WETLANDS
Wetland Restoration and Maintenance

Ecosystem Service Benefits

- Freshwater (inland) wetlands provide numerous ecosystem services. The public may be willing to pay on the order of $32 million per year for the 6,000 acres of inland wetlands treated, restored, or conserved by CCI projects.
- One specific service associated with restored inland wetlands is increased water storage, with a potential value of approximately $190,000 per year.
- Coastal wetlands also provide numerous ecosystem services that people value. The economics literature suggests that proximity to restored coastal wetlands may increase property values on the order of $12 million when annualized.
- The wetland restoration and maintenance projects may also offer flood and storm protection benefits to nearby households. Finally, eight of the wetland restoration and maintenance projects may also benefit endangered species.

OVERVIEW OF PROJECTS

Project activities
Construct, enhance, restore, and monitor wetland, salt marsh, riparian, meadow, and/or dune habitat

Implementing agencies
Department of Fish and Wildlife, Wildlife Conservation Board, and State Coastal Conservancy

25 projects
funded across 21 counties (2015-2020)

2,000 acres
of coastal wetlands treated

6,000 acres
of inland wetlands and mountain meadows treated

Between 2015 and 2020, CCI invested in 25 wetland restoration and conservation projects: 22 through the Department of Fish and Wildlife, two through the Wildlife Conservation Board, and one through the State Coastal Conservancy (CARB 2021). The primary activities of these projects are constructing, enhancing, restoring, and monitoring of wetland, salt marsh, riparian, meadow, and/or dune habitat. Some projects replaced non-native species with native vegetation, made river channel and road drainage improvements, or employed "pond and plug" techniques (i.e., excavating the floodplain and plugging channels with excavated material to form ponds). During this six-year period, CCI treated, conserved, or restored 2,000 acres of coastal and delta wetlands as well as 6,000 acres of inland wetlands and mountain meadows across 21 counties throughout California (CARB 2021). The county with the most restored inland wetland acres is Plumas while Contra Costa, Solano, and Humboldt counties each have more than 600 acres of restored coastal wetland acres.

This analysis provides information on the types and the magnitude of societal benefits potentially associated with restoring and maintaining wetlands. Appendix page A-5 describes the pathways through which these projects generate environmental changes as well as ecosystem service benefits. These activities can improve water quality, increase water storage availability, provide flood attenuation and storm protection benefits, offer recreational opportunities, and improve habitat for vulnerable species (EPA 2022). To demonstrate how people value these services, the analysis includes information on three different quantitative measures: 1) public willingness to pay (WTP) for freshwater inland wetland restoration, 2) the property value effects of costal wetland restoration, and 3) public WTP for increased water storage.[54] We also qualitatively describe some of the other benefits associated with wetland restoration, including avoided water treatment costs (from improved water quality), avoided property damage (through flood attenuation and flow reliability), values associated with species habitat, and improved or increased recreation opportunities.

WTP for freshwater (inland) wetland restoration.
Numerous studies across the United States have demonstrated that the public is willing to pay for the restoration of freshwater wetlands. The public values freshwater wetlands because they improve water quality, provide additional water storage, protect wildlife, and generate recreational and educational opportunities among other benefits. To estimate how much households in California are willing to pay for the complete set of CCI-funded freshwater wetland restoration projects, this analysis relies on a meta-analysis of 11 freshwater wetland valuation studies conducted in the US. To inform regulatory analyses of federal programs that restore wetlands, Moeltner et al. (2019) developed a multiple linear meta-regression model that estimates public WTP for wetland preservation. We utilize this model at the county-level for areas of the state with inland wetland restoration projects.[55] Employing the model requires data on baseline wetland acres (pre-project conditions from United States Fish and Wildlife Service 2022), new or restored wetland acres (on account of project

[54] From an economic perspective, WTP is a conceptually appropriate measure of value of a resource or service. WTP is the maximum amount of money an individual would voluntarily exchange to obtain a resource or environmental improvement, given budget constraints. In other words, WTP indicates the point at which the individual would be equally satisfied with having the good itself or with having the money to spend on other things.

[55] This analysis assumes all projects were completed the year they started at the local (sub-state) level. It also assumes all wetlands are forested, and that all projects have effects on the provisioning, regulating, and cultural functions of the baseline wetlands. Since we do not have any information to support these assumptions, we acknowledge that this methodology introduces error into our analysis.

activities, using data from CARB 2021), average household income, geographic region, and several other categorical variables as inputs to predict household WTP (U.S. Census Bureau 2021).

Across the 14 counties with inland wetland restoration projects, 6,000 new acres were added to the 760,000 baseline acres in those counties. The increase in functioning wetland area ranged from approximately 0.1 percent to 7.9 percent across counties. Our analysis finds that household WTP estimates ranged from $13.66 per household per year (Mariposa County) to $14.88 per household per year (Lassen County). Combined with the number of households in these counties, San Diego County had the highest potential WTP, with over 1.1 million households that may be willing to pay an estimated $16 million for wetland restoration projects in their county (U.S. Census Bureau 2021). In total, this analysis estimates that the public may be willing to pay **$32 million per year** for the 6,000 inland wetland acres restored.

Property value improvements associated with coastal wetland restoration. The link between proximity to wetlands and higher property values is well-documented, as wetlands can improve water quality and provide recreational opportunities (Boyer and Polasky 2004). These benefits are expected particularly for properties near coastal wetlands, which can support diverse fish and wildlife and provide shoreline anchoring, flood control, groundwater recharge, and aesthetic appeal. Mahan et al. (2000) find an approximately 0.02 percent increase in property values in Portland, Oregon per each acre increase in urban wetlands—including open-water coastal wetlands—an average of 2/3 of a mile away from each property. We apply this potential property value increase to properties in the same census tract as the CCI coastal wetlands projects.

To evaluate the impacts of added coastal wetlands from the projects, we first count the number of land parcels in each census tract containing a coastal wetlands project (nearly 11,000) and identify the median property value in the corresponding counties (County of Los Angeles 2022; U.S. Census Bureau 2021).[56] Combined with the results of Mahan et al., we estimate that the total present value increase in property values could be over $390 million, equivalent to **$12 million on an annualized basis** (assuming a 3 percent discount rate). The greatest share of this potential increase in property values occurs in Solano, Contra Costa, and Humboldt counties, accounting for 95 percent of the total potential increase, because of the large number of coastal wetland acres added to census tracts within these counties. The total potential benefit is spread across 2,000 acres of added coastal wetlands, amounting to a benefit of approximately **$5,700 per acre of coastal wetland**.

[56] Three counties containing coastal wetlands projects—Monterey, Contra Costa, and Humboldt—had two projects in the same Census tracts. To provide conservative estimates of property value increases, we do not double-count these land parcels.

WTP for increased water storage in inland wetlands.
To illustrate the potential magnitude of benefits, this analysis identifies the added acreage of inland wetlands from the CCI projects and values the potential avoided loss in water storage capacity. One acre of wetland one foot deep can store 330,000 gallons of water (Miller n.d.), and degraded meadows (freshwater wetlands) are able to store 30 percent less water than a fully functioning wetland (NFWF 2010). CCI projects restored nearly 6,000 acres of inland wetland across 14 counties, with the largest expansion of wetland acreage in Plumas and Sacramento counties. To apply the water storage capacity value to these wetlands, we assume that the project wetlands are one foot deep and find that the restored wetlands may be responsible for an additional **1,800 acre-feet** of water in their restored state, equivalent to approximately 590 million gallons.

There are various ways that these additional gallons of water can be valued. One way involves applying available data on the shadow prices of water – developed by researchers at UC Davis using a model known as the California Value Integrated Model (CALVIN) – to physical quantities of water saved in various use categories.[57] Shadow prices are WTP measures that generally reflect the economic value for a good or service whose value is difficult to calculate and not reflected in the market. Research utilizing the CALVIN model identifies that the average WTP to avoid a 5 percent water shortage for agricultural purposes ranges across regions in the state, varying from $79 per acre foot in the San Francisco Bay Area to $272 per acre foot in the South Coast (De Souza et al. 2011). The potential benefit from increased water storage in inland wetlands is valued at **$190,000 annually**, with an average benefit of **$30 per acre** of wetland.

Water also has a value if left in the ground for use by future generations. Fossil groundwater is a type of groundwater located deep beneath the surface that is considered a non-renewable resource because it takes thousands of years for the groundwater in these 'ancient aquifers' to recharge. The Lawrence Livermore National Laboratory recently released a study that examined 2,330 drinking wells and found evidence of fossil groundwater in 22 percent of wells (de Jong et al. 2020). To the extent that CCI projects are generating water savings in areas that overlap fossil groundwater resources, the benefits of the water savings associated with such projects may be better reflected by a bequest or option value because it reduces the pressure on these non-renewable groundwater resources.[58]

Avoided water treatment costs through reduced sedimentation.
Inland wetlands can improve water quality by sequestering nutrients and removing toxins from groundwater. This is because native and well-functioning inland wetlands have long and sense root and rhizome networks that limit erosion (NFWF 2010). For instance, one project in the Plumas National Forest in California demonstrated a 17.5 percent reduction in annual sediment production following a meadow restoration project (as cited in Conway 2012). While likely that CCI inland wetland restoration projects improve downstream drinking water quality, data are not available to quantify those ecological changes. One benefit of improved water quality is a reduction in the costs associated with water treatment before consumption. For context, recently the California Water Board

[57] The CALVIN model is an economic-engineering optimization model for California specifically. Details about the model are available here: https://calvin.ucdavis.edu/.

[58] Bequest value is the value people place on maintaining or conserving a resource for future generations. Option value is the WTP for a resource even though there is little or no likelihood the individual will use it.

indicated that annual sediment removal costs were $0.452 per cubic yard (about $730 per acre-foot) (California Water Board 2020-21).

Positive preference for increase in species abundance.
Wetlands can support diverse fish, plants, and other wildlife through enhanced wildlife habitat. Some of the CCI wetland projects document benefits to species living at or near the project sites, including aquatic and non-aquatic species. Through project monitoring activities, implementers describe at least 39 species benefiting from the projects. Wetlands can also help preserve habitat for endangered and threatened species; 3 threatened species and 6 endangered species may benefit from coastal wetland projects, while 2 endangered species may benefit from inland wetland projects. Examples of endangered species found in project sites include the Tidewater goby, Northern California steelhead, salt marsh harvest mouse, and mountain yellow-legged frog (CARB 2021). The economics literature demonstrates that the public exhibits a positive preference for increases in species abundance, especially for endangered and threatened species, although data from these projects are insufficient to quantify and monetize benefits.

Avoided property damage through flood attenuation and flow reliability.
Restoration of wetlands can reduce and delay peak flows on streams, resulting in a reduction in downstream flooding (NFWF 2010). Modeling efforts of similar inland systems in California demonstrate that flood peak may be reduced by 10 to 20 percent in a wet year and the baseflow may be increased by 10 to 20 percent during the following dry season (Ohara et al. 2013). On the other hand, restoration of coastal wetlands has the potential to reduce flooding and create storm protection (Ballard et al. 2017). Therefore, CCI wetland restoration projects have the potential to reduce flood- and/or storm-related property damage. The costs associated with flooding are highly context and location specific and cannot be evaluated for these project sites at a programmatic level.

Improved or increased recreation.
Wetlands provide and support opportunities for outdoor recreation (particularly downstream water-based recreation), hunting, nature observation, and ecotourism (Ballard et al. 2017). Some of the coastal wetlands projects funded by CCI may further enable these opportunities by

improving access to recreation sites, for example by adding interpretive signs and clear trail paths and offering educational opportunities (CARB 2021). The inland projects also provide opportunities for wildlife viewing and may support increased recreational opportunities. Additional or improved recreation and tourism provides value to people.

Table 7: Summary of Monetized Ecosystem Service Benefits for the Wetlands Projects by County (2021 dollars)

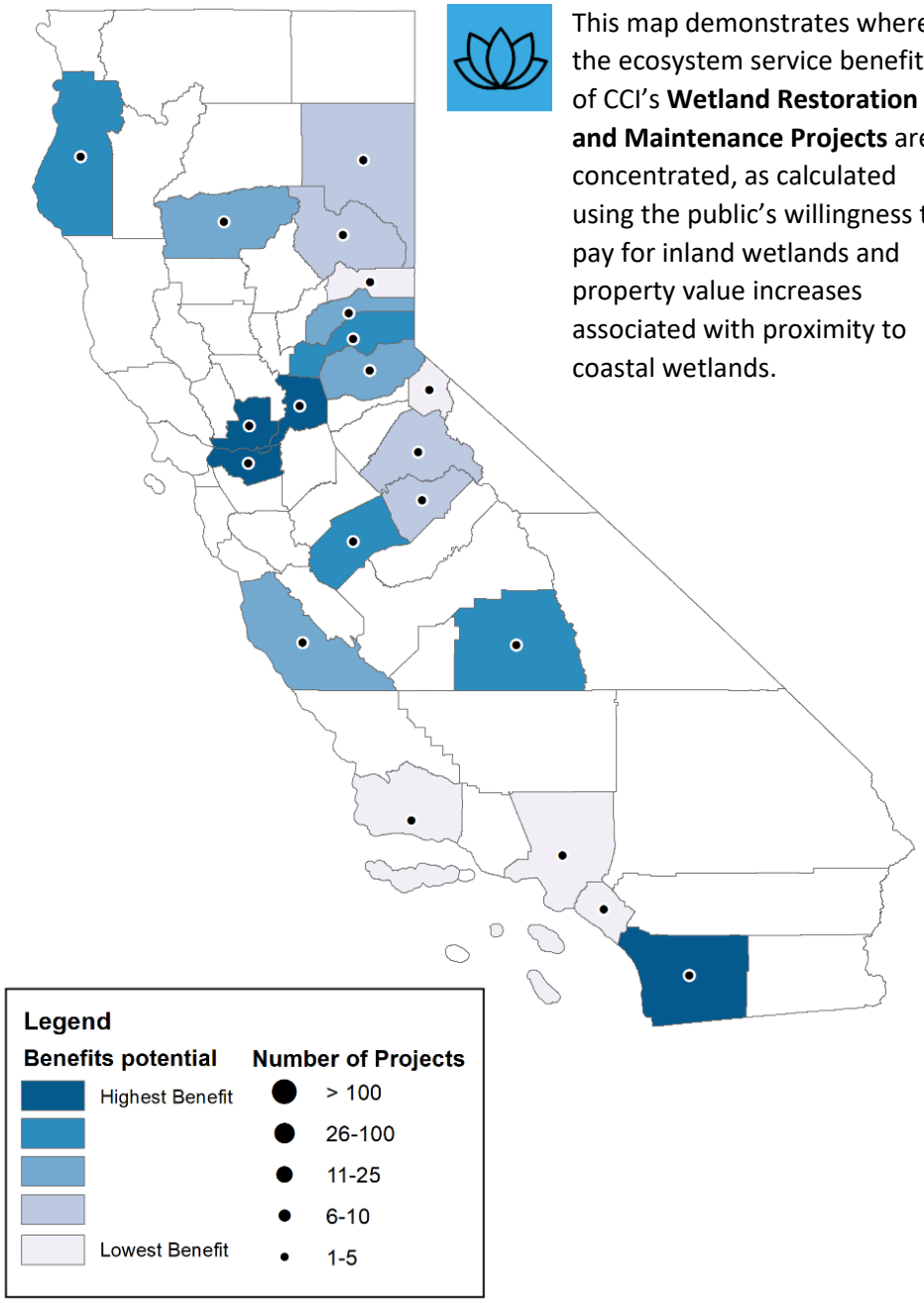
County	Total Inland Wetland Acres Treated[a]	Total Coastal Wetland Acres Treated[a]	WTP for Inland Wetland Acres (Annual)[b]	Increased Property Values Near Coastal Wetlands (Annualized)[b]	WTP for Water Storage at Inland Wetlands (Annual)[b]
Alpine	120	--	$5,700	--	$5,500
Contra Costa	--	600	--	$3,500,000	--
El Dorado	250	--	$1,000,000	--	$7,600
Humboldt	--	630	--	$3,200,000	--
Lassen	250	--	$140,000	--	$7,700
Los Angeles	--	3		$28,000	--
Mariposa	39	--	$110,000	--	$1,800
Merced	10	--	$1,200,000	--	$450
Monterey	--	100	--	$520,000	--
Nevada	490	--	$570,000	--	$15,000
Orange	--	10	--	$3,400	--
Placer	39	--	$2,100,000	--	$1,200
Plumas	2,700	--	$120,000	--	$81,000
Sacramento	1,700	--	$7,700,000	--	$52,000
San Diego	38	--	$16,000,000	--	$3,100
Santa Barbara	--	54	--	$95,000	--
Sierra	170	--	$17,000	--	$5,000
Solano	--	650	--	$4,500,000	--
Tehama	80	--	$350,000	--	$2,400
Tulare	90	--	$1,900,000	--	$4,000
Tuolumne	9	--	$320,000	--	$400
Statewide Total	**6,000**	**2,000**	**$32,000,000**	**$12,000,000**	**$190,000**

Sources and notes:

a. Data observed in CARB (2021) for projects implemented from 2015 to 2020.

b. Author calculations described in this report. The monetary values presented in this table are not necessarily additive to a single, total benefits value as they reflect alternative valuation methods and measures (e.g., market values, social welfare values) and may double-count the same benefit stream.

Figure 8: Spatial Distribution of Ecosystem Service Benefits Potential for the Wetlands Projects



Note: The benefit potential conveyed in this map considers the public's WTP for the services provided by inland wetlands and property value premiums associated with residing near coastal wetlands presented in Table 7.

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