USDA Natural Resources Conservation Service

Ecological site R016XA001CA
Tidally-Influenced, Freshwater

Accessed: 05/21/2025

General information

Provisional. A provisional ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model and enough information to identify the ecological site.

Figure 1. Mapped extent

Areas shown in blue indicate the maximum mapped extent of this ecological site. Other ecological sites likely occur within the highlighted areas. It is also possible for this ecological site to occur outside of highlighted areas if detailed soil survey has not been completed or recently updated.

MLRA notes

Major Land Resource Area (MLRA): 016X–California Delta

MLRA 16 – California Delta
Most of this area is in the California Trough Section of the Pacific Border Province of the Pacific Mountain System. A small part at the west edge of the area is in the California

Coast Ranges Section of the same province and division. This MLRA was originally the conjoined flood plain along the Sacramento and San Joaquin Rivers. As sediment from these rivers built up in San Pablo Bay, a delta formed, creating many streams that divide this nearly level area into “islands.” Strong levees and drainage systems are needed to protect the islands from flooding. Elevation of the islands ranges from below sea level to slightly above sea level. This area is underlain by interbedded marine, estuarine, and fine-grained non-marine sediments transported to the delta by the Sacramento and San Joaquin Rivers as they flowed into San Pablo Bay. As the sediments built up, a delta formed and freshwater mixed with brackish water in marshes and on flood plains. As the marsh vegetation became covered with new sediments, the organic matter content in the soils built up to very high levels. When drained and exposed to the air, these peaty soils oxidize and shrink and then subside.

Land resource unit (LRU) XA is influenced primarily by freshwaters fed from the Sierra Nevada watershed snow melts and rains, however in a large portion of the LRU it is still influenced heavily by the Delta tides.

Classification relationships

Using the December 2010 draft EPA ecoregion level IV: 7j, Delta polygon mostly closely overlaps with MLRA 16.

MLRA 16 mostly aligns with the USFS (1997) ecological subsection 262AI, Great Valley, Delta.

Ecological site concept

This site is a patchwork of freshwater water-obligate and facultative wet plant communities influenced by the ocean tides. It is found in the lowest positions on the landscape within the LRU and it's primary water sources come from the Sierra Nevada watersheds, consisting of snow melt and rains.

Soils are fine-textured, thermic histosols and cumulic mollisols with poor to very poor drainage. Salinity is limited and should not affect vegetation response; however there will be some mixing of ocean waters in parts of the ecological site that are closer to the western edge.

It is dominated by vegetation that is adaptable to changing water levels and anaerobic soils conditions, primary species consist of Schoenoplectus species, Eleocharis spp., and in some areas Salix spp. Patches where there are less lengthy periods of anaerobic conditions.

This site has extremely fertile soils and the histosols can very quickly lose their organic properties when either drained or suffering lengthy droughts. Therefore much of this ecological site has been converted to agriculture and altered significantly.

Salinity is relatively high and will have significant impacts on vegetation and management response.

Associated sites

R016XA002CA	**Freshwater, Stratified, Fluventic** 016XA002 occurs on natural levees primarily in the northern half of the LRU.
R016XA004CA	**Island Sandhills** 016XA004 occurs on mineral soils on ancient sand dunes near Oakley CA.
R016XB001CA	**Tidally-Influenced, Salt-Affected** 016XB001 are organic soils more heavily influenced by salt water from tides as occurring most extensively in Suisun Bay and supporting more saline-adapted species.

Similar sites

R016XB001CA	**Tidally-Influenced, Salt-Affected** 016XB001 appears to be a less productive site which following improvement for production agriculture favors salt tolerant species such as saltgrass and Phragmites.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Salix*
Herbaceous	(1) *Schoenoplectus acutus* (2) *Schoenoplectus californicus*

Physiographic features

This site is located in the freshwater-influenced, eastern portion of the delta, and is primarily fed by snow melt from the Sierra Nevadas. Slope gradients are mainly less than 1 percent and range from 0.5 to 2 percent.

Table 2. Representative physiographic features

Landforms	(1) Delta (2) Flood plain (3) Marsh
Slope	1–2%
Aspect	Aspect is not a significant factor

Climatic features

Soil moisture as influenced by water table fluctuations augment precipitation which is typically 100% rain as it is for the entire MLRA.

Table 3. Representative climatic features

Frost-free period (average)	290 days
Freeze-free period (average)	341 days
Precipitation total (average)	330 mm

Climate stations used

- (1) ANTIOCH PUMP PLT #3 [USC00040232], Antioch, CA

Influencing water features

Soil features

The soils associated with this ecological site can be subdivided into two groups, organic and mineral soils.

The organic soils are very deep and very poorly drained soils composed of herbaceous organic material derived from reeds and tules on reclaimed fresh water marshes on deltas. Some soils have mineral soil material derived from mixed alluvium below 20 to 40 inches from the soil surface.

Surface textures are typically muck, mucky silt loam and mucky clay loam. Subsurface textures vary from muck, silty clay loam, silty clay and clay.

The mineral soils are very deep, very poorly and poorly drained soils composed of herbaceous organic material derived from reeds and tules and mixed alluvium on flood plains on deltas.

Surface textures are typically silt loam, clay loam, silty clay loam and clay. Subsurface textures vary from stratified silt loam, clay loam, silty clay loam, silty clay and clay. . Electrical conductivity of the soil (EC) is less than 2 dS/m throughout.

These soils are very poorly drained with very slow to moderately rapid permeability. The high water table is root limiting for crops. Levees, drainage ditches and pumping of the water table alter the drainage of this soils. In un-drained areas roots are limited by the water table occurring from the surface to approximately 12 inches. Typically the water table is regulated to a depth of 3 to 4 feet below the soil surface. The soil moisture regime

is aquic and the soil temperature regime is thermic.

These soils are subject to subsidence. The hazard of soil blowing is severe when the soil is dry.

The organic soils that are correlated to this ecological site are the Kingile, Shinkee and Webile (clayey, mixed, euic, thermic Terric Haplosaprists), Rindge (Euic, thermic, Typic Haplosaprists), Venice (Euic, thermic, Typic Haplohemists) and Shima (Sandy or sandy-skeletal, mixed Euic, thermis Terric Haplohemists).

The mineral soils that are correlated to this ecological site are the Egbert, Gazwell, Peltier (fine, mixed, superactive, thermic Cumulic Endoaquolls), Ryde and Scribner (fine-loamy, mixed, superactive, thermic Cumulic Endoaquolls), Valdez (Fine-silty, mixed, superactive, nonacid, thermic Areic Fluvaquents).

This ecological site has been correlated with the following mapunits and soil components in MLRA 16:

CA013; Contra Costa County soil survey area, California

Ea; Egbert mucky clay loam;Egbert; 85
Kb; Kingile muck; Kingile; 84
Rd; Rindge muck, 0 to 2 percent slopes, partially drained, MLRA 16; Rindge; 85
Rh; Ryde silt loam; Ryde; 85
Se; Shima muck; Shima; 85
Vb; Venice muck; Venice; 85
Wa; Webile muck; Webile; 85

CA067; Sacramento County Area, California

139; Egbert clay, 0 to 2 percent slopes; Egbert; 85
140; Egbert clay, drained, 2 to 5 percent slopes; Egbert; 85
141; Egbert clay, partially drained, 0 to 2 percent slopes; Egbert; 75
142; Egbert clay, partially drained, 0 to 2 percent slopes, frequently flooded; Egbert; 85
155; Gazwell mucky clay, partially drained, 0 to 2 percent slopes; Gazwell; 85
200; Rindge muck, 0 to 2 percent slopes, partially drained, MLRA 16; Rindge; 85
201; Rindge mucky silt loam, partially drained, 0 to 2 percent slopes; Rindge; 95
202; Rindge mucky clay loam, 0 to 2 percent slopes; Rindge; 95
222; Scribner clay loam, partially drained, 0 to 2 percent slopes; Scribner; 85

CA077; San Joaquin County Area, California
146; Dello loamy sand, partially drained, 0 to 2 percent slopes; Dello; 85
147; Dello sandy loam, clayey substratum, drained, 0 to 2 percent slopes; Dello; 85
152; Egbert mucky clay loam, partially drained, 0 to 2 percent slopes; Egbert; 85

153; Egbert silty clay loam, partially drained, 0 to 2 percent slopes; Egbert; 85
154; Egbert silty clay loam, sandy substratum, partially drained, 0 to 2 percent slopes; Egbert; 85
155; Egbert-Urban land complex, partially drained, 0 to 2 percent slopes; Egbert; 50
190; Kingile muck, partially drained, 0 to 2 percent slopes; Kingile; 85
191; Kingile-Ryde complex, partially drained, 0 to 2 percent slopes; Kingile; 50
204; Peltier mucky clay loam, partially drained, 0 to 2 percent slopes; Peltier; 85
205; Peltier mucky clay loam, organic substratum, partially drained, 0 to 2 percent slopes; Peltier; 85
233; Ryde-Peltier complex, partially drained, 0 to 2 percent slopes; Peltier; 35
224; Rindge mucky silt loam, partially drained, 0 to 2 percent slopes, overwashed; Rindge; 85
225; Rindge muck, 0 to 2 percent slopes, partially drained, MLRA 16; Rindge; 85
191; Kingile-Ryde complex, partially drained, 0 to 2 percent slopes; Ryde; 35
230; Ryde clay loam, partially drained, 0 to 2 percent slopes; Ryde; 85
231; Ryde silty clay loam, organic substratum, partially drained, 0 to 2 percent slopes; Ryde; 85
232; Ryde clay loam, sandy substratum, partially drained, 0 to 2 percent slopes; Ryde; 85
233; Ryde-Peltier complex, partially drained, 0 to 2 percent slopes; Ryde; 50
243; Scribner clay loam, partially drained, 0 to 2 percent slopes; Scribner; 85
244; Scribner clay loam, sandy substratum, partially drained, 0 to 2 percent slopes; Scribner; 85
245; Scribner-Urban land complex, partially drained, 0 to 2 percent slopes; Scribner; 50
155; Egbert-Urban land complex, partially drained, 0 to 2 percent slopes; Urban land; 35
245; Scribner-Urban land complex, partially drained, 0 to 2 percent slopes; Urban land; 35
246; Shima muck, partially drained, 0 to 2 percent slopes; Shima; 85
247; Shinkee muck, partially drained, 0 to 2 percent slopes; Shinkee; 85
261; Valdez silt loam, organic substratum, partially drained, 0 to 2 percent slopes; Valdez; 85
263; Venice mucky silt loam, partially drained, 0 to 2 percent slopes, overwashed; Venice; 85
264; Venice muck, partially drained, 0 to 2 percent slopes; Venice; 85
273; Webile muck, partially drained, 0 to 2 percent slopes; Webile; 85

CA095; Solono County Area, California:

Eb; Egbert silty clay loam;Egbert; 85
Ec; Egbert silty clay loam, occasionally flooded; Egbert; 85
Ry; Ryde clay loam; Ryde; 85
Va; Valdez silt loam drained; Valdez; 85
Vc; Valdez silty clay loam; Valdez; 85

CA113; Yolo County Area, California:

Va; Valdez silt loam; Valdez; 85

Vb; Valdez silt loam, deep; Valdez; 85

Table 4. Representative soil features

Surface texture	(1) Silty clay loam (2) Clay loam
Family particle size	(1) Clayey
Drainage class	Very poorly drained to poorly drained
Permeability class	Very slow to moderately slow
Soil depth	152 cm
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-101.6cm)	7.62–30.48 cm
Soil reaction (1:1 water) (0-101.6cm)	4.5–8.4
Subsurface fragment volume <=3" (Depth not specified)	0%
Subsurface fragment volume >3" (Depth not specified)	0%

Ecological dynamics

Community Dynamics Section

This ecological site is a complex tidally-influenced riverine complex of marshes, seasonal wetlands and emergent wetland vegetation types. It is also the most extensive ecological site within the MLRA and making up approximately 54% of identified soils and comprising about 63% of the land resource unit. In the most general sense, this historically this site would be a series of islands subject to inundation by runoff and/or tidal waters several times each year.

This ecological site has been subject to some of the most extensive and intensive modification of any lands in the western US. In the late 1800s, agricultural interests initiated the construction of levees along some islands with most of these islands leveed by 1917. Following the leveeing, draining and burning of the hallmark organic soils (histosols) are legendary in the West for food production and having peat surface often exceeding 50’ thickness.

The soils of this ecological site are relatively new arrivals to the landscape with some of the oldest and deepest histosols having been radiocarbon dated to approximately 6,500 years BP (USGS, 2001) and corresponding to increased sea levels at the tail end of the

post-Ice Age melt-back. This period of increasing sea level transformed the underlying braided river networks of the current Delta into something more akin to a marine estuary. As a result of river waters meeting marine waters inland, fine sediment loads of the upper watersheds were increasingly deposited over the top of the old riverine system and these histosols developed as sediment and organic matter accumulated.

Under natural hydrology, this ecological site grades into the non-tidal aquoll ecological site. Within these two sites, inundation frequency varies dramatically. Only about half of the tidal extent was inundated by twice daily high tides, with the rest ranging from wetted (rather than actually overflowed) by daily tides to only wetted by spring tides (SFEI, 2012).

Organic soils support the freshwater emergent wetland (the buildup of organic material in peat occurs through anoxic conditions created by saturated soils). The mollic soils correlated to this ecological site likely similarly supported freshwater emergent species—this correlation was based on historical soil type descriptions that were reviewed for descriptions of soil properties, drainage characteristics, native vegetation, and agricultural uses indicative of perennial wetland or former wetlands (SFEI, 2012).

Soils of this ecological site are subject to subsidence due to oxidation of soil organic matter under the influence of soil aeration following historic and ongoing land treatments. At the lowest elevations of the ecological site, this has resulted in some areas subsiding well below surrounding estuary water table levels and necessitating pumping of intruding waters. In such cases, unrepaired levee breaches may result in these soils being permanently inundated as in the cases of Franks Tract, Big Break, Mildred Island, and western Sherman Island (Sherman Lake).

Where constructed levees have been installed across the range of this ecological site, most of the preexisting natural channels and levees have been muted by land levelling but many are still apparent on LIDAR imagery. This is due in part to differential shrinkage of organic soils relative to the underlying material. Within channels where organic material failed to historically accumulate, oxidation and shrinkage apparently occurs more rapidly than in adjacent areas with deep (>30’) peat substrates, thus exposing the underlying topography.

Narrow low elevation natural levees included in this ecological site were historically extensive within the San Joaquin portion of the MLRA. Occurrence of long-lived upland species such as walnut and oak was presumably rare while dominance by single aged stands of cottonwood and willow were more typical where those species could compete with cattail and tule. Such levees were typically a mixture of fine and coarse sediment but unlike the higher elevation levees associated with CA016XA002, these levees were typically subject to regular inundation by tidal waters and consolidation of sediment was largely localized and/or largely unpronounced due to frequent “washing” of the surface sediments and breaching of these levees. As a result of this tidal action, the height of many of these natural levees above the adjacent soils might have been as slight as a few inches or even be apparent only seasonally where tidal action was most influential.

The importance of natural levee height and channel sinuosity relative to vegetative pattern is not fully understood for this ecological site and the range of historic reports mainly focuses on dominant vegetation. However, it is conceivable that a great degree of variability in vegetation across the ecological site could be tied to island and channel hydrology as modified by position and elevation within the watershed. The likely pattern is that the closer to the headwaters an island occurred, the more likely that wider and more stable levees would develop. Considering an east to west cross section of the LRU, this would imply a likely decreasing potential for significant oak, sycamore and walnut presence as well as increased turnover of cottonwood in particular as large shallow-rooted trees in such soils eventually topple under their own weight if not by windthrow or force of floating debris.

Wetlands that support abundant freshwater rooted vegetation are classified as freshwater emergent wetlands. Salinities lower than 0.5 ppt generally characterize these wetlands (Cowardin et al. 1979). These marshes and swamps are associated with riverine floodplains (lands adjoining a channel that are subject to flooding every one to three years) and flood basins (extensive low-lying regions on the backside of natural levees) as well the upper regions of estuaries. Small freshwater emergent wetlands are associated with low-lying depressions and ponds, small channels, and localized areas of high groundwater. Freshwater wetlands are dominated by plant species such as bulrush or tule (*Schoenoplectus acutus*, *S. californicus*,
S. americanus), cattails (Typha spp.), sedges (Carex spp.), spikerushes (Eleocharis spp.), rushes (Juncus spp.), smartweed (Polygonum spp.), and the common reed (*Phragmites australis*; Brandegee 1893-4, Jepson 1913, Atwater 1980, Barbour et al. 2007, Hickson and Keeler-Wolf 2007).

Vegetation assemblages vary depending on physical drivers. For instance, *S. californicus* was likely more domininant in the western Delta and along channels given its wind and wave reisistent structure, while the taller *S. acutus* grows in more protected areas like those in the north Delta flood basins (Keeler-Wolf pers. comm.). Particularly in the western-central Delta, this habitat type includes woody shrubs such as willow (Salix spp., primarily S. lucida lasiandra) and ferns (Athyrium felix-femina) to make upa unique plant community, perhaps related to maritime influences (Atwater 1980,Keeler-Wolf pers. comm.). The wetland species are not precluded by seasonally dry conditions.

Freshwater emergent wetlands can be either tidal or non-tidal. Tidal freshwater emergent wetlands include those areas wetted at mean higher high water during low river stage and comprise what historical records often refer to as tidelands. Non-tidal freshwater emergent wetlands are not directly and predominantly affected by tidal action. However, tides may indirectly affect water table levels in freshwater emergent wetland and hydrological connectivity across landscapes during floods.

State 3 conceivably produces the most vegetative biomass due to agricultural inputs whereas the two preceding states are similar in overall productivity over long periods of

time.

State and transition model

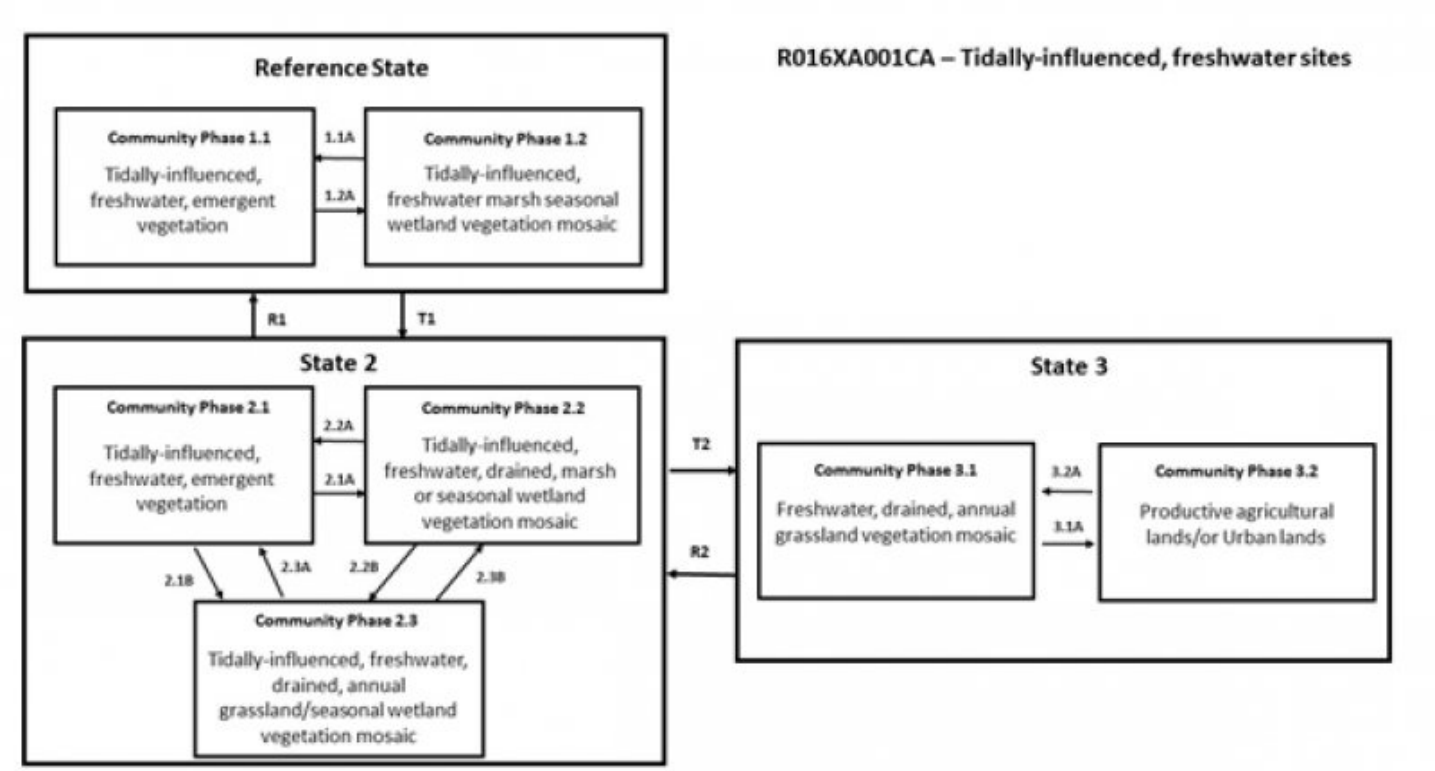

Figure 6. STM016XA001

State 1
Reference State

The species composition of the two community phases of the reference state are poorly documented in relation to the site and are better understood at the scale of the land resource unit (LRU) as a diverse mosaic of both marsh and riparian forest vegetation types. Through the influence of both tidal and riverine hydrology, these soils represent both the immediate depositional zone of upstream sediments as well the plant communities most likely to be controlled by high water table influences. This reference state consists two community phases, 1.1 which represents a recently disturbed, inundated and/or deposited soil dominated by pioneering emergent wetland vegetation, and community phase 1.2 representing a less recently disturbed and more diverse mosaic of herbaceous wetland communities. Not surprisingly, this vegetation of community phase 1.2 represents the continuous accumulation of organic material in the soil from onsite vegetation contributions leading to the histosol classification of the representative soils. While most of the LRU has been subjected to significant hydrologic alteration, echoes of these two community phases remain observable in areas which were deemed too economically difficult to reclaim for agricultural purposes or where such efforts to reclaim the land failed and the preexisting hydrology exerted itself.

Community 1.1
Tidally-influenced, freshwater, emergent vegetation

California bulrush and cattail are clearly dominant species appearing in uniform stands or in a mosaic. Minor species are common but having irregular distribution.

Community 1.2
Tidally-influenced, freshwater marsh seasonal wetland vegetation mosaic

Willows and cottonwood species codominant with cattail and bulrush in semi-concentric patterns with willows at the drier extents of perennial wetland areas. Spaces between ponded areas frequently near-monotypic dominance by cattail with occasional extensive stands of willows and/or limited stands of cottonwood trees.

Forest overstory. Cottonwood may occasionally exceed 13' tall but rarely reach full height potential.

Forest understory. Cottonwood and willow species in typically young, single aged stands. Generally, these trees do not reach mature height and rarely grow to more than 12' tall.

Pathway 1.2A
Community 1.1 to 1.2

Incidental and elevation of soils adjacent to sediment laden surface waters following regular tidal submersion and sediment contributions from upstream sources.

Conservation practices

Wetland Enhancement

Pathway 1.1A
Community 1.2 to 1.1

Reorientation of surface hydrology via short-interval flood event.

Conservation practices

Wetland Enhancement

State 2
Hydrologically Modified Freshwater Complex

This state represents a partially controlled hydrology with notably drier soil conditions than historic conditions afforded by the application of levees and in some cases dewatering by

pumping or marginally effective gravity drainage. It generally occurs side-by-side with State 3 in the form of fringe areas or blocks between actively cultivated fields or restored areas approaching some semblance of the reference state. The condition of these areas include some retention of natural topography and native vegetation. This is the most likely state that the ecological site could be restored to as has been pursued in areas such as Twitchell Island. There is potential in any State 2 community phase to restore conditions to the Reference State by removing artificial barriers to hydrology and other more superficial dewatering efforts. Due to the complexity of water flow regulation within the LRU, areas of approximate historic elevation and proximity to natural water flows present the highest opportunity for successful restoration to the Reference State. Restoration of this state in some cases presents unique complications for adjacent land management objectives which may be influenced by altered hydrology.

Community 2.1
Tidally-influenced, freshwater, emergent vegetation

California bulrush and cattail are clearly dominant species while giant reed (Arundo) is recognized as a problem in some areas contiguous to this ecological site and the LRU primarily along levees.

Community 2.2
Tidally-influenced, freshwater, drained, marsh or seasonal wetland vegetation mosaic

Willows and cottonwood species codominant with cattail and California bulrush in semi-concentric patterns with willows at the drier extents of perennial wetland areas. Spaces between ponded areas frequently near-monotypic dominance by cattail with occasional extensive stands of willows and/or limited stands of cottonwood trees. Alternately, shrub species such as wild rose and blackberry (native and introduced) may occupy areas with historically limited water and may be consistent with slugs of somewhat coarser soils deposited following higher flow events.

Forest overstory. Large cottonwood rare on low elevation seasonal wetland natural levees.

Forest understory. Salix and cottonwood in single aged cohort stands.

Community 2.3
Tidally-influenced, freshwater, drained, annual grassland/seasonal wetland vegetation mosiac

This is the standout community phase which differentiates this state as distinct from the Reference State. It is characterized by interspersed stands of Mediterranean climate-adapted upland vegetation indicative of dewatering of higher elevation portions of the landscape otherwise punctuated by perennial wetland and to a much lesser degree

freshwater marsh vegetation types at the lower elevations. Presence of the upland vegetation portion of the mosaic may pulse over time due to water table fluctuations this community phase with increases during prolonged periods of limited water availability and reduced extents following consecutive years of “surplus” soil water availability. Deep-rooted invasive perennial species such as pepper weed frequently are a problem within the soil moisture transition between pure annual grassland and wetland habitats proper.

Pathway 2.1A
Community 2.1 to 2.2

Incidental and elevation of soils adjacent to sediment laden surface waters following regular tidal submersion and sediment contributions from upstream sources.

Conservation practices

Wetland Enhancement

Pathway 2.1B
Community 2.1 to 2.3

Isolation by levee or dike, dewatering by pumping and gravity.

Conservation practices

Dike
Irrigation Land Leveling
Drainage Water Management

Pathway 2.2A
Community 2.2 to 2.1

Reorientation of surface hydrology via short-interval flood event.

Conservation practices

Wetland Enhancement

Pathway 2.2B
Community 2.2 to 2.3

Isolation by levee or dike, draining and pumping of subsurface water.

Conservation practices

Dike
Drainage Water Management

Pathway 2.3A
Community 2.3 to 2.1

Wetland enhancement involving reduced pumping of subsurface waters. Hydrology of adjacent land would likely be effected by this treatment.

Conservation practices

Wetland Enhancement

Pathway 2.3B
Community 2.3 to 2.2

Wetland enhancement involving reduced pumping of subsurface waters. Hydrology of adjacent land would likely be effected by this treatment.

Conservation practices

Wetland Enhancement

State 3
Hydrologically Controlled Agricultural Complex

This is the representative state with over 90% of the ecological site in agriculture production. Based on ground and surface water management and other agronomic inputs, this state is considered to produce the most biomass of any of the three states. This state represents the highest degree of alteration of the ecological site primarily through hydrologic alteration in the form of diversions and successful conversion to agricultural production. As a result of the historic reclamation practice of installing levees and the burning of the organic soil surface coupled with cultivation effects on carbon mineralization of organic accumulations, some of the histic soils have lost enough diagnostic organic matter content and subsequently have been classified as mollisols. Restoration of the ecological site when in State 3 is substantially more complex, primarily due to the agricultural resources at stake. Typically held as some of the most productive land in California, restoration efforts within State 3 require very careful planning especially where land ownership is complex. Additionally, some island areas of this ecological site have elevations significantly lower than flanking waterbodies and in such cases, the possibility of an open body of water occurring where the island exists is of substantial concern in some cases.

Community 3.1
Freshwater, drained, annual grassland vegetation mosaic

Absence of management following the near total alteration of surface and subsurface hydrology facilitates dominance by Mediterranean climate-adapted annual grassland communities with near exclusive dominance by introduced grass species. Some perennial invasive species such as pepper weed may persist in lowland areas where water collects and soil moisture conditions favor dominance.

Community 3.2
Productive agricultural use/or Urban lands

This community phase is characterized by the highest degree of land use for the ecological site. Vegetation and soils actively managed for agricultural production or has been developed for transportation or structural purposes.

Pathway 3.1A
Community 3.1 to 3.2

Agricultural crop production (or urban development).

Conservation practices

Conservation Crop Rotation
Drainage Water Management
Nutrient Management
Integrated Pest Management (IPM)

Pathway 3.2A
Community 3.2 to 3.1

Abandonment of agricultural operations.

Transition T1
State 1 to 2

Installation of upstream dams; installation of dikes and other water control structures; burning and leveling of organic soils; filling in of low elevation channels and ponds; pumping of subsurface waters.

Restoration pathway R1
State 2 to 1

Reduced dewatering of surface and ground waters, reintroduction of low relief topography, revegetation measures.

Conservation practices

Wetland Restoration

Transition T2
State 2 to 3

Advanced preparation for agricultural production including ground water management, land leveling and soil aeration.

Restoration pathway R2
State 3 to 2

Increase water table elevation, reestablish low elevation topographic relief, revegetate with native species composition.

Conservation practices

Wetland Restoration

Additional community tables

Other references

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Contributors

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Acknowledgments

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Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate. Current plant community cannot be used to identify the ecological site.

Author(s)/participant(s)	
Contact for lead author	
Date	
Approved by	
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:**

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2. **Presence of water flow patterns:**

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3. **Number and height of erosional pedestals or terracettes:**

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):**

5. **Number of gullies and erosion associated with gullies:**

6. **Extent of wind scoured, blowouts and/or depositional areas:**

7. **Amount of litter movement (describe size and distance expected to travel):**

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):**

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):**

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**

12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**

    Dominant:

    Sub-dominant:

    Other:

    Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):**

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14. **Average percent litter cover (%) and depth (in):**

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):**

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16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:**

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17. **Perennial plant reproductive capability:**
