SOCIO-ECONOMIC IMPACTS OF THE SOUTHERN FLOW CORRIDOR RESTORATION PROJECT

Tillamook Bay, Oregon

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EXECUTIVE SUMMARY

Completed in 2017, the Southern Flow Corridor (SFC) site is a 443-acre tidal wetland habitat restoration project located just north of Tillamook, Oregon. With a budget of $11,172,955 from a variety of state offices, federal agencies, NGOs, and private funding sources, the SFC project was designed to create salmon habitat and decrease flooding. Yet, many of the potential economic benefits provided by ecosystem services at the restored site were not monitored or valued. The National Oceanic and Atmospheric Administration (NOAA) and the Tillamook Estuary Partnership (TEP) commissioned this review of data gaps to better understand the potential contribution of the SFC restoration to economic benefits to the local community. This review is the product of an extensive literature review and a collection and assessment of the data available about the socioeconomic impacts of the restoration for service flows related to *water quality*, *flood mitigation*, *salmon habitat creation*, *carbon storage*, and *benefits to the community*. It also reports results from a new *housing market analysis* to determine if and how the restoration affected local housing values and an IMPLAN *economic impact analysis* of project spending conducted by NOAA. Here is a summary of findings.

Water Quality: The SFC restoration site is likely trapping sediment flowing into it from the Wilson and Trask Rivers, decreasing the amount of sediment settling in Tillamook Bay. This may decrease the frequency and/or amount of dredging needed to maintain shipping lanes, saving approximately $1,500 to $8,000 per year. Continued monitoring is recommended to quantify and value potential additional ecosystem service benefits associated with improvements in water temperature and dissolved oxygen levels. New research on abated nutrient loads is suggested as restored wetlands hold large potential to reduce agricultural runoff.

Flood Mitigation: Under a set of assumptions, it is estimated that reductions in flooding on Highway 101 may produce benefits associated with avoided travel costs of approximately $7,200 per flood event. No conclusion could be drawn from a comparison of flood insurance claims comparing moderate flood events before and after site restoration. Post-project modeling exercises suggest the restoration may reduce flooding significantly in the adjacent communities. There were large annual benefits from restoration found in the housing market analysis (see below) that likely can be attributed to reducing flood risk. Future studies are recommended to (i) quantify the flood reduction benefits as more events occur post-restoration and (ii) to investigate the potential benefits of the SFC site in mitigating the impacts of local sea level rise.

Salmon Habitat: Restoration of tidal wetland habitat led to an observed increase in the number of sub-yearling Chinook salmon and staghorn sculpin using the SFC site. Millions of dollars in economic benefits through use (recreational fishing) and non-use (existence value) values may be possible if the site contributes to increasing the abundance of returning adult salmon populations in Tillamook Bay. Further monitoring and research are needed to evaluate potential changes in both sub-yearling and returning adult populations of Chinook, coho and other species as the SFC site matures to realize and estimate these benefits of habitat restoration.

Carbon Storage: Estimates suggest the SFC site may store up to 27,000 tons of carbon through organic material accretion and burial. Using simplifying assumptions and current social cost of carbon estimates, the net present value of carbon storage is estimated to range from $530,000 to $736,000. The site has potential to emit greenhouse gases as the wetlands mature, so continued monitoring efforts are needed to track the net carbon fluxes at the restoration site in the future.

Benefits to the Community: Although no primary data were collected on recreation or other social and cultural benefits provided by the SFC restoration, this report provides examples of economic values for benefit flows that recreational fishing, hiking, or kayaking at the site may generate. Surveys soliciting information about site usage will be necessary to quantify the economic benefits of the site to the local community, indigenous peoples, and the state of Oregon.

Housing Market Analysis: A difference-in-differences hedonic pricing model suggests that housing prices in residential areas near the SFC restoration increased by 10 percent after completion of the project relative to homes further from the project. This represents an average benefit of $19,000 per home within ¾ of a mile of the site. Aggregated by the number of residential homes near the site, the total range of benefits resulting from the SFC restoration estimated from the econometric model is between $5.2 to $32.9 million, suggesting the housing market benefits alone may be greater than project costs ($11.2 million).

Economic Impact Analysis: During the four years of the SFC restoration (2013-16), an IMPLAN analysis conducted by NOAA estimates that the project supported 108 jobs and $14.6 million in total economic output in the state of Oregon.

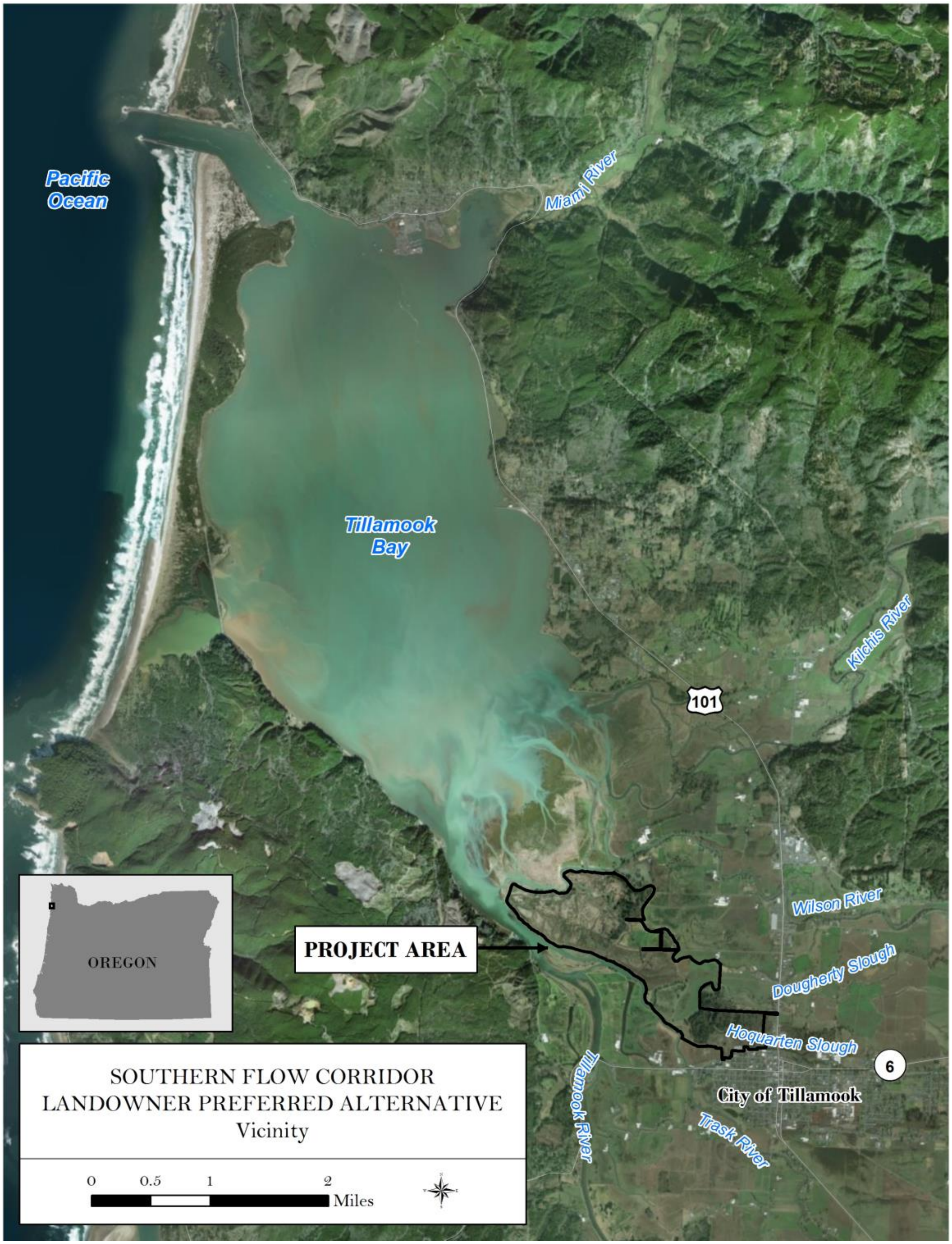
PROJECT BACKGROUND

Along the West Coast of the United States (US), approximately 85 percent of tidal wetlands have disappeared since European settlers arrived (Brophy *et al.,* 2019a). In Tillamook Bay, Oregon, construction of dikes and channels led to significant local declines in wetlands (Brophy, 2019). The loss of this habitat type has generated negative long-term effects on both developed areas nearby (e.g., flooding) and overall ecosystem function of estuaries (e.g., dwindling vital habitats for native fish and wildlife).

The Southern Flow Corridor (SFC) restoration site is an Oregon Solutions project designated by the Governor in 2007 with the goal of creating tidal wetland habitat and reducing flooding along the Tillamook Bay estuary (Tillamook County, 2017; Allen *et al.,* 2018). The project is located at the confluence of the Wilson and Trask Rivers near the city of Tillamook (Figure 1). Tillamook is located 74 miles west of Portland along the southeastern shore of Tillamook Bay. Highway 101 runs through the city north to south connecting the town to its two neighbors Bay City to the north and Pleasant Valley to the south. The city has a population of 5,231 (2019), and median per capita income of $25,259 (2021$; Census Bureau, 2020). The primary drivers of the local economy are agriculture, fishing, forestry, and manufacturing of dairy products, mostly by the famed Tillamook Creamery (Oregon Coast Visitors Association, 2020; Tillamook City Council, 2012). The Tillamook people, from which the county and town get their name, inhabited the area prior to the arrival of European settlers in 1851, with the city being founded in 1891.

The genesis of the SFC restoration project resulted from a 2006 storm event that caused flooding, erosion, and landslides around the town of Tillamook resulting in millions of dollars in damages. In the summer of 2007, a formal Declaration of Cooperation was signed by 24 local, state, and federal agencies, public organizations, members of legislative and executive government, and local farmer associations to address this flood risk (Tillamook County, 2017). A 15-member Design Team was created to start site planning and Northwest Hydraulic Consultants (NHC) from Seattle was contracted to create the technical designs and model the restoration's impact on local hydrology (Tillamook County, 2017). The final plan, *The Southern Flow Corridor Project-Land Owner Preferred Alternative*, was finalized in 2013, engineering plans by NHC were completed in 2015, and all necessary permits were issued by April 2016. A pre-project baseline site condition study was conducted from 2013 – 2015 to determine environmental conditions on the site before restoration (Brown *et al.,* 2016; Allen *et al.,* 2018).

Figure 1: Southern Flow Corridor Project Vicinity



Note: Figure from Allen *et al*., (2018) Construction activities started in May 2016 and concluded in December 2017 (Tillamook County, 2017). A post construction project effectiveness study of the site was conducted by the monitoring team to determine if the restoration had achieved project goals (Brown *et al.,* 2016; Brophy *et al.,* 2019b). Table 1 lays out the project timeline for the major stages of the SFC project.

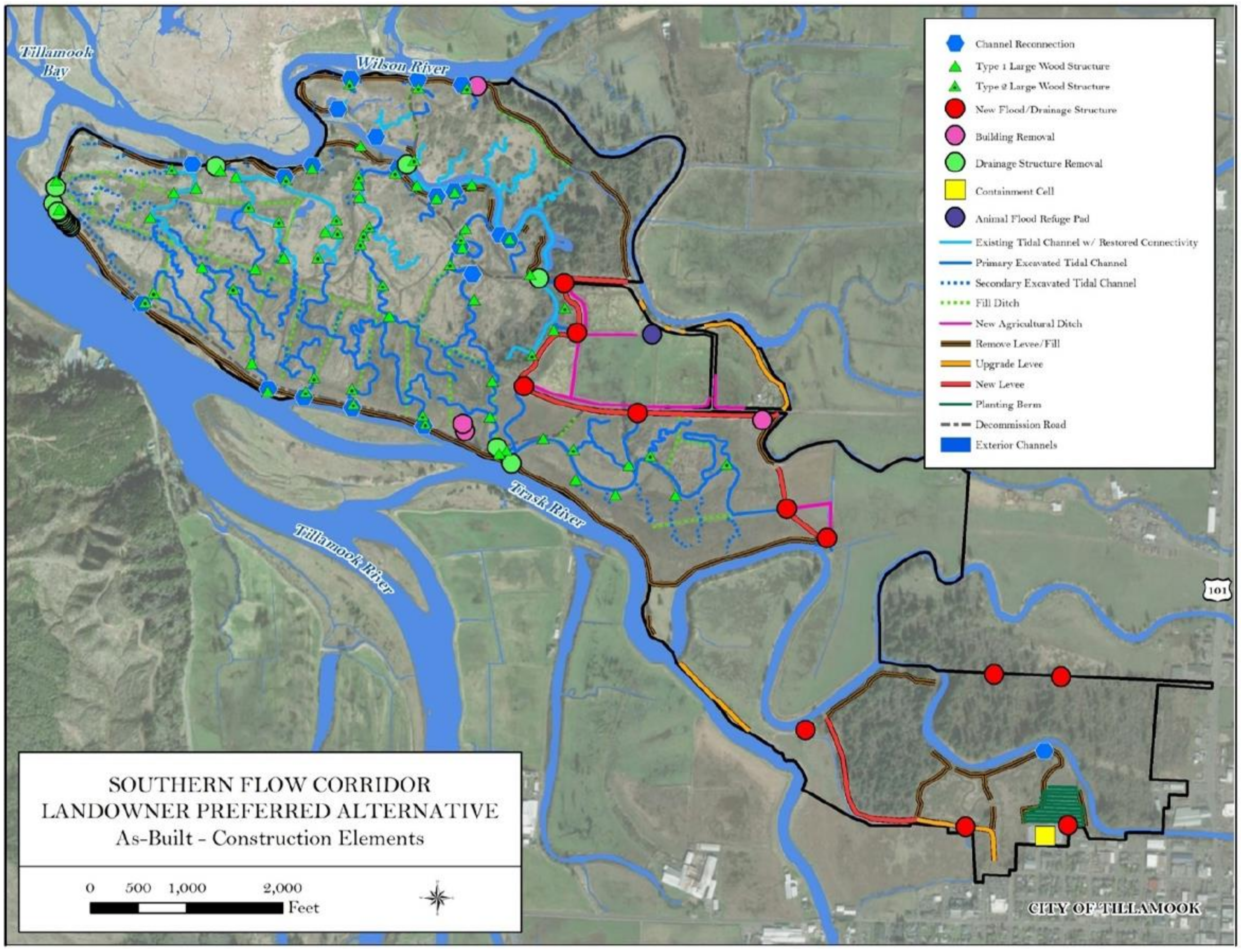
Table 1: Southern Flow Corridor Project Overview

Action	Timeframe
Land and Easement Acquisition	Sept. 2013—April 2016
Baseline Monitoring	Oct. 2013—May 2015
Design and permitting	Feb. 2014—April 2016
Construction	May 2016—Dec. 2017
Re-Planting	March 2018—May 2018

Source: Adapted from 2018 Management Plan (Allen *et al*., 2018; Table 13)

The SFC project area is 690 acres, 10 percent of the watershed's pre-diking tidal wetland area (Allen *et al.*, 2018). The project area pre-restoration consisted of 390 acres of county owned land and 8.7 acres of city land (Allen *et al.,* 2018). An additional 149 acres of farmland was purchased from private landowners in combination with 140 acres of farmland that were obtained through easements (Allen *et al.,* 2018). 3.9 miles of roads were removed, along with one (1) dilapidated house and three (3) barns. It combines several overlapping habitat conservation and restoration projects, including the restoration of 443 acres of tidal wetlands, the focus of this report (Tillamook County, 2017). These areas were restored from pasture and farmlands primarily through the removal or lowering of 5.2 miles of levees and the excavation of 200,000 cubic yards of soil from the site. Additionally, 15 tide gates were removed and replaced with a set of eight (8) tide gates and six (6) flood gates set further back from the sea (Allen *et al.,* 2018). Together, lowering the levees and moving back the tide gates opened the site to tidal forces (Allen *et al.,* 2018). To create the 13.2 miles of restored channels, 4.5 miles of agricultural ditches were filled, 18 tidal channels were reconnected to the main river, and an additional 18 main tidal channels were created throughout the project site. To promote the development of healthy tidal wetland habitat for fish and wildlife, 70 large woody debris structures were constructed, and 1,054 native plants were planted. Figure 2 provides a map of the site with the locations of restoration activities.

Figure 2: Southern Flow Corridor Landowner Preferred Alternative Restoration Actions



Note: Figure from Allen *et al*., (2018)

ECOSYSTEM SERVICE FLOWS FROM TIDAL WETLANDS RESTORATION

The SFC restoration effort was designed to promote improved ecosystem service flows to the local community. An ecosystem service flow is “the benefit people obtain from nature through use, consumption, enjoyment, and/or simply knowing [the] resource exists” (NOAA, 2014). For coastal ecosystems like tidal wetlands, these service flows can include protecting against storms and flooding, supporting fish and wildlife populations, providing scenic views, cleaning water, and providing a buffer against sea level rise (Barbier *et al.,* 2011). Many services provided by restored habitats have the potential to save local communities money by offsetting the cost of providing the service through other means (e.g., water filtration by wetlands instead of building a treatment plant). In consultation with the Tillamook Estuary Partnership (TEP), the NOAA Restoration Center and a variety of stakeholders, a set of important ecosystem services were determined to be the focus of this analysis: 1) water quality, 2) flood mitigation, 3) salmon habitat, 4) carbon storage, and 5) community benefits related to recreation services. The objective of this report is to increase understanding of these ecosystem service flows provided by restored wetland habitats in the Tillamook Bay and to assess how those services may provide economic value to the local community. First, existing data were collected and synthesized on ecosystem service flows impacted by restoration on the SFC site and economic valuation information that may be relevant to this effort. This report then focuses on potential avenues for a socio-economic analysis of the project, along with data limitations associated with quantifying the economic impact of ecosystem services likely improved by the restoration effort.

To improve coastal resilience for communities in the US, the importance and value of ecosystem services from tidal wetlands should be recognized in policy and restoration decisions. Coastal ecosystem restoration was recently touted as a pillar of a plan adding marine and coastal solutions to any Green New Deal legislation in the U.S. (Dundas *et al.*, 2020). A key to making this a reality is to develop solid evidence linking restoration decisions to impacts on ecosystem service flows (quantities) and the relevant values of those impacts on society (prices) (Guerry *et al.,* 2015). To operationalize this concept, it is vital to track changes in the provision of ecosystem services both before and after restoration activities. The before-after data comparison can be used to demonstrate that site conditions changed in the desired way, suggesting that the new ecosystem improvements are indeed providing flows of additional services to society. The second necessary component is to determine an appropriate economic valuation (i.e., price) of those measurable services. Considering the nonmarket nature of most ecosystem service flows provided by tidal wetlands, primary, or original, valuation efforts focusing on a specific site and targeting the relevant population is preferred, but often unavailable. Benefit transfer offers a potential alternative to use estimated values from other areas or time periods and apply them to the site of interest (Adamowicz *et al.,* 2016). These transfers can help policy analysis if done carefully (i.e., both the service valued and population affected are identical) but offer a "lower level of validity and reliability" compared to original valuation work (Richardson *et al.,* 2015, p. 52). A careful assessment of the economic benefits of a restoration project requires both accurately measured changes in the quantity of services provided and prices that reflect the willingness to pay for those services of the relevant parts of society impacted by the project.

There is a growing body of evidence that tidal wetlands provide large economic benefits to local communities through the provision of ecosystem services. A global meta-analysis suggests a median value of ecosystem services from a hectare of tidal wetlands each year (ha/yr) is $150 US$, with a mean value of $2800 US$ ha/yr (Brander *et al.,* 2006). The large difference between median and mean suggests that these values vary by continent, wetland type, wetland service, and valuation method used. Another meta-analysis suggests “human-made” or restored wetlands have the highest economic value relative to other wetland types (Ghermandi *et al.,* 2010). New evidence suggests constructed or restored wetlands near rivers offer the most cost-effective solution to reduce sediment and nutrient loads in watersheds (Hansen *et al.,* 2021).

Focusing on the service flows important in Tillamook Bay, Oregon, a review of the economic literature also supports potential benefits. Tidal wetlands have proven effective at improving water quality, especially in areas with non-point source pollution from agriculture (e.g., Kovacic *et al.,* 2000; Hansen *et al.,* 2021) similar to the Tillamook Bay area. A meta-analysis of the willingness to pay for water quality improvements from 30 wetlands throughout the US and Europe suggests that people were willing to pay around $79 per year ($163 in 2021 US$) for general improvements in water quality provided by wetlands (Brouwer *et al.,* 1999). Coastal wetlands along the Atlantic and Gulf coasts of the US were recently estimated to provide approximately 1.8 million US$/km^2 per year in protective benefits to coastal properties, although the authors note that these values vary widely across counties and are highly dependent on local conditions (Sun and Carson 2020). Salt marsh ecosystems have also been shown to accrete sediment to provide protection against sea-level rise (Morris *et al.*, 2002) and restored wetlands can mitigate sea-level rise vulnerability if the system contains abundant sediment (Liu *et al.,* 2021). Studies of the economic protective effects of coastal ecosystems are increasing, but prior to Sun and Carson (2020), have been limited to specific disasters (e.g., cyclone in India; Das & Vincent 2009) or regions (e.g., Louisiana, Barbier *et al.*, 2013; New Jersey, Dundas, 2017). To our knowledge, the economic value of storm and flood protection has not been estimated along the US West Coast or for Oregon coastal wetlands.

Tidal wetland restoration is likely to improve habitat for salmon (Beck *et al.,* 2001), especially in Oregon (Gray *et al.*, 2002). Such investments in habitat for Oregon Coast coho salmon (*Oncorhynchus kisutch*) were recently estimated to provide up to $518 million a year in total economic value for an additional return of 100,000 spawners in the Pacific Northwest region (Lewis *et al*., 2019). Increasing salmon runs also may have a large benefit to recreational anglers, and past work has suggested residents near Tillamook Bay are likely willing to pay for habitat improvements that increase allowable catch rates for coho salmon (Bell *et al*., 2003). Tidal wetlands also store billions of tons of carbon globally (Howard *et al*., 2017) and have potential to store more carbon per unit area than terrestrial counterparts (Taillardat *et al*., 2018). Recreation in wetlands is also a valuable economic activity (Bergstrom *et al*., 1990). Recreational fishing, hiking, birdwatching, and kayaking represent some of the many recreation opportunities at a publicly accessible tidal wetland like the SFC restoration site.

According to the 2018 SFC Management Plan (Allen *et al*., 2018), the four primary goals of the SFC project reflect concerns about flood reduction and ecosystem health: 1) improving habitat for native fish and wildlife species, 2) improving water quality through sedimentation; 3) reducing flood hazards, and 4) enhancing the overall health of Tillamook Bay. The first goal translates into project objectives to create new habitat for juvenile salmonids and other native fish and improve conditions for other wildlife species in the estuary. Many threatened and endangered salmon species, such as Chinook and coho, utilize tidal wetlands when they are young (Baldwin *et al*., 2012). Other notable fish species that may benefit from the project are winter steelhead and Pacific lamprey, both of which are registered as State Sensitive and Oregon Conservation Strategy Key Species (Allen *et al*., 2018). Tidal marsh habitat can be used by a range of other animals, such as California brown pelican, American peregrine falcon, olive-sided flycatcher, American bald eagle, band-tailed pigeon, and Townsend's big-eared bat (Allen *et al*., 2018; Baldwin *et al*., 2012). The second goal focuses on improving water quality in the estuary. These improvements can be achieved if restored tidal wetlands are successful at reducing suspended sediment loads, decreasing summer water temperatures, and improving dissolved oxygen (DO) levels. The third goal of the project addresses chronic flooding of nearby communities and Highway 101 (HW101). A primary focus is reducing the frequency and magnitude of floods impacting Tillamook's business corridor along HW101 and surrounding residential communities. Flood risk reduction may also lead to less damages to residential and commercial buildings and agricultural operations. Post-project consulting reports suggest that the SFC project has been successful at creating tidal wetland habitat and decreasing flood magnitude in approximately 4,800 acres of the surrounding area (Janousek *et al*., 2021; Collins, 2019; Allen *et al*., 2018). Lastly, the fourth goal of a healthier Tillamook Bay ties directly to the success of goals (1) and (2). Improved water quality and habitat in Tillamook Bay could lead to increased benefits from recreational activities, such as boating, wildlife viewing, and fishing.

SOCIO-ECONOMIC IMPACTS OF SOUTHERN FLOW CORRIDOR RESTORATION

A comprehensive look at the available literature suggests there are potentially large economic benefits associated with restoring tidal wetland habitat. Yet, the economic value of those benefits measured to date varies significantly across wetland type and location depending highly on local conditions (e.g., Sun and Carson, 2020). Unfortunately, there are very limited primary studies on the value of ecosystem services provided by tidal wetlands in Oregon and the high variability in existing estimates makes benefits transfer difficult to justify unless the service and local communities are nearly identical (Richardson *et al*., 2015). This section presents results from a NOAA economic impact analysis related to site restoration investments, synthesizes the available data on both ecosystem service flows and economic values at the SFC site, highlights the data gaps to assessing the local economic benefits of restoration, presents results from a new economic analysis of the housing market impacts of site restoration, and provides recommendations for planning of future habitat restoration efforts where multiple benefit flows are targeted.

NOAA Economic Impact Analysis

Nearly $11.2 million dollars were invested in the SFC restoration, with funding provided by a variety of governmental organizations (Allen *et al.*, 2018; Table 2). Construction costs represented 67 percent of the total budget, with land purchases and easement acquisition (19 percent), designs and permitting cost (9 percent), project management (3 percent), and baseline monitoring (2 percent) representing the remaining 33 percent.

Table 2: Southern Flow Corridor Project Funding

Funder	Total Funds [US$]	Source
FEMA	3,225,000	Federal
NOAA	2,700,000	Federal
OWEB	1,522,144	State
Oregon State Lottery Bonds	1,075,000	State
USFWS	816,019	Federal
Oregon Business Development Department	722,558	Federal/State
Regional Solutions	499,972	State
Other In-Kind and Cash	368,261	Local/Private
National Fish and Wildlife Foundation	244,001	Federal
Total:	11,172,955	

Source: Adapted from SFC 2018 Management Plan (Allen *et al.*, 2018 Table 14)

NOAA conducted an economic impact analysis to estimate the state and national economic activity generated by the restoration investment. The full report is provided in the Appendix and is summarized here. The analysis was conducted using IMPLAN, an input-output model that can estimate the direct, indirect, and induced effects of new spending in given industries. The sum of these effects approximates a total economic impact, given a set of specific assumptions. The direct effects associated with SFC restoration were dollars spent to plan, manage, design, and construct the project. The indirect effects were measured as the impact on material suppliers or other services that supported the project's construction, such as companies that supplied the gravel and sand for the restoration work. Lastly, induced effects were estimated as impacts to local businesses and industries providing goods and services to employees of firms that directly or indirectly benefited from SFC spending (e.g., restaurants, hotels). It is important to note that this analysis only considers the economic impacts of spending on restoration, not the impacts of the completed project.

Using these expenditures as inputs, IMPLAN estimated the project's economic output as industrial revenue created and jobs supported. The results suggest each $1 spent on SFC restoration in Oregon (direct effects) produced $1.70 in indirect and induced economic benefits for the state. Over the four years of restoration planning and construction, model results suggest the project supported 108 jobs and $14.6 million in industrial revenue for the state. This translates to approximately 27 jobs and $3.7 million in revenue each year. Overall, these results suggest that the restoration investment was successful at creating jobs and economic output during the planning and construction phase of the project.

Table 3: IMPLAN Estimates for Employment and Output Effects in Oregon

Impact Type	Employment (job-years)	Output (2015 USD)
Direct Effect	61.2	$8,061,526
Indirect Effect	17.6	$2,623,325
Induced Effect	29.4	$3,962,507
Total Effect	108.2	$14,647,358
Per year (4 years)	27.1	$3,661,840

Source: Economic Impacts of the Southern Flow Corridor Habitat Restoration Project by Travis Grout (*Appendix*)

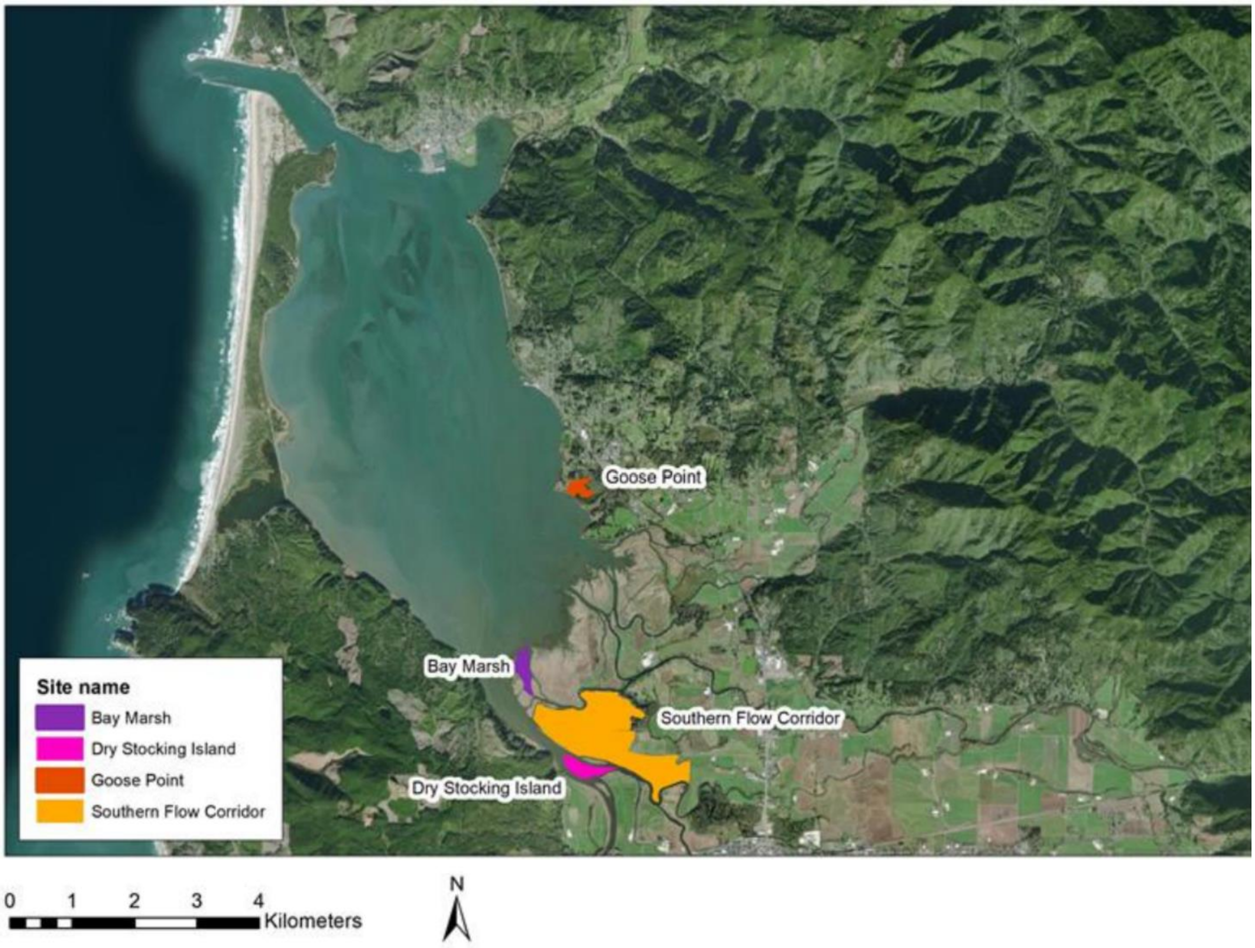
Ecosystem Service #1: Water Quality

Three water quality metrics at the SFC site were important for meeting project goals: 1) sedimentation, 2) temperature, and 3) dissolved oxygen. These dimensions of water quality were measured at various points before the restoration and both sedimentation and temperature were evaluated post-restoration.

Tillamook Bay has a history of high sediment deposition, partly due to an increase in deforestation within water sheds that feed into the bay from the periods of 1931-1954 (Komar *et al.*, 2004). Sediment load can cause issues with bay access for boats and can impact recreational crabbing and clamming activities if the sediment level is too high for long periods of time (Ainsworth et al., 2014). The removal of suspended solids was measured through sediment accretion rates at 37 locations before and after the project was restored (Brophy *et al.*, 2019b). Of the 37 locations, 27 were in the SFC site and 11 were distributed across three reference sites – Bay Marsh, Dry Stocking Island, and Goose Point (Figure 3). The results estimate that 2014 pre-restoration accretion rates for the SFC site were 7.93 ± 1.61 mm/yr of accreted soil and 2.94 ± 0.87 mm/yr average across the reference sites. Post-restoration (2017) measurements on the SFC site suggest accretion rates were 13.84 ± 0.74 mm/yr compared to 5.72 ± 1.09 mm/yr average across the reference sites. Peck *et al.*, (2020) estimated the average long-term accretion rate at high marsh reference sites to be between 0.8 mm/yr to 4.1 mm/yr. There remains uncertainty about how long it will take for the site to transition from the immediate post-restoration accretion rate to the long-term accretion rate (Janousek *et al.*, 2021). The difference in accretion rates between the SFC site and the reference sites is attributed to the SFC site's lower elevation due to post-diking subsidence and the timing of the study in the early stages of post-restoration recovery (Brophy *et al.*, 2019b; Janousek *et al.*, 2021). The restored SFC site is predicted to increase in elevation over time, with accretion rates declining to match the reference sites (Janousek *et al.*, 2021).

Given the lack of economic studies valuing the specific benefit of increased sediment capture from wetland restoration, an avoided costs exercise can be used to demonstrate the potential economic value associated with this service. The high level of sedimentation in Tillamook Bay has resulted in the U.S. Army Corps of Engineers (USACE) needing to dredge the shipping channels every 5-8 years to remove up to 50,000 cubic yards (yd^3) of sediment (Moffatt & Nichol 2015). Specific costs of these operations were not publicly available. Using a national database of dredging costs from the USACE, dredging costs in Portland, OR were estimated to be \$5.29 per yd^3 in 2014-2018 (Frittelli, 2019). Assuming the cost of dredging in Tillamook is similar to Portland, it would cost approximately \$264,500 to dredge 50,000 cubic yards of sediment. Using the SFC's post-restoration long-term accretion rate range of 0.8 mm/yr to 4.1 mm/yr multiplied by the 443 acres of restored tidal wetland results in a potential 1,434 to 7,351 m^3 (1,876 to 9,614 yd^3) of sediment being trapped in the restoration site each year (Brophy *et al.*, 2019b). To estimate the cost savings, we apply a discount rate to the predicted future estimates to accurately convert future cost savings into present day terms. Assuming a 5 percent discount rate and dredging every 8 years, these accretion rates imply that the SFC project may reduce annualized dredging costs between $1,500 to $8,000 or reduce the frequency of necessary dredging in Tillamook Bay. It must be noted that this estimate derives from a predicted long term accretion rate at the site (Peck *et al*., 2020) and cannot be directly attributed to a change induced by restoration activities. Improved understanding of how the SFC site affects overall sediment flows into Tillamook Bay, by observing and measuring sediment loads and costs of dredging the bay, could provide a more complete picture of the value of these ecosystem service flows.

Figure 3: Southern Flow Corridor and Reference Site Locations



Note: Figure from Allen *et al*., (2018)

Decreasing high water temperatures in summer months was another water quality improvement anticipated at the restoration site (Allen *et al*., 2018). High or abnormal water temperatures can impact the removal rate of nutrients, affect decomposition of organic matter, lower DO levels, and negatively impact the survival of juvenile salmon (Kadlec & Reddy, 2001; Yang et al., 2018; Kirwan et al., 2014). In-channel water temperatures were measured using

Odyssey conductivity and temperature loggers for one year pre- (2013-2014) and post-restoration (2017-2018) in the restored site and reference sites (Janousek *et al.*, 2021). The results showed that there was no significant change in daily mean water temperatures from pre- to post- restoration in the summer or winter seasons (Janousek *et al.*, 2021). However, this may change as the site develops and vegetation matures (Kalny *et al.*, 2017).

DO levels are important in aquatic habitats because having sufficient oxygen in the water is necessary for aquatic animals (e.g., clams, crabs, fish) to survive (NOAA, 2014). Oregon has seen increased hypoxia events over the last few decades along the coastline which can have additional impacts on local crabbing and fishing industries (Foden-Vencil, 2018). DO levels in the tidal channels were measured pre-restoration at the SFC project site (Hagerty, 2013). However, no post-restoration DO levels were measured at the time of this writing, so it was not possible to determine if the restoration project improved this element of water quality. Janousek et al., (2021) recommends that if more post-restoration monitoring funding becomes available, then additional studies on in-channel DO levels could be conducted.

Prior studies have demonstrated that improving DO could have significant economic benefits. For example, a study on the Delaware River, a waterway with historically very low levels of DO due to excess pollution, saw significant economic benefits from water quality improvements (Kauffman, 2019). These values were estimated using stated preference surveys focused on water quality impacts on both use and nonuse values (e.g., willingness to pay to keep the river clean for future generations), travel cost surveys to estimate the economic gains from the increased days of recreational boating and fishing due to the improved water quality, and market benefits such as increases in the sales of goods from the river (e.g., fish). This example demonstrates the potential for significant economic benefits associated with improving water quality-through increasing DO levels. If a future SFC study monitors DO in the restored channels and finds that there was a significant change relative to pre-restoration, there would be potential to estimate benefits from improved water quality at the site. Following Kauffman (2019), it would be important to survey local, state, or region-wide to estimate use and non-use benefits of improved DO and track any improvements in related markets (e.g., fishing).

Another option to assess the economic benefits of restoration related to water quality would be to measure nutrient retention on the SFC site. At the time of writing, there were no measurements made to determine if the SFC project impacts nitrate and phosphate levels in the waters that flow through the site. An EPA study from 2019 reports that Tillamook Bay (pre-SFC project) had high levels of nitrates from the rivers feeding the bay during the October-to-May rainy season (Rutila *et al.*, 2019). Thus, it could be hypothesized that the tidal wetlands restored at the SFC site may improve water quality entering the bay by capturing excess nitrogen and phosphorus. Assessment of nutrient flows and retention at the site could enable an avoided costs exercise related to water filtration (e.g., Breaux *et al*., 1995).

Ecosystem Service #2: Flood Mitigation

A primary goal of the SFC restoration was to mitigate chronic flooding in the surrounding area (Allen *et al*., 2018). Flooding can cause physical damage to property and infrastructure and produce both sizable repair costs and emotional trauma to community members (Reed *et al*., 2018; Hudson *et al*., 2017). HW101 historically floods in the area between the Wilson River and Hoquarton Slough, causing disruption and delays to traffic (Collins, 2019). Tidal wetlands can help mitigate flood height and duration by providing large areas for flood waters to spread out and be absorbed (Reed *et al*., 2018). In Tillamook, flooding from the Trask and Wilson rivers historically happens on a nearly annual basis and has been an important issue for the local community for some time (Tillamook County, 2017).

Extensive flood monitoring and modeling were conducted pre- and post-restoration for the SFC site by the consulting firm NHC (Collins, 2019). Pre-restoration flood frequency and magnitudes were found using historic annual river height gauge records going back to 1930 for the Wilson River and a patchier historical record of the Trask River (1922, 1933-1973, 1996-2018) (Collins, 2019). Pre-restoration, site models were created and calibrated using flood heights and records from historical floods in 1999, 2006, and 2007 (Collins, 2019). A moderate flood event on the Wilson River (5-year, 24,400 cfs) occurred in October 2017, allowing for a post-restoration flood model to be developed and calibrated (Collins, 2019). These modeling efforts suggest flood levels may be lower 3.4 miles up the Trask River, up to 4,800 acres would see some reduction in flood level, and delays on HW101 between Hall Slough and the Trask River may decrease by 2 hours. It is important to note these projections were developed with a pre-restoration model that includes multiple major flood events (e.g., peak crest on Wilson River > 19') compared to a post-restoration model with only one moderate event (peak crest on Wilson River ~ 17').

This report looks at FEMA flood insurance claims, HWY101 traffic delays avoided, protection against sea-level rise, and an original housing market analysis to describe the potential economic benefits from flood mitigation resulting from SFC restoration activities. Starting with FEMA National Flood Insurance Program (NFIP) claims (FEMA, 2021), we looked to find if there were any differences in claims or the number of claims between the 2017 post-restoration flood and events of similar magnitude before restoration activities. Table 4 displays the number of claims, average claim amount, National Weather Service flood stage designations for the Wilson and Trask Rivers and the corresponding maximum flood crest and peak flow reported for the event.

Table 4: FEMA Insurance Claims and Flood Event Information in Tillamook, OR

Month & Year of Flood Event	November 2006	January 2006	January 2009	January 2011	October 2017
Total NFIP Insurance Claims	$3,043,085	$75,011	$46,247	$0	$2,777
Number of Claims	51	2	4	3	2
Average Insurance Claim	$59,668	$37,506	$11,562	$0	$1,388
Wilson River Flood Designation	Major Stage	Moderate Stage	Moderate Stage	Flood Stage	Moderate Stage
Peak Crest Wilson (feet)	22.89	15.56	15.92	13.90	17.05
Peak Flow Wilson (cfs)	38,600	22,600	23,400	19,600	24,400
Trask River Flood Designation	Flood Stage	Flood Stage	Flood Stage	Flood Stage	Flood Stage
Peak Crest Trask (feet)	19.53	16.82	18.50	18.20	17.56
Peak Flow Trask (cfs)	17,800	12,600	17,000	15,200	14,800

Note: The first column shows a major flood event. The light gray shaded columns show pre-restoration moderate flood events of comparable magnitude to the one post-restoration flood (final column, light blue). Flood stage designations are made by the National Weather Service and decrease in severity from Major, Moderate, to Flood.

Review of these data suggest it is difficult to assess the impact of the SFC site on NFIP claims. First, there has been only one moderate post-restoration flood and there has yet to be a major flood. Second, the most comparable moderate floods and the 2017 post-restoration event all suggest single digit claims with varying average claim sizes from $0 to over $37,000. Third, Tillamook is impacted by flooding from 5 rivers and ocean tides, making it quite difficult to make comparisons between flooding events (USACE, 2005). While it is encouraging that the average claim amount was very low in 2017, we cannot draw any conclusions about the effects of the SFC restoration site on flood insurance claims at this time.

Next, the economic costs of detour time for commuters due to flooding on HWY101 is evaluated. When HW101 is closed, drivers must take a detour of up to 30 minutes to get around the flooding (Collins, 2019). A method used by the U.S. Department of Transportation, Federal Highway Administration was applied here to estimate the cost of the detour to drivers (Mallela

& Sadasivan, 2011). In 2019, there were 17,600 trips/day on average on HW101 at mile post (MP) 65.23, near Blue Heron Rd. in Tillamook between the Wilson River and Hoquarton Slough (TSMU, 2020). First, it was found that 13,904 trips/day (~79% of total travel for NW region of Oregon, 2019) at MP 65.3 were for personal business[1], (Bricka, 2019; TSMU, 2020). Next, the annual median income of residents from Tillamook ($25,259; U.S. Census Bureau, 2020) is used to calculate the value of travel time (VTT) in dollars per person per hour as follows:

$$VTT = \left[\frac{(X\% * median\ income)}{2080\ hrs}\right], \qquad [1]$$

where X is an assumption for the opportunity cost of time for travel. The Federal Highway Administration (FHA) assumes X is 50% for local travel and 70% for intercity travel (Mallela & Sadasivan, 2011). The calculated hourly value of travel time per person was $6.07/person/hr for local travel and $8.50/person/hr for intercity travel. Next, the hourly VTT for a vehicle on personal travel was calculated by multiplying the VTT by the average occupancy rate for the "West Region" of the U.S (1.71 people/vehicle; FHA 2017). This suggests an average vehicle per hour value of $10.38 for local travel and $14.54 for intercity travel. Finally, the travel delay costs could be calculated by multiplying the hourly VTT per vehicle by the average time it took to drive the detour (30 minutes) (Mallela & Sadasivan, 2011; Collins, 2019). Results suggest that for residents of Tillamook, the average cost of the detour per vehicle, per trip through the detour, was $5.19 for local travel and $7.27 for intercity travel. We can roughly approximate the benefit of reduced closure time by using the pre-restoration estimate from NHC of 2 hours of reduced closure time and making the simplifying assumptions that the number of cars per hour at MP 65.23 is the number per day divided by 24 hours and both local travel and intercity travel represent 50 percent of trips. Under these restrictive assumptions, the benefits of flood time reduction are approximately $7,200 per event. The timing of the flood event (e.g., middle of the night vs. morning commute) will impact the number of cars affected and the proportion of local and intercity trips could significantly alter the value per event, so the veracity of this estimate should be investigated using measurements from future closures.

Flood risk to Tillamook is increasing when factoring in future local sea level rise (LSLR). On the Oregon Coast, LSLR is predicted to increase flooding and erosion from storm surges, likely leading to increased costs from structure and property damage (ODFW, 2006). At the SFC site, LSLR is estimated to be 1.8 mm/yr (Peck, 2017; Brophy *et al.*, 2019b). This rate is lower than the estimated SFC site short term sediment accretion rate of 13.8 mm/yr but within the range of

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[1] Business-related trips were not included in this analysis because detailed local data on the nature and purposes of business trips likely to travel this section of HWY101 are not observable at this time.

long-term accretion rates estimated for the site (0.8 mm/yr to 4.1 mm/yr; Brophy *et al.*, 2019b). Therefore, it is not clear at this time whether the SFC site will be able to keep up with LSLR and maintain flood protection benefits for Tillamook.

Housing Market Analysis

A primary method for estimating the economic benefits of reduced flood risk is through examining revealed preferences of individuals through their choices in a local housing market. The choice of where to live and how much individuals are willing to spend on a particular house can reveal their preferences over the characteristics associated with that house, including structural elements like square footage and number of bathrooms, but also about environmental quality in the surrounding area. Here we investigate if flood risk perceptions changed after the SFC restoration project as revealed through local housing transactions using a hedonic pricing model. Previous work in Oregon on housing markets linked the aesthetic value of wetlands to housing prices, with results suggesting the effect could be positive or negative depending on the type of wetland and its inherent aesthetic appeal (Mahan *et al.*, 2000).

We use a difference-in-differences (DiD) approach, an econometric method designed to set up a natural experiment to identify the causal effect of the restoration on residential housing values (Shaw, 2021). We use housing sales in the city of Tillamook, Bay City, Garibaldi, and the unincorporated areas of the county near Tillamook Bay from January 2011 through September 2019, spanning before, during, and after restoration activities at the SFC site. We define treated parcels based on proximity to the SFC site. Homes sold outside of the treatment boundary (and likely unaffected by changes to the SFC site) are considered the control group. The treatment timing follows the completion of restoration activities and the 2017 flood event discussed previously. We estimate the following DiD model:

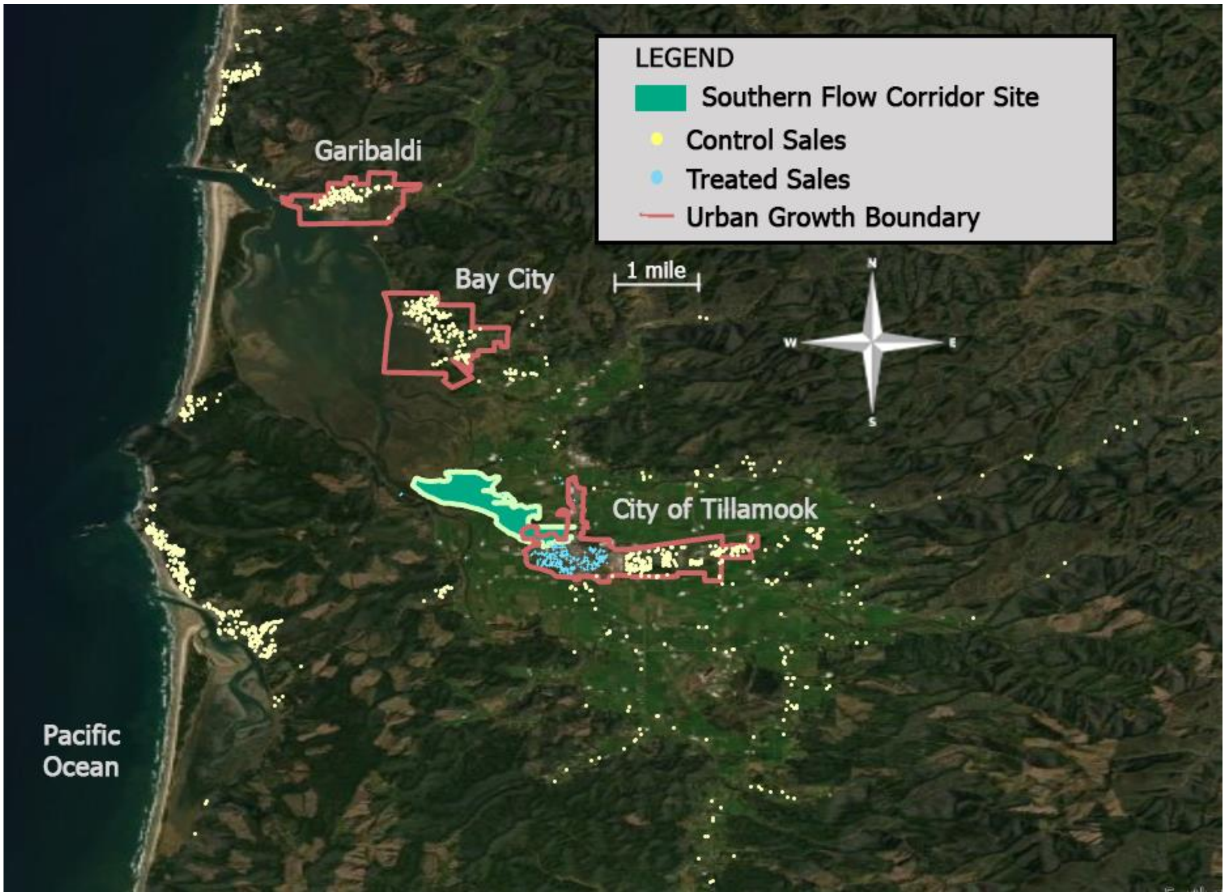
$$\log(price)_{ijt} = \alpha + \gamma SFC_j + \lambda Post_t + \delta(SFC_j * Post_t) + \beta \mathbf{X}_{ijt} + \mu_{t(q)} + \tau_t + \varepsilon_{ijt} \qquad [2]$$

where $price_{ijt}$ is the sales prices of house *i* in neighborhood *j* sold at year *t*, SFC_j is an indicator equal to 1 if the sale is near to or impacted directly by the SFC site, and $Post_t$ is an indicator equal to 1 if the home is sold after the restoration is completed. The vector $\mathbf{X}_{ijt}$ contains all structural and neighborhood characteristics of the home, $\mu_{t(q)}$ is a quarter sold fixed effect to control for seasonality of the housing market, τ_t is a year fixed effect to control for time trends in sales, and lastly, ε_{ijt} is the error term. The coefficient of interest is the difference-in-difference estimate (δ) which reveals the effect on housing prices that is attributable to the SFC restoration project.

Given the functional form of the model, this coefficient can be interpreted as a percentage effect on home values because of site restoration.

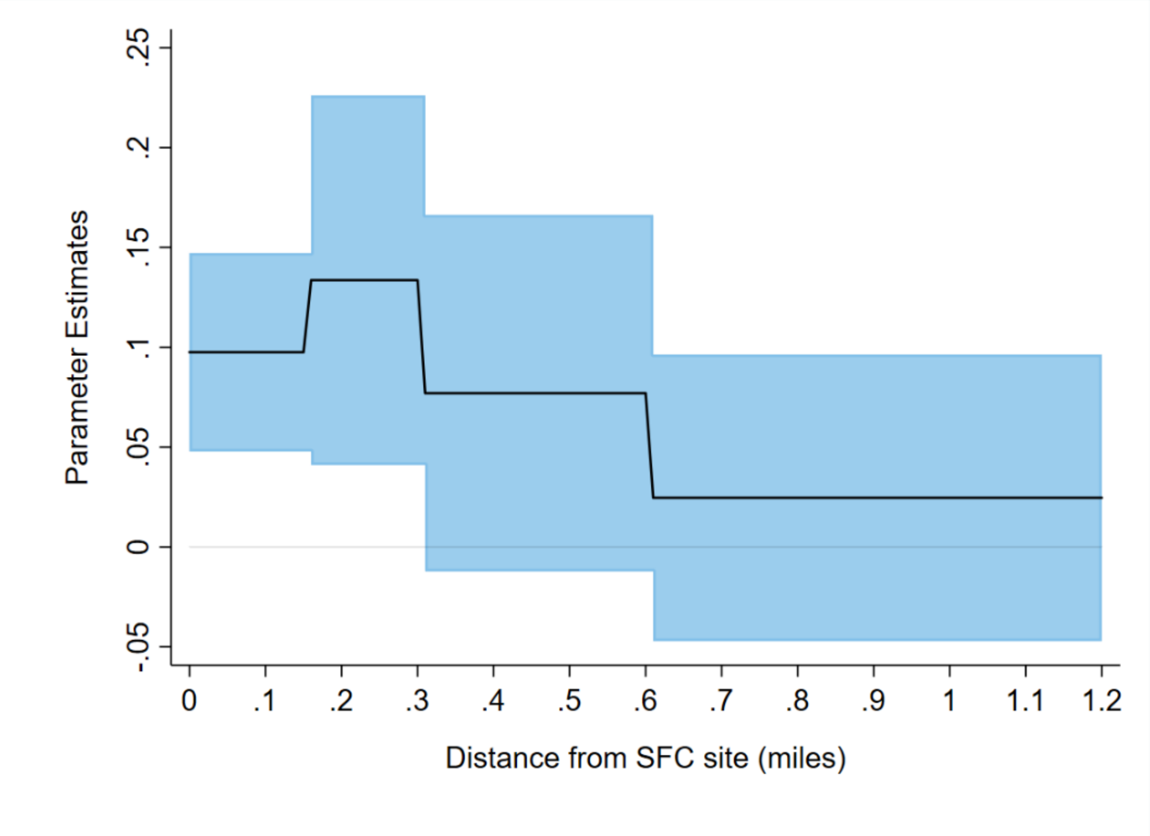
Our results suggest that houses near the SFC site after completion of the restoration sold for between 6 to 10 percent more than comparable homes in Tillamook away from the site, Bay City, Garibaldi, and unincorporated areas of the county near Tillamook Bay. This analysis is based on 1,622 observed transactions. In our main specification when treatment is defined as homes within ¾ mile of the SFC site (Figure 4), there are 283 treated housing sales and 1,339 sales used as controls and the estimated effect is significant and approximately 10 percent. This distance is chosen as the preferred model because further testing suggests the significance of the effect dissipates after approximately 1000 meters, or 0.6 miles from the site (Figure 5).

Figure 4: Housing Market Study Area with ¾ mile Treatment



Given the average home values in the treated area (~$195,800), we can estimate the total benefits of the restored wetland around $19,000 per home within ¾ of a mile and the annualized benefits (assuming a 3 percent discount rate and 13-year timeframe, the median home tenure in US) around $1,800 per home. Given that there are approximately 1,000 residential parcels that are within ¾ mile of the restoration site in Tillamook, our results suggest a housing market benefit resulting from the SFC restoration of $19.1 million, with the 95 percent confidence interval spanning $5.2 to $32.9 million. This suggests that it is possible that the housing market benefits alone could be enough to offset restoration costs ($11.2 million).[2] While these benefits are likely to reflect flood risk reduction, they could also capture aesthetic aspects of wetlands or access to recreation opportunities that also valuable to homeowners.

Figure 5: Estimated Price Effect Varies with Distance to the SFC Site



Note: Solid line represents the estimated effect and blue shading is the 95% confidence interval. The effect becomes statistically insignificant after 0.6 miles (~1000 meters).

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[2] It is important to note that numerous studies have found that housing market impacts related to flood risk changes tend to diminish over time and disappear completely within 4 to 6 years as experience with the change fades in collective memory (e.g., Atreya *et al*., 2013; Bin & Landry, 2013). Currently, we do not observe a large enough number of post-restoration transactions to test for this decay effect.

Ecosystem Service #3: Salmon Habitat Restoration

Tidal wetland habitat provides places for fish to grow, feed, hide from predators, and reproduce. One of the key goals for the SFC project was to restore critical estuarine habitat vital for juvenile salmon and native fish species (Greene, 2012; Allen *et al*., 2018). Numerous studies along the Pacific coast show that restored tidal habitat can increase juvenile salmon populations (Greene, 2012; Brophy *et al*., 2014; Jones *et al*., 2014). The SFC project set out to restore a gradient of tidal wetland habitat types (e.g., low marsh, high marsh, tidal flats) to recreate habitat conditions like what the area had been before it was diked, drained, and farmed (Tillamook County, 2017). Two years post-restoration, Janousek *et al*., (2021) found that plant species diversity had increased throughout the site compared to pre-restoration levels. Approximately 443 acres were restored to tidal wetland habitat, with mapped vegetation types including 52 acres forested tidal wetland, 25 acres shrub tidal wetland, 242 acres emergent tidal marsh, 96 acres tidally inundated bare ground, and 28 acres tidal channels or other habitats. Over time, these habitats are expected to change as bare areas become vegetated and vegetation gradually adapts to salinity and inundation gradients across the site (Janousek *et al*., 2021).

The primary method for creating aquatic habitat in the site was reconnection of the site's hydrology through channel creation and connection. This resulted in the restoration of 13.2 miles of channel habitat (Allen *et al*., 2018). A survey of fish distribution and abundance during low tide for the site was conducted pre-restoration and 2 years post-restoration (Janousek *et al*., 2021). Monitoring showed that abundance (catch per unit effort) of age-0 Chinook increased from 0.02 before restoration to 6.66 after restoration inside the SFC site (Janousek *et al*., 2021). The monitoring report also suggests that the young Chinook may have migrated from the Tillamook and Wilson Rivers to the SFC project site. Abundance of staghorn sculpin also measurable increased on the SFC site. Oregon Coast coho saw no significant change in population, but there was a minor change in distribution with a reduction in use of channel mouth habitats and a likely shift to smaller internal channels. Juvenile (age-0) chum abundance increased after restoration, but the statistical significance of the changes could not be determined due to low sample size and large numbers of zero counts. The effects on fish populations at the SFC project are summarized below in Table 5. It is important to note that changes found cannot be attributed to new fish "created" by the restoration effort because of the complex life histories and behavior of salmonids; for example, it is possible fish may have moved into the site from elsewhere in Tillamook Bay (Janousek *et al*., 2021). These population dynamics will likely change as the site develops further and fish populations adjust to the newly restored habitat.

It is possible to estimate the quantity of salmon that could be utilizing the site now for potential valuation efforts. First, a site inventory allowed calculation of the size of all the tidal channel habitat created by the restoration using GIS processes: 307,400 m^2. This area was multiplied by the catch per unit effort of 6.66 for the SFC site post-restoration and divided by 14 m^2, the sample area at each site for the fish population survey (Janousek *et al*., 2021). This calculation suggests up to 146,200 sub-yearling Chinook salmon could be using the SFC site as habitat. One study that reviewed survival rates of radio-tagged hatchery-raised Chinook salmon released into Tillamook Bay found an upper bound smolt to returning adult survival rate of 0.7% (Magnusson & Hilborn, 2003). If the 0.7% survival rate is applied to the estimated Chinook sub-yearling population that could be utilizing the SFC site, then 146,200 sub-yearling Chinook could result in an estimated 1,023 adult Chinook returns.[3] In another location in Oregon, a study on the Coquille River watershed estimated the number of adult wild Coho salmon “created” by a wetland restoration project. Unpublished data from ODFW were used to estimate the marine survival rate of coho salmon between 2001 and 2010 and results suggested that 11 to 27 adult coho were “created” by the restored wetlands each year per acre (Nickelson, 2012). It was noted in the study that the results only looked at the impact of restored winter habitat for coho and that the results are likely to be different for other locations and species (Nickelson, 2012).

Table 5. Fish Species Population Changes Observed at the SFC project

Fish Species	Population size impact from pre- to 2-yr post-restoration
Age-0 Chinook	Increase
Age-0 Chum	Undetermined*
Age-0 Coho	No Effect Detected
Age-1+ Coho	No Effect Detected
Staghorn Sculpin	Increase
Three-Spine Stickleback	Decrease
Age-0 Shiner Perch	No Effect Detected
Age-1+ Shiner Perch	No Effect Detected

*No statistically significant change was found, although an increase in Chum abundance was observed in a few sampling locations. Table based on data from Janousek *et al*., (2021).

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[3] There is some evidence that suggests survival rates of wild fish may be larger than hatchery-raised fish (e.g., Welch *et al*., 2020) but the magnitude difference is unknown.

However, this method could be replicated for coho and Chinook salmon coming out of the Tillamook, Wilson, and Trask River watersheds using ODFW data sets in the future after the SFC site matures.

The economic value of more salmon can be estimated in two ways with primary valuation studies. First, stated preference surveys can estimate the total economic value (both use and non-use values) of returning adult salmon. Results from Lewis *et al*., (2019, 2021) suggest that each household in the Pacific Northwest is willing to pay between $8 to $19 annually for 100,000 more returning adult Oregon Coast coho salmon. Applying their survey results and methods to an example of a change in coho abundance related to a hatchery closure in the Salmon River estuary (OR), Lewis *et al*., (2021) show the present value of a permanent increase in 1,190 returning adult coho per year for 50 years is between $32 and $63 million dollars. A second way economic value is often estimated for salmon is associated with use values through recreational fishing. Table 6 lists valuations of adult Chinook and coho for recreational angling, in $/per fish caught. Estimates for catching fish often have large ranges due to different species of fish being targeted under different conditions across many locations. It is important to note that these values are for catching a fish, not for all returning fish. Estimates are available for Tillamook Bay, ranging from $54 for catching a coho to $110 for catching a Chinook (Raja 1988).

Table 6. Recreational Value of Salmon to Recreational Anglers in Oregon

Species	Location	Per Fish Value ($2021)	Reference
Coho	Tillamook Bay	$53.74	Raja, 1988
	Oregon Ocean	$78.95	Caudill, 2002
Chinook	Tillamook Bay	$109.71	Raja, 1988
	Oregon Ocean	$78.99	Caudill, 2002
	Columbia River	$118.50	Caudill, 2002
	Columbia River	$157.98	Caudill, 2002
	Rogue River (Ocean)	$81.76	Helvoigt & Charlton, 2009
	Rogue River (River)	$296.38	Helvoigt & Charlton, 2009

Estimating an economic value for salmon habitat associated with the SFC restoration is confounded by several factors. First, as noted above, more Chinook smolts were sampled at the site post-restoration, but the sampling team was unable to determine if these salmon were new additions or simply migrants from other areas in the bay (Janousek, *et al*., 2021). This makes it difficult to attribute this increase to the restoration activities. Second, we were unable to find any primary valuation efforts focused on total economic value for Chinook. Estimates exist for recreational fishing for Tillamook Bay, but data on usage and catch rates of anglers on Tillamook Bay has not been collected to date. Third, Lewis *et al*., (2021) provide a method to value increases in Oregon Coast coho populations, but no increases in coho were found at the site to date. Lastly, there was a survey that focused on willingness to pay for coho salmon habitat in Oregon coastal towns a few decades ago (Bell *et al*., 2003). The study mailed coastal residents (including around Tillamook Bay) a survey that provided some background information on the state of coho salmon habitat and then asked how much they would be willing to pay to continue or start supporting salmon habitat creation. Table 7 displays results from the study for Tillamook Bay based on 410 completed surveys. These results suggest that the public values salmon habitat creation. However, the authors note that their point estimates were not statistically different from zero (5% level), suggesting at best an imprecise estimate of the benefits and at worse, a gross overestimate of value. Despite the high relevance of this study, the survey was conducted over 20 years ago and the imprecise estimates are problematic for policy analysis and estimation of the overall economic effect of the SFC restoration.[4]

Table 7. Mean Willingness to Pay for Coho Habitat Enhancement in Tillamook, OR

Estuary: Tillamook Bay	Mean WTP Estimate for Local Coho Enhancement (2021$)	
	High Income	Low Income
High Enhancement of Habitat	$185.35 ± 102	$57.20 ± 34.00
Low Enhancement of Habitat	$122.00 ± 85.25	$37.65 ± 27.15

Note: Estimates from Bell *et al*., (2003)

Ecosystem Service #4: Carbon Storage

Carbon storage and sequestration in restored coastal wetlands is receiving increased attention due to the threat of climate change from the emissions of greenhouse gases (GHGs) such as carbon dioxide and methane (Galatowitsch, 2009; Murray *et al*., 2011; Pendleton *et al*., 2012;

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[4] Although not quantified here, it is important to note the SFC site may also have a future impact on species not listed under the Endangered Species Act that are valuable to commercial fisheries, a significant economic sector in the region.

Janousek *et al*., 2021). Tidal wetlands capture and store carbon primarily through soil accretion (Murray *et al*., 2011) and have some of the highest carbon sequestration rates per area compared to all other ecosystem types (Lai *et al*., 2009). Pacific Northwest tidal wetlands have particularly high carbon stocks, suggesting very high carbon sequestration potential (Kauffman *et al*., 2020; Lai *et al*., 2009; Mcleod *et al*., 2011; Batzer, 2014). However, tidal wetlands also potentially off-gas GHGs (e.g., nitrous oxide, methane) due to natural processes such as decomposition (Bridgham *et al*., 2006; Moseman-Valtierra, 2013; Shiau, 2019; Windham-Meayers *et al*., 2018; Janousek *et al*., 2021). The release of these GHGs can offset some or all the benefits of the sequestered carbon in the soil (Al-Haj, 2020; Moseman-Valtierra, 2013; Windham-Meayers *et al*., 2018; Janousek *et al*., 2021).

The SFC site's carbon storage potential was estimated by the monitoring team using 12 sampling stations that were monitored for soil carbon density and carbon accumulation rates. The restored wetlands at the site are estimated to potentially store 27,000 tons of carbon over their lifetime, which is equivalent to 100,000 tons of carbon dioxide. However, it is not known how long it will take to capture and store that much carbon because the total carbon storage potential depends on how much soil is accreted, which can vary depending on changes in future site conditions such as sediment availability and local sea level rise (Brophy *et al*., 2019b; Peck *et al*., 2020). The monitoring team believed the project would still be sequestering part of that 27,000 tons 50 years in the future (Laura Brophy, Personal communication).

The economic value of the site's carbon storage potential can be estimated under a set of assumptions. First, we assume that the site will store all 27,000 tons of carbon in 50 years, and it will do so at a constant rate (540 tons of carbon per year for 50 years). Second, since the benefits accrue annually over a long-time horizon, we assume a discount rate between 3 to 5 percent. Third, we assume the social cost of carbon used currently by the Biden Administration ($51/ton; IWGSCGG, 2021) accurately reflects the value of 1 ton of carbon stored in an ecosystem. Under these assumptions, we can calculate the net present value calculation of carbon storage at the site as:

$$Net\ Present\ Value = \sum_{t=0}^{50} \frac{B_t}{(1+r)^t}, \qquad [3]$$

where B_t is the per year benefit of stored carbon, r is the discount rate, and t is time. This suggests a net present value of 27,000 tons of carbon storage at the SFC site between $530,000 and $736,000 for 27,000 tons of carbon stored over the next 50 years. As the site continues to develop, it is possible the carbon burial rate will change as well as the site's total carbon storage capacity. It is recommended that a future analysis be conducted to update the carbon burial timeline which could be used to estimate a new net present value.

On the other hand, tidal wetlands can also emit GHGs. To determine if the restored site was emitting more or less than its previous land use, emissions for the SFC site were measured pre- and post-restoration (Janousek *et al*., 2021). GHG emissions were monitored by 12 sampling stations distributed around the SFC and four (4) reference sites (Janousek *et al*., 2021). Two types of reference sites were used: disturbed farmed fields that were comparable to the SFC site when it was being grazed and farmed (two sites), and undisturbed tidal marshes near the SFC site (two sites) (Janousek *et al*., 2021). Six (6) of the sampling stations were spread around the SFC site to capture the emissions from the site's different land-use/land-cover zones (Janousek *et al*., 2021). Gas sampling was done using a dark chamber which contained sensors that monitored methane, nitrous oxide, and carbon dioxide levels (Janousek *et al*., 2021). Mean annual methane emissions rates for the pre-restoration stand-in reference site were estimated at 0.11 mol methane per square meter per year versus 1.5 mol methane per square meter per year post-restoration (Janousek *et al*., 2021). It is predicted from analyzing the undisturbed reference site, that as the SFC project ages its methane emission rate may decrease; however, future monitoring efforts would be needed to verify this prediction (Janousek *et al*., 2021). For carbon dioxide (CO_2), the mean pre-restoration emission rates were estimated at 129 mol carbon dioxide per square meter per year versus 70 mol carbon dioxide per square meter per year, post-restoration. The stand-in future mean emission rate was 148 mol carbon dioxide per square meter per year (Janousek *et al*., 2021). Finally, for nitrous oxide, the percent variation in gas emissions could not be found because the gas emission rates were too inconsistent, with many measurements having a zero reading (Janousek *et al*., 2021). For CO_2, if the emission rates are applied to all 443 acres ($1.79*10^6$ m^2) of restored tidal wetland habitat, then the pre-restoration site emitted 7,143 tons of CO_2 per year and the post-restoration site emitted 3,869 tons of CO_2 per year. Applying a $51/ton social cost of carbon to this decrease suggests the site produced approximately $167,000 in benefits per year from prevented CO_2 emissions. However, it should be noted that the site's CO_2 emission rates are expected to eventually exceed the pre-restoration levels as the SFC site ages, potentially diminishing any short-term benefit from lower current emissions. Future studies would be needed and are recommended to verify this prediction (Janousek *et al*., 2021).

A potential example for assessing carbon storage for the SFC comes from a study from Mississippi's Alluvial Valley (Jenkins *et al*., 2010). The authors studied carbon, methane, and nitrous oxide emissions above ground, carbon stored below ground in soils, and the carbon capturing rates of plants and other biological processes in the restoration site. The researchers then used models to project the GHG emissions and sequestering rates into the future. New studies at the SFC site could focus on capturing the full GHG flux of the SFC site annually moving forward.

Additional Benefits to the Community

Recreation was an ecosystem service that was noted as important by project designers and managers. The restored SFC site is publicly accessible and likely used for walking, fishing, kayaking, bird/wildlife watching, nature viewing, and educational activities. Unfortunately, no data were collected on the existence, type, or quantity of recreation usage at the SFC site. Recreation can bring large economic benefits to communities and a recent study suggests the value of recreation in Tillamook County in 2019 was over $737 million (Ghahramani, 2021). Many analyses have been conducted that monetize the value of a day spent bird/wildlife watching, nature viewing, and kayaking which are summarized in Table 8 below. Values for recreational fishing were presented in a previous section.

Table 8: Economic Values for Oregon Recreational Activities

Activity	Value [$2021]	Units	Source
Nature Photography/ Viewing	$36-$64	Person/Day	Rosenberger, 2018
Bird/Wildlife Viewing	$63-$471	Person/Day	Richard, 2016 Donovan *et al*., 2009 Ghahramani, 2021
Kayaking	$60-$108	Person/Day	Ghahramani, 2021 Rosenberger *et al*., 2017

Future studies could monitor recreation usage levels of the SFC site, then apply relevant valuation estimates to approximate economic benefits via benefit transfer methods. A willingness-to-pay survey could also be conducted of the local or regional community to find out how much they value access to recreational activities at the SFC site. The survey could be modeled after a study in Saginaw Bay coastal marshes in Michigan (Whitehead *et al*., 2006). Here researchers mailed surveys to known recreationalists and asked them a series of questions on how large of a donation they would be willing to make if said donation went to supporting recreational activities at the bay. Additionally, they asked how often people traveled to the site and where from. The data were then analyzed using the travel cost method to determine the survey participant's willingness to pay for recreation at that site.

There were no data collected on community, social, or cultural benefits from the SFC project. Valuing such benefits from a restored ecosystem can be challenging. However, studies such as one by Trimbach *et al.*, (2021), have found that people from all walks of life feel a strong connection to the place they live and a sense of stewardship for the environment that is around them. Another recent study tried to measure the value of wetlands to residents who live near them in Staffanstorp, Sweden (Pedersen *et al.*, 2019). A survey was sent out to 400 randomly selected residents who lived near one of three wetlands. The survey questions were modeled on environmental psychology to capture the value of the social and cultural benefits from the wetland by asking a series of questions about how much the wetlands contributed to 11 aspects of their quality of life. The results were that people highly valued the social and cultural benefits the wetlands provided although no monetary values were attached to the cultural values of the wetlands studied. Future work could investigate how the community around the SFC site values the cultural and educational ecosystem services provided by the SFC site. These services could include the visual aesthetic of the site, knowledge that it is helping endangered wildlife and fish, increased access to natural environments, and ties to culture and history. These services could be evaluated using willingness-to-pay surveys and/or models created from data on prices of local amenities such as housing prices.

Values from indigenous people should also be considered in future work. Tillamook tribal members could be interviewed to learn about the value of tidal wetlands and health of Tillamook Bay to their tribe's culture and history. There is archaeological evidence of human occupation of the bay as far back as 11,500 BP (Albright, 2020). There were two main Native American sites along the shore of Tillamook Bay which have been dated to the 15th-century (Albright, 2020). To find the value of the SFC site to tribal members today, a study similar to that used in Pederson *et al.*, (2019) could be performed. Members of the tribe could be asked how they value different ecosystem services provided by the SFC site as well as any additional services the estuary may provide for them including ties to historical traditions or educational opportunities. The survey could ask how they would value flooding mitigation, improvement in water quality, changes in fish, wildlife, or plant populations, and/or having increased access to tidal wetland habitats historically used by the tribe. The valuation does not have to be monetized. If deemed more appropriate, the survey could ask how much tribe members value different aspects of the SFC site on a scale of one to ten or some similar rating system. Monetizing access to cultural history or traditions can raise complex ethical questions and situations. Such a survey of tribal members should be created in partnership with representatives from the tribe to limit any ethical issues or cultural miscommunications.

LESSONS LEARNED

The Southern Flow Corridor project’s main goals were to improve habitat for native fish and wildlife species, improve water quality through reducing sedimentation, reduce flood hazards, and enhance the overall health of Tillamook Bay (Allen *et al*., 2018). The project was successful at decreasing flooding in the surrounding area and at restoring 443 acres of tidal wetland habitat (Allen *et al*., 2018; Janousek *et al*., 2021). As a result of the project’s successful habitat restoration, additional ecosystem services were created, which provide added benefits to Tillamook Bay and the local community. Data collected for the SFC project monitoring program were used in tandem with applicable research reports and publicly available data sets to provide estimates of the value of benefits provided by ecosystem services.

There are several important findings from this report. An economic impact analysis of the SFC project suggests that the project generated $14.6 million in total benefits and supported 108 jobs over four years in Oregon (see Appendix). The SFC restoration site is likely trapping sediment flowing into Tillamook Bay, which may result in dredging cost savings of $1,500 to $8,000 per year. Estimates of the cost savings in travel time due to reduced flooding on Highway 101 was estimated to be $7,200 per flood event. A hedonic pricing model suggests the capitalized total benefit to property owners near the site due to restoration could between $5.2 and $32.9 million dollars. There is promising evidence of increases in sub-yearling Chinook salmon using the SFC site, which could generate significant economic benefits as the site matures. Carbon storage on the site was valued up to $736,000 over the next 50 years, although emissions from the restored wetland have potential to offset the storage value. Finally, future surveys of recreation usage and perceived community benefits from the SFC project site have potential to reveal large social value of the project to the local community.

The main obstacles when trying to calculate the value of the ecosystem services provided by the restored habitat at the SFC site were gaps in the available data sets for the project due to the relatively young age of the project, and a lack of planning for an economic analysis from the project’s inception (Table 9). A key component is to collect (and continue to collect) relevant biophysical data to measure the quantity changes of ecosystem service flows. Socio-economic data also needs to be collected through surveys and stakeholder engagement to reflect how perceptions, usage, and values associated with ecosystem service flows may change from pre- to post-restoration. Without rigorous estimates of the impact that the restoration project had on both quantity of services provided and values (prices) of the local community for those services, generating economic benefit estimates is not possible. It is recommended for future projects that a team of economists and other social scientists be part of the planning and monitoring process before restoration activities commence. This will allow for the establishment of economic benefit priorities that can be incorporated into a pre- and post-restoration data collection strategy similar to the ecological monitoring strategy for the SFC site (Brophy & van de Wetering, 2014). For example, the recreation usage at the site has not yet been monitored post-restoration. Monitoring of the site to estimate usage is a relatively straight forward way to estimate the economic benefits provided by a new publicly accessible wetland area.

To realize the potential economic benefits of SFC restoration to the local community, it is recommended that monitoring efforts continue (and expand) for water quality and fish populations. As vegetation at the SFC matures, improvements in water temperature and DO levels are likely. Further research on the SFC site's ability to pull nitrogen and phosphorus from the Wilson and Trask Rivers could reveal significant economic benefits from improved water quality (e.g., Hansen *et al*., 2021). Populations of fish species of interest should continue to be monitored and new research should be pursued to understand how the SFC site affects the lifecycle of these fish. There are several Oregon-specific studies that suggest habitat restoration may increasing salmon populations (e.g., Nickelson, 2012) and can generate significant economic benefits (e.g., Lewis *et al*., 2019, 2021).

The extensive literature review conducted for this report revealed that economic benefits from coastal wetlands are generally place- and habitat-specific. Furthermore, the number of studies looking into the economic and social value of coastal wetland habitats on the US Pacific coast is very limited. NOAA, TEP, and other coastal resource/research management organizations may seek to support and promote increased socio-economic research on this critical habitat. As more information on the importance, impact, and value of the ecosystem services from coastal wetland habitats are understood, it will be easier to demonstrate the total economic value of investments in tidal wetland restoration.

Table 9: Data Gap Summary Table

Category	**Available Data** Pre-restoration (Pr) Post-restoration (Po)	**Data Needed**	**Economic value from literature**	**Limiting Factor for Evaluation**	**Economic Results**	**Monitoring Needed**	**Sources**
Water Quality	Sediment accretion rates (Pr, Po)	Impact on Sediment load entering bay	$5.29 per yd^3 excavated soil	Quantity: unknown amount of soil captured by SFC site	~ $10,000-$50,000 in avoided dredging costs	Soil capture at SFC Abatement of nutrient load from ag. runoff	Kalny *et al.*, 2017 Allen *et al.*, 2018
	Temperature (Pr, Po)	Future water temperature (Po)	None: Existing estimates are site and impact specific	Quantity: Δ Temp Price: $/degree	N/A	Future Water Temperatures	Brophy *et al.*, 2019b Frittelli, 2019
	DO levels (Pr)	DO levels (Po)	None: Existing estimates are site and impact specific	Quantity: Δ O_2 Saturation Price: $/$O_2$ Saturation level,	N/A	DO levels in main and side channels	Janousek *et al.*, 2021 Peck *et al.*, 2020
Flood Mitigation	Area with less flooding (Po)	Increased detail in flood damage mitigation (Po)	None: Existing estimates are site and impact specific	Quantity: # of structures with reduced flood damage Price: $ value of reduced flood damage	N/A	Survey of damages from future flood events	
	HW101 detour time (Po)	Increased accuracy of HW101 daily usage MP 65.23	Cost per vehicle, per trip through detour $5.19 (local) and $7.27 (intercity)	Quantity: # of cars spared from having to take detour during flood event	~ $7,200 avoided travel costs per event	Survey Traffic patterns MP 65.23	Mallela & Sadasivam, 2011

	FEMA NFIP claims (Pr, Po)	FEMA NFIP claims for more flood events (Po)	None: Existing estimates are site and impact specific	<u>Quantity</u>: Only one moderate post-restoration flood event	N/A	Survey FEMA NFIP claims from future flood events	Peck 2017 Brophy *et al.*, 2019b
	LSLR at SFC site (Pr, Po)	Impact on storm surge and flooding damages (Po)	None: Existing estimates are site and impact specific	<u>Quantity</u>: # of structures with reduced flood damage <u>Price</u>: $ value of reduced flood damage	N/A	Analyze benefits from SFC site of mitigation of LSLR and storm surge protection	Collins, 2019
Habitat Creation	Target fish species abundance via catch per unit effort (Pr, Po)	More abundance sampling (Po)	WTP for improved coho habitat: $37.65 to 185.35 WTP for ~ 1,200 additional spawning coho $32-$63 million over 50 years	<u>Quantity</u>: Increase of Target fish species attributable by SFC site <u>Price</u>: Use and non-use values for Chinook/coho abundance	N/A	Continued monitoring of fish populations Identify effects of SFC on abundance numbers Survey indigenous people and local community	Raja, 1988 Bell *et al.*, 2003 Magnusson & Hilborn, 2003 Nickelson, 2012 Lewis *et al.*, 2019 Lewis *et al.*, 2021 Janousek *et al.*, 2021

Carbon Storage	GHG emission rates Carbon burial rates 27,000 tons estimated CO_2 storage potential of site	Higher resolution GHG emission rates across site Estimate for timeline of carbon burial	$51 per ton of stored CO_2	<u>Quantity</u>: amount of GHG emissions from SFC site necessary of project level CO_2 equivalents emission balance	~ $530,308-$736,138 net present value of predicted 27,000 tons of stored CO_2	Study SFC site annual GHG flux Monitor carbon burial rates at site and create burial timeline	Janousek *et al.*, 2021
Additional Community Benefits	None	Recreation usage at site Social value to local community	Rec. Values for multiple activities (see table 8)	<u>Quantity</u>: # of people using site for recreation <u>Price</u>: $ value of project to community members	N/A	Survey recreational activity at the SFC site Survey community members on their value of SFC project	Donovan *et al.*, 2009 Richard, 2016 Rosenberger *et al.*, 2017 Rosenberger, 2018 Ghahramani, 2021

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APPENDIX

Economic Impacts of the Southern Flow Corridor Habitat Restoration Project

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Executive Summary

Federal, state, and local partners (including NOAA) spent approximately $9.3 million on the Southern Flow Corridor (SFC) wetland restoration project in Tillamook County, Oregon. Land and easements for the project cost another $1.9 million. This report uses input-output modeling software (IMPLAN) to estimate employment and economic output supported by spending on the SFC.

Over the course of the project (2013-16), the SFC wetlands restoration supported 156 jobs and $25.1 million in total economic output, in 2015 U.S. dollars. This includes the $9.3 million in direct spending on the project (direct effects), $6.1 million in indirect effects, and $9.6 million in induced effects. This is equivalent to 39 jobs and $6.3 million in GDP supported for each year of the project.

Oregon enjoyed the greatest portion of these benefits: the project supported 108 jobs and $14.6 million in total economic output in the state. On a per-year basis, the project supported 27 jobs and $3.7 million in spending in Oregon.

Project expenditures had a multiplier of 2.70. That is, the average dollar spent on SFC projects generated an additional $1.70 in economic output.

Introduction

Federal, state, and local partners invested $11.3 million in the Southern Flow Corridor (SFC) project between 2013 and 2016. Approximately $9.3 million of that total was spent on planning and executing wetlands restoration and infrastructure improvements in Tillamook Bay, Oregon. These expenditures had a direct impact on the organizations and employees paid to work on the project and generated further benefits as those dollars were re-spent on materials, services, and consumable goods. The objective of this report is to estimate the economic output, employment, labor income, and tax revenue generated by the SFC project.

Methods

IMPLAN is a widely used economic input-output model that produces estimates of the regional economic impacts generated by an initial change in spending in a defined political area (e.g., state, county). There are three types of effects – **direct, indirect, and induced effects** – that can

Appendix Table 1: Southern Flow Corridor Project Funding

Funder	Total budgeted	Restoration spending[a]	Type
FEMA	$3,225,000	$3,225,000	Federal
NOAA	$2,700,000	$2,700,000	Federal
OWEB	$1,522,144	$302,094	State
Oregon State Lottery Bonds	$1,075,000	$1,075,000	State
USFWS	$816,019	$816,019	Federal
Oregon Business Development Department	$795,647	$625,492	State/Federal
Regional Solutions	$500,000	$73,059	State
In-kind and local	$368,261	$118,261	Local
National Fish and Wildlife Foundation	$220,469	$180,703	Federal
Total	**$11,294,693**	**$9,272,859**	

Source: Tillamook County, January 2021

[a] Restoration spending includes all expenditures on goods and services for SFC projects. It excludes unspent funds and the cost of land and easements.

be summed together to produce the total effect for a given economic measure. In this analysis, we focus on key economic measures **output and employment**. These economic effects and measures are defined below, with descriptions provided to clarify how these effects and measures are used within the context of this project.

- ***Direct effects*** – The change in expenditures and employment occurring in industry sectors.
  Details: In this project, direct effects reflect the immediate regional economic effects of restoration activities on employment and output. Direct output effects reflect the wetlands restoration expenditures incurred throughout the project. For example, wetlands restoration expenditures were incurred throughout the planning, design, and construction phases of the restoration project. Direct employment effects account for the number of workers hired to contribute directly to the wetland restoration efforts. For example, job types that were reported as being directly utilized for this project included engineers, construction workers, and administrative positions.
- ***Indirect effects*** –The inter-industry change in transactions when supplying industries respond to increased demand from directly affected industries.
  Details: Indirect economic activity arises because expenditures associated with wetlands restoration generate an increase in demand for local goods and services provided by connected industries. This in turn leads to additional jobs and economic output in these industry sectors. Indirect jobs and output were generated in the

industries that supplied the materials or services, such as gravel and sand that are inputs to the wetlands restoration efforts.

- ***Induced effects*** –The change in local spending resulting from income changes in the directly and indirectly affected industry sectors.
  Details: Induced effects account for the increased household spending on local goods and services resulting from income increases generated by the direct and indirect effects. For example, induced jobs and output are generated when increased wages of employees in directly and indirectly affected industries are spent at local businesses and necessitates the hiring of additional staff at those establishments.

- ***Total effects*** – This is the summation of direct, indirect, and induced effects for two key economic measures – Output and Employment.

Direct, Indirect, Induced and Total Effects are produced for output and employment. These are defined below.

- **Output –** Output is the value of production by industry in a calendar year. It can be described as gross annual revenues plus net inventory change.

- **Employment –** Employment is defined to include full and part-time annual jobs for employees and self-employed workers. The IMPLAN model estimates employment in terms of average annual employment.

To estimate the regional economic impacts of a change in spending, the first step is to identify the amount of the initial spending change (direct effect), delineated by expenditure category. The data used in this analysis were provided by Tillamook County. The County provided a brief description of each expenditure, the amount spent, and the source(s) of relevant funding. The SFC project combined $7.0 million funding from federal agencies with $4.3 million in matching funds. The federal agencies providing funding were FEMA ($3.2 million), NOAA ($2.7 million), FWS (0.8 million), and National Fish and Wildlife Foundation ($0.3 million). State-level support came from the Oregon Watershed Enhancement Board ($1.5 million), Oregon State Lottery Bonds ($1.1 million), and Oregon Business Development Department ($1.1 million). Other support was provided by the Loren Parks Foundation, City of Tillamook, and in-kind contributions by state and local agencies.

Spending change by expenditure category was linked to one of the 528 pre-loaded industry sectors in IMPLAN. All expenditure data was transferred into Excel spreadsheets with expenditures linked to the appropriate North American Industry Classification System (NAICS) codes. The NAICS is a standardized system used by federal statistical agencies to classify business establishments. The sector descriptions used in this analysis included: management consulting services; engineering and related services; environmental and technical consulting services; newly constructed non-residential structures. Each of these IMPLAN industry sectors have defined industry relationships that link this initial sectoral spending to other industry sectors, which enables the calculation of indirect effects. When interpreting the results, it is important to bear in mind that these calculations are based on average spending patterns across broad industries rather than the actual spending by SFC partners, contractors, and suppliers. The analysis is useful in showing the approximate nature and scale of economic impacts from the SFC project; small differences in employment and output are not necessarily significant.

The IMPLAN analysis does not include $0.1 million budgeted but unspent and $1.9 million spent on land and easements for the project (though it does include legal and other transaction costs associated with land purchases). Simple asset transfers, like land passing from one owner to another, do not directly impact production. As such, they do not directly impact employment or demand as estimated by IMPLAN's input-output model. The transfer of $1.9 million to local property owners may, however, indirectly lead to economic activity by boosting spending by the beneficiaries. One would expect a household receiving a windfall from selling land or an easement to spend a portion of that new income on goods and services. We model the potential induced demand impacts of a $1.9 million boost to local household income (based on spending patterns of Oregon households with incomes between $100,000 and $150,000) at the end of the following section.

Results: Direct, Indirect, and Induced Economic Impacts

The expenditures (i.e., direct output) are used in IMPLAN to calculate indirect and induced effects for employment and output. As shown in Table 2, the SFC wetlands restoration supported 156 jobs and $25.1 million in total economic output, in 2015 U.S. dollars. This includes the $9.3 million spent by project partners on restoration (direct effects), $6.1 million in indirect effects in industries supplying materials and services to organizations working directly on the project, and $9.6 million in induced effects arising from employees' spending on goods and services. This is equivalent to 39 jobs and $6.3 million in economic output supported for each of the four years of the project.

Appendix Table 2. Employment and Output Effects of SFC Restoration Spending

	National		**Oregon**	
Impact Type	**Employment (job-years)**	**Output (2015 USD)**	**Employment (job-years)**	**Output (2015 USD)**
Direct Effect	67.3	$9,280,543	61.2	$8,061,526
Indirect Effect	29.9	$6,124,554	17.6	$2,623,325
Induced Effect	59.2	$9,649,322	29.4	$3,962,507
Total Effect	**156.3**	**$25,054,418**	**108.2**	**$14,647,358**
Per year (4 years)	39.1	$6,263,605	27.1	$3,661,840

Most of the jobs and spending supported by the SFC project were in Oregon. Overall, SFC spending supported 108 jobs in the state and led to $14.6 million in economic output (see Table 2). Annually, it supported an average of 27 jobs and $3.7 million in Oregon spending. It is also useful to compare the initial investment to the total economic impact: the multiplier effect of the SFC project. This metric allows easy comparison of the economic activity produced by a set amount of money invested in different ways. The $9.3 million investment in SFC habitat restoration led to $25.1 million in output, a ratio of 1:2.70. In other words, the average dollar spent on the SFC project (which directly supported jobs and output) led to another $1.70 in economic impact from indirect and induced spending. This compares favorably to the multiplier estimated by a previous study of 47 federally funded restoration projects, which found a ratio of expenditures to total output of 1:1.69.[*]

As noted above, the base IMPLAN specification does not include $1.9 million spent on land and easements for the SFC project because changing ownership of an asset does not directly impact production. However, those sales may induce additional economic activity by boosting the sellers' household income. Table 3 models the impact of an additional $1.9 million in new household income, plus the employment and output effects of other SFC restoration spending. The direct and indirect effects are the same as in the base model, but estimated induced effects rise to $28.7 million ($7.2 million/year) nationally and $16.6 million ($4.1 million/year) in Oregon. The project supported an estimated 178 jobs (45/year) nationally and 122 jobs (31/year) in Oregon.

Appendix Table 3. Effects of restoration spending plus induced spending effects from land sales

Impact Type	**National**		**Oregon**	
	Employment (job-years)	**Output (2015 USD)**	**Employment (job-years)**	**Output (2015 USD)**
Direct Effect	67.3	$9,280,543	61.2	$8,061,526
Indirect Effect	29.9	$6,124,554	17.6	$2,623,325
Induced Effect	81.1	$13,256,914	43.6	$5,887,005
Total Effect	**178.3**	**$28,662,010**	**122.3**	**$16,571,857**
Per year (4 years)	44.6	$7,165,503	30.6	$4,142,964

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[*] Samonte, G.PB., P.E.T. Edwards, J.E. Royster, V.C. Ramenzoni, and S. Morlock. 2016. Socioeconomic Benefits of Habitat Restoration. U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-F/SPO-XXX, 73 p.