Examining the Effectiveness of Nonprofit Groups' Expenditures on Species Recovery: The Case of Pacific Salmon and Steelhead*

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Abstract

The effectiveness and efficiency of environmental NGOs in recovering endangered and threatened species is not well studied in current literature. This paper provides the first estimation of the effect of environmental NGOs on populations of a threatened species using data on Pacific salmon. We develop a two-way fixed effects identification strategy that leverages salmon's biological features and exploits substantial within watershed variation in spending and species abundance. Our results show that both NGO and government conservation spending have a positive impact on the abundance of these species. We combine our main results with non-market benefit estimates and show that the benefits of recovering Oregon Coast Coho salmon exceed the costs.

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1 Introduction

Environmental groups actively devote resources to threatened species recovery. For example, over the period 1954-2004 the Nature Conservancy spent $5.3 billion on land acquisition to promote biodiversity (Davies et al., 2010). Smaller regional and local groups, including conservation organizations, land trusts, and riverkeepers, play a significant role as well. They coordinate advocacy for conservation policies, file lawsuits to force government action on behalf of wildlife, lobby state legislatures, monitor wildlife populations and water quality, restore habitat, and work with local landowners to promote conservation. Local groups in our study area (Washington, Oregon, California, and Idaho) spent $80.5 million per year on average during the period 1995 - 2014.

Examining the impact of environmental non-governmental organizations' (NGOs) expenditures on species populations can help us assess the effectiveness of conservation efforts and the cost of species recovery, and to understand the role of NGOs in this process. However, the effectiveness of these efforts remains unclear and has not been subject to rigorous empirical assessment. Data limitations and the non-random nature of spending decisions have thus far precluded a rigorous analysis of the impacts of NGOs on threatened species (Langpap et al., 2018) . There is no centralized database of these organizations' expenditures on species recovery. Additionally, the impact of NGOs' efforts likely accumulates over time with durable habitat investments, and detailed population counts covering sufficiently long periods are not available for most species. Finally, the temporal and spatial scales of many ecosystems are too broad to be experimentally controlled (Butsic et al., 2017) .

This paper overcomes these challenges by combining data on threatened and endangered Pacific salmon and steelhead in the four states in our study area with information on expenditures by environmental NGOs and government resource management agencies located in the region. Distinct population segments of Pacific salmon and steelhead have been listed as endangered or threatened under the Endangered Species Act (ESA) over the last 30 years, and population counts are available for each segment. Leveraging the detailed population data and biological features of salmonids, we use a quasi-experimental approach for identification.

Environmental groups have actively advocated for Pacific salmon and steelhead by filing petitions and lawsuits to compel listing decisions (*Oregon Natural Resources Council, Inc. v. Kantor*, 1996; *Natural Resources Defense Council v. Kempthorne*, 2007; *WildEarth Guardians v. Jeffries*, 2019). They have also directly participated in planning and implementation of habitat restoration projects over several decades (NMFS, 2016). Their reported program expenditures reflect these advocacy and management efforts. Using these data, we examine whether NGO investments have increased salmon and steelhead abundance in the region. Further, we study the mechanism through which these efforts help salmon recover. We use our findings to conduct a cost-benefit analysis of recovering a specific population in a federally defined evolutionarily significant unit, Oregon Coast Coho salmon.

This paper makes contributions to two strands of literature.

First, it contributes to the economics literature on endangered species conservation. While both government agencies and NGOs invest substantial amounts on threatened and endangered species, to date the economics literature has only studied government expenditures (Ferraro et al., 2007; Kerkvliet and Langpap, 2007; Langpap and Kerkvliet, 2010; Miller et al., 2002; Gibbs and Currie, 2012; Moore et al., 2022). This literature in general finds a positive impact of government funding on discrete species status. However, we are not aware of any previous empirical studies that estimate the impact of NGOs. We fill this gap by estimating the effect of NGOs' expenditures on the abundance of threatened Pacific salmon and steelhead, using government expenditure as a control variable. This paper is also the first econometric analysis to use species abundance data to examine the effect of conservation efforts on species recovery; previous studies use discrete recovery status categories (Ferraro et al., 2007; Kerkvliet and Langpap, 2007; Langpap and Kerkvliet, 2010). Leveraging the detailed abundance data, we are able to combine our estimated marginal effects with a biological fish growth model to determine the total costs of recovering one particular species.

Second, the paper contributes to the literature on the relationship between nonprofits, especially environmental nonprofits, and the provision of public goods. The topic of nonprofits and public good provision has long been of interest (Kingma, 1989; Ribar and Wilhelm, 2002; List, 2011). There is a growing body of literature on the economics of environmental groups (see Grant and Langpap (2024) for a review). Sundberg (2006) analyzes the relationship between land trust membership and public goods generated by land conservation. Grant and Grooms (2017) examine the relationship between environmental group activity and regulatory inspections and compliance with the Clean Water Act. Grant and Langpap (2019) find that expenditures by environmental groups in a watershed improve water quality. This paper is the first to examine the impact of environmental group activity on endangered and threatened species.

The paper proceeds as follows. Section 2 provides background on Pacific salmon and steelhead and environmental groups. In section 3, we describe our data. Section 4 describes our empirical methodology and how it overcomes identification challenges. In section 5, we present our results, and in section 6 we use them to conduct a cost analysis of species recovery. Section 7 tests the robustness of our results. The final section (Section 8) summarizes and concludes.

2 Background

2.1 Pacific Salmon and Steelhead

This study focuses on three species of Pacific salmon and steelhead in the U.S. states of Washington, Oregon, Idaho, and California: Coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*Oncorhynchus tshawytscha*), and steelhead trout (*Oncorhynchus mykiss*). Each species is further divided into two or more Evolutionary Significant Units (ESU) to identify distinct population segments for listing under the U.S. ESA.[1] Figure 1 shows the distribution of the three species and corresponding ESUs in the Pacific Northwest region.

[1] An ESU is a population that is "substantially reproductively isolated from conspecific populations and represents an important component in the evolutionary legacy of the species" https://www.fisheries.noaa.gov/laws-and-policies/glossary-endangered-species-act.

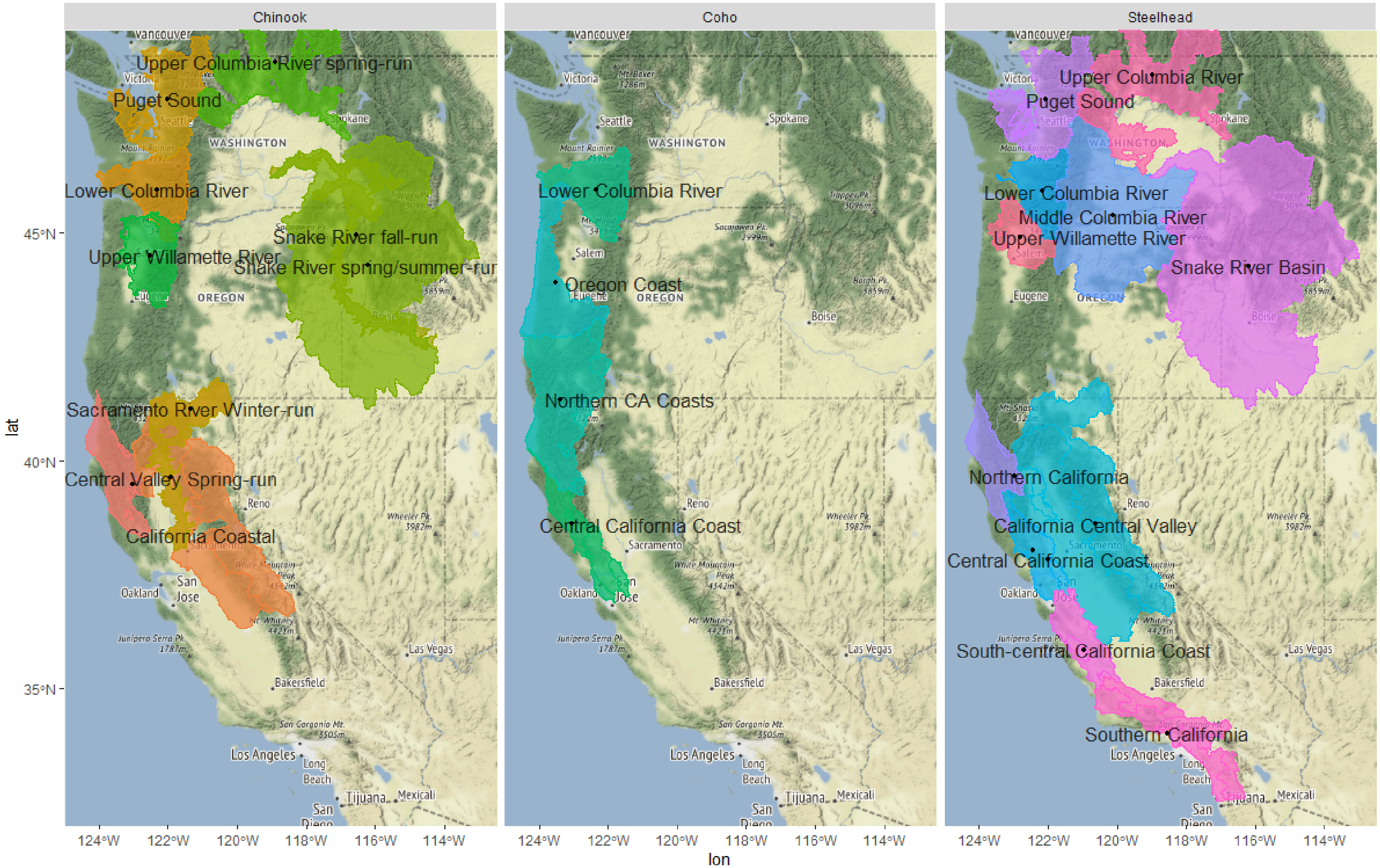

Figure 1. The Distribution of Endangered and Threatened Pacific Salmon and Steelhead

This figure shows the endangered and threatened Pacific salmon and steelhead ESUs categorized by species, namely Chinook, Coho, and steelhead. Each color represents a different ESU, and some species may have overlapping habitats (e.g., Snake River Chinook spring/fall run and Snake River Basin steelhead).

Pacific salmon and steelhead have unique life cycles that stretch from freshwater rivers into the ocean and back, which is essential for our identification strategy. After emerging from eggs, juvenile salmon stay in cool, slow-moving stream reaches. After spending one summer and winter in these rearing areas, juveniles migrate towards the ocean. Each species remains in the ocean for a different length of time before returning to their original spawning ground (Hansen and Quinn, 1998). Coho spend 18 months in the ocean, Chinook one to five years, and steelhead trout two to three years. Chinook and Coho die after spawning.

2.2 NGOs and Spatial Scale

Determining the relevant spatial scale is an essential element for the quasi-experimental design in this paper. Our choice of spatial scale relies on the fact that NGOs' activities likely affect anadromous fish populations through their impact on habitat quality in creeks, streams, and rivers, which are interconnected through water flow within a watershed. Hence, we account for factors impacting salmon habitat quality by using watersheds as the unit of observation. Furthermore, the groups in our data tend to operate at a local scale. For example, Trout Unlimited is a cold-water fisheries NGO that has multiple local chapters throughout the pacific coast states. Each chapter's activities occur near their local headquarters. We follow Grant and Langpap (2019) in using HUC8 watersheds as the unit of observation, which is the smallest area that a single NGO is likely to affect.[2]

2.3 Mechanism for Impact of Recovery Expenditures

Biologists have long held that habitat degradation and loss, hydroelectric dams and impoundments, harvest practices, and hatchery misuse (the four Hs) are the major factors contributing to salmon decline (Ruckelshaus et al., 2002). They have been the primary focus of salmon recovery research and conservation efforts.

Anecdotal evidence suggests that NGOs influence salmon populations mainly through the habitat channel. Individual NGOs improve habitat quality directly through restoration efforts, and indirectly through water quality monitoring and litigation.[3] The government's conservation efforts, on the other hand, have a broader

[2]The United States Geological Survey (USGS) uses a hierarchical system of hydrologic units to categorize watersheds. Each unit is assigned a unique Hydrologic Unit Code (HUC), named with 2-14 digits based on decreasing size class.

[3]Of 53 lawsuits directly advocating for Pacific salmon and steelhead since 2000, 33 are about habitat protection and 6 about dam removal or management.

scope. Salmon ESUs in our paper are listed as endangered or threatened under the ESA. Once listed, substantial resources are devoted to recovering species and their critical habitat, including investments in research, land acquisition, monitoring, propagation, and law enforcement. As a result, government recovery efforts are likely to improve salmon populations through all four channels.

3 Data

We collect data from multiple sources, constructing a panel of 85 watersheds in Washington, Oregon, California, and Idaho for the years 2000 to 2018. We focus on this time period because the 1990s saw exceptionally poor ocean conditions, which were widely considered the main cause for the low productivity of Pacific salmon and steelhead (Hare et al., 1999; Kilduff et al., 2015; Mantua et al., 1997; Ohlberger et al., 2016). We want to avoid the influence from extreme ocean conditions, which would overwhelm the effects we seek to measure.[4]

Salmon population data are collected by local agencies. They conduct annual surveys of streams and record the number of carcasses as the spawner population, since salmonids die after spawning. These counts are commonly used as an indicator of salmon abundance (Forest Science Project, 2000). The data are gathered and reported by StreamNet project, CalFish project, and State of Salmon in California project. The three projects collect and organize salmon abundance estimates from Oregon Fish and Wildlife Service, Washington Fish and Wildlife Service, Idaho Department of Fish and Game, and California Department of Fish and Wildlife. StreamNet data includes salmon abundance in Washington, Oregon, and Idaho. CalFish and State of Salmon in California provide similar data for California.

We aggregate the annual salmon abundance data from each stream to the HUC8 level. We use only the naturally spawning salmon population, and do not include salmon released from hatcheries.[5] The biological literature has found that hatchery-released fish can negatively impact the wild population (Hilborn and Winton, 1993; Waples, 1999; Myers et al., 2004; Jones et al., 2018) and recent research finds that the two populations are genetically different (Christie et al., 2016).

[4] We check for robustness to including data from the 1990s in section 7.

[5] Wild salmon and hatchery salmon can be distinguished by the presence or absence of the adipose fin. A hatchery fish has its adipose fin removed, while a wild salmon has an intact adipose fin. The StreamNet data include both wild salmon and hatchery salmon populations, but we only utilize the data on wild salmon population in this paper.

We use spawners per river mile, a measure commonly used in the biology literature, to measure salmon abundance. Using shapefiles of salmon distribution from the National Oceanic and Atmospheric Administration (NOAA), we divide the total salmon population by total river miles within each watershed.[6] Fish per river mile measures the density of species, taking into account the carrying capacity of the habitat. For this reason, it is preferred to total number of fish to quantify abundance.[7] Our dataset covers all species and their corresponding ESUs in the study region.

Our sample includes all the NGOs that could impact salmon through direct channels (i.e., monitoring) or indirect channels (i.e., restoring habitat), but does not include groups whose activities are unlikely to impact salmon. We select groups on the basis of their National Taxonomy of Exempt Entities (NTEE) codes, which are used by the Internal Revenue Service (IRS) to classify nonprofit organizations according to their focus areas. Specifically, we start with organizations with codes C (Environment) and D (Animal-Related), and then further narrow down our choice to the ten categories with activities most likely to directly impact salmonids and their habitats.[8] Then we collect individual NGOs' information from the National Center for Charitable Statistics (NCCS) Data Archive. We obtain each nonprofit group's Employer Identification Number (EIN), address, NTEE code, and annual total expenditures net of fundraising. Based on their addresses, we use the Google Map API to request the longitude and latitude of each organization. Finally, we adjust for inflation and aggregate annual expenditures to the HUC8 level. Our sample covers all 2,323 environmental and animal-related organizations in the four states.

An important control variable is government investment in endangered and threatened salmon. We obtain annual government expenditure data from the U.S. Fish and Wildlife Service Annual Expenditure Report. The report tracks all federal and state government expenditures towards every listed species in each ESU. As shown in Figure 1, a ESU is equivalent to a HUC4 or a HUC6, which is much larger than a HUC8. The expenditures include spending on "habitat management or acquisition, research, propagation (including surrogate species), recovery plan development or implemen-

[6]https://www.fisheries.noaa.gov/resource/map/critical-habitat-maps-and-gis-data-west-coast-region

[7]Results are robust to using total number of fish as well as a desnity-dependent model that includes lagged population count as a dependent variable. See Tables A1 and A2.

[8]The 10 NGO categories selected in this paper are: C01 (Alliances Advocacy), C20 (Pollution Abatement Control), C30 (Natural Resources Conservation Protection), C32 (Water Resources, Wetlands Conservation Management), C34 (Land Resources Conservation), C36 (Forest Conservation), D01 (Alliances Advocacy), D30 (Wildlife Preservation Protection), D31(Protection of Endangered Species), and D33 (Fisheries Resources).

tation, and mitigation".[9] In the case of salmonids, this includes expenditures on hatcheries. We adjust for inflation. To draw a fair comparison to NGO spending, we calculate the number of HUC8 watersheds within each ESU. Government spending at each ESU is divided by the number of HUC8s.

We also control for two key time- and spatial-varying limiting factors for salmon: dam removal and water temperature. Dam removal history comes from the USGS National Dam Removal Database, which includes final dam removal year and latitude-longitude of the dams.[10] We calculate the number of dams removed within each HUC8 each year.

Excessively high freshwater temperature is fatal for both young fish and spawners. We obtain water temperature data from the National Water Information System Water Quality Portal, which provides temperature readings from 360,000 monitoring locations across the four states.[11] To reduce the impact of outliers, we winsorize the data at the 99^{th} percentile. We also eliminate all non-routine hydrologic events, such as floods. For each HUC8, we calculate the annual average water temperature for all monitors located in the watershed.

Summary statistics for the data are shown in Table 1. Expenditures are cumulative; that is, NGO and government spending in time t include the corresponding cumulative conservation expenditures up to time t.[12]

Table 1. Summary Statistics

	Observation	Mean	SD	Min	Max
log(Fish Per Mile)	1365	0.191	(1.515)	-5.837	4.276
Cumulative NGO (Mill. $)	1365	8.799	(41.087)	0.000	648.228
Cumulative GOV (Mill. $)	1365	27.118	(33.116)	0.000	161.815
Water Temperature ($°C$)	955	11.960	(3.766)	1.408	25.200
No. Dams removed	1365	0.004	(0.060)	0.000	1.000

[9] https://www.fws.gov/library/collections/endangered-and-threatened-species-expenditures-reports

[10] https://data.usgs.gov/drip-dashboard/

[11] https://www.waterqualitydata.us/.

[12] The number of observations for water temperature is smaller than for other variables. We estimate our main models with and without controlling for water temperature, and our main conclusions do not change.

4 Empirical Model

The quasi-experimental design of this research builds off the scope of NGOs' activities and the biological features of salmonids. Since the NGOs in our data conduct their activities at a local scale, the impact of these local organizations is likely limited to areas no larger than the HUC8 watershed (Grant and Langpap, 2019). Conservation spending can impact the local freshwater ecosystem within the watershed where the spending occurs, but cannot affect ocean conditions, which are driven by larger scale global processes. The levels of NGO spending vary across watersheds and over the 18-year study period, and some watersheds never receive NGO expenditures. This large spatial and temporal variation in salmon abundance and NGO spending drives identification in our model. Figure 2 displays the substantial spatial variation in both salmon abundance and NGO spending, using 2015 as an example year. Government spending is not included in the figure because the scale of government spending is larger than the HUC8 level. Figure 3 shows the large temporal variation in salmon abundance, NGO spending, and government spending.

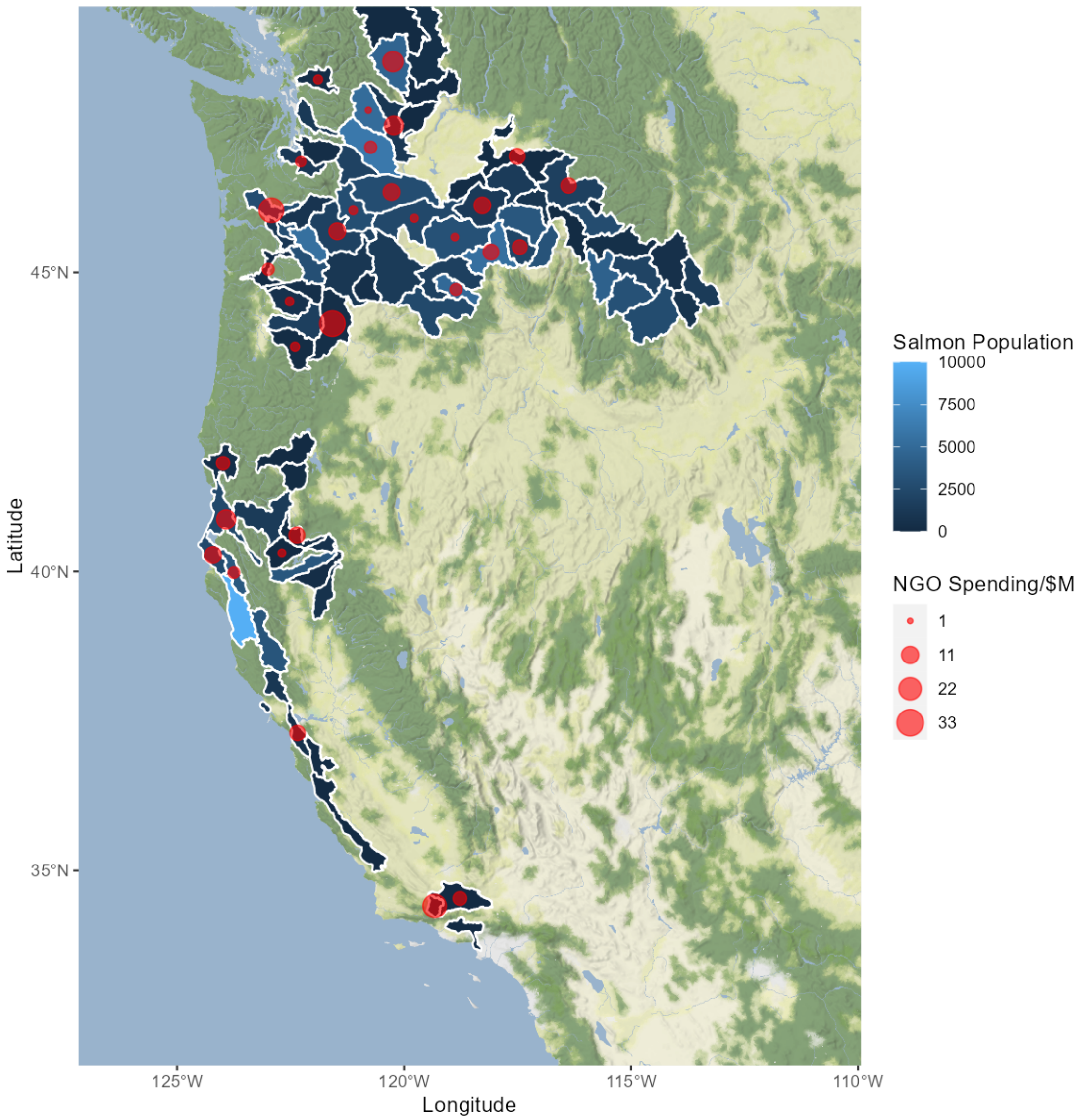

Figure 2. Spatial Variation of Salmon Population and NGO Spending

This figure displays the spatial variation of salmon population and NGO spending at the HUC8 level in 2015. Each HUC8 outlined by a white boundary is a unit of observation. The shade of each watershed indicates salmon abundance, and the size of the dots indicates the amount of NGO expenditures received in the watershed. Both salmon populations and NGO spending vary greatly across space.

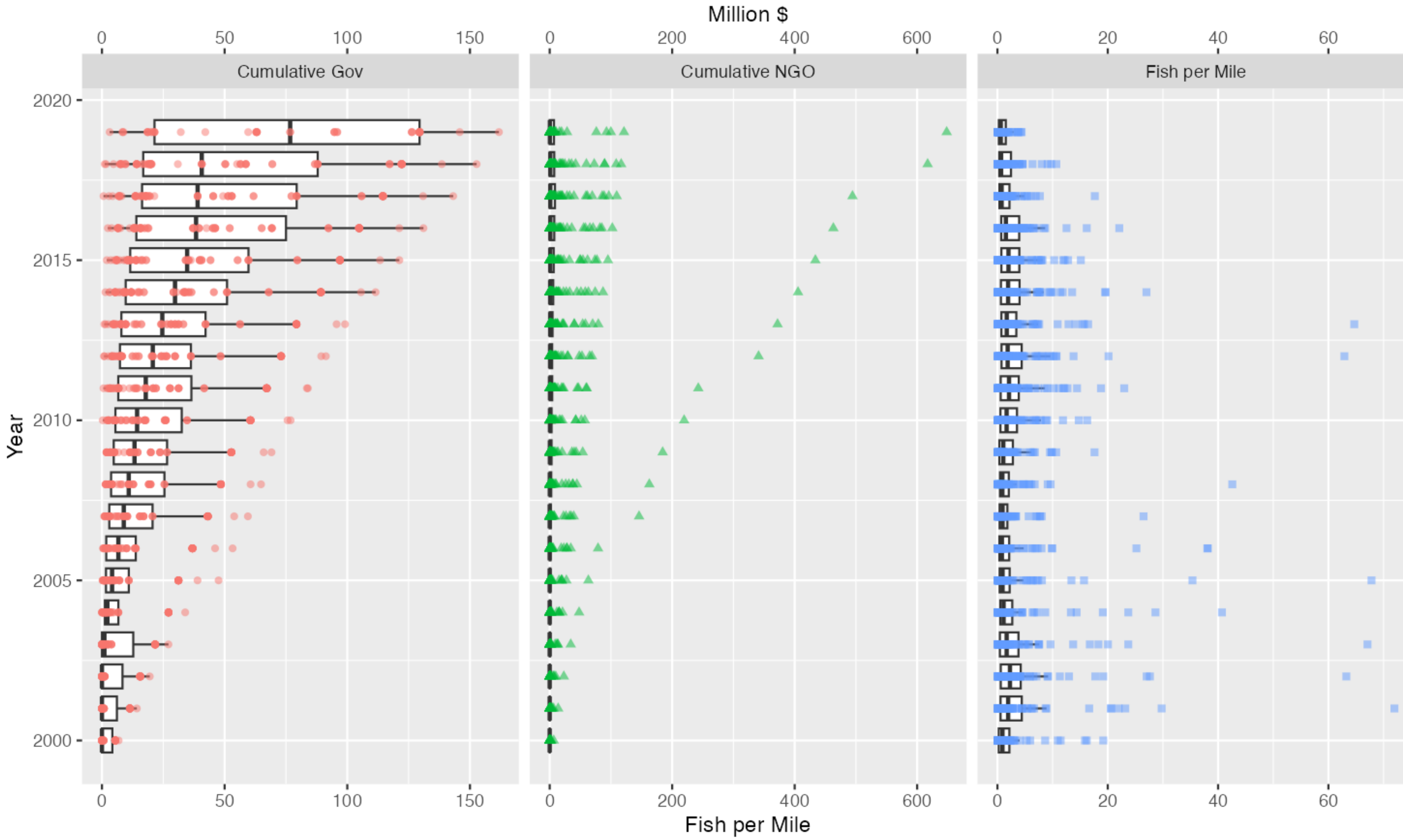

Figure 3. Temporal Variation of Salmon Population, NGO Spending, and Government Spending

This figure illustrates box plots of salmon population, NGO spending, and government spending per year. The three variables exhibit significant temporal variation.

A key feature of salmonid biology is that salmonids return to their native streams to spawn after spending several years in the ocean, and it is returning adult salmonid abundance that is measured, not abundance of juveniles. However, since NGO and government spending affect the local freshwater ecosystems rather than ocean conditions, we expect the impact of conservation spending on salmonid abundance to operate through its effect on juvenile fish rather than the returning adult salmon, which spend relatively little time in freshwater. Therefore, in our model we use lagged NGO and government expenditures, as well as lags of other controls, to capture the fact that conservation spending impacts juvenile fish, while adult abundance is measured. The use of lags also mitigates joint causation concerns, since lagged expenditures are not affected by current salmon population counts. Further, given that different species spend different amounts of time in the ocean, we estimate several versions of the model with varying lag times.

Another important consideration that guides our empirical specification is the fact that conservation expenditures targeting habitat are likely to result in improvements in durable natural capital. Therefore, a conservation investment made in year t may have a lasting impact on salmonid abundance in all years following year t. As a result, we measure conservation spending as cumulative expenditures in our model, starting in the year 2000.

Finally, we use watershed fixed effects to control for time-invariant and spatially-varying factors, such as current and historical land use practices (e.g. splash dams) that can have long-term impacts on salmon abundance (Steel et al., 2017). We use year fixed effects to control for time-varying and spatially-invariant factors, the most important of which is ocean conditions in the Pacific. We explicitly control for dam removal and water temperature because they impact salmon survival and vary across both time and space.

Our main two-way fixed effects model is:

$$\begin{aligned} log(Salmon_{it}) = \alpha_0 + \alpha_1 NGO_{i,t-m} + \alpha_2 GOV_{i,t-m} \\ + \alpha_3 Water_{i,t-m} + \alpha_4 Dam_{i,t-m} + \mu_i + \nu_t + \epsilon_{it} \end{aligned} \quad (1)$$

where $Salmon_{it}$ is the spawner population per river mile in watershed i and year t, $NGO_{i,t-m}$ is the cumulative expenditure (million dollars) of all the NGOs in watershed i up to year $t-m$, $GOV_{i,t-m}$ is government cumulative expenditures on listed ESUs within watershed i up to year $t-m$.[13] $Water_{i,t-m}$ is the annual average water temperature in the watershed. $Dam_{i,t-m}$ is the number of dams removed in the watershed i in year $t-m$. μ_i are watershed fixed effects, ν_t are year fixed effects factor, and ϵ_{it} is the error term.

5 Results

We estimate parameters in model 1 with different lag lengths ($m = 1, 2, \ldots, 5$). Table 2 displays our results. Standard errors are clustered at the watershed level. Estimated coefficients suggest that NGO spending has a positive and statistically significant impact on salmon populations for all the lag specifications considered. The coefficients of cumulative NGO spending indicate that a one million dollar increase in cumulative NGO expenditure in a HUC8 watershed will increase that watershed's salmon spawner population by 0.29% to 0.42%. However, a million dollar increase is not an empirically relevant change for this variable. NGO spending increases by 7.7%, or $5.38 million (given a mean of $70 million) per year on average during the study period. We therefore assess the impact of NGO spending by considering the effect of a $5.38 million increase in expenditures. This change leads to increases in a salmon population growth of 1.56% - 2.26%. While these numbers are nominally small, we note that during the study period salmon abundance increased by 3.6% per year on average. Therefore, our results suggest that 43% to 63% of the observed annual salmon abundance increase from 2000 to 2018 is attributable to NGO spending.

[13] We use the logarithm of fish per mile because the variable is right-skewed. We drop 22 observations with zero fish per mile, but verify robustness to log-like transformations and follow Chen and Roth (2024) to avoid sensitivity to scale. Results available upon request.

Table 2. Main Results

log(fish per mile)	m=1	m=2	m=3	m=4	m=5	m=1	m=2	m=3	m=4	m=5
$NGO_{i,t-m}$	0.0031***	0.0035***	0.0036***	0.0039***	0.0044***	0.0029***	0.0034***	0.0037***	0.0039***	0.0042***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$GOV_{i,t-m}$	0.0144***	0.0135***	0.0113***	0.0099**	0.0103***	0.0138***	0.0113***	0.0102***	0.0089**	0.0097**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
$Dam_{i,t-m}$	-0.0229*	-0.0051	-0.0182	-0.0013	-0.0073	-0.202**	-0.706	-0.446	-0.168	0.0674
	(0.012)	(0.015)	(0.014)	(0.013)	(0.011)	(0.097)	(0.483)	(0.381)	(0.329)	(0.061)
$Water_{i,t-m}$	-0.112	-0.645	-0.370	-0.138	0.0475	-	-	-	-	-
	(0.154)	(0.480)	(0.400)	(0.339)	(0.123)					
HUC8 FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Obs.	854	902	945	965	955	1163	1237	1316	1365	1365
AVG ME NGO	0.012	0.013	0.013	0.012	0.014	0.011	0.013	0.013	0.014	0.015
AVG ME GOV	0.055	0.049	0.039	0.032	0.032	0.053	0.043	0.036	0.031	0.034

[1] $* \ p < 0.10, \ ** \ p < 0.05, \ *** \ p < 0.01$.

[2] The last two rows report the average marginal effects of NGOs' and government expenditures.

As an alternative way to gauge the practical impact of NGO expenditures, we assess their effect on watersheds that did not receive any NGO investment during our entire study period. There are 23 such watersheds in our data (27% of the total 85 watersheds). For these watersheds, we first calculate predicted counts of fish per mile when NGO expenditures are zero. Next, we calculate fish per mile for a counterfactual scenario in which these watersheds receive the average NGO spending every year. Finally, we calculate the difference in predicted fish per mile for every year. We find that, on average, salmon populations would increase by 3.4% per year in these control watersheds. Again, relative to an average annual increase of 3.6% between 2001 and 2018, these effects are meaningful.

Government spending on conservation programs also has a positive and statistically significant impact – in particular, a $1 million increase in government spending raises salmon abundance by 0.89% to 1.38%. The magnitude of the impact of government spending is larger than that of NGO spending. This is probably because, as discussed in section 2, government spending is more directly tied to listed species and government recovery efforts impact salmon populations through a broader set of channels, including habitat restoration, propagation, monitoring, and law enforcement. On the other hand, NGO expenditures, as measured in our data, are less specifically focused on salmon, and likely only have direct impact through habitat maintenance and restoration. The average annual increase in government spending over our period 2000-2018 is $15.23 million/year, which would lead to a growth of salmon abundance by 14% to 21% per year.

Figure 4 displays fitted fish population trend and simulated trends representing counterfactual scenarios without government and NGO expenditures. The fitted population shows great variation over years.[14] Abundance dropped to 2.02 fish per mile in 2018, which is lower than abundance in the year 2000 (5.02, -60%). However, abundance would have decreased further below the year 2000 level, to 1.94 fish per mile (-61%) without NGO expenditures, 1.32 fish per mile (-74%) without government spending, and 1.26 fish per mile (-75%) without any expenditures. Our results therefore suggest that NGO and government investment helped prevent a steeper decline in salmonid abundance which, against a backdrop of negative ocean conditions, would have occurred in the absence of such spending.

[14]The observed salmonid abundance between 2000 and 2018 also exibits notable fluctuations. This is largely attributable to changes in ocean conditions, which is normal for anadromous fish (Beamish and Bouillon, 1993; Malick et al., 2015; Burke et al., 2013; Stout and Williams., 2012).

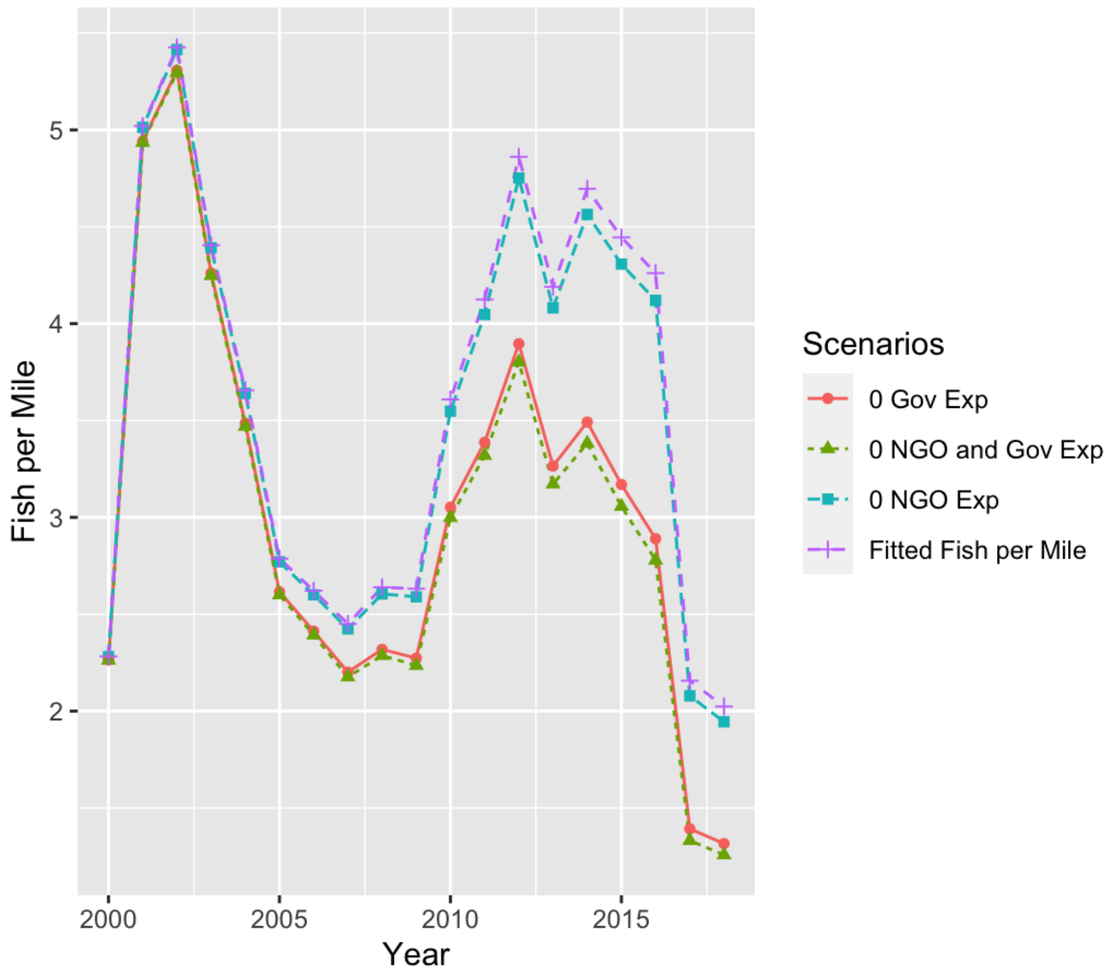

Figure 4. Fitted Fish/Mile and Predicted Fish/Mile without Spending by Year
This figure shows fitted average fish per mile across watersheds by year (both NGO and goverment invest) and predicted fish per mile when only NGOs invest (0 Gov Exp), when only the government invests (0 NGO Exp), and when neither NGOs nor the government invest (0 NGO and Gov Exp). We used the smearing estimates of the sum of linear prediction and predicted sample fixed effects to avoid wild swings of fixed effects during prediction.

6 Cost-Benefit Analysis

NGO and government expenditures reflect the costs of recovering species.[15] Our main model estimates the bio-physical impact of those investments on salmon abundance. In this section, we illustrate how these estimated impacts can be used to calculate the total cost of achieving given salmon recovery goals. Then, combining this estimated

[15]This does not include opportunity costs, such as the value of output forgone due to ESA-related restrictions.

conservation cost with previously estimated benefits of recovering a specific threatened salmon species (Lewis et al., 2019), we can estimate the net benefits of salmon recovery efforts.

We use Oregon Coast (OC) Coho salmon as an example, leveraging Lewis et al.'s (2019) estimated non-market values of different recovery scenarios involving this ESU. Using a choice experiment survey sent to the general population of the greater Pacific Northwest, they estimate benefits under different scenarios based on alternative conservation goals involving the species status (threatened or recovered), increase in abundance relative to a baseline, and speed of abundance increase. For comparison purposes, we use the same baseline and conservation goals as Lewis et al. (2019). Our calculation proceeds as follows. First, we calculate the number of returning fish necessary to achieve a specific recovery goal. Next, we use our estimated coefficients to calculate the investment required to ensure this number of returning fish. Finally, we compare total costs of achieving a given population goal with the benefit estimates from Lewis et al. (2019).

The baseline is 150,000 fish, which is the average OC Coho abundance from 1994 to 2015. The State of Oregon's Oregon Coast Coho Salmon Conservation Plan (2007) specifies a conservation goal of 525,000 fish to be achieved in 50 years' time. The Lewis et al. (2019) study built their choice experiment around this official conservation goal, but also included smaller returning fish goals of 250,000, 325,000, and 375,000 fish in the experimental design to estimate willingness-to-pay for abundance. We calculate the number of returning fish required each year to achieve these goals using a beta function (Yin et al., 2003), which was also used by Lewis et al. (2019) in their choice experiment:

$$RetFish(t) = RetFish(0) + (RetFish(T) - RetFish(0))(1 + \frac{T-t}{T-\tau})(\frac{t}{T})^{\frac{T}{T-\tau}} \quad (2)$$

Here $RetFish(t)$ is the number of returning adult fish in time t. The baseline fish abundance, $ReturnFish(0)$, at time 0 is 150,000 fish, T is 50 years and is based on the timeframe in the State of Oregon's Oregon Coast Coho conservation plan, and $RetFish(T)$ are the three different abundance scenarios (325,000, 375,000, or 525,000 fish). We divide the baseline fish abundance and conservation goals by total river miles of OC Coho habitat to calculate returning fish per mile. The parameter τ determines the path of salmon abundance growth. The value $\tau = 13.7$ defines the fast path, whereas $\tau = 38.7$ corresponds to the slow path. Figure 5 depicts the number of returning fish per mile for the two time path scenarios. A fast path has a relatively rapid increase in the number of returning fish at the beginning of the period, while a relatively stable increase in returning fish is shown in the slow path. Different salmon growth paths will result in different investment trajectories.

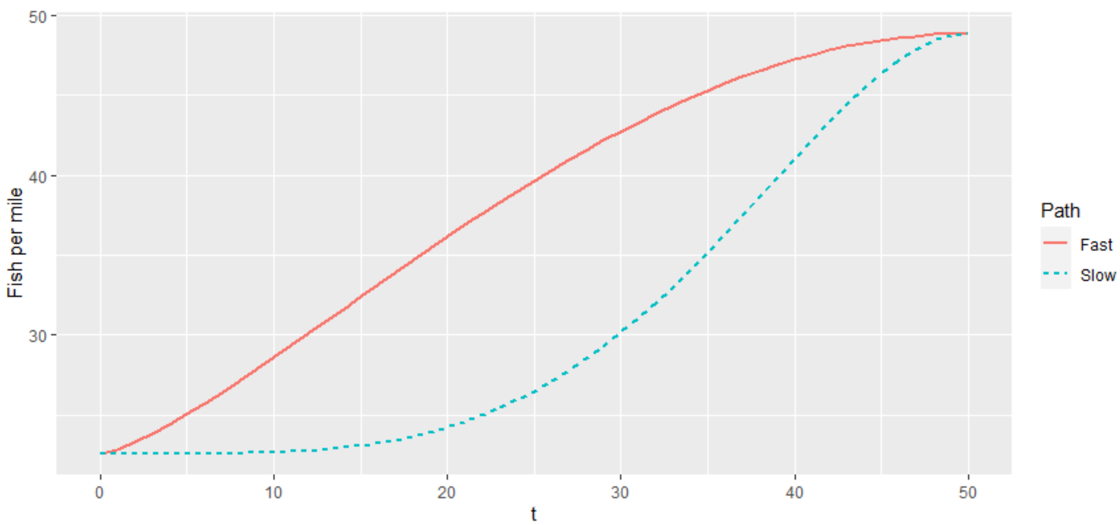

Figure 5. Salmon Population Growth Path with Different Growth Rates
This figure displays how τ determines the salmon population growth path.

The beta function (Eq. 2) determines the required increase in number of fish each year to reach the overall recovery goal. The estimated marginal effects for cumulative NGO and government spending from Table 2 allow us to estimate the increase in fish abundance in response to additional investments of \$1 million, for instance 0.014 and 0.031 fish/mile. Since the estimated marginal effect of NGO spending is smaller than that of government spending, we define a lower bound of total costs to occur when both government and NGOs invest in species recovery, and we define an upper bound for costs to occur when only the government invests. Equation 3 shows how to calculate each year's lower bound investments $INVST_t^l$ and Equation 4 shows how to calculate each year's upper bound investments $INVST_t^u$. ME_NGO is the estimated average marginal effects of NGOs expenditures on salmon population and ME_GOV is the estimated average marginal effects of government' expenditures from Equation 1. To be conservative, we use the smallest estimated marginal effects to represent the impact of spending (0.014 for NGO spending and 0.031 for government spending, from the main model with a 4-year lag), which will yield relatively high estimates of total costs.

$$INVST_t^u = \frac{RetFish(t+1) - RetFish(t)}{ME\_GOV} \tag{3}$$

$$INVST_t^l = \frac{RetFish(t+1) - RetFish(t)}{ME\_NGO + ME\_GOV} \tag{4}$$

Figure 5 illustrates the number of returning fish and the expenditures needed each year to achieve an abundance goal of 325,000 fish for the fast and slow growth paths. The figure also shows corresponding expenditures for two scenarios: when only the government invests (upper bound) and when both NGOs and government invest (lower bound). A fast recovery requires higher amounts of investment at the beginning of the 50-year period, while a larger investment is needed at the end of the period for a slower recovery.

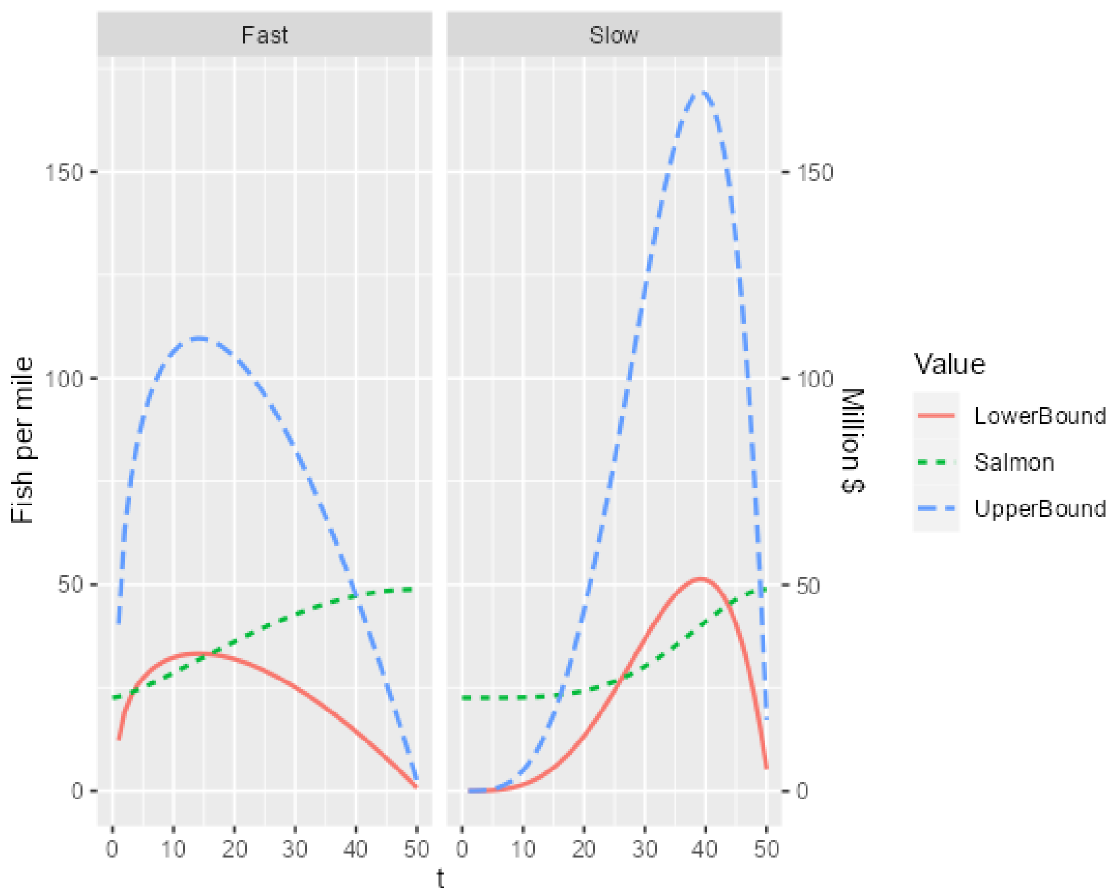

Figure 6. Slow Path and Fast Path of Investments to Recover OC Coho
This figure displays the trajectories of the upper-bound and lower-bound costs needed to achieve a population goal of 325,000 fish.

Finally, the present value of lower bound total costs, $TotalINVST_t^l$, and upper bound total costs, $TotalINVST_t^u$, over the course of 50 years can be obtained by using Equation 5 and Equation 6. We use a 2.1% discount rate, δ, for future salmon, which is estimated by Lewis et al. (2022) for the same species.

$$TotalINVST_t^l = \sum_{t=1}^{50} \frac{1}{(1+\delta)^t} INVST_t^l \tag{5}$$

$$TotalINVST_t^u = \sum_{t=1}^{50} \frac{1}{(1+\delta)^t} INVST_t^u \tag{6}$$

Table 3 lists the present value of the total costs and total benefits for each recovery scenario. Table 3 shows that, even when using the smallest estimated impacts, costs are much lower than benefits for each recovery scenario, while the highest net present value occurs in the scenario with a fast rate of change to the terminal (50-year) abundance of 525,000 returning spawners. This suggests that, at least for this ESU, combined NGO and government recovery investments generate positive net social benefits. Additionally, the fast recovery trajectory requires larger investments in earlier periods when compared to the slow recovery trajectory. Therefore, the present value of total costs for fast recovery is higher than for slow recovery.

Table 3. Costs and Benefits of Different Recovery Scenarios for OC Coho

Salmon Abundance (Baseline:150,000)	Growth Rate	PVTC [NGO+Gov, Gov]	PVTB[1]	PVNB [NGO+Gov, Gov]
325,000		[0.29, 0.43]	10.59	[10.30, 10.16]
375,000	Slow	[0.38, 0.55]	11.13	[10.75, 10.58]
525,000		[0.63, 0.91]	12.80	[12.17, 11.89]
325,000		[0.40, 0.58]	12.77	[12.37, 12.19]
375,000	Fast	[0.51, 0.74]	12.96	[12.45, 12.22]
525,000		[0.85, 1.24]	13.32	[12.47, 12.08]

[1] Lewis et al.(2019) report annual benefits over a ten-year period. To facilitate comparison, we calculate the present value of the total benefits for the entire ten-year period.

7 Robustness Checks

In this section we further examine the mechanisms through which NGO spending can influence salmon recovery.

7.1 The Role of Short-Term vs. Long-Term NGO Spending

The scope of NGOs' activities suggests that their efforts mainly impact salmon abundance through the habitat restoration channel. Our main model shows that lagged cumulative expenditures have a statistically significant effect on salmon abundance, which suggests that lagged spending impacts salmon over the long-term. In this section we further examine the hypothesis that NGO spending improves salmon recovery by increasing the stock of durable natural capital that enhances salmon habitat, and that the cumulative nature of NGO expenditures thereby has a long-term impact on salmon.

We separate cumulative expenditures into two parts: non-cumulative expenditure at year $t-m$ and expenditures that are accumulated until the preceding year, $t-m-1$, to avoid double-counting of expenditures and to capture two different effects. Non-cumulative expenditures in year $t-m$ capture the impacts of efforts that have short-term effects, such as reducing salmon harvest. Cumulative expenditures on the other hand capture impacts of activities that have long-term effects, such as restoration of durable habitat in riparian zones.

Results, shown in Table A3, confirm our hypothesis and provide evidence that lagged NGO spending affects salmon abundance primarily by increasing the amount of durable natural capital that enhances freshwater habitat. For contemporaneous expenditures and all lag lengths ($m = 1, \ldots, 3$), the short-term effect is not statistically significant for NGOs, while the long-term effects are significant. Government spending, which is more species-specific and larger, improves salmon abundance in both the short term and long term.

7.2 Depreciation of Investments

Our cost-benefit analysis is based on the assumption that NGO spending will generate a durable effect on the salmon population because it improves the quality of habitat. For instance, activities such as planting trees will have long-lasting benefits for salmon. In this section, we further test whether the effect of NGOs' expenditures changes over time. To do so, we run two sets of models and compare their results. In the first set of models NGO expenditures are accumulated over 5 years, whereas in the second set they are accumulated over 10 years. If the coefficient for the five-year accumulation of expenditures is the same as the coefficient for the ten-year accumulation of expenditures, it suggests the effect of NGO spending does not depreciate over time.

We run each set of models for lags $m = 1 - 5$. For each lag, we test whether the coefficients for 5-year cumulative NGO spending and 10-year cumulative NGO spending are statistically different. Results for the model without water temperature controls are shown in Table A4.[16] We fail to reject the null hypothesis that the coefficients are equal for $m = 1, 2, 3$. This suggests that NGO investments do not depreciate during time periods corresponding to lags up to 3 years. Along with the results from the preceding section (7.1), this provides evidence that habitat restoration achieved through NGOs' conservation efforts generates durable natural capital that provides a steady stream of long-run benefits for salmon.

7.3 Spillover Effects

The positive impact of NGO spending in one watershed has the potential to spill over and affect salmon abundance in other watersheds through the river network because at least some of the expenditures are on habitat restoration.[17] For example, if spending in an upstream watershed is successful in cooling river temperatures, then those same benefits should impact river temperatures in downstream adjacent watersheds. If there is such a spillover effect, our results provide a lower bound estimation of the impact.

We leverage the hierarchy of the HUC system to test for this spillover effect. We use HUC8 watersheds as the unit of observation in the main model. A HUC6 watershed is a larger geographical unit that can be subdivided into multiple smaller HUC8s. Additionally, a HUC6 can be nested within a larger unit, the HUC4. HUC8s that are contained in the same HUC6 or HUC4 share the same river system. Based on this hierarchy, we aggregate spending in HUC8 watersheds to the higher watershed level, HUC6 or HUC4.[18] If spillover effects from other HUC8s in the same river network exist, then variables representing spending from other HUC8s within the same HUC4 or HUC6 should be included in our main model from Equation 1. We test for spillover effects of NGO spending by estimating two alternative versions of Equation 1 that include, in addition to the original variables, NGO spending in the larger watershed (HUC4 or HUC6) net of expenditures in the HUC8 watershed. If there are spillover effects, expenditures in the larger watersheds would have an impact

[16] Results including water temperature are similar and available upon request.

[17] There are potentially other spillover effects, such as habitat restoration benefiting other species that share the habitat with salmon. However, this section focuses solely on spatial spillover effects.

[18] https://water.usgs.gov/GIS/huc.html

on salmon counts. As shown in Table A5, we do not find statistically significant spillover effects within the same HUC4 or HUC6.

7.4 Joint Causation

One concern with our identification strategy is the potential joint causation between NGO spending and fish populations, which may not be fully addressed by fixed effects. For example, if the salmon population drops, NGOs might increase their spending. This endogeneity would bias our results downwards. However, anecdotal evidence suggests that salmon population trends rarely influence spending because salmon populations often fluctuate wildly. For instance, in our sample the salmon population in a given watershed can increase from 0 to 400 fish per mile from one year to the next. NGOs typically do not invest based on these unpredictable trends. In this section, we empirically verify that salmon population trends do not drive NGO spending by estimating the following model:

$$NGO_{it} = \beta_0 + \beta_1 log(Salmon_{i,t-m}) + \beta_2 Contribution_{i,t-c} + \beta_3 GOV_{it} + \mu_i + \nu_t + \epsilon_{it} \tag{7}$$

The dependent variable, NGO_{it}, is the non-cumulative expenditure of NGOs in watershed i in year t. The main variable of interest is the fish population, $Salmon_{i,t-m}$. We test for effects of both contemporaneous and lagged salmon counts. We also control for contributions received by the NGOs and government expenditures, and include HUC8 and year fixed effects. Results are shown in Table A6. While these estimates cannot be interpreted as causal, we find no evidence of correlation between preceding salmon counts and NGO expenditures.[19]

7.5 Additional Years of Data

Our salmon population and spending records date back to 1990. However, in our main model we used only 2000-2018 data because ocean conditions caused the salmon population to be historically low in the 1990s, and spending was low during that time. We assess how our results are impacted by using the full data set, and examine if the effects of NGO and government expenditures were different during and after the 1990s. To do so, we estimate the model using data from 1990 to 2018, and interact

[19]These results are robust to including data from the 1990s as well as to using a three-year average of the fish population to allow for a response to longer-term changes.

cumulative NGO and government expenditures with a dummy variable that indicates whether the observation is from the period 1990 - 1999.

Results are shown in Table A7. Estimates indicate that the main result of a positive impact of nonprofit expemditures on salmon holds when we include the additional data. Furthermore, the coefficients on the interaction terms suggest that the effect of NGO expenditures on salmon counts was larger in the 1990s than in the rest of the study period. The effect of government expenditures, on the other hand, is not statistically significant during that decade.

8 Conclusion

This paper examines the effectiveness of NGOs' conservation efforts in recovering endangered and threatened species, using the case of Pacific salmon and steelhead along the Pacific coast of the United States. By exploiting salmon and steelhead's biological features, we estimate the impacts of cumulative NGO investments up to the time that salmon are juveniles in freshwater on the abundance of returning adult salmon. Our estimates yield several key findings.

First, we find strong evidence that NGO conservation efforts have a positive impact on salmon abundance, though the magnitude of the impact of NGOs' spending is smaller than that of government spending. However, the effect of NGO expenditure is meaningful in terms of the underlying annual rate of change of salmon abundance. Our results also suggest that NGO and government spending between 2000 and 2018 helped prevent a decline in salmonid abundance that would have occurred in the absence of such spending.

Second, our results provide a framework for calculating the costs of recovering Pacific salmon and, in combination with previously estimated non-market benefits (Lewis et al., 2019), for estimating the net present value of species recovery efforts. We illustrate the ability of our model to contribute to such a full cost-benefit analysis using the case of Oregon Coast Coho salmon. For this ESU, we estimate a positive net present value of all recovery scenarios considered. Even if we assume that only NGOs invest in OC Coho, the net present value of recovery efforts remains positive.

Third, our analysis reveals the mechanism by which NGO conservation efforts help promote salmon recovery. Based on the characteristics of these organizations and anecdotal evidence, we hypothesize that their expenditures mainly increase salmon abundance by improving their habitat. Multiple robustness checks support our hypothesis. This revealed mechanism highlights the importance of restoring habitat for the recovery of endangered and threatened species. Additionally, Pacific salmon and steelhead share habitat with many other species. Improving salmon habitat can also be beneficial to other species.

Further research on this topic would benefit from more detailed expenditure data. We use total annual NGO expenditures. A better understanding of the mechanism could be possible if expenditure data could be further categorized by species or usage. Government expenditure data is species-specific, but its usage is only categorized by land acquisition and other costs. With more specific expenditure data, a similar analysis could potentially provide guidance for targeting the most efficient expenditures, and thereby for better planning of species recovery.

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Appendix

Appendix Table A1. Total Number of Salmon as Dependent Variable

Total Number of Salmon	m=1	m=2	m=3	m=4	m=5	m=1	m=2	m=3	m=4	m=5
$NGO_{i,t-m}$	3.713**	3.9416**	4.2031**	3.8072**	3.6902**	3.337*	3.638*	3.786*	3.974*	4.277**
	(1.728)	(1.850)	(2.087)	(1.772)	(1.510)	(1.912)	(2.125)	(2.111)	(2.029)	(2.098)
$GOV_{i,t-m}$	24.529***	21.5595**	21.2697**	16.5283*	14.8161*	19.832**	16.203**	13.919*	13.323*	14.521*
	(9.154)	(8.963)	(10.488)	(9.312)	(7.601)	(7.670)	(7.987)	(7.846)	(7.645)	(7.625)
$Dam_{i,t-m}$	-220.650	-179.3064	-106.2332	-624.1151	-263.8601	-326.416	-280.163	-150.058	-536.520	-204.375*
	(383.463)	(363.319)	(464.244)	(642.768)	(245.266)	(277.968)	(248.579)	(412.056)	(620.295)	(113.100)
$Water_{i,t-m}$	-48.964**	-21.9746	8.1303	22.7797	-10.3901	-	-	-	-	-
	(23.439)	(20.485)	(19.079)	(20.010)	(13.043)					
HUC8 FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	863	911	954	974	963	1182	1258	1338	1387	1387

Appendix Table A2. Density Dependence Model with Log (*Fish per Mile*) as the Dependent Variable

log(Fish per Mile)	m=1	m=2	m=3	m=4	m=5	m=1	m=2	m=3	m=4	m=5
$NGO_{i,t-m}$	0.005***	0.007***	0.008***	0.009***	0.009***	0.005***	0.006***	0.007***	0.009***	0.008***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
$GOV_{i,t-m}$	0.015***	0.017***	0.023***	0.029***	0.036***	0.009**	0.016***	0.022***	0.031***	0.042***
	(0.004)	(0.004)	(0.005)	(0.007)	(0.009)	(0.004)	(0.004)	(0.006)	(0.007)	(0.009)
Fish per	0.024*	0.005	-0.000	-0.002	0.004	0.042**	0.014	0.006	-0.001	0.003
$Mile_{i,t-m}$	(0.012)	(0.006)	(0.006)	(0.005)	(0.005)	(0.017)	(0.011)	(0.009)	(0.005)	(0.005)
$Dam_{i,t-m}$	-0.287	-0.759*	-0.234	-0.676***	-0.065	-0.469*	-0.775**	-0.291	-0.687**	-0.046
	(0.258)	(0.416)	(0.511)	(0.230)	(0.179)	(0.253)	(0.386)	(0.477)	(0.288)	(0.149)
$Water_{i,t-m}$	-0.023*	-0.007	-0.009	0.019	0.005	-	-	-	-	-
	(0.013)	(0.015)	(0.018)	(0.018)	(0.014)					
HUC8 FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	799	758	661	551	430	1185	1030	879	730	590

Appendix Table A3. Non-Cumulative Expenditures and Cumulative Expenditures

$Log(FishPerMile)_{it}$	m=1	m=2	m=3	m=4	m=5	m=1	m=2	m=3	m=4	m=5
$NGO_{i,t-m}$	4E4	0.006	-0.011	0.004	0.020	-0.001	0.016	0.022	0.037	0.030
	(0.016)	(0.024)	(0.029)	(0.028)	(0.028)	(0.023)	(0.035)	(0.041)	(0.034)	(0.030)
$GOV_{i,t-m}$	-0.019	-0.002	0.006	-0.020	-0.024	-0.020	-0.030	-0.020	-0.044	-0.036
	(0.026)	(0.024)	(0.027)	(0.028)	(0.032)	(0.031)	(0.035)	(0.032)	(0.032)	(0.033)
$CMLT\ NGO_{i,t-m-1}$	0.004***	0.005***	0.006**	0.006**	0.005**	0.003***	0.005***	0.005*	0.004	0.004
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)
$CMLT\ GOV_{i,t-m-1}$	0.017***	0.015***	0.012***	0.012***	0.012***	0.016***	0.014***	0.012***	0.012***	0.012***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)
$Dam_{i,t-m}$	-0.092	-0.647	-0.388	-0.130	0.079	-0.185*	-0.688	-0.428	-0.123	0.108*
	(0.163)	(0.481)	(0.408)	(0.346)	(0.131)	(0.103)	(0.479)	(0.384)	(0.340)	(0.064)
$Water_{i,t-m}$	-0.025**	-0.006	-0.018	-0.002	-0.009	-	-	-	-	-
	(0.011)	(0.015)	(0.014)	(0.013)	(0.011)					
HUC8 FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	854	902	945	965	955	1163	1237	1316	1365	1365

Appendix Table A4. Depreciation of Spending

log(Fish Per Mile)	m=1		m=2		m=3		m=4		m=5	
	j=5	j=10	j=5	j=10	j=5	j=10	j=5	j=10	j=5	j=10
$NGO^{j}_{i,t-m}$	0.011***	0.009***	0.013***	0.011***	0.015***	0.011***	0.017***	0.011***	0.017***	0.011***
	(0.004)	(0.002)	(0.004)	(0.002)	(0.004)	(0.002)	(0.003)	(0.002)	(0.004)	(0.002)
$GOV_{i,t-m}$	0.013***	0.014***	0.011***	0.011***	0.010***	0.010***	0.009***	0.009***	0.009***	0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$Dam_{i,t-m}$	-0.198	-0.211	-0.670**	-0.684**	-0.430	-0.442	-0.149	-0.162	0.076	0.064
	(0.359)	(0.358)	(0.331)	(0.329)	(0.333)	(0.332)	(0.341)	(0.340)	(0.375)	(0.373)
HUC8 FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	1163	1163	1237	1237	1316	1316	1365	1365	1365	1365
$Prob > \chi^2$		0.6518		0.6990		0.2407		0.0188		0.0255

j is the time length for which we accumulate NGO spending. We test whether the coefficients of $NGO^{j=5}_{i,t-,m}$ and $NGO^{j=10}_{i,t-,m}$ are statistically the same. If we fail to reject the null hypothesis of equality, the impact of spending does not change over time. p-values for the test are in the last row.

Appendix Table A5. The Spillover Effect of NGO Spending

$Log(FishPerMile)_{it}$	m=1	m=2	m=3	m=4	m=5	m=1	m=2	m=3	m=4	m=5
$NGO\_HUC8_{i,t-m}$	0.003***	0.003***	0.004***	0.004***	0.004***	0.003***	0.003***	0.004***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$NGO\_HUC4_{i,t-m}$	$-5e{-}4$	$-4e{-}4$	$-1e{-}4$	$+2e{-}4$	$+2e{-}4$	-	-	-	-	-
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)					
$NGO\_HUC6_{i,t-m}$	-	-	-	-	-	$-1e{-}5$	$+3e{-}4$	$+4e{-}4$	$+6e{-}4$	$+7e{-}4$
						(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$GOV_{i,t-m}$	0.013***	0.011**	0.010**	0.009**	0.010**	0.014***	0.012**	0.011**	0.010**	0.011**
	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.004)	(0.004)	(0.005)
$Dam_{i,t-m}$	-0.186*	-0.704	-0.445	-0.164	0.068	-0.201**	-0.708	-0.447	-0.152	0.072
	(0.101)	(0.484)	(0.380)	(0.336)	(0.062)	(0.095)	(0.485)	(0.385)	(0.342)	(0.066)
$Water_{i,t-m}$	-0.217	-0.388**	-0.233	-0.781*	-0.281	-0.189	-0.164	-0.210	-0.762**	-0.259
	(0.545)	(0.173)	(0.317)	(0.427)	(0.603)	(0.447)	(0.475)	(0.409)	(0.357)	(0.445)
HUC8 &Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	1163	1237	1316	1365	1365	1163	1237	1316	1365	1365

Appendix Table A6. Effect of Fish Population on NGO Spending

NGO Expenditures	m=0	m=1	m=2	m=3	m=4	m=5
$log(FishPerMile_{i,t-m})$	-89366.280	-98525.824	-98525.824	-90032.554	-53555.311	-35837.252
	(36261.473)	(52146.255)	(55095.014)	(45812.528)	(38473.251)	(34246.654)
$Contribution_{it}$	0.976***	0.979***	0.989***	0.986***	0.979***	0.981***
	(0.128)	(0.126)	(0.122)	(0.122)	(0.124)	(0.123)
GOV_{it}	-0.138**	-0.149**	-0.151**	-0.150**	-0.149**	-0.131**
	(0.063)	(0.067)	(0.070)	(0.070)	(0.070)	(0.059)
HUC8 FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Observations	1953	1859	1775	1698	1622	1547

Appendix Table A7. Data for 1990-2015

Log(Fish Per Mile)	m=1	m=2	m=3	m=4	m=5	m=1	m=2	m=3	m=4	m=5
$CMLT\ NGO_{i,t-m}$	0.002**	0.002**	0.003***	0.004***	0.004***	0.001	0.002	0.002	0.003**	0.004**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
$CMLT\ GOV_{i,t-m}$	0.014***	0.015***	0.012***	0.010***	0.011***	0.012***	0.011***	0.011***	0.010***	0.012***
	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
$CMLT\_NGO_{i,t-m} *90s$	0.006*	0.010**	0.011*	0.017***	0.021***	0.010**	0.012***	0.014**	0.018**	0.020**
	(0.003)	(0.004)	(0.006)	(0.006)	(0.007)	(0.004)	(0.004)	(0.006)	(0.008)	(0.009)
$CMLT\_GOV_{i,t-m} *90s$	-0.007	-0.003	-0.008	-0.006	0.006	-0.005	-0.006	-0.005	-0.006	0.002
	(0.007)	(0.009)	(0.011)	(0.016)	(0.021)	(0.007)	(0.009)	(0.011)	(0.015)	(0.022)
$Dam_{i,t-m}$	0.052	0.101	-0.212	-0.024	0.156	-0.061	-0.595	-0.378	-0.128	0.150
	(0.116)	(0.295)	(0.420)	(0.236)	(0.157)	(0.133)	(0.582)	(0.430)	(0.198)	(0.159)
$Water_{i,t-m}$	-0.017	-0.017	-0.012	0.003	0.000	-	-	-	-	-
	(0.013)	(0.014)	(0.013)	(0.013)	(0.013)					
HUC8 FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	1157	1101	1147	1123	1068	1662	1655	1652	1623	1549