Upper left: mixed mexican rush (*Juncus arcticus* var. *mexicanus*), creeping wildrye (*Leymus triticoides*) and saltgrass (*Distichlis spicata*) ecotone below coastal sage scrub (*Artemisia californica*, *Baccharis pilularis*) on steep hillslopes. Upper right: western goldenrod (*Euthamia occidentalis*) and creeping wildrye dominate swale seep continuous with historic tidal marsh edge. Bottom: nearly monotypic clonal stand of marsh baccharis (*Baccharis douglasii*) dominates lower end of natural swale grading down to historic tidal marsh (modern salt pond) edge.



Figure 4 **Tidal creekbank gumplant vegetation** Upper Newark Slough prehistoric marsh, San Francisco Bay National Wildlife Refuge.. Upper left: gumplant (*Grindelia birsutula*, syn. *G. strica* var. *angustifolia*) traces the outline of tidal creeks and sloughs, providing local high tide refuge within the marsh plain, for resident marsh wildlife. The gumplant canopy is submerged by extreme high winter tides or storm surges. Upper right: Note concentration of gumplant along slough banks (yellow arrow) compared with natural terrestrial edges of salt marsh (blue) with relatively sparse gumplant cover. Photo courtesy of Refuge. Bottom: high tide cover provided by gumplant is concentrated along banks of small drainages and large sloughs, away from the terrestrial edge.



Figure 5. **Alkali-bulrush** (*Bolboschoenus maritimus*; blue arrow, above left) forms tall, dense, persistent shoot canopies within brackish marshes of the western Estuary, providing high tide cover within the marsh plain (sometimes higher and denser than gumplant canopies along adjacent terrestrial edges of marsh [yellow arrow]; see above, left; Bahia, Novato, Marin Co, 2005). The alkali-bulrush foliar canopy may be partially or fully submerged by extreme high winter tides or storm surges.



Figure 6. **Levee-edge gumplant**. Linear, tall stands of gumplant (yellow arrows) develop artificial “hedge” patterns along the high tide shoreline of levees in some restored tidal marshes, even where marsh plain development is too immature to support gumplant along tidal creek banks. Tidal marshes with natural terrestrial soil edges, in contrast, seldom if ever develop such extensive, dense stands of gumplant; see Figure 3). Right: Sonoma Baylands, 2005; Left: Carl’s Marsh, 2005 (San Pablo Bay, Petaluma River mouth vicinity, Sonoma Co.)