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RESEARCH

Western and Traditional Ecological Knowledge in Ecocultural Restoration

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ABSTRACT

The Delta Plan (DSC 2013) calls for "protecting and enhancing the unique cultural values" of California's Sacramento–San Joaquin Delta, a 2,800-km^2 (1,100 mi^2) region that was occupied by indigenous peoples for ~5,000 years. The legacies of Native Californians need to be included in the Delta Plan, especially Traditional Ecological Knowledge (TEK) of ways to gather, hunt, and fish for food; build shelters; prepare medicines; and perform ceremonies—along with ways to make tools, clothing, baskets, and shelters. Plants were not just collected but also tended, which involved planned burning, digging, planting, weeding, harvesting, and seed dispersal. Populations of plants that have cultural significance and unique values should be enhanced under the Delta Plan. While Western Ecological Knowledge (WEK) offers a strong foundation for restoration of species assemblages and ecosystems, TEK adds culturally-significant species to restoration targets and traditional management practices to achieve ecological resilience. We compare 11 attributes of WEK and TEK that aid ecological restoration; all are complementary or shared by these two ways of knowing. Both WEK and TEK emphasize adaptive approaches for managing natural resources, as mandated in the Delta Plan. We suggest that WEK–TEK restoration sites throughout the Delta can be linked (virtually) to honor cultural integrity and nurture a "Sense of Place" for Native Californians and others. At the same time, such a network could foster ways to achieve sustainability through the TEK ethic of reciprocity, which WEK lacks. A network of WEK–TEK sites could enhance unique cultural values while supporting passive recreation and attracting ecotourists.

KEY WORDS

Adaptive Management, Native Californian, reciprocity, restoration, Sacramento–San Joaquin Delta, Traditional Resource Management

INTRODUCTION

A goal of the Delta Plan (DSC 2013, see Executive Summary p. 3) is to protect and enhance "*the unique cultural*, recreational, natural resource, and agricultural *values* of the Delta as an evolving place“ (italics added). But the current plan for restoring cultural services is limited to preserving legacy towns settled by colonists and a 257-word description of California First Nations, compiled from many sources, not all of which are authentic for the Delta. Missing is the Native Californians' (First Nations') ~5,000-year-old culture, in which unique cultural values co-evolved in reciprocal relationships among humans, plants, fish, and wildlife, from the headwaters through the Delta to the ocean. Such a legacy deserves greater attention in plans to restore unique cultural values. In addition, knowledge of historical ecology is needed to manage current landscapes (Ford and Martinez 2000; Garone 2015; Grossinger et al. 2007; Whipple et al. 2012; SFEI 2016).

A further goal is to support a "Sense of Place," i.e., the Delta's values (cultural, recreational, agricultural and natural resource) as they evolve toward an uncertain future with changing climate and land use. By acknowledging, respecting, inviting, and using First Nations' Traditional Ecological Knowledge (TEK) to restore parts of the Sacramento–San Joaquin Delta (i.e., demonstration sites), we anticipate more holistic land stewardship and more sustainable resource management. To help fulfill the Delta Plan's (DSC 2013) intent to restore unique cultural values, we suggest beginning by restoring culturally-significant plant species that co-evolved with Native Californians.

We argue that Western Ecological Knowledge (WEK) and TEK are complementary ways of knowing that inform restoration targets (i.e., plant assemblages from WEK and culturally-important species from TEK). Both WEK and TEK feature adaptive approaches and both can inform restoration planning. However, their time-frames differ, i.e., WEK mostly develops through short-term research, replicated in many places, while TEK is place-based and developed over generations (Alwash 2013; Fawzi et al. 2016; Senos et al. 2006).

First, we briefly review historical aspects of Native Californian culture that are relevant to restoring parts of the Delta to foster a Sense of Place. Then, we illustrate how TEK complements WEK in establishing restoration targets, and how Traditional Resource Management (TRM; part of TEK) and Adaptive Management (part of WEK) can help achieve restoration targets. Next, we promote a TEK ethic of reciprocity, which can lead land stewardship toward sustainability. Finally, we list several visitor centers that interpret TEK and WEK for the public, and suggest ideas for the Delta.

A BRIEF HISTORY

Several California authors have documented historical ecology and management systems, e.g., Anderson (1999, 2005), Yoshiyama et al. (2001), Grossinger et al. (2007), Hankins (2009, 2013), and Stevens and Zelazo (2015). Their work builds on broader reviews (e.g., Berkes et al. 2000; Folke 2004; Senos et al. 2006; Kimmerer 2011; Brondizio and Le Tourneau 2016; and Mistry and Berardi 2016). We draw from these and other reports to envision the cultural landscape of the historical Delta.

The Delta supported many groups of Native Californians, who tended, gathered, hunted and fished in ways that sustained the region's natural resources. Plants and animals were not just harvested but also tended. According to Anderson (2005, p. 334), "As we now know, many of the classic landscapes of California—coastal prairies, majestic valley oak groves, montane meadows, the oak–meadow mosaic of Yosemite Valley—were, in fact, shaped by the unremitting labor of generations of native people. Moreover, these and other communities were managed intensively and regularly by these people, and that many have disappeared or changed radically in the absence of management shows they were not self-sustaining." Ecosystems in the Sacramento–San Joaquin Delta were regularly managed, not just for plants but also fish, grasshoppers, and wildlife. In the lower Cosumnes River watershed before 1850, key practices (especially planned burning) led to more open riparian woodlands, reduced water loss through evapotranspiration, attenuated peak flood flows, and prolonged stream-flow in the wet season. No doubt such land care influenced floodplain biodiversity and native fish productivity.

How many people lived in the Delta? Stevens and Zelazo (2015) reported that "Tending of the landscape by indigenous Californians is expected to have increased production and abundance of native fishes, sufficient to supply one-third of the Plains

Miwok (Mewuk) diet for as many as 57 individuals per square mile along the streams and sloughs in the study area (lower Cosumnes River) for at least 1,100 years" (see also Johnson 1976 and Yoshiyama et al. 2001). According to Stuart (2016a), the San Joaquin River supported villages with ~200 persons 5 to 10 miles apart, and a combined population of ~1,300 or more—perhaps the continent's most densely populated region north of Mexico. Similarly, Whipple et al. (2012) concluded that "The rich Delta ecosystem supported a population on the order of 10,000 people of the estimated 300,000 people in California, embracing four distinct linguistic groupings and numerous smaller communities....Villages, often marked by artificially constructed mounds (up to 300 feet or more in diameter) occupied the higher lands within the Delta, including natural levees and sand mounds" (Figure 1).

Along the San Joaquin River and its tributaries, uplands were connected by water, facilitating the clustering of villages. Language units and populations along waterways were likely near valleys with groves of oaks and abundant acorns (Stuart 2016a). As the seasons changed, so did people's tending, gathering, and harvesting activities. "The Northern Valley Yokuts were semi-sedentary.... [but shifted to obtain] other resources, such as acorns, as they became available within well-defined territories for fishing, gathering, and hunting. Settlements contained dome-shaped houses and shelters made of brush and tules.... Fish, fowl, acorns, and tule roots were the primary Northern Valley Yokut subsistence resources" (West and Welch 1996, p. 8). Other resources—such as corms, bulbs, grass and forb seeds, freshwater bivalves, and small mammals—were also important. Famine foods such as California buckeye, soap root and tules helped people survive years of low acorn mast (Figure 2).

Native Californians might have harvested over 500 species of plants (Stuart 2016a). Resource-management practices augmented some species and restricted others. Over ~5,000 years, the degree to which plant and animal populations were altered by early people would have been substantial. Then colonists arrived in the 1800s and began decimating Native Californian populations through genocide and slavery. When malaria was introduced in ~1832, it was rapidly spread by mosquitoes. Diseases depleted

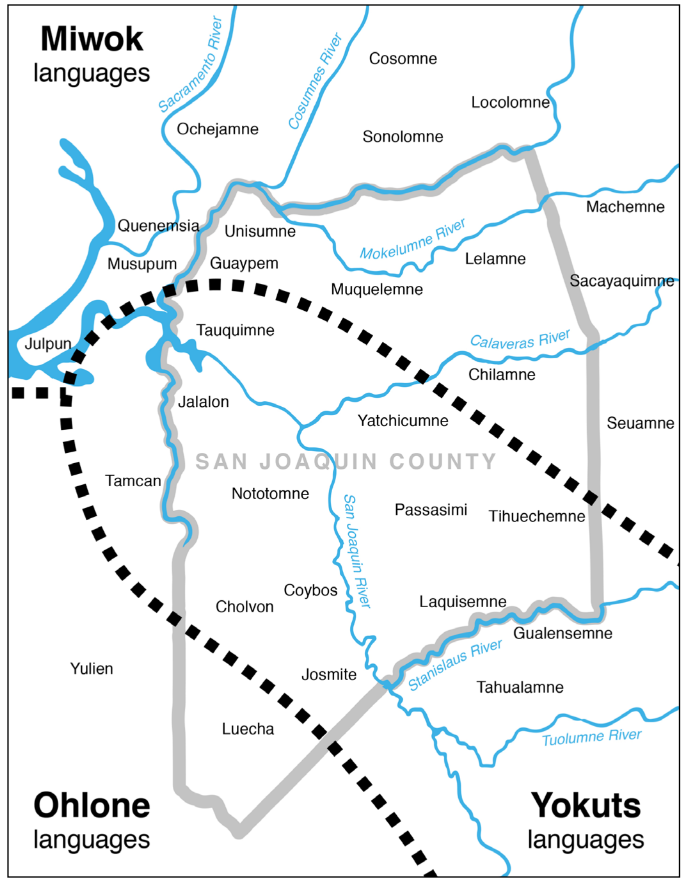

Figure 1 Map of Native Californian language groups in the early 1800s, in and around what is now San Joaquin County (modern boundary). Source: Stuart (2016a, p. 17), redrawn by S. Friedrich.

the Plains Miwok nations in northern San Joaquin County (Stuart 2016b) and throughout California. Indian slaves who labored in missions were casualties as well; Stuart (2016b) estimated that approximately three-quarters of slaves died there. Land tending diminished, and native vegetation was reduced to tiny remnants, surrounded by agricultural and urban lands (Figure 3).

Native Californian traditions, languages, and land-management practices are no longer obvious throughout the Sacramento–San Joaquin Delta. The shift from tended to untended ecosystems was rapid and near-complete. Without harvesting and frequent burning of understory vegetation—including tree seedlings and saplings—the gallery structure of riparian forests closed, as did park-like woodlands. The vast Tule marshes of the Delta became senescent

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Figure 2 Acorn flour in traditional California Indian hand-woven basket, shown with historical and modern tools. Photo: M. L. Stevens.

and impenetrable. Introduced annual grasses displaced native grasslands. Today, only 14% of the Delta's 725,600 acres support native trees, shrubs, and herbaceous plants (Figure 3). Of the remnant patches of native vegetation, only a handful have been continuously tended or traditionally managed. Broad floodplains once grew sedges that, when tended, produced long, straight rhizomes to meet the continual demand for baskets (Stevens 1999, 2004; Stevens and Zelazo 2015). Now, the region primarily supports agriculture, urban land uses, and tall levees that separate subsided land from straightened waterways. While the Delta is known as "One of the largest waterworks in the world" (Luoma et al. 2015), the region is still home to more than 750 species of plants and animals (Figure 3; Hickson and Keeler-Wolf 2007).

Is Native Californian history forgotten? Not by Native Californians. And not quite by those who colonized the Delta. Although contact with Europeans was disastrous for early California Indian populations, there were secret refuges and ceremonial sites, plus traditional knowledge-keepers who held onto cherished traditions. The Delta is valued and has been proposed for National Heritage Area status, i.e., a place "where natural, cultural, historic, and recreational resources combined to form a distinctive landscape and tell a nationally important story about the country and its experience" (Congressional approval is pending). It's time to enhance unique cultural values.

RESTORING CULTURALLY SIGNIFICANT PLANTS

It would be presumptuous to assume we could restore any indigenous people's homeland to habitats that their ancestors would have deeply regarded. Instead, we suggest beginning by promoting ecocultural restoration, i.e., engaging indigenous people in planning and decision-making, as well as learning and teaching about the roles traditionally adopted to manage how ecosystems were structured and how they functioned.

We propose featuring culturally significant plants (Box 1) in the Delta using complementary components of WEK and TEK, respectively. We promote a practical vision that reflects today's reality of human-altered ecosystems, and we highlight wetlands—for their extremely high value (Zedler and Kercher 2005). Also, permits to discharge materials into wetlands (those covered by the Clean Water Act) often lead to mitigation via restoration (NRC 2001). Mitigation projects (DSC, unpublished report, see "Notes") will add opportunities to restore culturally significant species to existing plans of EcoRestore, namely, ~12,140 ha (30,000 acres), comprising 7,082 ha (17,500 ac) of floodplain, 3,642 ha (9,000 ac) of

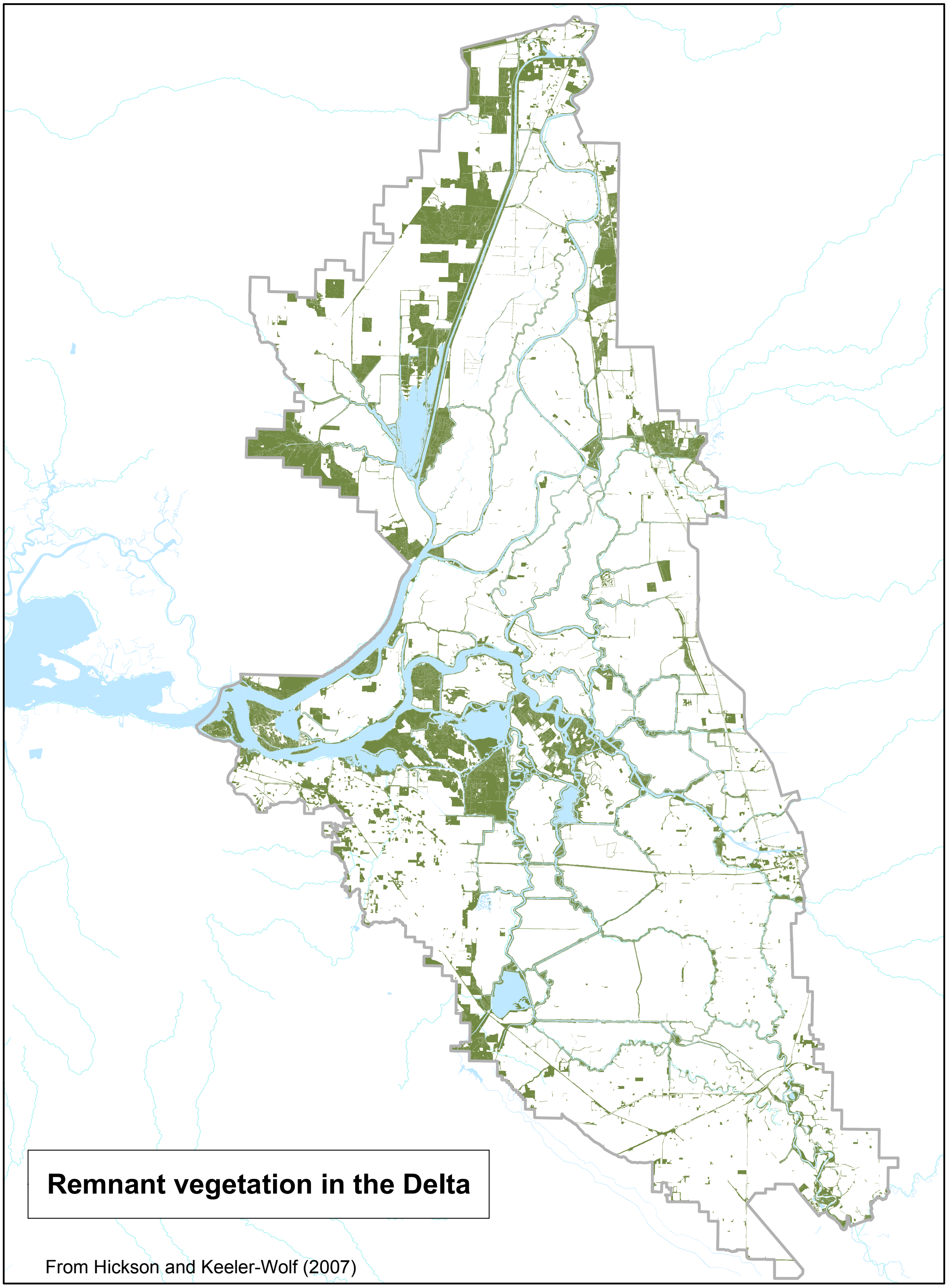

Figure 3 Remnant vegetation in the Delta. "Remnant" includes sites that support vegetation that is historical, was restored, was established after islands were flooded, and was established along sloughs after levees were built. Source: Hickson and Keeler–Wolf (2007, p. 35), re-labeled by D. Hickson.

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BOX 1

Defining Restoration

Our goals fit the Society for Restoration Ecology's definition of restoration, i.e., "the process of *assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed*" (*http://www.ser.org*). We include actions to shift highly degraded habitats toward reference ecosystems that are managed to sustain native biodiversity and ecosystem services, even if structure and function differ from historical conditions. We include actions to provide culturally significant species in the concept of restoration. We do not expect to turn back the clock.

tidal and subtidal habitat, 1,416 ha (3,500 ac) of managed wetlands to reverse subsidence and manage carbon, and over 405 ha (1000+ ac) for aquatic, riparian, and upland habitat- and flood-management projects.

First, to fulfill the Delta Plan's goal to protect and enhance unique cultural values, we propose identifying "target assemblages" with WEK taking the lead and by referring to remnant wetlands that retain native species (Figure 3; Hickson and Keeler–Wolf). Planning to establish and sustain native assemblages requires historical information on species composition.

A useful WEK approach is Wisconsin's survey of 1,012 of the state's least-altered wetlands, of which 416 sites were considered potential reference communities with assemblages of native plants to guide nearby vegetation restoration (O'Connor and Doyle 2017). Similarly, assemblages of native plants in the Delta's remnant vegetation can help set assemblage targets for nearby restoration (Hickson and Keeler–Wolf 2007). Culturally significant plants such as mugwort (Figure 4) can also be highlighted while remnant vegetation is monitored (e.g., by using the Rapid Assessment Method), thus suggesting places to enhance populations of target species (Figure 4; Table 1).

Second, once targets for restoring vegetation are developed, ethno-ecologists with local TEK can identify culturally significant plants (Figures 4 and 5) to add to appropriate target assemblages. An important example is riparian woodlands with *Carex barbarae* in the understory (Table 2).

Figure 4 Mugwort (*Artemisia douglasiana*), a very important medicine plant to Delta First Nations, known to be an early-succession species (resilient to fire), a nurse plant for other natives, and a strong competitor with non-native invasive species. Photo: M. L. Stevens.

Figure 5 Deergrass (*Muhlenbergia rigens*) and White root (*Carex barbarae*), weaving materials used for traditional California Indian baskets. Photo: M. L. Stevens.

BOX 2

White Root

White root is a widespread riparian understory plant that supported basket-making by producing up to 100 or more rhizomes in a season. Sedges are tended in beds to grow straight rhizomes up to 2 m long (untended beds produce short, twisted rhizomes) (Stevens 1999, 2004a, 2004b, 2004c). Based on historical records and traditions, people made coiled baskets using about 13 species of sedges, collectively called "white root," which produced tens of thousands of sedge rhizomes for use per tribelet annually (Stevens 2003). Today, *C. barbarae* is the primary sedge used by California basket-weavers. It is found in valley oak riparian woodlands from southern California to southern Oregon and from sea level to ~900 meters. White root grows well next to rivers and is able to withstand both drought and floods. Before European settlement, over one-third of California tribes used White root for basket weaving, such that a significant portion of the riparian forest understory was tended (Stevens 1999, 2004c). A tribelet (small extended family) would tend ~2.4 hectares (~6 acres) of sedge beds per year. Tending created an open riparian woodland, transportation corridors, and space for food-processing, as well as enabling early detection of predators.

Ten Steps to Tend and Use White Root
(Stevens 2004a)

Before tending, prayers are offered and permission asked from Spirit to gather and tend the sedge beds.

1. To harvest, cut live leaves and stems to ~30 cm to keep sharp-edged leaves from cutting hands.
2. Dig up rhizomes, following them through the soil; at the same time, remove extra plants and debris.
3. Use digging stick to loosen, aerate, and homogenize the soil.
4. Seasonally harvest after winter and spring rains moisten the soil.
5. Thin and weed to maintain spacing at ~0.5–1.0 m.
6. Pull extra plants and transplant nearby.
7. While they are fresh, de-bark and split rhizomes in two.
8. Coil 50–100 split rhizomes and tie; store and dry for ~1 yr.
9. When ready to weave baskets, scrape and sort rhizomes
10. Basket-weaving techniques using White root are specific to tribal traditions (Figure 6). Harvesting occurs every 2–4 years. Only one-third of plants are harvested at a time, to conserve all age classes ("grandmother, mother, child") at the site.

Table 1 Assemblages to target in restoration sites can be based on WEK of species' functional traits, when known (modified from Laughlin 2014).

Species and assemblages that are known to perform well under a site's abiotic conditions
Species that are similar to common invaders and might resist invasion, as well as species that might out-compete invaders
Species known to become dominants, and that provide desired ecosystem processes
Assemblages of species with diverse growth forms and functions that are complementary
Critical habitat for sensitive species of concern

Table 2 A selection of plant species, each with unique cultural value, suggested for use in Delta restoration based on TEK (selected by M. L. Stevens; see also Appendix A). Most species would also provide ecosystem services based on WEK, such as providing habitat and stabilizing banks.

White root (*Carex barbarae*)—ethno-botanically significant plant for baskets (Box 2)
Willow (*Salix* spp.) for baskets, building structures such as sweat lodges, and ramadas
California hazelnut (*Corylus cornuta*) for baskets, nuts (food)
Red bud (*Cercis occidentalis*) for intricate red and brown design elements as well as for both warp and weft of whole baskets
Deergrass (*Muhlenbergia rigens*) for baskets and seeds for pinole (food)
Milkweed (*Asclepias californica*) and Indian hemp (*Apocynum cannabinum*) for fiber in fish and deer nets, ceremonial regalia, baskets, sally bags, cordage
Tule (*Schoenoplectus acutus*) reeds, rhizomes, and pollen for food; material culture such as temporary ramadas, tule boats, and duck decoys
Grass and forb seeds, greens (leaves) and geophytes (bulbs and corms) for food and medicine
Grasses and other plants to support grasshoppers (a food item)
Fish, wildlife, and shellfish for food

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Historically, large areas of floodplain were needed to meet basket-making demands, given that White root takes 2–4 yrs to produce harvestable rhizomes, even with weeding and soil aeration. (Rhizomes go dormant during years with heavy rainfall and flooding.) Today, riparian woodlands occupy only ~5% of historical areas. Few continuously-tended beds remain, and access is often restricted on both public and private lands. By restoring floodplain vegetation—complete with a system of sustainable harvesting and tending of White root—rhizomes could remain accessible (and pesticide-free) for traditional California basket-weavers. Basket-weaving continues to be significant for many California Indians' ethnic and spiritual identity; it provides more than an income—it sustains a critical connection to the land. The California Indian Basketweavers Association formed in 1992; its mission is "to preserve, promote and perpetuate California Indian basketweaving traditions while providing a healthy physical, social, spiritual and economic environment for basketweavers." This includes providing access to tending and gathering the necessary materials (*https://ciba.org/*).

We envision beginning with portions of restoration sites that have broader goals. Ecocultural demonstrations would need to be small enough for local volunteers or clubs to tend. A participatory approach would be needed within an adaptive management framework (see below). Efforts to expand plantings of culturally significant plants could expand over time.

TEK COMPLEMENTS WEK

Adding restoration to sustain and restore unique cultural values does not mean eliminating goals that are already in place, because TEK complements WEK. In the practice of restoration, WEK restoration goals are anthropocentric: planners seek to regain species, communities, and ecosystems for their benefits to humans (Table 3). Indeed, the four classes of ecosystem services laid out in the Millenium Ecosystem Assessment (2005) are: provisioning (e.g., food, fiber), supporting (soil formation, productivity, nutrient cycling), regulating (e.g., flood control, water quality), and cultural (recreation, esthetics, art). In contrast, TEK takes a long view, often expressed as seven generations (Box 3).

BOX 3

Defining TEK

Ford and Martinez (2000, p. 1,249) described TEK as "the knowledge held by indigenous cultures about their immediate environments and the cultural management practices that build on that knowledge." They also refer to TEKW, which adds "wisdom" to reflect the moral, ethical, and spiritual dimensions of TEK. Berkes et al. (2000, p. 1,252) defined TEK as "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment….an attribute of societies with historical continuity in resource use practice." Senos et al. (2006) called it a "holistic integrative approach that incorporates the metaphysical with the biophysical." "TEK is as much about understanding the dynamics of ecosystems as about the description of their components" (Houde 2007).

TEK is the cultural knowledge system that informs Traditional Resource Management (TRM) strategies. Nolan and Turner (2011) point out that diverse ways of knowing and perpetuating local knowledge have intrinsic value and are culturally and socially important. TEK incorporates both a kin-centric stewardship worldview and a sense of individual responsibility for world balance and renewal. People are part of the landscape and responsible for stewardship into the future. Frank Lake states that "people see themselves as part of the land; the maintenance is partly because my grandchildren will maintain the integrity of the system" (personal communication with M. Stevens, 2018; unreferenced, see "Notes;" Table 4).

WEK and TEK are not just complementary but potentially synergistic in achieving data-based decision-making. Consider the example of the Great Lakes Indian Fish and Wildlife Commission (GLIFWC), which was recently described as a "hard-science Native organization" with reliable data on natural resources; at the same time, its view is holistic, with culture "infused throughout the structure, activities, and purpose of GLIFWC" (Loew 2014, pp. 59–61).

Table 3 Attributes of WEK and TEK that differ or are shared, based on literature cited in this review

Attribute	WEK	TEK	Both WEK and TEK
Prevailing ethic	Develop and exploit natural resources; focus on profit	Reciprocity; tend the earth so the earth can nurture humans and non-humans	Express the need for sustainability and resiliency
Time frame	Mostly short-term planning; long-term view often lacking	Inter-generational	Forward-looking
Predictions	Mostly quantitative	Mostly qualitative	Feed information back to reconsider next steps, as in Adaptive Management
Methods	Tests, sampling, statistical analyses	Trials, observations	• Observe, integrate, synthesize • Manage adaptively; use accumulated knowledge to improve methods
Accumulating data	Tendency to collect synchronic data (at one time) from many sites and many attributes	Diachronic database over a long period of time (chronosequence)	Respect evidence
Nature of data	Data are mostly objective, "value-free"	Observers tend to be resource users, strongly invested in data	
Reviewers	Peers, from narrow specialty of restoration, but from broad geographical range, anonymous	Elders, from local tribe, known and revered	Stake-holder opinions are sought
Records	Dense literature	Oral traditions	Experience is respected
Restoration actions	Often part of an academic culture; projects often involve experimentation; investigators aim to be objective	Harvests of resources depend on the quality and reliability of ecological observations: well-being and survival are at stake	Both learn by doing restoration in adaptive approaches
Goal for restoring habitats (examples)	Select species' traits to maintain desired vegetation or restore resilience, control exotics, denature toxins, and/or sustain net primary productivity (NPP) (Laughlin 2014). The online Explorer (TNC and WDNR 2018) finds potentially restorable wetlands to provide up to nine ecosystem services (abate floods; reduce sediment, P and N; protect shorelines and surface waters; store C, provide fish habitat & floristic integrity).	Select species' traits to maintain culturally-significant species for ceremonial and regalia production; food from herbaceous plants [e.g., greens, seeds for pinole, acorns, and geophytes (bulbs and corms)]; berries; medicines; fiber and material culture, especially baskets, which are a California Indian cultural icon	• Keep all the parts, as in "intelligent tinkering" • Restore a network of habitats in the Delta • Connect sites using maps, stories, and exhibits
Goal to include keystone species with multiple values and ecosystem services	Tussock Sedge (*Carex stricta*) to create micro-topography, foster de-nitrification, oxidize methane, and store carbon; widespread sedge meadow dominant in eastern U.S.	White root (*Carex barbarae*) for rhizomes to weave baskets and to stabilize river banks; a riparian understory dominant in California	Restoration "super plants" perform multiple services for the ecosystem and for people

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Table 4 Examples of Traditional Resource Management (TRM)

Using fire to create open, structurally-diverse habitat for culturally-significant plants and animals; to facilitate growth of new (and more palatable) plant shoots; and to produce suitable stems for baskets, mats, lodges, boats, duck decoys, nets, and traditional clothing (hats, capes, and dance skirts)
Selective harvesting on a phenological basis, e.g., restricting fish harvest during spawning
Managing for multiple species (cattails, rushes, sedges, bulrushes, fish, waterfowl, and bird eggs)
Retaining landscape patchiness and multiple seral stages (for wetlands: interspersed open water, and emergent and seasonal wetland vegetation, with perennial grasslands and riparian woodlands on higher ground)
Intermediate disturbance by humans, increasing biodiversity
Wetland tending includes burning (as above); coppicing (pruning) woody plants to produce straight stems; tilling and weeding; and harvesting rhizomes and bulb plants

ADAPTIVE APPROACHES TO LAND MANAGEMENT

Each knowledge system or "way of knowing" has developed frameworks for land care that encourage practitioners to "learn while restoring." Both WEK and TEK emphasize feedback learning, and both address uncertainty and unpredictability, which are intrinsic to all ecosystems (Table 3). In WEK, it is called "Adaptive Management," which the Delta Plan (DSC 2013) mandates. In TEK, it is the aforementioned TRM (Table 4), which includes respect for life, and recognition of the spirit and power in the plants, and a responsibility to pass information on to future generations (Stevens 2004b). WEK and TEK also support adaptive approaches to restoration (Zedler 2017). Both are place-based and emphasize feedback learning in unpredictable ecosystems; both aim to reduce uncertainties; both focus on repeated tests of knowledge; and both allow flexibility in decision-making (Table 3). WEK emphasizes establishing alternative hypotheses, testing, monitoring, interpreting results, and selecting the alternative that passes key tests. For highly-altered restoration sites, it will be prudent to identify several target assemblages (using WEK) and culturally-important species (using TEK) and then "learn while restoring," by monitoring outcomes and selecting the approaches that achieve acceptable outcomes. Indigenous people carefully monitored their gathering sites to sustain significant resources because the price of failure was starvation, migration, or death. "TEK largely serves the purpose of subsistence" (Houde 2007).

Today, the penalty is less severe, and the opportunities to learn are endless. From the above history we learn that there was no "original condition" to be restored, because plant communities were tended and harvested continually. We learn that desired targets often require continual management. This suggests plenty of latitude to suggest and test alternative assemblages, with a short-term goal of establishment and a long-term goal of persistence—both with various regimes of "tending." Larger restoration projects could test the area needed to provide "operational safe sites" to sustain resources in the face of uncertainty (Green et al. 2017). Operational safe sites are a variation of the precautionary principle and bet-hedging strategies: Wherever there are major uncertainties, consider testing alternatives and, when in doubt, restore more land and wetlands to hedge bets.

Berkes et al. (2000) explored how social mechanisms and traditional practices assisted early "multiple species management, resource rotation, succession management, and landscape patchiness management." All these practices required that people develop knowledge, adapt to new findings, and pass on information to sustain Native Californian society. Consistent with WEK Adaptive Management, TEK TRM had its basis in uncertainty (e.g., food supplies and other provisioning ecosystem services). Responses to environmental conditions were the feedback loops, e.g., reducing harvesting when a species became scarce, allowing recovery, and re-setting harvest limits. TEK would have guided daily, seasonal, and annual patterns of resource use as well as additional esthetic and spiritual uses of places and species.

A variation within Adaptive Management is to establish large field experiments that test alternative restoration actions while simultaneously restoring the site; experiments are phased so that early outcomes inform later actions, making it "adaptive restoration" (Zedler 2017). In selected waterways, it would be possible to test the effects of traditional practices (burning, tending) on habitat productivity to learn how floodplains influence the fecundity of California's native fish species. As mentioned earlier, such practices once contributed to fish populations' resiliency to fluctuating environmental conditions (Yoshiyama et al. 2001; Stevens and Zelazo 2015).

Planners need the knowledge and wisdom of TEK to suggest culturally important species, contribute methods of introduction, learn ways to tend plantings, and prescribe fire to manage ecosystems (Anderson 2005; Hankins 2013; Anderson and Rosenthal 2015).

We anticipate gains by joining the approaches of WEK and TEK (Box 4). Complementary approaches could yield clear targets for restorable assemblages and culturally significant species.

BOX 4

A WEK/TEK Scenario

Consider a proposed brackish marsh restoration. WEK hydrologic models can guide locations for breaching levees and planting seeds or plugs of tules (*Schoenoplectus* spp.). WEK practitioners can test alternative plantings (species, densities, combinations). But what if the outcome is extremely dense vegetation, such that fish and waterfowl are not attracted to use the marsh? Use of traditional fire management by TEK practitioners reduces senescent vegetation, allows tidal creeks to form, and provides access and habitat for multiple species. TEK researchers might test alternative ways to tend sites over time, harvesting tules to make boats. They might remember how California Indians once paddled freely through Delta marshes, creating a network of pathways that also served as conduits for tidal fluxes and daily fish migrations. TEK researchers might refer to ethnographic literature; create reciprocal and respectful relationships with traditional knowledge-holders, educators, land-managers, and elders; and, with permission, help tend and manage culturally-significant resources. Trials and observations of the larger ecosystem would suggest how best to proceed in additional areas. Both WEK and TEK are adaptive, and the ideas are complementary.

RECIPROCITY AND SUSTAINABILITY

The ethic of reciprocity seems essential to achieve sustainability. "One aspect of TEK often unrecognized is the emphasis that not only are humans dependent upon the nonhuman, but also that the reverse is often true" (Pierotti and Wildcat 2000, p. 1,337). Similarly, Turner et al. (2000) describe a philosophy of guardianship, i.e., resources are placed in peoples' care, not exploited for exclusive use. Thus, restoration aims to restore the land so the land can restore human well-being (Kimmerer 2013). In the Cosumnes River floodplains (Box 2), the tending of sedges prevented dominance by tall woody plants. When tending ceased, riparian succession occurred rapidly, and the delible tended sedge bed was replaced by shrubs and saplings of Oregon ash and poison oak. Similarly, native fish likely responded to lower-quality habitat after Native Californian burning and other practices ceased (Stevens and Zelazo 2015). The milkweed and Indian hemp—which were harvested in large numbers for nets, baskets, regalia, and fiber—are now largely missing from the contemporary Delta landscape. And their reduced distributions deplete habitat that is critical for current conservation goals, e.g., pollinators and monarch butterfly larvae that feed on milkweed.

How was fishing sustained? Current Delta waters are characterized as having low productivity, and juvenile Delta Smelt are described as poorly-fed (Hammock et al. 2015). Part of the answer is that waterways are no longer connected to productive marshlands dissected by channels and tributaries (SFEI 2016). But another part of the answer is the ethic of reciprocity. Historical sustainability involved careful observation of site conditions and weather, avoiding over-harvesting, removing unwanted species, and dividing and transplanting desired species. A core cultural value was (and is) an ethic of reciprocity: people tend the land so the land can sustain the people. To build sustainability and resiliency of socio-ecological systems, people need to know how their land-care actions affect their own well-being and that of future generations.

International examples further illustrate the efficacy of TEK in sustaining resilient landscapes and natural resources. In Romania, Hartel et al. (2016) found that historical challenges led to resilience that helps the current population cope with changing climate. People have maintained native vegetation, fertile soils, and valuable provisioning services by knowing that functional ecosystems and human well-being are strongly linked. Substantial traditional local knowledge has persisted and led to resilience, given

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an uncertain future. And in Iraq's Mesopotamian Marshes, a 20,000-km^2 region that has many parallels with the Delta, Marsh Arab culture thrived in *Phragmites*-dominated wetlands over thousands of years, until war and water-deprivation decimated virtually all of southern Iraq's native landscapes and indigenous lifestyle. Yet in a tiny fraction of their former extent, wetlands persist, and Marsh Arab elders are resuming ancestral practices (Alwash 2013; Fawzi et al. 2016). And in Queensland, Australia, aboriginal managers of mangroves can "describe, in detail, changes in river health over time that are not readily captured by standard water quality sampling techniques"; without their assistance, managers had little evidence that the "current health of the river is compromised from its pre-colonial state" (Brown et al. 2018). In Finland, indigenous fishers recognized the declining abundance of salmon in time to take action, by shifting some fishing of salmon to pike (Pecl et al. 2017). Local expertise and holistic views of ecosystems not only help indicate how biodiversity is threatened in a warming world, but also suggest steps to take toward sustainability.

FOSTERING A"SENSE OF PLACE"

Indigenous and rural societies place great value on traditional knowledge; it often defines their collective identity, even when their culture migrates into modern cities and alternative economic and physical landscapes. Indigenous people's Sense of Place (see page 2) embodies TEK concepts that all things are connected, and all things are related. Thus, early people valued, respected, and honored nature. "The idea of human history existing independently of local places and the natural world is foreign to the native peoples of North America, because for them their history cannot be separated from the entire geography, biology, and environment to which they belong" (Pierotti and Wildcat 2000, p. 1,334; see also Salmón 2000).

Native Californians developed a strong Sense of Place from daily contact with, and dependence on, nature. They developed deep empirical knowledge of the habitats that each species occupied by observing their surroundings and thinking spatially. Native worldviews are inseparable from place, unlike western European culture, in which one's place in

Figure 6 Basket-weaver making a traditional Miwok basket. The weaver is using tended/processed White root rhizomes as the sewing strand in a coiled basket. An awl is used to punch a hole in the foundation, to pull the rhizome through. Here, split willow stems make up the basket core, and Redbud is the primary design element. Photo: M. L. Stevens

history is viewed in relation to time, by looking back and forward (Pierotti and Wildcat 2000).

Thus, in the Delta, we suggest restoring examples of each habitat where early Indians tended and harvested culturally significant species: sand hills, meadows, marshes, streams, mudflats, riparian woodlands, and oak woodlands in upstream valleys. Each site could feature one or more culturally significant species (Table 2) and augment the Delta's remnant vegetation (Figure 3, Box 5). We envision accessible (visitor-friendly) demonstration sites that are preserved, enhanced, and restored. Such a collection of restored examples could become a network by connecting sites virtually through maps, stories, and interactive educational media that relate current remnants to historical landscapes. Given a deeper understanding of how early Indians thrived, demonstration sites could honor indigenous culture and help future generations manage and sustain the Delta.

Although we have some knowledge of how Native Californians hunted and gathered while they tended the land, further research is needed to connect

Figure 7 Willows (*Salix* spp.) coppiced to produce straight re-sprouts for baskets, ramadas, sweat lodges, and other essential elements of the material culture. Photo: M. L. Stevens.

human land care to landscape components, providing examples of how Native Californians moved across landscapes and shifted activities with seasonal changes in resource availability. Plantings of oaks, manzanitas, white root beds, camas beds, redbud bushes, and willow groves for coppicing (Figure 7) could illustrate traditional management actions and places that shift with the seasons. Demonstration sites with varied topography could feature patches of oak woodland, willow thicket, and marsh. Shifts in ecosystem boundaries might reveal resilience to changes in climate.

LOCATING ECOCULTURAL RESTORATION SITES

In recommending that ecoculturally significant species be recovered within the Delta, we aim to avoid resistance that other scientists have encountered when promoting TEK, e.g., difficulty describing the religious components and rituals of TEK and inability to fact-check oral traditions (Huntington 2000). Proposed ecocultural restoration sites would avoid places that are off-limits to the general public for any reason (sacred or ceremonial sites, gathering sites, and areas that supported fishing, hunting, processing, villages, or roundhouses). In sequence, we suggest prioritizing restoration targets for potentially restorable sites by comparing their opportunities for teaching and learning, their ability to support one or more culturally significant species, and permission from appropriate representatives of local sovereign First Nations (Table 2).

Earlier, David Stuart worked with California Valley Tribes and urged the San Joaquin County Historical Society to encourage all Tribes and Native Nations to help educate the County's citizens and visitors (see August 8, 2012 report available from *http://www.sanjoaquinhistory.org*). Existing plans (DSC 2018, unreferenced, see "Notes") indicate thousands of acres to be restored in the Delta. Parts of some sites could feature culturally significant plants and present information on associated animals. A digital and continually updated ecotourism map could show a network of sites being restored for visitors, education, recreation, and demonstrations of WEK–TEK complementarity (Table 3).

Across the country, Native American traditions are being interpreted for local residents and visitors in outdoor facilities designed for the public. For example, native food and medicinal plants are grown in experimental gardens in Cache Creek, California, and Grand Portage, Minnesota (Box 5). The Delta

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BOX 5

Examples of Facilities that Feature Native American Heritage

California

Cosumnes River Preserve (>50,000 acres, *http://www.cosumnes.org*) protects a riparian corridor from the headwaters to the Delta, with floodplains, wetlands, vernal pools, grasslands, endangered species, and land-care experimentation (Hankins 2013; Stevens and Zelazo 2015).

Effie Yeaw Nature Center (100 acres; *http://www.sacnaturecenter.net/*) on the American River, near Carmichael, features riparian and oak woodlands, shrub lands, meadows, aquatic habitats, and an environmental and cultural education center. Visitors experience Native Californian (Maidu) traditions through hands-on learning.

Bushy Lake (a 20-acre pond and surroundings; *http://www.bushylake.com/about/*) along the American River Parkway supports a collaborative, adaptive restoration project. Students and faculty from California State University–Sacramento are testing ways to achieve a fire-resilient landscape using native vegetation. Citizens participate in monitoring.

Chaw'se Indian Grinding Rocks (135 acres; *http://www.parks.ca.gov/?page_id=553*) is a state park in the Sierra Nevada foothills near Pine Grove. Visitors can see petroglyphs and 1,185 mortar holes—North America's largest collection, thanks to Valley oaks and abundant acorns. A regional museum has relicts from many tribal groups.

Cache Creek Nature Preserve (130 acres; *http://www.bioregion.ucdavis.edu/book/13_Lower_Cache_Creek/13_03_circ_ccnp.html*), near Woodland, protects a 16-mile creek segment from further sand/gravel extraction. A Tending and Gathering Garden was created by the California Indian Basketweaving Association (funded in part by Rumsey Indian Rancheria); it features traditional food, medicine, and basket-weaving plants. Research is encouraged to assess responses of biodiversity to Traditional Resource Management (TRM).

Minnesota

Grand Portage National Monument (*http://www.nationalparks.org/explore-parks/grand-portage-national-monument*) at the former Hudson Bay trading post in northeasternmost Minnesota features Ojibwe TRM with examples of gardening, parching wild rice, and restoring vegetation, especially sweetgrass, *Hierochloe odorata* (Zedler et al. 2011, unpublished report, see "Notes").

Wisconsin

Ho-Nee-Um Pond (Leaflet #25: *http://www.arboretum.wisc.edu/science/research/leaflets*) is a former Ho-Chunk village site at the 1,200-acre Arboretum at the University of Wisconsin–Madison (Leopold 1934). Visitor trails feature woodland and savanna (with oaks sustained using fire), coldwater springs, fen, and a lakeshore that once supported wild rice.

offers many opportunities to restore ecocultural values using WEK to select assemblages, TEK to add culturally significant species, and citizen scientists to monitor and tend those resources. Then, ecocultural restoration educators could illustrate how native materials are used in multiple ways. Ideas abound in how best to engage people in Adaptive Management and citizen science (Milligan and Kraus–Polk, unpublished, see "Notes"). All of these aims are consistent with Delta Plan mandates, and all would foster a Sense of Place with a Native Californian perspective.

CONCLUSION

To fulfill the Delta Plan's (DSC 2013) intent to protect and enhance unique cultural values, restoration efforts must include not just legacies of colonists who settled 200 years ago, but legacies of First Nations who influenced the landscape over ~5,000 years. We recommend using both WEK and TEK to select and restore Native Californians' culturally significant plants. The two ways of knowing are complementary: WEK offers a quantitative foundation for restoring plant assemblages; TEK identifies culturally-important species, teaches their ecocultural uses by Native Californians in all aspects of life, and specifies how to *tend* them, especially using fire, as learned and passed on for generations. Two mandates of the Delta Plan are also fulfilled by WEK and TEK, namely, offering adaptive approaches and fostering a Sense of Place. Both can be accomplished within a network of ecocultural restoration sites in the Delta. In addition, TEK offers an ethic of reciprocity, which seems critical to sustain restored lands for future generations.

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REFERENCES

Alwash S. 2013. Eden Again: hope in the marshes of Iraq. [Fullerton (CA)]: Tablet House Publishing. p. 1-242.

Anderson MK. 1999. The fire, pruning, and coppice management of temperate ecosystems for basketry material by California Indian tribes. Human Ecol 27:79–113. *https://doi.org/10.1023/A:1018757317568*

Anderson MK. 2005. Tending the wild: Native American knowledge and the management of California's natural resources. [Berkeley (CA)]: University of California Press. p. 1-526.

Anderson MK, Rosenthal J. 2015. An ethnobiological approach to reconstructing indigenous fire regimes in the foothill chaparral of the western Sierra Nevada. J Ethnobiology 35(1):4-36. *https://doi.org/10.2993/0278-0771-35.1.4*

Berkes F, Colding J, Folke C. 2000. Rediscovery of traditional ecological knowledge as adaptive management. Ecol Appl 10:1251-1262. *https://doi.org/10.1890/1051-0761(2000)010[1251:ROTEKA]2.0.CO;2*

Brondizio ES, LeTourneau F-M. 2016. Environmental governance for all. Science 352(6291):1272-1273. *https://doi.org/10.1126/science.aaf1160*

Brown MI, Pearce T, Leon J, Sidle R, Wilson R. 2018. Using remote sensing and traditional ecological knowledge (TEK) to understand mangrove change on the Maroochy River, Queensland, Australia. Applied Geography 94(2018): 71–83. *https://doi.org/10.1016/j.apgeog.2018.03.006*

[DSC] Delta Stewardship Council. 2013. The Delta Plan: ensuring a reliable water supply for California, a healthy Delta ecosystem, and a place of enduring value. Sacramento, CA: Delta Stewardship Council.

Fawzi NA-M, Goodwin KP, Mahdi BA, Stevens ML. 2016. Effects of Mesopotamian Marsh (Iraq) desiccation on the cultural knowledge and livelihood of Marsh Arab women. Environ Health and Sustainability [Internet]. [cited 5 January 2018]; 2(3):e01207. *http://doi.org/10.1002/ehs2.1207.* Available from: *https://esajournals.onlinelibrary.wiley.com/loi/23328878/year/2016*

Folke C. 2004. Traditional knowledge in social-ecological systems. Ecol Soc [Internet]. [cited 4 April 2018]; 9(3):7. Available from: *http://www.ecologyandsociety.org/vol9/iss3/art7/*

Ford J, Martinez D. 2000. Traditional Ecological Knowledge, ecosystem science, and environmental management. Ecol Appl 10(5):1249-1250. *https://doi.org/10.1890/1051-0761(2000)010[1249:TEKESA]2.0.CO;2*

Garone P. 2015. Managing the garden: agriculture, reclamation, and restoration in the Sacramento-San Joaquin Delta. Delta Narratives Project, California Delta Protection Commission. Available from: *http://www.delta.ca.gov/res/docs/DelHAI/Full_Paper_Garone.pdf*

Green AJ, Paloma Alcorlo E, Peeters THM, Morris EP, Espinar JL, Bravo-Utrera MA, Bustamante J, Díaz-Delgado R, Koelmans AA, Mateo R, et al. 2017. Creating a safe operating space for wetlands in a changing climate. Front Ecol Environ 15(2): 99–107. *https://doi.org/10.1002/fee.1459*

Grossinger R, Striplen CJ, Askevold RA, Brewster E, Beller EE. 2007. Historical landscape ecology of an urbanized California valley: wetlands and woodlands in the Santa Clara Valley. Landscape Ecol 22:103-120. *https://doi.org/10.1007/s1080-007-9122-6*

Hammock BG, Hobbs JA, Slater SB, Shawn A, Teh SJ. 2015. Contaminant and food limitation stress in an endangered estuarine fish. Sci Total Environ 532:316-326.

Hankins DL. 2009. The effects of indigenous prescribed fire on herpetofauna and small mammals in two Central Valley California riparian ecosystems. California Geographer 49:31-50. *http://hdl.handle.net/10211.2/2789*

https://doi.org/10.15447/sfews.2018v16iss3art2

Hankins DL. 2013. The effects of indigenous prescribed fire on riparian vegetation in central California. Ecol Processes 2013:2-24. *http://doi.org/10.1186/2192-1709-2-24*

Hartel T, Réti KO, Craioveanu C, Gallé R, Popa R, Ioniţă A, Demeter L, Rákosy L, Czúcz B. 2016. Rural social–ecological systems navigating institutional transitions: case study from Transylvania (Romania). Ecosystem Health Sustain 2(2):e01206. Available from: *https://esajournals.onlinelibrary.wiley.com/loi/23328878/year/2016* *https://doi.org/10.1002/ehs2.1206*

Hickson D, Keeler-Wolf T. 2007. Vegetation and land use classification of the Sacramento-San Joaquin River Delta. Vegetation and land use classification and map of the Sacramento-San Joaquin River Delta. Calif Fish Game. [cited 3 February 2018]. Available from: *https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=18211*

Houde N. 2007. The six faces of traditional ecological knowledge: challenges and opportunities for Canadian co-management arrangements. Ecol Soc 12(2):34. Available from: *http://www.ecologyandsociety.org/vol12/iss2/art34/*

Huntington HP. 2000. Using traditional ecological knowledge in science: methods and applications. Ecol Appl 10:1270–1274. *https://doi.org/10.1890/10510761010 [1270:UTEKIS]2.0.CO;2*

Johnson JJ, editor. 1976, Archaeological investigations at the Blodgett Site (CA-SAC-267), Sloughhouse Locality, California. Report to U.S. National Park Service. Tucson, AZ: Western Regional Office. Access with permission at Sacramento, CA: North Central Information Center.

Kimmerer RW. 2011. Restoration and reciprocity: the contributions of Traditional Ecological Knowledge to the philosophy and practice of ecological restoration. In: Egan D, editor. Human dimensions of ecological restoration. [Washington (DC)]: Island Press. p. 257-276.

Kimmerer RW. 2013. Braiding sweetgrass. [Minneapolis (MN)]: Milkweed Editions. p. 1-390.

Laughlin DC. 2014. Applying trait-based models to achieve functional targets for theory-driven ecological restoration. Ecol Letters 17:771–784. *https://doi.org/10.1111/ele.12288*

Leopold A. 1934. What is the University of Wisconsin arboretum, wild life refuge, and forest experiment preserve? Appendix A In: Calicott B. 1999. The Arboretum and the University: the speech and the essay. Trans Wisc Acad Sci Arts Letters 87:5-21.

Loew P. 2014. Seventh generation earth ethics: native voices of Wisconsin. [Madison (WI)]: Wisconsin Historical Society Press. p. 1-230.

Luoma S. Dahm C, Healey M, Moore J. 2015. Challenges facing the Sacramento-San Joaquin Delta: complex, chaotic, or simply cantankerous? San Franc Estuary Watershed Sci 13(3). Available from: *https://doi.org/10,15447/sfews.2015v13iss3art7*

[MEA] Millennium Ecosystem Assessment. 2005. Ecosystems and human well-being: synthesis. [Washington (DC)]: Island Press. p. 1-137.

Mistry J, Berardi A. 2016. Bridging indigenous and scientific knowledge. Science 352(6291):1274-1275. *https://doi.org/10.1126/science.aaf1160*

Nolan J, Turner N. 2011. Ethnobotany: the study of people and plant relationships. In: Anderson EN, Pearsall D, Hunn E, Turner N., editors. Ethnobiology. [Hoboken (NJ)]: Wiley & Sons. p. 135-150. *https://doi.org/10.1002/9781118015872.ch9*

[NRC] National Research Council. 2001. Compensating for wetland losses under the Clean Water Act. [Washington (DC)]: National Academies Press. p. 1-306.

O'Connor R, Doyle K. 2017. Setting floristic quality assessment benchmarks for inland wetland plant community condition across Wisconsin: establishing a reference wetland network. Report to WDNR Bureau of Water Quality, U.S. Environmental Protection Agency Wetland Program Development Grant CD 00E78202. [Madison (WI)]: Wisconsin Department of Natural Resources, Bureau Natural Heritage Conservation. Available from: *Ryan.OConnor@Wisconsin.gov*.

Pecl G, Araújo MB, Bell JD, Blanchard J, Bonebrake TC, Chen I-C, Clark TD, Colwell RK, Danielsen F, Evengård B, et al. 2017. Biodiversity redistribution under climate change: impacts on ecosystems and human well-being. Science 355(6332):eaai9214. 9 p. *https://doi.org/10.1126/science.aai9214*

Pierotti R, Wildcat D. 2000. Traditional ecological knowledge: the third alternative (Commentary). Ecol Appl 10:1333–1340.

Salmón E. 2000. Kincentric ecology: indigenous perceptions of the human-nature relationship. Ecol Appl 10: 1327–1332. *https://doi.org/10.1890/1051-0761 010[1327:KEIPOT]2.0.CO;2*

Senos R, Lake FK, Turner N, Martinez D. 2006. Traditional Ecological Knowledge and restoration practice. In: Apostol D, Sinclair M, editors. Restoring the Pacific Northwest. Washington DC: Island Press. p. 393-426.

[SFEI] San Francisco Estuary Institute–Aquatic Science Center. 2016. A Delta renewed: a guide to science-based ecological restoration in the Sacramento-San Joaquin Delta. Prepared for the California Department of Fish and Wildlife and Ecosystem Restoration Program. A Report of SFEI-ASC's Resilient Landscapes Program, Publication #799. [Richmond (CA)]: San Franc Est Inst-Aquat Sci Center [cited 16 November 2016]. Available from: *http://192.168.1.1:8181/ http://www.sfei.org/sites/default/files/project/SFEI_DeltaRenewed_102616_lowres.pdf*

Stevens ML. 1999. The ethnoecology and autecology of white root (*Carex barbarae*): implications for restoration [dissertation]. [Davis (CA)]: University of California. p. 1-182.

Stevens ML. 2003. The contribution of Traditional Resource Management (TRM) of white root (*Carex barbarae* Dewey, *Cyperaceae*) by California Indians to riparian ecosystem structure and function. In: Faber PM, editor. California riparian systems: processes and floodplain management, ecology, and restoration. [Sacramento (CA)]: Proceedings 2001 Riparian Habitat and Floodplains Conference, Riparian Habitat Joint Venture. p. 502-511.

Stevens ML. 2004a. White root: *Carex barbarae*. Fremontia 32(4):3-6. *https://cnps.org/wp-content/uploads/2018/03/Fremontia_Vol32-No4.pdf*

Stevens ML. 2004b. Living in a tended landscape—"Restorying" nature and culture. Guest editorial. Fremontia 32(4):2. *https://cnps.org/wp-content/uploads/2018/03/Fremontia_Vol32-No4.pdf*

Stevens ML. 2004c. Ethnoecology of selected California wetland plants. Fremontia 32(4):7-15.

Stevens ML, Zaloza E. 2015. Fire, floodplains and fish: the historic ecology of the Lower Cosumnes River Watershed. In: Yu PL, editor. Rivers, fish and the people: tradition, science and historical ecology of river fisheries in the American West. [Salt Lake City (UT)]: University of Utah Press. p. 1-28.

Stuart DR. 2016a. The native peoples of San Joaquin County: Indian pioneers, immigrants, innovators, freedom fighters, and survivors, Part 1. The San Joaquin Historian. [Lodi (CA)]: Official J San Joaquin County Historical Soc. Micke Grove Regional Park. [cited 4 April 2018]. Available from: *http://192.168.1.1:8181/ http://www.sanjoaquinhistory.org/documents/HistorianSummer2016.pdf*

Stuart DR. 2016b. The native peoples of San Joaquin County: Indian pioneers, immigrants, innovators, freedom fighters, and survivors, Part 2. The San Joaquin Historian. [Lodi (CA)]: Official J San Joaquin County Historical Soc. Micke Grove Regional Park [cited 4 April 2018]. Available from: *http://sanjoaquinhistory.org/documents/HistorianWinter2016.pdf*

Turner NJ, Boelscher Ignace M, Ignace R. 2000. Traditional ecological knowledge and wisdom of aboriginal peoples in British Columbia. Ecol Appl 10(5): 1275-12887. *https://doi.org/10.1890/1051-0761(2000)010%5B0423:TVDOSO%5D2.0.CO;2*

West J, Welch P. 1996. Draft Interim CALFED Report. Cultural Resources of the Sacramento-San Joaquin Delta. [Sacramento (CA)]: U.S. Bureau Of Reclamation, Mid-Pacific Region. [cited 3 March 2018]. Available from *http://www.calwater.ca.gov/Admin_Record/C-102133.pdf*

Whipple AA, Grossinger RM, Rankin D, Stanford B, Askevold RA. 2012. Sacramento-San Joaquin Delta historical ecology investigation: exploring pattern and process. CA: Report to California Department of Fish and Game and Ecosystem Restoration Program. [Richmond (CA)]: San Franc Est Inst-Aquat Sci Center Historical Ecol Program. Publication #672.

Yoshiyama RM, Gerstung ER, Fisher FW, Moyle PB. 2001. Historical and present distribution of Chinook Salmon in the Central Valley Drainage of California. In: Brown RL, editor. Contributions to the biology of Central Valley Salmonids, vol. 1. p. 71-176. Available from *https://swfsc.noaa.gov/publications/FED/00743.pdf*

https://doi.org/10.15447/sfews.2018v16iss3art2

Zedler JB. 2017. What's new in the adaptive management and restoration of estuaries and coasts? Estuar Coasts 40:1-21. *https://doi 10.1007/s12237-016-0162-5*

Zedler JB, Kercher S. 2005. Wetland resources: status, ecosystem services, degradation, and restorability. Ann Rev Environ Resour 30:39-74. *https://doi.org/10.1146/annurev.energy.30.050504.144248*

NOTES

Lake F. April 2018. In-person communication between F. Lake and M. Stevens about TEK and the California Delta. Dr. Frank Kanawha Lake is a research ecologist for the U.S. Forest Service and a descendant of the Karuk Tribe (Western Klamath mountains). Dr. M. Stevens is a Nez Perce tribal descendent, Colville Confederated Tribes.

[DSC] Delta Stewardship Council. 2018. Draft conservation framework: In: Appendix A: Summary of existing recovery plans, conservation strategies, and management approaches. Forthcoming.

Milligan B, Kraus-Polk A. 2016. Human use of restored and naturalized Delta landscapes. [Davis (CA)]: UC Davis Center for Watershed Sciences. Available from: *https://watershed.ucdavis.edu/library/human-use-restored-and-naturalized-delta-landscapes*

Zedler JB, Doherty JM, UW-Madison Botany 670 Students. 2011. An adaptive approach to restoring culturally-important plants at Grand Portage National Monument. Great Lakes Northern Forest Cooperative Ecosystem Studies Unit Task Agreement J6150090004, National Park Service. Available from: *jbzedler@wisc.edu*