Decrypting the Financial and Ecological Real Effects of Biodiversity Conservation

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Abstract

This paper explores the staggered implementation of critical-habitat designations under the U.S. Endangered Species Act (ESA) to study how biodiversity regulations shape corporate behavior and firm valuation. Using novel facility-level evidence, we show that firms subject to regional biodiversity conservation listings respond in two principal ways: (i) by reallocating pollutant releases from on-site to off-site treatment and disposal facilities, and (ii) by meeting mandated attainment ratios through the adoption of green technologies and hiring green-skilled labor. We further observe that firms with greater exposure to biodiversity regulations reduce on-site emissions and are valued at a discount, particularly in regions with increasing media attention to local biodiversity issues and stricter follow-up regulations. These firm mitigation efforts help improve biodiversity within designated habitats. However, by shifting pollution off-site, they also create negative environmental externalities at downstream disposal sites, highlighting a trade-off in regulatory outcomes and overall welfare.

Keywords: Biodiversity, Ecological Outcomes, Endangered Species Act, Pollutive Assets, Valuation

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1 Introduction

Global biodiversity loss has become a major economic challenge, with substantial implications for financial markets and corporate decision-making. The United Nations Development Programme estimates that, by 2030, biodiversity loss could potentially reduce global GDP by $2.7 trillion annually. To address the crisis, governments have introduced conservation policies—most notably the U.S. Endangered Species Act (ESA), overseen by the Fish and Wildlife Service. The ESA emphasizes the rescue of endangered species, focusing on threatened and endangered species as well as their habitats. The implementation of the ESA rests on two pillars: (1) the species listing process; and (2) the critical habitat designation. Since its enactment in 1973, the Act has progressively added species, along with their corresponding habitat protections. This act successfully rescued 291 species from extinction, with 39 fully recovered (Greenwald, Suckling, Hartl and Mehrhoff; 2019).

Although the ESA has demonstrably reduced species extinctions, its effects on corporate strategy and valuation remain largely unexplored. Prior research has focused on the Act's ecological design and listing procedures (Ando, Camm, Polasky and Solow; 1998; Ando and Mallory; 2012; Ando and Langpap; 2018), but little is known about how firms adapt their pollution practices and managerial decisions when their polluting plants fall within or adjacent to the newly designated critical habitat areas. Unlike uniform climate regulations applied nationally or at the state level, ESA habitat listings are rolled out incrementally across regions, creating regulatory pressure without prescribing explicit limits on pollutant discharges.

This raises an intriguing question: do ESA-impacted firms engage in "greenwashing" in response to environmental pressures without achieving substantive emissions reductions (He, Kahraman and Lowry; 2023; Duchin, Gao and Xu; 2022), or do they implement waste-management strategies to mitigate increasing regulatory risk (Bartram, Hou and Kim; 2022; Xu and Kim; 2022)? Leveraging plant-level emissions data, we delineate two principal adaptation channels: off-site redistribution of pollutants to external treatment and disposal facilities, and attainment strategies through green-technology adoption and skilled green-labour recruitment. We find that firm responses can partially alleviate regional biodiversity transition pressures, as shown by evidence that biodiversity improves around polluting plants within protected habitats. However, firm behaviour simultaneously imposes significant negative environmental externalities at downstream disposal sites, showing the unintended wel-

fare trade-offs in localized climate policies (Bartram et al.; 2022; Mahieux, Sapra and Zhang; 2025).

This paper examines the effect of biodiversity regulation on firm behavior and performance using a difference-in-differences framework that exploits their staggered designation of critical habitats across the United States from 2003 to 2017 (see Appendix Table **??**). We manually collect data on listed species and critical-habitat boundaries, then matched these shapefiles to the pollutive plants from the Environmental Protection Agency's Toxic Release Inventory (TRI) database. This enables us to identify pollutive establishments within or outside critical habitats (as well as buffer areas). Our sample consists of 9,303 pollutive plants with geographic data on ESA coverage. We classify as treated the 1,430 plants located within newly designated habitats or within a 30 km buffer, and as controls the 4,214 plants situated outside any habitat zone and at least 40 km from its boundaries—thereby minimizing spatial spillovers. Because these designations follow species' habitat ranges rather than administrative borders, this fine-grained spatial variation enables us to isolate the causal impact of ESA listings on plant-level emissions and overall firm performance from other regulatory policies.

By examining treated plants located in critical habitat areas before and after ESA listings, we find that these plants are more likely to reduce on-site pollutant emissions when facing regulatory risks compared to controlled plants. Furthermore, plants in critical habitat areas increased their off-site toxic releases to mitigate the pressure of direct emissions within these habitats. This suggests that establishments balance internal and external strategies to manage biodiversity transition risks under local environmental pressures. Beyond the pollution release relocation strategy, we find that treated plants are more likely to achieve attainment following ESA designations. Attainment means a facility no longer meets EPA TRI reporting requirements and is exempt from reporting.[4] This suggests that establishments balance internal and external strategies to manage biodiversity transition risks under local environmental pressures. Overall, our findings indicate that establishments reduce their onsite pollutant emissions, with higher attainment ratios reported in the Toxic Release Inventory (TRI) in response to stringent ESA policies.

[4]A facility no longer meets EPA TRI reporting requirements if it (1) does not exceed thresholds for manufacturing, processing, or using EPCRA Section 313 chemicals, (2) is no longer in a TRI-covered industry sector or subject to an EPA determination under EPCRA 313(b)(2), or (3) employs fewer than 10 full-time employee equivalents (less than 20,000 work hours annually). See https://www.epa.gov/toxics-release-inventory-tri-program/reporting-tri-facilities.

Building on our plant-level evidence, we extend our analysis to examine how firms respond to biodiversity regulations. To measure a firm's exposure to ESA regulations, we construct a dynamic measure representing the proportion of its plants located within critical habitats, as identified through the ESA listing process. Leveraging the regulatory shocks we identified, we investigate firms' responses to ESA enforcement. Our findings primarily reveal adjustments on the intensive margin, highlighting firms' regulatory risk management strategies. Firms with higher exposure to biodiversity conservation tend to reduce aggregate onsite pollution, enhancing their environmental profiles and mitigating biodiversity regulatory risks. These adjustments are achieved through green labor hiring strategically, in some cases, with insignificant economic slowdowns. In contrast to the onsite pollution at the firm level, we document a limited increase in offsite toxic releases among non-attainment samples. This suggests that while some firms may shift pollution to less regulated areas, the dominant strategy for managing regional ESA risks remains rooted in green adoption to result in a lower pollution. Consistent with plant-level evidence, more plants achieve attainment as firm-level ESA exposure increases. We further explore the potential mechanisms driving these attainments. Rather than resorting to divestiture or shutting down operations, our evidence shows that establishments achieve compliance primarily by adopting green technologies, particularly pollutant control technologies.

Next, we examine the impact of biodiversity regulations on firm performance. We first relate the firm level ESA exposure, which capture the transition risk, to the firm's market valuation measured by Tobin's Q as Li, Shan, Tang and Yao (2024). Specifically, we find that firm-level exposure to ESA regulations, which captures transition risk, is negatively correlated with Tobin's Q, indicating that ESA shocks are priced into equity markets as a persistent effect. The results are further supported by the negative Cumulative Abnormal Returns (CAR) observed after firms' plants are impacted by ESA listings. This indicates that the associated capital costs are perceived as a diversified source of environmental regulatory risk, causing firms with greater exposure to experience lower CARs. Building on prior studies that examine the relationship between environmental costs and financial performance (Xu and Kim; 2022; Bartram et al.; 2022), we explore the potential effect of ESA listings on firm productivity. Firms subject to biodiversity regulations mitigate onsite toxic emissions by transferring pollutants offsite and pursuing polluting plants to reach attainment, reflecting the transition costs incurred. However, due to the combined effects of onsite and offsite pollution adjustments, firms exposed to ESA regulations do not experience significant impacts on persistent productivity or sales. Instead, they accept a fixed disposal cost

in the form of green adoption and remote pollution. At the firm level, our evidence highlights environmental costs arising from green adoption and disposal activities. In financial markets, firms exposed to biodiversity conservation exhibit lower return on assets (ROA), reduced investment following biodiversity regulatory shocks, with these effects demonstrating both statistical and economic significance. Overall, our study underscores the financial costs firms incur in response to biodiversity conservation. Higher biodiversity conservation efforts contribute to a lower realized premium, illustrating the trade-offs firms face in navigating regulatory and financial pressures.

In our paper, we evaluate firm biodiversity by introducing an establishment-level biodiversity measure. We incorporate geographic information of firms' establishments with high-frequency grid-level bird metrics. Our establishment-level eBird metrics capture both high-resolution and high-frequency information on bird populations over time, allowing us to track temporal and regional changes in ecological conditions. Our findings indicate that biodiversity significantly improved in treated areas following the introduction of the Endangered Species Act (ESA). Specifically, in the 10km areas around the plants, the modified bird count increases by around 6% more than the control group after experiencing the realized ESA shock. Our findings suggest that areas or establishments exposed to ESA regulations tend to show enhanced regional biodiversity, partly due to firms' effective responses to regulatory pressures. These approaches provide a more nuanced view of firm environmental impacts.

Our analysis yields important welfare implications by quantifying the non-pecuniary externalities arising from corporate pollution displacement strategies. Under the maintained assumption of transportation cost minimization, we document an immediate and ecologically significant deterioration in biodiversity conditions at disposal sites linked to ESA-regulated establishments following policy implementation. The estimated effects represent economically meaningful declines of 16.4% relative to pre-treatment biodiversity levels, suggesting substantial welfare losses from spatial externalities. These results highlight a critical policy trade-off: while ESA legislation successfully protects designated habitats, it inadvertently creates ecological dead zones in peripheral areas. Our findings underscore the necessity of spatially integrated environmental regulation that properly internalizes these displacement costs.

Literature Review .

The central contribution of this paper is to provide new evidence on the financial and ecological real effects of biodiversity protection regulations through firms' responses regarding pollutive assets. Our findings suggest that when faced with biodiversity regulatory pressure, firms transfer pollutants offsite and pursue attainment, while also contributing to ecological improvement. Overall, our findings extend prior research on (1) environmental economics, (2) ESG, and (3) biodiversity finance by considering the biodiversity issues within a corporate framework.

First, within the field of environmental economics concerning ESA studies, our paper offers a unique examination of establishment-level ecological performance and its connection to corporate fundamentals and ESA efficiency. In contrast to existing literature focusing on broader regional impacts, such as Liang, Rudik, Zou, Johnston, Rodewald and Kling (2020a) which investigates air pollution regulations' effects on bird biodiversity, our study provides a detailed analysis at the firms' establishment level. Ferris and Frank (2021a) examines the impact of ESA as land regulation on employment at the establishment level and explores cross-regional heterogeneity in response to ESA restrictions. Auffhammer, Duru, Rubin and Sunding (2020) discusses the impact of ESA regulations on the vacant land market, highlighting a potential negative relationship between land value and species protection. Melstrom (2019) introduces a structural model to estimate oil industry land use sensitivity to ESA exposure. Our paper contributes to the literature by reconciling and elucidating the relationship between ecological regulatory shocks and corporate fundamentals, particularly through firms' responses to managing pollutive assets. This approach provides a novel perspective on the impact of ESA regulations.

Conceptually, our paper advances the literature on sustainable finance by extending the scope of ESG considerations to an ecological perspective. We specifically investigate how firms manage pollutive assets and adjust firm boundaries in response to exogenous ecological regulatory shocks. While recent literature has extensively covered climate finance and environmental finance, few studies emphasize on biodiversity issues. Most research focuses on firm-level implications in response to transition or physical risks. For example, Bolton and Kacperczyk (2021) and Bolton and Kacperczyk (2023) explore the impact of carbon transition risk on corporate performance and market valuation, while Hsu, Li and Tsou (2023) discusses the effects of pollution transition risk on the stock market. Pástor, Stambaugh and Taylor (2021) and Pástor, Stambaugh and Taylor (2022) integrate ESG preferences into

green asset pricing frameworks, documenting preference-driven cross-sectional equity premiums using MSCI green rating scores. Sautner, Van Lent, Vilkov and Zhang (2023) and Li et al. (2024) utilize firm-level earnings calls to capture climate-related risks and their implications for firm valuation and corporate behavior. Kruttli, Roth Tran and Watugala (2023) examines regional extreme weather risks and firm reactions, including market valuation and equity returns. The studies most similar to ours are Duchin et al. (2022) and Bartram et al. (2022), which investigate how firms response at the establishment level in response to transition risks. However, our paper introduces a novel focus on biodiversity policy and finance, offering a new framework based on the enforceability of ESA laws.

As an emerging area within climate finance, our paper makes significant contributions to the field of biodiversity finance. To the best of our knowledge, only a limited number of papers in economics or finance have explored this issue, and even fewer reconcile it with financial market. For instance, Thomas, Yao, Zhang and Zhu (2024) examine changes in firm ecological footprint using bird counts but focuses on responses to earnings surprises or cash flow shocks rather than biodiversity policy shocks. Similarly, Garel, Romec, Sautner and Wagner (2023) explore biodiversity and its implications on the financial market. Yet, Giglio, Kuchler, Stroebel and Zeng (2023) emphasize financial market implications of text-implied biodiversity risk without addressing the ecological changes for firms. Garel et al. (2023) also investigate firm-level biodiversity risk and stock returns but does not fully address the exogeneity of transition or physical risks. In contrast, our paper examines one of the most contentious biodiversity transition risks, the ESA in the US, and jointly identifies its ecological effects and financial market implications.

While prior studies such as Giglio, Kuchler, Stroebel and Wang (2024) focus on biophysical risks and broader macroeconomic implications of biodiversity loss, our research adds to the filed of studies by examining the transition risks and related financial costs and decision-making at the establishment and company levels. We consider the impact of stringent regulatory restrictions on biodiversity, offering insights into the corporate finance perspective that are not captured in macro-level analyses. Furthermore, unlike most existing financial studies using raw citizen-report bird data (Thomas et al.; 2024), we implement several strategies to mitigate biases stemming from variations in birding effort, imperfect detection rates, and observer expertise heterogeneity. Our approach, which is conceptually similar to the quasi-structural method proposed by Lerner and Seru (2022), also aligns with recent biodiversity research (Liang et al.; 2020a; Cazalis, Princé, Mihoub, Kelly, Butchart

and Rodrigues; 2020; Cazalis; 2022). We apply statistical adjustments for observation effort variability, species detection imperfections, and observer skill differences. Using our refined biodiversity measure, we map firm establishments from the EPA to their local ecological contexts, allowing us to construct detailed trajectories of establishment-level biodiversity impacts over time.

Finally, from a corporate finance perspective, our paper contributes to the literature on firm boundaries by focusing on the materialized ESA regulatory risk and how corporates manage such biodiversity pressure internally. We adopt an establishment perspective for corporate pollutant decision-making, similar to the approach of Stein (1997). They propose a structural framework illustrating that firm diversification through internal capital is contingent on efficiently selecting winning projects, an advantage stemming from superior headquarters information. Seru (2014) also demonstrates such a divisional view and shows that diversified firms, such as conglomerates, might influence innovation through firm boundary strategies. In the context of corporate behavior and ESG issues, Duchin et al. (2022) addresses research questions most comparable to ours. They examine how firms respond to stringent environmental policy risks through divestitures. In contrast, our paper assesses how firms utilize internal pollutant capital, particularly establishments, to manage regional Endangered Species Act (ESA) risks. For firms affected by ESA regulations at the local establishment level, we concurrently analyze their financial operations and ecological impacts consistently.

The structure of the paper is as follows. In Section 2, we introduce the background of biodiversity and the Endangered Species Act (ESA) for species protection. Section 3 presents the conceptual framework. Section 4 describes the data and summary statistics. Section 5 reports the baseline plant-level evidence. Section 6 further examines firm aggregate emissions and performance. Section 7 explores the underlying economic mechanisms, and Section 8 discusses ecological externalities and welfare. Finally, Section 9 concludes.

2 Biodiversity Background and the Endangered Species Act (ESA)

Biodiversity.

Biodiversity, encompassing the variety of life from genes to ecosystems, is a critical environmental and economic concern due to its role in maintaining ecosystem functioning and providing essential services for human well-being (Cardinale, Duffy, Gonzalez, Hooper, Perrings, Venail, Narwani, Mace, Tilman, Wardle et al.; 2012; Díaz, Settele, Brondízio, Ngo, Agard, Arneth, Balvanera, Brauman, Butchart, Chan et al.; 2019). The significance of biodiversity extends beyond ecological considerations. From an economic perspective, biodiversity can be conceptualized as natural capital generating a flow of ecosystem services, ranging from direct resource use to climate regulation (Barbier; 2011).

The loss of biodiversity is an increasing concern for society, with the World Economic Forum (2022) ranking it as the second most impactful and third most likely risk over the next decade [5]. This loss threatens to disrupt food and health systems and destabilize entire supply chains, posing significant risks to societal stability. The economic ramifications of biodiversity loss could be substantial, with projections suggesting it could cost up to 7% of global GDP by 2050 (TEEB; 2010).

From a corporate finance perspective, biodiversity risks fall into two main categories: physical risks and transition risks. Physical risks arise from the direct impacts of biodiversity loss on business operations. For example, pharmaceutical firms might encounter delays in drug development as a result of losing species with potential medicinal value (TEEB, 2010; diaz 2019). These physical risks can substantially influence a company's revenue streams and asset valuations. On the other hand, transition risks are associated with societal responses to biodiversity loss (Giglio et al.; 2023; Flammer, Giroux and Heal; 2023). These risks encompass changes in policies, market dynamics, and stakeholder expectations. For example, firms may face stricter biodiversity conservation regulations, shifts in consumer preferences toward eco-friendly products, or new requirements for biodiversity-related disclosures. Such transition risks can affect a company's financial performance by increasing operational costs or altering market conditions. Both types of biodiversity risks can materially impact a

[5]The Global Risks Report 2022 (17th Edition), https://tatsigroup.com/fa/wp-content/uploads/2022/02/the-global-risks-report-2022.pdf

firm's financial stability and risk profile (Giglio et al.; 2023). Companies highly exposed to biodiversity risks may experience elevated costs of capital as investors adjust their risk assessments to account for these factors.

The Endangered Species Act

The Endangered Species Act (ESA) of 1973, building upon earlier legislation, stands as a cornerstone of U.S. environmental protection, focusing on threatened and endangered species and their habitats. Its effectiveness is evident in preventing the extinction of 99 percent of protected species (Greenwald et al.; 2019). The ESA's implementation revolves around two key components: the species listing process and critical habitat designation. Species are listed based on scientific criteria, with habitat loss as a primary consideration. This process involves evaluating proposed species, identifying their current ranges, and determining their status as threatened or endangered. Once a species is listed, the ESA triggers regulatory mechanisms that significantly impact industrial operations. Notably, Section 9 prohibits the "taking" of listed species, broadly defined to include harming, harassing, or detrimentally modifying their habitat. This prohibition can substantially restrict land use, resource extraction, and industrial development, compelling businesses to reevaluate their operational strategies and expansion plans[6].

Concurrently with species listing, Section 4 of the ESA mandates the designation of "critical habitat", considered its most stringent regulatory instrument (Langpap, Kerkvliet and Shogren; 2018). The U.S. Fish and Wildlife Service (FWS) determines these specific geographical areas essential for species conservation based on the best available scientific data, while also considering economic and other relevant impacts. This designation, coupled with species protection measures, initiates a series of restrictions that significantly affect land use, resource extraction, and development activities in both public and private sectors (Auffhammer et al.; 2020). Consequently, businesses are compelled to reevaluate their operational strategies and expansion plans, underscoring the complex balance between species conservation and economic activities.

The enforcement of the ESA primarily falls under federal jurisdiction, with the U.S. Fish and Wildlife Service and NOAA Fisheries (for marine species) taking the lead. Recent reviews indicate that federal expenditures on the conservation of federally listed species make

[6]More details on the ESA can be found at https://www.fws.gov/sites/default/files/documents/endangered-species-act-accessible.pdf

up approximately 95% of total ESA spending (Mothes, Stemle, Fonseca, Clements, Howell and Searcy; 2021). However, state and local governments may play important supporting roles in implementation and enforcement as well. The stringency of enforcement can vary across states, with some, like California, having additional state-level requirements triggered by critical habitat designations under laws such as the California Environmental Quality Act (CEQA).

The implementation of the ESA has sparked complex debates due to its profound implications for establishments, firms, and entire industries. The listing process, involving diverse stakeholders such as scientific experts, environmental groups, and industry representatives, often becomes a battleground of competing interests. This tension frequently leads to a series of lawsuits and legal challenges, pitting environmental conservation against economic concerns (Langpap et al.; 2018)[7].

The designation of critical habitats, in particular, can lead to decreased property values and limited development opportunities (Greenstone and Gayer; 2009). Zabel and Paterson (2006) found that the number of building permits in municipalities decreased in areas designated as critical habitats. The ESA's effects extend to resource-intensive industries; Bošković and Nøstbakken (2017) reported that oil producers in Alberta's oil sands pay 24% less on average for regulated oil leases due to endangered species protections. Moreover, the Act can significantly influence employment patterns, with research showing long-run declines in timber industry employment of up to 13.9% following species listings (Ferris and Frank; 2021b). These restrictions and potential costs affect firms' financial decisions, from capital allocation and investment strategies to operational planning and risk management. The permitting process for activities that might affect listed species becomes more complex and costly, often requiring extensive environmental assessments and mitigation plans. Consequently, the ESA's provisions compel businesses to integrate biodiversity considerations

[7]A notable example of this tension and subsequent legal battles is the controversial listing of the northen spotted owl, which sparked intense debate between conservationists and the timber industry in the Pacific Northwest during the early 90s. Despite efforts to foster dialogue and reach compromise, including interventions by the Clinton administration, the listing resulted in significant ecological protections that drastically altered the region's timber industry (Charnley; 2006; Noon and Blakesley; 2006). This led to numerous lawsuits from both environmental groups, who sought stronger protections, and industry associations. who challenged the economic impacts. For instance, in 2007, a federal court rejected the U.S. Fish and Wildlife Service's recovery plan for the spotted owl, leading to years of revisions and additional litigation. In 2012, a new critical habitat designation further expanded protected areas, triggering more legal challenges from the timber industry.

into their strategic planning, potentially altering site selection, production processes, and supply chain management to ensure compliance and mitigate risks associated with species protection regulations.

3 Conceptual Framework

We examine an economy in which firms face biodiversity policy pressures alongside intensifying public monitoring, requiring them to manage pollutive assets to mitigate disruptions to local biodiversity and reduce regulatory risk. Specifically, federal mandates compel firms to enhance environmental quality by protecting critical habitats designated for endangered species. In response, firms can adopt two adaptation strategies. The first strategy involves reducing regional pollutant emissions and relocating pollution from onsite to offsite locations, thereby minimizing environmental threats to species through pollution shift. The second strategy entails achieving regulatory attainment or divesting local establishments in response to heightened regulatory pressure. Within this framework, firms navigate trade-offs by reallocating resources between these strategies to adapt to ESA policy impacts. At the aggregate firm level, biodiversity shocks are reflected in firm valuations in the stock market, and firms adjust their labour hiring decisions accordingly.

Within this economic framework, our first hypothesis explores how firms adapt to environmental requirements by manipulating both the onsite and offsite choices. The key assumption is that firms seek to balance regulatory costs between these two strategies. Our empirical approach to the intensive margin aligns with Naaraayanan, Sachdeva and Sharma (2021) and Fang, Hsu and Tsou (2023), who both demonstrate that when stringent policy risks materialize, firms tend to mitigate pollution based on relative environmental costs. In this circumstance, corporates have two options to reduce the regional pollutant impact through either onsite adaptation or remote pollution. Regarding the extensive margin, as argued by Duchin et al. (2022), firms can strategically adjust local pollution through the divestiture channel or quitting channels, where corporate efficiency may be improved (Bates; 2005; Mavis, McNamee, Petmezas and Travlos; 2020). More importantly, divestitures related to ESG issues have been shown to be effective in enhancing environmental policy quality, as demonstrated by Gantchev, Giannetti and Li (2022).

Our second hypothesis considers the enforceability of the ESA legislation, which has faced

criticism in the U.S. for an extended period. On one hand, economists and scientists have doubts about the act's enforceability or efficacy. One potential reason is the inadequacy of the fiscal budget to support species listing events, particularly given timing and budget constraints, as documented by Stroup (1995). Stokstad (2005) also highlights fiscal budget constraints as a critical issue for endangered species protection, even though some recovery can be observed for listed species. On the other hand, economic researchers have found that the ESA imposes negative constraints on economic development (Auffhammer et al.; 2020; Ferris and Frank; 2021a; Melstrom; 2021). These economic impacts are primarily channeled through employment and land use. Consequently, biodiversity might benefit from the economic slowdown or the conservation of critical habitats for endangered species. These conceptual frameworks are similar to those discussed by Fried (2018) and Hsu et al. (2023). Our null hypothesis is grounded in these frameworks: with stricter regulatory enforcement, the effective ESA could reduce firm activities and enhance regional biodiversity ecosystems.

Next, we develop our hypothesis based on the literature linking pollutant emissions to biodiversity destruction. This assumption is grounded in both economic and ecological evidence. Bird biodiversity, for instance, can be negatively impacted by air pollution, as noted by Liang et al. (2020a) and Thomas et al. (2024). Additionally, scientific evidence indicates that certain behaviors associated with establishments, particularly land waste and water pollution, may further harm bird richness. In sum, considering these channels connected to firm pollution (Yang and Jiang; 2021), our final hypothesis suggests a linkage between corporate pollution and species protection laws, including critical habitat protection. Conceptually, this assumption is similar to the carbon economics model, where taxation introduces policy uncertainty and attributes to lower environmental destructions as Fried (2018). As protection of critical habitats becomes more stringent, pollutant emissions at the establishment level are expected to decrease.

Finally, our last experiment examines the impact of regional biodiversity over financial performance. The conceptual framework is grounded in literature that identifies the negative effects of regional environmental policy and the financial fundamental, as shown by Naaraayanan et al. (2021) and Sautner et al. (2023). While our framework similarly addresses these issues, it extends to environmental concerns, conditional on the prior assumption regarding the legal enforceability of the ESA. This assumption aligns with the findings of Xu and Kim (2022), Fang et al. (2023), and Bartram et al. (2022); however, our focus shifts to the controversy surrounding biodiversity-related policies. Given firms' het-

erogeneous exposure to regional biodiversity conservation, these external shocks slow down corporate investment and reduce valuation over the financial market.

4 Data

Our empirical design relies on several critical datasets. First, we collect bird diversity data from the USFWS website and use GIS instruments to map it with the geographical locations of U.S. facilities from the Toxics Release Inventory (TRI) Program. After carefully matching the eBird data with U.S. plants, we use it as a proxy for establishment-level biodiversity. Next, we introduce ESA events as federal judicial shocks to species conservation and integrate these with the critical habitat data for species at the establishment locations. Finally, we merge establishment-level databases with publicly listed corporations from WRDS by matching parent company names.

4.1 Biodiversity Regulation

Our study utilizes data on critical habitat designations under the Endangered Species Act (ESA), obtained from the U.S. Fish and Wildlife Service (USFWS). This agency is responsible for designating and managing critical habitats for threatened and endangered species. We collect spatial data in the form of shapefiles from the USFWS's Environmental Conservation Online System (ECOS) GIS data portal. These shapefiles delineate the geographic areas containing features essential to the conservation of listed species. In addition to the spatial data, we gather information on the listed species associated with each critical habitat designation, including the species' common and scientific names, their listing status (threatened or endangered), and the date of critical habitat designation.

To integrate this information into our plant-level analysis, we matched the geographic locations of plants with the boundary shapefiles of each critical habitat listed by the ESA. This allowed us to identify plants located within critical habitats and those outside. To capture the potential spillover effects of regulations beyond the immediate critical habitat areas, we construct buffer regions of 30 km around each critical habitat.This approach enables us to examine not only the direct impacts on plants within critical habitats but also the potential spillover effects on nearby plants.

We categorized plants as "treated" if they are located within a designated critical habitat or its 30 km buffer zones. The treatment timing for each affected plant is set to the establishment date of the intersecting critical habitat. Plants that never intersected with any critical habitat designations or buffer zones, or those observed before the establishment date of nearby critical habitats during our study period, were categorized as control plants. To ensure a clearer comparison, we designate plants located between 30 km and 40 km buffer zones as neighboring plants and exclude them from both the treatment group and control group. This approach avoids potential regulatory leakage and maintains a clear distinction between treated and control plants. This methodology allows us to compare biodiversity and financial outcomes for treated plants (those within or near critical habitat designations) to control plants before and after the designation dates, providing insights into the direct and spillover effects of critical habitat designations on plant operations and financial performance. At the appendix of the paper, we attach the event list for endangered species initiated by US government. The events in Table A.3 range from 2003 to 2020 including multiple types of endangered species, including fishes, birds, amphibians, crustaceans, reptiles and mammals.

4.2 Bird Measures

While critical habitat designations and Endangered Species Act (ESA) listings cover a wide range of species, including birds, mammals, fish, and plants, comprehensive spatial-temporal data for all these species types are not readily available. Given this limitation, our study focuses on bird biodiversity as a proxy for overall ecosystem health and biodiversity. To this end, we rely on the eBird dataset, a comprehensive, global citizen science initiative managed by the Cornell Lab of Ornithology (Sullivan, Aycrigg, Barry, Bonney, Bruns, Cooper, Damoulas, Dhondt, Dietterich, Farnsworth et al.; 2014). This extensive dataset comprises standardized "checklists" submitted by volunteer birdwatchers, offering a rich source of bird observation data across diverse geographical areas and time periods.

The eBird data collection process involves volunteer birdwatchers using standardized protocols to record their observations. Each submission, referred to as a "checklist", represents a unique birding event. Observers record detailed information including species observed, counts of birds seen and/or heard, precise location (typically via GPS-enabled mobile applications), date, and time of observation. Additional data such as breeding behavior, habitat details, and observer effort (e.g., duration of observation, distance traveled) are often in-

cluded. This standardized approach ensures consistency in data collection, making eBird a valuable resource for various scientific fields, including ecological research, conservation biology, and increasingly, interdisciplinary studies (La Sorte, Fink, Buler, Farnsworth and Cabrera-Cruz; 2017; Horns, Adler and Şekercioğlu; 2018; Liang, Rudik, Zou, Johnston, Rodewald and Kling; 2020b).

Using this rich eBird dataset, we construct our bird biodiversity index at the establishment level. This granularity represents the most detailed scale possible given the spatiotemporal availability of the eBird data, balancing the need for local precision with the constraints of data coverage and computational feasibility. To create the biodiversity index, we aggregate the individual checklist observations within the 10 km circles surrounding each TRI plant. This process involves mapping each observation to its corresponding grid cell based on the recorded GPS coordinates.

The raw eBird measures, while geographically extensive, suffer from inherent limitations due to their dependence on citizen-reported observations. These data may imperfectly capture true population dynamics because they conflate actual ecological changes with variations in observer effort, expertise, and local environmental conditions. Significant heterogeneity across observers introduces measurement error in species identification and count accuracy, with potential systematic biases across both spatial and temporal dimensions. To mitigate these endogeneity concerns, we employ multiple identification strategies, including spatial robustness checks across varying regional specifications and alternative biodiversity metrics such as species-average measures within defined regions. This multi-dimensional approach allows us to better disentangle true ecological effects from observational artifacts while maintaining comprehensive coverage of biodiversity conditions.

4.3 Toxics Release Inventory (TRI)

In order to track firm operation regarding biodiversity management, under the assumption between pollution and biodiversity, we obtain the establishment level toxic release following Hsu et al. (2023) and Xu and Kim (2022) TRI data source. TRI is a publicly released data source by EPA (Environmental Protection Agency). They only record the plants which are within the non-attainment level or the facilities are on the list of a determination by the Administrator under EPCRA 313(b)(2). We consider the firm pollution performance at both the establishment and firm level as Table 1 and 2 display. Our table includes

the onsite pollutant emission ($Emission_{onsite}$), offsite emission ($Emission_{offsite}$) and the total emission ($Emission_{total}$) at the establishment level. Comparing the two options for emissions, onsite toxic emission 5.677 dominates offsite pollutant emission with 3.362 at the establishment (firm) level. To account for varying levels of chemical toxicity, we follow Hsu et al. (2023) to construct toxicity-weighted emissions ($WEmission_{onsite}$, $WEmission_{offsite}$, $WEmission_{total}$), which incorporate the differing toxicity levels across chemical categories.

Moreover, from the TRI database, we estimate the attainment performance of the local establishments each year. In our paper, we consider the attainment of US facilities as an alternative perspective for green realization. According to EPA TRI report[8], non-attainment firms are required to report their pollutant emission if they meet chemical-level activity threshold for pollution, and they are within a classified industry sector or within the shortlist of the Administrator under EPCRA 313(b)(2). The TRI database includes facility operational status information, indicating whether facilities are active or have ceased operations (inactive or shutdown). Within our study period, approximately 6% of facilities are classified as inactive, suggesting relatively stable operational patterns across reporting facilities. Table 2 illustrates related variables at the firm level. Following Hsu et al. (2023), we aggregate the facility pollution at the firm level and construct different pollution as for the establishment level. $Plant_Num$ denotes the count of TRI plants fully controlled by publicly listed firms. $Attainment_{num}$ ($Attainment_pct$, $Attainment_num(Excl)$, $Attainment_pct(Excl)$) refers to the diverse robust indicators for firm proportion to TRI attainment requirements. Regarding the firm-level exposure to the ESA shocks, we adopt the aggregate intensity as a proxy for the firm exposure to regulatory risk. With different measures including $Intensity$, $Intensity_{total}$, $Intensity_{onsite}$, we exploit the ratio of the critical habit designation shocked plants over total owned plants for firm cross-sectional exposure to ESA shocks [9].

[8] https://www.epa.gov/toxics-release-inventory-tri-program/reporting-tri-facilities#q1.

[9] For robustness, we exploit different firm-level ESA exposure, $Intensity$ denotes the ratio of shocked plants (after 2003) over total plants fully owned by the company. $Intensity_{total}$ refers to the ratio of ESA-impacted plants to total plants, weighted by each plant's total pollution emissions. $Intensity_{Onsite}$ means the ratio of ESA-impacted plants to total plants, weighted by each plant's onsite pollution emissions. $Intensity^{First}$ indicates the ratio of plants that are firstly shocked in a given year t over total plants. $Intensity^{First}_{Total}$ refers to the ratio of ESA-impacted plants that are firstly shocked to total plants, weighted by each plant's total pollution emissions. $Intensity^{First}_{Onsite}$ means the ratio of ESA-impacted plants that are firstly shocked to total plants, weighted by each plant's onsite pollution emissions.

4.4 Corporate Fundamentals

We incorporate the Compustat Data from WRDS to recover the firm fundamental variables. These variables include Tobin's Q, profitability (ROA), Leverage ($leverage$), Tangibility ($Tangibility$), firm size ($Asset$), firm profitability (ROA), cash holdings ($Cash$). The firm $profitability$ is inferred from firm Return of Asset. The Tobin'q estimation is estimated with the market value divided by the booked values. The leverage follows the estimation with total debt divided by total asset. For the $Asset$, we obtain it with logarithmic of firm market valuation.

To account for the influence of other environmental policy risks, we include a measure of environmental risk, derived from corporate earnings calls in Hassan, Hollander, van Lent and Tahoun (2017), as a control variable. Additionally, we obtain annual measures of financial constraints from Hoberg and Maksimovic (2015), which are developed using 10-K textual analysis.[10] Table 2 provides a summary of the firm-level statistics used in the final analysis.

4.5 Job Posting and US Patent

In order to capture the real effect of green adoption, we follow the different literature to recover the green innovation and green labor hiring decision. We use the data from USPTO. USPTO include a machine learning based green patent innovation. Alternatively, for robustness, we focus on the pollution control innovations based on the firm patents following Cheng, Lin and Yang (2024), and show a consistence of our main results. On the other hand, we utilize Lightcast data to construct green labor hiring variables, which reflect firms' demand for green skills in a given year. Specifically, we follow the Kelly, Papanikolaou, Seru and Taddy (2021), Sautner et al. (2023), Duchin et al. (2022) and implement the bag-of-word method to capture the corporate activeness in green hiring adoption. Our green labor hiring includes two types of measure. One with term frequency denoted as $Green_Labor^{tf}$. The other is denoted as $Green_Labor^{TFIDF}$.

[10] https://faculty.marshall.usc.edu/Gerard-Hoberg/MaxDataSite/index.html

4.6 Disposal Facility

To establish the connection between TRI plants and waste disposal facilities, we utilize the EPA's comprehensive databases of waste management infrastructure documented in the Incident Waste Decision Support Tool (I-WASTE DST). In total, we obtain information on 46 thousand unique disposal facilities across the continental United States (see the spatial distribution of these disposal facilities in Appendix Figure A.2a). The EPA categorizes disposal facilities based on their functional capabilities and applicable regulatory frameworks, including landfills (industrial waste, construction and demolition, municipal solid waste, and RCRA Subtitle C hazardous waste), combustion facilities (hazardous waste, medical/biohazardous waste, and municipal solid waste), recovery facilities, and wastewater treatment facilities. Each facility type is tracked through specialized EPA databases with specific identification systems and geographic coordinates maintained for regulatory compliance purposes.

Our matching methodology creates linkages between TRI plants and appropriate disposal facilities based on waste compatibility and transportation efficiency principles. For each TRI plant, we classify waste streams according to their "task_type", which determines the suitable disposal facility category required for processing that particular waste type. Using Google Map API services, we calculate realistic transportation logistics between plants and facilities, prioritizing actual transportation conditions that industrial carriers would encounter. This includes the real-world route distance in kilometers that waste-carrying vehicles must travel, along with practical transportation duration in minutes accounting for typical traffic conditions, road types, and transportation regulations for hazardous materials (see Appendix Figure A.2b for illustration). This approach implements our assumption that plants follow a least-cost approach when selecting disposal destinations, prioritizing the nearest appropriate facility that can process their specific waste while minimizing transportation costs. The matching process resulted in 14,323 unique plant-waste type combinations (TRIFD $\times$ task_type) representing 6,469 distinct TRI plants, successfully matched with 1,698 disposal facilities from the original set.

To assess ecological impacts around these disposal facilities, we constructed similar biodiversity measures within 10-kilimeters to 50-kilometers radius of each matched disposal location as documented in Section 4.2. Using the eBird database, we calculated several bird diversity metrics, including both raw and standardized indices based on various statistical models (Poisson and log-linear approaches with increasing complexity) that account

for observation effort and other factors influencing bird sightings. Our temporal analysis expanded these spatial relationships into an annual panel dataset comprising 104,835 observations, maintaining the integrity of all plant-waste combinations across multiple years. This comprehensive approach allows us to examine potential spillover effects from waste disposal operations on local ecosystems.

5 Plant-Level Responses: Difference-in-Differences

Our empirical strategy comprises two components. The identification strategy exploits variation in the implementation of the Endangered Species Act (ESA) at the establishment level, utilizing a staggered difference-in-differences (DiD) approach. The validity of this approach rests on the quasi-exogenous nature of ESA implementation relative to regional economic conditions, as enforcement occurs through federal regulation. The ESA laws were implemented from 2003 to 2020 by the FWS (U.S. Fish and Wildlife Service), as shown in Table A.3. Since this agency is mainly responsible for critical habitat designation and biodiversity conservation, the presumption of ESA exogeneity can be verified. For plants and firms within 30km regions of the critical habitat protection areas designated for the first time, we hypothesize that these establishments are regarded as the treated group in a DiD experimental design with heightened endangered species protection requirements regionally. In contrast, establishments located beyond 30km of critical habitat areas are treated as the control group. To ensure meaningful ESA impact and observable pre- and post-treatment outcomes, we apply specific criteria that at the plant level, we exclude establishments with consistently zero total releases, focusing on those with measurable environmental impacts.

At the firm level, we adopt continuous firm-level cross-sectional exposure as proxy for ESA shocks. The continuous firm level ESA exposures are introduced in Table 2 including *Intensity* et al. Therefore, in our sample, the firms with higher exposure to ESA refer to the groups of corporates with higher ESA exposed establishments. Since ESA-listed habitats are limited prior to 2003, we take plants covered by ESA listings before 2003 as located in "old habitat areas." We classify treated plants in our sample into two categories: those listed by ESA after 2003 (including the old habitat areas) and those listed by ESA for the first time after 2003 (excluding old habitat areas). Firms without any plants listed in the EPA Toxics Release Inventory database are excluded from our sample.

Overall, our identification assumption relies on the quasi-experimental variation created by ESA implementation shocks to establishments. In order to justify this pre-assumption, Figure 4 shows the overall trend of treated and control curves with total pollutant emissions. As continuous listing requirements from ESA are implemented, the ESA exposed plants shows a significant divergence with lower total pollutant emission compared with the control group in the post shock period. Ex-ante trends for the two groups are comparable with each other. Furthermore, to enhance the robustness of the result, Figure 5 illustrates the trend in the pollutant emission between treated and control groups around the time of the ESA initiation. The implementation of the ESA widens this gap, with areas exposed to the ESA intervention showing a significant declining trend in regional onsite pollution compared to control groups not affected by the ESA.

Given rigorous experiment with plant-level sample, our empirical analysis follows the trajectory from micro to relative macro evidence. Given the direct and indirect harms pollutant emissions pose to biodiversity, the regional tightened ESA from the federal FWS could restrict firms' pollution to nature, especially on the specific habitat location. We begin by analyzing pollutant releases at both onsite and offsite locations, focusing on how pollutive facilities respond to the regional biodiversity policies by strategically managing the locations of their toxic releases. We also examine the extensive margin, investigating whether firms divest pollutive assets in response to ESA-induced shocks. Another key consideration is that facilities listed in the EPA TRI database are exempt from reporting emissions once they achieve attainment, meaning they no longer exceed regulatory thresholds. Our analysis explores how ESA implementation influences the attainment of TRI facilities in detail. Expanding from the plant level to the firm level, we examine whether companies incorporate regional biodiversity considerations when responding to stringent regulatory shocks. Like Bartram et al. (2022) and Giroud and Mueller (2019), we integrate plant-level evidence to evaluate aggregate firm responses to biodiversity conservation shocks. By analyzing corporate fundamentals, we identify firms' operations to biodiversity regulatory risks and examine the implications for market valuations. Additionally, we investigate the demand for green skills, reflecting firms' investments in human capital as part of their broader green adaptation strategies.

5.1 Pollution Relocation Channel

We first consider the intensive margin of corporate performance in response to the Endangered Species Act through onsite pollution. Table 3 shows our results for the intensive margin of the establishment operation in response to an ESA regulatory shock. The main econometrics focus on the DiD framework. Our goal is to explore whether regional biodiversity conservation could result in the pollution of the variables:

$$log(Pollution_{i,j,t} + 1) = \beta_0 Treat_j \times After_t + a_j + b_{k,t} + \epsilon_{i,j,t},$$

where $log(Pollution_{i,j,t} + 1)$ represents the logarithm of one plus the toxic releases by firm i at plant j in industry k ($Emission_\tau, WEmission_\tau, \tau = onsite,\ offsite,\ total$), $Treat_j$ is a dummy variable that equals 1 if establishment j is located within 30 km of an area newly designated as critical habitat, and 0 otherwise. $After_t$ is a dummy variable that equals 1 if the year t after the implementation of the ESA implementation on establishment j, and 0 otherwise. a_j and $b_{k,t}$ refer to the related fixed effect (plant fixed effect and industry-year fixed effect), and the strength of the regression for identification relies on the control of the large proportion of fixed effect. With the robust controls of the establishment-level fixed effect, our regressions show robustness against cross-sectional plant-level confounding variables.

Our results demonstrate statistically significant evidence that establishments adjust their pollution levels in response to regulatory enforcement. The most notable response occurs in onsite pollution. As shown in Table 3, establishments in the treatment group significantly reduce toxic emissions, as documented in columns (1) to (4). Specifically, $Treat$ that equals one represents establishment j located within 30 km of an area newly designated as critical habitat in year t. This may include areas that were previously designated as critical habitat for one species but were newly listed for a different species after 2003. However, $Treat^{First}$ which equal to one only represents the plants first listed after 2003 excluding the old habitat. We find that the reduction in onsite pollution is more pronounced for plants newly listed under the ESA for the first time after 2003, highlighting the stronger impact of the initial regulatory shock on these facilities. This result remains robust when using toxicity-weighted emission measurements. These findings suggest that establishments actively reduce local pollution in response to biodiversity conservation requirements to mitigate their impact on local habitats.

Following ESA regional shocks, treated groups reduce their pollution by 13.3% in column

(1) (15.3% in column (3)) more than control groups. This finding remains robust when using toxicity-weighted emission measurements with 13% and 15.3% respectively. The effects maintain statistical significance when employing $Treat^{First}$ as the treatment indicator in our quasi-experimental design. The magnitude of these effects varies with the specification of the treatment indicator ranging from 10.7% to 11.5%. For establishments first treated after 2003 ($Treat^{First}$), shown in columns (5) to (8) of Table 3, the pollution abatement effect is more pronounced. These findings suggest that when faced with regional biodiversity conservation requirements, establishments actively reduce regional pollution to minimize their impact on local habitats.

By examining plant-level offsite pollution, our study reveals novel findings regarding pollution transfer behavior: establishments tend to redirect regional pollution to remote areas at relatively modest disposal costs. Table 4 columns (1)-(4) document a significant increase in remote pollution disposal among ESA-exposed establishments following the materialization of regulatory risk. Compared to the control group, treated establishments utilize approximately 17%, 18% (columns (1), columns (3)) more remote pollution disposal units, representing a 17%, 18% proportional increase in establishment-level offsite pollution. When considering historical treatment dating back to the ESA's inception in 1973, the effect strengthens from 17.4% to 20.3% with the inclusion of historically treated plants, equivalent to 17.4% (20.3%) of average establishment offsite pollution levels.

Considering both onsite and offsite releases of establishment pollution, we investigate the aggregate impact of critical habitat designation on establishments. The evidence from Tables 3 and 4 indicates that under stringent regulations, establishments strategically redistribute their pollution footprint by reducing onsite emissions while increasing remote disposal. This pattern raises a crucial question about the economic significance of disposal costs. Our findings in Table 5, using a quasi-experimental difference-in-differences approach, suggest no significant declining changes of 5.8%, 6.7%, 6.5% and 7.6% (column (1), (3), (5) and (7)) in total pollution for establishments exposed to critical habitat designation. This result remains robust across various treatment indicator specifications and toxicity-weighted average pollution emission measures. Together, these findings demonstrate that when faced with regional environmental risks targeting biodiversity conservation, firms manage their risk exposure through pollutant reallocation, accepting modest remote disposal costs while maintaining relatively stable overall pollution levels.

5.2 Attainment Channel

Under TRI reporting requirements, non-attainment status applies to facilities exceeding chemical activity thresholds within designated industry sectors. Facilities can achieve attainment by reducing the total volume of listed chemical emissions or adjusting emissions to remain below reporting thresholds, reflecting efforts toward green adaptation. Once a facility achieves attainment, it is no longer required to report to the EPA TRI. We analyze the attainment performance of facilities located within ESA-designated critical habitats, focusing on the short period following the regulatory shock to minimize the influence of other factors contributing to attainment. To assess whether ESA regulations impact establishments' attainment performance, we use the following difference-in-differences specification:

$$Attainment_{i,j,t} = \beta_0 Treat_j \times After_t + \beta_1 Treat_j + a_i + b_{k,t} + \epsilon_{i,j,t},$$

where $Attainment_{i,j,t}$ is an indicator that equals to one if plant j of firm i achieves attainment in year t, where time t is within the 3 or 5 years after the ESA shock, $Treat_j$ is an dummy variable that equals 1 if establishment j is located within 30 km of an area designated as critical habitat, and 0 otherwise. $After_t$ is a dummy variable that equals 1 if the year t after the implementation of the ESA implementation on establishment j, and 0 otherwise. a_j and $b_{k,t}$ refer to the firm fixed effect and industry-year fixed effect, respectively. Table 6 demonstrates the main results for this channel. Column (1) to (4) show that firms within the area of treated ESA are 1% (0.8%, 1.2%) more likely to reach attainment in 5 years. On average, this is equivalent to a 27.8% (22.2%, 33.3%) increase for establishment attainment in the following years. One potential concern for the attainment channel is that firms might operate through closing or inactivating plants to reach the standard. For robustness, we also exclude the samples identified as closing or inactive and show the results in Table A.4. After excluding establishments sold or closed, our results still hold with similar economic magnitude.

In addition to the evidence presented in Tables 3 and 4, which jointly suggest that firms not only mitigate onsite toxic emissions but also diversify risks by transferring emissions offsite, Table 6 highlights another response channel to biodiversity conservation requirements. Specifically, firms improve their TRI attainment performance by strategically managing their listed chemical emissions. In a subsequent section, we further demonstrate that firms with stronger green innovation capabilities achieve better attainment performance following the regulatory shock.

One potential channel as the response to regulatory shock is whether firms could close or divest in the ESA exposed establishments directly to cater into the critical habitat requirements. This channel is important as Duchin et al. (2022) documents that firms tend to sell the pollutant assets in the primary market to mitigate the environmental pressure. Since firms are required to request for permits catering to Endangered Species Act as Figure A.4 in Appendix C shows. Firms might also consider closing establishments as regional biodiversity conservation tightening. To verify these two alernative responses, we experiment these two mechanisms in Appendix B. Table A.5 and TableA.6 show the results whether firms operate through inactivating establishments to reach the standard of the EPA TRI Attainment or through selling the pollutive assets. Overall, we find that the relationship between ESA exposure and the establishment close is both statistically and economically insignificant, as well as the relationship between ESA exposure and the establishment sales. These results further verify our main hypothesis that ESA shocks materialize through corporate adjustment on chemical activities.

5.3 Ecological Outcome

With these improvements in corporate actions through pollution mitigation channels, an important question arises regarding whether these efforts translate into measurable improvements in biodiversity conditions, particularly at the establishment level. To evaluate this, we employ the establishment-level bird index as a proxy for ecological outcomes, reflecting the health and diversity of the local environment. Specifically, we examine the impact of regulatory shocks on biodiversity using the following model:

$$BirdCount_{i,j,t} = \beta_0 Treat_j \times After_t + a_j + b_t + \epsilon_{i,j,t}$$

where $BirdCount$ refers to the total adjusted bird count within a 10 km radius of establishment j of firm i at time t, $Treat_j$ is an dummy variable that equals 1 if establishment j is located within 30 km of an area designated as critical habitat, and 0 otherwise. $After_t$ is a dummy variable that equals 1 if the year t after the implementation of the ESA implementation on establishment j, and 0 otherwise. a_j and b_t refer to the establishment fixed effect and year-month fixed effect. Since bird count observations may be subject to seasonal variations, we control for the year-month fixed effect to account for any fluctuations in biodiversity.

Table 7 shows the results. After the designation of the critical habitat, the regional bird biodiversity for bird indeed improves correspondingly. With different establishment-level bird counts measures, the quality of ecological environment is improved by around 0.5 (0.6). For the measure of $Bird_{adj}^{log}$, this improvement is equivalent to a 30.4% increase in bird biodiversity compared to the average level. This is consistent with our main hypothesis that firms care about their biodiversity environmental because of the biodiversity conservation act. From biology perspective, our paper also quantify the economic evidence about the effectiveness of biodiversity conservation.

6 Aggregate Toxic Releases and Firm Valuation

6.1 Aggregate Pollution

In the previous section, we documented how firms manage pollutive operations at the establishment level in response to the biodiversity regulation. Given the geographical diversification of establishments, we next address the impact of ESA shocks at the plant level on firm valuation and the resulting fundamental changes. Our hypothesis is connected to the conceptual framework by Berger and Ofek (1995), Stein (1997) and Matvos and Seru (2014) where they discuss how firm diversification through internal capital market may affect the firm fundamentals. The core ingredient is determined by effective governance through the headquarter monitoring, which is parallel to winner pick in Stein (1997) or Berger and Ofek (1995) on efficient investment. Within these framework, we have a hypothesis that firms cannot efficiently invest, due to the cost of regulatory risk. We verify this statement with equation at the firm level as follows:

$$Y_{i,t} = \beta_0 Intensity_{i,t} + \gamma^{'} Control_{i,t} + a_i + b_t + \epsilon_{i,t},$$

where $Y_{j,t}$ refers to the firm-level toxic pollution including total pollution and toxicity-weighted average pollution. $Intensity$ denotes a continuous variable indicating the proportion of treated establishments relative to the total number of establishments. $Control_{i,t}$ denotes a vector of lagged firm-level control variables. a_i and b_t denote firm fixed effects and year fixed effects, respectively. The identification strategy relies on the assumption that firm-level proportion of ESA shocked establishment ratio is exogenous to the corporate foundings within the firm level. One potential concern of our regression is that ESA policy

might conflict with the environmental regulation on pollution. To rule out this interpretation, we implement the firm-level text-implied environmental regulation risk, $Environ_Risk$, as a control in the regression.

Table 8 shows our main results for corporate onsite pollution controlling firm level confounding variables. Consistent with establishment-level evidence, firms with high exposure to ESA shocks exhibit significantly lower onsite emissions compared to firms with low or no ESA exposure. This effect is statistically significant across both onsite pollutant emissions, as shown in columns (1) through (4), and alternative toxicity-weighted onsite emissions, as demonstrated in columns (5) through (8). In columns (3), (4), (7) and (8), we incorporate high-dimensional fixed effects to account for industry-year variations for robustness. In terms of economic magnitude, a one-standard-deviation increase in Intensity is associated with a 0.15% reduction in onsite pollution releases, as shown in column (2), and a 0.21% reduction, as reported in column (4). Consistently, the results still hold when we switch to alternative pollution measure, $WEmission_{i,t}$. In conjunction with the previous establishment-level results, our evidence shows that firms tend to reduce the overall onsite emissions in response to ESA shocks.

Table 9 examines the relationship between ESA shock intensity and firm-level offsite emissions. The results indicate a generally positive relationship between ESA proportional shocks ($Intensity$) and aggregate firm-level offsite emissions, aligning with our establishment-level findings that facilities tend to shift pollution from onsite to offsite locations. However, this relationship lacks statistical significance. A potential explanation is that as biodiversity conservation pressures intensify, firms' efforts to achieve TRI attainment lead to reduced total pollution at the aggregate firm level, offsetting some of the increases in offsite pollution at the aggregate firm level. Nevertheless, our empirical evidence consistently demonstrates that firms respond to regional biodiversity pressures primarily through adjustments in their onsite pollution levels.

Consistently, we also investigate the aggregate total pollution at the firm level. Even though with statistically significant reduction over onsite pollution, Table 10 shows that there are merely negative correlation between ESA proportional shocks and firm level total pollution, indicating that the onsite pollution mitigation dominate the aggregate pollution. This is partially due to the improvement of reaching attainment through green technology adoption. Therefore, within firm boundary, firms will adjust for internal transfer from onsite pollution to offsite pollution due to the regional pressure from biodiversity conservation.

6.2 Aggregate Attainment

Given the intensive margin on aggregate pollution, next, we test the extensive margin on establishment involvement at the firm level. The pivotal question is whether firms could reach for attainment at a relative aggregate level. As the firm boundary adjustment might not contribute to overall real efficiency (Stein; 1997; Bartram et al.; 2022). To evaluate this environmental efficiency, we design firm-level regressions to testify ESA shocks over firm attainment performance. Firms with more regional ESA exposure, estimated with higher proportion of ESA exposed establishments, tend to push more establishments under attainment both proportionally and absolutely in the following years.

$$Attainment_{i,t} = \beta_0 Intensity_{i,t} + \gamma^{'} Control_{i,t} + a_i + b_t + \epsilon_{i,t},$$

Where $Attainment_{i,t}$ refers to the total count of establishment attainments within critical habitat areas for firm i at time t.[11] The $Intensity$ denotes a continuous variable indicating the proportion of treated establishments relative to the total number of establishments. $Control_{i,t}$ denotes a vector of firm level control variables. a_i and b_t denote firm fixed effects and year fixed effects, respectively.

Table 11 displays the main results at the firm level for attainments. In Columns (1) and (2), which include year fixed effects and year-industry fixed effects respectively, we also control for the total number of plants ($Plant_Num$) to account for potential size effects. The results indicate that a one standard deviation increase in intensity is associated with a significant increase of approximately 0.084 and 0.078 in attainment counts within critical habitat areas. When we replace the dependent variable with the attainment percentage (attainment counts divided by the total number of plants), as shown in Columns (3) and (4), a one standard deviation increase in intensity corresponds to an increase of approximately 3.6% in attainment ratios within critical habitat areas. The effect diminishes slightly when we exclude transacted or sold establishments from the U.S. market. In this case, a one standard deviation increase in intensity is associated with an increase of 0.04 and 0.039 in attainment counts, as shown in Columns (5) and (6), and an increase of approximately 1.88% in attainment ratios, as reported in Columns (7) and (8).

In sum, our evidence shows that firms with a higher exposure to ESA shocks tend to push more establishments within the critical habitat areas under attainment than the less exposed

[11] This includes establishments that achieved attainment prior to the corresponding critical habitat listing.

firms. The channel is of great economic magnitude than the others implying that firms tend to take actions to transfer from brown to green. This is consistent with the literature in Fried (2018) documenting that firms tend to transform with green adoption or investment to reduce browm impact. Moreover, our evidence at the firm level also highlights the ESA pressure over has enforceability to shift firm to real green efficiency.

Therefore, the aggregate firm-level evidence demonstrates that firms with higher ESA risk exposure tend to mitigate and diversify these shocks by relocating pollution and achieving TRI facility attainments. This internal market management strategy reflects a consistent pattern observed at both the firm and establishment levels. While this transfer is about 1% to 2% impact over the pollution behavior, it could still facilitate to improve the regional biodiversity. More importantly, firms could utilize the capital market to reach for attainment standard of TRI. With green technique adoption or related risk management, this could push the establishments to reduce the emission externalities over regional biodiversity more efficiently.

6.3 Corporate Performance

In the prior sections, we examine the potential channels through which firms respond to biodiversity conservation pressures. These regulatory implementations entail a series of environmental risks that potentially influence corporate performance, as highlighted by Sautner et al. (2023) and Bolton, Kacperczyk and Wiedemann (2023) in their analysis of other ESG risks. We begin by examining firm valuation to determine whether biodiversity regulatory risk is priced into financial markets.

$$Y_{i,t} = \beta_0 Intensity_{i,t} + \gamma^{'} Control_{i,t} + a_i + b_t + \epsilon_{i,t},$$

where $Y_{i,t}$ denotes the $Tobin'Q$ of firm i at time t. The $Intensity$ denotes a continuous variable indicating the proportion of treated establishments relative to the total number of establishments. $Control_{i,t}$ denotes a vector of firm level control variables, and a_i and b_t denote firm fixed effects and year fixed effects, respectively.

Table 12 displays the main results for the impact of ESA exposure on firm valuation. As shown in column (1), with one standard deviation increase in $Intensity$, the firm Tobins' Q tends to decrease by 0.06 which is equivalent to a 3.5% decrease over the firm average Tobin's Q. For robustness, we also conduct alternative measures of firm-level ESA exposure repre-

sented by $Intensity_{total}$ and $Intensity_{total}$. $Intensity_{total}$ refers to the ratio of ESA-impacted plants to total plants, weighted by each plant's total pollution emissions. $Intensity_{Onsite}$ refers to the ratio of ESA-impacted plants to total plants, weighted by each plant's onsite pollution emissions. The construction of these two mreasures condider the relative determinal importance of the ESA treated plants measured by the pollutant releases amount. These measures all show that a higher ESA policy shock could significantly affect corporate valuation jointly ranging from 2.5% to 4% reduction in Tobin's Q with one standard deviation change in the different measures of ESA exposures.

In columns (4), (5), and (6), we focus on firm-level ESA exposures, excluding plants located in old habitat areas (pre-2003), to evaluate the impact of first-time shocks on firm valuation. Specifically, $Intensity^{First}$ represents the ratio of plants first exposed to ESA shocks in a given year t (post-2003) to the total number of plants. $Intensity^{First}_{Total}$ refers to the ratio of ESA-impacted plants first shocked after 2003 to total plants, weighted by each plant's total pollution emissions. Similarly, $Intensity^{First}_{Onsite}$ reflects the ratio of ESA-impacted plants first shocked after 2003 to total plants, weighted by each plant's onsite pollution emissions. Across these measures, the findings indicate that a higher ESA policy shock is associated with a significant reduction in corporate valuation, with Tobin's Q declining by 5% to 6% for a one-standard-deviation increase in ESA exposure. The results demonstrate that ESA risk exposure, particularly first-time shocks, leads to more pronounced devaluations in firm valuation in the financial markets.

In addition to analyzing firm valuation in response to ESA exposure, we examine the impact of the ESA on firm profitability and investment. Drawing on Fried (2018) and Hsu et al. (2023), a heightened perceived environmental risk is shown to reduce corporate profitability and investment, particularly when such risk materializes. To capture the effect at the time of biodiversity regulatory implementation, we develop a measure, $ESAShock$, defined as the proportion of plants newly added to the ESA relative to the total number of plants owned by firm i. This measure quantifies the magnitude of the ESA-induced shock on firm i during the implementation year t and the subsequent year t+1, where t represents the year in which the ESA regulations were enacted for the affected plants. Similarly, $ESAShock^{First}$ focuses exclusively on first-time shocks occurring after 2003, excluding plants located in old habitats designated before 2003.

Table 13 presents the results for corporate profitability and physical investment. Within our critical habitat designation experiment, firms with greater ESA shocks tend to have

lower profitability in Table 13 columns (1) and (2). The impact of the economic magnitude is conditional on whether the firm establishments have had similar experiences before. When the firms were exposed to ESA risks before 2003, within our sample period, the profitability of the firm was -0.019 lower. However, if the firms are historically first shocked by ESA, the decline in the firm profitability is relatively larger with -0.022. The heterogeneity coincides with the theoretical prediction of climate adaptation. Consistently, regarding the corporate investment, Table 13 also confirms the lower physical investment of firms in response to a higher shock derived from critical habitat designation act. Firms with higher ESA shocks experience -0.0182 lower physical investments compared to the ones without. The economic magnitude is larger for the group of firms without biodiversity adaptation before and therefore, the corresponding physical investment is 1.94% lower. Compared with the firm-level average of ROA and investment, all the corporate fundamentals are of great economic magnitude. Overall, these negative correlations between firm establishment ESA shocks and firm profitability confirm our economic hypothesis that firm valuation is shocked by the biodiversity conservation policy.

6.4 Stock Market Implications

Finally, we confirm the ESA pressure over the financial market by investigating its connection with equity prices. To capture this financial market effect, we exploit the Fama–French factor model to decompose the stock returns into systematic parts and abnormal risk premiums. Then, we use the annual cumulative abnormal return (CAR) to capture the monthly abnormal return at an annual frequency from Jan to Dec. The abnormal return is estimated with a long period of pre-event stock return. To guarantee stability, we exploit at least a 3-year monthly return to train the pre-event model. The regression is designed as follows:

$$CAR_{i,t} = \beta_0 ESAShock_{i,t}^{First} + \gamma^{'} Control_{i,t} + a_i + b_t + \epsilon_{i,t},$$

where $ESAShock_{i,t}^{First}$ captures the biodiversity conservation shocks experienced by firm i at time t, it is measured as the number of plants affected by ESA listing in year t divided by the total number of plants owned by firm i. This measure focuses exclusively on first-time shocks occurring after 2003, excluding those imposed on plants located in previously designated habitat areas. Table 14 presents the main results, showing that ESA legislation negatively impacts firm valuations, as reflected in the negative abnormal returns during the ESA shock period. A higher biodiversity regulatory shock contributes to 7.8% to 9.2% sen-

sitivity change in the firm market annualized returns. The negative impact is statistically significant when we control for firm alternative confoundings. The evidence coherently validates our hypothesis that biodiversity conservation policy has negative pressure over firm market valuation.

7 Economic Mechanism Analysis

Firms facing heightened biodiversity conservation pressures often adopt strategies to shift pollution from onsite to offsite locations. More significantly, they tend to align with greenness standards to comply with the EPA TRI toxic attainment requirements. These strategies substantially enhance firms' efforts toward environmental sustainability. Despite these insights, a critical question remains: how do firms adapt to the EPA TRI green standards?

7.1 Green Labour Hiring

To address this, we examine the environmental strategies firms employ to mitigate biodiversity conservation pressures. Our first conjecture focuses on green innovation. This hypothesis is grounded in the literature Acemoglu, Aghion, Bursztyn and Hemous (2012), and Fried (2018), which highlight the role of green innovation in reducing pollution emissions. Furthermore, to corroborate firms' efforts in adopting greener practices, we analyze green labor metrics. This approach strengthens our hypothesis that firms invest in green human capital to manage biodiversity-related risks.

Specifically, under increased biodiversity conservation pressures, firms may either recruit green-skilled labor to monitor and manage regulatory risks or deploy such labor to develop advanced techniques that mitigate these risks. This dual approach underscores the pivotal role of green human capital in addressing environmental and regulatory challenges.To verify the conjecture between green labor hiring and biodiversity conservation, we first run panel regression following:

$$Green_Labor_{i,t} = \beta_0 ESAShock_{i,t} + \gamma' Control_{i,t} + a_i + b_t + \epsilon_{i,t},$$

$Green_Labor_{i,t}$ represents the demand for employees with green skills, as reflected in the labor hiring activities of firm i at time t. This captures the firm's need for workers possessing the

necessary green competencies.[12] The key independent variable, $ESAShock_{i,t}$, measures the magnitude of the ESA-induced shock experienced by firm i. Given that our measure of green labor does not differentiate between specific skill sets within the broader category of green human capital, we assume that green labor primarily contributes either by monitoring compliance with operational regulations or by innovating techniques to replace traditional pollution-intensive production methods in non-attainment areas.

Table 15 presents the results linking ESA policy risk to green labor hiring. For robustness, we experiment with various measures of green human capital that incorporate alternative weighting schemes, ranging from job postings to firm-level data. The results consistently demonstrate that firms experiencing higher ESA shocks exhibit a significantly greater demand for green human capital in labour hiring. This relationship holds across different weighting schemes, reinforcing the robustness of our findings.

In summary, the regression analyses on green labor hiring validate our conjecture that firms leverage green labor to monitor compliance and mitigate potential biodiversity-related regulatory risks. Furthermore, a higher proportion of green human capital may positively impact firms' attainment ratios under regulatory standards.

7.2 Green Innovation

Alternatively, beyond green hiring, another pathway to achieving attainment standards is through green innovation. Firms facing biodiversity conservation pressures may adopt advanced green techniques to qualitatively reduce pollutant emissions. For instance, they might substitute harmful chemicals with environmentally friendly alternatives to comply with EPA attainment standards. Quantitatively, green innovation may also play a pivotal role by enabling firms to reduce pollutant emissions more effectively. As the total volume of pollution decreases, firms can meet EPA attainment thresholds. In this context, firms with robust green patent portfolios are more likely to attain regulatory standards, as early-stage innovation activities lay the foundation for the implementation or application of these technologies in TRI establishment attainment. To test this hypothesis, we develop regression models to examine whether firms with higher levels of green innovation, particularly innovation focused on pollution control, exhibit improved attainment ratios under heightened biodiversity

[12]This measure is constructed using data from Lightcast. We follow the OECD green definition to identify the necessary green skills and include all labor possessing such skills.

conservation pressures.

$$Attainment_{i,t} = \beta_0 \times Intensity_{i,t} \times Green_Innovation_{i,t} + \beta_1 \times Intensity_{i,t} + \beta_2 \times Green_Innovation_{i,t} + \gamma' Control_{i,t} + a_i + b_t + \epsilon_{i,t},$$

where the *GreenInnovation* is a dummy variable that equals one if the total number of general green patents held by firm i classified above by the USPTO is above the median number across firm, and zero otherwise. *PollutionControl* is a dummy variable that equals one if the total number of specific pollution control green patents classified by Cheng et al. (2024) held by firm i is above the median number across firm, and zero otherwise.

Table 16 presents the final results. We interact firm-level ESA exposure with the green innovation indicator, with a particular emphasis on pollution control innovation as a critical measure. Columns (1) and (2) demonstrate that increased green innovation enhances the likelihood of firms meeting the attainment standards established by the TRI. Similarly, Columns (3) and (4) reveal a statistically significant pattern, showing that a higher number of pollution control patents is associated with improved corporate attainment. Notably, this effect is more pronounced when focusing on pollution control-related innovation rather than general green adoption. These findings underscore the pivotal role of targeted green innovation in achieving regulatory compliance.

This evidence supports our conjecture that firms exposed to critical habitat designations face heightened regional environmental risks. Consequently, they predominantly focus on achieving attainment to meet the environmental quality standards set by the EPA. In addition to reallocating internal pollutant capital, these firms leverage green capital channels to monitor and manage environmental risks effectively.

7.3 ESA Enforceability and Monitoring

In the preceding sections, we establish a structural mechanism through which biodiversity conservation policies influence corporate behavior. Firms exposed to ESA regulations respond in two primary ways: 1), They leverage the internal pollutant capital market to shift pollution from onsite to offsite locations. 2), They proactively adopt green technologies or hire green-skilled labor to monitor and mitigate potential biodiversity-related regulatory pressures.

However, a critical question remains: how do corporations perceive the regulatory risks associated with biodiversity conservation? This topic is a subject of ongoing debate in the fields of nature and biology, with numerous studies challenging the effectiveness of the ESA in the U.S. (Stokstad; 2005). In this paper, we explore the effectiveness of species protection policies in influencing corporate behaviour and validate the effectiveness.

On the one hand, the link between ESA enforceability and corporate behavior may be direct, mediated through governance by the U.S. Fish & Wildlife Service. For example, as shown in Appendix C, Silicon Valley Power demonstrates how modern corporations are monitored under ESA legislation. Due to indirect damage to the critical habitats of five species, the company is supervised by the U.S. Fish & Wildlife Service to reduce NOx emissions, protect long-term habitat management, and control vehicle access—efforts that incur substantial financial expenditures.

Alternatively, the effectiveness of biodiversity conservation governance can also be evaluated through the monitoring role of social media. We hypothesize that the impact of ESA legislation on corporations is propagated via public monitoring through social media platforms. Table 17 presents the regression results, showing that counties with plants affected by ESA policies are more likely to attract media attention reporting biodiversity-related news. This statistically significant relationship suggests that regional social media serves as a crucial mechanism for disseminating ESA regulations and monitoring corporate compliance with biodiversity conservation standards. Following the ESA shock, the annual biodiversity-related news increases by 213.25 to 230.56 articles in the treated plant areas compared to control areas. The robustness of these findings is confirmed when we use news specifically focusing on the local biodiversity as the dependent variable in columns (5) to (8).

In addition to the monitoring of social media, the effectiveness of the ESA can also be assessed through the implementation of the Critical Habitat Designation Act. This Act is a sequential process, meaning that plants previously designated as critical habitats for one endangered or threatened species may also be designated as habitats for additional species. We hypothesize that plants already assigned as habitats are more likely to be relisted compared to those without any prior listing, which stresses the increasing pressure of stringent regulatory requirements. To test this hypothesis, we run the following regression:

$$HabitatDesignations_{j,t} = \beta_0 \times ESA_Plant_{after2003,j,t} + \beta_1 ESA_Plant_{before2003,j,t} + a_{s,t} + \epsilon_{j,t},$$

where $HabitatDesignations_{j,t}$ measures the number of species' critical habitat listings cov-

ering plant j at time t. $ESA_Plant_{after2003,j,t}$ is an indicator that equals one if plant j has been designated as a critical species area (listing after 2003) at time t, and 0 otherwise. $ESA_Plant_{before2003,j,t}$ is an indicator that equals one if plant j has been designated as a critical species area (listing prior to 2003) at time t, and 0 otherwise. As shown in Table 18, plants already subject to ESA shocks are significantly more likely to be associated with multiple protected species' habitats afterwards, reflecting the pressure exerted by stringent regulatory measures. Combined with green technology adoption and labor hiring, our findings reinforce the idea that establishments facing heightened biodiversity conservation pressures are actively working to improve regional habitat quality, thereby contributing to broader biodiversity conservation goals.

8 Ecological Externalities and Welfare

Previous research has documented an increase in local bird species richness at industrial facilities located within habitats designated under the Endangered Species Act (ESA). This ecological improvement stems from ESA compliance, which mandates that plants redirect toxic pollutants to off-site treatment and disposal facilities rather than discharging them on-site. Consequently, the pollution burden shifts to these remote disposal sites, which now absorb the toxins previously emitted within ESA-protected habitats. A key policy question emerges: What are the biodiversity consequences at these disposal sites? Whether pollution relocation generates negative externalities remains an open empirical issue.

We leverage satellite location data from the Environmental Protection Agency (EPA) to identify remote disposal facilities linked to establishments in the National Establishment Time-Series (NETS) database, using the smallest distance to assign each disposal site to its nearest NETS plant. This approach rests on the plausible assumption that firms minimize transportation costs when selecting disposal locations. Using this linkage, we estimate biodiversity outcomes ($Bird_{30km}^{Total}$, $Species_{30km}^{Average}$) within a 30-kilometer radius of disposal sites. For robustness, we employ multiple species-level proxies, including endangered bird populations and total species counts, to capture potential ecological spillovers. These estimates aim to isolate non-pecuniary effects on biodiversity, complementing the more extensively studied pecuniary ESG mechanisms discussed in Hong, Kubik and Shore (2024). Our baseline specification is:

$$Biodiversity_{i,t}^{Total} = \beta_1 Treat^{First} \times After_t + Control_{i,t} + \epsilon_{i,t}$$

Table 19 presents the main results. We define $Treat^{First}$ as an indicator for establishments subject to ESA enforcement post-2003, employing a difference-in-differences (DiD) framework where ESA-regulated plants constitute the treatment group. To address potential confounding from historical ESA exposure, we also define treatment as all establishments ever subject to ESA regulations. Both specifications yield statistically and economically significant effects: columns (1) and (3) show that biodiversity near disposal sites linked to ESA-treated plants declines by 2,653.32 (0.146 standard deviations), representing 93.5% and 16.4% of mean disposal-site biodiversity, respectively. The effect amplifies when using historical exposure (columns (2) and (4)), with declines of 3,088.28 (0.161 standard deviations).

Our findings underscore significant negative externalities from pollution relocation, with important policy implications. Tighter ESA enforcement may inadvertently incentivize firms to externalize regulatory risk by diverting pollutants to remote disposal sites, exacerbating ecological degradation in those areas. This suggests the need for more spatially integrated environmental regulation. Notably, our estimates likely understate the true social cost, as they exclude pecuniary losses to disposal-adjacent communities. Incorporating such costs remains a challenging but critical direction for future research.

9 Conclusion

Our paper provides a comprehensive framework for examining how firms respond to the Endangered Species Act (ESA) in the U.S., and evaluate the effectiveness of biodiversity conservation in corporate pollution management. We further investigate the impact of biodiversity policies on firm valuation in financial markets. This analysis is conducted at the most granular level available in the scientific literature.

By integrating EPA TRI reporting facility data with critical habitat designations under the Endangered Species Act (ESA), we examine the impact of biodiversity conservation on corporate decision-making. Additionally, we develop an establishment-level bird index to measure dynamic changes in the biodiversity environment. Utilizing a quasi-experimental Difference-in-Difference approach, we identify a causal link between ESA-induced shocks and their joint financial and ecological implications. At the micro level, firms tend to manage

biodiversity conservation in two dimensions: first, by transferring onsite pollution to offsite locations without reducing the relative intensity of pollution; second, more essentially, by pushing exposed establishments under attainment to minimize their vulnerability to biodiversity conservation requirements. At the aggregate firm level, these evidences align with the micro-level story where firms monitor biodiversity conservation efficiently. Due to environmental risks, firms struggle to achieve higher market valuations, as their diversification strategies are constrained by regulatory friction, leading to lower investment and profitability. However, from an ecological perspective, our paper confirms that ESA enforcement through corporate channels has a significant impact on the surrounding biodiversity environment.

Our analysis reveals that ESA legislation generates significant non-pecuniary negative externalities. By compelling firms to relocate pollution to remote disposal sites as a means of mitigating local regulatory risk, the policy inadvertently degrades biodiversity in surrounding ecosystems. The deterioration is both immediate and economically substantial following ESA implementation. From a welfare-theoretic perspective, these findings underscore two critical policy implications: (1) the need for accelerated technological innovation in corporate pollution abatement, and (2) the importance of spatially integrated environmental regulation that internalizes biodiversity externalities across jurisdictions.

Through this empirical framework, we establish a foundational structure that links corporate finance with biodiversity regulatory risk. By identifying how risk propagates from regional governments to corporate operations, we demonstrate how firms respond internally. From a policy-making perspective, our empirical work is valuable in explicitly highlighting the economic losses and biodiversity gains associated with regulatory actions. In contrast to purely scientific research, we quantify these economic and ecological outcomes within a consistent framework. This approach provides a motivation for further normative research on how to optimally design biodiversity policies and how firms manipulate the biodiversity conservation specifically.

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10 Figure

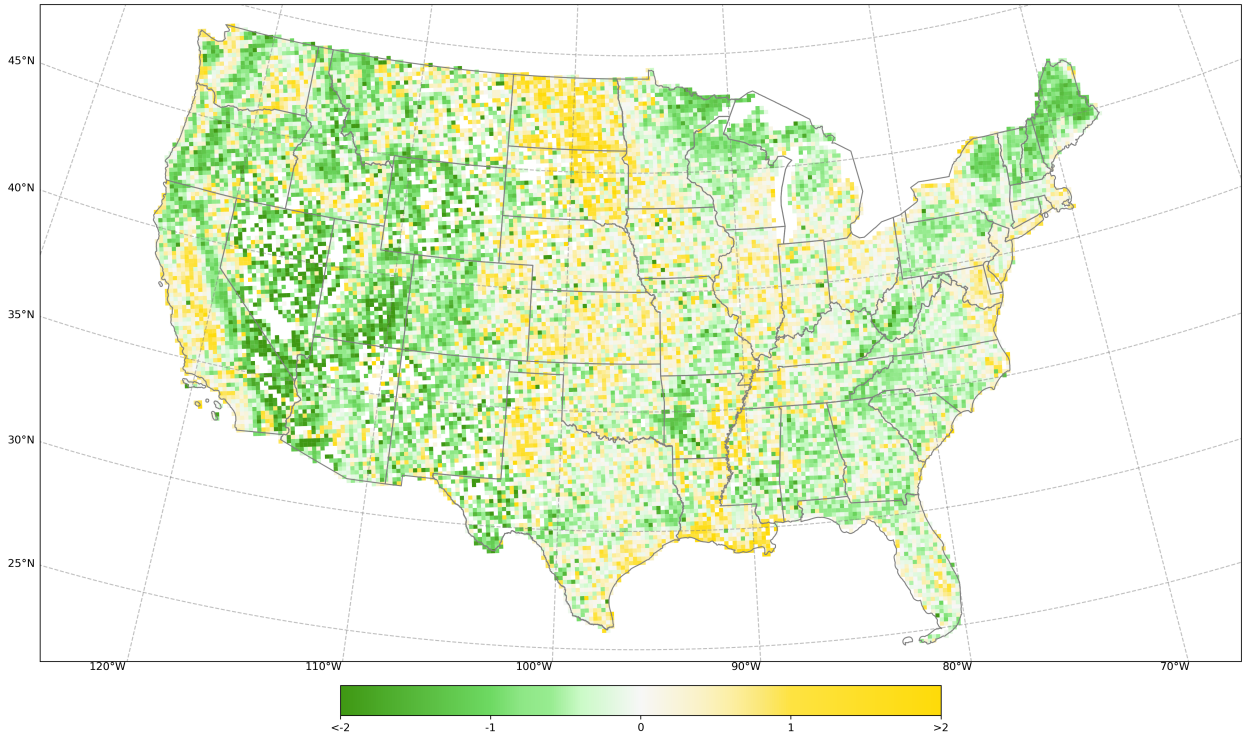


Figure 1: Geographic Distribution of Bird Biodiversity in the Contiguous United States (2002-2022 Average)

Note: This figure displays the geographic distribution of averaged bird biodiversity index ($Bird_{Std}^{Log}$) within non-overlapping 20 $\times$ 20 km grid cells across the contiguous United States, calculated using data from the eBird dataset, a global citizen science initiative managed by the Cornell Lab of Ornithology. The mapped variable is the normalized value of grid-month-year fixed effects recovered from the Poisson regression, as detailed in Section 4. The color scale ranges from green to yellow, with green indicating relatively higher values of bird biodiversity and yellow representing relatively lower values, compared to the average. Black lines on the map indicate state boundaries.

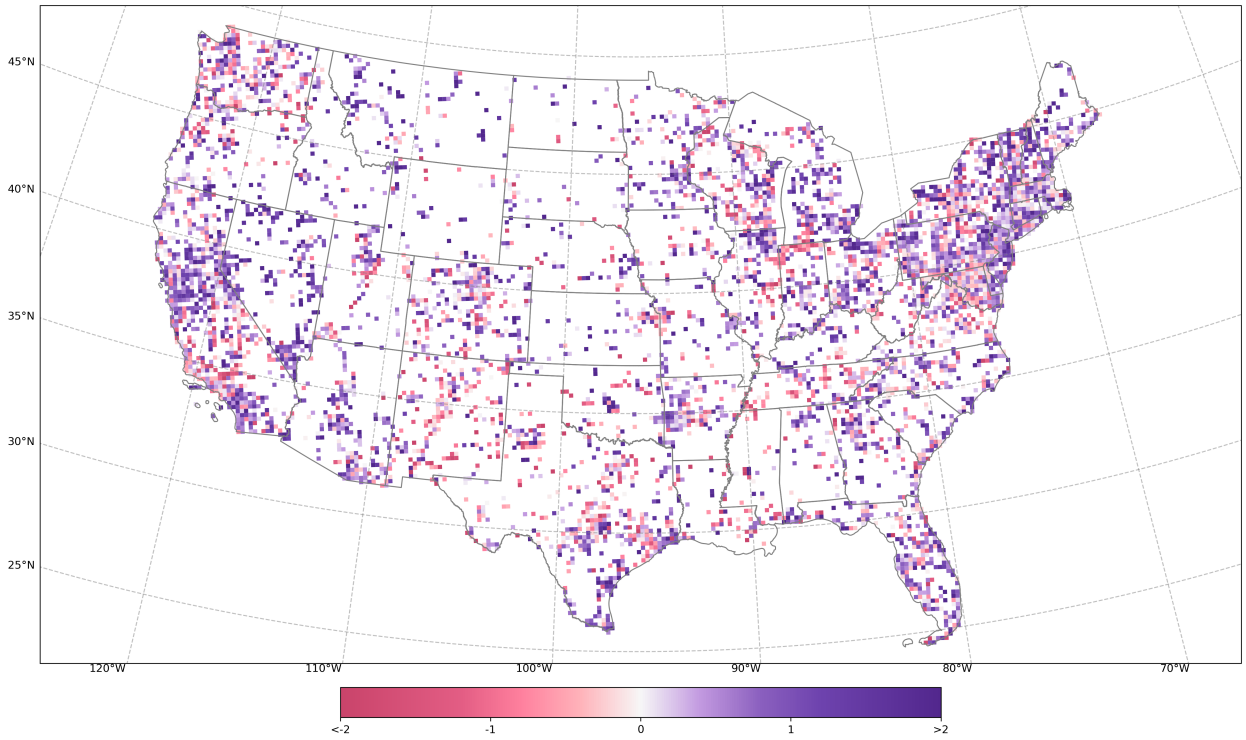
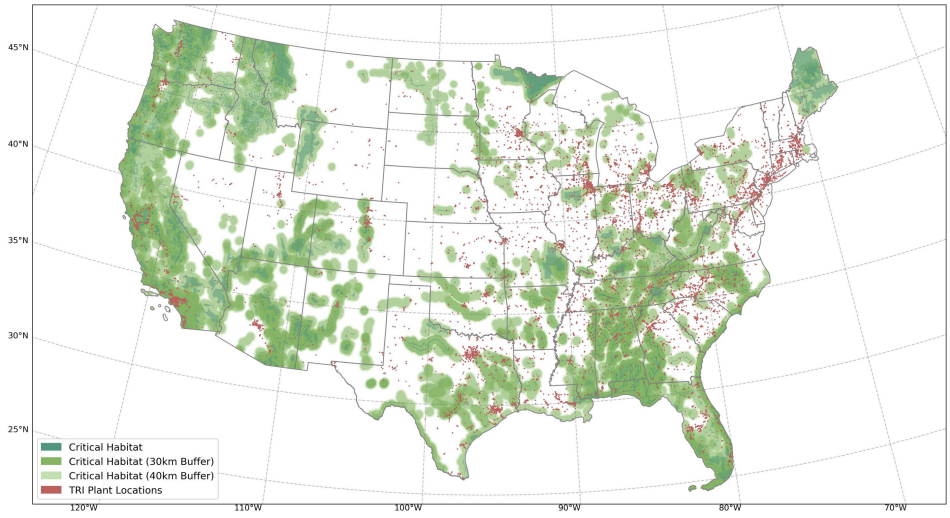


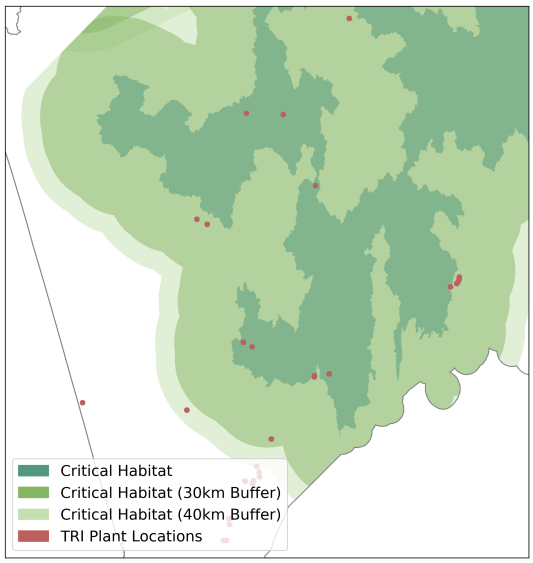
Figure 2: Change in Bird Biodiversity in the Contiguous United States (2002-2022)

Note: This figure illustrates the change in averaged bird biodiversity index ($Bird_{Std}^{Log}$) within non-overlapping 20 $\times$ 20 km grid cells across the contiguous United States between 2002 and 2022. The map shows the difference in biodiversity values over this 20-year period, calculated by subtracting the 2002 values from the 2022 values for each grid cell. The color scale ranges from red to blue, with blue indicating a relative increase in bird biodiversity and red representing a relative decrease. Areas closer to white indicate little change.

Figure 3: TRI Plants and ESA Policy in the US



(a) Distribution of TRI Plants and Critical Habitat Designations across the Continental United States



(b) Critical Habitat Designations in Maine

Note: These two panels show the distribution of Toxic Release Inventory (TRI) plants (red dots), critical habitat designations (green areas) across the contiguous United States. Panel (a) shows the locations of all TRI-listed establishments and critical habitat designations assigned by the EPA by the end of 2022, along with 30 km and 40 km buffer zones Buffer regions are area colored with shadowed regions. Panel (b) focuses on TRI locations and critical habitats within Sagadahoc county, Maine. Black lines represent state boundaries.

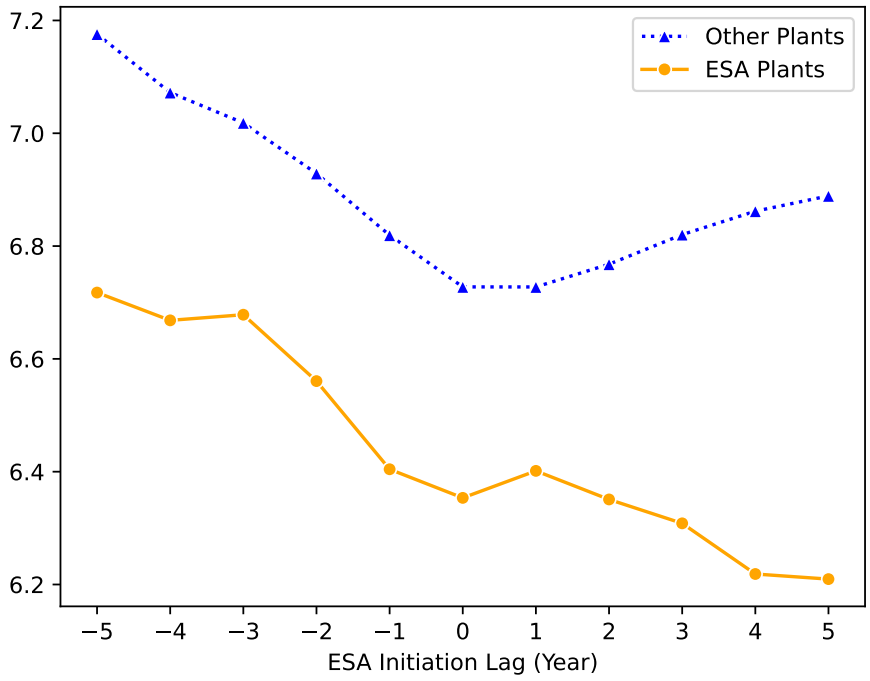


Figure 4: Total Pollution Trend for Establishments

Note: This figure illustrates the trend of total pollution releases for pollutive establishments. The x-axis represents the time gap (in years) between the reported pollution release year in the EPA dataset and the initiation year of ESA for the corresponding establishment. The y-axis shows the logarithm of total pollution releases. The orange line represents the average total pollution releases of establishments subject to ESA regulations ("Treated Plants"). The blue line represents the average total pollution releases of establishments not subject to ESA regulations ("Control Plants").

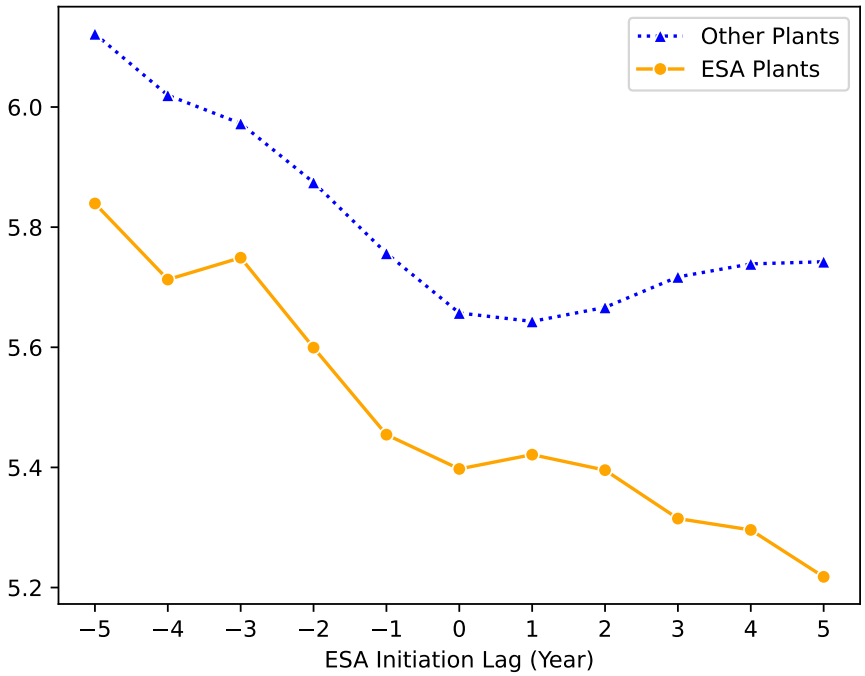


Figure 5: Onsite Pollution Trend for Establishments

Note: This figure illustrates the trend of onsite pollution releases for pollutive establishments. The x-axis represents the time gap (in years) between the reported pollution release year in the EPA dataset and the initiation year of ESA for the corresponding establishment. The y-axis shows the logarithm of onsite pollution releases. The orange line represents the average onsite pollution releases of establishments subject to ESA regulations ("Treated Plants"). The blue line represents the average onsite pollution releases of establishments not subject to ESA regulations ("Control Plants").

11 Table

Table 1: Establishment-level Summary of Statistics

VarName	Obs	Mean	SD	Min	P10	P25	Median	P75	P90	Max
$Emission_{onsite}$	75534	5.677	4.805	0	0	0.054	5.778	9.74	12.3	15.215
$Emission_{offsite}$	75534	3.362	4.175	0	0	0	0.095	6.909	9.928	13.565
$Emission_{total}$	75534	6.73	4.677	0	0	2.079	7.444	10.427	12.718	15.395
$WEmission_{onsite}$	75263	6.135	5.102	0	0	0.077	6.376	10.489	13.084	16.041
$WEmission_{offsite}$	75263	3.609	4.431	0	0	0	0.095	7.402	10.51	14.366
$WEmission_{total}$	75263	7.215	4.943	0	0	2.398	8.016	11.163	13.491	16.157
$Treat$	75534	0.276	0.447	0	0	0	0	1	1	1
$Treat^{First}$	75534	0.244	0.429	0	0	0	0	0	1	1
$Attainment$	75534	0.036	0.186	0	0	0	0	0	0	1
$Close/Inactive$	75534	0.006	0.079	0	0	0	0	0	0	1
$Sale$	75534	0.01	0.1	0	0	0	0	0	0	1
$Bird_{total}^{10km}$	44767	7385	20672.68	0	2.0	44.0	645.0	4812.0	18800.4	387625.
$Bird_{total}^{20km}$	44767	24099	55235.86	0	15.00	257.00	3315.00	19571.75	70981.50	948639.00
$Bird_{total}^{30km}$ (Disposal)	44775	2827.23	16726.61	0	0	3	32	329	2715	380477
$Species_{total}^{30km}$ (Disposal)	44775	0.89	0.64	0.00	0.00	0.44	0.80	1.24	1.78	6.00

Note: This table shows the summary of statistics for US establishments on TRI from 2003 to 2019. $Emission_{onsite}$ denotes the onsite establishment emission. $Emission_{offsite}$ refers to the offsite emission for establishments. $Emission_{total}$ refers to the total emission for establishments summing all the listed chemicals on the TRI. $WEmission_{onsite}$ denotes the weighted average onsite establishment emission. $WEmission_{offsite}$ refers to the weighted average offsite emission for establishments. $WEmission_{total}$ refers to the weighted average total emission for establishments summing all the listed chemicals on the TRI.$Treat$ refers to the establishments that are within the 30 km circle region classified as critical habitat designation following ESA from 1973. $Treat$ refers to the establishments that are within the 30 km circle region classified as critical habitat designation following ESA from 2003. Attainment means the facility satisfies the TRI report standard. $Close/Inactive$ refers to the closing status of the establishments from TRI report. Sale refers to the establishment transaction status in the primary market following NETS definition. $Bird_i^{total}$ implies the bird biodiversity statistics at the establishment level. We count the total number of endangered birds within 10(20) kilometers of the establishment. $Bird_{total}^{30km}$ refers to the identified disposal surrounding bird biodiversity total number within 30 kilometers. $Species_{total}^{30km}$ denotes an alternative measure of bird biodiversity within 30 kilometers area of the identified disposal facilities, where we estimate the average species number as an alternative to bird biodiversity.

Table 2: Firm-Level Summary of Statistics

VarName	Obs	Mean	SD	Min	P10	P25	Median	P75	P90	Max
$Emission_{onsite}$	8639	8.926	4.882	0	0.01	5.974	9.882	12.486	14.726	18.697
$Emission_{offsite}$	8639	6.636	4.983	0	0	0.068	7.552	10.865	12.741	18.329
$Emission_{total}$	8639	9.886	4.463	0	2.398	7.633	10.74	13.003	14.958	18.698
$WEmission_{onsite}$	8639	9.549	5.129	0	0.008	6.539	10.64	13.334	15.571	19.357
$WEmission_{offsite}$	8639	7.062	5.242	0	0	0.068	8.134	11.496	13.464	18.91
$WEmission_{total}$	8639	10.503	4.68	0	2.775	8.177	11.464	13.772	15.751	19.358
$Plant_Num$	8639	8.474	15.049	1	1	2	4	9	20	229
$Attainment_{num}$	8639	0.104	0.434	0	0	0	0	0	0	16
$Attainment_{pct}$	8639	0.019	0.105	0	0	0	0	0	0	1
$Attainment_{num}(Excl.)$	8639	0.056	0.304	0	0	0	0	0	0	7
$Attainment_{pct}(Excl.)$	8639	0.01	0.077	0	0	0	0	0	0	1
$Intensity$	8639	0.144	0.244	0	0	0	0	0.214	0.444	1
$Intensity_{total}$	8146	0.137	0.289	0	0	0	0	0.071	0.642	1
$Intensity_{onsite}$	7811	0.134	0.289	0	0	0	0	0.055	0.64	1
$Intensity^{First}$	8639	0.121	0.219	0	0	0	0	0.179	0.364	1
$Intensity^{First}_{total}$	8146	0.116	0.266	0	0	0	0	0.039	0.5	1
$Intensity^{First}_{onsite}$	7811	0.115	0.267	0	0	0	0	0.028	0.505	1
$ESAShock$	8639	0.029	0.111	0.000	0.000	0.000	0.000	0.000	0.077	1.000
$ESAShock^{First}$	8639	0.025	0.099	0.000	0.000	0.000	0.000	0.000	0.063	1.000
$TobinsQ$	8638	1.731	0.882	0.567	1.021	1.189	1.486	2.005	2.71	19.549
$Leverage$	8435	0.424	0.861	0	0.046	0.227	0.383	0.545	0.718	45.617
$Tangibility$	8444	0.297	0.195	0	0.096	0.146	0.241	0.402	0.613	0.94
$Asset$	8452	7.916	1.775	1.712	5.695	6.645	7.869	9.144	10.287	13.709
$Profitability$	8137	0.102	0.07	-0.544	0.037	0.064	0.098	0.134	0.179	1.282
$Cash$	8452	0.104	0.11	0	0.009	0.026	0.069	0.146	0.245	0.992
$Fin_constraint$	7257	-0.348	0.493	-2.133	-0.975	-0.638	-0.35	-0.061	0.277	2.147
$Environ_risk$	7452	7.551	1.299	0	6.151	6.884	7.598	8.312	9.011	12.59

Note: This table shows the summary of statistics for US establishments on TRI from 2003 to 2019. $Emission_{onsite}$ denotes the onsite establishment emission. $Emission_{offsite}$ refers to the offsite emission for establishments. $Emission_{total}$ refers to the total emission for establishments summing all the listed chemicals on the TRI. $WEmission_{onsite}$ denotes the weighted average onsite establishment emission at the firm level. $WEmission_{offsite}$ refers to the weighted average offsite emission for establishments at the firm level. $WEmission_{total}$ refers to the weighted average total emission for establishments summing all the listed chemicals on the TRI at the firm level. $Plant_Num$ denotes the number of the plants affiliated with each firm. $Attainment_{num}$ refers to the firm average plants that reach the attainment.$Attainment_{pct}$ denotes to the firm attainment percentage that reach the attainment.$Attainment_{num}(Excl)$ refers to the firm average plants that reach the attainment excluding plants transacted or closed.$Attainment_{pct}(Excl)$ denotes to the firm attainment percentage that reach the attainment excluding plants transacted or closed. $Intensity$ indicates the fraction of establishments that are exposed to ESA policy. $Intensity_{total}$ indicates the fraction of establishments that are exposed to ESA policy from 1973. $Intensity$ indicates the fraction of establishments that are exposed to ESA policy. $TobinQ$ denotes the market value to book equity . $Profitability$ is calculated with the profitablity of the firm. $Leverage$ refers to the debt to total asset. $Tangibility$ denotes the tangible assets. $Asset$ refers to the logarithmic of total asset. $Cash$ denotes the cash holdings. $Fin_Constraint$ refers to the Hoberg and Maksimovic (2015) proposed text-implied financial constraint. $Environ_Risk$ indicates the Hassan et al. (2017) proposed environmental regulation risk.

Table 3: Establishment-level Onsite Pollution

	$log(Emission_{onsite}+1)$				$log(WEmission_{onsite}+1)$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Treat^{First} \times After$	-0.133*		-0.153**		-0.130*		-0.153**	
	(-1.85)		(-2.17)		(-1.69)		(-2.02)	
$Treat \times After$		-0.108		-0.115*		-0.107		-0.115
		(-1.58)		(-1.72)		(-1.47)		(-1.60)
Constant	5.700***	5.698***	5.703***	5.700***	6.158***	6.157***	6.161***	6.158***
	(559.53)	(516.23)	(571.59)	(524.81)	(563.75)	(519.17)	(574.73)	(527.04)
Plant FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y			Y	Y		
Year*Industry FE			Y	Y			Y	Y
R-squared	0.895	0.895	0.898	0.898	0.894	0.894	0.897	0.897
Observations	75443.000	75443.000	75425.000	75425.000	75170.000	75170.000	75152.000	75152.000

Note: This table shows the regressions of plant pollution over ESA policy shocks. The dependent variables are $Emission_{onsite}$, $WEmission_{onsite}$ respectively.$Emission_{onsite}$ denotes the plant onsite. $WEmission_{onsite}$ refers to the weighted average offsite pollution. $Treat^{First}$ denotes the establishment within the 30km region of the critical habitat designation according to ESA since 2003. $Treat^{First}$ denotes the establishment within the 30km region of the critical habitat designation according to ESA since 1973. The $Treat^{First} \times After_t$ denotes the ESA shocked establishment for plant i at time t since 2003. $Treat \times After_t$ refers to the ESA shocked establishment after 1973. A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Establishment-level Offsite Pollution

	$log(Emission_{offsite}+1)$				$log(WEmission_{offsite}+1)$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Treat^{First} \times After$	0.167*		0.176*		0.155		0.164*	
	(1.79)		(1.89)		(1.56)		(1.65)	
$Treat \times After$		0.188**		0.203**		0.174*		0.189**
		(2.16)		(2.31)		(1.87)		(2.03)
Constant	3.341***	3.334***	3.340***	3.332***	3.590***	3.584***	3.589***	3.582***
	(252.71)	(235.84)	(252.76)	(234.64)	(254.67)	(237.45)	(255.47)	(236.87)
Plant FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y			Y	Y		
Year*Industry FE			Y	Y			Y	Y
R-squared	0.755	0.755	0.760	0.760	0.754	0.754	0.759	0.759
Observations	75443.000	75443.000	75425.000	75425.000	75170.000	75170.000	75152.000	75152.000

Note: This table shows the regressions of offsite pollution over ESA policy shocks. The dependent variables are $Emission_{offsite}$, $WEmission_{offsite}$ respectively.$Emission_{offsite}$ denotes the plant onsite. $WEmission_{offsite}$ refers to the weighted average offsite pollution. The $Treat^{First} \times After_t$ denotes the ESA shocked establishment for plant i at time t since 2003. $Treat \times After_t$ refers to the ESA shocked establishment after 1973. A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Establishment-Level Total Pollution

	$log(Emission_{total}+1)$				$log(WEmission_{total}+1)$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Treat^{First} \times After$	-0.058		-0.067		-0.065		-0.076	
	(-0.75)		(-0.89)		(-0.80)		(-0.96)	
$Treat \times After$		-0.021		-0.015		-0.030		-0.024
		(-0.29)		(-0.21)		(-0.40)		(-0.32)
Constant	6.743***	6.738***	6.744***	6.737***	7.229***	7.225***	7.232***	7.225***
	(619.03)	(579.38)	(626.74)	(584.52)	(628.99)	(587.34)	(636.40)	(592.31)
Plant FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y			Y	Y		
Year*Industry FE			Y	Y			Y	Y
R-squared	0.869	0.869	0.873	0.873	0.870	0.870	0.873	0.873
Observations	75443.000	75443.000	75425.000	75425.000	75170.000	75170.000	75152.000	75152.000

Note: This table shows the regressions of plant total pollution over ESA policy shocks. The dependent variables are $Emission_{total}$, $WEmission_{total}$ respectively.$Emission_{total}$ denotes the plant onsite. $WEmission_{total}$ refers to the weighted average offsite pollution. $Treat^{First}$ denotes the establishment within the 30km region of the critical habitat designation according to ESA since 2003. $Treat^{First}$ denotes the establishment within the 30km region of the critical habitat designation according to ESA since 1973. The $Treat^{First} \times After_t$ denotes the ESA shocked establishment for plant i at time t since 2003. $Treat \times After_t$ refers to the ESA shocked establishment after 1973. A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: EPA TRI Establishment Attainments

	Attainment				Attainment			
	Within 5 years after ESA				Within 3 years after ESA			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Treat^{First} \times After$	0.010**	0.008**			0.008*	0.007*		
	(2.19)	(2.24)			(1.67)	(1.83)		
$Treat^{First}$		0.003				0.003		
		(1.27)				(1.41)		
$Treat \times After$			0.012***	0.008**			0.011**	0.008**
			(2.85)	(2.36)			(2.44)	(2.07)
$Treat$				0.004**				0.005**
				(2.05)				(2.24)
Constant	0.032***	0.033***	0.032***	0.032***	0.032***	0.032***	0.032***	0.032***
	(79.23)	(83.68)	(73.58)	(75.13)	(98.37)	(92.86)	(91.77)	(83.59)
Plant FE	Y		Y		Y		Y	
Year FE		Y		Y		Y		Y
Year*Industry FE	Y	Y	Y	Y	Y	Y	Y	Y
R-squared	0.180	0.101	0.180	0.101	0.180	0.102	0.180	0.102
Observations	69628	69745	69628	69745	67445	67589	67445	67589

Note: This table shows the regressions of establishment attainment over ESA policy shocks. The dependent variables are $Attainment_{5\ years}$, $Attainment_{3\ years}$ respectively.$Attainment_{5\ (3)\ years}$ denotes the indicator implying that firms are off the list of TRI in the next 5 (3) years. $WEmission_{total}$ refers to the weighted average offsite pollution. $Treat^{First}$ denotes the establishment within the 30km region of the critical habitat designation according to ESA since 2003. $Treat^{First}$ denotes the establishment within the 30km region of the critical habitat designation according to ESA since 1973. The $Treat^{First} \times After_t$ denotes the ESA shocked establishment for plant i at time t since 2003. $Treat \times After_t$ refers to the ESA shocked establishment after 1973. A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Plant-level Biodiversity Conservation Response

	Dependent variable: Disposal Endangered Biodiversity			
	$Bird_{10km}^{Total}$		$Bird_{20km}^{Total}$	
	(1)	(2)	(3)	(4)
$Treat^{First} \times After$	1,538.973*	6,777.125***		
	(934.725)	(2,213.796)		
$Treat \times After$			1,505.719*	6,562.234***
			(856.484)	(2,046.125)
Observations	44,767	48,920	44,767	48,920
Year FE	Y	Y	Y	Y
Disposal FE	Y	Y	Y	Y
Adjusted R^2	0.552	0.592	0.552	0.592

Note: This table shows the regressions of plant-level bird index over ESA policy shocks. The dependent variables are $Bird_{adj}^{log}$, $Bird_{std}^{log}$ respectively.$Bird_{adj}^{log}$ denotes the ebird estimated biodiversity adjusted with log nonlinearity. $Bird_{std}^{log}$ refers to ebird based bird biodiversity standardized with logarithmic algorithm. $Treat^{First}$ denotes the establishment within the 30km region of the critical habitat designation according to ESA since 2003. $Treat^{First}$ denotes the establishment within the 30km region of the critical habitat designation according to ESA since 1973. The $Treat^{First} \times After_t$ denotes the ESA shocked establishment for plant i at time t since 2003. $Treat \times After_t$ refers to the ESA shocked establishment after 1973. A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Firm-Level Onsite Pollution Releases to ESA Intensity

	$log(Emission_{onsite}+1)$				$log(WEmission_{onsite}+1)$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intensity	-0.472*	-0.615*	-0.610**	-0.859**	-0.557**	-0.721**	-0.720**	-0.996**
	(-1.76)	(-1.83)	(-1.99)	(-2.27)	(-1.97)	(-2.05)	(-2.22)	(-2.52)
Leverage		0.0118		0.0142		0.0152		0.0164
		(1.36)		(1.26)		(1.64)		(1.38)
Tangibility		-0.492		-0.0293		-0.436		0.166
		(-0.71)		(-0.04)		(-0.59)		(0.22)
Asset		0.566***		0.621***		0.655***		0.737***
		(4.63)		(4.82)		(5.03)		(5.55)
Profitability		-0.539		-0.635		-0.483		-0.606
		(-1.04)		(-1.19)		(-0.87)		(-1.07)
Cash		-0.271		0.134		-0.205		0.177
		(-0.46)		(0.23)		(-0.33)		(0.30)
Fin_Constraint		-0.0767		-0.0390		-0.0595		-0.0218
		(-0.72)		(-0.34)		(-0.54)		(-0.19)
Environ_Risk		-0.0351		-0.0168		-0.0369		-0.0164
		(-1.45)		(-0.68)		(-1.39)		(-0.60)
Constant	9.022***	4.759***	9.064***	4.117***	9.659***	4.683***	9.706***	3.784***
	(232.02)	(4.59)	(205.25)	(3.75)	(236.69)	(4.22)	(207.71)	(3.33)
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y			Y	Y		
Year*Industry FE			Y	Y			Y	Y
R^2	0.914	0.910	0.922	0.917	0.913	0.908	0.922	0.916
Observations	8586	6093	8449	5904	8586	6093	8449	5904

Note: This table shows the regressions of firm onsite pollution to the firm ESA intensity. The dependent variables are $Emission_{Onsite}$, $WEmission_{Onsite}$ respectively.$Emission_{Onsite}$ denotes the firm-level onsite pollution. $WEmission_{Onsite}$ refers to the firm-level weighted average offsite pollution. *Intensity* indicates the fraction of the establishments for firm i time t that are exposed to ESA shocks. The firm $profitability$ is inferred from firm Return of Asset. The $Tobin'q$ estimation is estimated with the market value divided by the booked values. The *leverage* follows the estimation with total debt divided by total asset. For the *Asset*, we obtain it with logarithmic of firm market valuation. *Fin_Constraint* denotes the text-implied financial constraint from Hoberg and Maksimovic (2015). $Environ_Risk$ refers to the environmental regulation risk from Hassan et al. (2017). A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Firm-Level offsite Pollution Releases to ESA Intensity

	$log(Emission_{offsite}+1)$				$log(WEmission_{offsite}+1)$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intensity	0.491	0.111	0.799	0.547	0.312	-0.0842	0.562	0.277
	(1.05)	(0.22)	(1.64)	(1.09)	(0.65)	(-0.16)	(1.13)	(0.54)
Leverage		-0.0158		0.00398		-0.0152		0.00583
		(-0.98)		(0.20)		(-0.89)		(0.27)
Tangibility		-1.167		-0.514		-0.840		-0.0554
		(-1.01)		(-0.39)		(-0.70)		(-0.04)
Asset		0.547***		0.415**		0.583***		0.463**
		(3.06)		(2.03)		(3.10)		(2.15)
Profitability		0.229		0.0117		0.00103		-0.222
		(0.26)		(0.01)		(0.00)		(-0.23)
Cash		-0.387		-0.348		-0.201		-0.200
		(-0.48)		(-0.39)		(-0.23)		(-0.21)
Fin_Constraint		0.0478		0.148		0.0630		0.163
		(0.28)		(0.86)		(0.36)		(0.91)
Environ_Risk		-0.0649*		-0.0443		-0.0712*		-0.0497
		(-1.88)		(-1.28)		(-1.96)		(-1.37)
Constant	6.585***	3.139**	6.575***	3.896**	7.039***	3.277**	7.039***	3.917**
	(97.54)	(2.06)	(93.45)	(2.20)	(102.15)	(2.04)	(97.78)	(2.10)
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y			Y	Y		
Year*Industry FE			Y	Y			Y	Y
r2	0.813	0.821	0.831	0.836	0.810	0.818	0.829	0.834
Observations	8586	6093	8449	5904	8586	6093	8449	5904

Note: This table shows the regressions of firm offsite pollution to the firm ESA intensity. The dependent variables are $Emission_{Offsite}$, $WEmission_{Offsite}$ respectively.$Emission_{Offsite}$ denotes the firm-level onsite pollution. $WEmission_{Offsite}$ refers to the firm-level weighted average offsite pollution. *Intensity* indicates the fraction of the establishments for firm i time t that are exposed to ESA shocks. The firm $profitability$ is inferred from firm Return of Asset. The $Tobin'q$ estimation is estimated with the market value divided by the booked values. The *leverage* follows the estimation with total debt divided by total asset. For the *Asset*, we obtain it with logarithmic of firm market valuation. *Fin_Constraint* denotes the text-implied financial constraint from Hoberg and Maksimovic (2015). $Environ_Risk$ refers to the environmental regulation risk from Hassan et al. (2017). A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Firm-Level Total Pollution Releases to ESA Intensity

	$log(Emission_{total}+1)$				$log(WEmission_{total}+1)$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intensity	-0.283	-0.401	-0.313	-0.462	-0.397	-0.528	-0.461	-0.634
	(-0.90)	(-1.14)	(-0.89)	(-1.18)	(-1.21)	(-1.40)	(-1.25)	(-1.53)
Leverage		0.00471		0.00972		0.00751		0.0122
		(0.54)		(1.12)		(0.80)		(1.37)
Tangibility		-0.468		0.287		-0.289		0.618
		(-0.66)		(0.37)		(-0.38)		(0.77)
Asset		0.667***		0.708***		0.756***		0.823***
		(5.59)		(5.40)		(5.87)		(5.97)
Profitability		0.417		0.353		0.413		0.326
		(0.77)		(0.62)		(0.74)		(0.57)
Cash		0.267		0.698		0.366		0.774
		(0.47)		(1.16)		(0.59)		(1.21)
Fin_Constraint		-0.0387		0.0100		-0.0310		0.0179
		(-0.39)		(0.09)		(-0.30)		(0.16)
Environ_Risk		-0.0243		-0.0130		-0.0263		-0.0127
		(-0.95)		(-0.48)		(-0.98)		(-0.44)
Constant	9.952***	4.695***	9.984***	4.118***	10.59***	4.578***	10.63***	3.756***
	(217.94)	(4.47)	(197.83)	(3.51)	(222.67)	(4.03)	(200.07)	(3.05)
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y			Y	Y		
Year*Industry FE			Y	Y			Y	Y
r2	0.898	0.898	0.907	0.905	0.897	0.897	0.908	0.905
Observations	8586	6093	8449	5904	8586	6093	8449	5904

Note: This table shows the regressions of firm total pollution to the firm ESA intensity. The dependent variables are $Emission_{total}$, $WEmission_{total}$ respectively.$Emission_{total}$ denotes the firm-level onsite pollution. $WEmission_{total}$ refers to the firm-level weighted average offsite pollution. *Intensity* indicates the fraction of the establishments for firm i time t that are exposed to ESA shocks. The firm $profitability$ is inferred from firm Return of Asset. The $Tobin'q$ estimation is estimated with the market value divided by the booked values. The *leverage* follows the estimation with total debt divided by total asset. For the *Asset*, we obtain it with logarithmic of firm market valuation. *Fin_Constraint* denotes the text-implied financial constraint from Hoberg and Maksimovic (2015). $Environ_Risk$ refers to the environmental regulation risk from Hassan et al. (2017). A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Firm-Level Establishment Attainment to ESA

	$Attainment_{num}$		$Attainment_{pct}$		$Attainment_{num}(Excl.)$		$Attainment_{pct}(Excl.)$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intensity	0.345***	0.321***	0.149***	0.148***	0.166***	0.159***	0.0764***	0.0771***
	(5.90)	(5.00)	(5.41)	(5.27)	(4.36)	(3.90)	(3.63)	(3.40)
Plant_Num	0.0327***	0.0317***			0.0162***	0.0161***		
	(4.26)	(5.14)			(3.69)	(4.57)		
Leverage	-0.00213	-0.00882**	-0.000400	-0.00176	-0.00211**	-0.00774*	-0.000230	-0.00154
	(-1.58)	(-2.29)	(-1.24)	(-1.62)	(-2.40)	(-1.84)	(-1.12)	(-1.36)
Tangibility	0.0792	0.0339	-0.00425	-0.0159	0.0425	-0.0259	0.00223	-0.0127
	(0.51)	(0.23)	(-0.20)	(-0.62)	(0.54)	(-0.30)	(0.14)	(-0.60)
Asset	0.0164	0.0202	0.000642	-0.0000542	0.0263**	0.0198	0.00702**	0.00612*
	(0.90)	(0.90)	(0.15)	(-0.01)	(2.46)	(1.58)	(2.33)	(1.66)
Profitability	-0.253***	-0.163*	-0.0366**	-0.0410**	-0.157***	-0.117*	-0.0341***	-0.0331**
	(-3.51)	(-1.66)	(-2.03)	(-2.16)	(-2.86)	(-1.91)	(-2.81)	(-2.35)
Cash	0.0698	0.0894	-0.0259	-0.0198	0.0587	0.0856	0.00911	0.00925
	(0.85)	(0.90)	(-1.14)	(-0.84)	(1.00)	(1.40)	(0.42)	(0.40)
Fin_Constraint	0.0223	0.00819	0.00298	0.00281	0.0214	0.0163	0.00204	0.00228
	(1.20)	(0.48)	(0.83)	(0.76)	(1.47)	(1.42)	(0.85)	(0.86)
Environ_Risk	0.00382	0.00295	0.000577	0.000496	0.00550	0.00577	0.000316	0.0000917
	(0.69)	(0.54)	(0.70)	(0.54)	(1.62)	(1.58)	(0.50)	(0.13)
Constant	-0.384*	-0.399*	-0.00607	0.00332	-0.352***	-0.288**	-0.0579**	-0.0446
	(-1.86)	(-1.67)	(-0.16)	(0.08)	(-3.17)	(-2.32)	(-1.99)	(-1.28)
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y		Y		Y		Y	
Year*Industry FE		Y		Y		Y		Y
r2	0.259	0.352	0.252	0.304	0.211	0.306	0.237	0.279
Observations	6093	5904	6093	5904	6093	5904	6093	5904

Note: This table shows the regressions of firm-level pollutive establement attaintments to the firm ESA intensity. The dependent variables are $Attainment_{num}$, $Attainment_{num}(Excl)$ respectively.$Attainment_{num}$ denotes the firm-level number of attainment plants within the critical habitats. $Attainment_{num}(Excl)$ refers to the firm-level number of attainment plants within critical habitat excluding closed or transacted in the primary market. $Intensity$ indicates the fraction of the establishments for firm i time t that are exposed to ESA shocks. The firm $profitability$ is inferred from firm Return of Asset. The $Tobin'q$ estimation is estimated with the market value divided by the booked values. The $leverage$ follows the estimation with total debt divided by total asset. For the $Asset$, we obtain it with logarithmic of firm market valuation. $Fin_Constraint$ denotes the text-implied financial constraint from Hoberg and Maksimovic (2015). $Environ_Risk$ refers to the environmental regulation risk from Hassan et al. (2017). A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12: Firm-Level TobinsQ and ESA Intensity

	TobinsQ					
	(1)	(2)	(3)	(4)	(5)	(6)
$Intensity$	-0.236*					
	(-1.68)					
$Intensity_{total}$		-0.188**				
		(-2.30)				
$Intensity_{onsite}$			-0.176**			
			(-2.03)			
$Intensity^{First}$				-0.277*		
				(-1.82)		
$Intensity^{First}_{total}$					-0.193**	
					(-2.20)	
$Intensity^{First}_{onsite}$						-0.212**
						(-2.42)
$Leverage$	0.0202***	0.0218***	0.0196***	0.0202***	0.0218***	0.0198***
	(3.10)	(3.42)	(3.40)	(3.10)	(3.43)	(3.43)
$Tangibility$	-0.282	-0.290	-0.352*	-0.286	-0.290	-0.351*
	(-1.43)	(-1.44)	(-1.76)	(-1.44)	(-1.44)	(-1.75)
$Asset$	-0.347***	-0.363***	-0.371***	-0.348***	-0.364***	-0.371***
	(-7.61)	(-7.73)	(-7.83)	(-7.64)	(-7.75)	(-7.85)
$Profitability$	1.547***	1.378***	1.293**	1.547***	1.379***	1.295**
	(2.91)	(2.61)	(2.47)	(2.92)	(2.62)	(2.49)
$Cash$	0.561***	0.608***	0.627***	0.564***	0.608***	0.631***
	(3.07)	(3.21)	(3.22)	(3.08)	(3.21)	(3.23)
$Fin_Constraint$	0.0504*	0.0381	0.0404	0.0498*	0.0388	0.0406
	(1.67)	(1.24)	(1.28)	(1.65)	(1.26)	(1.29)
$Environ_Risk$	-0.0187***	-0.0203***	-0.0172**	-0.0187***	-0.0205***	-0.0174**
	(-2.65)	(-2.69)	(-2.30)	(-2.67)	(-2.72)	(-2.33)
Constant	4.601***	4.744***	4.824***	4.607***	4.750***	4.829***
	(11.06)	(11.04)	(10.96)	(11.09)	(11.05)	(11.00)
Firm FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
r2	0.678	0.653	0.650	0.678	0.653	0.651
Observations	6092	5737	5493	6092	5737	5493

Note: This table shows the regressions of firm-level TobinsQ to the firm ESA intensity. $Intensity$ indicates the fraction of the establishments for firm i time t that are exposed to ESA shocks. The firm $profitability$ is inferred from firm Return of Asset. The $Tobin'q$ estimation is estimated with the market value divided by the booked values. The $leverage$ follows the estimation with total debt divided by total asset. For the $Asset$, we obtain it with logarithmic of firm market valuation. $Fin_Constraint$ denotes the text-implied financial constraint from Hoberg and Maksimovic (2015). $Environ_Risk$ refers to the environmental regulation risk from Hassan et al. (2017). A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 13: The Effect of ESA Shock on Profitability and Investment

	ROA		Investment	
	(1)	(2)	(3)	(4)
ESAShock	-0.0189*		-0.0182***	
	(-1.78)		(-3.25)	
$ESAShock^{First}$		-0.0219*		-0.0194***
		(-1.85)		(-2.98)
Leverage	0.00163	0.00163	-0.00107***	-0.00107***
	(1.46)	(1.46)	(-3.54)	(-3.53)
Tangibility	-0.0799*	-0.0802*	-0.113***	-0.113***
	(-1.66)	(-1.67)	(-5.51)	(-5.54)
Asset	-0.0394***	-0.0394***	0.000427	0.000403
	(-6.47)	(-6.47)	(0.16)	(0.15)
Profitability	0.270***	0.270***	0.122***	0.122***
	(5.26)	(5.28)	(6.49)	(6.52)
Cash	0.0540**	0.0538**	-0.000812	-0.00107
	(2.57)	(2.57)	(-0.07)	(-0.09)
Fin_Constraint	-0.00105	-0.00110	0.00283	0.00278
	(-0.37)	(-0.39)	(1.48)	(1.45)
Environ_Risk	-0.00131	-0.00132	-0.00171***	-0.00172***
	(-1.25)	(-1.26)	(-2.70)	(-2.72)
Constant	0.354***	0.354***	0.107***	0.107***
	(5.91)	(5.91)	(4.06)	(4.07)
Firm FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
r2	0.463	0.463	0.505	0.505
Observations	6092	6092	6088	6088

Note: This table presents the regression results on the temporary effects of firm profitability and investment in response to ESA policy shocks. The dependent variables are *ROA* and *Investment* respectively. *ESAShock* refers to the proportion of plants newly added to the ESA at time t relative to the total number of plants owned by firm i. $ESAShock^{First}$ refers to the proportion of plants newly added to the ESA at time t relative to the total number of plants owned by firm i, excluding plants located in old habitats designated before 2003. The firm $profitability$ is inferred from firm Return of Asset. The *leverage* follows the estimation with total debt divided by total asset. For the *Asset*, we obtain it with logarithmic of firm market valuation. *Fin_Constraint* denotes the text-implied financial constraint from Hoberg and Maksimovic (2015). $Environ_Risk$ refers to the environmental regulation risk from Hassan et al. (2017). A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 14: ESA Shock and Stock Return

	Dependent variable: Cumulative Abnormal Return		
	$CAR^{(0,12)}_{Annual}$		
	(1)	(2)	(3)
ESA$Shock^{First}$	−0.078	−0.075*	−0.092**
	(0.048)	(0.045)	(0.046)
Leverage		0.011	0.011
		(0.008)	(0.009)
Asset		−0.013***	−0.200***
		(0.003)	(0.028)
Tangibility		−0.111***	−0.281**
		(0.034)	(0.138)
Profitability		0.011	−0.616***
		(0.117)	(0.119)
Cash		−0.062	−0.291***
		(0.052)	(0.101)
Fin_Constraint		0.011	−0.005
		(0.010)	(0.016)
Environ_Risk		−0.006	−0.010
		(0.005)	(0.006)
Year FE	Y	Y	Y
Firm FE	Y		Y
Observations	8,255	6,027	6,027
Adjusted R^2	0.051(df = 5413)	0.026(df = 5413)	0.095(df = 5413)

Note: This table presents the stock market's response to ESA policy shocks. The dependent variables are annualized CAR (cumulative abnormal return). The training of the CAR is based on monthly Fama-french factor model. The window for training is 3 years before the end of month. CAR is calculated by sum annual abnormal return of every calendar year. $ESAShock^{First}$ refers to the proportion of plants newly added to the ESA at time t relative to the total number of plants owned by firm i, excluding plants located in old habitats designated before 2003. The firm $profitability$ is inferred from firm Return of Asset. The $Tobin'q$ estimation is estimated with the market value divided by the booked values. The *leverage* follows the estimation with total debt divided by total asset. For the *Asset*, we obtain it with logarithmic of firm market valuation. *Fin_Constraint* denotes the text-implied financial constraint from Hoberg and Maksimovic (2015). $Environ_Risk$ refers to the environmental regulation risk from Hassan et al. (2017). A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 15: Green Labour Hiring Implications

	Green_Hiring^{TF}				Green_Hiring^{TFIDF}			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ESAShock	0.592**	0.478**			0.534**	0.425**		
	(2.57)	(2.28)			(2.49)	(2.17)		
ESAShock^{First}			0.521***	0.525***			0.459**	0.460**
			(2.69)	(2.60)			(2.55)	(2.48)
Employment	0.967***	0.996***	0.970***	0.999***	0.851***	0.881***	0.853***	0.884***
	(4.22)	(4.09)	(4.23)	(4.10)	(3.95)	(3.87)	(3.96)	(3.88)
Leverage	-0.00488	-0.00440	-0.00475	-0.00449	-0.00700	-0.00651	-0.00686	-0.00657
	(-0.55)	(-0.52)	(-0.54)	(-0.53)	(-1.06)	(-1.07)	(-1.04)	(-1.08)
Tangibility	-0.805	-0.562	-0.775	-0.562	-0.832	-0.653	-0.803	-0.651
	(-0.91)	(-0.60)	(-0.87)	(-0.59)	(-1.01)	(-0.74)	(-0.97)	(-0.74)
Asset	0.266*	0.279*	0.269*	0.277*	0.259*	0.273*	0.262*	0.272*
	(1.74)	(1.68)	(1.76)	(1.67)	(1.80)	(1.76)	(1.82)	(1.75)
Profitability	-0.493	-0.374	-0.477	-0.382	-0.316	-0.205	-0.300	-0.211
	(-1.35)	(-0.99)	(-1.31)	(-1.01)	(-0.91)	(-0.57)	(-0.87)	(-0.58)
Cash	-0.565	-0.324	-0.553	-0.326	-0.372	-0.197	-0.361	-0.199
	(-1.00)	(-0.56)	(-0.97)	(-0.57)	(-0.74)	(-0.38)	(-0.71)	(-0.39)
Fin_Constraint	0.0218	-0.0309	0.0243	-0.0304	0.0487	-0.00452	0.0510	-0.00407
	(0.19)	(-0.26)	(0.22)	(-0.26)	(0.48)	(-0.04)	(0.50)	(-0.04)
Environ_Risk	-0.0159	-0.0188	-0.0160	-0.0188	-0.0125	-0.0137	-0.0126	-0.0138
	(-0.73)	(-0.81)	(-0.74)	(-0.81)	(-0.65)	(-0.67)	(-0.65)	(-0.67)
Constant	4.406***	4.141***	4.369***	4.146***	2.993**	2.728**	2.958**	2.732**
	(3.47)	(2.95)	(3.42)	(2.95)	(2.48)	(2.05)	(2.44)	(2.05)
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry FE		Y		Y		Y		Y
r2	0.820	0.828	0.820	0.828	0.834	0.843	0.834	0.843
Observations	2728	2724	2728	2724	2728	2724	2728	2724

Note: This table shows the regressions of the green labour hiring over ESA policy shocks. The dependent variables are $Green_Hiring^{TF}$, $Green_Hiring^{TFIDF}$. $Green_Hiring^{TF}$ implies the term frequency of green job postings for firm i at time t. $Green_Hiring^{TFIDF}$ implies the term frequency adjusted by inverse document frequency scores for green job postings for firm i at time t. *ESAShock* refers to the proportion of plants newly added to the ESA at time t relative to the total number of plants owned by firm i. $ESAShock^{First}$ refers to the proportion of plants newly added to the ESA at time t relative to the total number of plants owned by firm i, excluding plants located in old habitats designated before 2003. *Employment* is the logarithm of the employment of firm i at time t. The firm *profitability* is inferred from firm Return of Asset. The $Tobin'q$ estimation is estimated with the market value divided by the booked values. The *leverage* follows the estimation with total debt divided by total asset. For the *Asset*, we obtain it with logarithmic of firm market valuation. $Fin_Constraint$ denotes the text-implied financial constraint from Hoberg and Maksimovic (2015). $Environ_Risk$ refers to the environmental regulation risk from Hassan et al. (2017). A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 16: Impact of Green Technology on Establishment Attainment to ESA

	$Attainment_{num}$			
	(1)	(2)	(3)	(4)
$GreenInnovation * Intensity$	0.235*	0.251**		
	(1.87)	(2.07)		
$PollutionControl * Intensity$			0.412***	0.436***
			(2.81)	(2.87)
$Intensity$	0.229***	0.182**	0.262***	0.225***
	(2.86)	(2.05)	(4.70)	(3.55)
$GreenInnovation$	0.0248	0.0117		
	(0.50)	(0.27)		
$PollutionControl$			0.0463	0.0462
			(0.88)	(0.96)
$Plant_Num$	0.0325***	0.0315***	0.0324***	0.0309***
	(4.45)	(5.35)	(4.47)	(5.43)
Control	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
Year FE	Y		Y	
Year*Industry FE		Y		Y
r2	0.261	0.353	0.263	0.356
Observations	6093	5904	6093	5904

Note: This table shows the impact of firm innovation on the attainment of pollutive establishments. The dependent variables $Attainment_{num}$ are the total count of establishment attainments within critical habitat areas for firm i at time t. $GreenInnovation$ is a dummy variable that equals one if firm holds general green patents classified by the USPTO, and zero otherwise. $PollutionControl$ is a dummy variable that equals one if firm holds specific pollution control green patents classified by Cheng et al. (2024), and zero otherwise. $Intensity$ indicates the fraction of the establishments for firm i time t that are exposed to ESA shocks since 1973. The firm $profitability$ is inferred from firm Return of Asset. The $Tobin'q$ estimation is estimated with the market value divided by the booked values. The $leverage$ follows the estimation with total debt divided by total asset. For the $Asset$, we obtain it with logarithmic of firm market valuation. $Fin_Constraint$ denotes the text-implied financial constraint from Hoberg and Maksimovic (2015). $Environ_Risk$ refers to the environmental regulation risk from Hassan et al. (2017). A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 17: Media Coverage of Biodiversity News Related to ESA

	$News_{biodiversity}$				$News_{biodiversity}(StronglyRelated)$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Treat^{First} \times After$	229.925***		213.253***		76.641***		72.302***	
	(9.64)		(9.37)		(10.55)		(10.34)	
$Treat \times After$		230.558***		215.972***		77.838***		74.027***
		(10.70)		(10.41)		(11.75)		(11.56)
Constant	115.879***	111.157***	118.276***	113.549***	33.927***	32.193***	34.551***	32.819***
	(34.26)	(31.89)	(36.65)	(33.82)	(32.95)	(30.04)	(34.87)	(31.66)
Plant FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y			Y	Y		
Year*Industry FE			Y	Y			Y	Y
R-squared	0.550	0.551	0.569	0.570	0.644	0.645	0.656	0.657
Observations	75443.000	75443.000	75425.000	75425.000	75443.000	75443.000	75425.000	75425.000

Note: This table shows the regressions of regional biodiversity related news report over ESA policy shocks. The dependent variables are $News_{biodiversity}$, $News_{Biodiversity}(StronglyRelated)$ respectively.$News_{Biodiversity}$ denotes the count of news from the ravenback that has key words on biodiversity. $News_{Biodiversity}(StronglyRelated)$ denotes the count of news from the ravenback that has key words on biodiversity with robustness. $Treat^{First}$ denotes the establishment within the 30km region of the critical habitat designation according to ESA since 2003. $Treat^{First}$ denotes the establishment within the 30km region of the critical habitat designation according to ESA since 1973. The $Treat^{First} \times After_t$ denotes the ESA shocked establishment for plant i at time t since 2003. $Treat \times After_t$ refers to the ESA shocked establishment after 1973. A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 18: Augmented Habitat Designation for ESA-Covered Plants

	Habitat Designations					
	(1)	(2)	(3)	(4)	(5)	(6)
$ESA_Plant_{after2003}$	0.0649***	0.0341***			0.0567***	0.0216***
	(3.93)	(7.63)			(3.46)	(3.71)
$ESA_Plant_{before2003}$			0.174***	0.181***	0.165***	0.178***
			(3.78)	(3.83)	(3.59)	(3.70)
Constant	0.0436***	0.0481***	0.0474***	0.0472***	0.0394***	0.0441***
	(19.17)	(18.75)	(14.53)	(14.43)	(13.36)	(14.69)
State FE	Y		Y		Y	
Year FE	Y		Y		Y	
State*Year FE		Y		Y		Y
R-squared	0.0582	0.488	0.0586	0.488	0.0589	0.488
Observations	75534	75506	75534	75506	75534	75506

Note: This table shows the augmented habitat designations for the ESA-Covered plants. The dependent variables $HabitatDesignations_{j,t}$ measure the number of species' critical habitat listings covering plant j at time t. $ESA_Plant_{after2003,j,t}$ is an indicator that equals one if plant j has been designated as a critical species area (listing after 2003) at time t, and 0 otherwise. $ESA_Plant_{before2003,j,t}$ is an indicator that equals one if plant j has been designated as a critical species area (listing prior to 2003) at time t, and 0 otherwise. We include fixed effects are included at the Sate and Year fixed effects, or $State \times Year$ fixed effects. All errors are robust with clustering at the plant level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 19: Unintended Negative Consequences of ESA on Disposal Site Areas

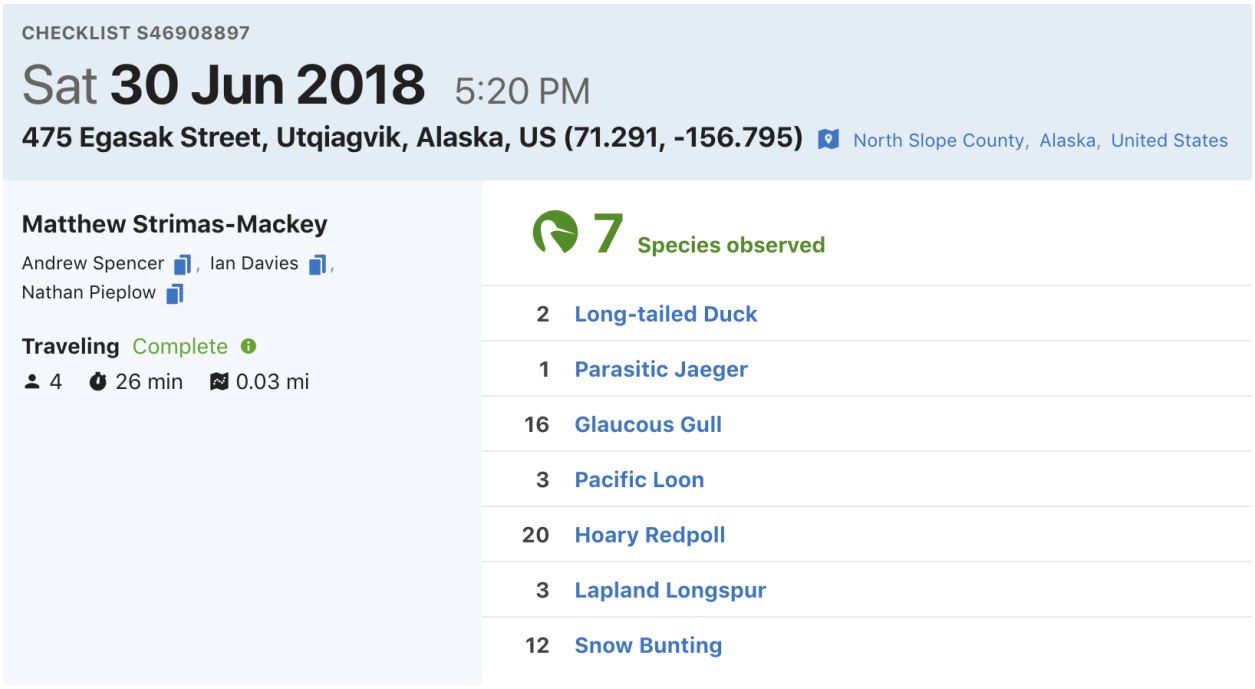
	Dependent variable: Disposal Regional Biodiversity			
	$Bird_{30km}^{Total}$		$Species_{30km}^{Average}$	
	(1)	(2)	(3)	(4)
$Treat^{First} \times After_t$	−2,653.325***		−0.146***	
	(786.222)		(0.032)	
$Treat \times After_t$		−3,088.281***		−0.161***
		(809.280)		(0.033)
Observations	25,411	25,411	25,411	25,411
Year FE	Y	Y	Y	Y
Plant FE	Y	Y	Y	Y
Adjusted R^2	0.312	0.312	0.336	0.337

Note: This table shows the remote connected disposal for the ESA-Covered plants to highlight the social welfare of ESA policy implementation. The dependent variables $Bird_{30km}^{Total}$ ($Species_{30km}^{Average}$) measure the number of (bird) species' critical habitat listings covering plant j connected disposal at time t. $Treat^{First}$ is an indicator that equals one if plant j has been designated as a critical species area (listing after 2003) at time t, and 0 otherwise. $Treat$ is an indicator that equals one if plant j has been designated as a critical species area (listing prior to 2003) at time t, and 0 otherwise. We include fixed effects are included at the plant and Year fixed effects. All errors are robust with clustering at the plant level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix A Figure

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Common Name	Genus	Species	Number	Species Com	Location Name	Latitude	Longitude	Date	Start Time	State/Pr	Country	Protocol	Number	Duration	All obse	Effort Dist	Effort area acres	Submission Comments
2	Canada Goose			45	Pair	Tim's House			2/4/2007	13:30	MD	US	stationary	2	90	Y			Windy and warm, high 90s
3	Mallard			3		Tim's House			2/4/2007	13:30	MD	US	stationary	2	90	Y			Windy and warm, high 90s
4	Common Loon			4	Juvenile	Tim's House			2/4/2007	13:30	MD	US	stationary	2	90	Y			Windy and warm, high 90s
5	Horned Grebe			6		Tim's House			2/4/2007	13:30	MD	US	stationary	2	90	Y			Windy and warm, high 90s
6	Northern Gannet			40	Flying arou	Tim's House			2/4/2007	13:30	MD	US	stationary	2	90	Y			Windy and warm, high 90s
7	Double-crested Cormorant			8		Tim's House			2/4/2007	13:30	MD	US	stationary	2	90	Y			Windy and warm, high 90s
8	Great Blue Heron			1		Tim's House			2/4/2007	13:30	MD	US	stationary	2	90	Y			Windy and warm, high 90s
9	Black Vulture			2		Tim's House			2/4/2007	13:30	MD	US	stationary	2	90	Y			Windy and warm, high 90s
10	Turkey Vulture			8	Soaring ov	Tim's House			2/4/2007	13:30	MD	US	stationary	2	90	Y			Windy and warm, high 90s
11	Osprey			3		Tim's House			2/4/2007	13:30	MD	US	stationary	2	90	Y			Windy and warm, high 90s
12	Tufted Titmouse			2		Tim's House			2/4/2007	13:30	MD	US	stationary	2	90	Y			Windy and warm, high 90s
13	European Starling			25		Tim's House			2/4/2007	13:30	MD	US	stationary	2	90	Y			Windy and warm, high 90s
14	Yellow-rumped Warbler			2	One male,	Tim's House			2/4/2007	13:30	MD	US	stationary	2	90	Y			Windy and warm, high 90s
15	Pine Warbler			5		Tim's House			2/4/2007	13:30	MD	US	stationary	2	90	Y			Windy and warm, high 90s
16	Canada Goose			7		Casa Del Jeff			2/8/2007	14:00	MD	US	traveling	4	30	Y	1.5		Hot and humid, high 90s
17	Mallard			18		Casa Del Jeff			2/8/2007	14:00	MD	US	traveling	4	30	Y	1.5		Hot and humid, high 90s
18	Ring-necked Duck			3		Casa Del Jeff			2/8/2007	14:00	MD	US	traveling	4	30	Y	1.5		Hot and humid, high 90s
19	Brown Thrasher			2		Casa Del Jeff			2/8/2007	14:00	MD	US	traveling	4	30	Y	1.5		Hot and humid, high 90s
20	Pine Warbler			2		Casa Del Jeff			2/8/2007	14:00	MD	US	traveling	4	30	Y	1.5		Hot and humid, high 90s
21	Swamp Sparrow			3		Casa Del Jeff			2/8/2007	14:00	MD	US	traveling	4	30	Y	1.5		Hot and humid, high 90s
22	White-throated Sparrow			13		Casa Del Jeff			2/8/2007	14:00	MD	US	traveling	4	30	Y	1.5		Hot and humid, high 90s
23	Northern Cardinal			8		Casa Del Jeff			2/8/2007	14:00	MD	US	traveling	4	30	Y	1.5		Hot and humid, high 90s
24	Common Grackle			9		Casa Del Jeff			2/8/2007	14:00	MD	US	traveling	4	30	Y	1.5		Hot and humid, high 90s
25	House Finch			3		Casa Del Jeff			2/8/2007	14:00	MD	US	traveling	4	30	Y	1.5		Hot and humid, high 90s
26	American Goldfinch			10		Casa Del Jeff			2/8/2007	14:00	MD	US	traveling	4	30	Y	1.5		Hot and humid, high 90s
27	House Sparrow			3		Casa Del Jeff			2/8/2007	14:00	MD	US	traveling	4	30	Y	1.5		Hot and humid, high 90s
28	Brant			150		Paul's Boutique			2/8/2007	3:00 PM	MD	US	stationary	4	60	Y			Hot and humid, high 90s
29	Canada Goose			6		Paul's Boutique			2/8/2007	3:00 PM	MD	US	stationary	4	60	Y			Hot and humid, high 90s
30	Bufflehead			25		Paul's Boutique			2/8/2007	3:00 PM	MD	US	stationary	4	60	Y			Hot and humid, high 90s
31	Purple Martin			7		Paul's Boutique			2/8/2007	3:00 PM	MD	US	stationary	4	60	Y			Hot and humid, high 90s
32	Tufted Titmouse			5		Paul's Boutique			2/8/2007	3:00 PM	MD	US	stationary	4	60	Y			Hot and humid, high 90s
33	Carolina Wren			3		Paul's Boutique			2/8/2007	3:00 PM	MD	US	stationary	4	60	Y			Hot and humid, high 90s
34	Blue-gray Gnatcatcher			2		Paul's Boutique			2/8/2007	3:00 PM	MD	US	stationary	4	60	Y			Hot and humid, high 90s
35	American Robin			15		Paul's Boutique			2/8/2007	3:00 PM	MD	US	stationary	4	60	Y			Hot and humid, high 90s
36	European Starling			5		Paul's Boutique			2/8/2007	3:00 PM	MD	US	stationary	4	60	Y			Hot and humid, high 90s

(a) eBird Checklist (CSV version)

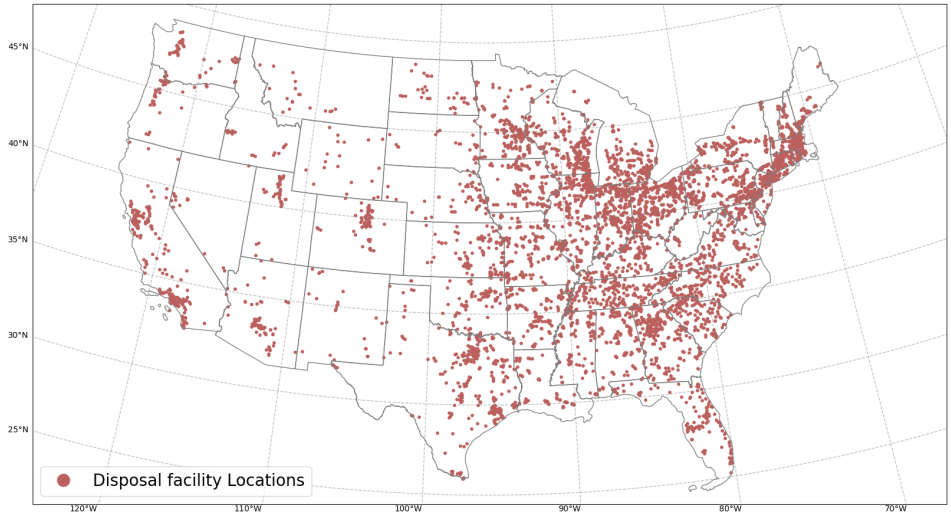


(b) eBird Checklist (Online version)

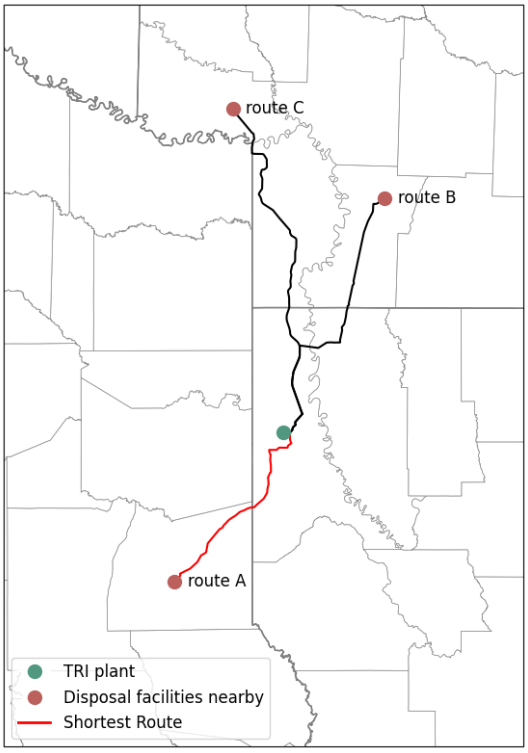
Figure A.1: Example of a Properly Formatted eBird Checklist

Note: This figure illustrates an example of the eBird checklist, where each row represents a unique bird observation. The spreadsheet includes columns for various details such as species name, number observed, location, date, time, and environmental conditions. (Source: eBird Help Center https://support.ebird.org/en/support/solutions/articles/48000907878-upload-spreadsheet-data-to-ebird)

Figure A.2: Disposal Facilities in the US

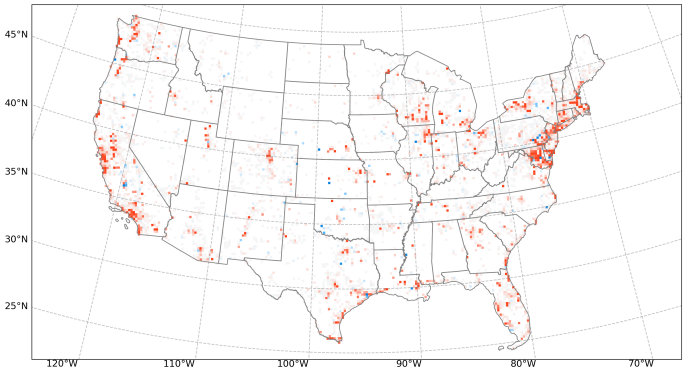


(a) Spatial Distribution of EPA-Documented Waste Disposal Facilities across the United States

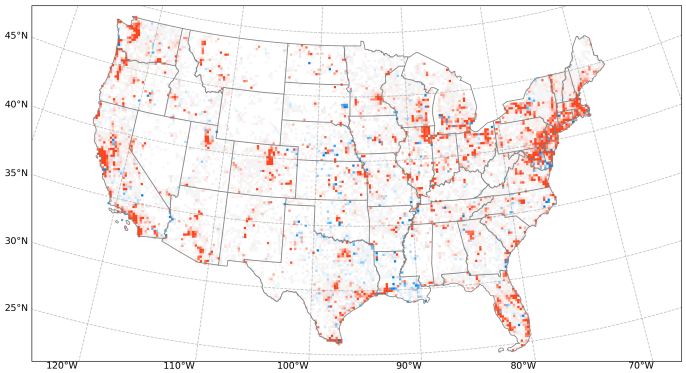


(b) Illustrative Example of TRI Plant-Disposal Facility Matchign Methodology

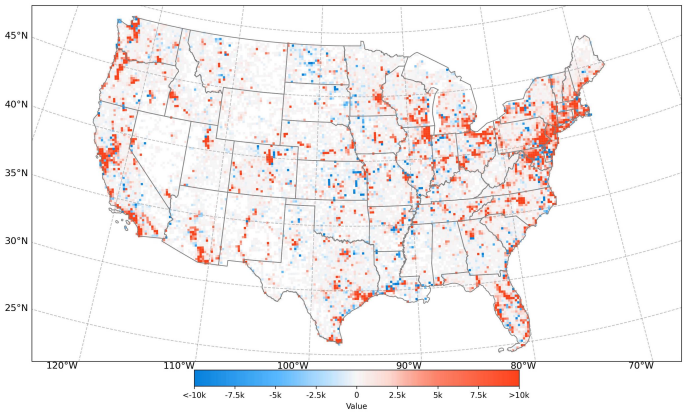
Note: Panel (a) shows the geographic distribution of relevant waste disposal facilities documented in the EPA's Incident Waste Decision Support Tool (I-WASTE DST) database. Panel (b) illustrates the transportation efficiency-based matching methodology for a representative TRI plant (marked in green) and three potential disposal facilities (marked in red) capable of handling its specific waste type. Using Google Map API, we calculated actual transportation routes between TRI plants and potential disposal facilities (shown as solid lines) accounting for road networks and typical traffic conditions. Route A (distance 81.9 kilometers and estimated duration 61 minutes), Route B (distance 109.6 kilometers and estimated duration 76 minutes), and Route C (distance 139.8 km, estimated duration 83 minutes) represent the practical paths waste would travel. Following our least-cost approach assumption, Route A, as the closest appropriate facility, would be selected by the plant for waste disposal. This methodology was applied across all TRI plants in our dataset to determine optimal waste transportation patterns based on both waste compatibility and geographic proximity.



(a) Biodiversity from 2005 to 2010



(b) Biodiversity from 2011 to 2016



(c) Biodiversity from 2017 to 2022

Figure A.3: Biodiversity at the 20km Grid Level at the Time Varying Level

Note: These three panels illustrate the distribution of bird biodiversity across U.S. counties during three distinct time periods. Panel (a) shows the average monthly bird biodiversity for each county during the period from 2002 to 2008, covering 2,831 counties. Panel (b) presents the bird biodiversity data for the period from 2009 to 2015, with an expanded coverage of 3,092 counties. Panel (c) displays the distribution of bird biodiversity from 2016 to 2022, encompassing 3,094 counties. The distribution of values in these three panels uses a consistent scale.

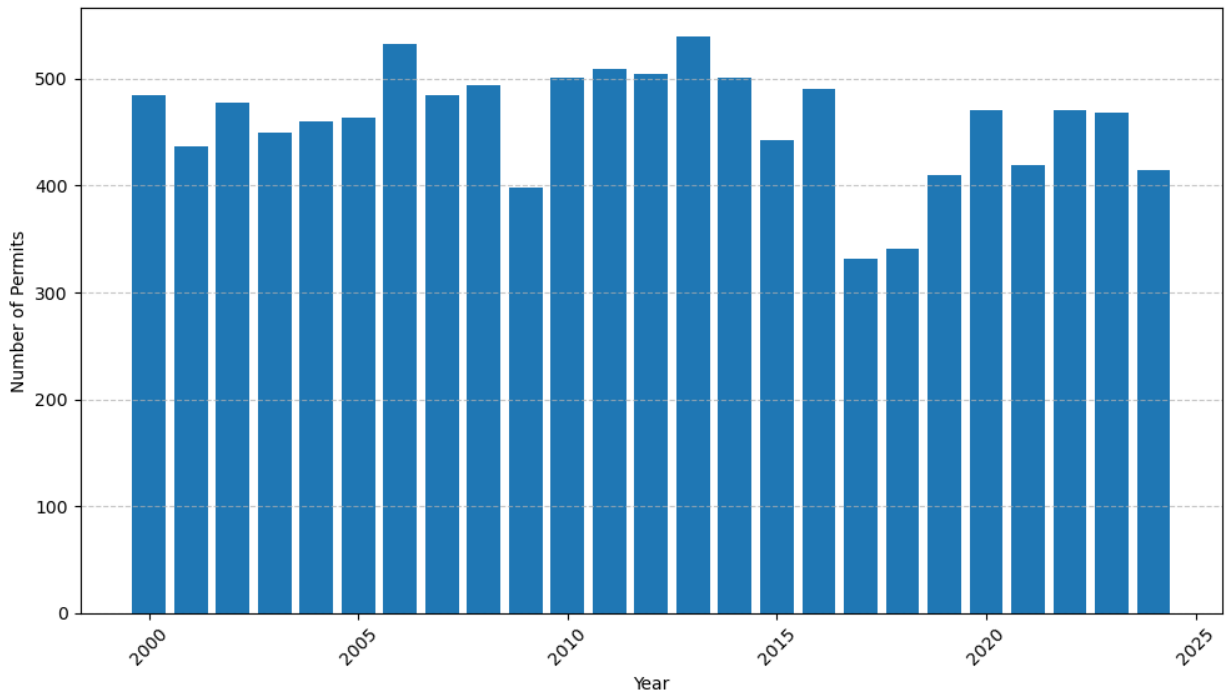


Figure A.4: Permit Counts for Corporate Operation for ESA by Year

Note: This table displays the requests for consultation permits from the US Fish & Wildlife. The consultation permits are related to corporate operations within the critical habitat area from 2000 to 2024.

Appendix B Table

Table A.1: Establishment-level Variable Descriptions

Variable	Definition
$Bird^{log}_{Adj}$	Refers to the total adjusted bird count within a 10 km radius of establishment j at time t, modeled using a logarithmic transformation.
$Bird^{log}_{Std}$	Refers to the total standardized bird count within a 10 km radius of establishment j at time t, modeled using a logarithmic transformation.
$Attainment^{3\ year}_{i,j,t}$	An indicator that equals to one if plant j of firm i at t reach attainment in the following 3 years after the first ESA shock.
$Attainment^{5\ year}_{i,j,t}$	An indicator that equals to one if plant j of firm i at t reach attainment in the following 5 years after the first ESA shock.
$Close/Inactive$	Indicates whether establishment j of firm i has ceased operations or is inactive.
$Sale$	Indicates whether establishment i of firm j has been sold.
$Emission^{Total,j,t}$	Refers to the total emissions of establishment j reported in the TRI at time t.
$Emission^{Offsite,j,t}$	Refers to the offsite emissions of establishment j at time t.
$Emission^{Onsite,j,t}$	Refers to onsite emissions of establishment j at time t.
$WEmission^{Total,j,t}$	Refers to the total emissions of establishment j at time t, weighted by the pollution toxicity score (ranging from 1 to 6).
$WEmission^{Offsite}$	Refers to the offsite emissions of establishment j at time t, weighted by the pollution toxicity score (ranging from 1 to 6).
$WEmission^{Onsite}$	Refers to the onsite emissions of establishment j at time t, weighted by the pollution toxicity score (ranging from 1 to 6).

(Continued from previous page)

Variable	Definition
$HabitatDesignation_{j,t}$	Refers to the number of species' critical habitat listings covering plant j at time t.
$News_{biodiversity}$	Refers to the number of biodiversity-related news articles associated with establishment i at time t.
$Treat_j$	A dummy variable that equals 1 if establishment j is located within 30 km of an area designated as critical habitat, and 0 otherwise.
$Treat_j^{First}$	A dummy variable that equals 1 if establishment j is located within 30 km of an area designated as critical habitat (based on the first ESA listing after 2003) and 0 otherwise (excluding critical habitat areas designated before 2003).
$After_t$	A dummy variable that equals one if year t occurs after establishment j has been covered by an ESA listing, and zero otherwise.
$ESA_Plant_{after2003}$	A dummy variable that equals one if establishment j at time t has already experienced shocks from ESA listings after 2003, and zero otherwise.
$ESA_Plant_{before2003}$	A dummy variable that equals one if establishment j at time t has already experienced shocks from ESA listings prior 2003, and zero otherwise.

Table A.2: Firm-level Variable Descriptions

Variable	Definition
$Attainment_{num}$	Refers to the total count of establishment attainments within critical habitat areas for firm i at time t.
$Attainment_{pct}$	Refers to the total count of establishment attainments within critical habitat areas divided by the total number of plants of firm i at time t.
$Emission^{Total,i,t}$	Refers to the total emissions of firm i at time t.
$Emission^{Offsite,i,t}$	Refers to the offsite emissions of firm i at time t.
$Emission^{Onsite,i,t}$	Refers to the onsite emissions of firm i at time t.
$WEmission^{Total,i,t}$	Refers to the total emissions of firm i at time t, weighted by the pollution toxicity score (ranging from 1 to 6).
$WEmission^{Offsite,i,t}$	Refers to the offsite emissions of firm i at time t, weighted by the pollution toxicity score (ranging from 1 to 6).
$WEmission^{Onsite,i,t}$	Refers to the onsite emissions of firm i at time t, weighted by the pollution toxicity score (ranging from 1 to 6).
$ROA_{i,t}$	Refers to the return on assets (ROA) of firm i at time t, where $ROA = Income\ Before\ Extraordinary\ Items/TotalAssets$
$Investment_{i,t}$	Refers to the investment of firm i at time t.
$TobinsQ$	Refers to the Tobin's Q of firm i at time t
$Green_Hiring^{TF}$	Refers to the term frequency of green job postings for firm i at time t.
$Green_Hiring^{TFIDF}$	Refers to the term frequency adjusted by inverse document frequency scores for green job postings for firm i at time t.
$Intensity_{i,t}$	Refers to the ratio of ESA-shocked plants (post- 2003) over total plants fully owned by the company for firm i at time t.
$Intensity_{total,i,t}$	Refers to the ratio of ESA-shocked plants (post- 2003) over total plants of firm i at time t, weighted by each plant's total pollution emissions.
$Intensity_{onsite,i,t}$	Refers to the ratio of ESA-shocked plants (post- 2003) over total plants, weighted by each plant's onsite pollution emissions.

(Continued from previous page)

Variable	Definition
$Intensity_{i,t}^{First}$	Refers to the ratio of ESA-shocked plants (post-2003) to total plants, excluding those already covered by old habitat designations prior to 2003.
$Intensity_{total,i,t}^{First}$	Refers to the ratio of ESA-shocked plants (post-2003) to total plants, weighted by each plant's total pollution emissions, excluding those already covered by old habitat designations prior to 2003.
$Intensity_{onsite,i,t}^{First}$	Refers to the ratio of ESA-shocked plants (post-2003) to total plants, weighted by each plant's onsite pollution emissions, excluding those already covered by old habitat designations prior to 2003.
$ESAShock$	Refers to the proportion of plants newly added to the ESA at time t relative to the total number of plants owned by firm i.
$ESAShock^{First}$	Refers to the proportion of plants newly added to the ESA at time t relative to the total number of plants owned by firm i, excluding plants located in old habitats designated before 2003.
$Plant_Num$	Denotes the count of TRI plants fully controlled by publicly listed firms.
$Employement$	The logarithm of the employment of firm i at time t.
$Leverage$	Refers to the leverage ratio of firm i profit at t
$Tangibility$	Refers to the tangible asset ratio firm i at t
$Asset$	The logarithm of the total asset of firm i at time t.
$Profitability$	Refers to the profitability of firm i at time t, where $Profitability = (OperatingIncome - InterestExpense - IncomeTaxes)/LaggedTotalAssets$
$Cash$	Refers to the cash holdings of firm i at time t
$Fin_Constraint$	Refers to the financial constraint measure developed from Hoberg and Maksimovic (2015).

(Continued from previous page)

Variable	Definition
$Environ_Risk$	Refers to the logarithm of one plus $PRiskT_environment$, the environmental policy risk derived from corporate earnings calls in Hassan et al. (2017).

Table A.3: ESA Species Listing Events

Publication Date	Species Group	Scientific Name
20030219	Fishes	Hybognathus amarus
20030319	Fishes	Acipenser oxyrinchus (=oxyrhynchus) desotoi
20040727	Fishes	Notropis topeka (=tristis)
20040831	Birds	Strix occidentalis lucida
20041124	Amphibians	Ambystoma californiense
20050823	Amphibians	Ambystoma californiense
20051013	Fishes	Notropis girardi
20060210	Crustaceans	Branchinecta longiantenna
20060210	Crustaceans	Lepidurus packardi
20060210	Crustaceans	Branchinecta lynchi
20060210	Crustaceans	Branchinecta conservatio
20060914	Amphibians	Rana muscosa
20061002	Reptiles	Masticophis lateralis euryxanthus
20071023	Amphibians	Eleutherodactylus cooki
20071212	Crustaceans	Branchinecta sandiegonensis
20071219	Birds	Polioptila californica californica
20090210	Amphibians	Ambystoma bishopi
20090210	Amphibians	Ambystoma cingulatum
20090519	Birds	Charadrius melodus
20090619	Fishes	Salmo salar
20100317	Amphibians	Rana draytonii
20101018	Fishes	Salvelinus confluentus
20101207	Fishes	Etheostoma chermocki
20101214	Fishes	Catostomus santaanae
20101215	Mammals	Zapus hudsonius preblei
20110209	Amphibians	Anaxyrus californicus
20110831	Amphibians	Ambystoma californiense
20120612	Amphibians	Rana sevosa
20121004	Amphibians	Eleutherodactylus juanariveroi
20121016	Fishes	Etheostoma phytophilum
20121204	Crustaceans	Streptocephalus woottoni
20130103	Birds	Empidonax traillii extimus
20130206	Fishes	Eucyclogobius newberryi
20130820	Amphibians	Eurycea tonkawae
20130820	Amphibians	Eurycea waterlooensis
20130822	Fishes	Crystallaria cincotta
20131003	Birds	Eremophila alpestris strigata
20140710	Reptiles	Caretta caretta
20140912	Mammals	Lynx canadensis
20160511	Amphibians	Rana pretiosa
20160804	Birds	Brachyramphus marmoratus

Table A.4: EPA TRI Establishment Attainments (Excl. Close and Sale)

	Within 5 years after ESA Attainment (Excl. Close and Sale)				Within 3 years after ESA Attainment (Excl. Close and Sale)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Treat^{First} \times After$	0.008**	0.007**			0.008**	0.006*		
	(2.40)	(2.35)			(2.15)	(1.96)		
$Treat^{First}$		0.003				0.003		
		(1.59)				(1.58)		
$Treat \times After$			0.010***	0.007**			0.009***	0.006**
			(2.93)	(2.54)			(2.73)	(2.15)
$Treat$				0.004**				0.004**
				(2.06)				(2.13)
Constant	0.017***	0.018***	0.017***	0.017***	0.017***	0.017***	0.017***	0.017***
	(57.61)	(50.88)	(53.72)	(46.18)	(76.44)	(56.99)	(71.68)	(52.35)
Plant FE	Y		Y		Y		Y	
Firm FE		Y		Y		Y		Y
Year*Industry FE	Y	Y	Y	Y	Y	Y	Y	Y
R-squared	0.188	0.085	0.188	0.085	0.187	0.085	0.187	0.085
Observations	69628.000	69745.000	69628.000	69745.000	67445.000	67589.000	67445.000	67589.000

Note: This table shows the regressions of plant pollution over ESA policy shocks. The dependent variables are $Attainment_{5\ years}$, $Attainment_{3\ years}$ respectively.$Attainment_{5\ (3)\ years}$ denotes the indicator implying that firms are off the list of TRI in the next 5 (3) years excluding the closed and transacted plants over the primary market. $WEmission_{total}$ refers to the weighted average offsite pollution. $Treat^{First}$ denotes the establishment within the 30km region of the critical habitat designation according to ESA since 2003. $Treat^{First}$ denotes the establishment within the 30km region of the critical habitat designation according to ESA since 1973. The $Treat^{First} \times After_t$ denotes the ESA shocked establishment for plant i at time t since 2003. $Treat \times After_t$ refers to the ESA shocked establishment after 1973. A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.5: EPA TRI Establishment Close/Active Channel

	Close/Inactive							
	Within 5 years after ESA				Within 3 years after ESA			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Treat^{First} \times After$	-0.001	-0.001			-0.002	-0.001		
	(-0.65)	(-0.77)			(-1.09)	(-0.84)		
$Treat^{First}$		-0.000				0.000		
		(-0.06)				(0.31)		
$Treat \times After$			0.000	-0.000			0.000	0.000
			(0.22)	(-0.07)			(0.14)	(0.23)
$Treat$				-0.000				0.000
				(-0.01)				(0.36)
Constant	0.006***	0.006***	0.006***	0.006***	0.006***	0.006***	0.006***	0.006***
	(42.66)	(39.55)	(36.20)	(37.08)	(59.78)	(44.26)	(49.98)	(40.85)
Plant FE	Y		Y		Y		Y	
Firm FE		Y		Y		Y		Y
Year*Industry FE	Y	Y	Y	Y	Y	Y	Y	Y
R-squared	0.149	0.049	0.149	0.049	0.149	0.050	0.149	0.050
Observations	69628.000	69745.000	69628.000	69745.000	67445.000	67589.000	67445.000	67589.000

Note: This table shows the regressions of the closed/inactive status of establishments over ESA policy shocks. The dependent variable is closed/inactive indicator for a given establishment respectively.$Close_/Inactive$ denotes the indicator implying that establishments are inactive/closed or not. $Treat^{First}$ denotes the establishment within the 30km region of the critical habitat designation according to ESA since 2003. $Treat^{First}$ denotes the establishment within the 30km region of the critical habitat designation according to ESA since 1973. The $Treat^{First} \times After_t$ denotes the ESA shocked establishment for plant i at time t since 2003. $Treat \times After_t$ refers to the ESA shocked establishment after 1973. A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.6: EPA TRI Establishment Sale Channel

	Sale							
	Within 5 years after ESA				Within 3 years after ESA			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Treat^{First} \times After$	0.002	0.002			0.002	0.002		
	(1.08)	(1.26)			(0.66)	(1.01)		
$Treat^{First}$		-0.000				-0.000		
		(-0.16)				(-0.14)		
$Treat \times After$			0.002	0.001			0.001	0.001
			(0.98)	(0.72)			(0.59)	(0.47)
$Treat$				0.001				0.001
				(0.53)				(0.51)
Constant	0.009***	0.009***	0.009***	0.009***	0.009***	0.009***	0.009***	0.009***
	(43.99)	(49.69)	(41.33)	(43.98)	(52.29)	(50.84)	(50.15)	(45.68)
Plant FE	Y		Y		Y		Y	
Firm FE		Y		Y		Y		Y
Year*Industry FE	Y	Y	Y	Y	Y	Y	Y	Y
R-squared	0.150	0.073	0.150	0.073	0.149	0.073	0.149	0.073
Observations	69628.000	69745.000	69628.000	69745.000	67445.000	67589.000	67445.000	67589.000

Note: This table shows the regressions of the transacted status of establishments in the primary market over ESA policy shocks. The dependent variable is transacted indicator for a given establishment respectively.$Sale$ denotes the indicator implying that establishments are transacted or not in the primary market. $Treat^{First}$ denotes the establishment within the 30km region of the critical habitat designation according to ESA since 2003. $Treat^{First}$ denotes the establishment within the 30km region of the critical habitat designation according to ESA since 1973. The $Treat^{First} \times After_t$ denotes the ESA shocked establishment for plant i at time t since 2003. $Treat \times After_t$ refers to the ESA shocked establishment after 1973. A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix C Corporate Operational Adaptations Under ESA Permits – Trends and Cases

The implementation of the Endangered Species Act (ESA) demonstrates distinctive patterns in permitting activity over the past two decades, characterized by both stability and notable fluctuations. From 2000 to 2023, permit numbers have generally oscillated between 400 and 500 annually, with a significant peak occurring in 2005 when permits exceeded 500 cases. The evolution of permitting trends reveals three distinct phases: a period of relative stability in the early 2000s, a sustained elevation between 2010 and 2015 with permits consistently ranging from 475 to 525 annually, and a subsequent moderation to approximately 400-450 permits per year from 2020 onwards (Figure A.4).

Case I: Silicon Valley Power. [1]

Silicon Valley Power (SVP)'s Don Von Raesfeld Pico Power Plant exemplifies how modern infrastructure projects must extensively modify their operations to accommodate endangered species protection. Operating on just 2.86 acres, this sophisticated facility combines high-capacity power generation (122 MW net, 147 MW peak) with advanced environmental controls. The facility's technical complexity is evident in its infrastructure, featuring dual General Electric LM-6000PC Spring gas turbine generators and comprehensive emission control systems, including selective catalytic reduction units and oxidation catalysts. However, SVP's greatest operational challenge stems from the plant's proximity to critical habitats of five protected species, including the threatened Bay checkerspot butterfly and four endangered plant species: Santa Clara Valley dudleya, Coyote ceanothus, Metcalf Canyon jewelflower, and Tiburon paintbrush. The most significant environmental concern centers on how the plant's NOx and ammonia emissions could indirectly impact these species through deposition on nearby serpentine grasslands.

SVP's response to these environmental challenges demonstrates the comprehensive nature of modern ESA compliance. The company's Low-Effect Habitat Conservation Plan mandates

[1] U.S. Fish and Wildlife Service. (2014, June 18). Proposed low-effect habitat conservation plan for the Bay checkerspot butterfly and serpentine grasslands, City of Santa Clara, Santa Clara County, California. FWS–R8–ES–2014–N056;FF08E00000–FXES11120800000F2–145. Federal Register, 79(117), 34779–34780. https://www.federalregister.gov/d/2014-08851

Table A.7: Firm-Level Onsite Pollution Releases to ESA Intensity (New Habitats)

	$log(Emission_{onsite}+1)$				$log(WEmission_{onsite}+1)$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Intensity^{First}$	-0.184	-0.190	-0.248	-0.353	-0.243	-0.271	-0.313	-0.448
	(-0.61)	(-0.50)	(-0.75)	(-0.84)	(-0.77)	(-0.68)	(-0.90)	(-1.02)
Leverage		0.0117		0.0144		0.0151		0.0165
		(1.34)		(1.30)		(1.62)		(1.42)
Tangibility		-0.511		-0.0294		-0.457		0.164
		(-0.75)		(-0.04)		(-0.62)		(0.22)
Asset		0.566***		0.623***		0.654***		0.739***
		(4.61)		(4.81)		(5.01)		(5.52)
$Profitability$		-0.568		-0.682		-0.515		-0.657
		(-1.10)		(-1.28)		(-0.93)		(-1.16)
w_Cash		-0.254		0.153		-0.186		0.198
		(-0.44)		(0.26)		(-0.30)		(0.33)
Fin_Constraint		-0.0791		-0.0372		-0.0623		-0.0199
		(-0.74)		(-0.32)		(-0.56)		(-0.17)
Environ_Risk		-0.0348		-0.0158		-0.0366		-0.0153
		(-1.44)		(-0.63)		(-1.37)		(-0.56)
Constant	8.976***	4.698***	9.006***	4.011***	9.607***	4.619***	9.640***	3.668***
	(244.89)	(4.52)	(224.39)	(3.63)	(250.26)	(4.15)	(229.60)	(3.20)
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y			Y	Y		
Year*Industry FE			Y	Y			Y	Y
r2	0.914	0.910	0.922	0.916	0.913	0.908	0.922	0.916
Observations	8586	6093	8449	5904	8586	6093	8449	5904

Note: This table shows the regressions of plant pollution over ESA policy shocks. The dependent variables are $Green_Hiring^{TF}$, $Green_Hiring^{TFIDF}$. $Green_Hiring^{TF}$ implies the term frequency of green job postings for firm i at time t. $Green_Hiring^{TFIDF}$ implies the term frequency adjusted by inverse document frequency scores for green job postings for firm i at time t. ESA indicates the count of the establishments for firm i time t that are exposed to ESA shocks since 1973. ESA^{First} indicates the count of the establishments for firm i time t that are exposed to ESA shocks since 2003. The firm $profitability$ is inferred from firm Return of Asset. The $Tobin'q$ estimation is estimated with the market value divided by the booked values. The *leverage* follows the estimation with total debt divided by total asset. For the *Asset*, we obtain it with logarithmic of firm market valuation. $Fin_Constraint$ denotes the text-implied financial constraint from Hoberg and Maksimovic (2015). $Environ_Risk$ refers to the environmental regulation risk from Hassan et al. (2017). A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.8: Firm-Level offsite Pollution Releases to ESA Intensity (New Habitats)

	$log(Emission_{offsite}+1)$				$log(Emission_{offsite}+1)$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Intensity^{First}$	0.974**	0.618	1.363***	1.203**	0.755	0.390	1.088**	0.907*
	(2.00)	(1.21)	(2.87)	(2.49)	(1.50)	(0.72)	(2.21)	(1.77)
Leverage		-0.0159		0.00422		-0.0152		0.00604
		(-0.98)		(0.21)		(-0.88)		(0.28)
Tangibility		-1.174		-0.476		-0.850		-0.0245
		(-1.01)		(-0.36)		(-0.71)		(-0.02)
Asset		0.549***		0.417**		0.583***		0.465**
		(3.07)		(2.04)		(3.10)		(2.16)
$Profitability$		0.202		-0.0269		-0.0266		-0.263
		(0.23)		(-0.03)		(-0.03)		(-0.27)
Cash		-0.380		-0.340		-0.192		-0.190
		(-0.47)		(-0.38)		(-0.22)		(-0.20)
Fin_Constraint		0.0473		0.150		0.0620		0.165
		(0.28)		(0.87)		(0.36)		(0.92)
Environ_Risk		-0.0646*		-0.0436		-0.0709*		-0.0489
		(-1.87)		(-1.26)		(-1.96)		(-1.35)
Constant	6.538***	3.064**	6.525***	3.794**	6.993***	3.208**	6.989***	3.814**
	(110.55)	(2.00)	(113.67)	(2.13)	(114.85)	(1.98)	(117.64)	(2.03)
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y			Y	Y		
Year*Industry FE			Y	Y			Y	Y
r2	0.813	0.821	0.832	0.836	0.810	0.818	0.829	0.834
Observations	8586	6093	8449	5904	8586	6093	8449	5904

Note: This table shows the regressions of plant pollution over ESA policy shocks. The dependent variables are $Green_Hiring^{TF}$, $Green_Hiring^{TFIDF}$. $Green_Hiring^{TF}$ implies the term frequency of green job postings for firm i at time t. $Green_Hiring^{TFIDF}$ implies the term frequency adjusted by inverse document frequency scores for green job postings for firm i at time t. ESA indicates the count of the establishments for firm i time t that are exposed to ESA shocks since 1973. ESA^{First} indicates the count of the establishments for firm i time t that are exposed to ESA shocks since 2003. The firm $profitability$ is inferred from firm Return of Asset. The $Tobin'q$ estimation is estimated with the market value divided by the booked values. The *leverage* follows the estimation with total debt divided by total asset. For the *Asset*, we obtain it with logarithmic of firm market valuation. $Fin_Constraint$ denotes the text-implied financial constraint from Hoberg and Maksimovic (2015). $Environ_Risk$ refers to the environmental regulation risk from Hassan et al. (2017). A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.9: Firm-Level offsite Pollution Releases to ESA Intensity (New Habitats)

	$log(Emission_{offsite}+1)$				$log(Emission_{offsite}+1)$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Intensity^{First}$	0.974**	0.618	1.363***	1.203**	0.755	0.390	1.088**	0.907*
	(2.00)	(1.21)	(2.87)	(2.49)	(1.50)	(0.72)	(2.21)	(1.77)
Leverage		-0.0159		0.00422		-0.0152		0.00604
		(-0.98)		(0.21)		(-0.88)		(0.28)
Tangibility		-1.174		-0.476		-0.850		-0.0245
		(-1.01)		(-0.36)		(-0.71)		(-0.02)
Asset		0.549***		0.417**		0.583***		0.465**
		(3.07)		(2.04)		(3.10)		(2.16)
$Profitability$		0.202		-0.0269		-0.0266		-0.263
		(0.23)		(-0.03)		(-0.03)		(-0.27)
Cash		-0.380		-0.340		-0.192		-0.190
		(-0.47)		(-0.38)		(-0.22)		(-0.20)
Fin_Constraint		0.0473		0.150		0.0620		0.165
		(0.28)		(0.87)		(0.36)		(0.92)
Environ_Risk		-0.0646*		-0.0436		-0.0709*		-0.0489
		(-1.87)		(-1.26)		(-1.96)		(-1.35)
Constant	6.538***	3.064**	6.525***	3.794**	6.993***	3.208**	6.989***	3.814**
	(110.55)	(2.00)	(113.67)	(2.13)	(114.85)	(1.98)	(117.64)	(2.03)
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y			Y	Y		
Year*Industry FE			Y	Y			Y	Y
r2	0.813	0.821	0.832	0.836	0.810	0.818	0.829	0.834
Observations	8586	6093	8449	5904	8586	6093	8449	5904

Note: This table shows the regressions of plant pollution over ESA policy shocks. The dependent variables are $Green_Hiring^{TF}$, $Green_Hiring^{TFIDF}$. $Green_Hiring^{TF}$ implies the term frequency of green job postings for firm i at time t. $Green_Hiring^{TFIDF}$ implies the term frequency adjusted by inverse document frequency scores for green job postings for firm i at time t. ESA indicates the count of the establishments for firm i time t that are exposed to ESA shocks since 1973. ESA^{First} indicates the count of the establishments for firm i time t that are exposed to ESA shocks since 2003. The firm $profitability$ is inferred from firm Return of Asset. The $Tobin'q$ estimation is estimated with the market value divided by the booked values. The *leverage* follows the estimation with total debt divided by total asset. For the *Asset*, we obtain it with logarithmic of firm market valuation. $Fin_Constraint$ denotes the text-implied financial constraint from Hoberg and Maksimovic (2015). $Environ_Risk$ refers to the environmental regulation risk from Hassan et al. (2017). A full set of fixed effects and control variables are included at the plant, Year and $Industry \times Year$ at the industry level. All errors are robust with clustering at the firm level. Standardized beta coefficients; t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

substantial financial and operational commitments across three key dimensions. First, SVP must maintain permanent protection of 40 acres of serpentine grasslands through a conservation easement and acquire 43.3 tons of NOx emission credits. Second, the company must follow strict operational protocols, including limited vehicle access and rigorous equipment maintenance requirements to prevent environmental contamination. Third, and perhaps most significantly, SVP bears ongoing responsibilities for long-term habitat management, including population monitoring, invasive weed control, controlled grazing implementation, and regular vegetation health assessments. These obligations represent not just initial capital investments but a fundamental reshaping of the company's operational framework to integrate environmental stewardship into its core business practices. This case illustrates how ESA compliance has evolved beyond simple mitigation measures to require comprehensive, long-term corporate commitments to environmental protection.

Case II: Indiana Crossroads Wind Farm II LLC [2]

The Indiana Crossroads Wind Farm II project demonstrates how renewable energy developments must proactively integrate ESA considerations into their core design and operations. The project's scale - 42 wind turbines spread across 28,778 acres - amplifies the complexity of balancing clean energy production with wildlife protection. What distinguishes this case is the sophisticated approach to managing impacts on four specific bat species protected under the ESA: the Indiana bat, northern long-eared bat, tricolored bat, and little brown bat. The company's strategy involved securing a carefully structured six-year Incidental Take Permit (ITP) that established precise numerical limits on species impact: up to 18 Indiana bats, 2 northern long-eared bats, 18 tricolored bats, and 18 little brown bats over the permit duration.

The company's Habitat Conservation Plan (HCP) represents a new generation of corporate environmental stewardship, combining operational adaptations with proactive conservation initiatives. Rather than simply minimizing harm, the plan incorporates multiple layers of species protection. At the operational level, the company implements sophisticated turbine control protocols during peak bat activity periods, particularly during low

[2]U.S. Fish and Wildlife Service. (2020, June 25). R-Project transmission line, Nebraska; Revised proposed habitat conservation plan for the American burying beetle and draft supplemental environmental impact statement. FWS–R6–ES–2014–0048;FXES11140600000–245–FF06E22000. Federal Register, 85(123), 38124–38125. https://www.federalregister.gov/d/2024-02490

wind speeds when bats are most active. The financial commitment extends beyond direct operational modifications to include contributions to approved conservation banks and in-lieu fee programs. Moreover, the company's approach encompasses innovative conservation measures, such as funding initiatives to treat white-nose syndrome in bat populations. This comprehensive strategy is underpinned by intensive monitoring programs to evaluate the effectiveness of these mitigation measures, demonstrating how modern ESA compliance requires corporations to adopt a scientific, data-driven approach to species protection while maintaining their core business operations.

These two cases, drawn from different industrial sectors, collectively illustrate how ESA requirements are driving the evolution of corporate environmental management from simple compliance to comprehensive stewardship. They demonstrate that successful adaptation to ESA requirements demands not just financial investment but a fundamental reimagining of how businesses operate in environmentally sensitive areas.

Appendix D Data Summary

Appendix D.1 eBird Data

The bird biodiversity measures in this study are constructed based on the eBird dataset, a comprehensive, global citizen science initiative managed by the Cornell Lab of Ornithology (Sullivan et al.; 2014). Launched in 2002, eBird compiles bird checklists from diverse locations and dates, serving as one of the primary sources of large-scale, real-time bird observation data for thousands of species worldwide, including over 900 species regularly observed in the United States. As of 2023, eBird houses more than 1 billion bird observations globally, contributed by over 700,000 participants across all countries. Its vast spatial and temporal coverage provides a comprehensive view of biodiversity trends across different regions and time periods. Consequently, this extensive dataset has become widely utilized in various scientific fields, including ecological research, conservation biology, and increasingly in interdisciplinary studies (La Sorte et al.; 2017; Horns et al.; 2018; Liang et al.; 2020b).

The data collection process in eBird is designed to be both flexible and standardized. Volunteer birdwatchers (or observers) use standardized protocols to record species, counts of birds seen and/or heard during their birdwatching activities, as well as the date, time, and location, typically using GPS-enabled mobile applications or web interfaces. Each submission, referred to as a "checklist", represents a unique birding event and may include additional information such as breeding behavior, habitat details, and observer effort (e.g., duration, distance traveled). Importantly, each checklist is marked as either "complete" or "incomplete" by the submitting observers. This distinction indicates whether they are submitting a complete list of all birds seen during their observation period, which is crucial for inferring species absences in subsequent analysis. An example of a checklist can be found in Appendix figures A.1.

Observers use various checklist protocols (e.g., traveling, stationary, historical, incidental) to record their observations, allowing for the aggregation of data ranging from causal bird lists to highly structured surveys. This standardized yet flexible approach enables eBird to accommodate diverse birding practices while maintaining data consistency. The comprehensive data collection method allows for continuous monitoring of bird populations across seasons and locations, providing a rich resource for scientific research and conservation efforts.

To ensure data quality, eBird employs a multi-tiered validation process. Automated filters first flag unusual or unexpected observations based on species, spatiotemporal location, date, and count. These flagged submissions are then reviewed by an extensive network of regional experts before being accepted into the dataset. This rigorous approach, combining automated screening with expert review, helps maintain the integrity and reliability of the data (Kelling, Johnston, Hochachka, Iliff, Fink, Gerbracht, Lagoze, La Sorte, Moore, Wiggins et al.; 2015; Sullivan et al.; 2014).